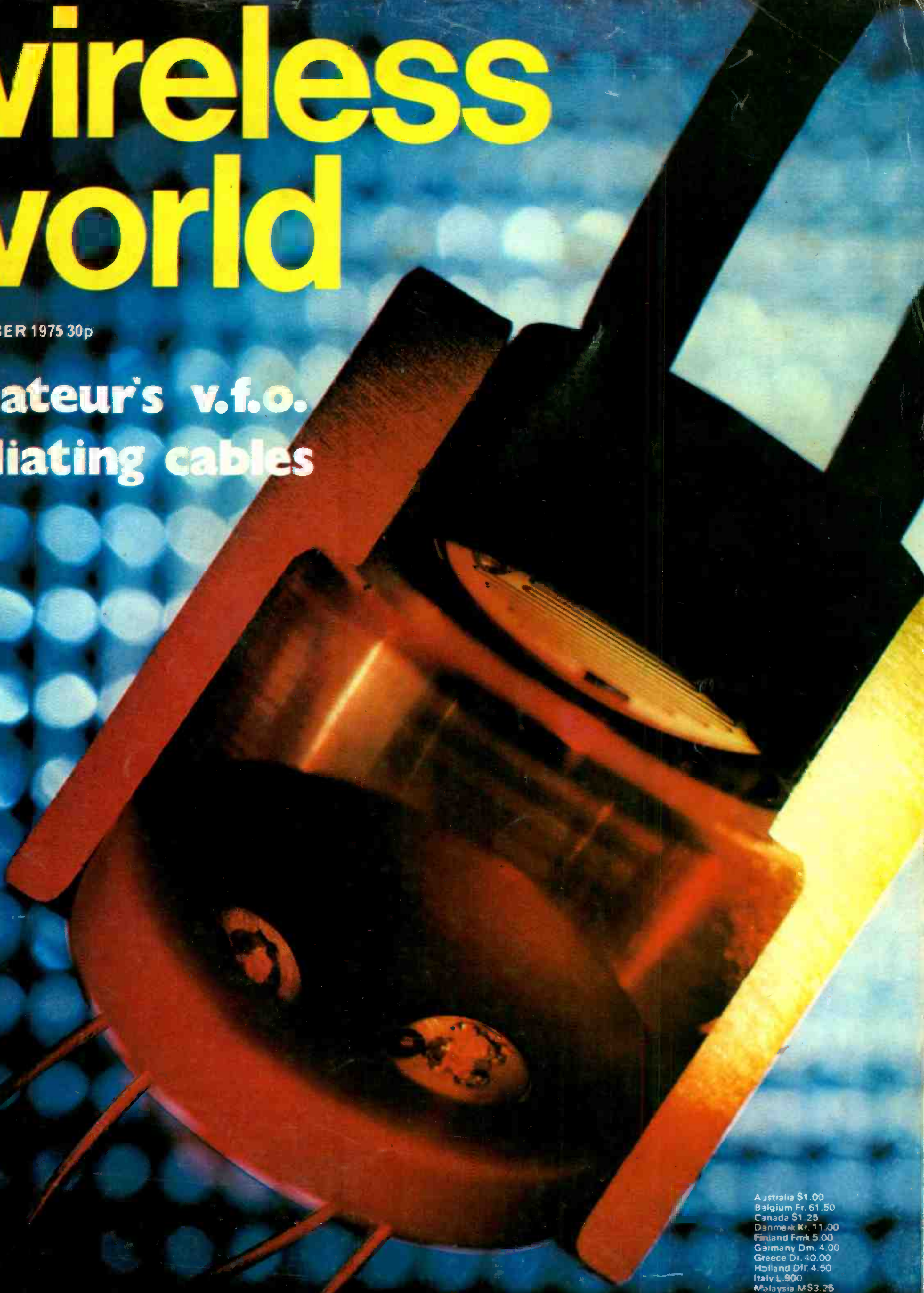
# wireless world

SEPTEMBER 1975 30p

## Amateur's v.f.o.
## Radiating cables



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# Vital Issues

The issues are quite regular–and they discuss issues of vital importance to everyone who uses electronic test equipment.

The periodical, *Marconi Instrumentation,* which is mailed out free to all **mi** customers three times annually, contains technical articles about our latest instruments and up-to-the-minute information on their application to the solutions of measurement problems. It is written by engineers *for* engineers in English with summaries in four other languages.

And that's not all, by any means. **mi** *Contact* is a newspaper published six times a year to keep you in touch with news and progress in the measurement business. Then there are our hardback publications, too. Already, there is a volume on TV Video Transmisson Measurement written by the Head of BBC Measurement Systems Laboratory, and another book discusses the techniques and development of 'white noise' testing. Shortly we will be publishing a book on pulse code modulation, by a senior Post Office engineer.

There are technical data sheets, applications notes, catalogues, concise catalogues and product brochures, all aimed to help you measure.

Are you reading us?

## mi: THE COMMUNICATORS

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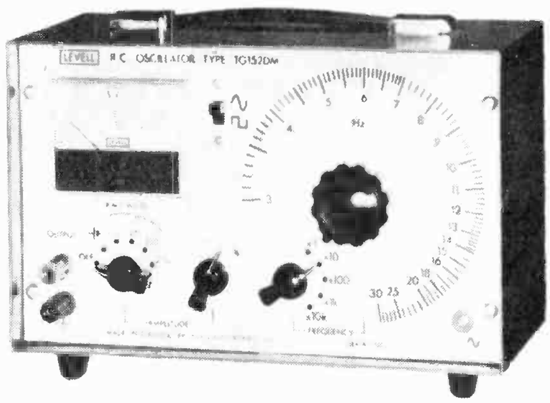
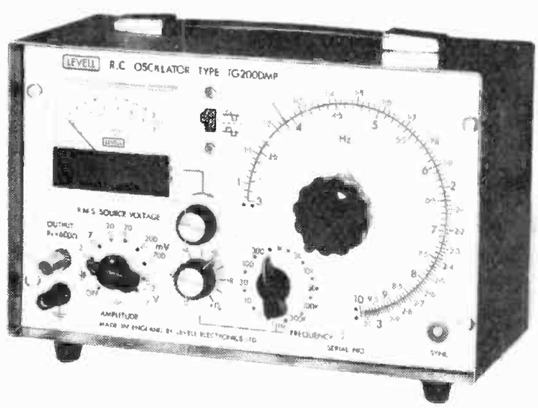
## ANALOGUE



| | |
|---|---|
| FREQUENCY | 3Hz to 300kHz in 5 decade 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. **£53**

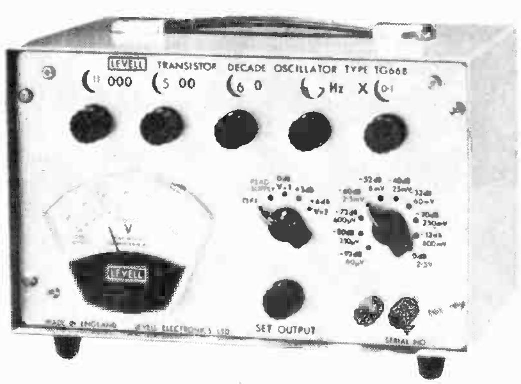
**TG152DM** With meter. **£63**



| | |
|---|---|
| FREQUENCY | 1Hz to 1MHz in 12 semi-decade ranges. 0 to 1% fine control included on TG200DMP |
| ACCURACY | ±2% ±0.03Hz. |
| SINE OUTPUT | 7V r.m.s. down to <200μV with Rs = 600Ω |
| DISTORTION | <0.1% to 5V, <0.2% at 7V from 10Hz to 100kHz. |
| SQUARE OUTPUT | TG200D, DM & DMP only. 7V peak down to <200μV. Rise time <150nS. |
| SYNC. OUTPUT | >1V r.m.s. sine in phase with output. |
| SYNC. INPUT | ±1% freq. lock range per volt r.m.s. |
| METER SCALES | TG200M, DM & DMP only. 0/2V, 0/7V & −14/+6dBm. |
| SIZE & WEIGHT | 7″ high x 10¼″ x 5½″ deep. 10 lbs. |

| TG200 | TG200D | TG200M | TG200DM | TG200DMP |
|---|---|---|---|---|
| **£63** | **£66** | **£73** | **£76** | **£80** |

## 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 = 600Ω |
| 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. **£170**

**TG66A** Mains & battery model. **£190**

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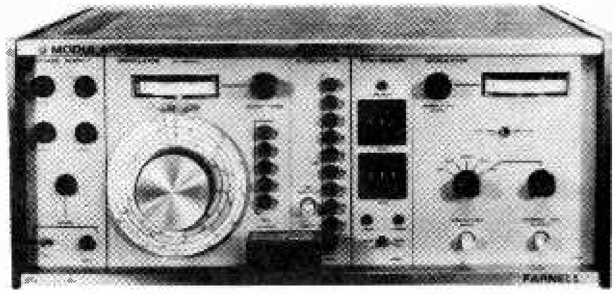
Prices include batteries and U.K. delivery. VAT extra.
Optional extras are leather cases and mains power units.
Send for data covering our range of portable instruments.

WW—005 FOR FURTHER DETAILS

# r.f. test equipment

**TM6 R.F. MILLIVOLTMETER**
1mV to 300V f.s.d.
50kHz to 1.5GHz
Useful to 3GHz
Near true r.m.s. readings on low ranges

**WW—039 FOR FURTHER DETAILS**



**MODULAR SIGNAL GENERATORS**

100kHz to 12MHz
M1A/ABM AM/FM Signal Generator
M1A/ADM Synthesised AM/FM Signal Generator
M1A/ACS Sweep Generator

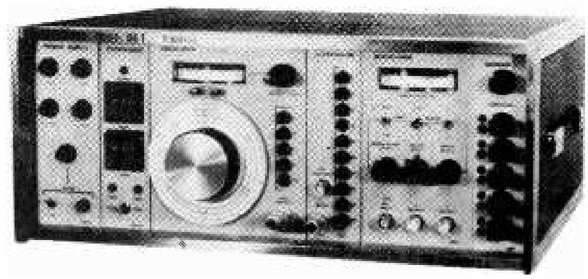
10MHz to 100MHz
M2/ACM AM/FM Signal Generator
M2/ADM Synthesizer AM/FM Signal Generator
M2/ACS Sweep Generator

10MHz to 512MHz
M3A/ABM AM/FM Signal Generator
M3A/ACM Synthesized Signal Generator
M3A ACS Sweep Generator

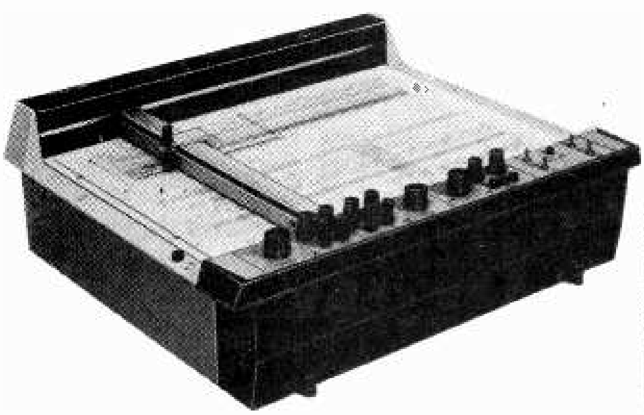
**WW—040 FOR FURTHER DETAILS**

A range of general purpose r.f. signal generators, synthesizers and sweepers is offered covering 100kHz to 512MHz. Specialist instruments include a Marine Test Set covering 0.1 to 12MHz for use with receivers with narrow i.f. filters for S.S.B. reception and u.h.f./v.h.f. Test Sets suitable for work on alerters, pocket pagers and two-way personal radios. All the equipment is programmable and may therefore be used in A.T.E. systems or operated manually.

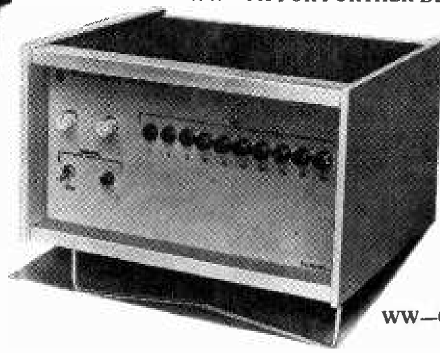
Complementary r.f. test equipment includes an r.f. millivoltmeter, a programmable attenuator and an x-y recorder.



**T6003 TEST SET**
Synthesized signal generator 0.1 to 12MHz
Accuracy _ 5PPM. Resolution 100Hz
3 to 50Hz narrowband sweep Five settable markers
A.M./F.M. capabilty Built-in detector
**WW—041 FOR FURTHER DETAILS**



**X-Y RECORDER**
A3 Size flatbed Ideal for use with sweepers
Also available with timebase for general use
Electrostatic paper hold Disposable pens
**WW—042 FOR FURTHER DETAILS**



**PA112 ATTENUATOR**
Manual or programmable operation
0-122dB in 1dB steps
Uses thick film technnlogy and reed relay switching
Small size
Built-in power supply
**WW—033 FOR FURTHER DETAILS**

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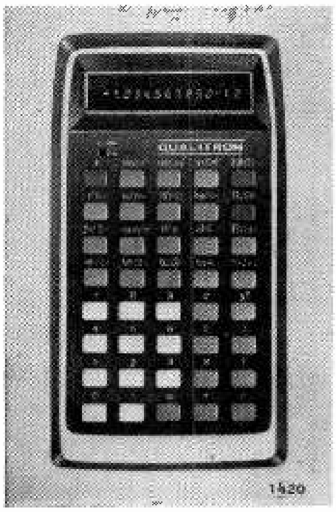
# MEET OUR SCIENTISTS

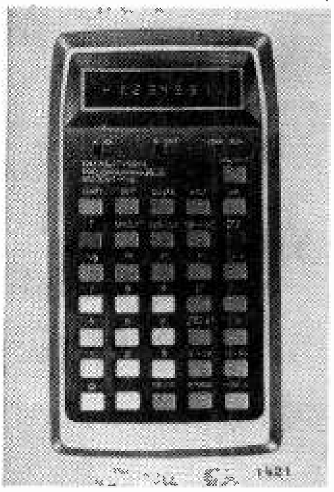
## Q1 1420 — SENIOR




- Automatic selection of correct notation for result display (scientific or floating point)
- Dome keyboard for excellent response and preventing double entry input
- Algebraic mode operation
- Chain operations
- Change sign operation
- Three memories
- Display and memory exchangeable
- Trigonometric functions (sin, cos, tan)
- Inverse-trigonometric functions ($\sin^{-1}$, $\cos^{-1}$, $\tan^{-1}$)
- Radian or degree selectable
- $\pi$ constant
- Logarithms (ln, log)
- Anti-logarithms ($e^x$, $10^x$)
- Combinatorial functions (n!, $\binom{n}{k}$, $(n)_k$)
- Normal distribution function (Pr(x))
- Gamma function ($\Gamma$ (x))
- Group operations ($\Sigma\pm$, $\sigma$, $\bar{X}$, ||x||)
- Group controls (K↑, K↓, Σ↑, Σ↓ $CL_{GRP}$)
- Power function ($y^x$)
- Reciprocal (1/x)
- Square root ($\sqrt{x}$)
- Square ($x^2$)
- Sum of squares ($\Sigma x^2$)
- Summation ($\Sigma X$),
- Item count (n)
- Mean value ($\bar{X}$)
- Mixed chain operations with parentheses approach (up to two levels)
- 14-digit LED display
- 10-digit mantissa with sign and 2-digit exponent with sign for data entry or results ($10^{-99} \sim 10^{99}$)

**PRICE: £61.55** *(Excluding VAT)*

## Q1 1421 — PROGRAMMABLE




BESIDES HAVING THE CAPABILITY OF A SCIENTIFIC CALCULATOR:

- 9-digit LED display
- 8 digits capacity for data entry or results ($10^{-8} \sim 10^{8}$)
- Full floating point
- Automatic display blanking
- Three-register operational stack
- Change sign operation
- Reverse polish notation
- Display and Y-register exchangeable
- One accumulating memory (Memory store, Memory recall, M + X, M − X and M + $X^2$)
- Trigonometric functions (sin cos, tan)
- Inverse-trigonometric functions ($\sin^{-1}$, $\cos^{-1}$, $\tan^{-1}$)
- Radians and degrees exchangeable
- $\pi$ constant
- Logarithms (ln, log)
- Anti-logarithms ($e^X$)
- Power function ($y^X$)
- Reciprocal (1/x)
- Square root ($\sqrt{x}$)
- Square ($X^2$)

IT CAN LOAD ANY 102 STEPS PROGRAM TO HELP YOU SOLVE THE REPEATED, ENORMOUS, COMPLEX PROBLEMS:

The Qualitron Programmable Calculator can be used to memorize any combination of key entrys while in the LOAD mode, then automatically plays back the programmed sequences as often as desired in the RUN mode.

Up to 102 steps can be stored in multiprogram sequence blocks. Each block, or program can be executed individually or you can make the decision to branch to specific program, run each in series or perform intermediate calculations from the keyboard.

**PRICE: £45.97** *(Excluding VAT)*

## Q1 1439—FINANCIAL


SPECIFICATION

- 9 digit green tube display
- 8 digits capacity for dats entry or results ($10^{-8} \sim 10^{8}$)
- Fixed point (0, 1, 2, . 7 places) or full floating point selectable
- Dome keyboard for excellent response and preventing double entry input

BASIC FUNCTION (+, ,x,−,%) AND MEMORY

- Algebraic mode operation
- Constant operations
- Repeat operations
- Chain operations
- Percentage with automatic add on and discount
- Change sign operation
- Four memories

SPECIAL FUNCTION

- Financial operations
- Cost, sell, margin operations
- Trend line opeations
- Delta percentage operations
- Item count (n)
- Mean value ($\bar{X}$)
- Square root ($\sqrt{X}$)
- Summation ($\Sigma X$)
- Sum of squares ($\Sigma X^2$)

**PRICE: £24.63** *(Excluding VAT)*

## Q1 1419 — ADVANCED

SPECIFICATION

- 14 digit LED display
- 10-digit mantissa with sign and 2 digit exponent with sign for data entry or results ($10^{-99} \sim 10^{99}$)
- Automatic selection of correct notation for result display (scientific or floating point)
- Dome keyboard for excellent response and preventing double entry input

BASIC FUNCTION (+,-,x,− ) AND MEMORY

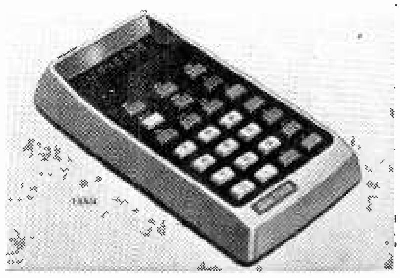
- Algebraic mode operation
- Constant operations
- Repeat operations
- Chain operations
- Change sign operation
- Display and Y register exchangeable
- One accumulating memory
- Display and memory exchangeable

SPECIAL FUNCTION

- Trigonometric functions (sin, cos, tan)
- Inverse trigonometric functions ($\sin^{-1}$, $\cos^{-1}$, $\tan^{-1}$)
- Hyperbolic functions (sinh, cosh, tanh)
- Inverse hyperbolic functions ($\sinh^{-1}$, $\cosh^{-1}$, $\tanh^{-1}$)
- Radian or degree selectable
- $\pi$ constant
- Logarithms (ln, log)
- Anti logarithms ($e^x$, $10^x$)
- Power function ($y^x$)
- Reciprocal (1/x)
- Square root ($\sqrt{X}$)

**PRICE: £31.25** *(Excluding VAT)*

## Q1 1444 — SLIDE RULE



SPECIFICATION

- 9-digit green tube display
- 8 digits capacity for data entry or results ($10^{-8} \sim 10^{8}$)
- Full floating point
- Floating negative sign
- Dome keyboard for excellent response and preventing double-entry input
- Automatic display blanking

BASIC FUNCTION (+,-,x,+,% ) AND MEMORY

- Algebraic mode operation
- Constant operations
- Repeat operations
- Chain operations
- Percentage with automatic add-on and discount
- Change sign operation
- Display and Y-register exchangeable
- One accumulating memory

SPECIAL FUNCTION

- Reciprocal (1/x)
- Square root ($\sqrt{x}$)
- Square ($x^2$)

**PRICE: £18.62** *(Excluding VAT)*

**Special Offer:** Prices quoted are valid only during September and October

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**ELECTRONIC VALVES + SEMI CONDUCTORS** **for Teonexport only**

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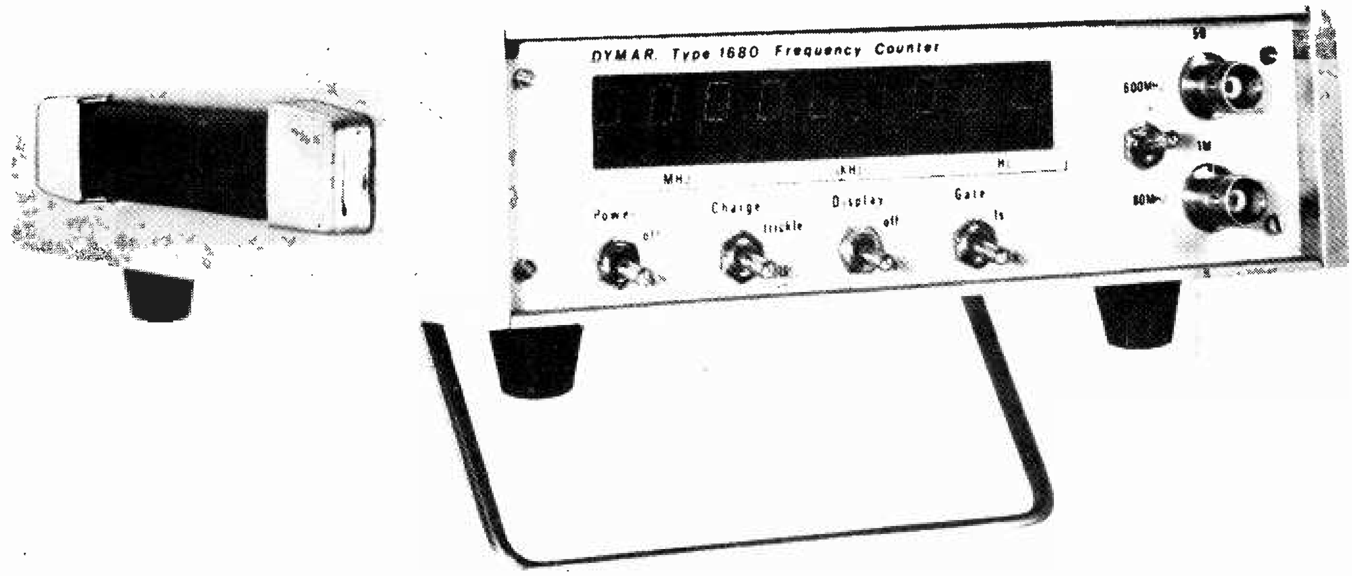
# The Dymar 1680 portable frequency counter




## 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 eight-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.

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**the name in radiotelephones**

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

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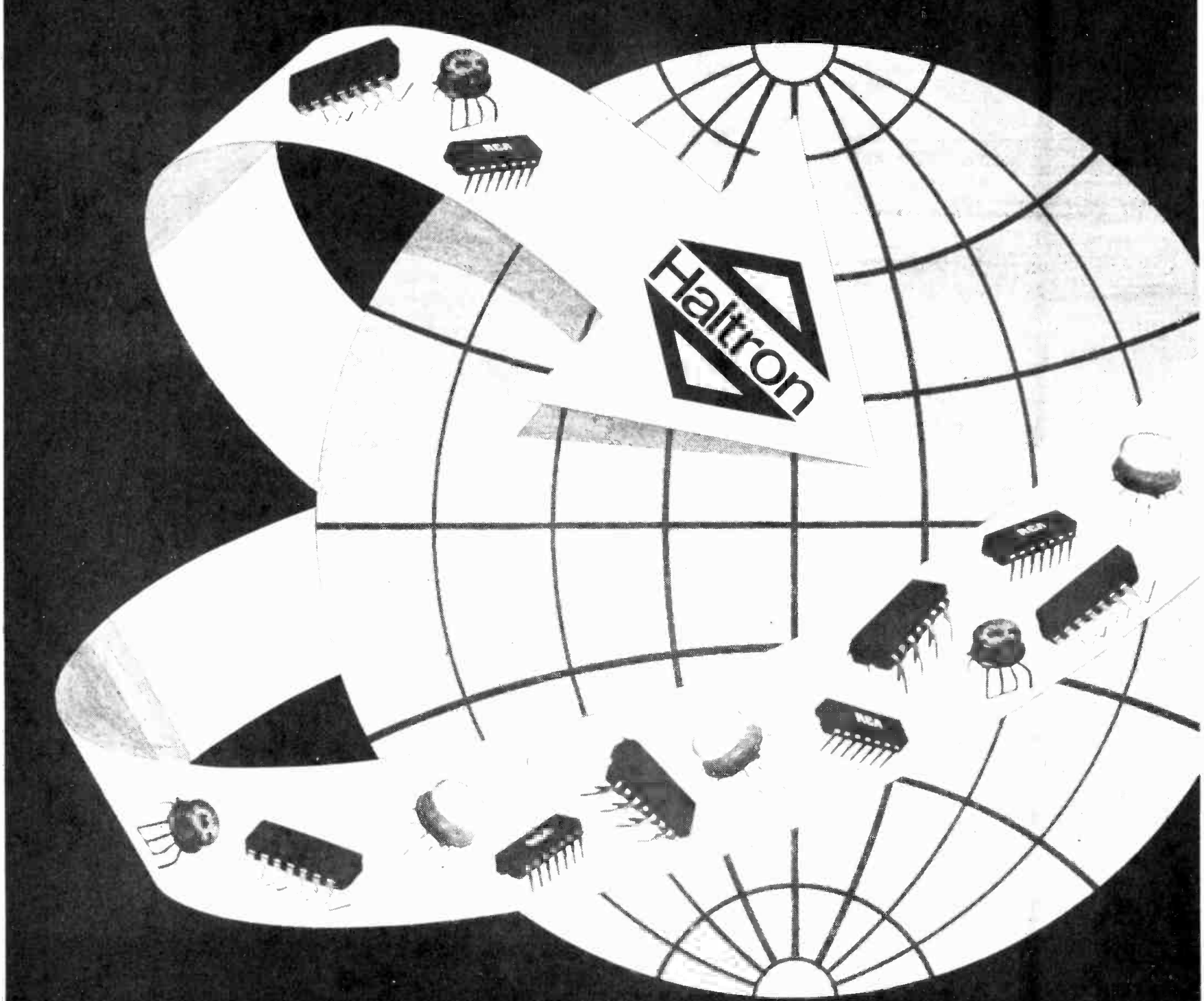
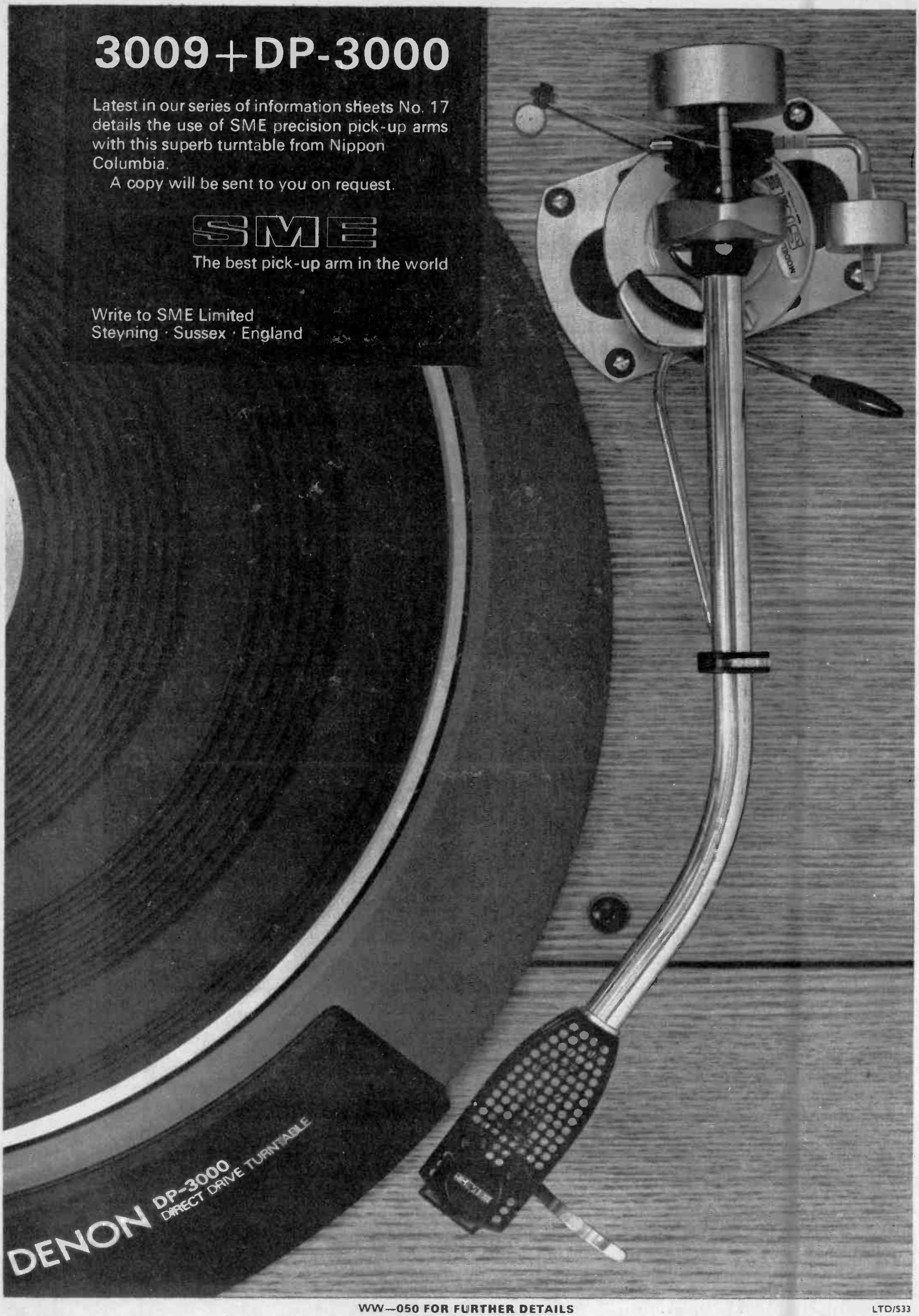

Haltron
RCA


3009+DP-3000
Latest in our series of information sheets No. 17 details the use of SME precision pick-up arms with this superb turntable from Nippon Columbia.
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The best pick-up arm in the world
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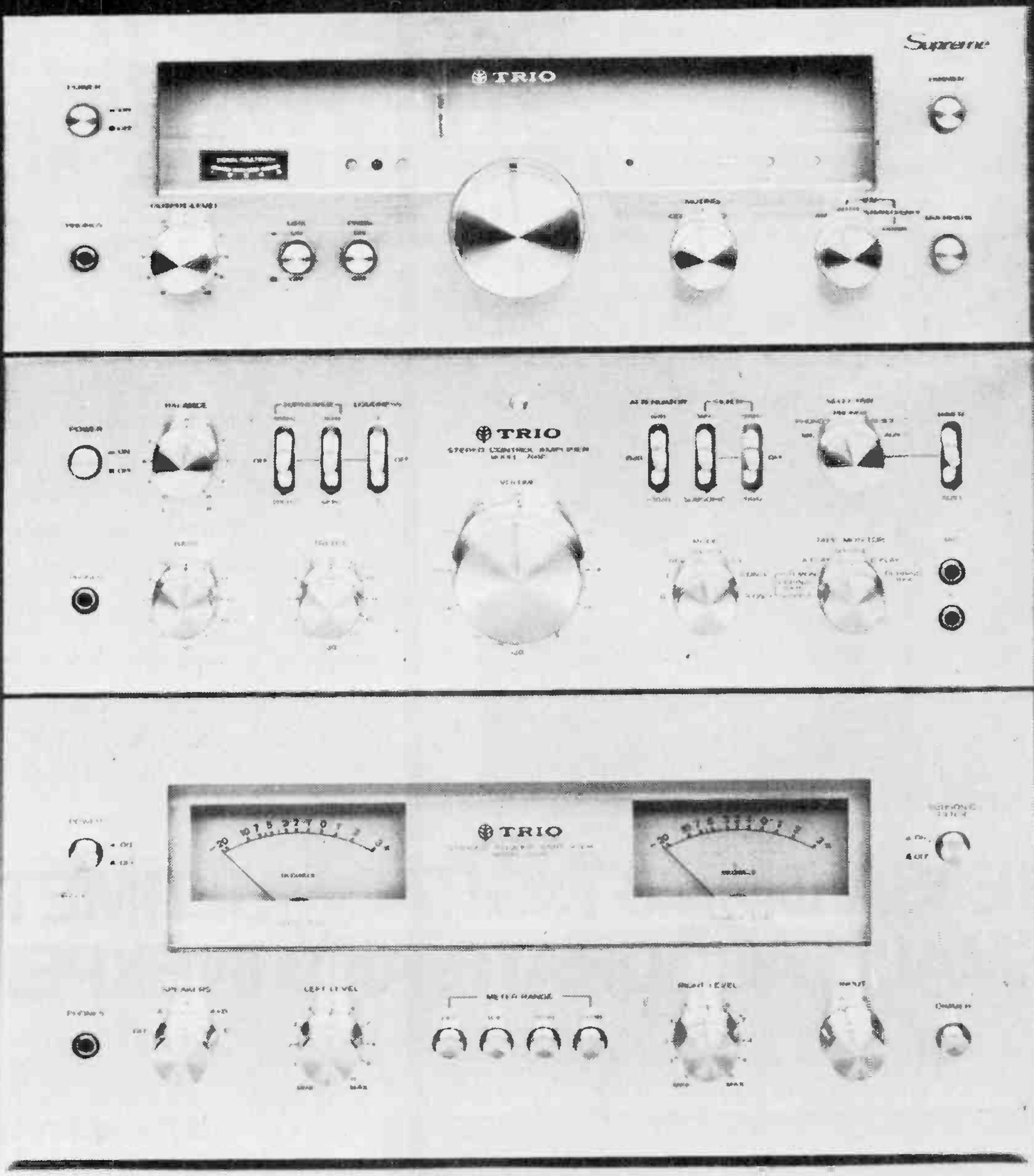
DENON DP-3000 DIRECT DRIVE TURNTABLE




# £1,120 SOUNDS A LOT UNTIL YOU HEAR WHAT YOU GET FOR IT.

The trouble with equipment this advanced is there are so many features we haven't room for them here. But if you write to the address below we'll send you the details that will convince you £1,120 isn't a lot to ask. TRIO

The 700T stereo tuner £390.00. The 700C control amplifier £300.00. The 700M power amplifier £430.00. Prices shown are maximum selling prices excluding VAT.
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In addition to our popular Logic Tutors, we now have a fairly large selection of I.C.Patchboards, an Analog Tutor, a Digital Arithmetic Tutor and a unique Microprocessor Educational Kit.

You ought to get details.

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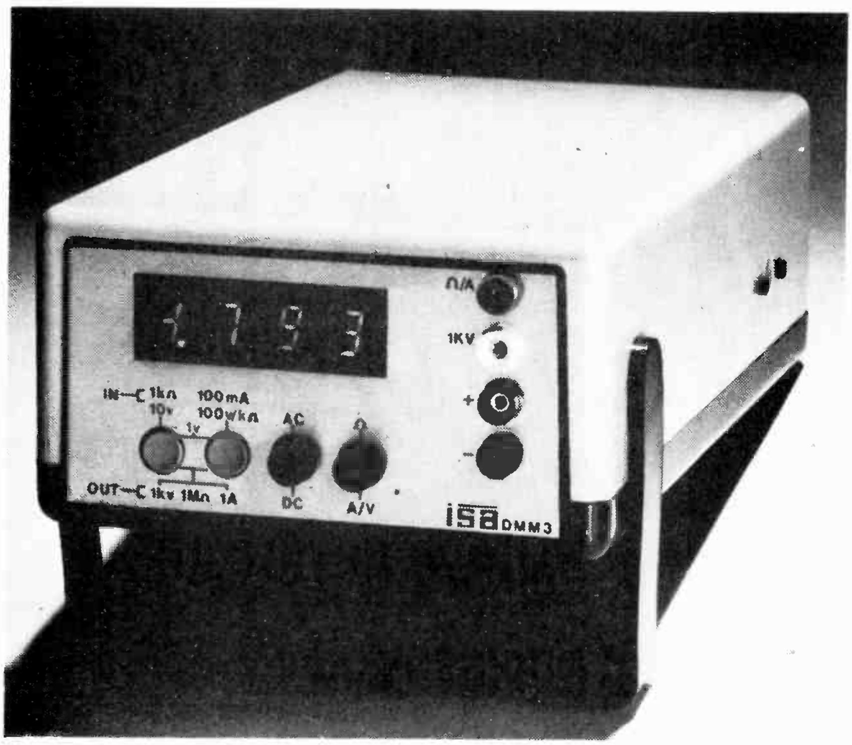
Tel. 0606 41696 and 41697

WW—058 FOR FURTHER DETAILS

# THE ISA DMM3 DIGITAL MULTIMETER IT'S SMALL, ACCURATE, AND INEXPENSIVE




Now–a digital multimeter for the price of an analogue instrument.

At only 190mm x 105mm x 60mm it's easily portable, yet dual slope integration gives it an accuracy of ±·3% at 2V DC to ±1% at 1000V AC. 15 ranges are covered –DC voltage at ± 2–2000 with dual polarity and polarity indication, AC voltage 2–1000, AC DC amps ·2–2, resistance 2KΩ/2MΩ. Read-out is presented on an 8mm LED display with a maximum reading of ±1999. Powered by 4 internal HP2 batteries, with a life of up to 40 hours. Designed and manufactured entirely in the UK.

Price £47.50 plus VAT.

And currently, that's pretty good value.

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Industrial Sub-Assemblies Ltd., 37 Telegraph Street, Cottenham, Cambridge. Telephone (0954) 50590


# Now suitable for U.K., European and American voltages...

Minimod, the versatile British range of encapsulated power supplies first introduced in 1973, has now been extended to cover European and North American mains voltages (and is interchangeable with most American types). Normally available ex-stock, all units are fully stabilised with fold back current limiting – the 5V models have over voltage crowbar too!

STANDARD MODELS

| Type Number | Output Voltage | Output Current Amps | Short Circuit Current mA (Typical) | % Regulation Line and Load (Typical) |
|---|---|---|---|---|
| PU01 | 5 ± 0.1 | 0.5 | 370 | 0.3 |
| PU02 | 5 ± 0.1 | 1.0 | 770 | 0.5 |
| PU03 | 15 - 0 - 15 ± 0.2 | 0.10 | 37 | 0.1 |
| PU04 | 15 - 0 - 15 ± 0.2 | 0.20 | 84 | 0.1 |
| PU05 | 12 - 0 - 12 ± 0.2 | 0.12 | 45 | 0.1 |
| PU06 | 12 - 0 - 12 ± 0.2 | 0.24 | 120 | 0.2 |
| PU11 | 18 - 0 - 18 ± 0.2 | .15 | 50 | 0.1 |
| PU10 | 15 ± 0.2 | .10 | 37 | 0.1 |
| PU12 | 12 ± 0.2 | .10 | 45 | 0.1 |
| PU13 | 18 ± 0.2 | .065 | 23 | 0.1 |

Input voltage ranges 103 - 126V, 200 - 240V. 210 - 250V. Frequency 50 - 400 Hz all types.

Comprehensive specification given in brochure GT 29b which is available on request.

**★SPECIAL DESIGN SERVICE**

*Custom built units for applications requiring different specifications are produced as part of our standard service. Try us first.*

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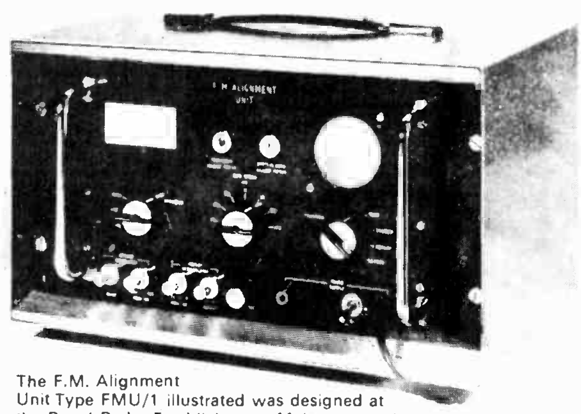
WW—067 FOR FURTHER DETAILS

# "Ampex and WHAT?..."

# The JAMES SCOTT Alignment Units for D.R. and F.M. Multi-Channel Tape Recorders.



The F.M. Alignment Unit Type FMU/1 illustrated was designed at the Royal Radar Establishment, Malvern, to suit Ampex Recorders working on the IRIG intermediate band specification (using ES 100 Electronics) e.g. Model Numbers FR 1200, FR 1260, FR 1300, FR 1800L, FB 400, PR 500

If you have a sophisticated Ampex Recorder—Align it to the Manufacturers specification using our Alignment Units for D.R. & F.M. Systems.

**Speedy and inexpensive**

For Further information and Technical Literature Write or telephone.

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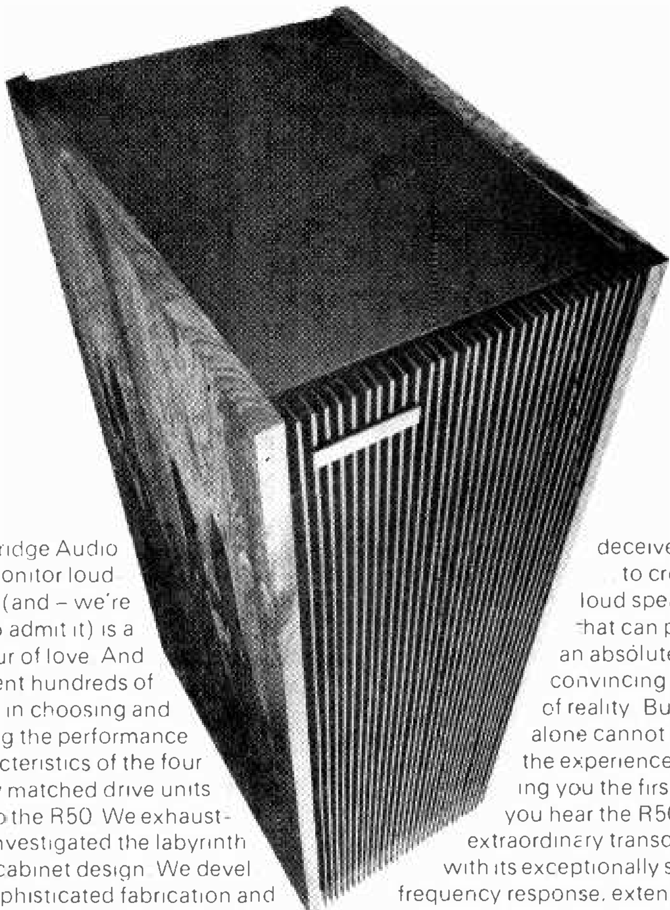
WW—021 FOR FURTHER DETAILS

# THE ILLUSION OF REALITY



Our Cambridge Audio R50 monitor loud speaker (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 crossover 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**

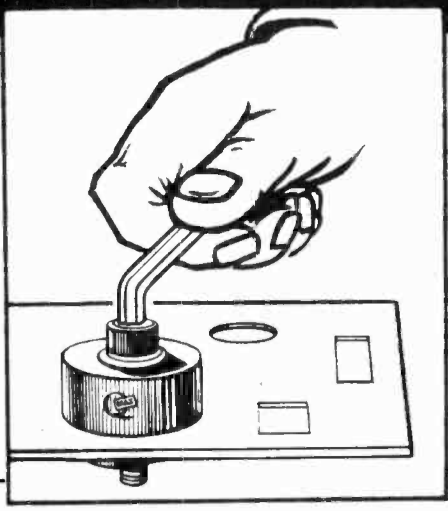
for people who listen to music
Cambridge Audio Limited
The River Mill
St. Ives
Huntingdon PE17 4EP
Telephone St. Ives 62901

**WW—061 FOR FURTHER DETAILS**

# Q MAX

# SHEET METAL PUNCHES

## FOR QUICK CLEAN HOLES



- Easiest and quickest way of punching holes in sheet metal (up to 1.625mm).
- Simple operation ● **100% British**
- Burr-free holes — no jagged edges
- **57 Metric and Linear sizes**

**Used all over the world by:** Government services — Atomic, Military, Naval, Air, G.P.O. and Ministry of Works; Radio, Motor and Industrial manufacturers, Plumbing and Sheet Metal Trades, Garages, etc.

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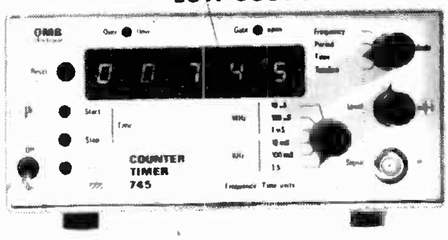
WW—051 FOR FURTHER DETAILS

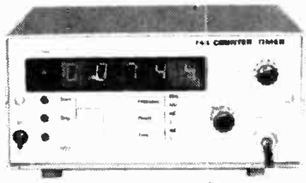
## LOW-COST INSTRUMENTS




**NEW!**
**£82**
+ £1.50 p.p.
+ VAT

### 745 COUNTER TIMER

Measures frequency, period, time and totalises
32 MHz frequency range (DC coupled)
5-digit .3" LED display
6 Gate times/Time units, 10µs to 1 S in decades
Sensitive, protected FET input



### 744 COUNTER TIMER

**£74** + £1.50 p.&p. + VAT

Measures frequency, period and time
30MHz frequency range (DC coupled)
5-digit, long-life incandescent display
Sensitive, protected FET input

### 643 FUNCTION GENERATOR

**£86** + £1.50 p.&p. + VAT

Accurate, digital frequency setting .01Hz–1MHz
Wide range external control of frequency
Triangle, Squarewave and Low Distortion Sinewave outputs
50Ω + simultaneous outputs
DC offset

*Delivery is normally ex-stock—telephone for confirmation*
*Prices correct at time of going to press, subject to change without notice*

**OMB ELECTRONICS**
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**Tel. Farningham (0322) 863567**

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# GROOVAC


## vacuum record cleaner

Vacuum cleaning is the best way to remove dust, especially fine dust. Now with the Groovac, vacuum cleaning is available for extracting the particles from inside record grooves which are responsible for record and stylus wear — while your record is playing.

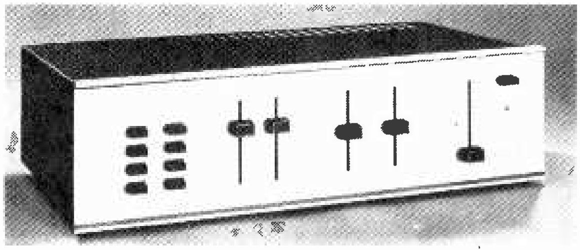
*For full details please write to:—*

**RI AUDIO** Kernick Rd, Penryn
Cornwall, England

WW—035 FOR FURTHER DETAILS

# A NEW STANDARD FOR SOUND REPRODUCTION

## HD250 High Definition Stereo Control Amplifier



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

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

| | |
|---|---|
| **Power output.** | |
| Rated: | 50 watts average continuous power per channel, into any impedance from 4 to 8 ohms, both channels driven. |
| Maximum: | 90 watts average power per channel into 5 ohms load. |
| **Distortion.** | |
| Pre-amplifier: | Virtually zero. (Cannot be identified or measured as it is below inherent circuit noise.) |
| Power amplifier. at rated output: at 25w output: | Less than 0.02% (typically 0.01% at 1kHz). |
| Overload margin. Disc input | 40 dB min. |
| **Hum and noise output** | |
| Disc: | —83dBV Measured flat with noise bandwidth of 23kHz (ref. 5mV.) |
| | —88dBV Measured with 'A' weighted characteristic (ref. 5mV.) |
| Line: | —85dBV Measured flat (ref. 100mV.) |
| | —88dBV 'A' weighted (ref. 100mV.) |
| **Size:** | 17 inches × $4\frac{3}{4}$ inches × 11 inches deep overall. |
| **Weight:** | 21 lb. |

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

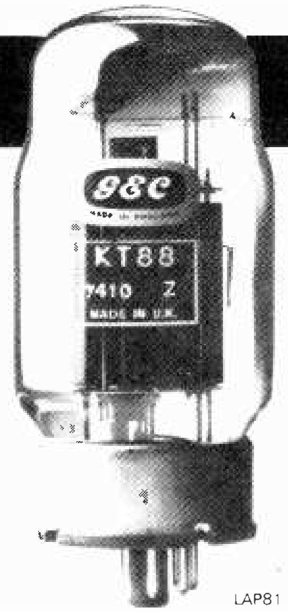
**RADFORD AUDIO LIMITED, BRISTOL, BS3 2HZ Telephone: 0272 662301**

WW—016 FOR FURTHER DETAILS

# Problem.

Where to obtain devices for push-pull audio power amplifiers which give good linearity and don't blow up on the slightest overload.

# Solution.




M-OV audio beam tetrodes. A pair of KT66s will give up to 50W and a pair of KT88s will give up to 100W.
And M-OV audio triodes, too: a pair of DA42s gives up to 200W and a pair of DA 100s gives up to 300W.

**EEV and M-OV know how.**

LAP81

THE M-O VALVE CO LTD. Hammersmith, London, England W6 7PE.
Tel: 01-603 3431. Telex: 23435. Grams: Thermionic London. G&C

WW—008 FOR FURTHER DETAILS

# Great Sound...

THE S3 PRESSURE UNIT has been designed to meet the growing demand for considerably increased power handling capacity without the sacrifice of either efficiency or frequency response. It features a powerful ceramic magnet and a strong but light diaphragm and voice coil assembly with many new features. It is a robust reliable unit of exceptional quality. The S3 is one of the units of the Vitavox Power Range

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*Company* ..........
*Address* ..........
.......... V/75/1

**VITAVOX**
Limited
Westmoreland Road
London NW9 9RJ
Telephone: 01-204 4234

Each of these bridges has ten decade ranges and can be used to measure any type of component or complex impedance. Transformer ratio-arms are used to cover a very wide range of measurement using a minimum number of standards which are set digitally. The three terminal facility provided by this type of bridge enables small values of capacitance or high values of resistance to be measured at the end of long lengths of cable. Components can also be effectively isolated electrically from a complex network allowing individual measurements to be made without disconnection from the circuit being necessary.

## The world's most universal audio bridges

# Wayne Kerr's B224 and B642



**The B224 is a manually operated bridge,** the resistive and reactive terms being independently set to a null indicated on the meter. A rechargeable battery is fitted in order to make the instrument portable.

**The B642 balances itself automatically.** The meters read real and quadrature terms and highly stable analogue outputs are provided which are directly proportional to capacitance and conductance above 10Ω impedance and also to inductance and resistance below 10Ω. One or two decades can be set to provide the first significant figures of the measurement, thereby increasing the meter sensitivity by 10 or 100 times. If a chart recorder is connected to the output of either term, drifts in component values to at least four significant figures can be observed.

SPECIFICATION

| | B224 (Manual balance) | | B642 (Autobalance) | |
|---|---|---|---|---|
| Frequency | 1592Hz (internal)<br>200Hz – 50kHz (external) | | 1592Hz (internal)<br>200Hz – 20kHz* (external) | |
| Ranges for specified accuracy | | | | |
| | 0.1% | 0.3% | 0.1% | 0.3% |
| C | 100fF – 10μF | 10μF – 10mF | 1pF – 10μF | 10μF – 10mF |
| G | 1n℧ – 100m℧ | 100m℧ – 1k | 10n℧ – 100m℧ | 100m℧ – 100℧ |
| L | 1mH – 10kH | 100nH – 1mH | 1mH – 10kH | 1μH – 1mH |
| R | 10Ω – 1GΩ | 1mΩ – 10Ω | 10Ω – 100MΩ | 10mΩ – 10Ω |

NOTE: 0.1% accuracy relates to parallel component measurements above 10Ω impedance. 0.3% accuracy relates to series component measurements below 10Ω impedance.

*Manual operation only

For more information, telephone Bognor Regis on (02433) 25811 or write to the address below:

**WAYNE KERR**
Durban Road, Bognor Regis, Sussex PO22 9R2
Telex: 86120. Cables: Waynkerr Bognor
*A member of the Wilmot Breeden group*

**AGENTS:** **PARIS:** TEKELEC-AIRTRONIC 626-02-35 **LORRACH:** BRINDI GMBH 07621-10742 **STOCKHOLM:** SCANTELE AB 24 58 25 **OSLO:** FEIRING INSTRUMENTS A/S 68.63.60. **BRUXELLES:** ETABLISSEMENTS MIRAVOX S.P.R.L. 35.41.73 **MILAN:** BELOTTI 54.20.51 **KOBENHAVN NV:** HANS BUCH & CO A/S TA 5170 **RIJSWIJK (Z.H.):** C.N. ROOD N.V. 99.63.60.

**WW—059 FOR FURTHER DETAILS**


People often bring their need to us. They know the Whiteley speciality. Being helpful! And the item that started life as a customer request, joins the Whiteley product list, ready to help other designers over a problem. You, perhaps? Consider a neat relay assembly — one or two dry reed switches with a rating of 25W, housed in a mounting tube, with either 'normally open' or 'change-over' contacts. Around them, a coil operating from 8, 12, 24 or 50V supply, 30kV isolated from the contacts. The whole unit mounting on a 0.25" insulating plate with a couple of 3 way tag strips. If you're interested, ask for a data sheet. But more, keep Whiteley in mind as the people who make useful things.

*Surprising how often you'll find*

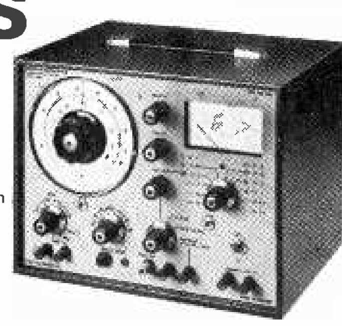
# Whiteley make it.

**Whiteley Electrical Radio Co. Ltd.**
Mansfield, Notts NG18 5RW, England. Tel: 0623 24762.

**WW—060 FOR FURTHER DETAILS**

# ROGERS

## AUDIO TEST EQUIPMENT



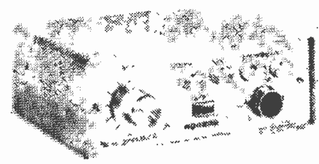
A comprehensive, versatile range of test equipment primarily designed for the measurement of high quality audio equipment but with additional applications in the electronics industry in general. The equipment is of particular interest to the professional audio engineer, recording studios, broadcasting authorities and educational establishments.

**DM344A Distortion Factor Meter.** Designed to make accurate and rapid measurements of total harmonic distortion generated within high quality audio amplifiers, recording and transmission equipment. **Selling Price: c/w Bench Case £175.00 + VAT.**

**S324 Low Distortion Oscillator.** Generates a pure sine wave and has been designed as a general purpose low distortion signal source. The primary application, used in conjunction with the DM344A, is the measurement of total harmonic distortion. **Selling Price: c/w Bench Case £80.00 + VAT.**

**AM324 AF Millivoltmeter.** Designed for voltage measurements in the audio and low RF ranges and principally for measuring low level signals in high impedance circuits. **Selling Price: c/w Bench Case £75.00 + VAT.**

**PS1A.** Regulated Mains Power Supply. **Selling Price: £18.50 + VAT.**



**Model 'A' Noise Generator.** A portable battery operated unit designed for carrying out listening tests on loudspeakers. 'Pink' or 'White' noise can be selected and output can be continuous or burst. Output is continuously variable. **Selling Price: £37.50 + VAT.**

*Full Colour Literature describing the complete range may be had on request*

**ROGERS DEVELOPMENTS (Electronics) LIMITED**
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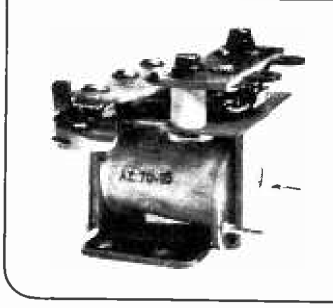
Telephone: 01-697 8511 (3 lines)

**WW—030 FOR FURTHER DETAILS**

# Switching problems? Rely on Zettler.

Producing 30 basic types of relay and 15.000 variants with regard to contact stacks, terminals, energizing current and contact material, Zettler is among the largest manufacturers of electro-mechanical components.

Our product range comprises:
Low profile (flatform) · Timing · Miniature · Low contact capacity · Hermetically sealed · Stepping · Mains switching · Latching Contact stacks · Solenoids




**High-current Switching Relays AZ 70...72**
High contact rating, low energization requirement and fast switching times.
1 make, or 1 make and 1 break contact.
AC switching capacity: 2500 VA.
Max. voltage: 250 V AC.
Max. current: 30 A.
Coil voltages: 6 to 240 V DC.

We resolve your switching problems rapidly and expertly. Please contact us for further details.

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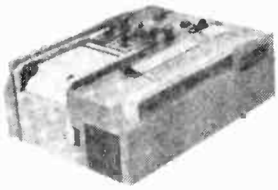
**Please look us up at the INTERNEPCON Exhibition, Brighton, 14-16 OCT., STAND No. 3314, Red Hall, Metropole Convention Centre.**

**WW—013 FOR FURTHER DETAILS**

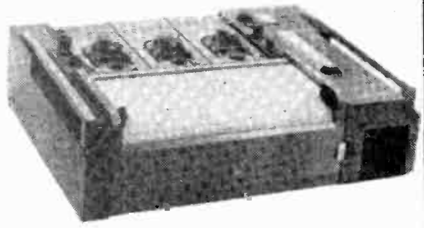
# FAST RESPONSE STRIP CHART RECORDERS

Made in USSR



Type H320-1
Single pen

Type H320-3
Three-pen



**Specification**

| | |
|---|---|
| Basic error | 2.5% |
| Sensitivity | 8mA F.S.D. |
| Response | 0.2 sec. |
| Width of each channel | 80mm |
| Chart speeds, selected by push buttons | 0.1–0.2–0.5–1–2.5–5–12.5–25mm/sec |
| Chart drive | 200-250v 50Hz |

**Recording:** Syphon pen directly attached to moving coil frame, curvilinear co-ordinates

**Equipment:** Marker pen, Timerpen, Paper footage indicator, 10 rolls of paper, connectors, etc.

**Dimensions:** H320-1: 285x384x16.5mm
H320-3: 475x384x16.5mm

PRICE: H320-1 £80.00
H320-3 £130.00
Exclusive of VAT

*Available for immediate delivery*

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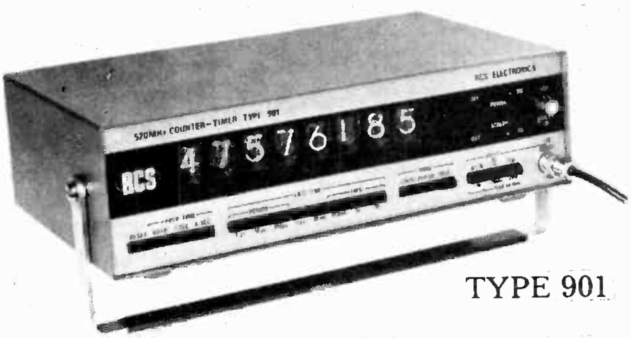
# *FREQUENCY COUNTERS*

*HIGH PERFORMANCE REASONABLY PRICED ELECTRONIC INSTRUMENTS*




TYPE 901

CRYSTAL OVEN
TWO TONE BLUE CASE

£370 **520** MHz

Sensitivity 10mV. Stability 5 parts $10^{10}$

| | | | | | |
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| 301M | 32MHz 5 Digit | £75 | 401 | 32MHz 6 Digit | £118 |
| 501 | 32MHz 8 Digit | £175 | 701 | 50MHz 8 Digit | £185 |
| 701A | 80MHz 8 Digit | £195 | 801M | 300MHz 8 Digit | £285 |
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Start/Stop versions plus £12

Type 101 1MHz 100KHz 10KHz Crystal Standard £80
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SUPPLIERS TO: Ministry of Defence, G.P.O., B.B.C. Government Dept., Crystal Manufacturers and Electronic Laboratories world-wide.

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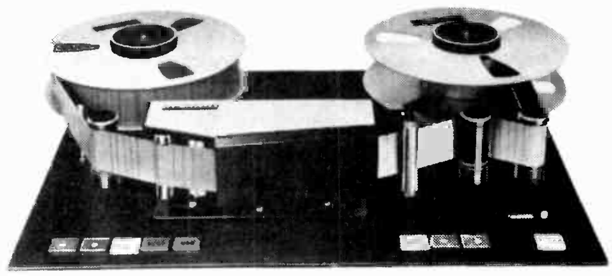
# NEW FROM brenell

MULTITRACK 600 SERIES
2" TAPE TRANSPORT



**Price £1,850** + VAT

Also available complete with Electronics

Finance Available

**BRENELL ENGINEERING CO. LTD.**
231/235 Liverpool Road, London N1 1LY
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# TV Waveform Monitor EV4040...


## One of the EV range of TV waveform, vector & picture monitors – ask for details

**ELECTRONIC VISUALS LIMITED** P.O. Box 16, Staines, Middlesex, TW18 9LF Tel: Staines 56186.

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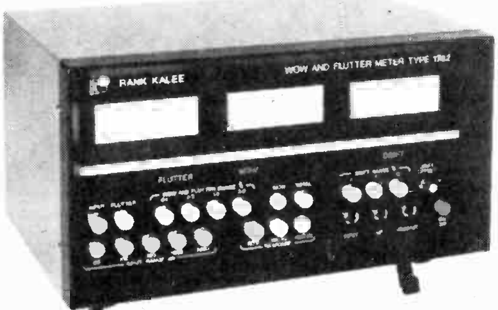


# * The new Rank WOW & FLUTTER Meter Type 1742

**Fully transistorised**
for high reliability

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

**High accuracy**
with crystal controlled oscillator

**Simple to use**
accepts wide range of input signals with no manual tuning or adjustment

**Two models available:**
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*For further information please address your enquiry to*
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Rank Film Equipment, PO Box 70
Great West Road, Brentford
Middlesex TW8 9HR
Tel: 01-568 9222· Telex 24408· Cables Rankaudio Brentford

**RANK FILM EQUIPMENT**

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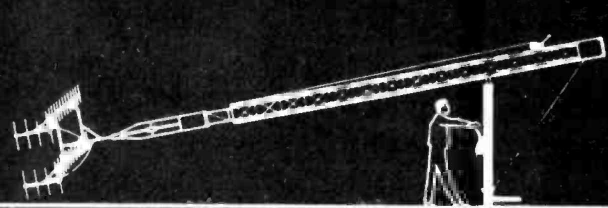
# INSIST ON VERSATOWER



Acclaimed as the World's leading telescopic tiltover tower in the field of radio communication
Models from 25' to 120'

Look for the name

**STRUMECH**

Strumech Engineering Co Ltd
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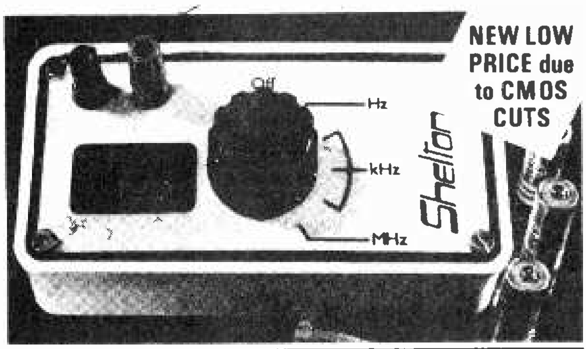
**MEASURE FREQUENCY ANYWHERE WITH MULTIMETER SIZE INSTRUMENT POWERED BY FOUR PENCELLS**

**Latest technology miniature device uses four 0.3" LED digits to display frequency. 5 ranges with coupled decimal point give resolution of 0.1Hz to 1kHz in decade steps.**

**TAKES UP ALMOST NO BENCH SPACE.**

**NEW LOW PRICE. £67.50 inc p&p ex vat.**

**Mains PSU available which fits inside ready drilled case.**




* Also: FX-1 FREQUENCY MULTIPLIER (X 60.X 100) £29.50 *

## MINIATURE BATTERY FREQUENCY METER FM-1

**FOUR-DIGIT MEMORY DISPLAY**
**FIVE RANGES**
**4 ppm CRYSTAL**
**SIZE 6¼ x 3¼ x 2¾ in —including knob and terminals**

**Shelton INSTRUMENTS LTD., 24 Copenhagen Street, LONDON N1 Tel: 01-278 6273**

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# NOW IT'S THE AMCRON M600

## M600 POWER AMPLIFIER

## 1350 watts
### DC-Coupled

The M600 amplifier is a new high-power amplifier capable of providing 1,350 watts RMS over a bandwidth of DC to 20 kHz. 70 volts RMS at the output terminals, very low noise and distortion. AC/DC selector switch, plug-in front panel circuit board, built-in fan for cooling and the ability to connect two M600s together to double the power and output voltage, are just some of the features which place the Amcron M600 in the forefront when considering power amplifiers.
Driving shakers and vibrators, motors, and difficult speaker systems, providing power for material or components testing or used as a large distribution amplifier, the M600 is equally at home.

Brief specifications

| | |
|---|---|
| RMS power out | 750 watts into 8 ohms<br>1,350 watts into 4 ohms |
| DC output | 20 amps (supply fuse limited) |
| Power bandwidth | DC to 20 kHz + 1 db—0 db 600 W into 8Ω |
| Phase response | + 0 db — 15 db DC — 20 kHz |
| Slew rate | 16 V/µsecond |
| Damping factor (8Ω) | greater than 400 DC—1 kHz |
| Hum & noise | 120 db below 600 Watts |
| THD | less than 0.05% DC—20 kHz, 600 W into 8Ω |
| Dimensions | 19" std rack, 8¾" H, 16½" deep. Wt. 92 lb. |

Coupling two M600s together through a socket provided at the back of each amplifier produces a 140 Volt balanced output. This configuration is called an M2000, and produces 2 kilowatts into an 8ohm load. A peak catching meter, and threshold lights provide convenient front panel output monitoring.

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MACINNES HOUSE, CARLTON PARK INDUSTRIAL ESTATE, SAXMUNDHAM, SUFFOLK IP17 2NL
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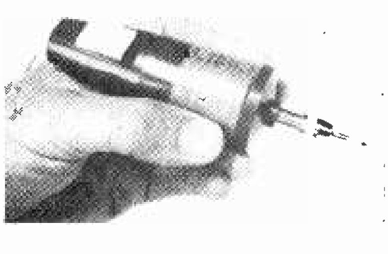
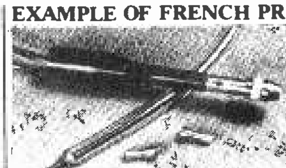
*AVAILABLE IN KIT FORM OR SEPARATES*

*Diameter* 33mm
*Weight* 160g
*Length* 125mm
*Torque* 105cmg
*RPM* approx. 3000 at 12V DC
*Power* 9/14V DC Batteries or AC/DC transformer



Drill. £7.00 P&P 25p

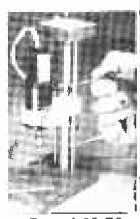
**EXAMPLE OF FRENCH PRECISION ENGINEERING**



Flexible drive. £5.00 P&P 22p

Now in use by the following: GPO, BBC, Atomic Energy Authority, British Nuclear Fuels, Weekend TV, Ministry of Defence, Hospitals, Opticians, etc.

See our Stand at the 23rd International Handicrafts & **DIY EXHIBITION**
Empire Hall, Olympia. Aug 23-Sept 6. 1975



Stand £3.76 P&P 40p

*UK DISTRIBUTOR*
**PRECISION PETITE LTD**
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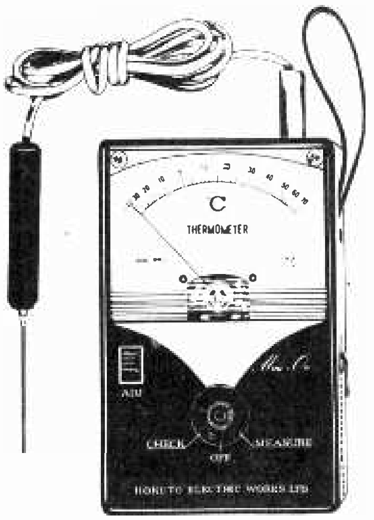
**TEDDINGTON, MIDDX. UK**
**TEL. 01-977 0878**
*SAE for leaflets, price list and order form*

WW—017 FOR FURTHER DETAILS

# ELECTRONIC INDUSTRIAL THERMOMETER



## THE MODERN WAY TO MEASURE TEMPERATURE

A Thermometer designed to operate as an Electronic Test Meter. Will measure temperature of Air, Metals, Liquids, Machinery, etc., etc. Just plug-in the Probe, and read the temperature on the large open scale meter. Supplied in zippered vinyl case with transparent front and carrying loop. Probe, and internal 1½ volt standard size battery.

**Model "Mini-On 1" measures from − 40°C to + 70°C, price £17.50**
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Write for further details to

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

WW—043 FOR FURTHER DETAILS

*Contractors to H.M. Govt. P.O.*

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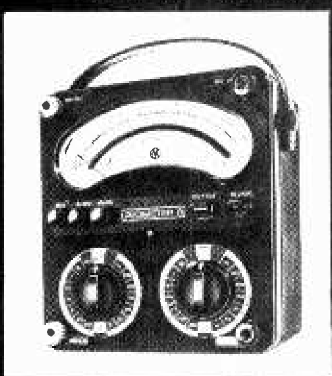
## *7–14 DAYS SERVICE*

◄ MODEL 8 MK.V



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ALSO SUPPLIERS OF GEC RISSO AND OTHER MULTI-RANGE TEST SETS

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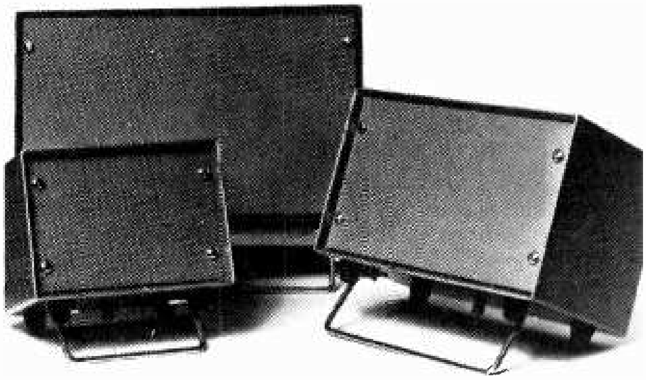
WW—020 FOR FURTHER DETAILS

# OLSON *MINICASES*



Standard minicases are made from 20g. mild steel sheets zinc-coated and finished in silver grey hammertone stove enamel. Front panels made from 18g. steel, finished in light grey high gloss enamel.

| Type | Overall Dimension Width | Height | Depth | Case no vents | Case with vents | Chrome leg |
|---|---|---|---|---|---|---|
| 21 | 6½" | 4½" | 4½" | — | 3.92 | 0.90 |
| 22 | 8½" | 5½" | 5½" | — | 4.40 | 0.90 |
| 23 | 10½" | 6½" | 6½" | — | 5.25 | 0.95 |
| 24 | 12½" | 7½" | 7½" | — | 5.74 | 0.95 |
| 25A | 6½" | 4½" | 4½" | 3.80 | 4.28 | 0.90 |
| 25B | 6½" | 4½" | 6½" | 4.00 | 4.48 | 0.90 |
| 26A | 8¾" | 5¾" | 6¼" | 5.37 | 5.85 | 0.95 |
| 26B | 8¾" | 5¾" | 8¼" | 5.62 | 6.10 | 0.95 |
| 27A | 12¼" | 7½" | 5½" | 5.75 | 6.35 | 0.95 |
| 27B | 12¼" | 7½" | 8" | 6.35 | 6.95 | 0.95 |
| 28A | 14" | 10½" | 6½" | 6.95 | 7.55 | — |
| 28B | 14" | 10½" | 8½" | 7.55 | 8.15 | — |
| 29A | 10" | 4" | 6" | 4.85 | 5.33 | 0.95 |
| 29B | 10" | 4" | 8" | 5.15 | 5.63 | 0.95 |
| 30A | 12" | 5" | 6" | 5.25 | 5.85 | 0.95 |
| 30B | 12" | 5" | 8" | 5.56 | 6.16 | 0.95 |
| 31A | 14" | 6" | 6" | 5.75 | 6.35 | 0.95 |
| 31B | 14" | 6" | 8" | 6.05 | 6.65 | 0.95 |
| 61 | 15½" | 7½" | 9½" | — | 8.75 | — |
| 62 | 17½" | 8½" | 9½" | — | 10.15 | — |
| 63 | 16½" | 9½" | 9½" | — | 10.15 | — |
| 64 | 15½" | 7½" | 12½" | — | 10.15 | — |
| 65 | 17½" | 8½" | 12½" | — | 11.60 | — |
| 66 | 16½" | 9½" | 12½" | — | 11.60 | — |

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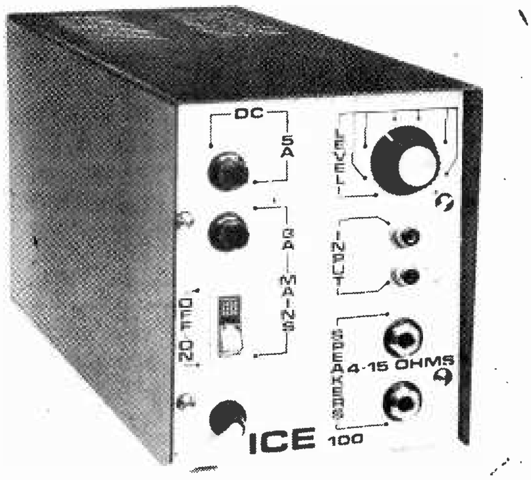


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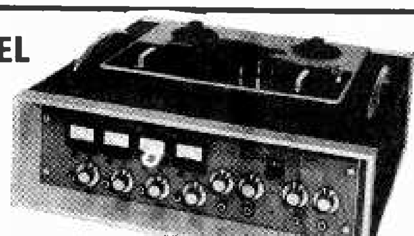

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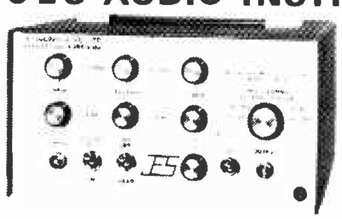

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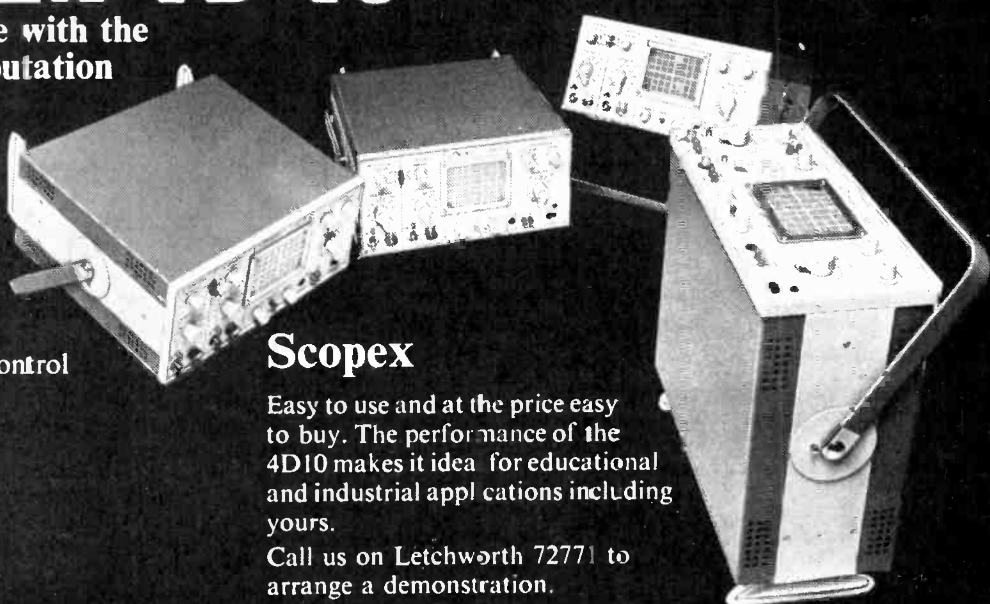

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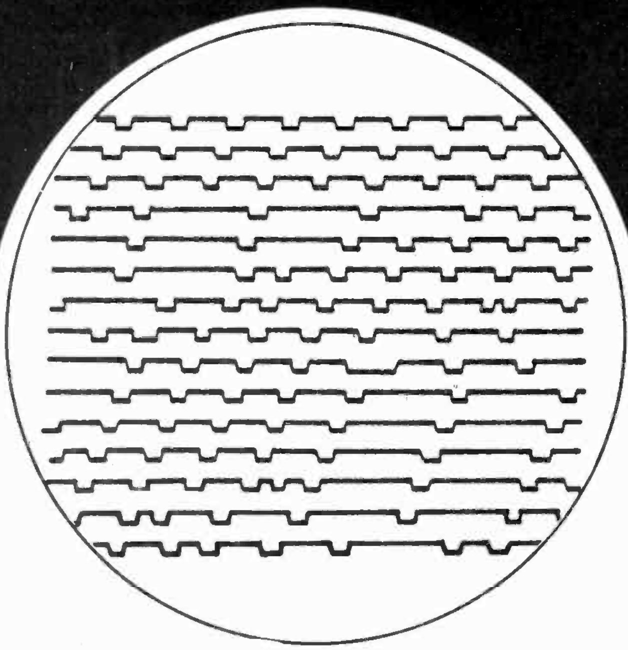

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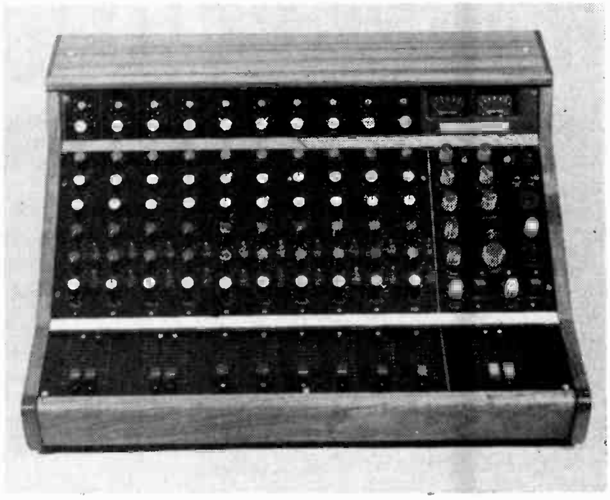

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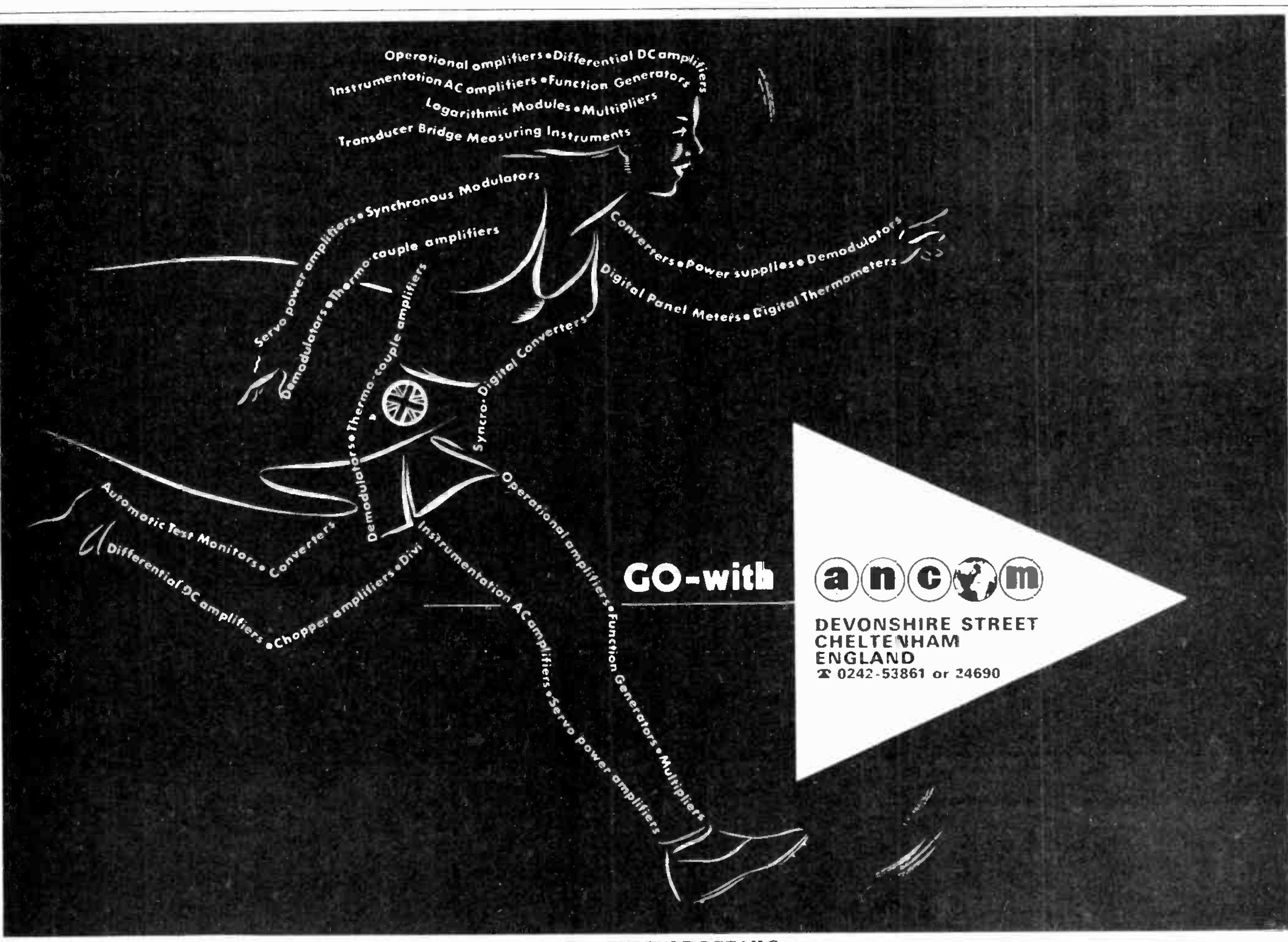

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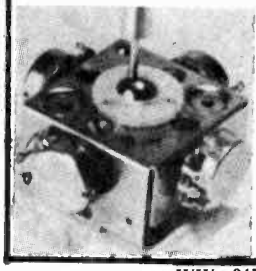

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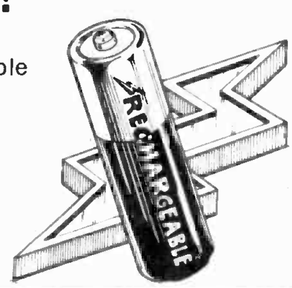


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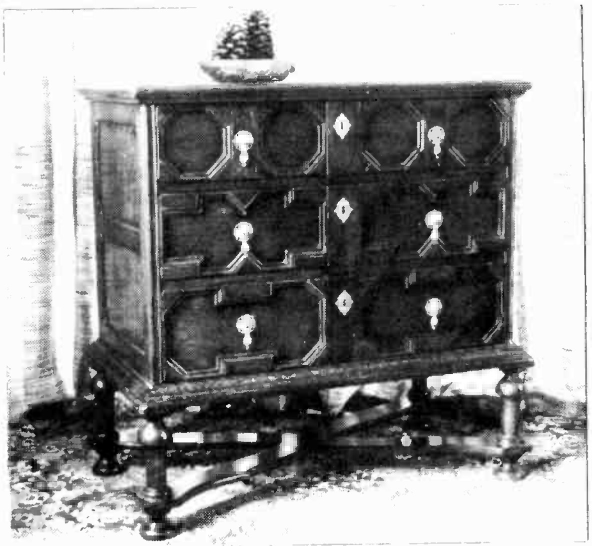

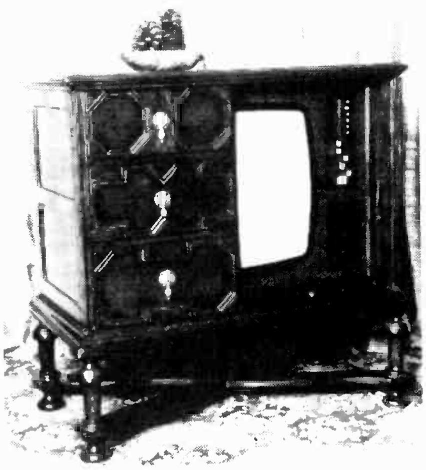

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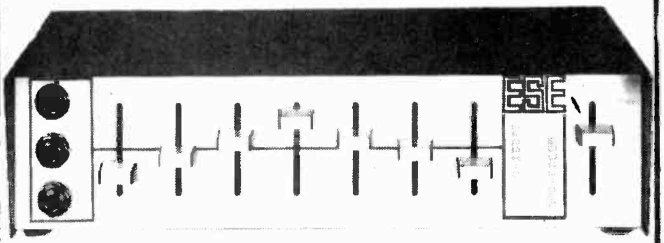


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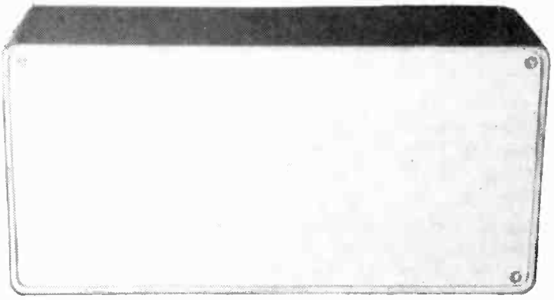

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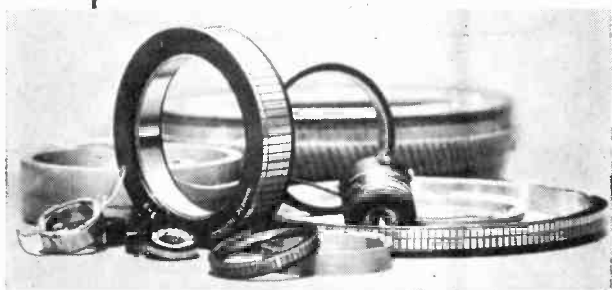

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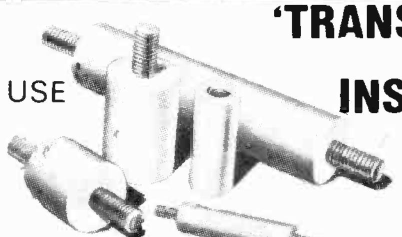

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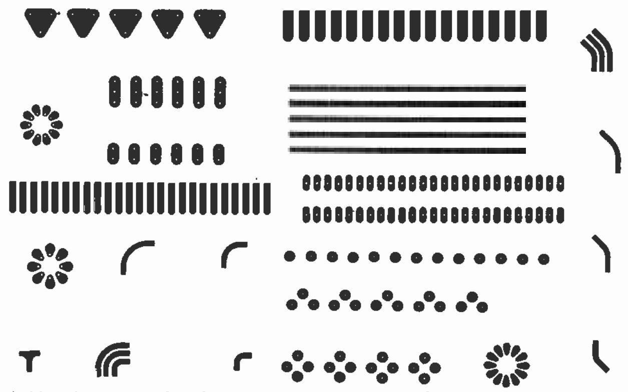

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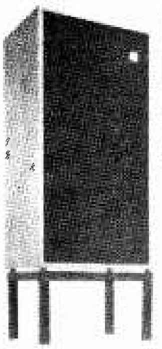

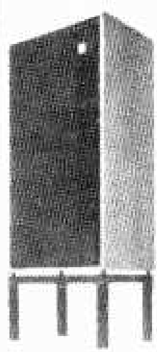

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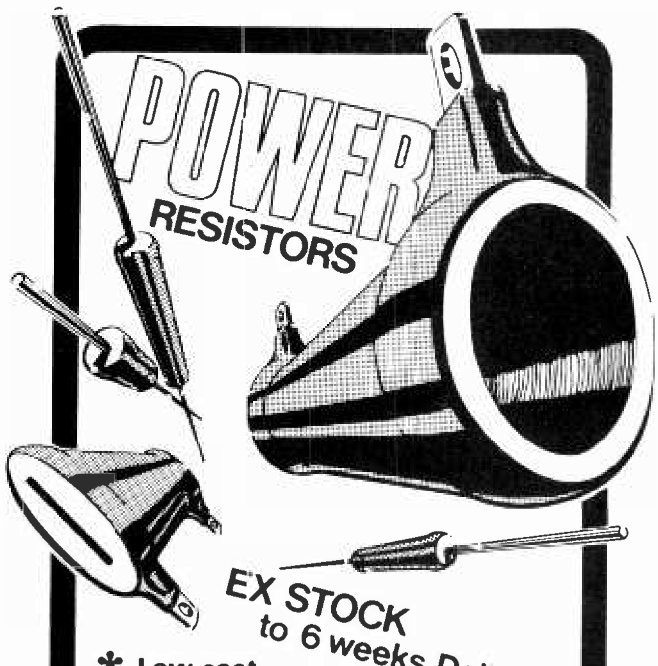


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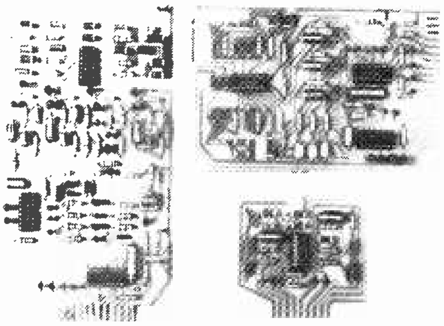

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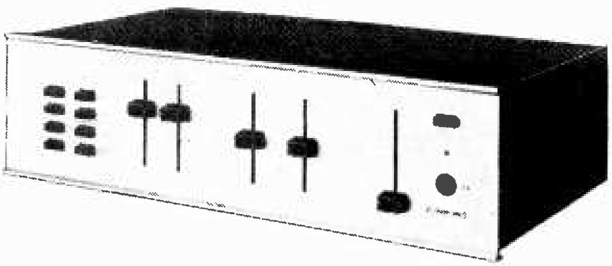

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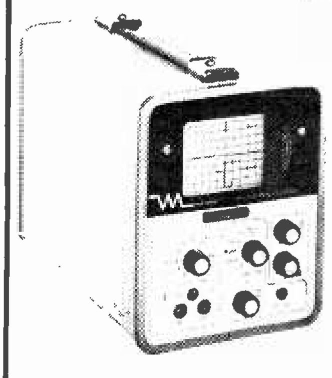

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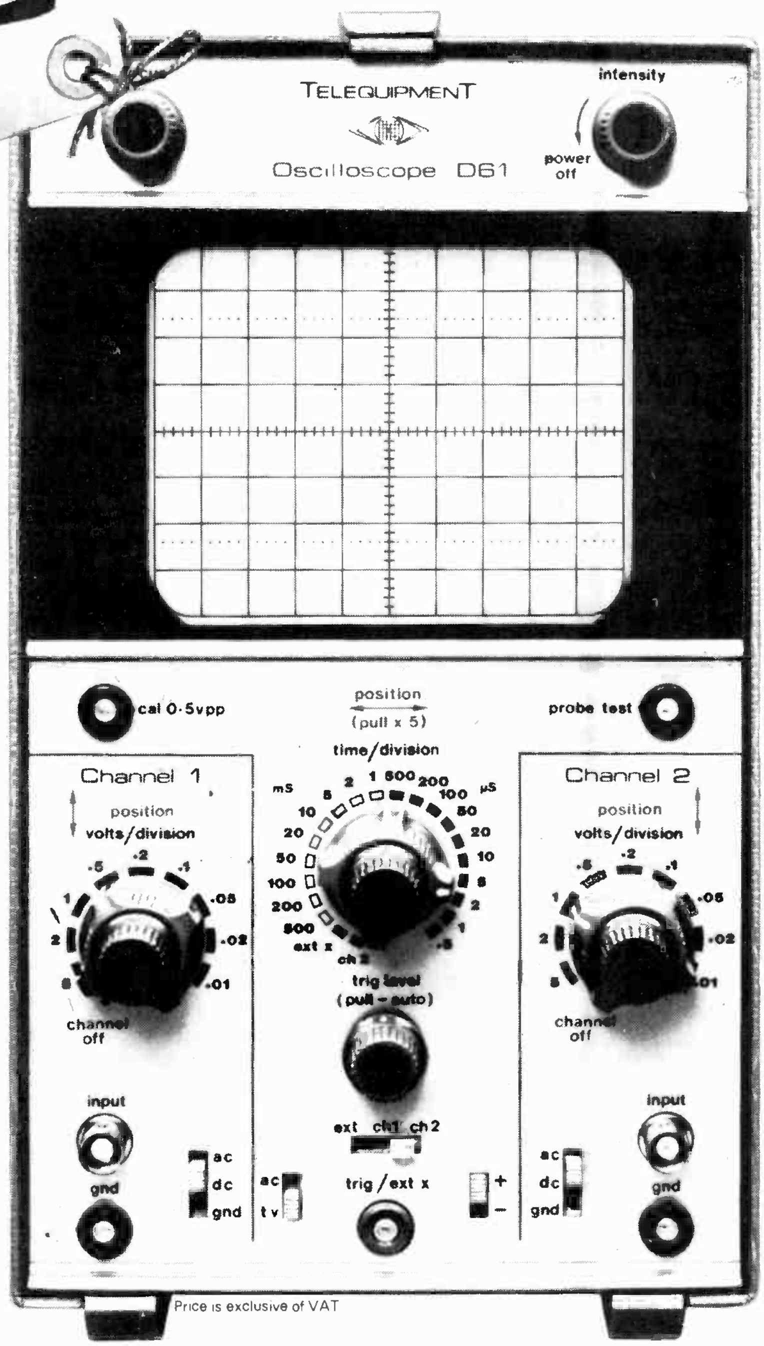


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# wireless world

## Electronics, Television, Radio, Audio

SEPTEMBER 1975 Vol 81 No 1477

## Contents



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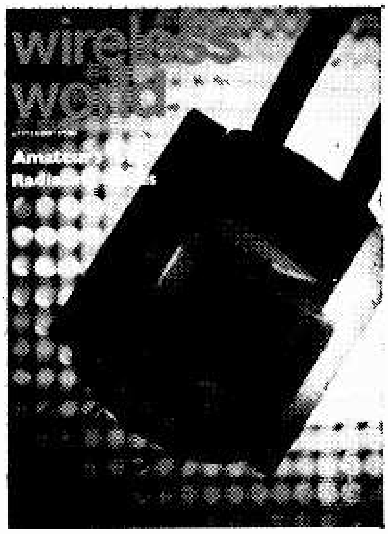

**This month's front cover** shows the construction of an Audix Ltd opto coupler for conveying signals between circuits which have to be electrically isolated
*(Photographer Paul Brierley)*

## IN OUR NEXT ISSUE

**Improving TV sound.** Advanced constructional design for television tuner provides high quality audio and video signals

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Administration Director: George H. Mansell
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There are still some rugged individuals around who believe that the consumer should be able to look after himself. *Caveat emptor*, let the buyer beware, and all that. They really think it is healthier for him to protect his own interests when purchasing goods, even at the risk of being swindled occasionally. This is all right when you're buying a quarter kilo of butter or a pair of shoes. But when you are faced with the more complicated and expensive products of our technological society — hi-fi equipment, colour television sets, electronic calculators, electronic watches and the like – it's altogether a different matter. You really need the help of the experts in the collective form of consumer protection associations and their publications. Unfortunately our rugged individuals are supported by many traders who regard "consumerism" (they probably invented this pejorative term) as an unwarranted interference with their right to sell to people any kind of rubbish they can be gulled into buying.

If the consumer protection movement were left on a national basis, things would have probably bumbled on unsatisfactorily for the British consumer for a long time. But now, with our membership of the Common Market confirmed by the referendum, there is a new twist to the situation. European consumerism arrives with the force of law from Brussels. The Treaty of Rome says there shall be no technical barriers to free trade among the Member States, and the EEC has been busy framing common standards to overcome these technical barriers. In our own field much of this is based on the work of the long established International Electrotechnical Commission. Whereas the main object of common, or "harmonized", standards is to permit free trade, some will also have the effect, because backed by European law, of enforcing consumer protection. One such standard is the so-called "Low Voltage Directive" for the safety of electrical equipment, which is discussed in some detail in this issue.

Such European initiatives are to be welcomed. One cannot help having doubts, however, about the length of time they are bound to take. EEC standardisation on electrical safety began with a conference in 1966. If such relatively straightforward questions as the practices likely to cause fire or electrocution are going to take so long, what will happen with standardisation which depends on more subjective criteria such as the quality of sound reproduction or television pictures? By the time the cumbersome process of decision making has reached a conclusion the technology will have moved on and subjective standards will have changed. But the heart of the EEC seems to be in the right place, and if the motivation is strong enough some good for the consumer will come out of it.

# Radiating cables in buildings and city streets

## An investigation of radiating properties for localized radio coverage

by R. Johannessen & P. K. Blair

*Standard Telecommunication Laboratories*

With the growing needs for radio-communication, radiating cables are finding increased acceptance in many different areas as a convenient interface between radio base stations and space. The usefulness lies in the degree of control of the coverage given to the designer in that good radio communication is achieved between a base station and mobiles in the vicinity of the cable whereas other localities have a restricted field strength. Thus by using radiating cables and locating them where communication is desired, the frequency spectrum pollution is greatly reduced compared to the case when conventional antennas are employed at the base station.

This article describes two uses of radiating cables in which this feature is important. The first is in an indoor application where the object is to achieve good communication within a building coupled with minimal external leakage. In the second case, a possible use for such cables in city streets is considered.

### Indoor application

In order to obtain a qualitative idea of the performance of such installations, extensive measurements have been carried out at the building complex belonging to STL in Harlow and it is these measurements which are reported on in this section.

The laboratories are located in flat countryside immediately east of the A11 Harlow bypass. Between the A11 and the laboratories is a cluster of trees. Towards the south and east of the laboratories the aspect is generally open. Fig.1 shows a plan view of the layout of the buildings. Each building is known by a reference letter shown in Fig.1, thus the four buildings facing south are known as U,S,E and D.

The main features of the site are as follows:-

Four similar blocks U,S,E and D are set out in a straight line, each block having two floors. At the east end is C block having four floors. These five blocks are characterized by having a central corridor with laboratories and offices on both sides. Corridor and labs are separated by walls which, over 90% of their height, have a solid metal construction, the upper 10% being glass. Z block has a metal/glass wall running east west such that the northern part of the building — about ¼ of total floor area — is offices, the rest being laboratory in generally open plan arrangement. The north and south walls of blocks U, S, E, D and Z plus the east wall of block C are about 50% glass.

Three cables are located in the laboratories. They all start between D and E blocks. One cable runs through E,

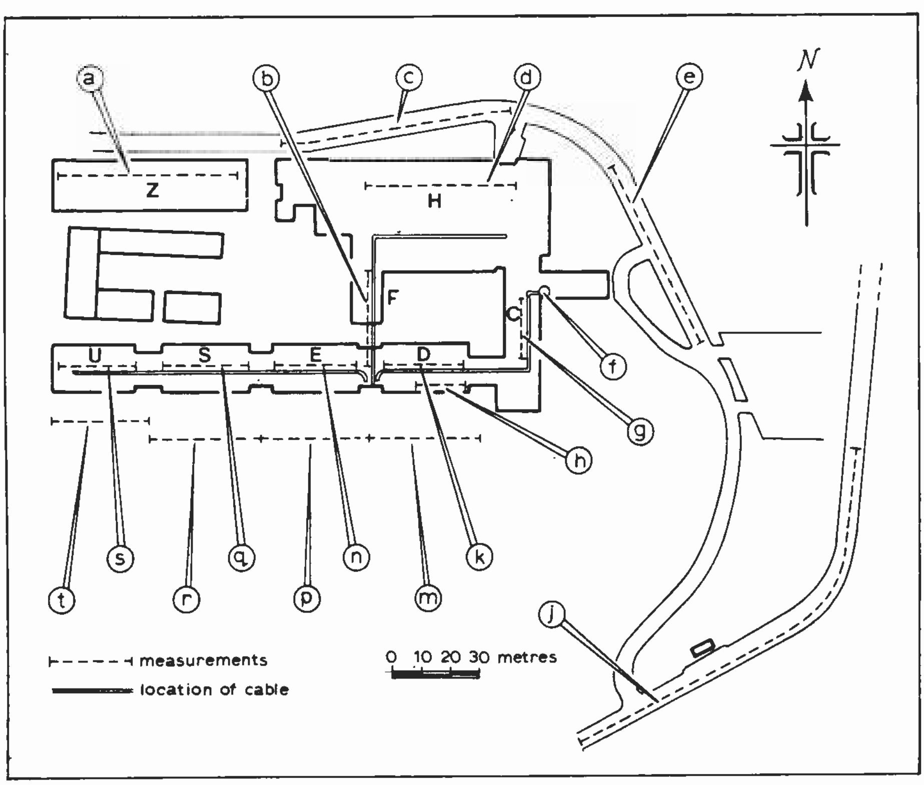



*Fig. 1. Layout of building complex and summary of results.*

**Table 1**

| Reference in Fig. 1 | Floor level | Coupling | Standard devn. |
|---|---|---|---|
| a | 2 | 109 | 3.4 |
| | 1 | 129 | 5.6 |
| b | 2 | 66 | 4.1 |
| | 1 | 56 | 4.9 |
| c | 1 | 116 | 3.6 |
| d | 1 | 93 | 4.1 |
| e | 1 | 114 | 5.1 |
| f | X | 87 | 6.4 |
| g | 4 | 87 | 4.7 |
| | 3 | 79 | 4.6 |
| | 2 | 71 | 3.3 |
| | 1 | 58 | 5.4 |
| h | 1 | 79 | 5.7 |
| j | 1 | 110 | 6.0 |
| k | 2 | 66 | 3.2 |
| | 1 | 49 | 4.8 |
| m | 1 | 87 | 3.9 |
| n | 2 | 52 | 4.0 |
| | 1 | 44 | 3.6 |
| p | 1 | 85 | 2.8 |
| q | 2 | 60 | 3.6 |
| | 1 | 47 | 3.8 |
| r | 1 | 89 | 3.5 |
| s | 2 | 78 | 4.4 |
| | 1 | 54 | 3.4 |
| t | 1 | 96 | 3.6 |

S and U blocks between ground floor and the 1st floor. The second cable runs along D and C block between ground and 1st floor level and then runs up the elevator shaft at the end of C block. The third cable runs along F and H blocks between ground and 1st floor. A cross section of buildings U, S, E, D would show that the cable is positioned above the ground floor suspended ceiling. Thus between the cable in S block and the front of the building is first the metal/glass wall and then the outside wall.

The cables used were all of the long continuous slot type with an opening of 180°. The nominal coupling of the cable at 450MHz is 60-70dB for a range from the cable axes of 1 to 5 metres and the insertion loss is in the region of 73dB/km at the same frequency. Both coupling and insertion loss are the values measured with the cable in a nominal free space environment.

The three cables were connected together so that a reasonable impedance match existed. The combined cables were energised at 454MHz (u.h.f. band) using a Starphone mobile radio transmitter thoroughly screened.

The signal levels at different points inside and outside the buildings were measured by a series of runs. Each run is shown in Fig.1 as a broken line along which a receiver was moved. For each such run some 100-200 spot measurements were taken of the received signal level from a vertical $\lambda/4$ dipole connected to the receiver. The results for each run are shown in Table 1. The first number for each run is the floor number such that 1 represents the ground floor. The second figure is the difference in dB between the signal power received and that flowing out of the transmitter. The mean value for the run is the one recorded. The third figure is the standard deviation for all the measurements for that run.

## Results commentary

Note that the signal level drops as one moves along the cable from block E through block S and to block U. Similarly from block D to block C. This is mainly due to the insertion loss of the cable. Also the signal level is strongest on the ground floor and weaker one floor up. This is due to there being thin false ceiling tiles between ground floor and the cable, whereas between cable and the top floor is a layer of concrete which attenuates the signal. In the case of C block the two upper floors are in general far from the cable. The signal level there is due partly to that picked up from C block ground floor, partly from the lift shaft of C block and partly from the cable running into F block. In the case of Z block the signal level on the top floor is stronger than on the ground floor. This is probably due to the shadowing casued by the low buildings positioned between U block and Z block.

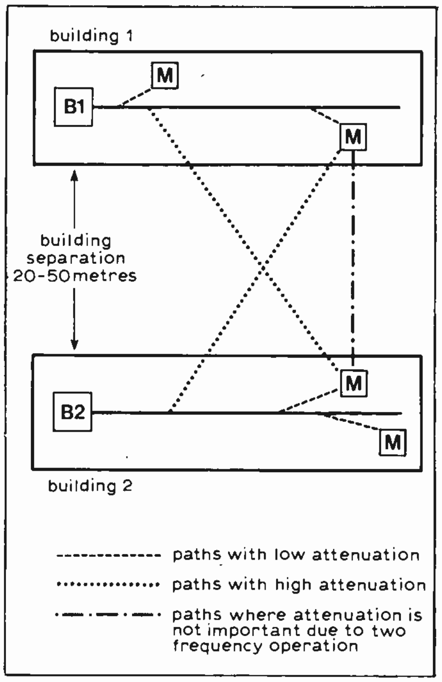



*Fig. 2. Mechanism of co-channel working. "M" indicates mobiles.*

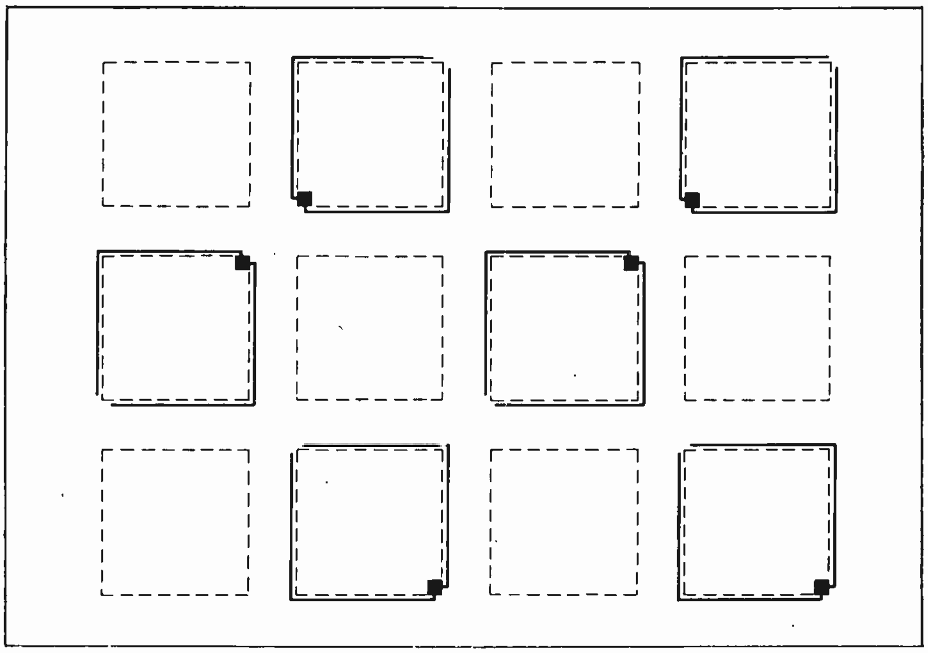
A very large difference is noted between ground floor of F block and ground floor H block. This is due to two factors; first, measurements in H block had to be carried out much further from the cable than was possible in F block and second, a solid brick wall was positioned between the cable position in H block and the place of the measurement. Along the front of the building it will be noted that there is in the order of 40dB difference between outside measurements and those on the ground floor immediately under the cable. The signal level on the surrounding roads has in all cases a mean value at least 100dB below the level fed into the cable.

It will also be noted that the coupling on the ground floor in buildings U, S, E D, C and F is closer than the nominal coupling for the cable. This is probably due to the cable coupling into pipes and other cables located in the same ceiling ducting as is the radiating cable.

Fig. 2 indicates how it is now possible for mobiles in building 1 to talk to base station B1 via its cable, while the mobiles in building 2 talk on the same frequency to base station B2 via its cable.

An indication of the degree of protection between two buildings can be given by considering Z block compared to S block. In Z block upstairs the received signal level to 95% probability is $109-1.96\times3.4$ which is 102.3dB below transmitted signal level. In S block upstairs the 95% probability for wanted signal is $60\times1.96\times3.6$ which is 67.1dB below transmitted signal or a difference of 35.2dB from that in Z bloc.

*Fig. 3. Arrangement of radiating cables in small cell system.*



## Cables for city streets

Commenting on the increasing demand for radio spectrum, paralleled by the population explosion, Hardeman[1] says that in the US, pockets of excessive crowding occur in just about all bands under 10GHz and new technology is one of the means required to relieve the pressure. Land mobile users in the US have saturated the v.h.f. and u.h.f. bands and are now searching for the most efficient methods to apportion a new band at 900MHz. Japan has an equal problem both at 150 and 460MHz and Linney[2] has outlined the steps the UK Post Office are taking to meet the growing demand for their Radiophone service. The problem is the same – where to find frequencies to satisfy a growing number of users.

An approach which has been proposed for use in the US cities is the cellular approach[1,3] which takes advan-

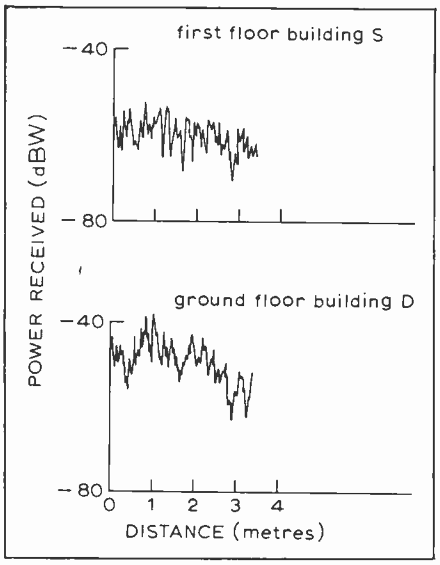
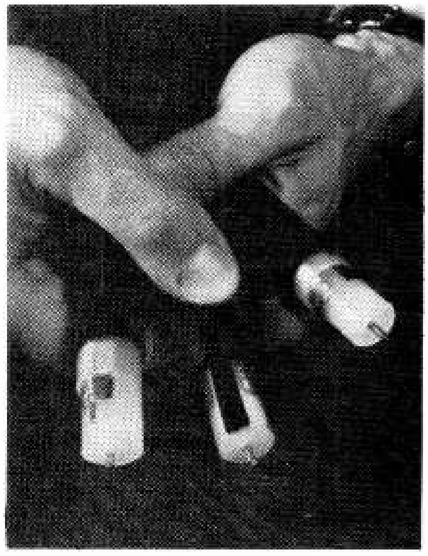
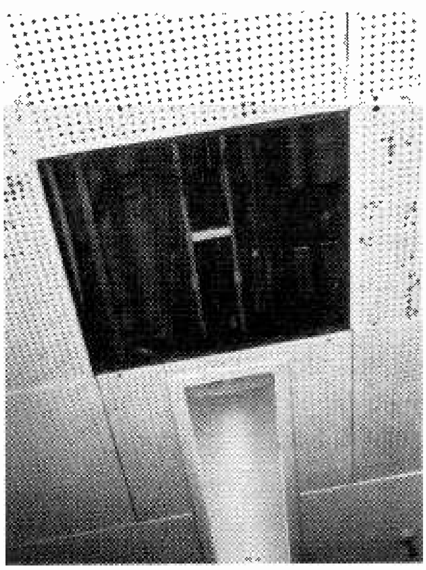



*Fig. 4. Signal level variations measured in buildings S and D. The power received (vertical scale) is at the terminals of λ/2 dipole for 1W into the cable system.*



*Three types of radiating cable made by STC Cable Division.*



*Ceiling of E1 showing how the cable is laid without any complicated fixings and next to a variety of other pipes and cables.*

tage of the large geographical distances between co-channel mobiles. It is claimed that potentially, the cellular approach requires much less spectrum to provide a given quality of service to the user. The size of the cells determines how efficiently the radio spectrum is used — the smaller the cells the more times the frequency can be repeated without mutual interference between users. But the smaller the cell, the more complicated and costly must be the organization of the system including position finding of the mobile, assigning of frequency and switching of frequency as the mobile moves from one to a neighbouring cell.

## Cables for the cell

One problem with the cellular approach is the extent to which a message to/from one cell spills into a neighbouring cell. This is aggravated by the need to overcome building shadowing with higher transmitter power than that required for free space propagation. Thus in order to have sufficient signal strength in all streets within one cell, there is likely to be excessive signal strength in some parts of the neighbouring cells.

Radiating cables appear to offer a natural solution to this since the signal level drops off rapidly as one moves beyond the cable ends[6]. Furthermore if the radiating cables are located along the streets, effectively distributing the antenna where coverage is desired, there will only be minimal shadowing by the buildings.

In Fig. 3 a possible approach is shown in a city where the streets can form a regular pattern. The broken lines represent the building outlines. The shaded blocks are transceivers connected to one or more radiating cables. The adoption of centre or end feeding for the cable will depend upon building geometry and frequency used. Assuming the base of a building is 100 metres square and an end fed arrangement is used, the cable would be around 400 metres long corresponding to an insertion loss of typically 12dB at 160MHz or 33dB at 900MHz.

An audio connection will be required between the transceivers working the cables and a central exchange. Possibly ordinary telephone line could fulfil this function.

Assuming the radiating cables are located on the external walls of buildings one can expect a coupling loss of about 90dB. The precise loss is a function of cable type, fixing method employed and the degree to which the surroundings re-radiate. Four hundred metres of cable operating at 160MHz can be expected to have an insertion loss of about 12dB. Man made interference levels in urban areas are known to be high; however, it will be recalled that whereas the insertion loss of a cable increases with increasing frequency, the ignition interference level falls. Walker[4] suggests a drop in interference level of 20dB when the frequency is increased from 150MHz to 900MHz.

## Vehicle location

Common to all small cell systems is the need for vehicle location and following. The control system must know where a vehicle is and as it moves towards the boundary with another cell another frequency must be in readiness or the same frequency in the neighbouring cell must be cleared. The smaller each cell is, the greater becomes the requirement for vehicle following; thus more rearrangement of channels may become necessary during one particular radiocall. McClure[5] has outlined some of the control functions and formats which could be used in a free radiating small cell system. The radiating cable provides a medium for position location and a variety of methods could be considered as candidates for study.

It will be appreciated that there are very many further aspects to this proposed scheme which require further study and careful analysis. For example, the interface and interaction with the telephone switching system, the channelization scheme and associated controls, position finding methods for operation with radiating cable systems, the integration of the system with other "free radio" schemes and, last but not least, its cost effectiveness.

This article was originally presented as a paper at the Communications 74 conference on radio and data communications held in Brighton.

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# Electrical safety, standards and the law

## The background requirements for electrical safety

by Basil Lane
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**September 1, 1975 sees the introduction of a new regulation under the umbrella of the Consumer Protection Act. It results from the promulgation of the "Low Voltage Directive" from the Common Market Commission and brings within the scope of trading standards officials the new question of the electrical safety of a wide range of electrical appliances, not previously covered by Home Office regulations. This article examines the scope and the background of the law, methods of identifying safe products and the impact of the technical requirements upon manufacturers of electrical equipment.**

Since our recent referendum on the Common Market and its affirmative outcome, many of the political, commercial and trading problems under discussion in Community committees become of more direct interest to the UK public at large. Of particular interest to designers, manufacturers and distributors of electrical and electronic equipment are the new safety regulations due to come into force on September 1, 1975.

### Treaty of Rome — a background

In signing the Treaty of Rome, the United Kingdom agreed to become subject to a number of basic rules governing membership of the European Economic Community (EEC). These rules are contained within the Articles, a number of which relate to trading within the Community. For example an extract from Article 3 says that there should be moves towards "the elimination between Member States of Customs duties and of quantitative restrictions on the import and export of goods and of all other measures having an equivalent effect." The first two speak for themselves, but the second requires some further qualification. This is provided in Article 100 of the Treaty of Rome, which provides for the removal of barriers to trade which are based on technical grounds.

Since one of the principal barriers to trade between countries is the often conflicting electrical and other safety requirements, this was clearly an area that the EEC Council had to examine. The results of their deliberations came on February 19, 1973 in the form of an EEC Council directive to the Member States. Commonly called the Low Voltage Directive, it has the somewhat more specific subtitle of "On the harmonisation of the laws of the Member States relating to electrical equipment designed for use within certain voltage limits."

Within this directive are 14 Articles which in substance make the following points to the governments of the Member States. The comment is made that at the moment some of the Member States require electrical goods to meet specific requirements before they can be offered for sale. In others, no such regulations exist. The directive therefore requires that the Member States should move towards a common form of safety legislation based on "provisions or standards already laid down by other international bodies or by one of the bodies which establish harmonised standards."

This means the recommendations of the International Electrotechnical Commission (IEC) or the standards agreed by the Committée European de Normalisation Electricale (CENELEC), a section of the larger body CEN. The CENELEC standards on safety are adopted from another European organisation CEE, which deals only with electrical safety matters.

Since no harmonised standard exists as yet, the directive acknowledges the fact by laying down certain requirements which were supposed to be implemented by law, within each of the Member States within 18 months of the date of the directive. There was one exception, that of Denmark, where existing legislation was rather more complex, and the Council felt that they should be given up to five years to fall into line.

As yet, the British Government has not implemented this directive in law, but is about to do so (at the time of writing) and so it is impossible to quote the letter of the law as it will appear. For this reason, and since I am assured that it contains no more than appears in the directive (though couched in different terms), a closer examination of the Articles of the directive is desirable.

The first Article says that the directive deals with all electrical equipment designed for use with a voltage rating of 50V a.c. to 1kV a.c. and 75V d.c. to 1.5kV d.c. The second Article says that laws must be made to ensure that only goods "constructed in accordance with good engineering practice in safety matters" and that it should not, when properly used, endanger humans, domestic animals or property. The main requirements of this Article are listed under Annex 1 of the directive and include proper marking of the goods with the manufacturer's trade mark or brand name, proper assembly of components for safety, proper design to avoid electrical hazards in normal use; temperatures, arcs or radiations likely to cause harm should not be produced, proper protection against non-electrical hazards should be provided for and standards of insulation should be adequate for forseeable conditions

In addition mechanical requirements should be of such a standard that no hazards are caused by external "non-mechanical influences" or by overload conditions.

Article 3 says that, subject to the provisos of subsequent Articles, if the goods meet the previous requirements that free trade within the Member States shall be allowed and not prevented on the grounds of safety. Article 4 prevents the application of stricter regulations than those listed by electricity companies before permitting connection to the supplies. Article 5 says that harmonised standards should be used to determine compliance with Article 2 and defines a harmonised standard as being one which has been drawn up by common agreement of the Member States by a competent authority. These standards should be flexible to allow for upgrading to suit technical advances.

Article 6 is important, since it relates to the situation where there are no harmonised standards and says that in that case, the authorities should regard equipment which complies with the recommendations of the IEC, or the similar document prepared by CEE, as being of the appropriate standards of safety. If there are any objections to these standards, then they have to be made within three months of the date of the directive. (The UK has entered such an objection stating that the recommendations of BS415:1972 are of a higher standard of safety and should therefore be adopted particularly in respect of sound and vision equipment.)

Article 7 provides also for the situation where no harmonised standard exists and says that where the safety regulations applying to goods manufactured in other Member States are equal to, or higher than, ours, then we should regard such products as being suitable for free trade and within our own standards of safety.

Article 8 is both complex and far reaching, since it admits the possibility of the harmonised, or accepted, standards being inadequate in the light of technical development. Essentially it says that where a piece of electrical equipment does not conform to the recognised standard, but the manufacturer claims that it meets the requirements of Article 2 (that it *is* safe), then he may submit a report to an appeal body nominated, presumably by the Member State, for further consideration.

Article 9 deals with the situation where a product is banned from sale or "its free movement is impeded". In such a case the Member State must inform all the others in the EEC that it has done so and then go on to explain why. If an objection is raised by any of the Member States, they must then all go into a huddle and consult. If after three months still no agreement is reached, then the case has to go to one of the appeals bodies referred to in Article 8, but which must be outside the territory of the Member States concerned and not previously concerned with consultations on that case. That appeal body will then make a ruling based on Article 2 only (not with reference to particular standards). After the ruling has been given there is a period of grace of one month for further objections and then the Commission (the European administrative body) will pronounce an opinion or recommendation.

Article 10 deals with safety marks and certification of products. Conformity (and thus free trade) with the directive can be indicated by a safety trade mark


*The BEAB safety marks: top BS3456 for "white goods"; bottom BS415 for "brown goods".*

or by a certificate. There is also the third alternative, intended primarily, though not exclusively, for industrial equipment, where the manufacturer may make a declaration of conformity. Marks and certificates have to be established by common agreement, by specified bodies appointed to issue them.

Article 11 says that information shall be circulated to all the others by each Member State about the appeals bodies, the safety marking or certifying bodies, the standards bodies working towards harmonisation and who publishes the harmonised version of the standard in each Member State.

Three other Articles conclude the directive, but they are not of immediate interest here. As far as our own regulation is concerned, the substance will be drawn from Article 2 of the directive and the associated annexe mentioned above.

### Law-making

No Act of Parliament is necessary to bring this regulation within the scope of the law since powers already exist to permit such additional regulations to be made under the Consumer Protection Act. Essentially the document containing the regulation is "laid" with the Minister and under what is known as the "negative resolution procedure" can bypass Parliamentary debate. Unless, that is, a motion is tabled either for its amendment or annulment. In the event that no such motions are tabled, the regulation becomes law from the moment the Minister applies his signature. However, present practice has been to allow a period of grace of a month or two after publication to give all who are likely to be affected time to become aware of the new regulations. Notes on the enforcement of the new safety regulation will appear later in this article.

Since the Consumer Protection Act applies to all points of sale in the course of a business, the new regulation will also take effect in a like fashion. This means that anyone in the chain of sale of an electrical appliance is liable to prosecution if the goods he is selling do not comply with the requirement of electrical safety. This brings into question the problem of pipeline stocks, and here the period of grace is intended to cope with this situation. It was pointed out by a spokesman for the Department of Prices and Consumer Protection that "It is difficult to defend any general deferment of the regulation since, in effect, it simply requires electrical goods to be safe when used for their intended purpose. It is to be hoped that no equipment which is unsafe in normal use is being offered for sale."

The regulation is, it would seem, as simple as the EEC directive since it does not specifically qualify what is meant by the word "safe". This has already caused considerable argument in committees and meetings and is clearly a point that had to be dealt with by the Department of Prices and Consumer Protection. To provide this information and in accord with the provisions of the Low Voltage Directive, a guidance document has been prepared to be associated with the regulation – but not forming part of it. It will *not* be part of the law, but is intended as a guidance to enforcement authorities. To quote the DPCP spokesman again "... it is likely that the Courts will take it into account in the event of a prosecution." In defining safety, the guidance document has adopted the approach of the directive and has specified national standards which substantially meet the requirements of the regulation and adds that when a harmonised standard is agreed, this will take over as the defining standard. Again, no copies of the guidance document are available at the time of writing, but it is believed that two of the standards quoted are BS415:1972 and BS3456. The former deals mainly with so-called brown goods (radio, television and audio equipment) whilse BS3456 is mainly concerned with other household appliances.

An advisory committee has been formed to assist in the formulation and updating of this guidance, the members being drawn from industry, trade associations, consumer associations and the DPCP and the BSI.

### Safety marking etc.

The Low Voltage Directive mentions the only obligatory aspect of certification or safety marking, by stating that such marks and certificates have to be approved by law (in our case as a trade mark) and the certifying bodies accepted by the Government. The law does *not* require goods to be safety marked or certified, nor does it require a manufacturer to make a safety declaration.

But what are the implications if a manufacturer decides not to adopt any of the above procedures? First, it is likely that his products will be subject to scrutiny when exporting within the EEC (thus free trade will be impeded). Secondly his product could be the subject of an early scrutiny by UK enforcement authorities. Thirdly it is unlikely that large department stores or wholesalers will accept his products without proof of compliance with the law, for fear of being prosecuted themselves. Some large stores, such as Littlewoods, already operate a test laboratory of their own to examine goods for electrical or mechanical safety.

What then, are the problems of demonstrating compliance with the law? The best and most "watertight" method is to obtain an approval and safety mark through one of the facilities offered in the UK. Four licencing authorities have been set up here, and the one most concerned with electronic equipment is the British Electrotechnical Approvals Board (BEAB), and its safety marks are illustrated in Fig. 1. These marks have not achieved the status of approval by the Member States, principally because the tests of safety are based on our purely national British Standards. However, under the Low Voltage Directive, moves are being made to provide for eventual acceptance.

The BEAB was formed in 1960 as a non-profit making company limited by guarantee. It is governed by a board of management drawn from the BSI and several trade and industry associations. It is purely an administrative and certifying body and has no laboratory as such. Many tests which it requires are undertaken by the BSI laboratory and ATL. Since the BEAB have produced a 12 page document dealing with the methods of applying for approval, this will not be dealt with here. However, some notes will be given later on how to ensure an efficient processing of an application and test procedures.

The regulations governing the granting of a certificate and mark to the manufacturer are quite tough and subject to a list of rules, called the Certification Trade Mark Regulations. These rules are laid by the Registrar of Trade Marks and very briefly say that nobody can use the safety trade mark of the BEAB without official approval and the granting of a certificate. This is fairly obvious, but what is not so obvious is what may happen if a certificate is not granted, despite a claim by the manufacturer that his product is safe. This suggests, for example, that the product has failed in an area where the appropriate BS may be considered by the manufacturer to be inadequate.

There are two possibilities, depending upon whether the manufacturer believes the inadequacy exists *before* submitting his goods for approval, or if he disputes the results of tests made already. In the latter case he may submit a report to an appeals committee at the BEAB, consisting of a chairman supplied by BEAB, representatives from BREMA in the case of "brown goods", the electrical supply industry and the BSI. They consider the appeal purely on technical grounds and their decision is final, subject to an appeal made direct to the Registrar of Trade Marks.

Now it should be carefully emphasised that this appeals routine is nothing to do with that mentioned in the Low Voltage Directive, which is more concerned with goods that have been banned from sale by legal process. It is probable, however, that the appeals committee for Marks will also deal with appeals arising out of proceedings instituted by trading standards enforcement officers.

In the case where the manufacturer starts off by believing that the appropriate standard is inadequate, he has the opportunity of claiming so, under what is known as the "innovation clauses" in the two relevant British Standards. In BS 415, this clause comes under para. 3.2 and says "Notwithstanding the requirements specified in this Standard, designs or constructions to which the tests specified do not fully apply but which give an equivalent degree of durable safety may be regarded as complying with the requirements of this Standard, subject to the findings of a special investigation by the approving authority and pending an issue of an amendment or extension to this standard." The same clause is inserted in BS 3546 : Part 1 : 1974.*

This procedure is of vital importance, since it represents the aspect of the requirements for appeals laid down by the Low Voltage Directive, but in this instance purely at a national level, since we are not, as yet, using harmonised standards for the evaluation of safety. In an excellent description of the activities of the BEAB, Zweigbergk[1] details the special investigation test schedule.

If a manufacturer decides that he wishes to invoke this innovation clause, he says so in his original application for approval and if the appliance is accepted for test it then becomes his responsibility to prepare a draft test schedule for those aspects of safety in that part of his appliance that he considers to be inadequately covered by the appropriate standard. The BEAB then will arrange for the test house to test samples of the appliance, using not only the test schedule prepared by the manufacturer but also tests devised by the test house, which may be added in the light of their considerable experience in this field.

At this stage, a meeting is convened of the technical committee mentioned above and a representative from the manufacturer, to finalise the preparation of the BEAB "special investigation test schedule." Sometimes the initial tests may suggest that the manufacturer has to make some modification, followed by a further submission of a sample for testing to secure approval. When this is done successfully the manufacturer has to formally ratify the schedule, which is then forwarded to the appropriate BSI technical committee for consideration to be included in the standard. In the meantime, an interim approval and certificate may be granted to the manufacturer, pending publica-
for consideration to be included in the standard. In the meantime, an interim approval and certificate may be granted to the manufacturer, pending publica-
tion of the amendment or addition to the standard. If, however, during the interim period, additional information comes to hand from outside sources (since at the BS stage the schedule is made available to any manufacturer), then the BEAB committee may withdraw approval.

The marks of the BEAB are not the only safety marks to achieve recognition in the UK. Since it was the intention of the Low Voltage Directive that marked goods should have free movement within the EEC, these come under the heading of the "CB" scheme, the CENELEC Protocol Agreement, the Ê mark scheme and the <HAR> mark scheme for cables. These marks and their extent of usage are described in a bulletin from the Technical Help to Exporters (THE) service of the BSI[2].

## Law enforcement

Bearing in mind that it is not a requirement of the law that one should declare compliance with the safety regulations, in any of the forms described above, the enforcement of the law by the trading standards officers will be of immediate interest.

The information printed here is based on information given either over the telephone with appropriate officials, or delivered in speeches by Ministry officials. *It cannot be taken to be an expression of the exact word of the law.*

The enforcement authority is the local Weights and Measures Office (now known as the Trading Standards Office). Its officers are not usually experts in any one subject, such as electrical safety, and thus will usually rely on the advise of qualified experts, or on the offices and test facilities of approvals authorities. They are bound only by the regulation printed in the Consumer Protection Act and do *not* have to regard the standards mentioned above as being the ultimate arbitor of safety. Even a safety marked appliance can be unsafe, due to inadequate quality control at the factory. Prosecution under the Consumer Protection Act is rare and this largely arises from the wide powers of discretion operated by the trading standards officers. In most cases, if the retailer, wholesaler and manufacturer react promptly to the comments of the official, by withdrawing from sale or agreeing to modify affected items, no further proceedings will be taken.

The law applies, as I have said, at all stages, even at the design stage, but usually the officer will acknowledge that small retailers may not have the knowledge to be aware of potential safety hazards and so will shift his attentions to the manufacturer. Where a successful prosecution is made, the results of the case have to be submitted to all the Member States, since it could well affect local approval of that same item.

## Comment and advice

This part of the article is, as stated, comment and advice offered by the author in the light of the investigations leading to the preparation of this article. It does not necessarily coincide with the official view, but often does reveal little understood aspects of electrical safety and the regulations.

One of the commonest cries heard from those who will be affected by the regulation is, "Why did I not know before? Where can I get such information in the future?" In most instances the answer lies in your trade associations. Each association, provided it is not purely nationalistic in its nature, (i.e. consisting entirely of Japanese product importers) may apply for a place on the appropriate technical committees of the BSI. Since these committees are consulted at various stages during the preparation of regulations, such as the Safety Regulation, prior knowledge may be offered to individual members of associations on a confidential basis. Second, the THE service of the BSI, issues information on standards and relevant legislation, both here and in the other countries of the world. Any manufacturer, exporter (or even some importers!) may join this service. The BSI itself also issues bulletins on national standards, which may be obtained by applying for membership. *Wireless World* itself will also operate a letter enquiry service on this topic (see paragraph at the end of this article) and for the public at large many questions about safety regulations can be answered by the advisory services of the various consumers' associations. The Department of Prices and Consumer Protection also publishes a monthly document called the Consumer Information Bulletin, which may be obtained on request.

So far I have not given any specific information on the goods affected (except in the terms of the Low Voltage Directive), and these are very wide. Such items as industrial plant already have been covered by the law under the old Factories Act and now under the all-embracing Health and Safety of Work Act of 1974 and the original Electrical Regulations of 1908, which still apply. However, under household appliances, any electrically operated item powered from the supplies listed previously falls under the arm of the new regulation. This even includes such unlikely items as some loudspeakers, since the audio voltages can in some cases exceed the minimum voltage specified! Study of the relevant British Standards is thoroughly recommended, even though the convoluted language and reference to additional standards does not make for easy reading.

As far as safety marking is concerned, most goods designed or manufactured by readers of this magazine come within the purview of the BEAB. It seems that their facilities are being stressed beyond the limits, by the flood of equipment they have now included within their range of approvals (recently all kinds of audio equipment). The BSI laboratories have six test officials working full time and it can take over 14 days to test, say, a television receiver. In a recent call for applications for approval of cassette recorders 174 were received, so it is anyone's guess what the overall situation will be when all other items are called for. Some moves are being made to alleviate the situation, but no information on this has been officially released. In addition, moves are being made to combat complaints from importers that their products are at the back of the queue.

It certainly seems unlikely that there will be very much audio equipment carrying a BEAB label this autumn, not because it has failed the tests, but more likely because it has not even reached the starting post! Delays are being caused by manufacturers not studying all of the BEAB documents, some of the more obvious delays arising from failure to observe the requirement to pay for the test before it is done, and also the supplying of spare parts to replace those damaged during the testing process. If manufacturers were to apply the tests of BS415 (or 3456 where relevant) themselves, prior to submission, and list the results on a report offered with the sample, and then supply the spares they found were needed, with the sample, then the length of time required by the BSI laboratories would be considerably shortened.

The BSI operate an approvals scheme (and Mark) for components and if these are used in the manufacture of an appliance, this too can reduce the time taken for tests. Lists of approved items are available from BEAB (for appliances) and the BSI laboratories (for components). Components and appliances of foreign origin may be supplied for approval and are subject to all the same rules as for British made goods.

Since the marks made are only a type approval, the manufacturer is subject to surveillance visits by BEAB inspectors who have to be satisfied that the standards of production and quality control are high enough to maintain the quality seen in the sample. Finally, failure of the appliance to *operate* under the safety tests does not imply failure to comply with the standard *as long as it "fails safe"*.

## Enquiries

Professional readers having enquiries about the regulations, standards, or services mentioned in this article, particularly if they are of a technical nature, may write to the Editor putting their points. A number of these may be selected in the future for publication, with an appropriate answer. Readers wishing to make enquiries should clearly mark their envelopes with the words "Safety Regulations". We cannot guarantee to answer all queries with a personal reply, or with specific information, since in some cases it may prove better to refer the enquiry to a more specialized authority.

## References

1. Zweigbergk, Brig. C. A. Safety of household electrical appliances. *Proc. I.E.E. Reviews*, vol. 119, No 8R, Aug. 1972.
2. Approval of electrical equipment: Europe. THE information bulletin INF 100/18. Pub. THE, British Standards Institution, Maylands Ave, Hemel Hempstead, Herts, HP2 4SQ.

* This procedure does not appear in IEC 65 which is proposed as the harmonized standard.

## Sixty Years Ago

**Low life in Lisbon.** The following disgraceful revelation was printed in our September 1915 issue and illustrates the depths to which "wireless" had sunk. One might have known those beastly Huns would be involved.

**Portugal**

"Three wireless installations fully equipped with Morse apparatus have been found in different parts of Lisbon. One wireless station was discovered on the fourth floor of a house in the town. Five arrests were made of persons, who confessed to having erected three other stations in different localities of Lisbon. They were apprehended by order of the Government. Further information goes to show that the Germans are at the bottom of the matter."

# News of the Month

## Crystals for calculators

A crystal puller has been introduced which is claimed to be the first designed specifically for the routine production of GaP, a semiconductor used in the manufacture of light emitting diodes. The system incorporates several technical advances giving large crystals with accurately defined shapes. The large scale production of cheap gallium phosphide is expected to lead to its widespread use in calculator and digital watch displays.

The system, called the Melbourn, is 16 feet high and weighs three tons. It grows GaP crystals by the Czochralski method using liquid encapsulation and high gas pressures to prevent the dissociation of the gallium and phosphorus. The system will produce crystals of up to 5kg in weight and three inches in diameter. This is an order of magnitude larger than crystals grown on existing equipment. Crystal diameters can be kept within 1mm of a specified size and this gives high yields of useable material. The Melbourn is the result of a joint three year research and development programme between Metal Research Ltd of Royston, Herts and the National Research Development Corporation.

## Bureau of Higher Degrees

Information on the availability of relevant higher degrees in electrical and electronic engineering and physics in the UK is now obtainable from the Bureau of Higher Degrees, a telephone information service, based on a simple retrieval system, which has recently been set up by the Institution of Electrical Engineers in association with the Institute of Physics, the Institution of Electronic and Radio Engineers and the National Electronics Council. The Bureau will provide information on all types of higher awards, especially industry based degrees and sandwich courses. It could be of particular benefit to training officers and management in educational establishments and industry who are responsible for advising on higher degrees, as well as helping the individual graduate seeking advice on higher degrees.

A telephone call to the appropriate number (01-235 6111 extension 36 for information on physics or 01-240 1871 extension 313 for information on electrical and electronic engineering) will give access to the following information: availability of courses, where these are located, whether Science Research Council or Engineering Industry Training Board assistance is available, details on the courses and a contact within the educational establishment.

## Telemetry brings in North Sea oil

Advanced telemetry, control and monitoring equipment will play a major role this year in helping to bring North Sea oil to shore. One of the most recent systems will be a remote control and monitoring scheme which incorporates u.h.f. radio links for use on an offshore drilling and production platform. The equipment will transmit control information and monitor activity over a distance of two kilometres between the drilling and production platform and a single point tanker mooring of about 135,000 tons displacement at which 80,000 ton tankers will load.

In addition to being used to transmit control signals and receive response indications, the u.h.f. radio system will be used as a voice link between the tanker loading module and the 200,000 ton platform. At present, a total of 32 indications will be transmitted over the link and all essential controls and safety devices will operate via the telemetry equipment. One of the most important monitoring roles which the equipment will play is in fault detection. In addition, the telemetry equipment will enable the tanker crew to shut down the pumping operations in the event of a major problem such as a fractured feeder pipe. The supply of this equipment is a contract won by M.L. Engineering (Plymouth) Ltd, from Mobil North Sea.

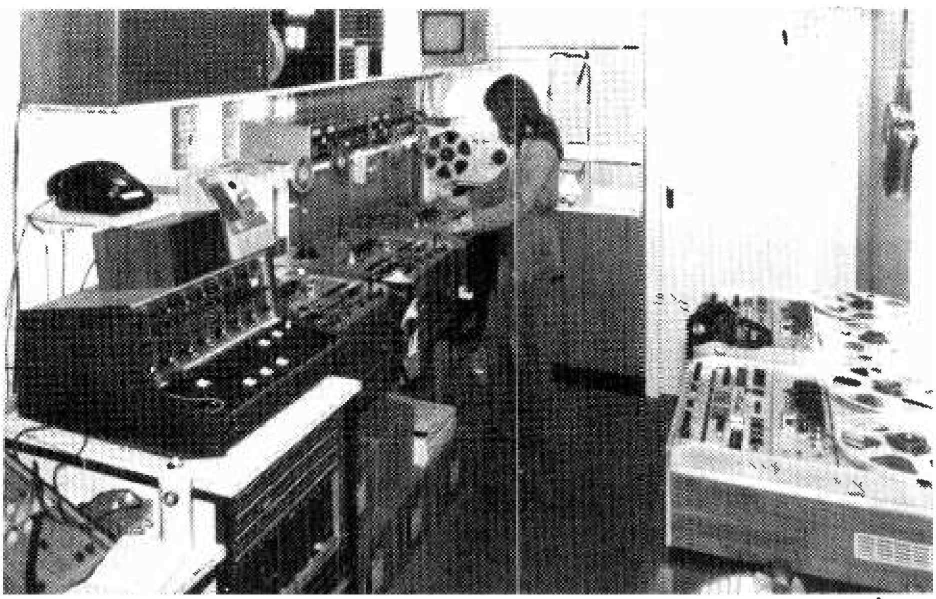
## Bouncing ball detector

A method of automatically detecting whether a tennis ball bounces on or near a line and of assisting the umpire in scoring has been developed and patented by a South London inventor, Dr David Supran. The same principle could be applied to several other sports such as squash, football, golf and snooker.

The invention is particularly significant in view of the number of disputes over linesmen's calls at Wimbledon matches and other tennis events.

The cloth cover of the tennis balls used in the invention contains steel fibres similar to those used for the manufacture of special wigs and stockings. These make the cover electrically conductive. In addition, on and adjacent to those lines on a tennis court where key decisions are required suitably coloured tapes can be sited, each bearing 15 parallel channels of flat copper wire. When the special tennis ball bridges any pair of the narrow strips of copper, an electrical circuit is completed and a signal is transmitted to a

*Independent Radio News, one of London's broadcasting stations, has taken delivery of six Ferrograph transportable tape recorders for use in its outside broadcast unit at Westminster. Playback is fed out on lines to independent local radio stations, to IRN's central newsroom and to Independent Television News.*



Computer Automation minicomputer. The computer is programmed to interpret such a signal as the ball being "out", and a bleep is sounded from a visual display unit next to the umpire. The bleep is audible to umpire, players and spectators alike. If the ball is "in", there is no audible signal but the word "in" is displayed on the v.d.u. screen. In all cases, the umpire can override the system. HE could also control a public scoreboard and other display monitors. A number of tennis courts could be controlled by one minicomputer.

## Chart recorder controls furnace

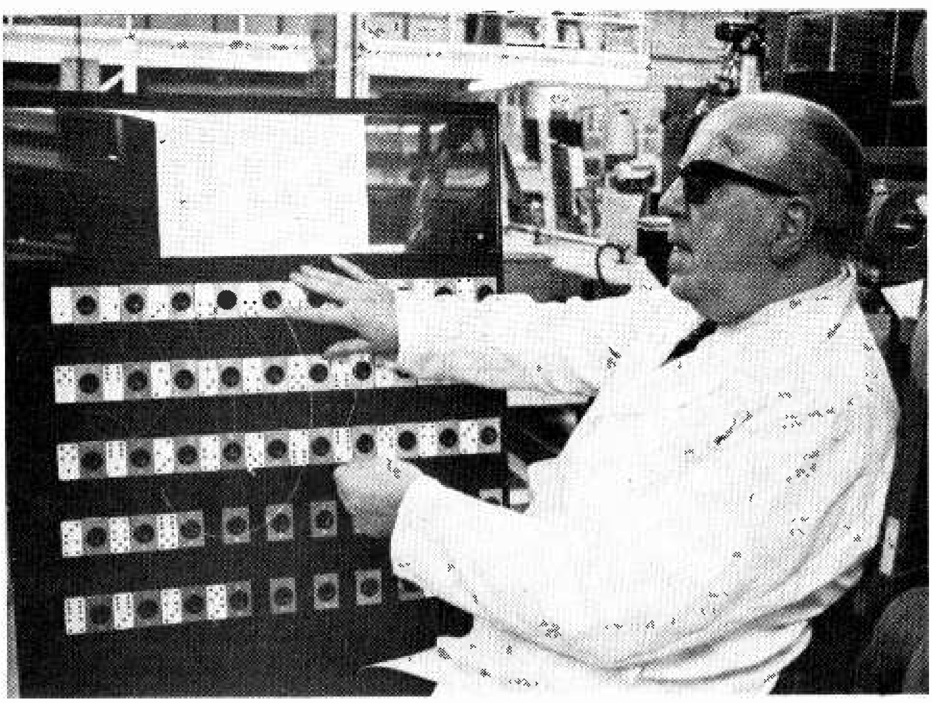
A novel application of an x-y recorder has been developed at the Research Centre of the British Steel Corporation, Motherwell. The recorder controls tempering furnaces to predetermined heating and cooling cycles, in the process of stress-relieving steel samples.

The modular x-y recorder is converted to its controlling role by the addition of a chart drive unit and photo-electric curve follower. The plug-in curve follower module is substituted for one of the amplifier modules, while its light sensing head is mounted in place of the recorder pen. Having decided on the temperature cycle required for a particular sample, the British Steel engineers draw the appropriate profile on the recorder chart for the sensing head to follow. Output voltage level from the curve follower module is then set so as to be consistent with the change in output from the furnace thermocouple over the required temperature range. The furnace controller is also adjusted to give a temperature reference point. Then, during the process, a temperature comparator compares voltage levels from the thermocouple and the curve follower. The difference determines the operation of the furnace controller and thus the pre-drawn temperature curve is followed precisely. A cold junction reference is inserted between comparator and thermocouple to ensure that control remains constant over wide changes in ambient temperature. The recorder chosen for this application is a Bryans model which has a chart drive unit and photo-electric curve follower as standard accessories.

## CCTV in Westminster Abbey

A c.c.t.v. system consisting of three cameras wired to a video selector and with pictures displayed on a 12in monitor has been installed at Westminster Abbey to enable the Abbey organist to see the West Door (where processions form), the Henry VII Chapel (used for weddings) and the Master of Choristers in the choir. A second system for sound reinforcement has also been completed. All the engineering with the exception of the loudspeakers has been carried out by Pye Business Communications. The loudspeakers were designed for the Abbey by Mr Paul Taylor who donated the patent rights to the Dean and Chapter. The loudspeakers were constructed and tested by the Department of the Environment Building Research Station in collaboration with the Institute of Sound and Vibration Research at Southampton University.

*Albert Stroud, a war-blinded employee of M.E.L. Equipment, operates a set of Braille dominoes, each indicating a different wire needed to be cut for radio receivers. This involves handling 48 different colour coded leads in ten different combinations containing from 7 to 100 different wires where lengths vary between 4in and 2ft. Quite a task for a blind man.*



## Fingerprint file

The Metropolitan Police at New Scotland Yard in London are to be provided with an information system called Videofile at a cost of approximately £2M over the next two years. The system involves video recording techniques and will be used by NSY to assist its fingerprint identification process. The system will store the fingerprint impressions on magnetic tape so that they may be retrieved rapidly for visual comparison. Impressions are presently held in document form. Under the new system, incoming requests for fingerprint identification – both normal ten-finger "rolled" impressions and also "latent" fingerprints left at the scene of a crime – will be classified for search purposes by fingerprint officers. The police national computer will then be used to produce possible matches from ten fingerprint and display the possible matches on a cathode-ray tube screen for visual comparison by experts.

The primary objective of the system is to extend the capability of the NSY staff of highly-trained fingerprint experts in coping with the anticipated file increases, which could be about 3.5 million fingerprint sets within a decade, creating problems of space and qualified fingerprint staff availability if the existing manual system were to be used. Videofile is a trade mark of the Ampex Corporation.

## Briefly

**Royal Television Society Convention.** Television and the future needs of the public will be the theme of the third Royal Television Society bi-annual convention at King's College, Cambridge, September 18-21 this year. Mindful of the work of the Annan Committee looking into the future of broadcasting, the Society hopes to create a forum in which the public needs from television can be stated and the response of the broadcasters obtained.

# Variable frequency oscillator for the amateur

## A phase lock loop design using discrete components

by I. J. Dilworth, B.Sc.,

*Department of Electrical Engineering Science, University of Essex*

The need for a flexible, stable and variable frequency source for use in a transmitter or receiver local oscillator in an amateur band station has never been more evident that at the present time. The approach of generating a 70 MHz carrier facilitates operation on 144 and 432MHz by multiplication, and by using a v.h.f. local-oscillator receivers of high performance and single conversion are possible.

A useful way of generating stable high-frequency signals which are frequency agile is to arrange a lower-frequency oscillator to control a higher one such that the latter assumes the stability of the former. By phase comparison it is possible to derive a controlling element which when applied to the high-frequency oscillator, via a feedback loop, performs this function. It is relatively easy to achieve a high order of stability in a v.f.o. at a low frequency but it is not so straightforward when the frequency approaches the megahertz region. It is true that with due care the problem is not so awesome; nevertheless if the frequency is kept below the MHz region repeatability of results is assured, particularly when the constructor has limited time and equipment.

In this design an 800kHz v.f.o. is used to control a 72MHz v.c.o., the resulting error in stability being only ten times that of the 800kHz oscillator.

**This novel approach provides stability by using a low-frequency control oscillator.**

### Oscillator

Reference to Fig. 1 will show how locking is achieved. A sample of the 72 MHz signal is mixed down to 9.29MHz with a quartz crystal local oscillator. This signal is then amplified and squared through a digital comparator before being divided down in a decade counter. The resulting 929 kHz signal is then applied to one input of an exclusive OR gate employed as a comparator. The other input is supplied with the v.f.o. signal via the same type of digital comparator to bring it up to the logic levels. The output of the gate is proportional to the phase difference between the two signals and after filtering, to obtain only the d.c. component, this voltage is applied to the v.c.o. to maintain an in-phase signal with that of the v.f.o. Any drift in the crystal oscillator is also compensated for in the v.c.o. because it will always try to maintain a zero phase shift with the v.f.o.

The output at 72 MHz is first fed to a buffer and then to a frequency doubler, because in this application it was desired to produce a signal in the 144 MHz band. Since the intermediate frequency is divided by ten in the decade counter, variation of the 800 kHz v.f.o. is effectively multiplied by ten. For a one megahertz covering at 72MHz the 800 kHz v.f.o. needs to tune only over 100 kHz. Clearly drift of the v.f.o. will also be multiplied by ten at this output frequency, but it is relatively easy to construct a stable oscillator at 800 kHz and a suitable design is included. To avoid problems of modulating the 72 MHz signal with either the 63.71 MHz crystal oscillator or the 8.29 to 9.29 MHz i.f. being generated it is necessary to ensure high isolation between the mixer and the output stages. Therefore, one must be very careful with layout and avoid any urges to economise with the buffering. Whether the application be a transmitter v.f.o. or a receiver local oscillator cleaness in the output spectrum is essential. One could simplify the

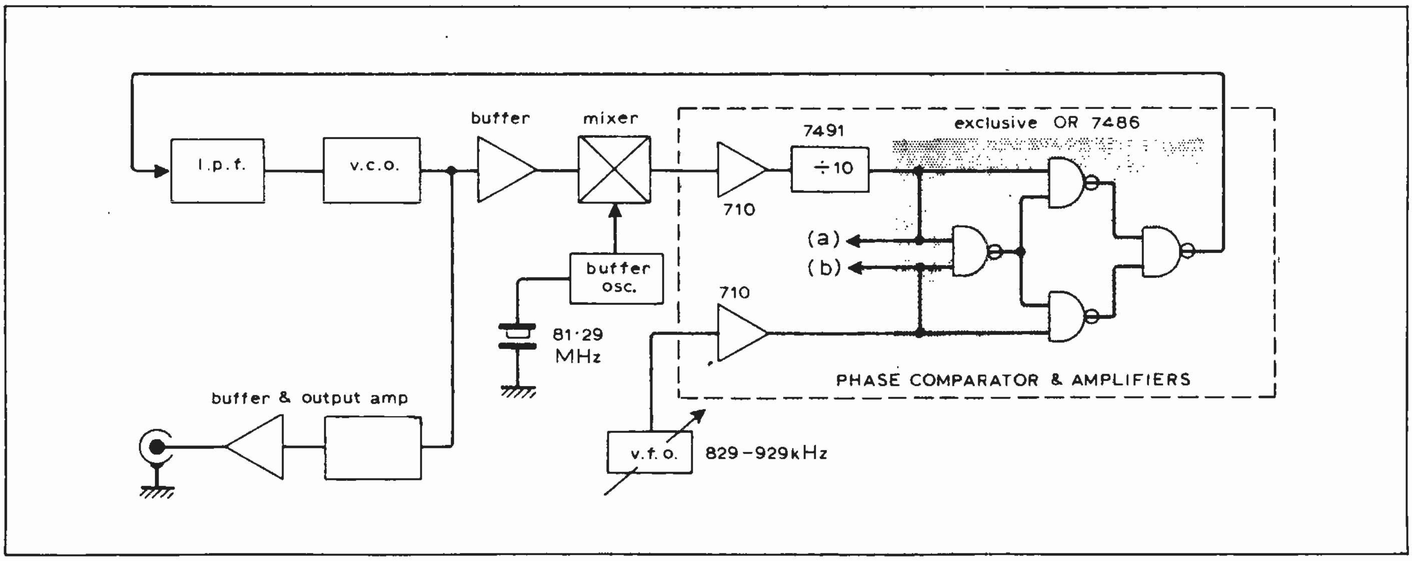



*Fig. 1. Block diagram illustrating how phase locking is achieved.*

buffering circuit but it is not everyone who has a spectrum analyser necessary to set up the unit if the full circuit is not employed. All that is required in setting up the v.f.o. is a grid dip oscillator and a receiver.

### Circuit units

The crystal oscillator uses an available unit and is intended for fundamental operation at 63.71 MHz. See Fig. 2. One could use a lower-frequency unit with the appropriate multiplier chain, provided suitable filtering was employed before the mixer, but if one is starting from scratch then it is nearly as cheap to use a 60 MHz crystal rather than a lower-frequency one. The oscillator is straightforward — the tuned collector resonates at the fundamental frequency and the class B buffer stage provides the correct injection for the mixer with the additional filtering of its tuned-circuit.

The mixer consists of a gate injected f.e.t., the tuned circuit in the drain being broadly resonant over 8 to 9 MHz, providing a load for the i.f. signal. The transformer coupled output is then fed into the SN72710 comparator which squares and amplifies the signal prior to the decade counter which consists of a SN7490. The SN7486 gate performs the comparison of the i.f. signal and the v.f.o. The comparator circuit has proved very useful in practice because the SN72710 devices have a bandwidth up to 30 MHz and are insensitive to input level changes above a threshold of around 10mV. One practical point to note however is that since the outputs of the gates are square waves, screening of the computer output before it reaches the amplifier and low-pass filter is essential otherwise there may be unwanted signals in the station receiver.

To obtain the required swing from the v.c.o. it is necessary to amplify the voltage from the 7400 output. This is conveniently achieved with an operational amplifier whose output is filtered with the network $R_{15}$-$C_{18}$ which is the low-pass filter. The variable resistor on the non-inverting input of the 741 provides for initial setting of the output voltage, while $R_{16}$ provides a high impedance to the tuning diode and the v.c.o. but does not upset the d.c. bias to the tuning diode because there is very little current needed in this configuration. The diode ($D_1$) suggested allows sufficient swing in capacitance at 70MHz to provide a 1 MHz change in output frequency with the voltage applied. It is possible to use a 1N916 variety and achieve similar results but with reduced capacitance swing and hence frequency variation. This is because $C_{19}$ has to be increased in value to allow the Vackar oscillator to oscillate with the lower Q factor of this type of diode. However, if a smaller swing in frequency can be tolerated this approach is possible.

The output of the oscillator is split two ways: one path goes to a source follower whose output is fed to two more buffers before the mixer; the other path goes to the output amplifier chain. Variations in the circuit of the output chain are unlimited and one design is shown in Fig.2. Transistor $Tr_9$ is a buffer followed by a doubler arrangement providing about 10dBm output power into 50 ohms which is sufficient to drive most class C stages.

### Variable frequency oscillator

The oscillator shown in Fig. 3 has proved very stable and trouble free. The

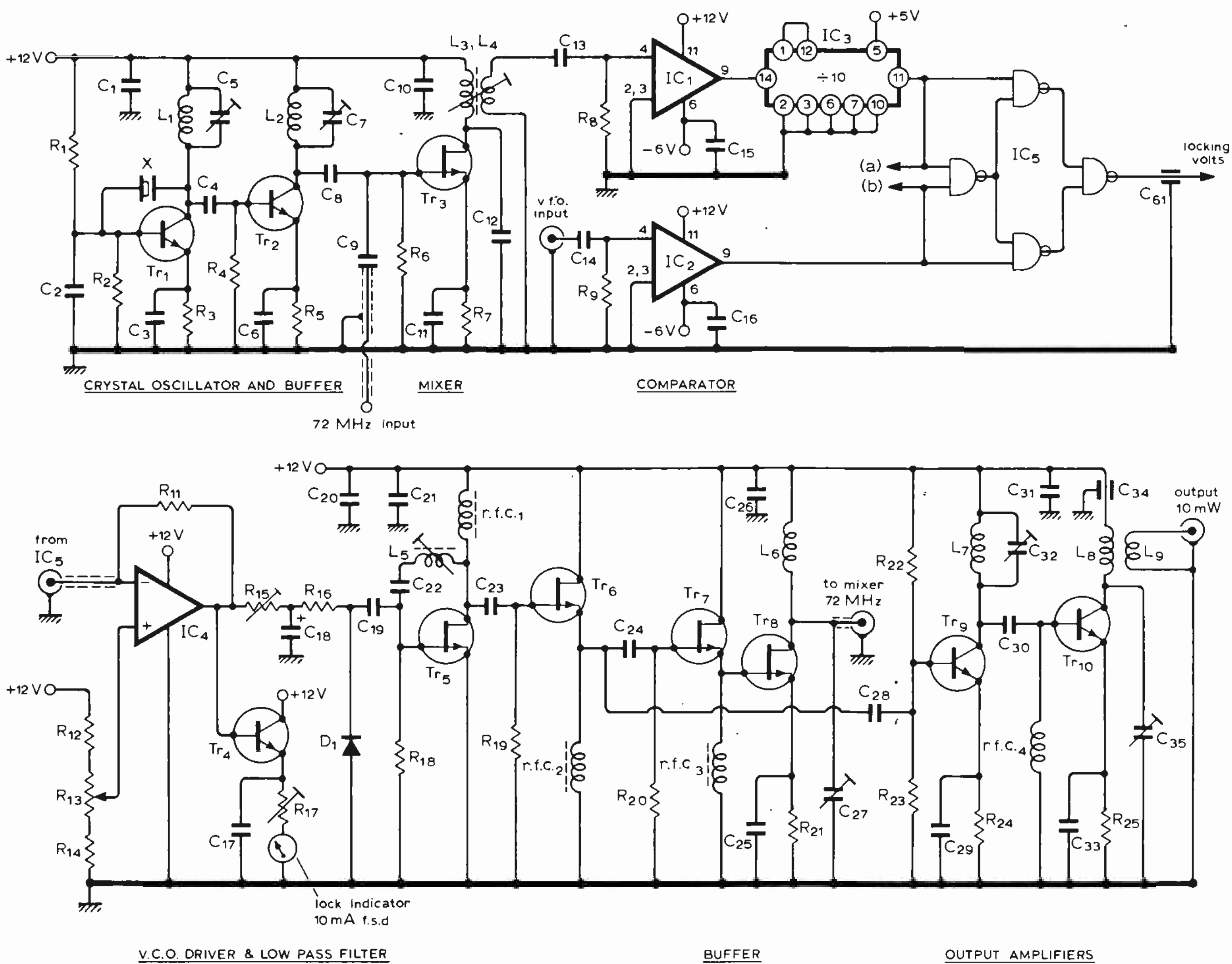
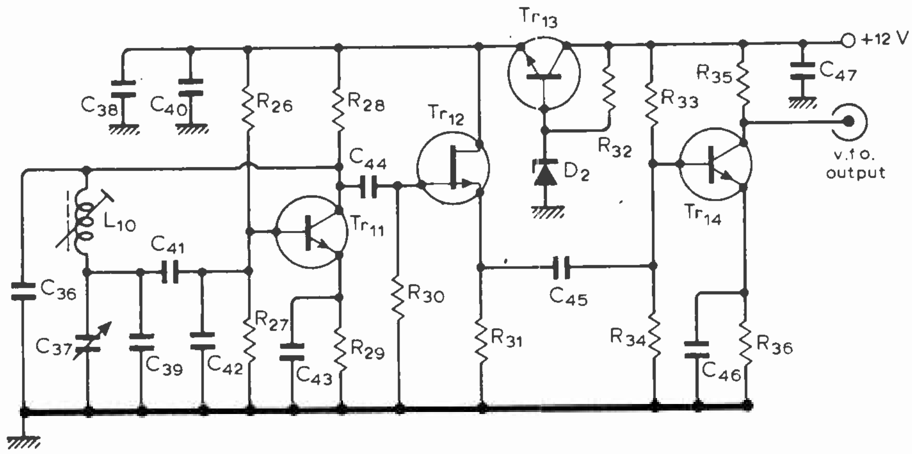



*Fig. 2. V.f.o. circuit divided into two parts for mounting on separate boards as shown in Fig. 4 and 5.*

*Fig. 3. Stable Vackar type variable low-frequency oscillator tuning between 829 and 929kHz.*



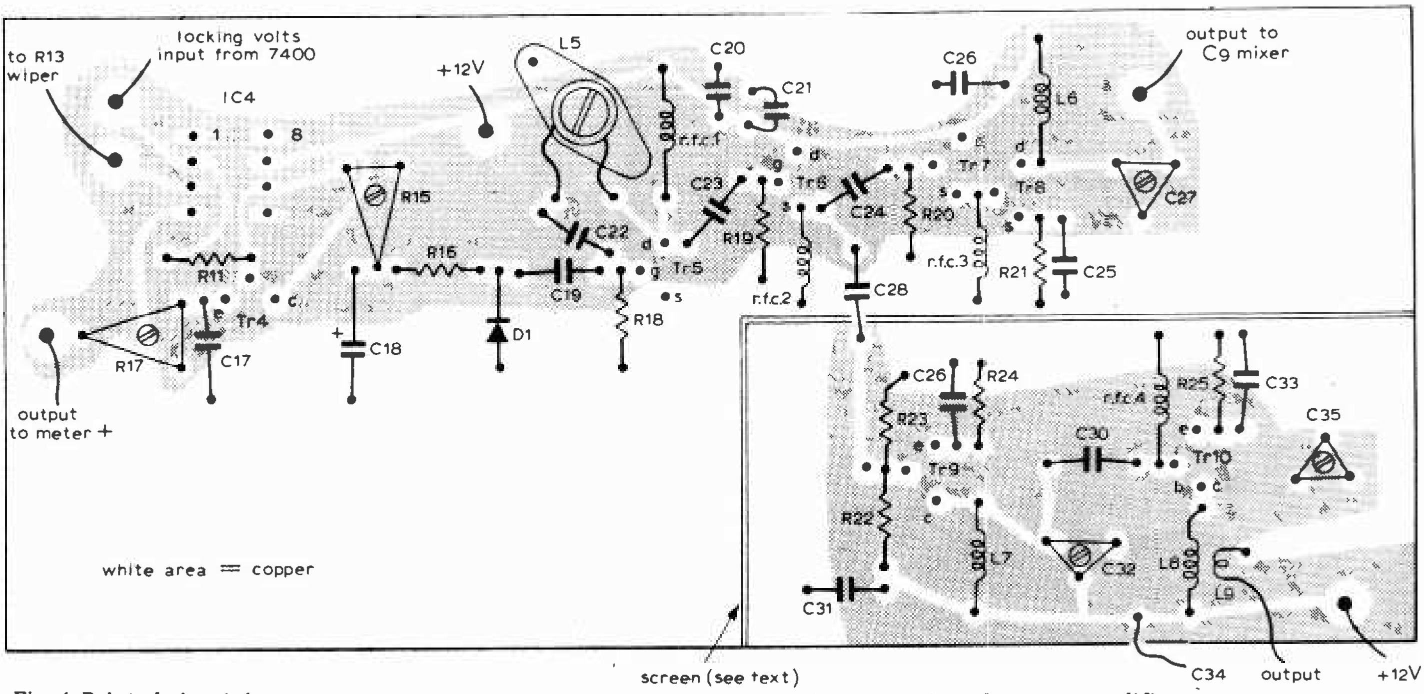




*Fig. 4. Printed circuit layout of v.c.o. (viewed from component side) with driver circuit and output amplifiers. The output amplifiers should be screened, as shown, using 1½in high copper strip.*

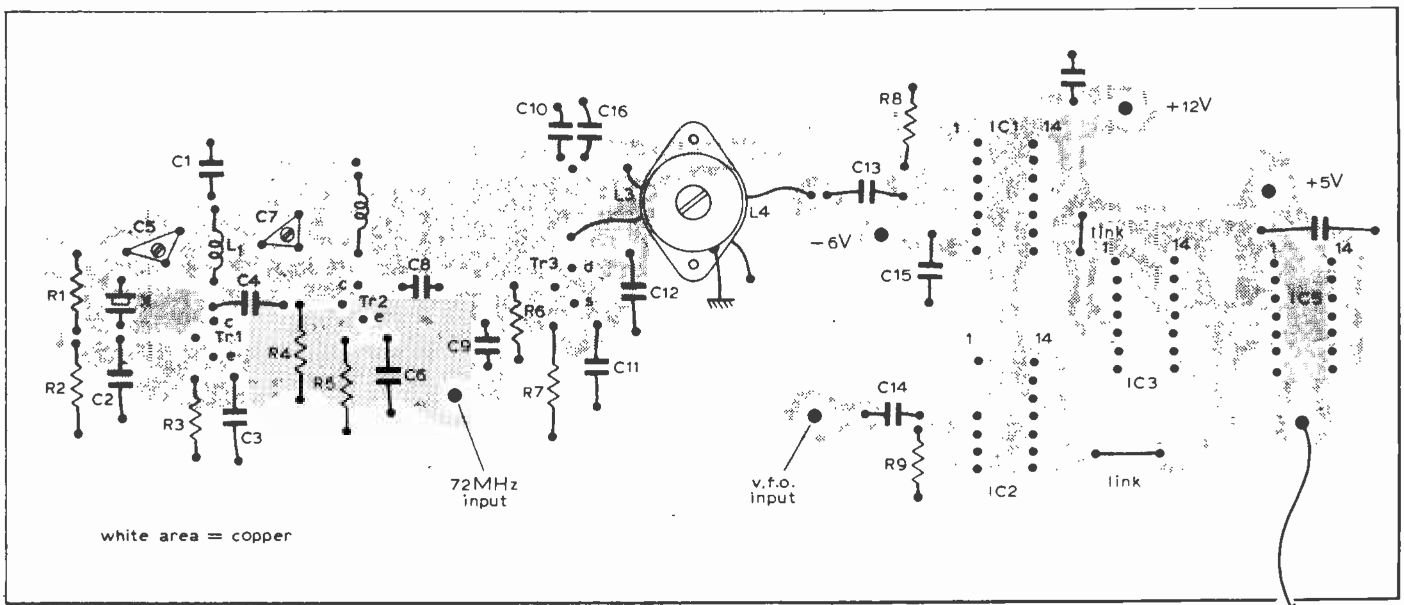



*Fig. 5. Printed circuit layout of phase-lock circuitry (viewed from component side) containing crystal oscillator, mixer, and comparator.*

basic circuit is a Vackar type and by using the type of capacitors suggested no trouble should be experienced with drift and stability provided the oscillator is mounted in a good insulated box, preferably filled with polyurethane foam. The output is buffered with a source follower and amplified for injection into the comparator with $Tr_{13}$. A series voltage regulator is used to supply the oscillator and buffer as this was found to be superior to just supplying the oscillator. With the components indicated a swing of around 100kHz is produced over the frequency desired.

## Construction

Suggested printed circuit layouts are shown in Fig. 4 and 5. It is convenient to make the v.f.o. unit on two boards each housed separately, one containing the phase lock circuitry and the other the v.c.o. and buffers. A separate box for the low-frequency controlling oscillator, tuning dial and drive is also required. The use of double sided p.c.b. is advisable (component side etched to form an earth plane as shown in Fig. 4 and 5) because this facilitates easy earthing of components and good screening. Components are non critical (if the p.c. layout is used components of

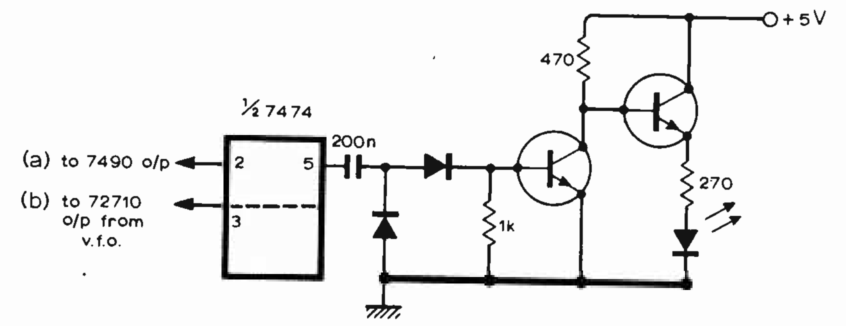



*Fig. 6. Simple add on phase lock indicator – when (a) and (b) are in phase the bistable is at logic 1 or 0; in either event the l.e.d. is on. Under no-lock conditions the heterodyne produced causes the l.e.d. to extinguish.*

**Resistors — all ¼W unless marked**

| | |
|---|---|
| 1 | 15k |
| 2 | 6.8k |
| 3 | 270 |
| 4 | 6.8k |
| 5 | 220 |
| 6 | 100k |
| 7 | 2.2k |
| 8 | 10k |
| 9 | 10k |
| 11 | 270k |
| 12 | 1.8k |
| 13 | 100Ω linear |
| 14 | 820 |
| 15 | 50k lin min skeleton |
| 16 | 270k |
| 17 | 10k lin min skeleton |
| 18 | 100k |
| 19 | 1M |
| 20 | 1M |
| 21 | 1k |
| 22 | 10k |
| 23 | 2.7k |
| 24 | 220 |
| 25 | 220 |
| 26 | 22k |
| 27 | 10k |
| 28 | 4.7k |
| 29 | 3.3k |
| 30 | 1M |
| 31 | 2.2k |
| 32 | 220 |
| 33 | 100k |
| 34 | 33k |
| 35 | 3.3k |
| 36 | 1.5k |
| 37-44 | 5.6k |
| 45 | 470 |
| 46 | 330 |
| 47 | 3.3k |
| 48 | 470 |
| 49 | 4.7k |
| 50 | 680 |
| 51 | 1k |
| 52 | 1k |
| 53 | 1k lin min skeleton |
| 54 | 5.6k |
| 55 | 2.7k |
| 56 | 1k lin min skeleton |
| 57 | 10k |
| 58 | 220Ω ½W |

**Capacitors — C**

| | |
|---|---|
| 1 | 0.1 disc ceramic |
| 2 | 10pF ceramic |
| 3 | 0.01μF disc ceramic |
| 4 | 10pF ceramic |
| 5 | 4-2pF variable Mullard 808 |
| 6 | 0.01μF disc ceramic |
| 7 | 4-20pF variable Mullard 808 |
| 8 | 15pF silver mica |
| 9 | 2pF ceramic |
| 10 | 0.1μF disc ceramic |
| 11 | 0.01μF disc ceramic |
| 12 | 6.8pF tantalum |
| 13 | 0.001μF disc |
| 14 | 0.001μF disc |
| 15 | 0.1μF disc ceramic |
| 16 | 0.1μF disc ceramic |
| 17 | 0.1μF disc ceramic |
| 18 | 6.4μF 10V |
| 19 | 18pF silver mica |
| 20 | 0.1μF disc ceramic |
| 21 | 0.001μF disc ceramic |
| 22 | 10pF ceramic |
| 23 | 10pF ceramic |
| 24 | 10pF ceramic |
| 25 | 0.01μF disc ceramic |
| 26 | 0.1μF disc ceramic |
| 27 | 4-20pF variable 808 |
| 28 | 10pF ceramic |
| 29 | 0.01μF disc ceramic |
| 30 | 18pF |
| 31 | 0.1μF disc ceramic |
| 32 | 4-20pF Mullard 808 |
| 33 | 0.47μF paper |
| 34 | 0.001μF feed through |
| 35 | 4-20pF Mullard 808 |
| 36 | 1500pF polyester |
| 37 | 100pF airspaced |
| 38 | 0.1μF disc ceramic |
| 39 | 180pF silver mica |
| 40 | 0.001μF disc |
| 41 | 100pF silver mica |
| 42 | 1500pF polyester |
| 43 | 0.1μF disc ceramic |
| 44 | 50pF silver mica |
| 45 | 50pF silver mica |
| 46 | 0.1μF disc ceramic |
| 47 | 0.1μF disc ceramic |
| 48 | 0.47μF paper |
| 49 | 1000F 40V electrolytic |
| 50 | 250μF 25V |
| 51 | 0.47μF paper |
| 52 | 100μF 15V |
| 53 | 0.47μF paper |
| 54 | 1000μF 5V |
| 55 | 0.1μF disc ceramic |
| 56 | 1000μF 40V electrolytic |
| 57 | 250μF 25V |
| 58 | 0.1μF disc ceramic |
| 59 | 100μF 15V |
| 60 | 0.1μF disc ceramic |
| 61 | 0.001μF feed through |

**Coils and chokes —L**

All r.f.cs are Radiospares 1 amp types

1 10 turns ¼in o.d. 22 s.w.g. airspaced
2 9 turns ¼in o.d. 22 s.w.g. airspaced
3 30 turns on Aladdin pot cored former 28 s.w.g.
4 15 turns in centre of former
5 7 turns 22 s.w.g. on Aladdin F804 former slug tuned
6 6 turns 22 s.w.g. ¼in airspaced
7 8 turns 22 s.w.g. airspaced ¼in o.d.
8 4 turns 22 s.w.g. airspaced ¼in o.d.
9 1 turn pushed into L8 insulated 22 s.w.g.
10 100 turns pile wound on slug tuned ⅜in former

**Crystal** 63.71MHz overtone. HC18U

**Transistors — Tr**
1, 2, 9, 10 ME3002
3, 5, 6, 7, 8, 12 2N3819
4, 11, 13, 14, 15, 16, 18 BC109
17, 19 2N3055
20, 21 ZTX500

**Diodes — D**
1 MV 1650 (Motorola)
2 5.6V 200mW zener
3 8.2V 20mW zener
4 5.6V 200mW zener
5 3.3V 200mW zener
6-9 diode bridge 1A 100V p.i.v.

**Integrated circuits — IC**
1, 2 SN72710
3 SN7490
4 741
5 SN7486

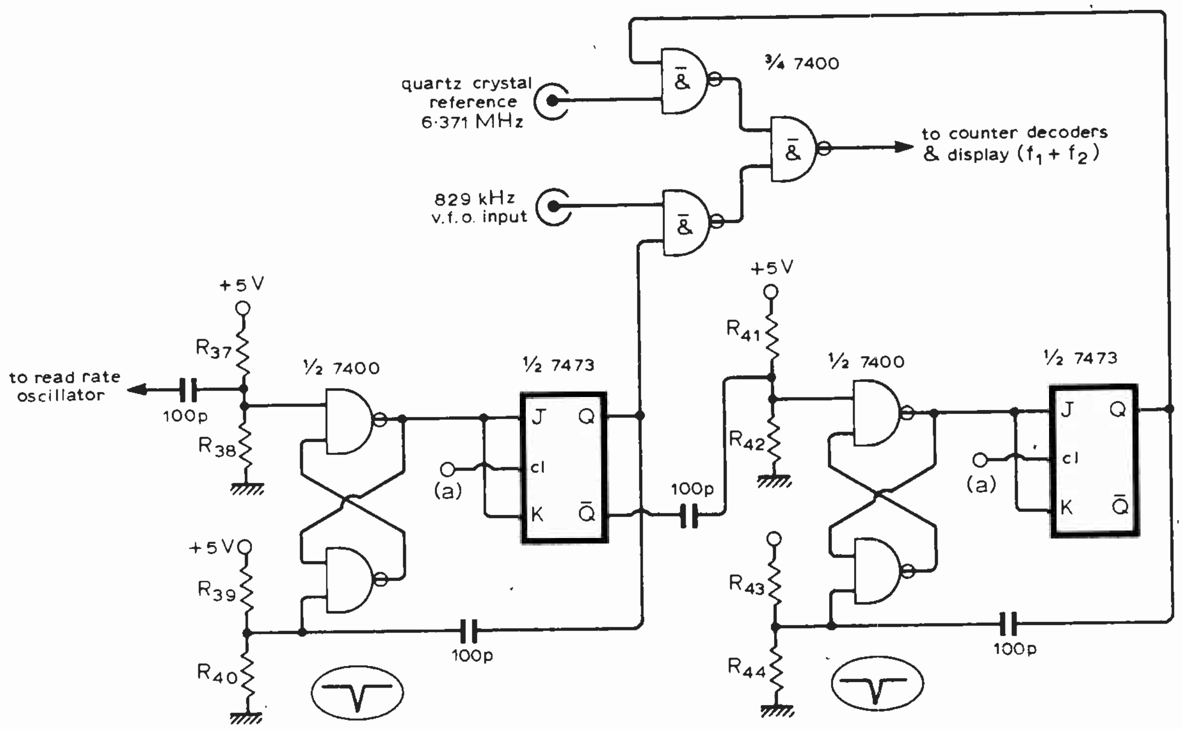



*Fig. 7. Frequency-addition circuit to display output frequency – the read rate oscillator in the counter is routed into the cross coupled gates, the output is transferred to input gate only when the gating pulse is present. The output pulse of the 7473 sets a second pair of cross coupled gates which load a further 7473 flip-flop whose output is only present after the gating pulse at the clock input. Provided the counter is not reset in this period the display will show the sum of the two input frequencies.*

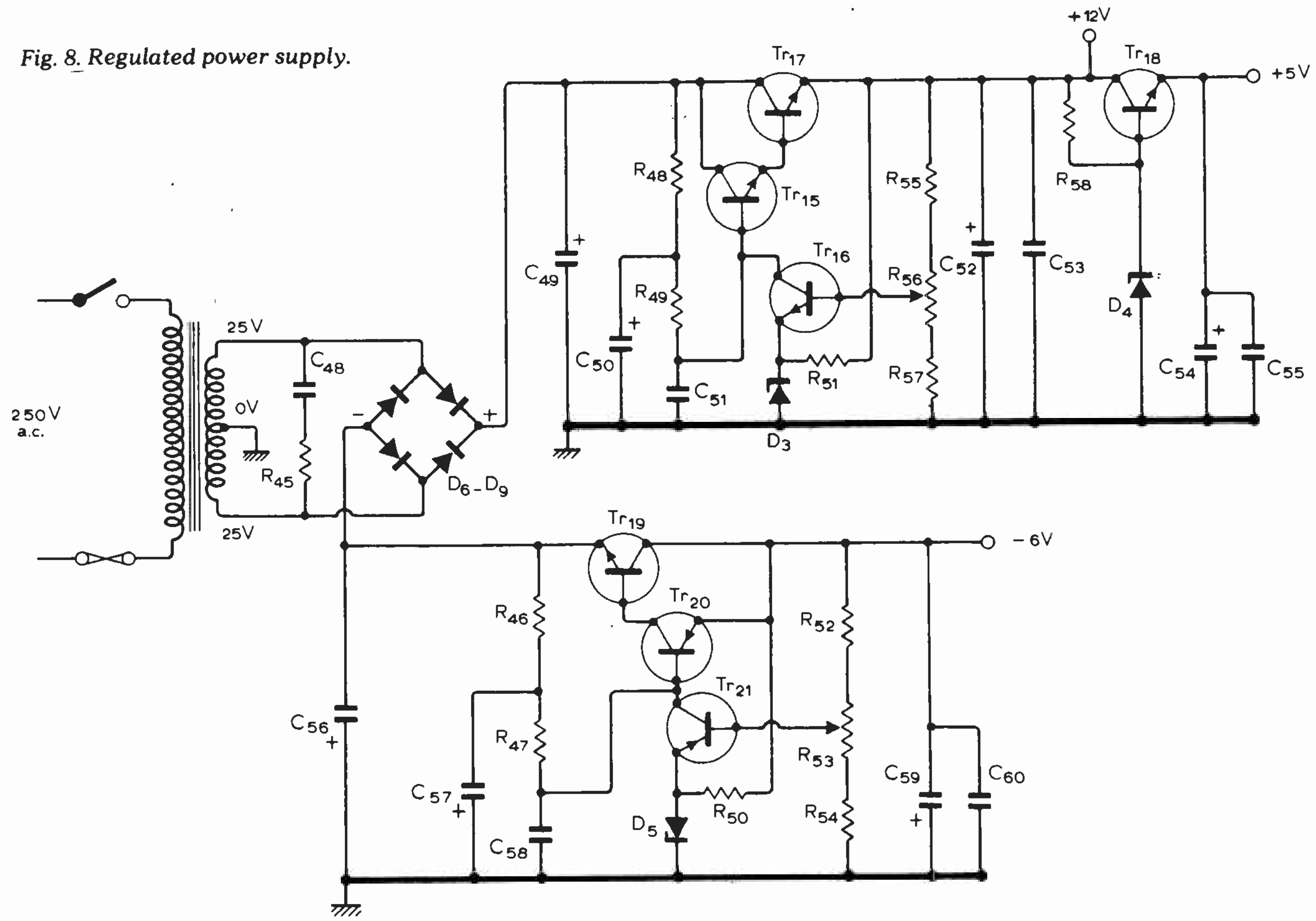



*Fig. 8. Regulated power supply.*

the correct size must be employed). Do not forget to join both sides of the board with links in the several indicated places to avoid instability caused by the earth plane floating up at an r.f. potential. Adequate decoupling of the control voltage is essential as any r.f. reaching the v.c.o. at this point will cause wierd and wonderful effects. Because the logic requires five volts it is necessary to use a separate supply for this, not just a zener dropper. It is easy for the supply rail to be modulated with logic pulses, so this must be decoupled efficiently.

The original low-frequency v.f.o. was constructed in a diecast box, measuring two inches deep. This allowed the p.c.b. to be mounted in the centre of the box while the rest of the volume was filled with foam as suggested to produce a stable chamber.

## Alignment and testing

First — ensure that the crystal oscillator is working by resonating the coils with a grid dip oscillator or simply rotate the variable capacitor $C_5$ until a signal is produced. Peak the output of $Tr_2$ by monitoring the strength of the signal on a g.d.o. Next with no input on the 741 from the NAND gate, adjust $R_{13}$ until the voltage at the output is roughly 4V positive. Leave $R_{15}$ at about 1kΩ and adjust $L_5$ until a signal is obtained at roughly 72.5 MHz, the frequency does not have to be accurate. Next adjust the voltage on the op-amp to +4V if it has moved, and readjust $L_5$. The signal should be reasonably stable and not microphonic. Disconnect $C_{28}$ from the f.e.t. buffer. Connect the output of $Tr_8$ to $C_9$ in the mixer, setting $C_{27}$ half way. After checking that the v.c.o. will swing over at least 1MHz between 0 and 12V on adjusting $R_{13}$, monitor the voltage at the output pin of $IC_1$.

Adjust $L_3$ until the voltage registers 1.5 to 2.0V, indicating that it is squaring the i.f. signal. Swing the v.c.o. over the required range and ensure that it is still squaring by adjusting $L_3$ as necessary. If there is difficulty with this, increase $L_4$ with a few more turns. Slight adjustment of $C_{27}$, which should be almost set, may improve mixing at the edges of the coverage.

Next check that the v.c.o. is tuning over the correct frequency range — 829-929k Hz and apply it to $IC_2$ making sure that this is squaring. Setting this to 880kHz (mid-band) and the control voltage on IC4 to about 6V tune $L_5$ to produce an output at 72.5 MHz, this should be easily receivable using a small wire placed on the bench. Connecting $IC_5$ output to the input of $IC_4$ and adjusting $R_{13}$ will produce a lock condition which can be recognized because the pot is being turned and the meter is not moving. Adjusting $C_{37}$ in the v.f.o. will cause the meter needle to move up and down depending on which direction the frequency is being moved. The loop bandwidth is lowered with $R_{15}$ until a clean signal is produced which has no amplitude modulation. Too much resistance will produce a long lock-in time and this should be set to around midway for best results, although there is no reason why it should not be set higher. Tuning of the output stages is straight forward — $Tr_9$ being tuned to 72 MHz and $Tr_{10}$ to 144 MHz.

Check that all is well by tuning plus and minus the carrier 8 to 9MHz and adjust $C_{77}$ and $C_{27}$ for minimum signal if necessary.

## Using the v.f.o.

Lock should be obtained on switch-on or as soon as the low-frequency reference oscillator is present at the comparator input. The loop bandwidth of the filter is approximately 1 kHz and therefore the locking time is 1ms. The meter being driven from the operational amplifier output serves to indicate that the v.c.o. is tracking with the 800kHz v.f.o. A more elegant way of doing this is shown in Fig. 6. Although this system is not foolproof it could be used to good effect.

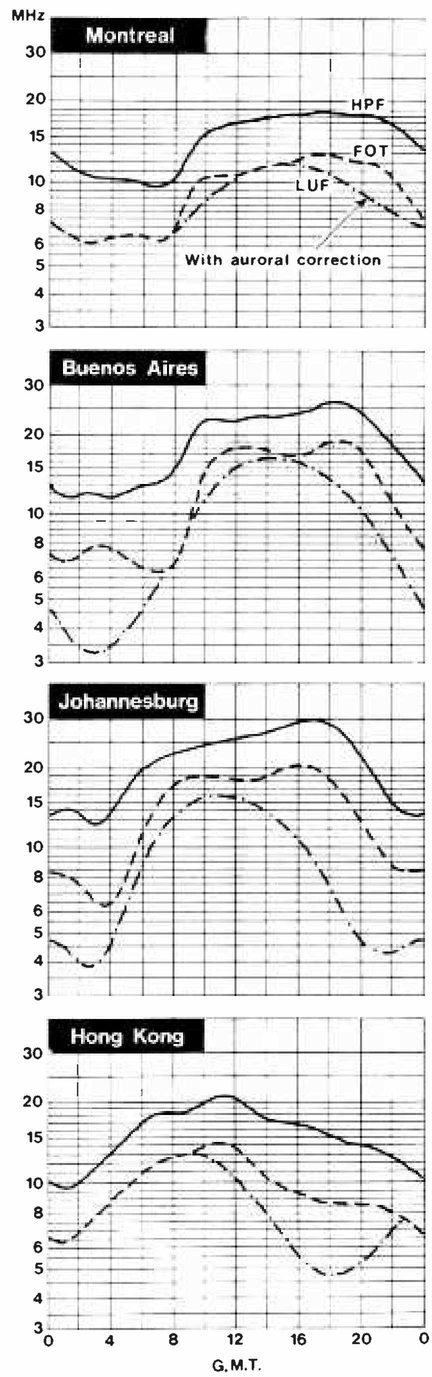
If the v.f.o. is to be used in a transmitter then some means of measuring the output frequency will be needed. If one has a direct reading frequency counter at the output there is no problem. Nevertheless it is possible to use a lower-frequency counter indirectly. For example one method is to measure the 829 kHz v.f.o. frequency and add to this, in the counter, the difference between this and the output frequency. An output frequency of 72 MHz corresponds to a frequency of 829 kHz in the v.f.o., if this is stored in a counter and a frequency of 6.37 MHz is injected, from a crystal oscillator, before the counter is reset. The true 72MHz output frequency will result. A possible modification to some frequency counters is shown in Fig. 7.

Depending on the frequency at which it is desired to radiate, buffering and frequency selective stages must be incorporated at the output before it is used with an aerial system. The output stage as it stands produces a component at 144MHz, approximately 18dB stronger than the 72MHz component, and was intended for the first in a chain of class C stages. Frequency modulation is easily applied to the v.c.o. by introducing a few millivolts onto the tuning diode. Care should be taken with screening however if this is tried.

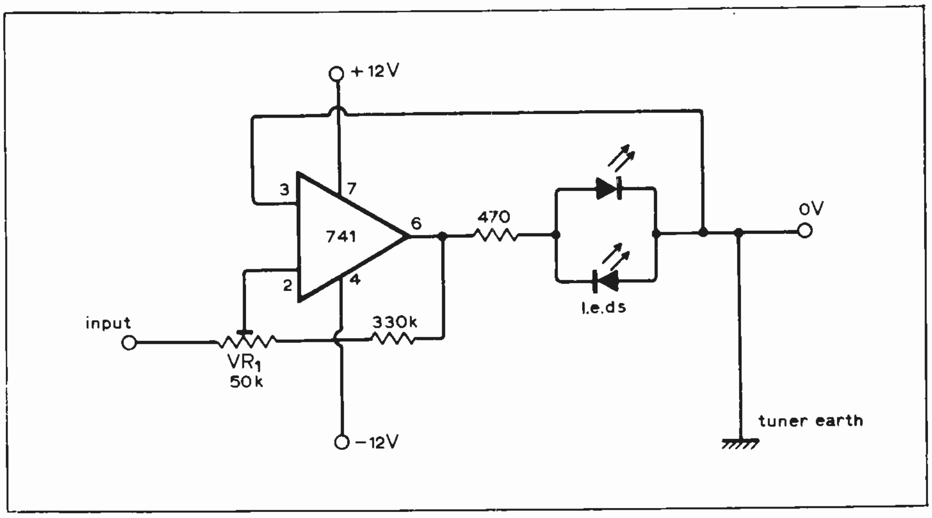
# HF predictions

Magnetic activity commented on in recent months has diminished rapidly. September is usually a good propagation month so generally improved conditions should prevail despite it being predicted as the month of sunspot minimum.

Temperate latitude zones will benefit most because magnetic activity has smaller effect at low latitudes and solar activity a greater effect at high and low latitudes.



# Circuit Ideas




## Simpler f.m. tuning indicator

Several circuits of tuning indicators have been featured in recent issues of *Wireless World*, and much comment has been aroused. The one shown here will no doubt attract its share, but it does have some good points.

It is simple to build, inexpensive and reliable. Operation is also simple. With the l.e.d.s fitted at either end of the tuning scale the cursor is moved away from whichever l.e.d. is on, to a dead spot, i.e. both off, which is the correct tuning point.

Tuning for "lights off" has two main advantages. Firstly, current consumption is minimized. Both lights can not be on together, and on-tune current is about 2mA. Secondly, a slight drift off-tune, or mis-tuning, is more readily seen. A light coming on, even slightly, is more obvious than one going off or at less than full brightness.

The circuit shown requires a dual polarity power supply, but if a suitable supply is not available in the tuner/amplifier a sub-miniature transformer is adequate.

The circuit including power supply can be built on a scrap of Veroboard. Component types and values are not critical, nor are power supply voltages. $VR_1$ is adjusted to give a dead-spot on tune, wide enough to stop the l.e.ds flickering with loud speech or music. The 470ohm resistor is included to limit the l.e.d. current to a safe value. It may be altered to suit individual tastes in brightness, or where different supply voltages are used.

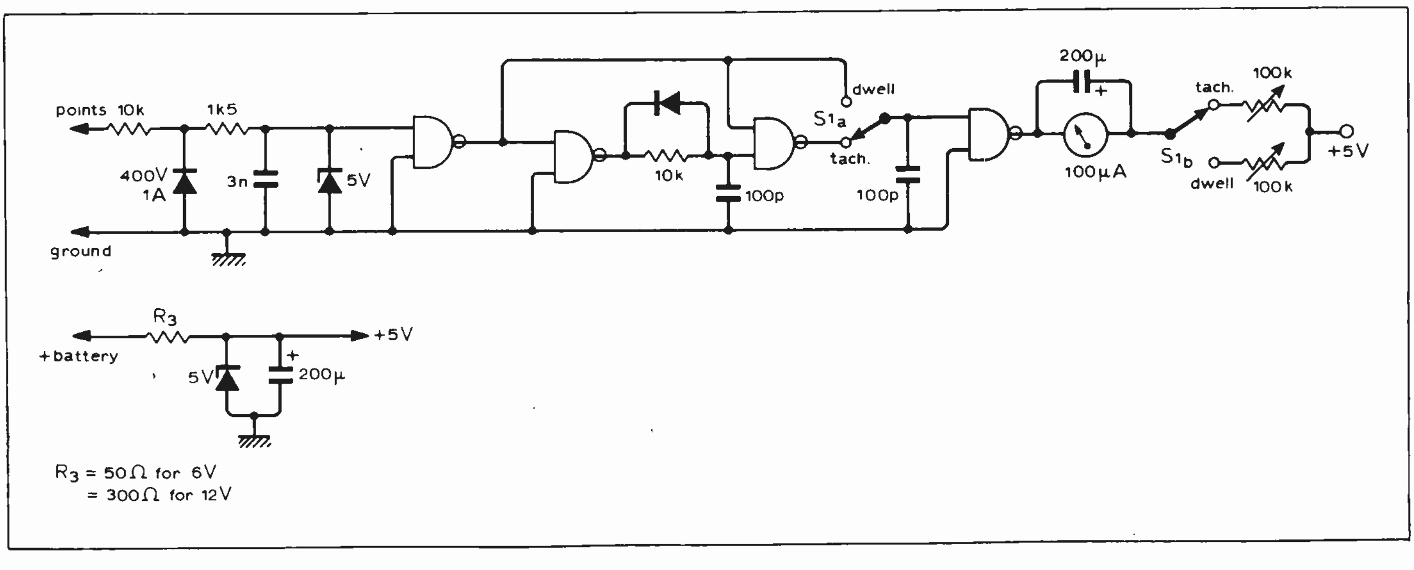
H. Hodgson,
Thornaby,
Cleveland

## Tach-dwell meter

I've been looking for a tach-dwell meter that would use few parts, but would still give me high accuracy and reliability and be relatively inexpensive. I finally built the meter shown which uses a SN7402 NOR gate as the major part. The advantages of this circuit are simplicity, low cost, and high reliability. Reliability comes from the excellent wave shaping and constant amplitude. Also there is no internal battery to wear out. As a point of interest, the zeners need not be used. The base-emitter junctions of most silicon transistors are 5 volt zeners.

Besides using a known good tach-dwell meter to calibrate the unit, a signal generator can be used. Select the maximum rev/min to be indicated, multiply this number by the number of cylinders, then divide by 120. The answer is the frequency in Hz. A further possibility is use the a.c. mains. Connect "points" and "ground" across the secondary of a 24-volt transformer and use a battery for power. Select a maximum rev/min of 2,000 and adjust for a reading of 1500 rev/min (for a four cylinder engine; for a six cylinder adjust for 1,000 rev/min and for eight cylinders adjust for 750 rev/min, with proportionately lower f.s.ds).

N. Parron,
Eynsham, Oxfordshire.



# Letters to the Editor

## ANALOGUE VS DIGITAL READOUT

Your editorial in the July issue reminds me of the problems which arose in the electrical component industry when it was thought that digital readout production test instruments were much quicker than analogue. The female testers soon "told us where to get off" as their throughput and bonus earnings fell considerably because of the time it took to determine a simple (say) resistance measurement of "not greater than" or "not less than" on a digital type ohmmeter, and to put a tolerance on of 10% really confused the issue. Coloured pass-band bands on an analogue indicating meter take all the thinking by operators out of the task, and operators get so skilled in judging the speed the needle moves across the red/green coloured scale that they do not wait for the pointer to stop, knowing at once whether it is a "pass" or "fail". And, woe betide the test gear engineer who uses a poorly damped instrument on a "go/no go" test set.

Digital instruments are best used where absolute accuracy is demanded, but, then, that costs money!

E. J. Williams,
Emsworth,
Hampshire.

## ELECTRODYNAMICALLY INDUCED E.M.F.

I see that the old controversy about induced e.m.f.s has surfaced again as part of some interesting correspondence (D. C. E. Todd and N. G. S. Taylor, letters, July issue).

We may be near opening up again the old dichotomy between the "flux cutting" advocates and the "flux linking" school of thought. I have a leaning towards the "linking concept," because, to me, it is closer to the ideas of the vector field and curl. Regarding the aeroplane conundrum, if you glance at Fig. 1 then when the wings – as a linear conductor – cross the uniform magnetic field lines, the "cutting" theorists claim that an e.m.f. exists between the ends. I am suspicious of this statement because the induced e.m.f. must be completely round a circuit anyway. This is seen by Faraday's Law – in its differential equation form:

$$\text{Curl}\,\bar{E} = -\frac{\partial \bar{B}}{\partial t}$$

As readers may know, $\bar{E}$ is a vector describing the electric field strength in units of volts per metre. (Curl just says that crawling along an $\bar{E}$ line (a "line integral") we must go right round in small loops at the point in question, i.e. under these conditions, $\bar{E}$ lines can have no start or finish.) $\bar{B}$ is the magnetic flux *density;* that is, how much flux is passing through unit area at the said point. To get the total flux, we multiply by the area. The differential with respect to time simply yields the "rate of change" requirement for the physical effects to be observed. The minus sign is Lenz's law, which is required for energy conservation requirements. Now all this is just standard electro-magnetic theory which umpteen textbooks contain. (A good one is "Electromagnetic Waves and Radiating Systems" by Jordan, Prentice Hall.) But a closer examination of the equation gives us plenty of clues

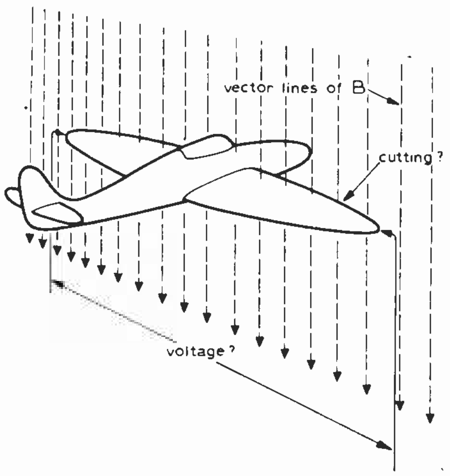



*Fig. 1*

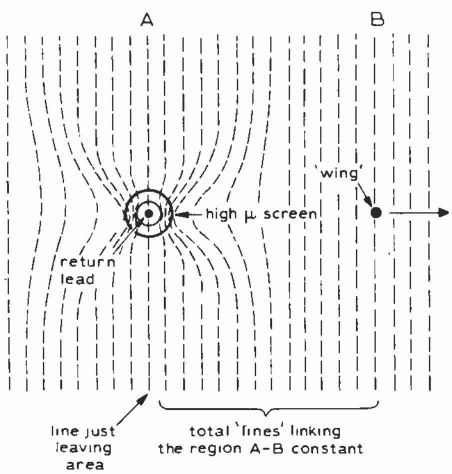



*Fig. 2*

to the problem. We only get an e.m.f. *round* the circuit if we *change* the magnetic flux going *through* the plane of the circuit at right angles. (Vector tyros might note that $\bar{B}$ can only be related to Curl $\bar{E}$, by a normal or right angles relationship. The operation "Curl" is a *vector product* type.)

Returning now to the magnetically screened return lead for the voltmeter. Does it make any difference to screen it? I suggest no, as a glance at Fig. 2 shows. The presence of the high permeability material will certainly distort the steady magnetic field, but if you imagine the whole "circuit" to move at right angles through the field, then a moment's reflection should convince you that the *total flux linking the circuit is constant,* therefore

$$A\,\frac{\partial \bar{B}^*}{\partial t}$$

is everywhere 0 and therefore the integrated Curl $\bar{E}$ is never anything but 0. Even on the "cutting" view, just as many lines will enter the area by crossing the "wing" as will leave the area by moving through the screen and second conductor. From whichever view, no flux linkage change occurs, therefore no e.m.f. is observed.

*Really it is the $\frac{\partial B}{\partial t}$ *integrated* over the area.

K. L. Smith,
University of Kent at Canterbury.

I was interested to see the recent letters in your journal regarding movement through a magnetic field. The initial statement that no current is induced in a circuit in motion through a constant magnetic field is correct. This rules out the use of moving-coil voltmeters.

The same argument applies equally to the arrangement proposed by Messrs Todd and Taylor since the presence of screening material does not affect the constancy of the magnetic field within the voltmeter circuit.

Possible solutions and a deeper insight into the problem are gained by a proper relativistic treatment of the situation. Because the horizontal magnetic field is relevant, I shall consider a simplified case in which the magnetic field appears to an observer stationary with respect to the earth to be vertical with intensity $B$. The field seen by an observer on an aeroplane moving horizontally with velocity $\underline{v}$ is found by performing a Lorentz transformation. The result of the calculation shows that the electromagnetic field has two components: a vertical magnetic field of intensity $\gamma B$ and a horizontal electric field of strength $vB/c$ where $\gamma = (1-v^2/c^2)^{-1/2}$ and c is the speed of light. The electric field seen from the aeroplane is no mere mathematical illusion but is as real as the earth's magnetic field itself.

Once the question is seen in this light the answer is simple, at least in

principle, since the motion of the aircraft may be measured by any device capable of being affected by an electric field. Such detectors could be made, for example, from semiconductor elements used like field effect transistors or from electron beam deflection systems such as cathode-ray tubes. It is another question, however, whether such a small electric field could be measured in practice.
Colin R. Masson,
Edinburgh

Concerning the query put forward by D. C. E. Todd and N. G. S. Taylor in the July issue (whether the e.m.f. generated by a conductor passing through the earth's magnetic field could be measured if the voltmeter leads were screened by high-permeability material), since the loop formed by the conductor and voltmeter leads would still embrace a constant magnetic flux one suspects the answer would still be no.

There is, however, a different approach to the problem. If a meter were placed at the *centre* of the conductor, the arrangement would be similar to a fixed dipole exposed to the magnetic component of a radio field. But because in this case the field would be both weak and unvarying, and traversed at a speed far below that of radio waves, the problem of measuring the e.m.f. generated might not be readily soluble, unless perhaps the "dipole" was rotated at as high a rate as mechanically reasonable, so converting the "signal" (taken off from slip rings) from d.c. to a.c. Does anyone see any objection in principle?
"Cathode Ray"

## TELETEXT DEMONSTRATION

I was rather surprised to read, in your report on the 1975 Spring Trade Shows in the July News of the Month, some very unfavourable comments on the Teletext receiver that Philips were showing.

The receiver shown was certainly an experimental one, but apart from a portion of decorative trim becoming detached, would certainly not merit the description "battered."

We believe that the reason why it was not displaying a Ceefax page at the time your reporter saw it was probably because the "After hours" button had been depressed. This provides synchronisation and enables a page to be retained in the memory and displayed when there are no broadcast transmissions. However, when an attempt is made to call up another page, the result is a blank screen since the "After hours" button has disconnected the broadcast signal.

During the experimental transmissions, decisions obviously have to be made as to what features are to be included and how far the operation of the receiver has to be proof against such effects. Obviously, the Teletext receiver we were demonstrating will have to be modified to avoid this sort of thing, and indeed we have to decide whether "After hours" operation is a worthwhile feature.

Meanwhile, we would like to assure you that great interest was shown by our dealers in this receiver, as appears to be the case wherever Teletext is demonstrated.

M. A. E. Butler,
Philips Electrical Ltd,
Croydon.

## DOLBY KIT FILTER ADJUSTMENT

The use of the BBC test transmissions seemed to me to be a little hit-and-miss for setting-up the 19kHz filter of the Dolby noise reducer (July issue) since the vital zero modulation part only lasts for about two minutes. I also did not have a suitable signal generator available.

However, a little thought showed that a precise 19kHz signal was available from pin 10 of my MC1310 stereo decoder when receiving a stereo signal. Since thas is the signal that the filter is required to attenuate it seemed logical to use this for alignment purposes. The signal was applied with a 2MΩ potentiometer in series and alignment was easily completed using the signal generator instructions.

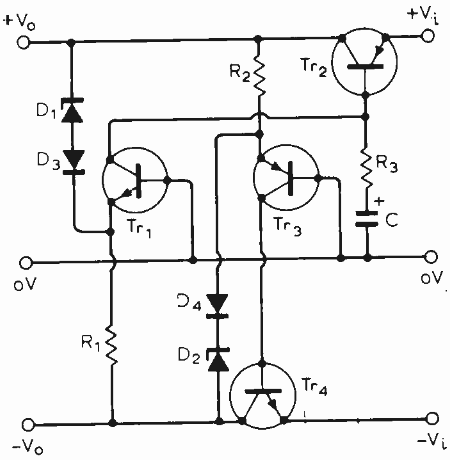
There was possibly some modulation of the signal as the meter flickered slightly, but in spite of this the null was very precise.

Your readers may find this of interest to enable them to set up their kits without having to wait for Radio 3 to close down.

M. S. Maisey,
Coulsdon,
Surrey.

## POWER SUPPLY PROTECTION

The voltage stabilized, symmetrical power supply described by O. Holmskov in the May 1975 issue (Circuit Ideas, p.226) can also be made short circuit proof by the addition of two diodes. If the positive and negative rails of the original circuit are shorted together the zener diodes $D_1$ and $D_2$ can be destroyed by the excessive currents flowing along the paths provided by $Tr_1$, $D_1$ and $D_2$,




$Tr_2$. This can be prevented by the inclusion of diodes $D_3$ and $D_4$ as shown in the accompanying diagram. The inclusion of these diodes naturally increases $+V_0$ and $-V_0$ slightly due to the diode forward voltage drop, but otherwise the circuit operates as described in the original article. Since carrying out this modification it has not been possible to damage the circuit in any way.
Lothar Bischoff and
David W. Branston,
Erlangen,
W. Germany.

## GOOD SERVICE

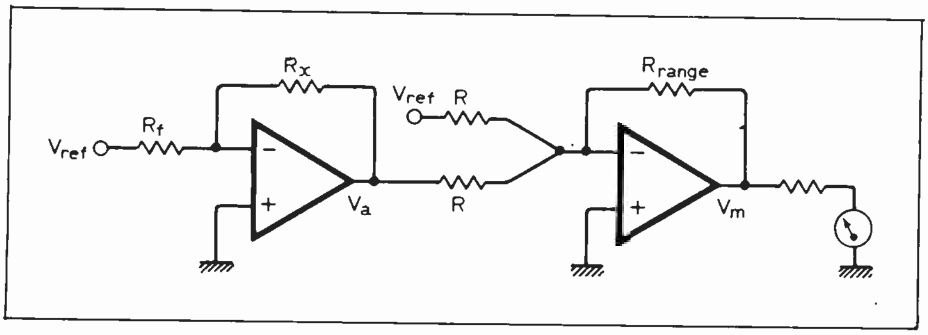
I have recently purchased test equipment from John Crichton, 558 Kingston Road, London. I should like to place on record the first class after sales service that I have received from Mr F. R. Galka, their manager. I have received a photostat copy, and other components, despite the fact that the equipment is ex-service.

It is very rare these days, as you may well know, to receive such service, and good to know that we still have businessmen like F.R.G.
F. V. Mourant,
St Peter Port,
Guernsey.

## RESISTANCE COMPARATOR

The Letters column of *W.W.* can be relied upon to thump the slightest signs of carelessness or rashness on the part of authors in previous issues. This time I did not even get four weeks' grace, for only a few days after publication of the July issue I found a little note pushed under my office door from one of our research students, Mr P. Choi of the Plasma group, which clearly shows my "crime" to be that of gross inelegance.

His reference (below) to the Company concerns his past role as "employee" in my mythical Curly Wire Co. which goes into battle at Project time in




the undergraduate practical class – fastening upon the possible shortcomings of thermocouples from the dastardly rival Layphlat Wire Co. at that time I recall. Mr Choi writes:

"Dear Mr Curly,

It is great to see the Co. at work again as indicated by the Resistance Comparator in the July issue of *W.W.* I was, however, a bit disenchanted with the full circuit on p.333 when Fig. 3 looked so neat. After some restless moments in the bath, it came to my mind that by rearranging $V_{ref}$ we could eliminate much of your circuit: (see above)

Then, $V_m = -R_{range}(V_{ref}/R + V_a/R)$

$$= \frac{-R_{range}}{R}(V_{ref} - V_{ref}\cdot R_x/R_f)$$

$$= \frac{R_{range}}{R}\cdot V_{ref}\cdot\Delta$$

where $R_x = R_f(1 + \Delta)$ as before."

Well done, Mr Choi, this is a very elegant scheme indeed.

D. Griffiths,
Imperial College,
London, SW7.

## SUICIDE SOLDERING

Mr Parkins' letter on soldering in the February issue raises some nice safety problems. For a person to receive a fatal shock it is necessary to pass some 70 mA, through the body*, some of this appearing as a potential difference across the heart causing ventricular fibrillation.

Since the mains live is referenced to the earth at the star point the risk of electrocution is obviously increased by strapping the operator to earth. To receive a shock it is only necessary for the person to touch one piece of live equipment, e.g. 'scope, soldering iron, or convector fire, and the unfortunate operator will be unable to release at least one pole of the circuit. The contact resistance of a deliberate connection to the person will be much lower than, say, a brushing contact.

If it is strictly necessary to earth the operator then the maintenance of the equipment must be of a very high order. I would suggest monthly inspections and tests for earth continuity, earth leakage, and insulation. Alternatively the power supply to the equipment should be isolated from the mains via a suitable transformer and monitored with earth leakage trips set at 2-5mA. This would render any shocks non-lethal, if somewhat painful. I would further suggest that the habit of sitting on electric heaters should be discontinued and space heating introduced, as the cost of isolating the heaters would be prohibitive.

P. S. Reckless,
Bromley,
Kent.

* Hospital Technical Memorandum No. 8, H.M.S.O.

## DOPPLER DISTORTION

Over the past few months you have printed letters by Mr D. Edgar, Mr J. Moir and "Cathode Ray" prompted by Mr Moir's April 1974 article "Doppler distortion in loudspeakers". It seems that some of your readers are uneasy about his initial account of this effect, which he attributes to the fact that a low frequency drive signal contributes a component to the cone velocity which Doppler-shifts the frequency of the radiated sound due to a high frequency drive signal simultaneously applied to the cone. In his example (low frequency 100Hz, high frequency 3kHz modulation index M = 0.1) the frequency deviation swings from +10Hz to −10Hz and back 100 times a second, but the modulated signal consists essentially of just the carrier and two sidebands separated from it by ±100Hz. Thus a bandpass filter with a bandwidth of 1Hz and a central pass frequency of 3005Hz would hardly respond at all to the radiated sound, whereas one tuned to 3100Hz would respond strongly. Evidently, as Gabor's acoustical uncertainty relation[1] should lead one to expect, the idea of instantaneous frequency is quite misleading when $M \ll 1$.

An alternative and more basic description of the modulation process avoids these difficulties in interpretation. Suppose that a loudspeaker cone is subjected simultaneously to a complex high frequency signal producing a component of cone displacement *d(t)*, and to a complex low frequency signal producing a component of displacement $d_m(t)$. We assume that all the frequencies involvled in *d(t)* are much higher than all those involved in $d_m(t)$, and that the wavelengths associated with the high frequency signal in air are smaller than the cone diameter. In the presence of the displacement due to the low frequency signal the radiated high frequency sound waves are given a handicap start of $d_m(t)$, corresponding to a time handicap of $d_m(t)/c$, where *c* is the velocity of sound in air. Thus the radiated high frequency signal is proportional to $d\,(t + d_m(t)/c)$. The wave profile is almost unaffected, but there are smooth local fluctuations in the time scale. Reverting to an example equivalent to that given by Mr Moir, if $d(t) = a \sin 2\pi ft$ and $d_m(t) = a_m \sin (2\pi f_m t + \epsilon_0)$ then the radiated high frequency signal near the cone surface will be

$$a \sin 2\pi\left[ft + \frac{a_m}{c}\sin(2\pi f_m t + \epsilon_0)\right],$$

where $a_m/c$ corresponds to the modulation index *M*. For $M = 0.1$ we have a signal of constant amplitude, and a phase which oscilllates with the period of the modulating signal, but by a mere $\pm\pi/5$ radians. It is not surprising that many people cannot believe that the ear could detect such subtly camouflaged distortions.

However Mr Moir claims that the members of his listening panel were able to distinguish between music reproduced with relatively high and relatively low levels of "Doppler distortion", and that they characterised the former as "rough" – surely a surprising comment in view of the smooth and coherent changes in the radiated waveforms produced by the modulating process. It is therefore worth asking whether the original modulation may be made audible by some effect of room acoustics. Has he considered that in a listening room the direct wave and the waves reflected from the walls will in the presence of "Doppler distortion" produce multipath interference effects at the listener's ear, similar to those sometimes encountered in f.m. radio reception?

I have carried out a rough calculation using a single reflected wave, and it appears that, under room conditions, two-path interference can give rise to amplitude modulation sidebands up to a third as strong as the original Doppler modulation sidebands for certain ranges of values of the phase differences between direct and reflected waves of the modulating frequency. The erratic dependence of the amplitude modulation so produced on the modulating frequencies and on the listener's position within the room might well make music reproduced by a speaker which introduces large amounts of Doppler modulation sound "rough". However, from this standpoint speakers which were otherwise comparable, but produced widely different amounts of Doppler modulation, should be hard to tell apart in an anechoic room.

C. F. Coleman,
Wantage,
Oxon,

**Reference**

1. D. Gabor, *J.I.E.E.* vol. 93, p.429, 1946.

# Transmitter power amplifier design — 1

## Circuit techniques and practical considerations for mobile radio h.f. and v.h.f. communications

by W. P. O'Reilly, M.Sc., M.I.E.E.

*The Plessey Company Ltd*

**In this three part series of articles the author has set out to illustrate the latest design procedures, components and construction techniques used in today's advanced mobile radio transmitters. Part I discusses classification according to frequency bands and the modulation process to be used. The capabilities of present state of the art devices for various applications are indicated. Also in this first article, design procedures are detailed for power amplifiers suitable for operation at h.f. using single sideband modulation. In the second article design procedures for various types of v.h.f. power amplifiers are detailed. Part III details design procedures for some of the special components used in the amplifiers described in parts I and II.**

Power amplifiers for mobile radio transmitters may be classified according to the frequency band covered and to the type of modulation employed. In this series of articles power amplifiers for the high frequency and very high frequency bands are described. The h.f. band extends from 1.5MHz to 30MHz and the v.h.f. band covers frequencies from the top of the h.f. band to approximately 300MHz. These bands are further sub-divided according to the type of traffic they are primarily allocated for; e.g. ship-to-shore radio telephone, mobile radio, broadcast, aircraft bands and several others. The design of a transmitter power amplifier varies considerably with the type of modulation to be employed. In pulsed systems, for example pulse code modulation, the information is contained in the presence or absence of signal and not in the amplitude or phase of the signal. Provided its bandwidth is adequate to permit the required data rate the power amplifier used in such systems cannot distort the signal and so linearity of input/output transfer function is of no consequence. Where several frequencies exist simultaneously in the transmitted signal, as in amplitude modulation (a.m.) systems, it is important that the amplifier should not excessively distort the signal. This restriction is necessary not only to avoid loss of quality or intelligibility of the received signal but also to avoid the generation of new and unwanted signals of sufficient magnitude to cause interference in adjacent channels. This type of interference, termed intermodulation distortion (i.m.d.), is discussed in more detail under the heading of power amplifiers for single sideband (s.s.b.) transmitters.

In the v.h.f. bands s.s.b. is not yet in common use but some data modulation systems require high linearity transmitters to avoid distortion which could otherwise result in errors in the received data and spreading of the spectrum into adjacent channels by intermodulation. Many v.h.f. mobile radio links use frequency modulation (f.m.). Instantaneously in an f.m. signal only one frequency is present and since intermodulation distortion can only occur when two or more signal frequencies are present a linear power amplifier is not required.

Hence power amplifiers may be classified into four groups:— pulse transmitters where amplitude and phase linearity are of no importance; double sideband transmitters in which input/output amplitude transfer function non-linearity (often expressed as a percentage envelope distortion) must be contained within prescribed limits; s.s.b. and certain types of data transmitters in which a high degree of linearity of the amplitude and phase components of the input/output transfer function is required; and f.m. transmitters in which linearity is of no importance. These differ from the first type in that the output power is present at all times during transmission and the amplifier must be adequately rated for continuous operation.

**Table 1**

| Operating Conditions: Mode | Bias class | h.f. 1.5-30 MHz | v.h.f. Low band 30-76 MHz | v.h.f. High band 100-175 MHz | u.h.f. 225-400 MHz 15 | Microwaves 1GHz | 2GHz | 3GHz | 4GHz |
|---|---|---|---|---|---|---|---|---|---|
| Linear (p.e.p)* | Class A | | | 30 | 35 | 15 | 2.5 | 1.0 | |
| | Class AB | 300 | 50 | 30 | 70 | | | | |
| c.w./f.m. | Class C | 300 | 80 | 100 | 100 | 40 | 20 | 12 | 6 |
| a.m.i. Pcarrier | Class C | 70 | 40 | 30 | 20 | | | | |
| a.m.i. p.e.p. | Class C | 280 | 160 | 120 | 80 | | | | |
| pulsed | Class C | | | | 300 | 150 | 35 | 20 | |

*p.e.p. — peak envelope power

### Device capability

The latest generation of mobile radio equipment is almost exclusively solid state in design. Hybrid and integrated circuits are used in the lower power sections of the transceivers and r.f. power transistors form the basis of design of the transmitter power amplifiers. The techniques required to manufacture these r.f. power devices are extremely exacting and are costly to acquire; it is significant that less than half of the world's major semiconductor manufacturers have chosen to enter this sphere of activity.

The design of a power transistor for r.f. operation is a complex consideration of "trade-offs" between such parameters as cut-off frequency, power gain, bandwidth, ruggedness, efficiency and output power. Not all of these may be maximized simultaneosly, and the transistor designer has to select his starting semiconductor material, the device geometry and diffusion profiles to achieve a compromise which is suitable to the intended application. Very fine geometry is necessary for a high cut-off frequency; yet fine structures, as well as being the lowest yield types, are generously less rugged than coarser ones. Similarly maximum output power does not coincide with maximum gain or efficiency. The bandwidth achievable is only partly determined by the design of the active device. The transistor package, as well as being the main factor determining the power dissipation capability of the device, has a major effect on the input bandwidth. The inductance of the metalization and bonding wires determines the Q factor of the base circuit which is normally the ultimate bandwidth limitation.

For mobile radio, devices are available for the three usual, most popular supply voltage sources. These are eight volts for personal radio telephones and 12 volts and 28 volts for vehicle equipment. For very high output from a single transistor there are advantages in using a higher supply rail, and some 50 volt devices are becoming available. These are at present finding application in fixed station equipment. Table 1 details the maximum power output capability of r.f. power transistors from h.f. to microwave frequencies for each of the four types of application previously discussed.

## Biasing r.f. power transistors

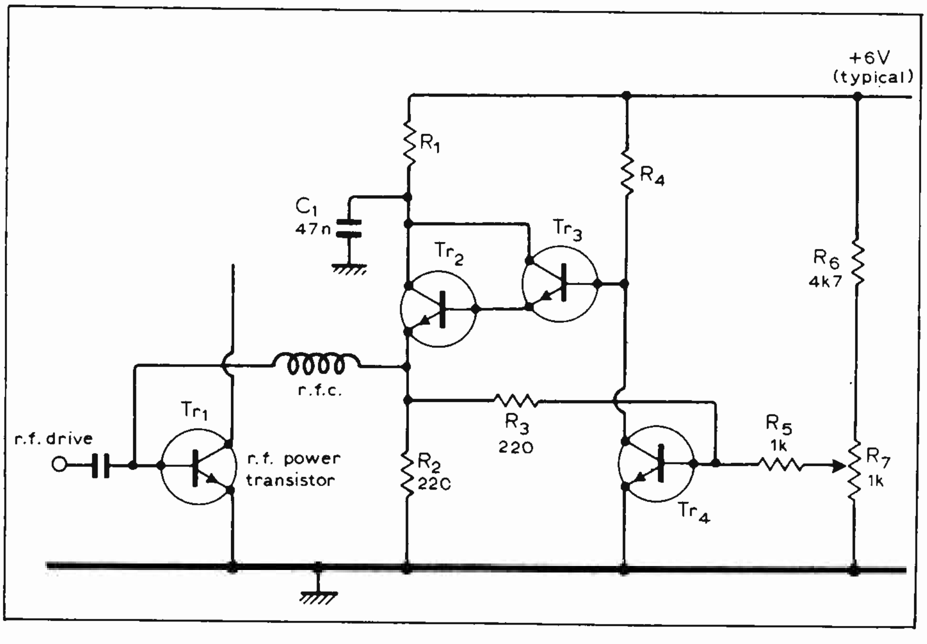
The bias point of a transistor in an amplifying circuit is described in terms of the quiescent collector current, i.e. the current existing before the drive signal is applied. The three main classes of bias used in r.f. amplifiers are: (i) class A in which the base-emitter junction is forward biased so that a large quiescent collector current is obtained. The drive signal modulates this current equally in either sense. Provided the maximum drive signal is not excessive this class of bias provides very linear amplification. The output

**Table 2**

| Operating Condition | Output Power (watts p.e.p.) | Efficiency (%) | two-tone i.m.d. (dB) |
|---|---|---|---|
| Class A | 7 | 20 | −45 |
| Class AB Lightly driven | 12 | 40 | −38 |
| Class AB Fully driven | 25 | 65 | −28 |
| Class C | 35 | 75 | −12 |

power is limited by the steady-state heat dissipation and low efficiency (typically 25% for intermodulation products of level 50dB below full output at h.f.); (ii) class B or class AB in which the base-emitter junction is biased to the verge of conduction — or in the case of class AB to produce a small quiescent collector current — so that as soon as a drive signal is applied the transistor conducts collector current ideally of magnitude proportional to drive signal. A high degree of linearity can be obtained from class B or class AB amplifiers if the bias point is accurately maintained. The efficiency achievable is much greater than for class A bias and hence higher output power can be obtained from the same device; (iii) class C bias is used in f.m. and pulsed continuous wave amplifiers. The base-emitter junction is biased beyond cut-off (generally to zero volts) and the device conducts when the drive signal is increased sufficiently to turn on the base-emitter junction. At low frequencies the collector current is a succession of almost rectangular pulses occurring for short periods centred at the peak of the drive voltage waveform. The collector efficiency can be as high as 80% and is mainly limited by the saturation voltage of the transistor. As

*Fig. 1. Temperature compensated bias circuit.*




the cut-off frequency is approached, however, the collector current waveform becomes more sinusoidal due to the limited gain of the transistor at harmonics of the drive frequency. The conduction angle therefore increases and may even exceed 180°, and under these conditions the efficiency and output power are less than can be obtained at lower frequencies. Since the drive signal must exceed a certain value before any output power is obtained it follows that the input/output transfer characteristic is extremely non-linear.

## Power amplifiers for s.s.b.

Table 2 shows the typical performance of a 2N5707 r.f. power transistor operating at 30MHz. The 2N5707 has a cut-off frequency of typically 150MHz and is characterized for class AB operation up to 30MHz and class C operation above 30MHz. The linearity of an amplifier is commonly tested by driving the amplifier with two equal amplitude r.f. signals separated in frequency by an audio frequency. Spectrum analysis of the output waveform displays the amplifier input signals and also the intermodulation products generated in the non-linearities of the transfer characteristic. If the two input frequencies are $f_1$ and $f_2$ it can be shown[1] that third order products occur at frequencies $2f_1 - f_2$ and $2f_2 - f_1$. Similarly fifth order products are $3f_1 - 2f_2$ and $3f_2 - 2f_1$ and so on. These odd-order products are serious since they occur close to the carrier frequency and are not removed by any output filters or tuned circuits, and so they constitute interference to users of adjacent channels. The C.C.I.R. linearity requirements for s.s.b. transmitters are for intermodulation products to be at least −25dB with respect to the level of either of two equal test tones. From Table 2 it can be seen that adequate linearity can be obtained from class AB operation of a transistor specially designed for linear operation, and most mobile radio s.s.b. transmitters use this class of bias in the output stage.

In order that the driver stage distortion shall not significantly degrade the i.m.d. performance of the output stage the linearity of the driver stage must be at least 10dB better than that of the output stage at the peak envelope power (p.e.p.) output. Hence driver stages must either use class AB bias and run well below full output, or, at the expense of increased power consumption, class A bias must be used.

## Bias circuits

Since the most important factor determining the linearity of a power amplifier is the class of bias employed, it is essential that the bias point should be accurately maintained over the operating temperature range and under drive conditions. The base current of the power transistor consists of a succession of near half sinewaves the d.c.

component of which must be supplied by the bias circuit; otherwise the transistor would generate a self bias tending to cut-off the base-emitter junction. Many quite complicated circuits have been devised to obtain a temperature stablized low impedance bias voltage. Most of these systems depend upon a temperature sensitive element such as a thermistor, diode or transistor mounted in close thermal contact with the power transistor. Since it is the temperature dependence of a transistor base-emitter junction which requires matching, this function can be performed very well indeed by using another, but of course much smaller and cheaper, transistor. Fig. 1 shows a bias circuit which uses a transistor, $Tr_4$, as the temperature sensor. The current density in $Tr_4$ is arranged, by suitable choice of $R_4$, to be similar to the quiescent current density required in the r.f. power transistor. As a result the temperature coefficient of base-emitter voltage is the same for the sensor as for the r.f. power device and a constant quiescent current is obtained over a wide temperature range. The pre-set potentiometer permits adjustments of the quiescent current to the optimum value and with the circuit values quoted adjustment over the range 0.5 volts to 0.8 volts is possible at 25° C which is sufficient to accommodate the expected spreads in turn-on voltage for silicon r.f. power transistors. The circuit is a feedback amplifier set for less than unity gain, and hence the output impedance is very low (typically 0.01Ω).

The optimum bias impedance for best linearity is usually between 0.3Ω and 1Ω depending on the size of the output transistor, and the r.f. choke between the bias supply and the base of the power transistor may be selected to provide this resistance. Since the current drawn from the bias circuit depends upon both the output power (p.e.p.) and the minimum d.c. gain of the power transistor, the value of $R_1$ should be chosen to limit the available bias current. This provides some degree of protection in the event of excessive drive signal being applied to the amplifier. Based on a minimum d.c. current gain of 10 for the power transistor, suitable current limits are 8mA per watt p.e.p. for amplifiers running from 28 volts, and 18mA per watt p.e.p. for 12 volt systems.

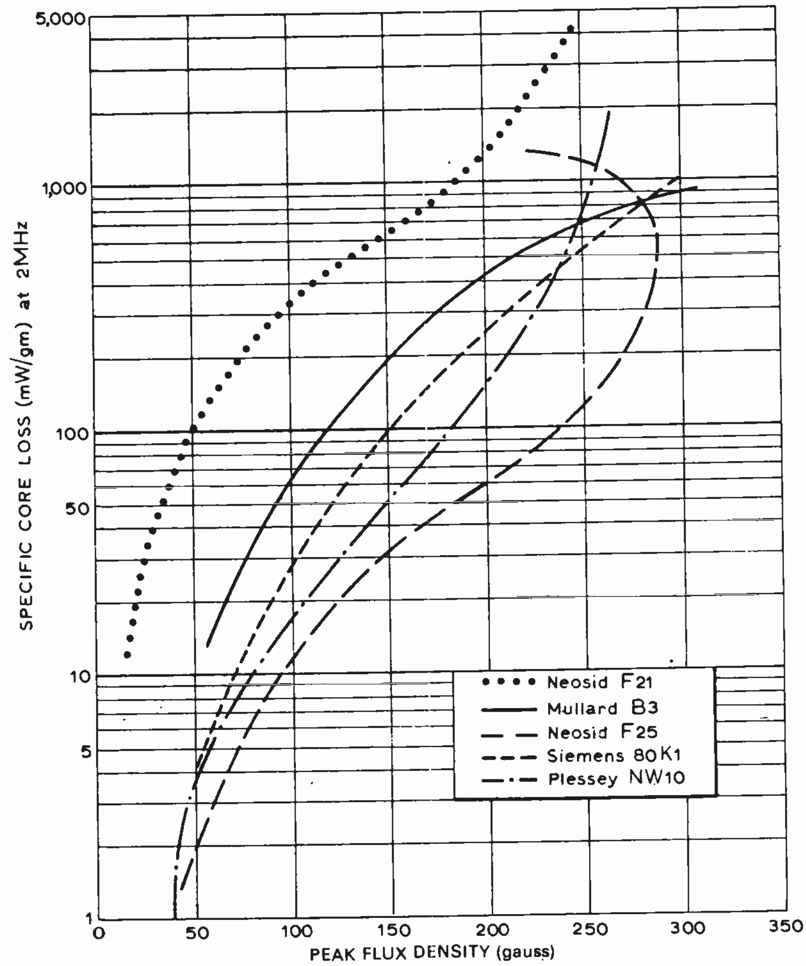



*Fig. 2. Ferrite core loss versus flux density for different types of core.*

## Broadband matching

Transmitter power amplifiers are intended for operation between defined source and load impedances. Either 50Ω or 75Ω are generally specified. The power transistors, however, are low impedance devices so that impedance transforming networks are required at the input and output of each stage. For a single transistor operating in class AB the load impedance to achieve the required output power is determined by the maximum available voltage swing at the collector. For broadband h.f. amplifiers it is normal to operate two transistors in push-pull thus minimizing the second harmonic output. (In a well designed amplifier of this type the second harmonic output is typically 25dB below the fundamental.) The peak available voltage swing is determined by the supply voltage, $V_{cc}$, and the r.f. saturation voltage, $V_{sat}$, of the transistors. At present $V_{sat}$ is typically four volts for 28-volt devices used near to their maximum frequency and power capability, and two volts for 12-volt devices. When a push-pull amplifier is operating into a perfectly matched load the output power capability for minimal peak compression (i.e. intermodulation products better than −35dB) is related to the collector load resistance, $R_L$ by the equation:

$$\text{p.e.p.} = \frac{(V_{cc}-V_{sat})^2}{2R_L} \qquad (1)$$

If the signal drive is increased the output power will increase by typically 2dB before the i.m.d. products are degraded to −25dB. To ensure that the amplifier remains linear when running at full power into a moderate load mismatch and also to allow for some losses in the output matching network equation (1) without a correction factor should be used to determine the load resistance. Optimum collector load resistance per transistor at various output power levels is detailed in Table 3 based upon push-pull operation and typical values of $V_{sat}$. For single ended amplifiers, which are generally used only in narrow band applications, the power output for each stated load resistance is approximately halved.

The required impedance ratio for the output matching network may be determined by reference to Table III. Maximum bandwidth is achieved using transmission line transformers in which the inter-winding capacitance and leakage inductance of conventionally wound transformers are avoided. This is achieved by using transmission lines as the conductors forming the windings. The geometry of this is arranged to provide a characteristic impedance which is optimum for the values of source and load resistance in the circuit. At h.f. ferrite cores are generally used to obtain the high primary inductance necessary for operation at the low frequency end of the band. Toroids, pot-cores or multi-aperture cores may be used since the high frequency performance is primarily determined by the transmission line windings and not by the ferrite material. Care must be taken in the selection of ferrite cores to avoid operating at too high a flux density as this results in excessive power loss and possible overheating of the windings or even loss of permeability if the temperature exceeds the Curie point. The i.m.d. contribution due to non-linearity in the transformer cores should not be ignored. Fig. 2 shows curves of specific power loss (in milliwatts per gram of ferrite) against flux density for various grades of ferrite measured at 2MHz. It can be seen that when the flux density exceeds about 0.01 weber meter$^{-2}$ most ferrites become non-linear and unless special cooling arrangements are made overheating is likely to occur. Of special importance is the need to avoid materials called Perminvar ferrites which contain cobalt. These exhibit extremely low loss in small signal circuits for which they are recommended, but they may be permanently damaged by high flux densities.

The design procedure for broadband transmission-line transformers is best illustrated by an example. The single stage push-pull amplifier of Fig. 3 is required to operate between 50Ω source and load impedances and to produce 50 watts p.e.p. from a 28-volt supply over the frequency band 2MHz to 30MHz. From Table 3 each transistor requires a collector load resistance of 6Ω. The output power from each transistor is combined in the balance-to-unbalance hybrid transformer, $T_3$. A 4:1 transformer, $T_4$, then raises the impedance level to 50Ω to match the load. The primary reactance of each transformer winding is required to be at least three times the load resistance presented to that winding at the lowest operating frequency. Thus for each winding of $T_3$ and $T_4$ the required primary inductance is 3μH. Selecting initially a 38mm Mullard toroid in grade B3 ferrite (type

**Table 3**

| Output (watts p.e.p.) | Optimum load resistance(Ω) 28V amplifiers | 12V amplifiers |
|---|---|---|
| 10 | 30 | 5 |
| 20 | 15 | 2.5 |
| 50 | 6 | 1.0 |
| 100 | 3 | 0.5 |

FX3027) the required number of turns per winding may be calculated from

$$N = \sqrt{\frac{L}{\mu_o \mu_r} \cdot \frac{l}{A}} \qquad (2)$$

where $L$ = required inductance, $\mu_r$ = relative permeability = 100 for grade B3, and $\mu_o$ = free space permeability = $4\pi \times 107$

$$\frac{l}{A} = \frac{\text{magnetic circumference}}{\text{C.S.A. of toroid}}$$

$= 2440\text{m}^{-1}$ for FX3027

From equation (2), $T_3$ and $T_4$ require eight turns per winding. To determine whether a sufficiently large toroid has been selected the maximum flux density, $B$, must now be calculated from

$$B = \frac{V}{4.4 f.N.A.} \qquad (3)$$

where $V$ is the maximum r.m.s. voltage across the winding at the lowest operating frequency, $f$. Using equation (3) a maximum flux density of 0.006 Wbm$^{-2}$ is predicted for $T_3$ and $T_4$ and at this flux density the specific core loss for $B_3$ ferrite is 16mW per gm of core material. The total loss in each 18gm transformer core is thus estimated at 290mW, which is an acceptable amount

*Fig. 3. Fifty-watt p.e.p. push-pull amplifier.*

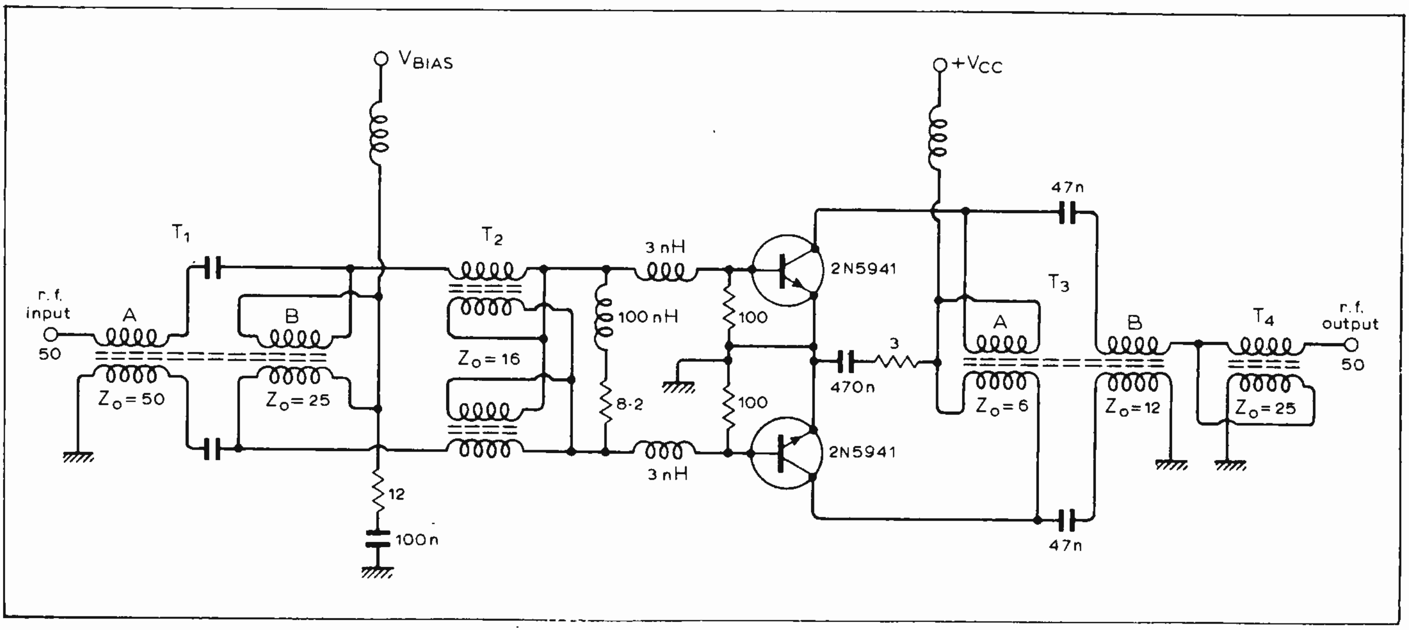
from thermal considerations and will not significantly degrade the i.m.d. performance of the amplifier.

The optimum characteristic impedance for the transformer windings can be shown to be

$$Z_o = \sqrt{Z_{source}} \times \sqrt{Z_{load}} \qquad (4)$$

Transformer $T_3$ thus requires an impedance of 6Ω for winding $A$ and 12Ω for winding $B$, while for $T_4$ a characteristic impedance of 25Ω is required. The transmission-lines may be realised using several high impedance lines (such as bifilar enamelled copper-wires which have typically an 80Ω impedance) connected in parallel. Alternatively coaxial cables or, especially where a low impedance is necessary, copper tapes printed onto either side of an insulating material such as Mylar or glass reinforced p.t.f.e. may be used.

The transformers for the input network, $T_1$ and $T_2$, are designed in a similar manner but, since they are operated at a lower power level, smaller ferrite cores may be used. The power from the source is applied to the phase-splitting transmission-line hybrid transformer. Transformer $T_1$ which converts from 50Ω unbalanced to 50Ω balanced. A 9:1 transformer, $T_2$, is used to match the source to the transistors which have a typical input impedance at 50MHz of 2.5−j0.2Ω. A very close match is obtained at the top of the frequency band, but at lower frequencies the input impedance of the transistor is higher due to the increased current gain which magnifies the contribution to input impedance made by the emitter ballasting (current sharing) resistors. In order that a reasonably constant input impedance over the whole frequency band is obtained a compensating network is generally required. It is normal to incorporate in this network components to reduce the effects of the gain/frequency slope of the transistor which is usually 5 or 6dB per octave. A



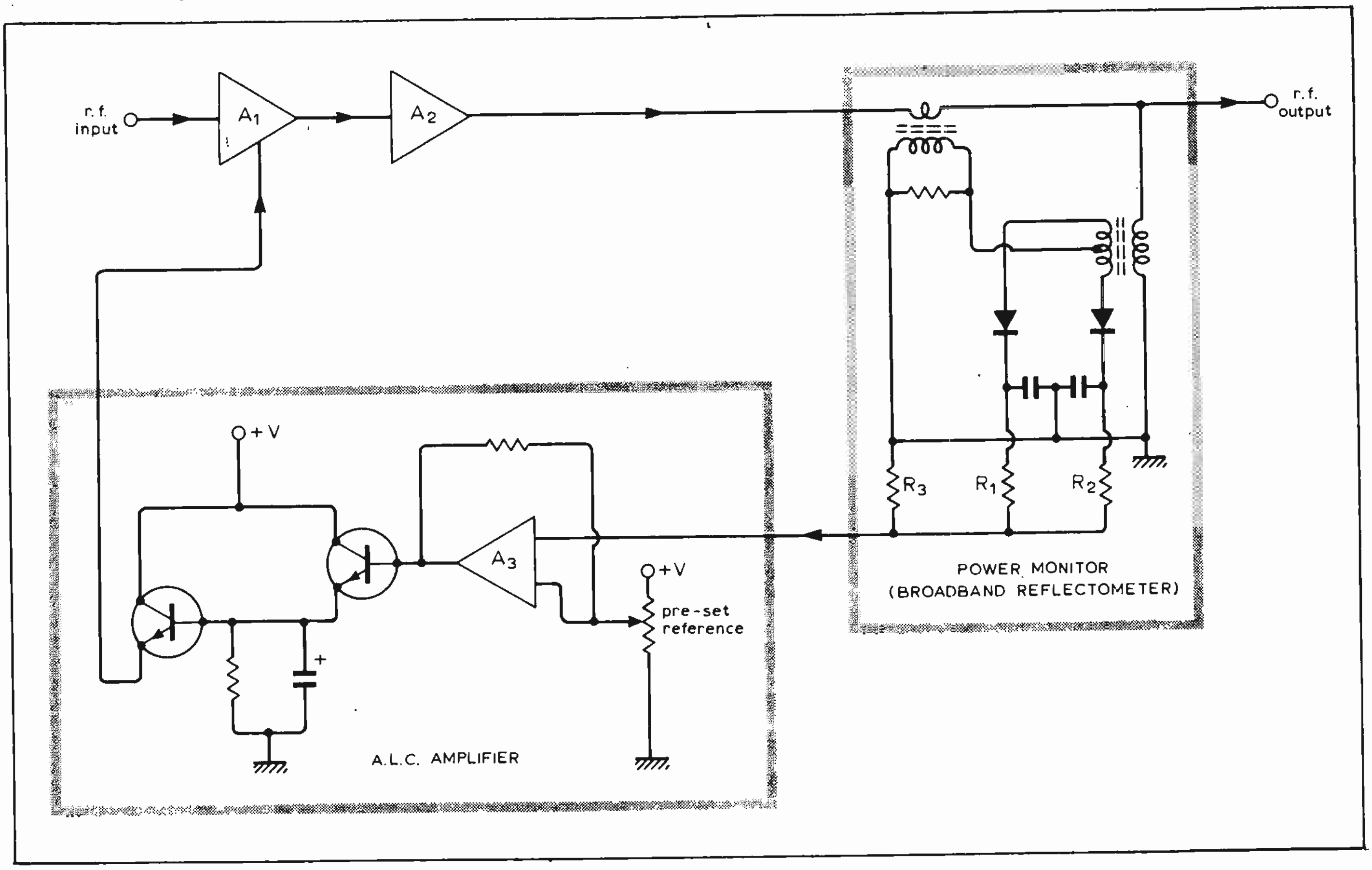



*Fig. 4. Typical automatic level control system. $A_1$ – gain controlled pre-amplifier, $A_2$ – driver and power amplifier stages, $A_3$ – operational amplifier.*

simple network to provide a degree of compensation has been incorporated in Fig. 3.

## Level control and load mismatch protection

The requirement for high linearity in s.s.b. transmitter power amplifiers makes it essential that the output power is maintained within the linear capability of the amplifier, and so some means of controlling the drive power is necessary. To achieve this an automatic level control (a.l.c.) loop is generally incorporated. Most a.l.c. systems consist of three basic units:– a gain controlled element in the forward path of the amplifier, an output power monitor – which can either be a simple output voltage and current detector or, ideally, forward and reflected power detectors – and a comparator or high gain amplifier having an adjustable reference for setting up the output power. A typical system is illustrated in Fig. 4.

The gain controlled element is usually the first block in the amplifier chain. The essential characteristics are rapid response time, linearity maintained over a dynamic range of at least 10dB and a low noise figure. The signal handling capability should be as great as possible since this determines the amount of broadband amplification required and hence, together with the noise figure, ultimately limits the output signal-to-noise ratio. Even when an a.l.c. loop is incorporated it is good practice to ensure tht the gain/frequency response of the power amplifier is as level as possible in order to minimise the radiation of broadband noise power at frequencies remote from the operating channel. A popular method of achieving a linear gain controlled function involves the use of junction diodes in a bridge network. The impedance of the diodes is altered by varying their d.c. bias thus altering the attentuation in the network and controlling the level of input signal to the power amplifier. Very high linearity can be achieved using p-i-n diodes which are now available with carrier lifetimes which make them suitable for operation as variable attenuator elements at frequencies down to 2MHz. Active circuits are available which may perform the variable gain function. The Plessey SL610C integrated circuit r.f. amplifier has a gain control range in excess of 46dB and a noise figure of less than 5dB. For applications in which the broadband gain must be minimized, for example where electromagnetic compatibility considerations are stringent as in equipments for co-sited deployment, the variable gain stage must be capable of handling large input signals. Unless special circuit techniques are used[2] active devices are generally unsuitable. For such applications the diode bridge, with several diodes in series for each arm is suitable. Other more elaborate systems have been devised including saturable reactors in attenuator networks and banks of electronically switched fixed attenuators.

An excellent power monitor system consists of detectors sensing the forward component, $P_f$, and reflected component, $P_r$, of the output power using a wideband reflectometer. Such an arrangement is shown in Fig. 4 in which the level control signal is a function of both $P_f$ and $P_r$ so that the amplifier output is adjusted to a safe level for any load mismatch. The net output power is related to load v.s.w.r., $S$, by:–

$$P_{out} = P_f - P_r = \text{p.e.p.} \cdot \frac{4S}{(K^2+1)(S-1)^2 + 4S}$$

The factor $K$ is determined by the relative sensitivity of the forward and reflected power monitors, and in Fig. 4 if $R_3 \ll R_1$ and $R_2$ then $K$ is the ratio $R_1/R_2$. The maximum safe value of $K$ is dependent upon the breakdown voltage of the transistors and the supply voltage, but to ensure that the amplifier linearity is not significantly degraded for mismatched loads it is normal to set a value of $K$ between 1.7 and 2.6 which provides an output power reduction of between 1.5dB and 3dB for a load mismatch of 2:1 v.s.w.r.

The remaining block in the a.l.c. loop is the comparator or a.l.c. amplifier. In the simple arrangement of Fig. 4 a pre-set reference is applied to the inverting input of an operational amplifier and the signal from the output power monitor is applied to the non-inverting input. If the output power monitor exceeds the level set by the reference the a.l.c. amplifier provides an output signal which reduces the gain of the controlled element and so reduces the drive to the power amplifier. The circuitry at the output of the a.l.c. amplifier provides a rapid response to reduce the gain but will only allow the gain to increase slowly. This is necessary in order to avoid distortion of the r.f. envelope which would, of course, constitute additional i.m.d. To protect the power transistors from damage due to excessive drive or faulty antenna conditions the "attack time" of the a.l.c. system must be as short as possible; the thermal time constant of many r.f. power transistor chips is less than one millisecond, and at low frequencies compared with the cut-off frequency, $f_T$, of the device localised hot-spots may occur under high stress conditions the thermal time constants for which are often only a few tens of microseconds. In many practical a.l.c. loops, however, in order to ensure that the loop is stable some compromise is made between attack and decay time requirements. These difficulties may be overcome by using a more complex system[3] involving two a.l.c. loops, one having very rapid responses, e.g. 1μs attack and 10ms decay, and the second having a 5ms attack and 1s decay. When a transient (such as a broken antenna feed cable) occurs the transistors are immediately protected by the fast loop. After a few milliseconds the slower loop takes over control and the amplifier continues to operate safely providing a linear but reduced output.

## Combining for higher power

At present the maximum output power which can be achieved from a push-pull stage using two devices is about 500 watts. It is unlikely that such larger transistors will be available for some time for broadband amplifiers due to the difficulty of matching the very low and reactive input impedances. For the present, in any case, to achieve higher powers several transistors must be used. Little success has been obtained by simply parallelling devices, since the input impedance is reduced and matching difficulties occur. Also it is difficult to ensure that the power load is shared evenly between the devices and it is necessary to run the average transistor well below its maximum capability in order to ensure that the most heavily stressed unit is not destroyed. In parallel connected circuits, it is not uncommon for failure of one transistor to result in excessive stressing of the surviving units which fail successively. Such catastrophic failures may be avoided by using the hybrid combiners shown in Fig. 5. Each device is presented with the correct load impedance and if a unit fails the surviving devices are isolated from the faulty unit and continue to drive matched loads. Under these conditions the hybrid combiner diverts some of the output power into the ballast resistors and the output of the amplifier is reduced. By combining push-pull modules of approximately 100 watts to 500 p.e.p. capability, transmitter power levels of several kW have been obtained.

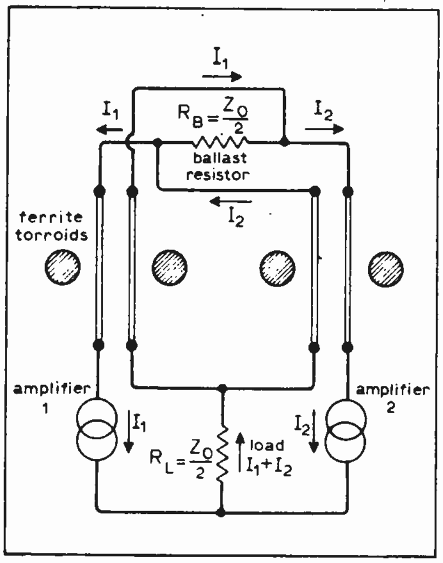



*Fig. 5. Zero degree hybrid line combiner.*

The second article in this series will deal with circuit techniques and design procedures for medium and high power solid state amplifiers operating in the v.h.f. bands. A final article will discuss in more detail the design of some of the special components such as transmission-line transformers and strip-line components for v.h.f. circuits which are used in r.f. power amplifiers, together with advice on construction techniques and on precautions to be adopted during initial testing of prototype power amplifiers.

## Acknowledgement

The author wishes to express his thanks to The Plessey Co. Ltd. for permission to publish this series of articles.

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1. R.C.A. Application Note No. 3764.
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3. Matthaei, G. L. Tables of Chebyshev impedance transforming networks of low-pass filter form, *Proc. IEEE*, Vol. 52, Aug. 1964, pp.939-963.

# Literature Received

Suppressors for mains-borne interference are the subject of leaflets issued by BHS Electronics (Sales). The devices are balanced twin inductors on ferrite ring cores and a capacitor, epoxy encapsulated in an aluminium can. Working currents are 1A, 3A, 5A and 6A. Available from Bercourt House, York Road, Brentford, Middx. ...................... WW401

The range of miniature earphones, headsets, switches etc., made by Danavox are briefly described in Edition 3 of "Electro Acoustic Components Catalogue". The 43-page booklet is obtainable from Danavox (GB) Ltd, "Broadlands," Bagshot Road, Sunninghill, Ascot, Berks SL5 9JW .................................. WW402

Collet knobs for panel controls are the subject of the new Radiatron catalogue, publication RE10. A wide range of colours and mechanical styles is described. The catalogue is by Radiatron Components Ltd, 76 Crown Road, Twickenham, Middx. ............................... WW403

Prices of Ferranti E-Line transistors (including pro-electron types) are contained in a single price list now issued by Ferranti Ltd, Electronic Components Division, Gem Mill, Chadderton, Manchester .......................... WW404

A leaflet on miniature keylock and dual in-line rocker switches is published by Highland Electronics Ltd, 33-41 Dallington Street, London EC1V 0BD................................. WW405.

A brochure on the Thermalloy range of device and board mounting components and heatsinks is available from Suvicon Ltd, Westminster House, 188-190 Stratford Road, Shirley, Solihull, West Midlands, B90 3AQ .................... WW406

APPLICATIONS

Requirements and setting-up procedure to obtain optimum sub-carrier amplitudes in an f.m. multiplex telemetry system are described in a 12-page application note entitled "Amplitude adjustment of FM Subcarriers", published by EMR Telemetry, Weston Instruments Inc., P.O. Box 3041, Sarasota, Florida 33578, U.S.A............ WW407

"Programming Manual for the M6800 Microprocessor" has recently been published by Motorola at £2.50. Available from Motorola distributors.

Methods of achieving savings in industrial electrical energy consumption by the use of power factor capacitors are detailed in the new publication by Bryce Capacitors Ltd, of Helsby, Cheshire ............................. WW408

EQUIPMENT

Dc. to d.c. converters for use in telecommunication systems are described in an ITT publication "DC/DC Converters", available from Electrical Product Division, ITT Components Group, Edinburgh Way, Harlow, Essex ............. WW409

Complete details of the range of measuring instruments made by Advance Electronics are given in the new Data Book, which covers oscilloscopes, counters, d.vms, pulse and signal generators and chart recorders. The 58-page 1975/6 Data Book is obtainable from Advance Electronics Ltd, Roebuck Road, Hainault, Essex...... WW410

A short-form catalogue from the American firm, CVI, offers details of a range of video instrumentation for scientific and industrial use. Instruments described include slow-scan equipment, digitizers, disc memories and X-Y indicators. The catalogue can be obtained from CVI, Inc., P.O. Box 928, Boulder, Colorado 80302, U.S.A........... WW411

# Electronic circuit calculations simplified

## 4 — RC combinations in d.c. circuits

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

Previous articles in this series have dealt with problems involving resistance only and capacitance only. We shall now consider circuits the behaviour of which is determined by a combination of resistance and capacitance. Firstly we shall consider the behaviour of such combinations in d.c. circuits in which valves or transistors are switched on and off by pulses.

**Ripple in rectifier circuit.** A number of circuits can be reduced to the simple form shown in Fig. 1. This shows a capacitor C which can be charged from a d.c. source via the resistor $R_1$ (when S is closed) and discharges through the resistor $R_2$ (when S is opened). One example of such a circuit occurs in a rectifier (Fig. 2) where C is the reservoir capacitor, $R_1$ represents the forward resistance of the rectifier and $R_2$ represents the load. The switch S can be

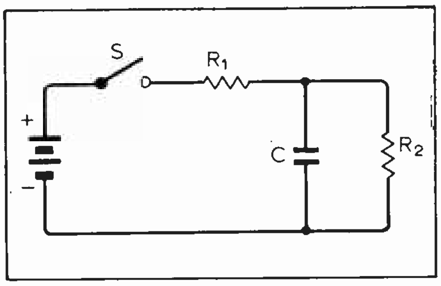


*Fig. 1. Simple circuit for charging and discharging a capacitor.*

regarded as incorporated in the rectifier which is made conductive and non-conductive by the alternating voltage applied to it.

Suppose we wish to calculate the ripple on the d.c. supply from a half-wave rectifying circuit such as that shown in Fig. 2. For simplicity we can ignore the forward resistance of the rectifier, i.e. in Fig. 1 we can assume $R_1 = 0$. Thus the charging of C is instantaneous and the whole of the period between successive charges of the capacitor is occupied in supplying power to the load $R_2$. For 50-Hz mains this period is 1/50th second i.e. 20ms and if the load requires a current of say

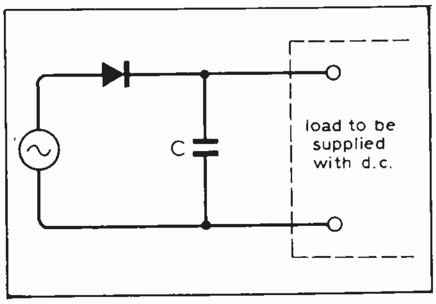


*Fig. 2. A half-wave rectifier circuit can be regarded as an example of the circuit of Fig. 1.*

50mA the charge removed from the capacitor in this period is given by

$$Q = It$$
$$= 50 \times 10^{-3} \times 20 \times 10^{-3}$$
$$= 10^{-3} \text{ coulomb.}$$

We calculate the drop in voltage across C caused by the removal of this charge from the expression

$$V = \frac{Q}{C}$$

Suppose C is 100μF

$$V = \frac{10^{-3}}{100 \times 10^{-6}} V$$
$$= 0.1V$$

Clearly the ripple is inversely proportional to the magnitude of the reservoir capacitor. It is also directly proportional to the load current and to the interval between successive charges. Thus the ripple can be halved by using full-wave rectification for which the interval is only 10ms.

This calculation was made with the aid of two formulae

$$Q = It \text{ and } V = \frac{Q}{C}$$

Many circuits operate by virtue of the charging and discharging of capacitors and the calculation of the values of components to use in such circuits can usually be made using these two expressions.

**Time constant.** As the next calculation consider the circuit shown in Fig. 3 which can be regarded as part of a pulse amplifier. The input to the base of $Tr_1$ is assumed to be a pulse signal which holds $Tr_1$ conductive or cut off. The collector load resistor is $R_1$, and C represents the total capacitance effectively in parallel with $R_1$: this includes the output capacitance of $Tr_1$ and the input capacitance of the circuit $Tr_1$ feeds. When $Tr_1$ is cut off, C charges via $R_1$: when $Tr_1$ is turned on, C discharges through the transistor.

Consider first the charging of C. C is initially discharged and the full supply voltage $V_{cc}$ appears across $R_1$. From Ohm's law the charging current is $V_{cc}/R_1$. When C is fully charged, there is no charging current and therefore no voltage across $R_1$. Thus we can say that the average current through $R_1$ during the charging process is $V_{cc}/2R_1$. How long will this take to charge C to the supply voltage? We know that

$$Q = It \text{ and } V = \frac{Q}{C}$$

Eliminating Q between these, we have

$$t = \frac{VC}{I}$$

Putting $I = V/2R_1$ gives

$$t = 2R_1C.$$

This simple relationship is very useful in showing the rate at which voltages can

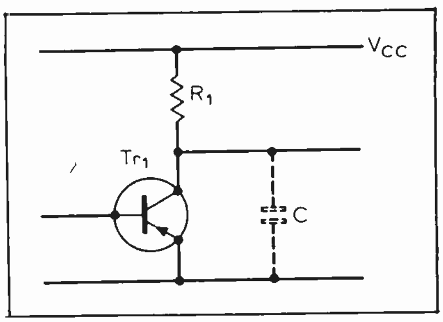


*Fig. 3. The stray capacitance C is charged via $R_1$ when $Tr_1$ is cut off.*

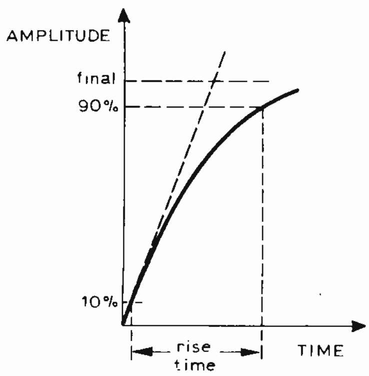


*Fig. 4. Definition of rise time of a pulse.*

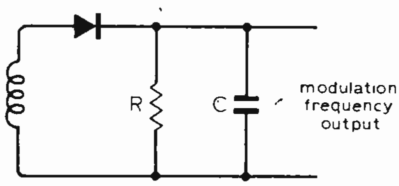


*Fig. 5. Essential circuit of a diode a.m. detector.*

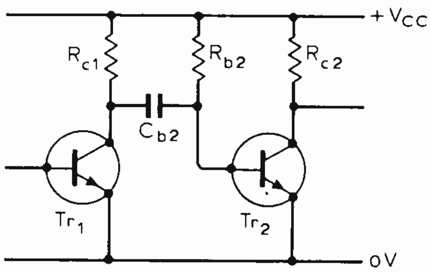


*Fig. 6. $R_{b2}C_{b2}$ are the timing components in this simplified monostable circuit.*

change across a capacitor. In a practical circuit it is impossible to charge or discharge a capacitor instantaneously (as assumed in the first calculation in this part). It takes time to put charge in or take it out and the time is determined, as this simple expression shows, by the product of the capacitance and the resistance of the external circuit. The product $RC$ is known as the time constant and this expression shows that the time taken for a full charge of the capacitor is twice the time constant.

As a numerical example suppose in Fig. 3 $R_1$ = 2 kilohms and C = 20 pF, both typical practical values. C will completely charge in

$$2R_1C = 2\times 2\times 10^3\times 20\times 10^{-12}\ \text{second}$$
$$= 0.08\mu s$$

This is just under $0.1\mu s$ – just sufficient, in fact, to be able to reproduce the leading and trailing edges of the line sync pulses in the 625-line television signal.

**Rise time.** The speed of voltage rises e.g. in the leading edge of a pulse is of great concern in pulse circuitry and is usually measured by the time taken for the voltage to rise from 10% to 90% of the final value. This is known as the rise time. (There is a corresponding definition for the fall time.) In the above derivation we calculated the time taken for the voltage across C to rise from zero to the supply voltage. Our calculation was, however, optimistic because we assumed, by working in terms of the average charging current, that the current falls linearly to zero. In practice the steepness of the current fall becomes progressively less as charging proceeds and it takes longer to charge C than our simple calculation suggests. In fact the rise time is approximately equal to 2.2 times the time constant. This is another relationship which is very useful in calculations on pulse circuits. The rise time for a simple $RC$ combination is illustrated in Fig. 4, which also shows that the waveform of the voltage across the capacitor is not linear but exponential in shape.

As a numerical example suppose a rise time of not less than $1\mu s$ is required from a circuit in which the total capacitance cannot be reduced below 25pF. What is the maximum value of resistance than can be used? From the relationship

$$\text{rise time} = 2.2RC$$

we have

$$R = \frac{\text{rise time}}{2.2C}$$

$$= \frac{1\times 10^{-6}}{2.2\times 25\times 10^{-12}}\ \text{ohms}$$

$$= 18\ \text{kilohms}$$

**Constant-current discharge.** Let us now consider the discharge of C in Fig. 3. This is achieved by turning $Tr_1$ on and thus the capacitor discharges, not into a linear resistor, but into the collector-emitter terminals of a conductive transistor. If C discharged into a linear resistor then the current in the resistor would fall as the voltage across it (and the capacitor) falls: the current is, in fact, at all times proportional to the voltage (Ohm's law again!). The transistor does not behave in this way. Although the current through the transistor falls as the voltage across it falls, the current fall is much less than for a linear resistor and, to simplify calculation, it is justifiable to assume that the current through the transistor remains constant during discharge of the capacitor.

Let us assume that the transistor is biased, during discharge of C, to take a current of 10mA and let us further assume that the supply voltage is 20. How long does it take to discharge C? We can use the expression deduced earlier namely

$$t = \frac{VC}{I}$$

Substituting

$$t = \frac{20\times 20\times 10^{-12}}{10\times 10^{-3}}\ \text{second}$$

$$= 0.04\mu s$$

An important feature of this discharge is that it is achieved by taking a constant current from the capacitor. As a result the voltage across the capacitor falls linearly with time (not exponentially as when the capacitor discharges into a constant resistance). A linear voltage change is, of course, useful in timebase circuits and ramp generators: charging or discharging a capacitor by means of a constant current is the usual way of generating such voltages.

**Diode detector circuit.** Another commonly-used circuit which operates by virtue of the charging and discharging of a capacitor and in which the choice of the time constant is important is the diode a.m. detector shown in its simplest form in Fig. 5. The problem is to calculate values of R and C suitable for a particular application.

The mode of operation of the circuit has much in common with that of the half-wave rectifier of Fig. 2. The detector input is an alternating signal (the carrier wave) and the diode conducts during positive-going half cycles and charges the capacitor to the peak value of the carrier input. During negative-going half-cycles the capacitor discharges through the load resistor. This is precisely what happens in the mains rectifier circuit but in the detector circuit the input frequency is much higher, e.g. 1MHz in a medium-wave a.m. receiver.

In the mains rectifier the diode input signal is of constant amplitude: for the diode detector the input amplitude rises and falls about its mean value in accordance with the waveform of the modulating signal. It is essential, to avoid distortion, that the voltage across the capacitor should faithfully follow the changes in the amplitude of the diode input due to modulation. Usually there is little difficulty in following increases in amplitude because the diode forward resistance is low and the capacitor can quickly be charged to a new higher voltage. Difficulties can arise, however, when the amplitude of the diode input falls: to avoid distortion the capacitor must be able to discharge through the load resistance so quickly that it has to be recharged by every positive-going half-cycle even though the amplitude of successive half-cycles is falling. We can estimate the time constant required to achieve such a performance in the following way.

The greatest rate of change of carrier amplitude occurs at the highest modulating frequencies and when these have their greatest depth of modulation. At the highest modulating frequency $f_{max}$ the time taken for the carrier amplitude to change from its maximum to its minimum amplitude is half the period of the modulating frequency i.e. $1/2f_{max}$. In this time C must be able to discharge completely through R. We have already seen that the time taken for a complete discharge of C is approximately 2RC. Thus we can say

$$2RC=\frac{1}{2f_{max}}$$

from which

$$RC=\frac{1}{4f_{max}}\ *$$

As a numerical example consider the vision detector in a 625-line television receiver. The maximum modulating frequency is 5.5MHz and thus

$$RC=\frac{1}{4\times5.5\times10^6}\text{ second}$$

$$=0.045\mu s$$

The product of $R$ and $C$ must not therefore exceed 0.045μs. This is a very small time constant and if $R$ is made greater than a certain value C becomes impossibly small. Let us therefore fix C at say 15pF, reasonably greater than the stray capacitance inevitable in the circuit. This gives $R$ as

$$R=\frac{0.045\times10^{-6}}{C}$$

$$=\frac{0.045\times10^{-6}}{15\times10^{-12}}\text{ ohms}$$

$$=3\text{ kilohms}$$

Now consider a detector to be used in a medium-wave receiver. Due to high-frequency cut-off in the transmissions and in the i.f. circuits of the receiver the highest modulating frequency at the detector input can be taken as 5kHz and, for this value, we have that the detector time constant is given by

$$RC=\frac{1}{4f_{max}}$$

$$=\frac{1}{4\times5\times10^3}\text{ second}$$

$$=50\mu s$$

This is a large time constant which gives considerable freedom in the choice of values for $R$ and $C$. $R$ should be large compared with the diode forward resistance but, provided this requirement is met, should be as small as possible and a value of 5 kilohms is commonly used. For this value of $R$ we have

$$C=\frac{\text{time constant}}{R}$$

$$=\frac{50\times10^{-6}}{5\times10^3}\text{ F}$$

$$=0.01\mu F$$

**Control of pulse duration.** $RC$ circuits play an essential part in the operation of pulse-generating circuits such as multivibrators and the time constants are important because they determine the duration of the generated pulses. This can be illustrated by Fig. 6 which shows an RC circuit $R_{b2}C_{b2}$ coupling $Tr_1$ collector to $Tr_2$ base. These two transistors are assumed to be a monostable multivibrator but, for simplicity, the direct coupling between $Tr_2$ output and $Tr_1$ input has been omitted.

Because $Tr_2$ base is connected to its emitter by $R_{b2}$ $Tr_2$ is normally conductive and the direct coupling to $Tr_1$ ensures that this is non-conductive. $Tr_1$ collector voltage is therefore normally at the supply positive voltage $V_{cc}$ and $Tr_2$ base voltage is normally near the supply negative value: thus $C_{b2}$ is charged to the supply voltage $V_{cc}$. This is typical of the stable state of the circuit in which it can remain indefinitely. The circuit can, however, be compelled to leave the stable state by a positive-going signal applied to $Tr_1$ base to turn $Tr_1$ on. This causes $Tr_1$ collector voltage to fall and this fall is communicated to $Tr_2$ base by $C_{b2}$ so cutting $Tr_2$ off. The effect of this triggering signal is thus to reverse the states of the two transistors. The same effect could also be achieved by applying a negative-going triggering signal to $Tr_2$ base.

Now consider the circuit conditions for $C_{b2}$ immediately after $Tr_1$ is made conductive. The terminal connected to $Tr_1$ collector is now effectively at supply negative voltage: the other terminal is connected via $R_{b2}$ also to supply negative as shown in Fig. 7. $C_{b2}$ is still charged to the supply voltage $V_{cc}$ and immediately begins to discharge through $R_{b2}$. It is, in fact, the voltage generated across $R_{b2}$ by the discharge current which keeps $Tr_2$ cut off.

As soon as the discharge is completed $Tr_2$ begins to conduct again. Thus $Tr_2$ is held non-conductive during the whole of the discharge of $C_{b2}$ and a positive-going pulse is generated at its collector the duration of which is governed by the time constant $R_{b2}C_{b2}$. The problem is to calculate the values of $R_{b2}$ and $C_{b2}$ required to give a required pulse duration.

We have already deduced a simple expression for the discharge time of an $RC$ combination: it is $2RC$. Thus we can say that the duration of the positive-going pulse generated at $Tr_2$ collector is given approximately by $2R_{b2}C_{b2}$. As a numerical example suppose these pulses are required to have 10μs duration. $R_{b2}C_{b2}$ must hence be 5μs. If $R_{b2}$ is 5 kilohms, $C_{b2}$ is given by

$$C_{b2}=\frac{\text{time constant}}{R_{b2}}$$

$$=\frac{5\times10^{-6}}{5\times10^3}\text{ F}$$

$$=1nF$$

Fig. 8 shows a variant of this circuit in which $Tr_2$ base resistor is returned to supply positive. This does not fundamentally alter the operation of the circuit. Immediately after $Tr_1$ is turned on the circuit conditions for $C_{b2}$ are as pictured in Fig. 9. If we rearrange this as shown in Fig. 10 we can see that the supply voltage across $C_{b2}$ and the supply voltage $V_{cc}$ are in series so that the voltage across $R_{b2}$ available to drive discharge current through $R_{b2}$ is double that in the previous circuit and the discharge of $C_{b2}$ is accordingly faster. At the beginning of the discharge there is a voltage of $V_{cc}$ across $C_{b2}$ which keeps $Tr_2$ turned off. As discharge proceeds the voltage across $C_{b2}$ falls, reaching zero when $C_{b2}$ is discharged. At this instant $Tr_2$ begins to conduct again and the base current in $Tr_2$ anchors the voltage at one end of $R_{b2}$ to supply negative. The other end of $R_{b2}$ is still, however, connected to $+V_{cc}$ so that there is still a voltage of $V_{cc}$ across $R_{b2}$ even though $C_{b2}$ is completely discharged.

We can deduce how quickly the capacitor is discharged in this circuit in the following way in which, for simplicity, we will dispense with the suffices to R and C. The voltage across R is $2V_{cc}$ at the beginning of the discharge and $V_{cc}$ at the end of it. The average voltage during the discharge process is thus

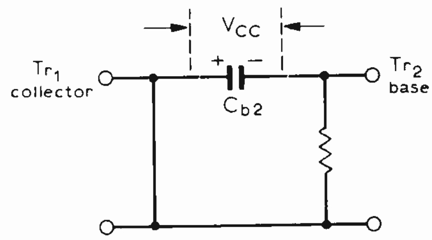


*Fig. 7. Circuit conditions for $C_{b2}$ (Fig. 6) immediately after $Tr_1$ has been turned on.*

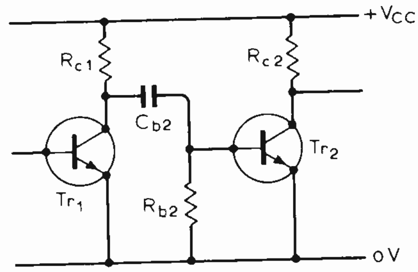


*Fig. 8. Variant of the circuit of Fig. 6.*

* A more rigorous analysis of this problem shows that a more accurate value of the time constant is given by

$$RC=\frac{1}{2\pi f_{max}}$$

$1.5V_{cc}$ and, from Ohm's law, the average discharge current is given by $1.5V_{cc}/R$. If the discharge takes $t$ seconds then the charge removed from the capacitor by this current is given by $It$, i.e. $1.5V_{cc}t/R$. From the relationship $V = Q/C$ we can deduce that the removal of this charge from the capacitor will produce a fall in voltage across it equal to $1.5V_{cc}t/RC$. Because the capacitor is completely discharged this fall in voltage must be equal to $V_{cc}$. Thus we have

$$\frac{1.5V_{cc}t}{RC} = V_{cc} \text{ which gives } t = 0.67RC^*$$

Thus the discharge of the capacitor is three times as fast as in the circuit of Fig. 6.

As a numerical example, suppose we wish to generate 50µs pulses at $Tr_2$ collector in the circuit of Fig. 8. Then

$$0.67RC = 50\mu s \text{ giving } RC = 75\mu s.$$

A suitable value for $R$ may be 10 kilohms. This gives

$$C = \frac{\text{time constant}}{R}$$

$$= \frac{75 \times 10^{-6}}{10^4} \text{F} \quad = 7.5\text{nF}$$

**Free-running or astable multivibrator.** By combining two circuits of the type shown in Fig. 8 we produce the circuit of Fig. 11, a free-running or astable multivibrator. This generates current pulses continuously in the two transistors and the duration of the pulses can be made any desired value by appropriate choice of the time constants. The duration of the off-period of $Tr_2$ is determined by the time constant $R_{b2}C_{b2}$ and is given approximately by $0.67 \times R_{b2}C_{b2}$ as shown in the previous paragraphs. Similarly the duration of the off-period of $Tr_1$ is given by $0.67\ R_{b1}C_{b1}$. The sum of these two periods makes up one complete cycle of operation of the multivibrator and thus we have

free-running period of multivibrator

$$= 0.67(R_{b1}C_{b1} + R_{b2}C_{b2})$$

from which

free-running frequency of multivibrator

$$= \frac{1}{0.67(R_{b1}C_{b1} + R_{b2}C_{b2})}$$

If $R_{b1} = R_{b2}$ and $C_{b1} = C_{b2}$ the circuit is symmetrical and generates square waves at each collector. The frequency of the square waves is given by

$$f = \frac{1}{1.33R_bC_b}$$

* The first part of an exponential curve is almost linear and therefore this is quite a good approximation: a rigorous analysis gives $t = 0.69RC$.

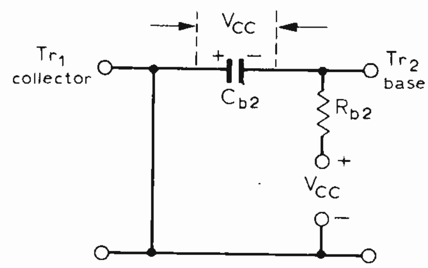


*Fig. 9. Circuit conditions for $C_{b2}$ (Fig. 8) immediately after $Tr_1$ has been turned on.*

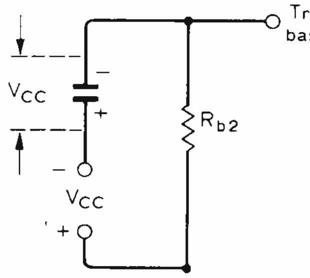


*Fig. 10. Rearrangement of Fig. 9 showing the effective doubling of the voltage providing the discharge current.*

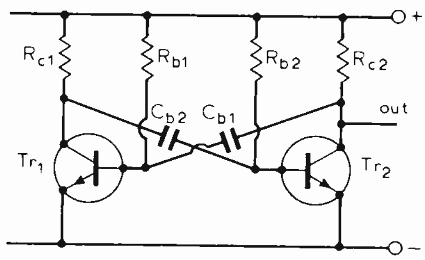


*Fig. 11. A free-running multivibrator circuit.*

As a numerical example suppose we wish to generate square waves at approximately 50Hz. What values of $R_b$ and $C_b$ should be used? We have

$$R_bC_b = \frac{1}{1.33f}$$

$$= 15\text{ms}$$

This is the time constant required to give a free-running frequency of approximately 50Hz. Astable multivibrators are, however, frequently synchronised at the frequency of an externally-applied signal and synchronisation is usually achieved by terminating the unstable periods earlier than would occur naturally, e.g. by applying positive-going sync signals to the base of an n-p-n transistor. Thus the free-running frequency of a multivibrator to be synchronised should be made lower than that of the sync signal and in the above example it would be wise to make the free-running frequency lower than 50Hz by increasing the time constant to say 20ms.

It would appear that any combination of resistance and capacitance would be suitable provided the product is 20ms. This is not true, however, for there must be a certain relationship between $R_c$, $R_b$ and $C_b$ to obtain a satisfactory performance. For example when a transistor is cut off its collector voltage rises, causing the base voltage of the other transistor also to rise until this reaches zero (the emitter voltage). The other transistor then begins to conduct and anchors one terminal of $C_b$ effectively at earth potential so that the collector voltage of the first transistor can rise only by virtue of $C_b$ charging through $R_c$. Thus the collector-voltage rise is slowed down, being governed by the time constant $R_cC_b$. As shown earlier in this article the rise time is given approximately by $2R_cC_b$. For a rapid rise time the time constant $R_cC_b$ must be as small as possible.

There is also a relationship between $R_c$ and $R_b$. For $R_b$ determines the base current of transistor when it is conducting and a simple application of Ohm's law gives this current as $V_{cc}/R_b$. The collector current is $\beta$ times this i.e. $\beta V_{cc}/R_b$. This collector current, in flowing through $R_c$, must generate a voltage large enough to bring the collector voltage down to zero otherwise the multivibrator cannot operate properly. The collector voltage swing is given by $\beta V_{cc}R_c/R_b$ and this must at least equal $V_{cc}$ i.e. $R_b$ must be less than $\beta R_c$. Thus the following three relationships must be satisfied:

$R_bC_b$ is fixed by the required frequency of operation

$R_cC_b$ should be as small as possible

$R_b$ must be less than $\beta R_c$

Suppose the supply voltage is 12 and we decide that the collector current in the on transistors shall be 5mA. Then from Ohm's law $R_c$ must be at least 2.4 kilohms. If $\beta$ is 100 $R_b$ must be less than $100R_c$ i.e. 240 kilohms. A suitable value would be 200 kilohms. We can now calculate $C_b$ thus

$$C_b = \frac{\text{time constant}}{R_b}$$

$$= \frac{20 \times 10^{-6}}{200 \times 10^3} \text{F}$$

$$= 0.1\mu\text{F}$$

The rise time is

$$2R_cC_b = 2 \times 2.4 \times 10^3 \times 0.1 \times 10^{-6} \text{ second}$$

$$= 0.5\text{ms approximately}$$

When a transistor is turned on its collector voltage can fall very rapidly because there is no large capacitance to be charged or discharged when this occurs. Thus the voltage pulses generated at the collectors have better fall times than rise times.

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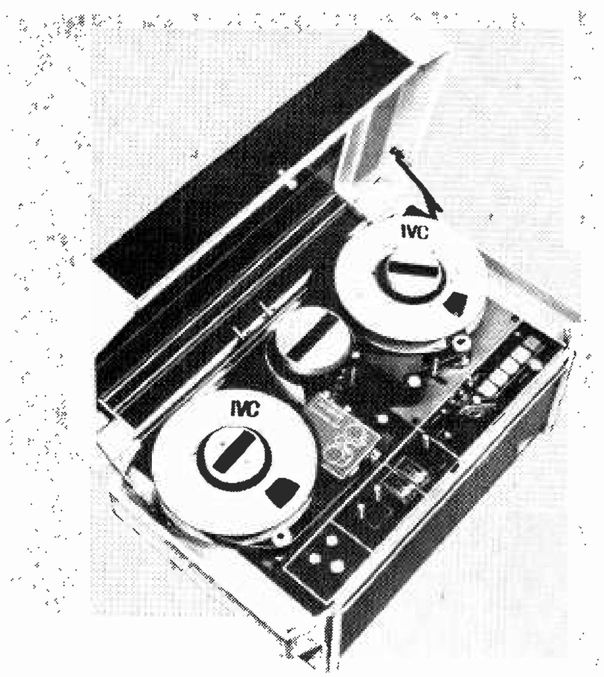


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by R.B.C. Copsey, M.I.E.E.
*Merton Technical College, London*

Very low frequency waves are used for long range communication where high reliability and freedom from ionospheric disturbances are of prime importance. Carrier frequencies are usually between 14 and 20kHz and because these frequencies are low, and aerial circuits tend to have a high Q, it is necessary to restrict the bandwidth of the transmitted signal, permitting only the use of telegraphy. On/off keying (A1) and frequency shift keying (F1) are both used.

One of the early stations built for shore-to-ship communication was the British Post Office station at Rugby, which first came into service in 1926, operating on 16kHz with the call sign GBR. At the time of its opening it was the most powerful transmitter in the world, employing 54 ten-kilowatt water-cooled valves in parallel[3]. The station has been in almost continuous service since, although various improvements have been made[4], notably to its frequency stability, and to its radiated power output which has been increased from 40 to 65kW.

Due to their high degree of phase stability and long range v.l.f. waves are also used for radio navigation systems. The Omega system[5], will eventually employ only eight transmitters to provide a world-wide navigation system. The eight synchronised transmitters will operate sequentially on a number of carrier frequencies between 10.2 and 13.6kHz. By measuring the phase difference between signals received from pairs of transmitters it is possible to determine lines of position which are hyperbolic in shape, and hence, with the aid of an Omega chart, to find one's position in terms of latitude and longitude. The ultimate accuracy of the system is determined by the phase stability of the transmitters, 1 in $10^{12}$, and by the phase stability of the propagation medium. By making suitable corrections for diurnal shifts, it is expected that the overall error in position fixing will not exceed two nautical miles[5].

Many of the radiation characteristics required for v.l.f. transmitting aerials are identical for the Omega system and for communications. Some of the more important requirements are:

- omnidirectional radiation in the horizontal plane
- vertical polarization
- radiation in the vertical plane should be confined as far as possible to the horizontal component
- high power handling capacity
- high efficiency
- ability to operate continuously in all weathers

Communication systems require a bandwidth of around 100 to 150Hz but changes in carrier frequency are seldom necessary. Omega systems need far less bandwidth because each "mark" has a duration of at least 0.9 second; but the aerial system must be re-tunable in less than 0.2 second, as this is the interval between radiation on successive frequencies.

There are two other important requirements for the Omega aerial. One of these is phase stability. If an aerial with a Q of 200, operating at a frequency of 10kHz, is considered, then a 0.1% (10Hz) change in resonant frequency due to changes in temperature, humidity or even the aerial moving in the wind, would produce a phase difference of 20° which is equivalent to moving the aerial 1.67km or approximately 0.9 nautical miles. The phase of the radiated field is therefore controlled by comparing the aerial current with a stable reference and the resulting phase error signal is used in a feedback loop to correct the aerial tuning to maintain a high degree of phase stability. The other important requirement is that the aerial should have only one "phase centre" so that the apparent source of radiation should be a single fixed point, irrespective of the direction of approach.

Aerials used in the Omega system are required to radiate about 10kW, which provides a satisfactory signal-to-noise ratio with the very narrow tracking bandwidth, of the order of 0.01Hz, which is used in an Omega receiver. For communication purposes, where receiver bandwidths are of the order of 100Hz for telegraphy, the transmitters need a higher power to achieve an adequate signal-to-noise ratio and powers of 50 to 1000kW are radiated.

The simplest type of aerial which will provide omni-directional radiation in the horizontal plane, with vertical polarization, is the vertical monopole. With wavelengths lying between 10 and 30km, it is clearly impracticable to construct a quarter-wave Marconi aerial, and even with an aerial height, $h$, of 300m, the electrical length of the vertical conductor, $h360/\lambda$, is only a few degrees.

The radiation pattern in the vertical plane from an electrically short monopole is shown in Fig. 1, where the radiated field strength is proportional to

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Very low frequency waves lying in the range of 10 to 30kHz are unique in that given sufficient radiated power, they have a useful range extending continuously to the antipodes.

In effect the D region of the ionosphere and the surface of the earth, most of which is sea water with comparatively high conductivity, form a spherical waveguide, allowing the wave to travel with little attenuation. Gould and Carter[1] show an almost constant average daylight attenuation of about 2.7dB per 1,000km, for ranges from 4,000 to 12,000km from the transmitter at a frequency of 16kHz. This waveguide mode of propagation provides a high degree of phase stability, although there is some phase change at night when the effective height of the D layer rises.

Numerous studies have been made of the behaviour of v.l.f. waves, and changes of phase due to propagation variations can be predicted with reasonable accuracy. One other notable characteristic of v.l.f. waves is their ability to penetrate sea water, enabling submerged submarines to receive radio messages. Attentuation due to sea water varies from about 7dB/m at 40kHz to 3.5dB/m at 10kHz (ref. 2).

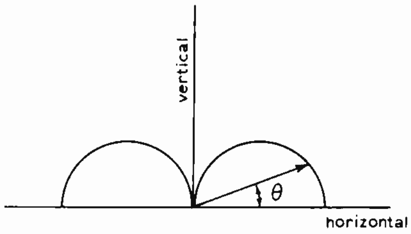


*Fig. 1. Field strength in vertical plane.*

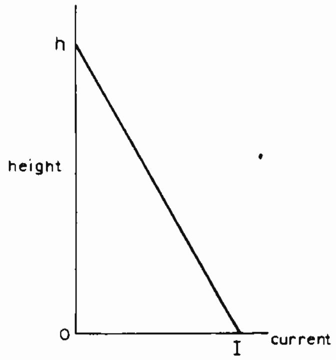


*Fig. 2. Current distribution in monopole.*

cos θ, where θ is the angle of "take off" of the wave relative to the horizontal The r.m.s. current distribution in such a monopole varies from a maximum, *I*, at the base, to zero at the top, as shown in Fig. 2. The radiated field strength is proportional to the average current multiplied by the height of the aerial, i.e. $Ih/2$. It is customary to regard this as $h_e \times I$ where $h_e = h/2$, and is called the effective height or radiation height of the aerial. The ratio of effective height to physical height $h_e/h$, the aerial form factor, is equal to ½ in the case of an electrically short monopole, compared with $2/\pi$ or 0.636 for a quarter-wave aerial.

The radiation resistance, $R_r$, of an aerial is that resistance which, multiplied by the square of the aerial current, *I*, gives the power radiated: $R_r = 160\pi^2 \times h_e^2/\lambda^2$ ohms. At a frequency of, say, 15kHz λ is 20,000m, and the radiation resistance of a 300m monopole would be 0.09Ω.

Many circuit designers are more familiar with artificial or dummy aerials than with the aerials themselves. Both receiver and transmitter specifications are written in terms of performance from, or into, a specified artificial aerial. Fig. 3(a) shows the circuit which simulates a v.l.f. aerial. *C* will be around 0.02 to 0.25μF, and *R* about 0.1 to 1.0 ohms. In Fig. 3(b), R has been split into its component parts: $R_r$ represents the radiation resistance; $R_c$ is the effective aerial conductor resistance; $R_s$ is an equivalent series resistance representing the losses in the aerial insulators, corona, masts and stays, and in the soil close to the aerial; and $R_g$ represents the losses in the ground and earth connection. The power radiated is $I^2R_r$, so the percentage efficiency of the aerial itself is $100\% \times R_r/(R_r+R_c+R_s+R_g)$.

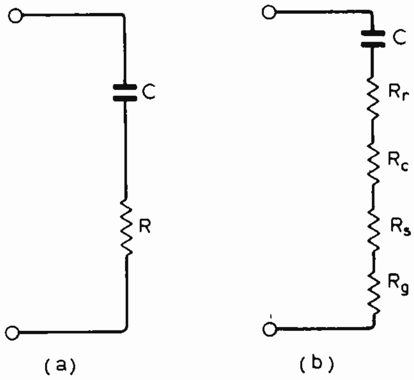


*Fig. 3. Simulation of v.l.f. aerial.*

The monopole considered earlier had a radiation resistance of only 0.09Ω, so you can see that the efficiency of this type of aerial is likely to be very low. Ground losses are usually minimized by using buried radial conductors, and conductor losses can be minimized by using numbers of conductors in parallel. The resistance of solid conductors is largely determined by skin effect, which, for copper, results in a skin depth of about 0.5mm at 15kHz. Conductivity is therefore proportional to the diameter of the conductor, so that doubling the conductivity of a given conductor results in a fourfold increase in weight and material cost, so that economic considerations play a large part in the lives of v.l.f. aerial designers.

Aerial efficiency can be considerably improved by raising the aerial form factor, such that the effective height more nearly approaches the physical height. This may be achieved by adding horizontal conductors to the top of the monopole, as in the inverted L and T type of aerial. In the case of the v.l.f. aerial it is more usual to find a large network of conductors connected to the top of the monopole. By this means it is possible to increase the aerial form factor from 0.5 to about 0.7, which doubles the radiation resistance. A further advantage of the "top hat" of the aerial is that its capacitance is increased, resulting in a much lower voltage across the aerial insulators. Sometimes the top capacitance is in the form of a symmetrical network of conductors radiating from the top of the vertical system, as in the case of the NATO transmitter[6] at Anthorn in Cumberland. This type of aerial is referred to as an umbrella aerial, due to its similarity to an umbrella frame.

Aerial efficiency has been defined as the ratio of radiation resistance to the total resistance of the aerial-earth system, but it must be remembered that the aerial needs to be tuned to present a substantially non-reactive load to the transmitter. One possible circuit configuration is shown in Fig. 4. The current which flows in the aerial tuning inductor (a.t.i.) is clearly equal to the aerial current and the power in the loss resistance of the a.t.i. can be considerable. However, by using a capacitance top to the aerial, its total capacitance is increased, so that the inductance required in the a.t.i. is decreased, resulting in a smaller loss

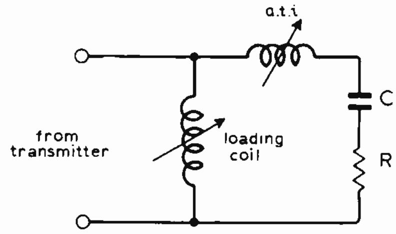


*Fig. 4. Aerial tuning circuit.*

resistance and hence the total power loss is reduced.

An approximation to the static capacitance of the aerial may be made by regarding the aerial as a parallel-plate capacitor and making an allowance for the fringe effects. The area of the top plate of the capacitor is easily calculated, and the fringe effect may be allowed for by adding an area equal to the perimeter of the top hat multiplied by the average height of that perimeter [7].

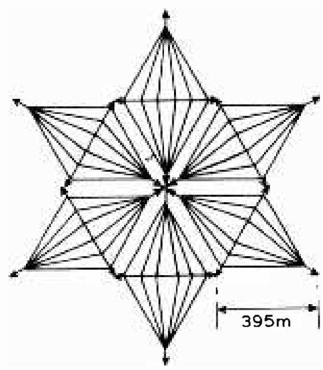


*Fig. 5. "Top hat" of Anthorn aerial.*

An example will make this clearer. Fig. 5 shows the plan view of the top hat of the Anthorn aerial[8], which has an average height of 183m. The total area of the star-shaped top hat is approximately $8 \times 10^5$ m², and the perimeter is $12 \times 395 = 4740$m. The effective extra area due to fringing is therefore $4740 \times 183 = 8.7 \times 10^5$m². The total area upon which the capacitance must be calculated is therefore $(8 \times 10^5) + (8.7 \times 10^5) = 16.7 \times 10^5$m². Capacitance of a parallel-plate capacitor is $A\epsilon_0/d$, where *A* is the plate area in m², *d* is the distance between plates, and $\epsilon_0$ is the permittivity of free space ($8.854 \times 10^{-12}$). The aerial capacitance is therefore 81nF. The capacitance quoted in the reference is 95nF but this includes the capacitance of the cage forming the vertical part of the aerial, and the capacitance of the aerial insulators.

It will be apparent from Fig. 4 that the current in the aerial must return to the transmitter via the earth connection and therefore the resistance of the earth system must be as low as possible in the interests of efficiency. High conductivity ground may be selected for the aerial site, as has been done in the case of the NATO v.l.f. transmitter at Anthorn, where the site is at the extremity of a lowlying peninsula on the Solway Firth.

To improve the ground conductivity still further, copper wires of 4mm diameter, buried to a depth of 30cm, radiate from the centre of the aerial system at 2° intervals, and extend over the whole area covered by the aerial. Alternate conductors, i.e. those at 4° intervals, extend to the edge of the site.

## Mechanical construction

The usual method of supporting the aerial system is by means of guyed masts, which are cheaper than self-supporting towers. Lattice masts with a triangular cross-section are normally used, as this shape provides anchoring points 120° apart for the stays, which are usually fitted at heights of every 50m or so.

The conductors which form the aerial down-lead and top capacity are usually steel-cored aluminium cables of about 2.5 to 4cm diameter, similar to those used for overhead electric power transmission. This diameter cable is necessary to prevent corona, rather than for its current carrying ability. Anti-corona rings and insulators are fitted at the support points. It is interesting to note that at v.l.f. the onset of corona occurs at a voltage about 17% lower than on 50Hz power systems.

## Some unusual aerials

The aerials so far mentioned have been fairly conventional in design, but there have been some unusual systems.

One of these was the German Goliath transmitting station built in 1943 near Kalbe on the marshes of the river Milde (ref. 7, p.144). This aerial used three identical interconnected hexagonal shaped top capacitances, shown in Fig. 6. Each hexagon had an insulated tubular centre mast which was tuned with its own a.t.i., and a fourth a.t.i. was connected between the transmitter output and the common connection to the six up leads at the centre of the system.

By using this multiple tuning technique a very high overall efficiency was achieved, resulting in a radiated power varying from 300kW at 15kHz to 900kW at 60kHz.

The chief reason for the improved efficiency of the multiple tuned aerial is that the earth current is shared by the earth systems. Suppose the system consists of n aerials, each being tuned and carrying a current of $I$ amps. If the earth resistance were $R_g$ ohms, the total power loss would be $nI^2R_g$ watts. If only one aerial were used, having the same earth resistance $R_g$, but with a current of $nI$ amps, then the power loss would become $(nI)^2R_g$ watts, which is $n$ times as great as with multiple tuning. The earth losses are therefore reduced in direct proportion to the number of multiple sections.

A similar technique has been used in the U.S. Navy station at Cutler, Maine, where the aerial consists of two separate star-shaped umbrella systems, each similar to the Anthorn aerial but larger. Each system has its own tuning inductors and they are normally operated in parallel.

Hills and valleys have also been used for v.l.f. aerials. The Post Office Station at Criggion, built during the Second World War as a standby for Rugby, originally used only three masts, the other two supports for the aerial array being situated on adjacent hill tops. Valley span aerials are also used, in which the transmitter is located in the dip between the hills and the top capacitance spans the valley. Such a system has been planned for the Omega station in Hawaii.

## Japan's Omega station

The Omega transmitter being built by Japan [10] is situated by a bay in the north-west corner of the island of Tsushima in the Korea Strait. Its aerial is unique in that it employs a single insulated tubular mast, 450 metres high, with a top capacitance consisting of 16 4cm diameter conductors radiating outwards and downwards from the top of the mast. The active length of each top conductor is about 315 metres. The earth system consists of 90 radial conductors, each about 200 metres long, spaced at 4° intervals.

The mast itself is about three metres diameter, and is made up of 68 cylindrival sections. The weights of the sections vary from about 19 tons for the lower units to 16 tons for the upper ones. Stays are spaced approximately 120° apart, and fitted at six levels. Each stay is broken up into separate lengths by means of six insulators.

The whole assembly is supported on an insulator unit, comprising six insulators, which is designed to stand a maximum working load of 3300 tons.

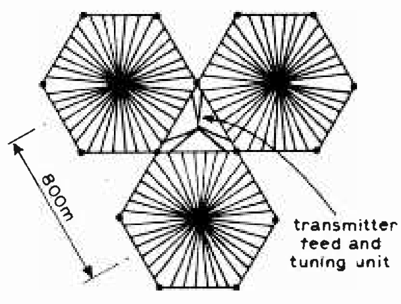


*Fig.6. "Top hat" of Goliath aerial.*

| | Rugby | Anthorn | Goliath | Cutler | Tsushima |
|---|---|---|---|---|---|
| Number of masts | 12 | 13 | 18 | 26 | 1 |
| Average height (m) | 250 | 200 | 175 | 258 | 450 |
| Site area ($km^2$) | 3.0 | 2.5 | 2.6 | 9.5 | 0.13 |
| Static capacitance (nF) | 80 | 95 | 115 | 225 | 34.4 |
| Effective height (m) | 133 | 112 | 137 | 145 | 200 |
| Radiation resistance (mΩ) | 80 | 56 | 85 | 100 | 73 |
| Q of system | — | — | 500 | 365 | 470 |
| Normal working voltage (kV r.m.s.) | 110 | 120 | 180 | 210 | 170 |
| Power output (kW) | 450 | 550 | 700 | 2000 | 135 |
| Radiated power (kW) | 65 at 16kHz | 50-100 from 16 to 20kHz | 350 at 16kHz | 1550 at 14.7kHz | 10 at 10.2kHz |
| Percentage efficiency | 14.4 at 16kHz | 9.1 at 16kHz | 50 at 16kHz | 77.5 at 14.7kHz | 7.6 at 10.2kHz |

## Typical aerials

The major physical and electrical characteristics of some of the aerials mentioned are listed in the table. For comparison, the effective height, radiation resistance, and Q of the communication aerials have been normalized to a frequency of 16kHz. Performance figures for the Omega station are based on the scale model described in reference 10 and they refer to a frequency of 10.2kHz.

Figures marked "Q of system" are approximate and refer to the Q of the aerial earth system plus the a.t.i. The effective Q of the aerial circuit under working conditions will be less than the figure quoted due to the output impedance of the transmitter.

Efficiency is tabulated as the ratio of radiated power to transmitter output power. This is not necessarily the maximum possible efficiency, as damping resistors are sometimes included to widen the bandwidth.

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# Research Notes

## E.E.G. test for telepathy?

Research on extra-sensory perception at Stanford Research Institute, California, has produced what looks like a useful screening process for picking out people who possess telepathic powers without themselves being aware of the fact. It results from a chance observation made during an experiment which failed. In this experiment one subject, the "home" subject, had a light flashed in his eyes at frequencies of 6 or 16 flashes per second. This tends to lock the alpha rhythm (normally about 10Hz). If by telepathy the "remote" subject's alpha rhythm were also locked the e.e.g. would reveal the effect. In fact no such effect was observed, but in a few remote subjects the alpha rhythm was depressed in amplitude while the light was flashing. The remote subjects who showed this effect had no consciousness of the state of the light. When asked to say when it was flashing they did no better than chance.

## Better propagation forecasts?

A new way of predicting solar activity has been discovered by G. M. Brown of University College of Wales, Aberystwyth. It stems from his observation that there is a strong correlation between the sun's effect on the earth's magnetic field and the number of sunspots *six years later*. The reason for this is not known, but it holds good over a time span which goes back to 1885, and the correlation is very close indeed. If it proves to be a genuine effect and not a freak of statistics then it could give radio propagation experts a valuable method of improving their short-wave propagation predictions.

The magnetic effect in question operates on the horizontal component of the earth's field. This normally goes through a minimum at about 11.00 hours local time, but on "Abnormal Quiet Days" (AQDs) the minimum is at some other time. It is the AQDs which predict the sunspot numbers. Since AQDs are most frequent at sunspot minima it could be that they mark the beginning of new cycles of solar activity rather than the end of old ones. "If this relationship proves valid it implies that the sun 'breathes' with an 11-year-period, such that the size of a solar activity maximum is determined at the very beginning of a cycle, or, perhaps the very end of the preceding cycle, from the "depth" of the solar minimum."

## Wave power looks good

The subject of a piece of writing which contains the words wavelength, bandwidth, matching, resonant, tuned, and reciprocity might be expected to be some sort of electrical circuit. Yet all these terms (and others familiar to the electrical or electronic engineer) are to be found in a letter to *Nature* (vol. 254, p504) about a purely mechanical device. It is a gadget for extracting the energy from ocean waves. First proposed by S. Salter of the Mechanical Engineering Department at Edinburgh University, the "Salter cam" has now been investigated by the Marchwood Engineering Laboratories of the CEGB. The Salter cam is a floating boom whose cross section is roughly the shape of a duck's body. As a wave passes beneath it, the cam is given a twist. This exploitation of the twisting part of the wave's energy is the important element in the design. The question is: how much wave energy is extracted? The Marchwood results show that with exact matching of the dimensions of the cam to the wavelength the efficiency can exceed 90%, while the 3dB bandwidth covers about one octave. These results have been obtained using small cams in a test tank, and have yet to be confirmed with full sized devices in real sea conditions, but certain losses in the system are frequency-dependent and should be less for full-sized ocean waves.

Some means of transferring the energy to the shore will have to be developed. Possibly the motion of the cams could be used to pump water.

A useful consequence of the efficiency of the cam is that the water behind it is calm, most of the wave energy having been extracted. So the device seems to have possibilities as a floating breakwater.

## Digital filters reveal weather trends

Statisticians have long used a mathematical device, the moving average, for removing the short-term peaks and troughs from a time-series of data and so revealing the underlying trend. The "moving average" process is analogous to a low-pass filter, which removes high-frequency noise and lets pass a low-frequency signal.

Information stored in electrical form can be passed through a real low-pass filter. Scandinavian research workers have been using this trick to very good effect to smooth away the short-term fluctuations from climatological data. The data go back about 1 000 years and were smoothed by means of a digital low-pass filter whose cut-off was set at various intervals up to 200 years. The results reveal an unexplained correlation between the climate in England and that in Greenland, with a time-lag of 286 years. On this basis, the further outlook in Britain is colder.

## Ear temperature clue to brain-damage

Measurements taken with the aid of a thermistor probe suggest that the temperature just inside a newborn baby's ear may provide a diagnostic test for brain damage. When doctors at the London Hospital Medical School compared the temperature of the ear of a newborn baby with that of the oesophagus they found that the ear temperature was consistently 0.2deg.C higher. This is not surprising in view of the discovery that in a normal baby 70% of the body heat is generated in the brain, compared with less than 20% in a resting adult. It is hoped that ear temperatures may vary from the norm in brain-damaged babies and so provide a simple means of diagnosis.

## Holes in the ionosphere to aid radio astronomy?

The exhausts from large space-rockets make holes in the ionosphere. The release of large quantities of gas mops up free electrons and so reduces ionization. The Spacelab launch made an ionospheric hole which persisted for several hours.

A suggestion has been made that such a hole, in the right place, would permit radio astronomy at frequencies which normally do not reach the earth.

## Towards the 12GHz consumer f.e.t.

When direct TV broadcasting from satellites begins there will be a need for cheap active devices for use in home receivers. In Japan, a process for making gallium arsenide microwave f.e.ts is under development. Only one mask is required. This creates titanium gate contact strips 3 microns wide, on a surface layer of p-type gallium aluminium arsenide grown on the n-type layer of GaAs which forms the channel. A etching process removes unwanted gate material and undercuts the base contact strips by 1 micron. The undercut strips act as umbrellas to shield the channel material from the subsequent metallisation processes which create the source and drain contacts.

# A digital waveform synthesizer

## Variable a.f. function generator

by R. A. J. Youngson

The output of the waveform generator is a series of consecutive, negative-going, voltages of equal duration and of independently variable level. Thus complex waveforms can be synthesized.

The circuit described (see Fig 2) divides each cycle into 32 bits providing control of up to the fifteenth harmonic. Fig. 1 shows the synthesis of a sinusoid. The amplitude *A* of each pulse is adjusted to form an approximation to the curve required.

### Circuit

Essentially, the circuit is designed to decode a series of five-digit binary numbers to a one-of-thirty-two output. A square-wave oscillator, using a Schmitt trigger (½SN7413) and a few external components, drives a chain of six binary dividers (one SN7493 and one SN7473). The purpose of the first divider is to ensure that the mark-space ratio of the input square-wave is 1:1, otherwise a variation in the output pulse width would result. The Q outputs of the next four divider stages are connected to the A, B, C, D inputs of two SN74154 four-bit-binary to one-of-sixteen decoders. These inputs are common to both decoders. The Q and $\overline{Q}$ outputs of the last divider stage are coupled to the strobe inputs of the two decoders as shown in Fig. 2. This arrangement ensures that the decoders operate alternately as the states of the outputs of the last divider change. The normal state of the decoder outputs is logic 1 and for any output this is switched to 0 when the binary code corresponding to that ouptut is applied to the A, B, C, D inputs, There are two strobe inputs in each decoder. If either or both of these is at logic 1, than all the outputs will be at 1 regardless of the state of the A, B, C, D inputs. Only if both of the strobe inputs are grounded will the device perform the decoding function. Fig. 3 shows a truth table for the switching of the decoders.

Each of the thirty-two ouptuts is grounded through a 20kΩ potentiometer, the moving contact of each being connected to an output bus via a 100kΩ isolating resistor. In the logic 1 state, the outputs of the decoder are at about +4V but because of the large number of paralleled resistors, this is dropped to between 150 and 200mV, still allowing an adequate signal to noise ratio. The output impedance lies between 3 and 4kΩ.

Since there are six stages in the divider chain, the output frequency is

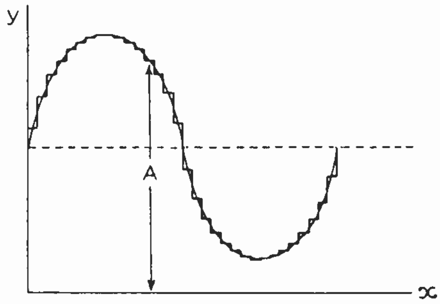
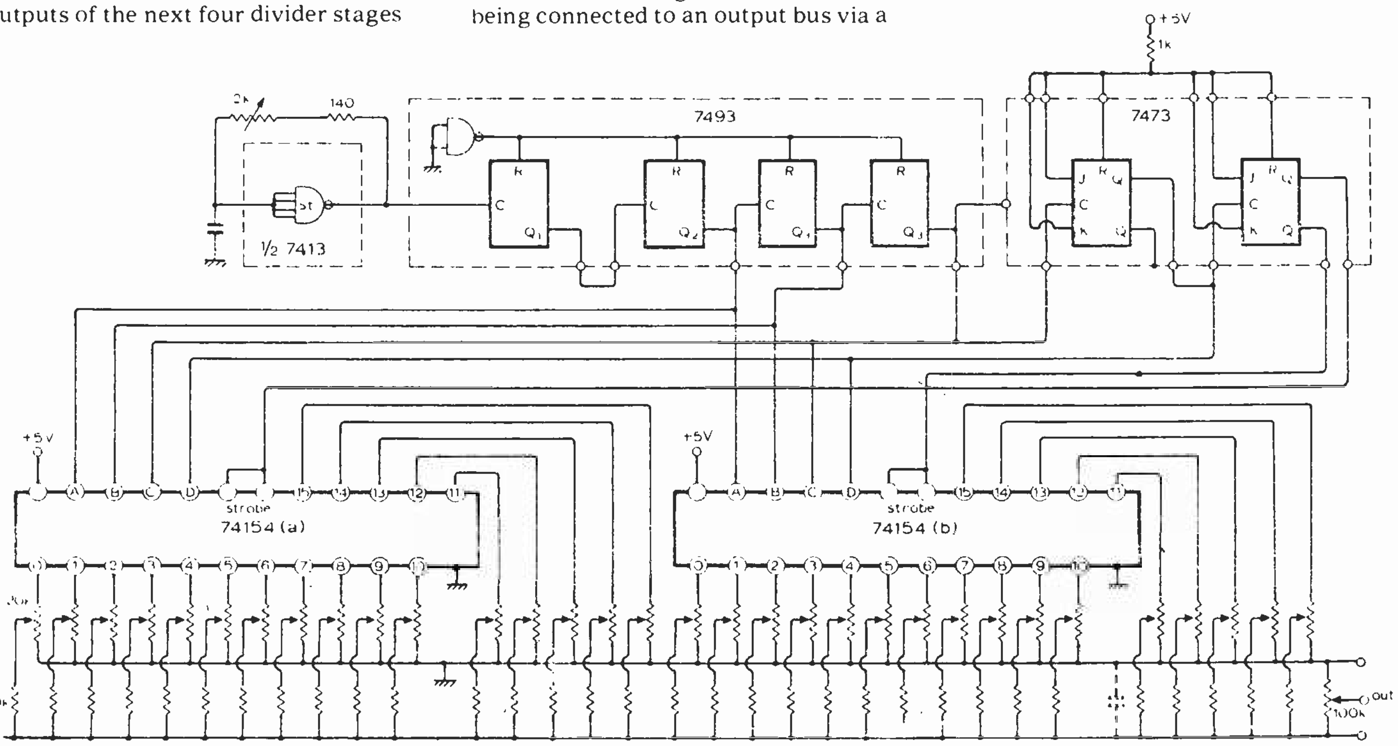



*Fig.1. Synthesis of a sinusoidal waveform.*

*Fig.2. Circuit diagram of synthesizer.*



only 1/64 of the input frequency, so the oscillator has to run at up to about 1MHz to achieve an output frequency range of from a fraction of a hertz to about 20kHz. The clock oscillator described is capable of covering about four octaves with a single capacitor. If a second capacitor, of exactly equal value, is switched in parallel, the frequency drops by an octave—a useful characteristic in a musical instrument.

The t.t.l. short rise and fall times permit a precise output waveform with no easily detectable gaps between pulses. In addition, the frequency-determining elements should be stabilized against temperature or voltage changes. The levels of all the outputs from the decoders are uniform, permitting accurate calibration of the 32 controls.

The circuit requires only one 5V supply, but this must be well stabilized. This is most conveniently accomplished by using an i.c. regulator. The current consumption of the whole circuit is less than 140mA.

The output waveform is most readily appreciated on an oscilloscope. For some purposes a stepped waveform is inconvenient, and a 0.01μF capacitor wired across the output will filter out the steps to give a smooth waveform. This value is sufficient at most audio frequencies but a larger value is required (i.e., 1 or 2μF) if the device is used as an envelope generator at very low frequencies.

### Construction

The main circuitry is conveniently fitted on 0.1in pitch Veroboard. It is best to arrange the two decoders so that all the outputs can be taken from one edge of the panel in the correct order. The miniature potentiometers used were mounted in two rows of 16, an inch apart, but an alternative arrangement may be preferred. Colour-coded wires are recommended for the connections between the circuit board and the control panel.

### Applications

The original purpose of the device was as a generator of musical waveforms but there are wider applications. When used as a musical tone synthesizer, waveform patterns, such as photographs of oscilloscope tracings, may be copied. Due observance of fine detail will be found to be important. One should, however, bear in mind that the waveform is not the only parameter that governs the sound.

The device may be used as an envelope generator to control a voltage-controlled amplifier supplied with tones from a further waveform generator, so producing accurate attack and decay curves each time a note is played. It can be arranged that the first half of the generator cycle is used for the attack curve and the second for the decay curve.

| DIVIDER OUTPUTS | | DECODER (a) | DECODER (b) |
|---|---|---|---|
| Q | $\bar{Q}$ | | |
| 1 | 0 | all outputs 1 | decoding |
| 0 | 1 | decoding | all outputs 1 |

*Fig.3. Truth table for decoder switching.*

The form of the output is, of course, entirely independent of frequency and a third application is the use as a rhythm generator by appropriately reducing the clock frequency. A sequence of up to 32 beats in a bar may be produced, the loudness as well as the presence or absence of each being independently controllable. Realistic effects are possible ranging from single beats to a drumroll.

Yet another application is as a voltage source for a voltage-controlled oscillator so as to produce a sequence of 32 controllable pitches. The device could, for instance, be programmed to play the bass notes of a short musical composition.

**Acknowledgement:** The author is indebted to earlier workers who evolved the basic ideas on which this device operates.[1,2]

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## What are Circards?

Circards are a unique way of collating and presenting data about circuits in a compact and easily retrievable form. The sets of 203×127mm (8×5in) double-sided cards are designed for easy filing in standard boxes and for easy access at the desk or at the bench, where transparent plastic wallets keep the cards in good condition.

Each card normally describes operation of a selected circuit, gives *measured* performance data and graphs, component values and ranges, circuit limitations and modifications to alter performance. Suggestions for further reading are included together with cross references to related circuits. The Circard concept was outlined more fully in the October 1972 issue of *Wireless World*, pp.469/70.

Topics covered so far in Circards are:
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# How speech can be compressed and expanded

## Methods of speeding or slowing speech reproduction without distorting nuances or intelligibility

by S. L. Silver

**In past years, variable speech-control devices employing electromechanical techniques have been commercially available as an auxiliary unit for reel-to-reel tape machines. Recently, however, with the advances in sophisticated electronics and complex solid-state circuitry, rate-variable equipment has been produced as a built-in facility in cassette machines for the time compression and expansion of recorded speech.**

In our speech-oriented technology, the recorded voice is becoming increasingly significant in the transfer of information. But owing to the physiological limitations of the organs of speech, we lack the ability to produce speech as rapidly as the ear-brain perceptual mechanism can process it. Normally, average speaking rates range from about 110 to 175 words per minute, whereas the capacity of the human auditory system to absorb speech in real time is more than twice that rate. It follows, therefore, that in order to cope with the proliferation of audio data, we should take advantage of our higher listening-rate capability by utilizing some form of rate-controlled speech processing.

The simplest approach is to reproduce tape-recorded speech at a faster rate than it was originally recorded. This may be feasible for small speed-up ratios, but larger variations (in the order of 50 percent) would result in serious deterioration of quality and intelligibility. What happens, of course, is that the speech spectrum is proportionately scaled-up in time, thus distorting the normal voice pitch. One solution to the problem lies in compressing the recorded speech signals as a function of time during playback, so as to accelerate the speaking rate without altering the pitch or tonal quality of the voice. Conversely, the speech rate could be slowed down by expanding the recorded signals in a pitch-invariant manner.

With these methods, the listener is allowed to control the playback rate of audio presentation and, hence, select his optimum listening speed without sacrificing intelligibility and comprehension.

### Potential applications

Although rate-controlled speech has already proved its usefulness in some fields, modern methods have opened up a wide range of potential applications. For example, listening to time-compressed speech can provide an efficient learning medium for individuals with special educational problems, such as the visually handicapped. With high-speed listening, recorded conference proceedings can be reviewed rapidly, since more subject matter is reproduced in a given time.

In transcribing recorded speech directly to the typewriter, the word rate can be adjusted according to the individual's typing ability. Also, programme material for a radio broadcast transmission can be played back within the desired time limit, without the need for editing the recorded text.

During expansion, recorded speech can be slowed down to a convenient word rate for teaching retarded children, and in speech therapy in general. Low-speed listening can also be helpful in learning a foreign language, where the listener is able to set his own listening pace, making it easier to imitate the articulatory gestures of speech production. Similarly, in linguistic studies, a low word rate enables the listener to make more precise phonetic transcriptions.

In order to gain better insight into the technical aspects of compressed and expanded speech in time, one must appreciate the dynamic and phonetic characteristics of vocal sounds. Therefore, before considering the methodology of rate-altered speech, it would be useful to explore briefly some of the fundamental features of the speech process in acoustical terms.

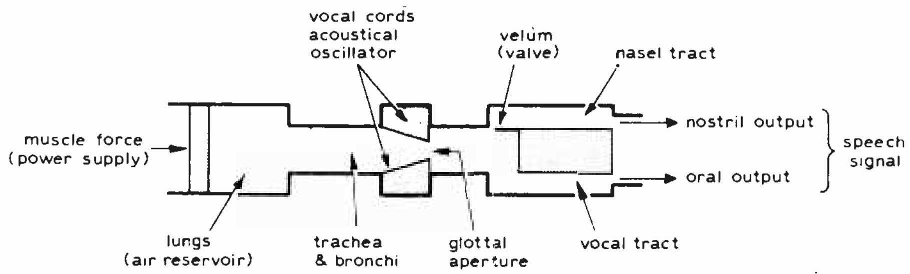


*Fig. 1. Schematic representation of the human vocal system.*

### Speech production

Speech signals consist of rapid fluctuations in air pressure, wherein sound energy is generated and radiated by the vocal system. A schematic representation of the voice-producing mechanism is shown in Fig. 1. A column of air is expelled from the lungs, passes through the glottal aperture, and drives the vocal cords into forced oscillation. The vocal cords, acting like an acousto-mechanical relaxation oscillator, chop up, or modulate the air stream into near-periodic sawtooth pulses. These time-pressure patterns, in turn, excite the vocal tract where the position of the articulators (tongue, lips, palate, etc.) establish certain resonant conditions.

### Sample-and-discard methods

Human speech may be regarded as the process of transforming a message from sequence of basic sound units — the phonemes — into a continuous acoustical signal that conveys information to the listener. Phonemes are considered to be the minimum recognizable speech components that can be distinguished from any other speech sounds produced. Natural connected speech, however, does not merely consist of isolated sound elements or discrete events. The acoustical attributes of each sound unit constantly change the flowing speech pattern due to the merging influence, or interaction, between adjacent phonemes. In this process, phonemes are produced at the rate of about 10 to 20 per second, the duration of a single sound element ranging up to 100ms.

Fortunately, the time interval of the average phoneme in continuous speech exceeds the minimum duration necessary for intelligible perception by the listener. The temporal redundancy of vocal communication, in effect, is sufficiently high to permit direct manipulation of the time-scale of a complex waveform. This is an important factor when considering the sample-and-discard method of speech processing.

In an experimental demonstration of speech compression, Garvey[1,2] edited recorded voice tapes in such a way as to produce speech sounds with a high word rate. Using a manual sampling technique, he carefully cut the tape into periodic sections (independently of the speech content), discarded tiny interspersed segments, and spliced the remnants together. He found that the shortened composite tape, when reproduced at normal speed, retained most of the original voice quality.

Subjective tests were then carried out to determine the effects of increased compression rates on intelligibility. The results are illustrated by the curve plotted in Fig. 2. Here the compression rate, expressed in percentage, is defined as the ratio of the playback speed to the normal recording speed, e.g., a compression rate of 100 percent corresponding to normal reproducing speed. Speech compression at 200 percent indicates that reproduction is twice as fast, so that playback time is 50 percent of recording time. Clearly, the curve shows that intelligibility is remarkably good at compression rates up to 200 percent after which it declines sharply to 400 percent, where it becomes extremely poor.

It should be pointed out that a distinction must be drawn between the intelligibility of single words and the comprehension of complex information. A word is considered intelligible if the listener can recognize it and repeat it, but comprehension signifies the retention of ideas in which specific facts can be subsequently recalled. Generally, as the word rate of compressed speech is accelerated, comprehension declines more rapidly than intelligibility. Another point of consideration is that the degree to which speech sounds can be speeded up without loss of listening comprehension is highly dependent upon the difficulty of the recorded passages and the familiarity of the listener with the subject matter.

## Electromechanical techniques

Obviously, the manual sample-and-discard method is time-consuming and impractical, and it would be necessary to implement the control of speech rate by automatic means. It is possible to perform time compression by the elimination of those pauses between words that exceed a preset time interval. Pause suppression can be accomplished by means of a fast-acting stop-start clutch, which automatically stops the tape player during the pause interval and restarts it in the presence of speech signals.

Unfortunately, such a system ignores the fact that speech is not merely a chain of words randomly linked together, but is structured by grammatical rules to transmit complex data to the hearing mechanism. In this process, the pauses (as well as the stress levels, intonation patterns, and inflections) introduced by the talker are used by the listener to decode these complex ideas. Accordingly, the natural pause-to-speech sound relationship at the juncture of phrases and sentences, and even the intermittant hesitation pauses between words, should be maintained for maximum listening comprehension.

In order to preserve the relative rhythm of the original recorded speech sounds during speech processing, time-controlled speech may be achieved by automatically sampling the signals in

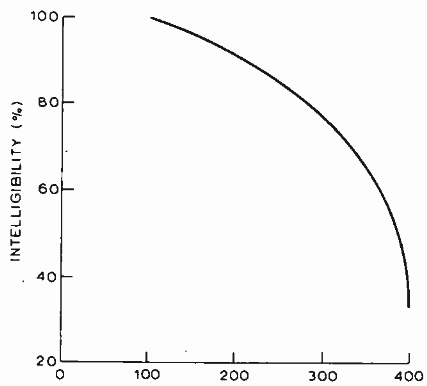


*Fig. 2. Speech intelligibility versus compression rate curve (after Garvey).*

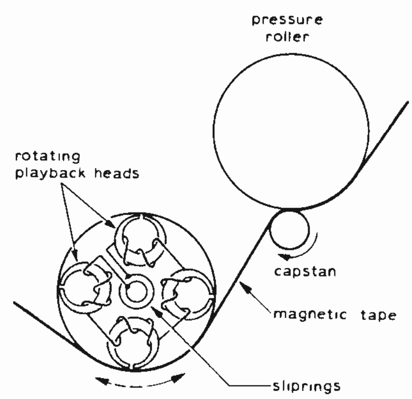


*Fig. 3. Schematic view of the rotary head assembly (after Springer).*

periodic segments. About thirty years ago, Gabor[3] proposed an electromechanical scheme for compressing speech by implanting a magnetic head assembly in a rotating wheel and scanning a magnetic tape.

In the 1950s, Fairbanks *et al.*[4] developed apparatus employing multiple pickup heads set in a revolving drum operating in conjunction with a magnetic tape loop. The differential tape-to-drum speeds could be varied independently to attain any degree of compression or expansion. Subsequently, the Acoustical Time Regulator designed by Springer,[5] utilized a rotary head assembly capable of direct reproduction because of synchronization between tap speed and head rotational speed. Further development of this device produced the Information Rate Changer, which combined the functions of pitch and tempo regulation.

## Rotary-head processor

Referring to Fig. 3 the rotary-head processor incorporates four separate playback heads mounted in quadrature, with the tape wrapped around the head assembly for one-quarter of the perimeter. Signal outputs from all heads are connected in series and passed through a slip-ring arrangement, then fed to a pre-amplifier in a conventional way. In the tempo-change function, the rotational speed of the playback heads is linked in such a way with the rotational speed of the capstan, i.e., the linear speed of the tape, that a constant pitch is maintained over a wide range of speeds.

In the compression mode, the playback time is shortened by skipping individual segments of the taped speech. Here the head assembly rotates in the same direction as tape travel, with the tape-to-head gap velocity equal to the speed at which the tape was recorded. The absolute tape velocity (with respect to the tape deck) determines the time duration of the compressed speech. During this operation, one head gap leaves the tape-contact area while an arriving head establishes contact. However, at the instant of transition, a definite interval will recur when the tape-segment signal between the head gaps will be effectively omitted, thus contributing nothing to the reproduced output.

In the expansion mode, the playback time is lengthened by repeating individual segments of the recorded tape. Here the head assembly rotates in a direction opposite to tape action, while maintaining a constant relative tape velocity equal to the recorded speed. In this case, two head gaps establish tape contact almost simultaneously; one head gap picks up an individual tape segment as the next head gap reproduces the same segment. In order to prevent the occurrence of detectable distortion, the repetitive interval during expansion (or the discard interval

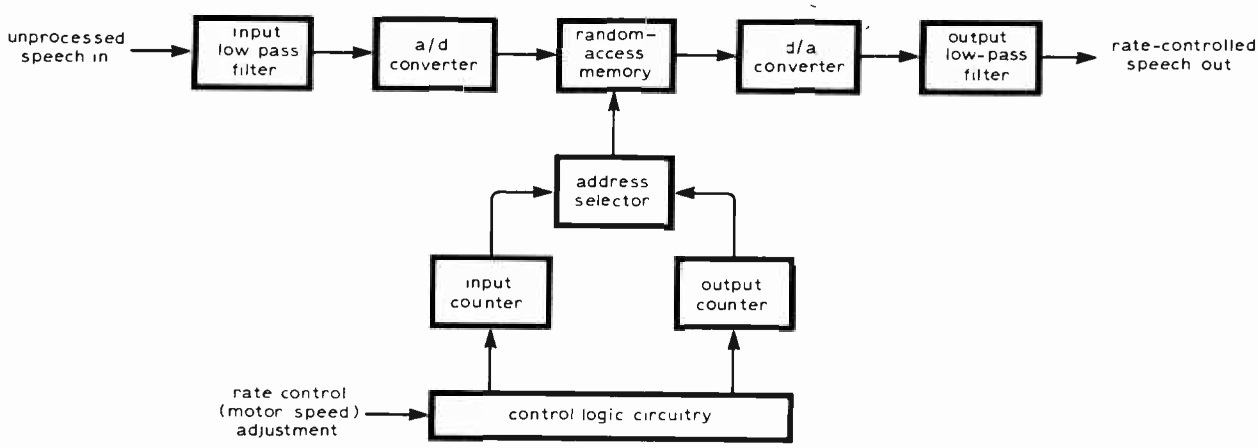


*Fig. 4. Simplified block diagram of a speech processor using electronic sampling techniques.*

during compression) must be shorter than the average basic sound unit. For this reason, the segmented lengths are fixed precisely in time, say 30ms, which is considered below the perception threshold of audible disturbances.

In the pitch-change function, it is possible to raise or lower the pitch simultaneously with, or independently of, the tempo. Under these conditions, rotating the head assembly in the direction of tape motion and decreasing the relative tape-to-head gap velocity will result in a lowering of the pitch. Rotating the heads in a reverse direction will have the opposite effect. The pitch-change function may have potential value as an aid for individuals with certain types of hearing impairment. For example, by shifting the voice spectrum down by some factor, say one octave, in real time, speech sounds can be transposed within the range of hearing of partially deaf persons.

## Electronic techniques

In contrast to electromechanical systems, speech compression can be performed electronically without discarding discrete portions of the input signal. An example of this approach is the Harmonic Compressor[6] which uses spectral analysis and synthesis to produce a pitch-normalized output. Initially, the speech signal is applied to a bank of 36 bandpass filters (covering the range from 200 to 7,400Hz) which separate the signal components into 200-Hz bands. The filtered output of each channel, in turn is fed to its corresponding frequency divider, thus halving the frequencies of the narrow-band signals. The output from all channels is finally combined in a summing network, and filtered to remove the distortion components.

To restore the half-frequency signals to their normal values, the synthesized speech is recorded on tape and then reproduced at double speed. The word rate is now twice the normal rate, with the voice pitch normalized with the original speech signal. Although the Harmonic Compressor is restricted to a compression factor of two, the principle, of course, is applicable to other speed-up ratios. Speech expansion may be accomplished by frequency multiplication instead of division.

At present, time compression/expansion of speech is being implemented with digital processing using electronic sampling techniques.[7] The sampling theorem states that if the sampling rate is a minimum of twice the highest frequency components of a continuous signal, the sampled version of that signal can be converted back to its original form. Accordingly, the speech signals to be processed are low-pass filtered at the input to ensure that there is no acoustic energy above the maximum frequency of interest, then applied to an analogue-to-digital converter at the appropriate sampling rate. If, for example, the desired upper frequency limit of the filtered signal is 7kHz, and the speech to be compressed is speeded-up by a factor of 2.5, then the sampling rate is required to be a maximum of 35kHz.

In the electronic speech processor shown in Fig. 4, the input counter stores the sampled signals in successive locations of the random-access memory (r.a.m.), with the final location followed by the initial one. The stored samples are retrieved by the output counter (at a fixed rate) from consecutive locations of the memory. Finally, the data is converted back to analogue form, then low-pass filtered at the output to reconstruct a rate-altered version of the original speech signal.

In effect, the r.a.m. provides a means for sequential storage and presentation of signal samples, and, since the frequencies of the original signal have been restored with respect to memory space, they are reproduced at their normalized values. The relationship between the variable read-in rate and the constant read-out rate determines the compression and expansion ratios of the pitch-corrected output. Thus, if the read-out rate from the memory is made variable, the speech processor can function as a pitch-changer.

In a commercially available cassette machine which incorporates a digital signal processor, the basic assembly is made up of printed circuit cards. In the playback mode, the listening speed can be varied continuously (with a single control) from 0.5 to 2.5 the normal recording speed, without altering the pitch characteristics of the signal. Tape speed automatically reverts to normal when the machine operates in the record mode. The transport mechanism employs servo-regulated speed control with tachometer feed-back to establish a linear relationship between read-in rate and capstan motor speed. Also, an input facility is provided to compress or expand audio signals from an external variable-speed source.

Another electronic sampling approach to speech processing makes use of analogue shift registers, commonly known as bucket-brigade devices. These units, however, are still undergoing development, the main objective being to integrate the basic system on a low-power chip.

This article has been reprinted from the American sound engineering magazine *db*.

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# Sorting out signs

## Sign conventions in electric and magnetic circuits

by A. T. Morgan, M.Sc.,M.I.E.E., M.I.Mech.E.

*Middlesex Polytechnic*

**To correctly interpret the results of calculations about electrical networks, it is important to be logical and consistent. This article outlines a logical system using conventional methods of treating circuit and phasor diagrams.**

The matter of notations and sign conventions is one which often causes confusion. For example, one often reads the statement that induced e.m.f. in an inductance coil is $-Ldi/dt$ without any indication of which is the positive direction of applied voltage, induced e.m.f. or current! Also, from many transformer circuit diagrams, it is impossible to decide what the relative polarities of the two winding voltages are.

To write the equations that describe the behaviour of an electrical network and correctly interpret the results of calculations, it is essential to make clear a logical and consistent system of notations and sign conventions.

Scroggie* has pointed out some of the difficulties and confusions that may be encountered and has suggested a new and interesting method of labelling currents and voltages in circuit diagrams and phasor diagrams. This article outlines a logical system using conventional methods of dealing with circuit and phasor diagrams.

### Resistance circuit

Consider first the simplest possible circuit consisting of a single resistance with an applied voltage $v$. First choose a convention for the positive direction of $v$ as shown by the arrow (arrow head positive) and for $e_R$, the voltage drop across the resistance, which is clearly the same voltage see Fig. 1(a). Now choose a positive direction for the current $i$ as shown by the arrow. With the selected positive directions of voltage and current, a positive applied voltage would give a positive current. The power, which is the product of voltage and current, is positive i.e. passing from the source to the resistance. Also, as a positive applied voltage $v$ would give a positive current $i$, then if $v$ is sinusoidal then $i$ will be sinusoidal and in phase with $v$, i.e. the power factor is unity and the phase angle zero, see Fig. 2(a). One can write

$$v = e_R = i\,R$$

where $R$ is a positive quantity.

We use lower-case letters for instantaneous values of quantities and upper-case letters for phasors.

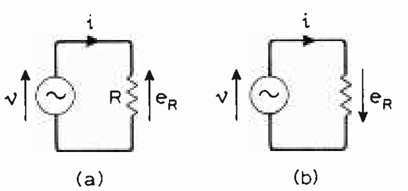



*Fig. 1*

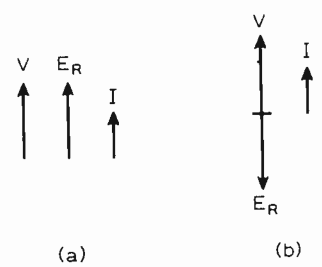



*Fig. 2*

Suppose that the positive voltage and current directions had been selected as shown in Fig. 1(b). Notice that in this case all voltage and current arrows point the same way round the loop. The applied voltage $v$ and the resistor voltage $e_R$ are now equal and opposite, i.e.

$$v + e_R = 0 \text{ or } v = -e_R.$$

$$\text{Also } v = i_R \text{ and } e_R = -i_R.$$

The phasor diagram is shown in Fig. 2(b).

You may find this convention for resistance strange. However it is quite common when considering an inductance to consider applied voltage and inductor voltage or "induced e.m.f." as equal and opposite. The above convention would thus make for consistency!

Notice that in this case the supply power $P\,(vi)$ is positive while the resistor power $P_R\,(e_R i)$ is negative. Thus positive power is power generated and negative power is power dissipated. It is not necessary to know if a source or sink of power exists between any pair of terminals, as the algebraic sign of the power indicates whether power is being generated or dissipated. One can write the energy equation $P + P_R = 0$.

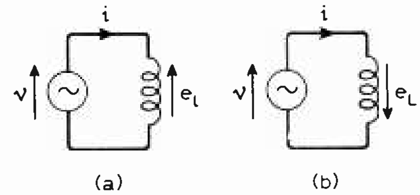



*Fig. 3*

### Inductance circuit

Consider the simple inductance circuit shown in Fig. 3. The sign conventions for voltage and current have been selected and Figs. 3(a) and (b) show two alternative choices for the positive direction of inductor voltage $e_L$. (Compare with Figs. 1(a) and (b).)

Consider first diagram (a). If the current is positive and increasing then the inductor voltage will be in the opposite direction to the current i.e. positive. Thus

$$e = +Ldi/dt.$$

Kirchhoff's law gives

$$v - e_L = 0, \text{ thus}$$

$$v = e_L = Ldi/dt.$$

Putting the operator d/dt equal to j for a.c. sinusoidal operation:

$$V = E_L = j\omega LI = X_L I, \text{ where } X_L = j\,\omega\,L.$$

The phasor diagram is as shown in Fig. 4(a). Notice that the expression for $e_L$

* Phasor Diagrams by M. G. Scroggie (Iliffe).

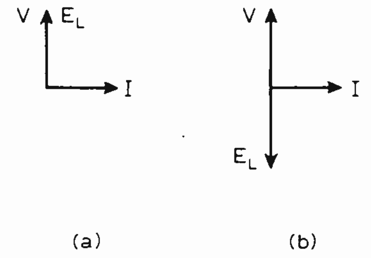



*Fig. 4*

above does not contain the usual minus sign. It is however correct.

Next, consider Fig. 3(b). If the current is positive and increasing the inductor voltage $e_L$ which is in the opposite direction to the current, is now negative i.e. in the opposite direction to the new positive direction. Thus

$$e_L = -L di/dt \text{ or } E_L = -j\,\omega LI.$$

$$\text{Also } v + e_L = 0; \text{ so } v = -e_L.$$

The phasor diagram is shown in Fig. 4(b).

Notice that the expression for $e_L$ now contains the customary minus sign. The minus sign is usually quoted but without any meaning as explained previously. Also notice that the statement sometimes made that the minus sign signifies that the voltage $e_L$ opposes the current is incorrect. It is sometimes in the same direction as the current. It does of course oppose the change in current.

In the rest of this article the conventions for resistance and inductance are as shown in Figs. 1(a) and 3(a) i.e. with positive voltage and current arrows in opposite directions. This is not any better than other alternatives. All that is required is a statement of the conventions adopted followed by consistency in the use of them. Remember that at any pair of terminals, positive voltage and current arrows in the same direction means that positive power is power generated, whereas positive voltage and current arrows in opposite directions means that positive power is power dissipated.

## RL circuit

Consideration of an RL series circuit is now straightforward. In Fig. 5(a),

$$v - e_R - e_L = 0$$
$$v = e_L + e_R$$

and the phasor diagram is below (b).

One often sees the phasor diagram for this circuit drawn as shown in Fig. 6(b).

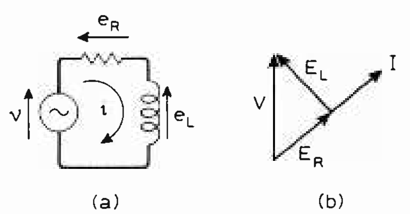



*Fig. 5*

This corresponds to the conventions shown in Fig. 6(a), although this is rarely stated. Notice that the positive direction of voltage $e_L$ is taken to be the same way as positive current whereas positive resistor voltage is taken the opposite way to current.

$$v - e_R + e_L = 0$$
$$v = e_R + (-e_L)$$

where $e_R = +iR$ and $e_L = -Ldi/dt$. i.e. applied voltage is equal to resistor voltage plus a term equal and opposite to inductor voltage. This seems to be unnecessarily complicated.

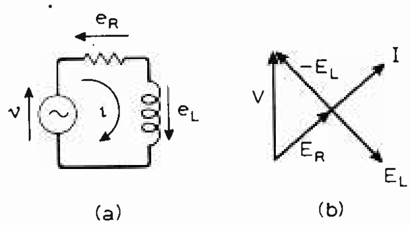



*Fig. 6*

## Circuit with two way power flow

In Fig. 7 both boxes can act as either sources of power or sinks. In this case the power flow may be from left to right or vice versa. With the positive voltage directions as shown it would be equally logical to adopt either of the alternatives shown in Fig. 7 for positive current direction i.e. indicating positive power flow from left to right or vice versa.

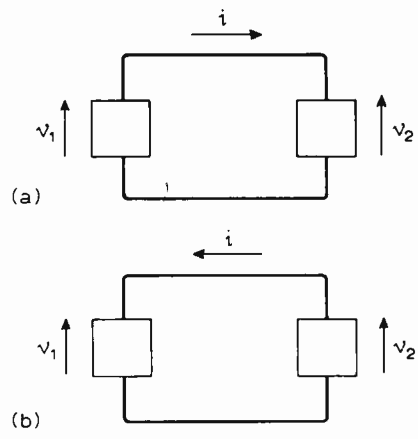



*Fig. 7*

Adopting alternative (a), positive power flow from left to right, and drawing the phasor diagram as shown in Fig. 8(a), the phase angle between current and voltage indicates the direction of power flow. If $I$ has a component in phase with $V_1$ then the power flow is positive, i.e. from left to right. If $I$ has a component in antiphase with $V_1$ as in Fig. 8(b) then the power flow is negative i.e. from right to left.

For an impedance $Z$ between the two boxes, as shown in Fig. 9, the corresponding phasor diagrams will be as shown in Fig. 10. Equation representing Figs. 10(a) and (b) is $V_1 = V_2 + IZ$.

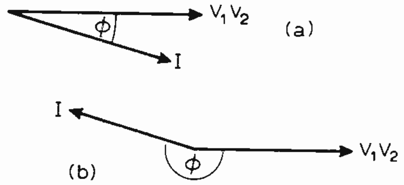



*Fig. 8*

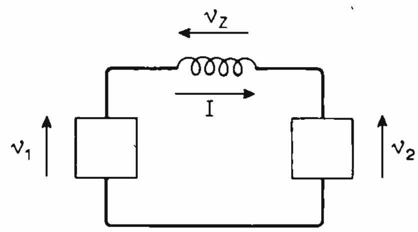



*Fig. 9*

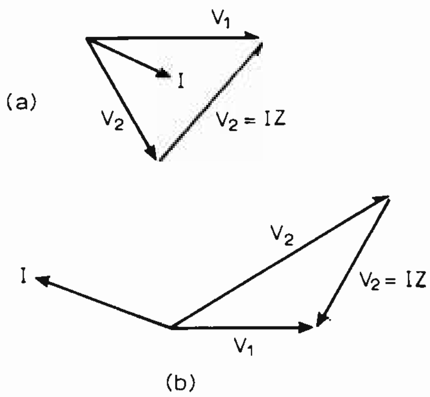



*Fig. 10*

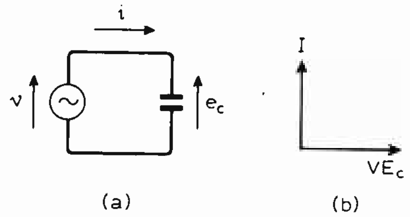



*Fig. 11*

The above example could represent an a.c. machine where $V_2$ is the generated e.m.f., $V_1$ the terminal voltage and $Z$ the impedance. It could also represent a transmission line of impedance $Z$ and voltages $V_1$ and $V_2$ at either end.

## Capacitive circuits

In accordance with the principles already discussed, the circuit and phasor diagrams for capacitive circuits may be drawn as follows.

**Simple capacitive circuit — Fig. 11(a)**

When the current is positive, the voltage $e_c$ will be increasing positively. Thus

$$i = +C\,de/dt.$$

In terms of a.c. phasors

$$I = +j\omega CE_c \text{ or } E_c = -I\,j/\omega C$$

Also

$$v - e_c = 0 \text{ or } v = e_c$$

The phasor diagram is shown at (b).

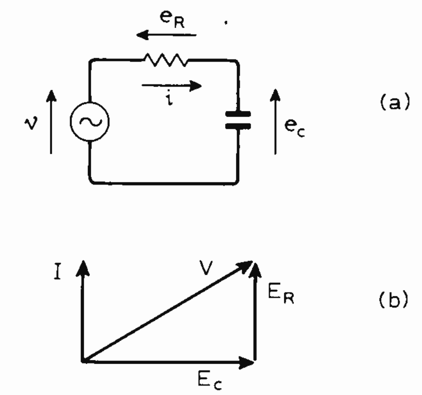



*Fig. 12*

**RC circuit — Fig. 12(a)**
We have

$$v - e_R - e_c = 0$$
$$v = e_R + e_c$$

The phasor diagram is shown at (b).

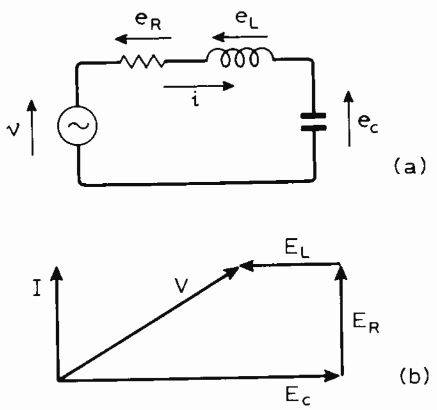



*Fig. 13*

**RCL circuit — Fig. 13(a).**
We have

$$v - e_R - e_L - e_C = 0$$
$$v = e_R + e_L + e_C$$

The phasor diagram is shown in (b).

## Magnetically coupled circuits: transformers

For two magnetically-coupled circuits, i.e. a transformer. Assume as usual that an alternating magnetizing current and the flux produced by it are in phase i.e. they are proportional to each other (linear magnetic circuit assumed) and a positive current gives a positive flux. Thus the positive direction of flux linking a coil is that produced by a positive current. As self inductance is defined as the ratio of flux linkage to current, we are defining self inductance as a positive quantity.

Mutual inductance however (also defined as the ratio of flux linkage to current) will be taken as an algebraic quantity, positive or negative. Once positive flux directions are defined for both coils, one can say that if a positive current in one coil produces a flux in the negative direction in the other coil, then the mutual inductance is negative and vice versa. Notice that we are giving more information than the commonly used dot notation, as the dot notation does not tell us the direction of flux produced by a current.

Now consider a transformer consisting of two co-axial coils wound in the same sense as shown in Fig. 14(a). For simplicity, assume unity turns ratio i.e. the two coils are identical. For the moment, neglect resistance and leakage flux i.e. assume maximum coupling. Then $L_1 = L_2 = M$.

Positive directions of voltage and current in the two windings have been selected as previously outlined; also the positive flux directions in both coils. As this is the same direction in both coils, the mutual inductance is positive. Notice that the power must be positive at one pair of terminals and negative at the other, i.e. input power at one pair of terminals and output power at the other. In electro-mechanical devices of course, it is possible to have positive power i.e. power input at both terminals. We then must obtain energy in some other form e.g. mechanical energy output.

Assume that the primary winding has a sinusoidal applied voltage $V_1$ and the secondary winding is open circuited. (The terms primary and secondary are purely arbitrary.) The instantaneous values of voltages $e_1$ and $e_2$

$$e_1 = +L_1\, di_1/dt$$
$$e_2 = +M\, di_1/dt$$

Notice that $e_1$ and $e_2$ have the same sign if $M$ is positive. This clearly must be so as a positive current in either coil produces flux in the same direction. The a.c. phasor equations are as follows

$$E_1 = +j\omega L_1 I_1$$
$$E_2 = +j\omega M I_1$$

$E_1$ and $E_2$ are in phase, as shown in Fig. 14(b)

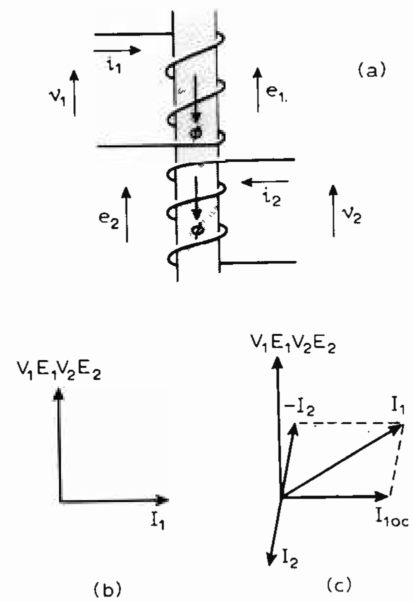



*Fig. 14*

Also for identical coils with maximum coupling $L_1 = L_2 = M$ and thus $E_1 = E_2$

Also

$$V_1 - E_1 = 0 \text{ and } V_2 - E_2 = 0$$
$$\text{Thus } V_1 = +E_1 \text{ and } V_2 = +E_2$$

If the secondary winding was wound in the opposite sense, making the mutual inductance negative, then $e_1$ and $e_2$ would be of opposite sign, and $E_1$ and $E_2$ would be in anti-phase. However, the previous conditions can be restored merely by reversing the positive directions of current and voltages in the secondary winding.

Reversing the positive current direction will restore $M$ to a positive value and thus reverse the sign of $e_2$. But the reversed value of $e_2$ acts in the opposite direction due to the reversal of the positive $e_2$ direction. Thus the answers obtained are still correct.

Now consider the transformer to be carrying a load current $I_2$ due to the connection of an impedance across the secondary terminals. The current $I_2$ is shown in the phasor diagram of Fig. 14(c). $V_2$ and $I_2$ represent a negative power i.e. output power. There will be an additional current $-I_2$ in the primary circuit whose flux cancels that of $I_2$ i.e. always of opposite sign and of equal magnitude i.e. in phase opposition, Fig. 14(c). Otherwise the total flux and also $E_1$ would alter. This cannot be so since $E_1$ is equal in magnitude to $V_1$, the r.m.s. value of which is assumed to be constant. The total primary current is given by

$$I_1 = I_{1oc} + (-I_2)$$

where $I_{1oc}$ is the value of $I_1$ with the secondary open circuited, Fig. 14(b).
$E_1$ and $E_2$ are now given by

$$E_1 = +j\omega L_1 I_1 + j\omega M I_2$$
$$E_2 = +j\omega L_2 I_2 + j\omega M I_1$$

As $L_1 = L_2 = M$ for identical coils and maximum coupling. then

$$E_1 = E_2 = +j\omega L(I_1 + I_2)$$

As $I_1 + I_2 = I_{1oc}$ from the equation above, we see that the values of $E_1$ and $E_2$ are unchanged from the open circuited condition, as already stated.

Now include winding resistances $R_1$ and $R_2$ and leakage inductances $l_1$ and $l_2$. The diagrams will now be as shown in Fig. 15 (a) (b). The two circuit equations will be

$$V_1 - E_{R1} - E_{l1} - E_1 = 0$$
$$V_2 - E_{R2} - E_{l2} - E_2 = 0$$

where

$$E_{R1} = +R_1 I_1 \text{ and } E_{R2} = +R_2 I_2$$
$$E_{l1} = +j\omega l_1 I_1 \text{ and } E_{l2} = +j\omega l_2 I_2$$

Thus

$$V_1 = I_1 R_1 + j\omega l_1 I_1 + E_1$$
$$V_2 = I_2 R_2 + j\omega l_2 I_2 + E_2$$
$$\text{Also } E_1 = E_2 + j\omega L(I_1 + I_2)$$

## Iron losses

Iron losses can be taken into account in the usual way by inserting a suitable resistance across the voltage $e_1$. The phasor representing the no load current is then at an angle less than 90° to the voltage $e_1$.

## Alternative transformer diagrams

The diagrams shown in Fig. 16 show alternative circuit and phasor diagrams as they are often drawn for the transformer. The diagrams also show the conventions which have been assumed, although these are usually not stated at all.

The equations are

$$V_1 = (-E_1) + I_1R_1 + j\omega l_1 I_1$$

$$E_2 = V_2 + I_2R_2 + j\omega l_2 I_2$$

Notice the following points.

- It is assumed that if winding impedances are neglected, the applied voltage and induced e.m.f. in the primary are equal and opposite. In the secondary, induced e.m.f. and terminal voltage are of the same sign. Notice the inconsistency.
- Positive electrical power in the primary is power input; positive power in the secondary is power output.
- As the secondary current $i_2$ and the compensating primary current are equal and opposite, one concludes that a positive current in both windings give fluxes in the same direction. However, this convention is rarely, if ever, stated. As mentioned previously, if it is stated and positive currents are clearly defined, there is no need for the dot convention.

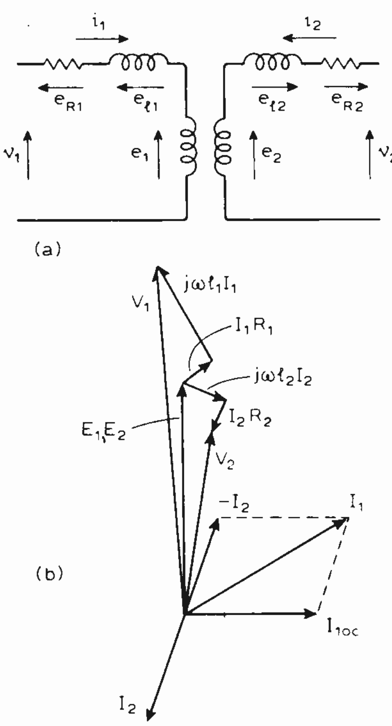



Fig. 15

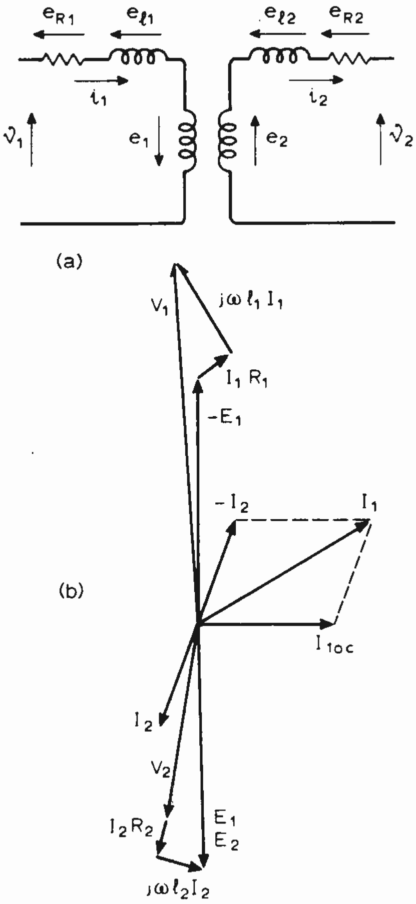



Fig. 16

## General coupled circuit theory

The previous discussion has been concerned with the so-called "pgwer transformer theory." Now consider the general coupled circuit theory using self and mutual inductances.

Refer again to the coupled coil system shown in Fig. 14 (a). The two circuit equations can be written

$$v_1 = i_1R_1 + L_1\frac{di_1}{dt} + M\frac{di_2}{dt}$$

$$v_2 = i_2R_2 + L_2\frac{di_2}{dt} + M\frac{di_1}{dt}$$

For sinusoidal operation, the equations become

$$V_1 = I_1R_1 + j\omega L_1 I_1 + j\omega M I_2 \quad (1)$$

$$V_2 = I_2R_2 + j\omega L_2 I_2 + j\omega M I_1 \quad (2)$$

Let $V_1$ be an applied voltage and let $I_2$ be obtained by connecting an impedance $Z = R + j\omega L$ across the winding.

$$V_2 = ZI_2 \quad (3)$$

Notice that with the positive directions defined as in Fig. 14 (a) a positive voltage applied to $Z$ would give a negative current. Hence the minus sign in equation (3).

Equations (1), (2) and (3) can be solved to give

$$\frac{V_1}{I_1} = R_1 + \frac{\omega^2 M^2}{|Z_S|^2} . R_S + j\omega\left(L_1 - \frac{\omega^2 M^2}{|Z_S|^2} . L_S\right) \quad (4)$$

where

$R_S = R + R_2$, $L_S = L + L_2$, $Z_S = R_S + j\omega L_S$

Also equations (2) and (3) give

$$I_1 = -I_2\frac{(R_2 + j\omega L_2 + Z)}{j\omega M} \quad (5)$$

From equation (5) the phasor for $I_1$ leads $I_2$ by an angle between 90° and 180°. From equations (1), (2), (4) and (5) we can sketch the phasor diagram as shown in Fig. 17. The phasors for $V_1$, $V_2$, $I_1$ and $I_2$ in Fig. 17 would of course be identical to those in Fig. 15.

## Networks with more than one mesh

Fig. 18 shows a more complex network with more than one mesh (three in this case.) The positive directions of the three mesh currents are indicated. Also, the positive directions of the branch currents in the inductances have been indicated to obtain mutual inductance voltage terms correctly. The voltage equation for mesh three is

$$V_1 = R_1I_3 + j\omega L_1(I_3 - I_1) + j\omega M_{13}(I_2 - I_1) + j\omega M_{12}(I_3 - I_2) + j\omega L_2(I_3 - I_2) + j\omega M_{23}(I_2 - I_1) + j\omega M_{21}(I_3 - I_1) - j/C_3$$

The other equations will be obtained similarly.

Before the problem can be completed, the sign of the various mutual inductances must be specified. For example, if a current in the indicated positive direction in $L_3$ produces a positive flux in $L_1$ i.e. a flux in the same direction as a current in the indicated positive direction in $L_1$ would produce, then $M_{13}$ is positive. This information could be given by means of the dot convention, but it should be noted that when there are more than two coils, it may be necessary to use different types of dots for different pairs of coils.

## Electro-mechanical device

In the simple electro-mechanical device shown in Fig. 19, mechanical energy is involved by the movement of the

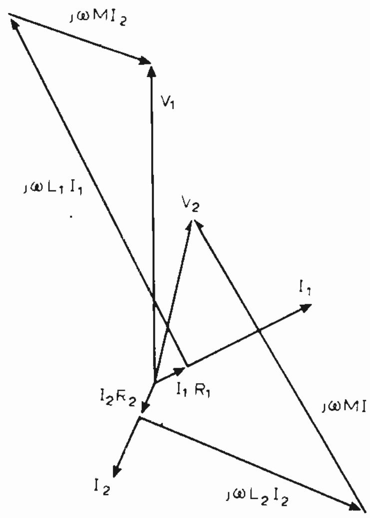



Fig. 17

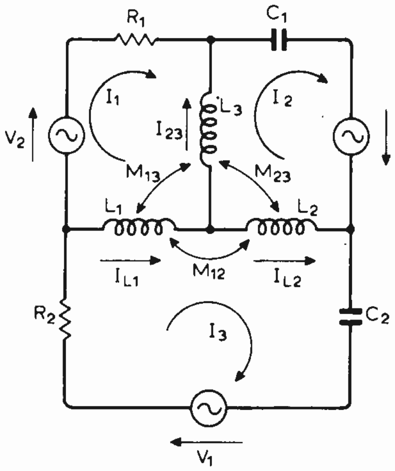



*Fig. 18*

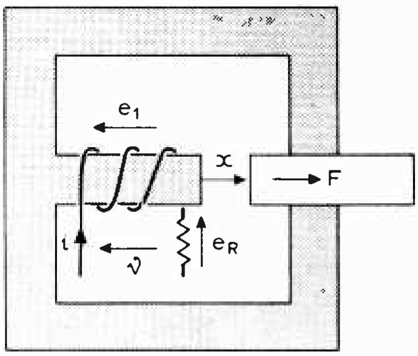



*Fig. 19*

plunger under the action of the electromechanical force on it. The assumed positive directions of the electromagnetic force $F$ and the distance of the plunger from a fixed point x are shown in Fig. 19. Mechanical energy will be produced by the device if the force $F$ moves in the direction of the force i.e. if $F$ and $dx/dt$ are both positive or both negative.

The mechanical power is

$$P_m = F dx/dt$$

Thus a positive value of $P_m$ signifies mechanical power output.

The electrical power input to the coil is

$$P_e = v\,i = i\left(\frac{d}{dt}(Li) + Ri\right)$$

$$= i^2R + iL\frac{di}{dt} + i^2\frac{dL}{dt}$$

The rate of increase of stored energy in the field is

$$P_f = \frac{d}{dt}(\tfrac{1}{2}Li^2) = Li\frac{di}{dt} + \tfrac{1}{2}i^2\frac{dL}{dt}$$

Now if $P_h$ is the energy converted to heat, i.e. $i^2R$, the energy equation is as follows

$$P_e = P_h + P_f + P_m$$

$$i^2R + iL\frac{di}{dt} + i^2\frac{dL}{dt} =$$

$$Li\frac{di}{dt} + \tfrac{1}{2}i^2\frac{dL}{dt} + F\frac{dx}{dt} + i^2R$$

$$F\frac{dx}{dt} = \tfrac{1}{2}i^2\frac{dL}{dt}$$

$$F = \tfrac{1}{2}i^2\frac{dL}{dx}$$

This is a familiar answer, but in which direction is the force? Clearly, from the diagram, $dL/dx$ is negative, i.e. for increase in $x$, $L$ decreases. Also $i^2$ must be positive. Therefore $F$ must be negative, i.e. in the direction such as to close the gap.

## Summary

If the positive directions of all quantities are clearly defined, writing and solving the equations of any electrical network or electromechanical device is straightforward and no confusion should arise. The procedure is summarized below.

- Indicate chosen positive directions of currents.
- Indicate positive voltage directions by arrows (heads positive). The branch of the network will be as shown in Fig. 20 (a) or (b).
- note the meaning of positive power. In Fig. 20 (a) positive power is dissipated power. In Fig. 20 (b) positive power is generated power.
- If a branch of the network contains an impedance $Z$, we have

$V_Z = +ZI$ Fig. 20 (a)
or $V_Z = -ZI$ Fig. 20 (b)
where $Z$ is $R$ or $j\omega L$ or $-j/\omega C$ for a.c. sinusoidal conditions.

- For circuits with magnetically coupled coils, determine the algebraic sign of all mutual inductances with reference to the chosen positive current directions in the inductances.

$V_Z' = +Z'I'$ using the system of Fig. 20 (a)
or $V_Z' = -Z'I'$ using the system of Fig. 20 (b)

where $Z = \omega M$ and $M$ is the mutual inductance between the impedance across which $V_Z'$ exists and an impedance in another branch carrying a current $I'$.

- The electrical network equations can now be written.
- For mechanical devices, define positive directions of force, position, speed, etc and note the significance of positive mechanical power, i.e. input power to the device or output power.

The results of calculations will now give the correct signs and thus directions of all quantities.

(a)

(b)

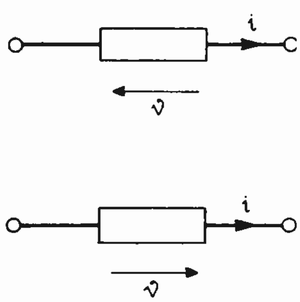



*Fig. 20*

## Books Received

**Control Technology — pupils' assignments** and **follow-up sheets** are two tutotial books aimed at pupils who are taking science subjects. The first publication deals with mechanics and electronics projects, the second book is a progression from the first with the same subjects being dealt with in more detail. Price £1.80 each. Pp.108 and 150. The English Universities Press Ltd, Saint Paul's House, Warwick Lane, London EC4V 4AH.

**Small Appliance Repair Guide Vol. 2** by Leo G. Sands, **4 Channel Stereo from Source to Sound** by Ken Sessions, **Practical Circuit Design for the Experimenter** by Don Tuite, and **Basic Digital Electronics** by Ray Ryan. Tab Books, Blue Ridge Summit, Pa.17214, U.S.A.

**Wideband Voltage Amplifiers** by C. W. Davidson, is a soft-back handbook which explains the design procedure of amplifiers operating from d.c. to tens of MHz. Basic principles and circuits, feedback, input/output stages, and high gain amplifiers are dealt with in six chapters, a concluding section covers applications of high gain d.c. amplifiers. Price £1.95, Pp.112. Intertext Publishing Ltd, 158 Buckingham Palace Road, London SW1W 9TR.

**Electrical Installations and Regulations** by Michael Neidle is intended to assist students studying for the City & Guilds electrical installation work, (No. 235) course B certificate. The Macmillan Press Ltd, 4 Little Essex Street, London, W.C.2.

A Review of the Principles of Electrical and Electronic Engineering Vol.4 — **Microwaves, Communications and Radar** edited by L. Salymar. Six chapters by four authors discuss microwaves, aerials, communication theory, noise, communication systems and radar. The book is suitable for students or those interested in the above topics and contains formulae and diagrams where applicable. Price £2.50. Pp.190. Chapman & Hall Ltd, 11 New Fetter Lane, London EC4P 4EE.

# High-stability VHF receiver

The 1990R Series of Eddystone General Purpose VHF Receivers provides reception facilities for AM, FM, CW and pulse transmissions.
Model 1990R/1 covers the band 25-235MHz. Model 1990R/2 has additional ranges extending the coverage to 25-500MHz.

All 1990R receivers are equipped for high-stability working with either a synchroniser (illustrated) or a 10-channel crystal facility. Provision is also made for operation with externally derived oscillator signals as an alternative to continuous tuning with the free-running local oscillator.

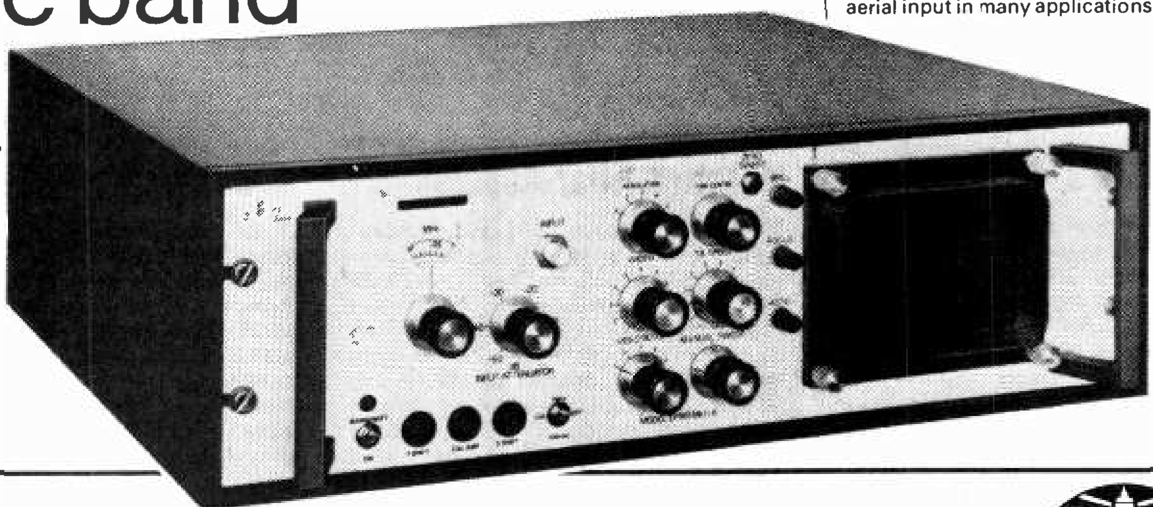
**Eddystone Radio Limited**
Member of Marconi Communication Systems Limited
Alvechurch Road, Birmingham B31 3PP, England
Telephone: 021-475 2231 Telex: 337081
A GEC-Marconi Electronics Company

WW—004 FOR FURTHER DETAILS

# A clear view of the band

Eddystone EP961 MkII Panoramic Display Units provide visual monitoring of all signals in a selected band.
MkII-A is tunable from 50kHz to 800kHz, matching the IFs used in MF and HF communication receivers.

MkII-B covers 500kHz to 36·5MHz. It is ideal for use with VHF and UHF receivers for monitoring FM broadcasts and communication transmissions, and its usefulness extends into the laboratory field.
Both versions can be used with direct aerial input in many applications.



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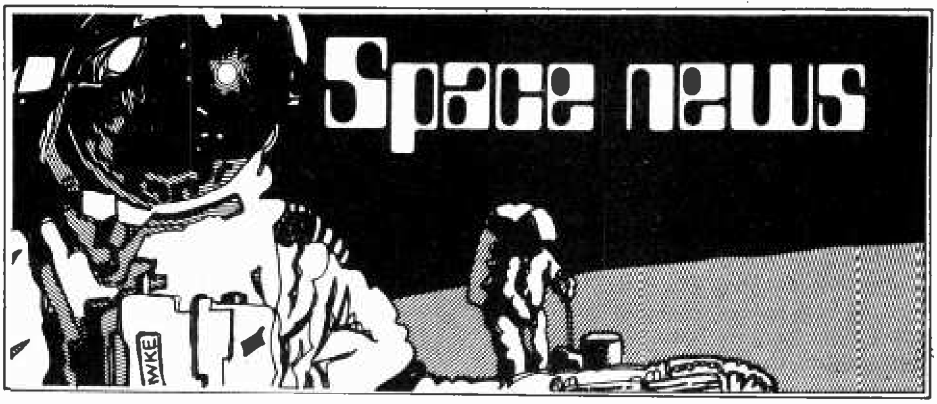



## Last Intelsat IV launch

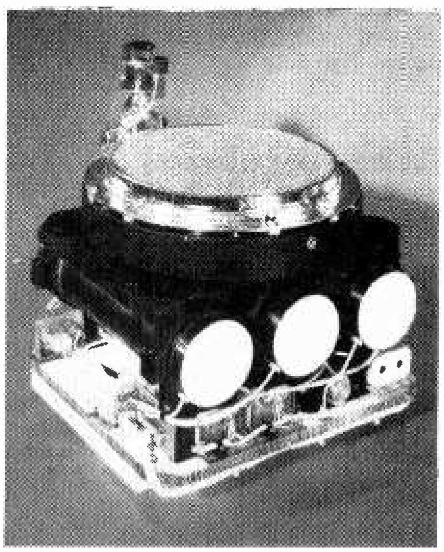
The seventh link in the current chain of global communications satellites now ringing the Earth was launched earlier this year from Cape Canaveral, USA. The 3,000-pound satellite was launched towards a 22,300-mile-high synchronous orbit to become the second such spacecraft over the Indian Ocean. Operation of the satellite segment of the Intelsat-owned system is conducted by the Communications Satellite Corporation. Comsat said that each satellite has an average use of 4,000 telephone circuits or a capability of providing 12 television channels, or various combinations of telephone, television and data transmissions. The current Intelsats are the fourth and largest generation of communications satellites since Early Bird (Intelsat I) joined Western Europe and the United States with telephone and television service ten years ago. Since 1965 trans-oceanic telephone traffic has grown from an estimated three million calls a year to more than 50 million in 1974, a steady growth rate of 20 per cent annually. To handle the predicted growth, Hughes, under contract to Intelsat, is building a new generation of satellites called Intelsat IVA. Six spacecraft are under construction. The first in the series is scheduled to be launched from Cape Canaveral this summer for service over the Atlantic Ocean.

## Communications satellite moves to India

The largest and most powerful communications satellite ever built was moved a third of the way around the globe early in June to place it in a position for an instructional television experiment involving several thousand villages in India. NASA's Applications Technology Satellite-6 was launched into a geosynchronous orbit on May 30, 1974 and has since been used in the experimental tracking of spacecraft, ships and aircraft and also in the use of satellite television for education and even medical diagnosis. The satellite provided one communications link during the US-Soviet Apollo Soyuz test project. After ATS-6 arrived at its new station about July 1, it was checked out prior to use in mid-July to track the Apollo and Soyuz spacecraft and to relay television and data from the orbiting spacecraft to Earth. This was the first time that a satellite had been used to relay television from a manned spacecraft to the planet's surface.

The satellite move was designed to bring it within range of India for the Satellite Instructional Television Experiment, scheduled to be formally inaugurated on August 1. The experiment is a joint effort by NASA and the Indian Space Research Organization. In this experiment, the spacecraft will be used by the Indian Government to relay daily TV programmes to 5,000 villages and cities in seven states through India. About half the villages will be equipped with TV sets augmented by converters and small antennas to receive the television signal after it is rebroadcast from a ground terminal in the area. Following the year-long experiment in India, the satellite will be returned to a position in range of the USA for further experimental use.

*Rotation modulation collimator, Experiment A, on board Ariel 5, the Science Research Council's X-ray astronomy satellite, was an experiment to accurately determine the positions of cosmic X-ray sources. The accuracy in determining the position of a source is limited by counting statistics and accuracy in the knowledge of the satellite's pointing position, which can be determined by the experiment itself if an already well determined source is in the field.*



## ASTP's ranging system

The v.h.f. ranging system for the Apollo Soyuz Test Project used the Command Module and Soyuz v.h.f. link to provide a ranging capability of 200 nautical miles with ±250 feet accuracy. The system consists of a Lunar Module v.h.f. set, a command module v.h.f. set, a Lunar Module Ranging Tone Transfer Assembly (RTTA) and Command Module Digital Ranging Generator (DRG) from the Apollo programme. The Lunar Module v.h.f. sets and Ranging Tone Transfer Assemblies were installed in the Soyuz.

## European Space Days

Approximately 200 people from 30 countries including Algeria, Brazil, Canada, India, Iran and Nigeria participated in the European Space Days, May 27-29, organized at the European Space Research and Technology Centre, Noordwijk, Netherlands. The aim was to demonstrate Europe's space capability to an invited audience representing telecommunications authorities and other users of space systems.

Speaking at the presentation of European space programmes, the Secretary General of the International Telecommunications Union, Mr M. Mili, said that the ITU welcomed and encouraged Europe's firm intention to play an important role in the peaceful uses of outer space. He believed that the programmes of the new European Space Agency offered a particularly well-chosen range of satellites for research and for applications of unquestionable value. The Secretary General of Eurospace, Mr Y. Demerliac, recalled that since 1962 Europe had developed 43 satellites, including four for telecommunications and/or television. European industry had built 36 of the 104 ground stations or antennas of the Intelsat network, and had sold more than two-thirds of these to non-European countries.

# World of Amateur Radio

## Less television interference

The latest television and radio interference complaints report from the Home Office Radio Regulatory Department — covering 1974 — shows a marked decline in the total of all complaints (—21.7% to 48,371) and also in those ascribed to amateur radio transmitters (—26.6% to 886). This is the first time for many years that the number of complaints traced to amateur operation has fallen below a thousand: l.w./m.w., 75; Band 1, 140; Band 2, 71; Band 3, 108; Bands 4-5, 480; mobile services, 12. The biggest decline is in complaints to v.h.f. television which are down by over a half, with u.h.f. complaints holding fairly steady. Part of the credit must go to the television industry which at last seems to be making efforts to design u.h.f. domestic receivers reasonably immune to strong local signals. Indeed, if only television sets did not radiate so many harmonics from line timebases and switched-mode power supplies it seems that real progress could be made in bringing viewers and amateur radio into a happy relationship.

## SOE's suitcase sets

Still to be heard on the amateur bands are numbers of the B2 suitcase sets produced during the war for the Special Operations Executive (later part of Special Forces) the British "cloak and dagger" organisation set up in July 1940. SOE's appointed task, until it disbanded in 1946, was to co-ordinate and initiate subversive and sabotage activities against the enemy and its Signals Directorate was responsible for providing clandestine radio links into Europe and elsewhere, independently of the secret Intelligence radio circuits.

Many of the SOE signals people were, or later became, radio amateurs, including some of the base station operators who were often girls recruited into FANY.

Sir Colin Mc V. Gubbins has claimed that the most valuable link in secret operations were the agents with h.f. c.w. sets — "without these links we would have been groping in the dark." Tragically such communications were extremely vulnerable to enemy interception and "funkspiel" radio games, such as the German North Pole operation in Holland, and much of SOE's later signals work was in developing techniques to speed up communications to counter the highly organised D/F teams. They also produced many methods of charging batteries in the field including the "beach chair" pedal generator, bicycle generators, wind generators and even portable steam-driven generators and thermocouple chargers.

At the recent 30th anniversary dinner of the Special Forces Club, at which Prince Charles was guest of honour, a display was staged on the theme of communications. Codes and signal plans were provided by Leo Marks; 450MHz S-phone equipment, originally conceived in 1941 by the late Bert Lane, was shown by Flt Lt Charles Bovill; and suitcase sets and MCR1 miniature communications receivers by Major John Brown, G3EUR, who was largely responsible for the development of the A2, A3, B1, B2, B3 and MCR1 equipments.

## Sun shines on 28MHz

Mid-summer in a sunspot minimum year is not the most likely time for transatlantic 28MHz openings: the exception that proves the rule that you can never be sure was the evening of July 4. K3NPV was so surprised at what he found on "ten" that he changed to 21MHz and sent out a "QST" message: "28MHz is wide open to Europe," as indeed also was 21MHz. By that day Mike Matthews, G3JFF of Portsmouth, had already worked 28 countries on 28MHz this year and even when the F layer is reluctant to bounce back 28MHz signals, Sporadic E can provide useful contacts. Early July was also a good period for v.h.f. propagation with the Gibraltar beacon reported heard in London on July 2 and Danish stations worked through the London GB3LO repeater on July 5.

## When portable is fixed

My dictionary defines "portable" as "movable (article), convenient for carrying" but it seems the Home Office is having semantic problems over this: suddenly it has become hot and bothered about amateurs using hand-held equipment "while walking." In a curious decision it has pronounced that the operation of such equipment is at present covered neither by the normal licence (which permits "portable" operation) nor by the amateur (sound mobile) licence; walking use of equipment is therefore being sanctioned by a special letter of authorisation to the mobile licence. This means amateurs will need the extra mobile licence to exercise this facility: presumably if you stand still you are working "portable" but if you move while transmitting you become a "pedestrian mobile." It seems a little like the old regulation that allowed the young ladies at the Windmill Theatre to appear in the altogether only so long as they maintained a rigid pose, and presumably the Home Office is now tackling the problem of how many amateurs can transmit while dancing on a pin head.

## In brief

Honorary secretary of the Radio Amateur Invalid and Bedfast Club, is now Mrs Rita Shepherd, G3NOB, 59 Pantain Road, Loughborough, Leics, LE11 3LZ.... With five 144MHz repeater stations now operational in the UK the FM Group London reports that additional stations are being planned for Martlesham, Suffolk; Barnsley, Yorkshire; Black Hill near Glasgow; Buxton, Derbyshire; Luton, Beds (432MHz); Bacton, Norfolk; Cambridge (432MHz); Newquay, Cornwall; Aberdeen; Birmingham; and Carmel, Dyfed. The Carmel repeater hopes to use the callsign GB3WW which some readers recall was used from the *Wireless World* offices at Dorset House in connection with the journal's 60th anniversary during April 1971.... At Kingston-upon-Thames Magistrates Court an amateur recently pleaded guilty to causing interference and using a station for wireless telegraphy without a licence in connection with interference to the London repeater station GB3LO.... September mobile rallies include those at Peterborough (Walton School) on September 21; Castle Grounds, Antrim on September 21; and Netteswell School, Harlow on September 28.... Paid up membership of the British Amateur Radio Teleprinter Group is almost 350 of which about 230 hold British callsigns and some 100 British r.t.t.y. stations are active on 144 MHz.... An amateur 625-line PAL colour television station with an effective radiated power of 12kW (vision) and 600 watts (sound) is being operated daily in Sydney, Australia by Vic Barker, VK2ZVV/T and Ian MacKenzie, VK2ZIM/T with a vision frequency of 442.3MHz and a 64-element phased array aerial.... The GB3SN repeater at Four Marks, Hampshire is now fully operational on 145.125MHz input, 145.725MHz output. Coverage extends from Devon to Kent and north into Wales and Cambridge. The station is run by the UK FM Group (Southern) and the transmitter has an e.r.p. of 70 watts from aerials 250 metres above sea level (access tone 1750Hz for 0.5s followed by callsign).

PAT HAWKER, G3VA

# New Products

## Temperature protection unit

A temperature protection unit designed for use with positive temperature coefficient thermistors (to BS4999) and intended for the protection of electric motors, has been introduced by ITT. The thermistors are embedded in the winding of motors and electrically connected to the ZK1 unit which is mains powered and has a switching capability up to 2.2kVA at 240V a.c. ITT Components Group Europe, Thermistor Division, Stephen Street, Taunton, Somerset.

**WW 310 for further details**

## Adhesive cable clips

A small adhesive cable clip measuring about two cm square will secure a bundle of cables up to five cm diameter and support up to 55g. To fix the clip a backing paper is removed and the mount is pressed onto the required surface which must be clean, dry and smooth. Panduit Ltd, Sittingbourne Industrial Park, Unit 22a, Crown Quay Lane, Sittingbourne, Kent.

**WW 302 for further details.**

## Desoldering gun

The Ersa Vac 40 is a de-soldering gun that operates by melting the solder and "sucking up" the molten metal via a regulated vacuum. A separate mains-powered power/vacuum supply is provided and the total power consumption is around 50W. Greenwood Electronics, Portman Road, Reading RG3 1NE.

**WW 303 for further details**

## Ten-turn potentiometer

A ten-turn potentiometer, model 3541, uses a new composite called Hybriton which combines a wirewound and conductive plastics element. The makers say this provides a potentiometer with long life, infinite resolution, and a low temperature coefficient. The component is available with resistances from 1 to 100kΩ, has a linearity within ±0.25%, and a resistance tolerance of ±10%. Bourns (Trimpot) Ltd, Hodford House, 17 High Street, Hounslow, Middx TW3 1TE.

**WW 305 for further details**

## Charge-coupled image sensor

The SID51232 from RCA is a 512 × 320 element silicon image sensor which can replace conventional TV camera tubes. This sensor is a self-scanned device based on c.c.d. technology and is claimed to be the first solid-state image sensor to generate standard 525-line video, compatible with existing TV monitors and accessories. The sensor is supplied in a hermetically-sealed, 24-connexion ceramic package containing an optical glass window. RCA Electro-Optics & Devices Division, Lincoln Way, Sunbury-on-Thames, Middx. (See August issue, p.362).

**WW 317 for further details**

## High-voltage resistors

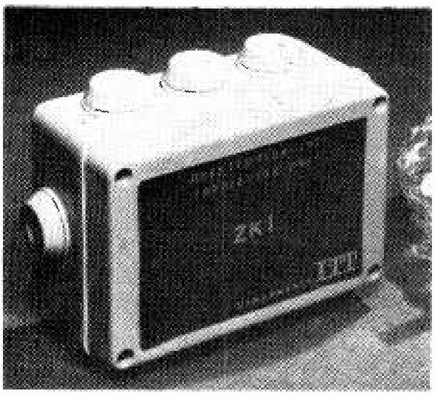
Mullard has introduced a new range of metal-glaze resistors which will withstand 10kV d.c. at power levels up to 1W. Resistance values extend from 1 to 68MΩ with a tolerance limit of ±5%, and resistance stability of typically less than 1% change after 1000 hours at 0.5W in an ambient temperature of 70°C. Mullard Ltd, Mullard House, Torrington Place, London WC1.

**WW 304 for further details**

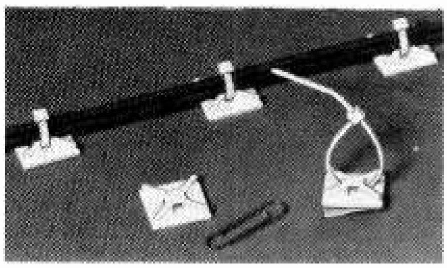
## F.m. - receiver filters

The Toyocom TQF 2599/3079 and QN 0071 are claimed to be the lowest price crystal-filters available for broadcast-band stereo f.m. receivers. The filters are designed to be used in pairs — one being separated from the other by an isolating amplifier stage. In this configuration the filters provide a 3dB bandwidth of 120kHz either side of the 10.7 MHz i.f., with the —70dB point at around ±300kHz. Walmore Electronics Ltd, 11 Betterton Street, London WC2H 9BS.

**WW 309 for further details**




WW310



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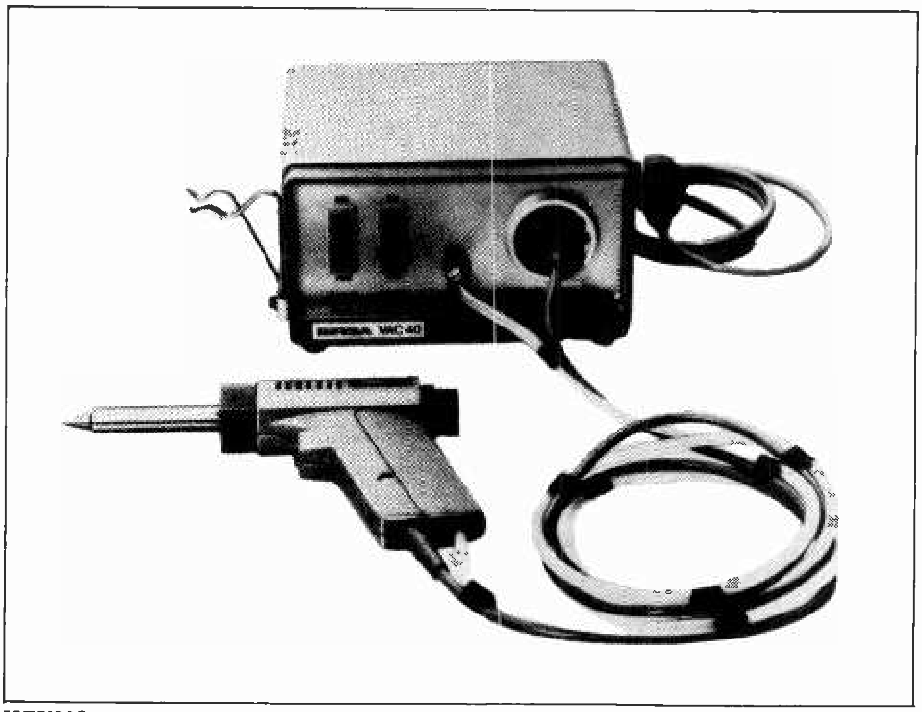



WW303

## Micromotors

The Escap 23D series of motors comprises the 23D21-216 and 23D21-213 which offer a mechanical time constant of 10ms; moments of inertia of 5.80 and 4.45 x $10^{-7}$ kgm$^2$ respectively; starting torques of 295 and 245 x $10^{-4}$ Nm respectively. The motors, which are claimed to have an efficiency of around 80%, operate from 12 and 15V, have outputs of 3.8 and 3.4W with no-load speeds of 4900 and 5250 rev/min. Portescap (UK) Ltd, 204 Elgar Road, Reading, RG2 0DD.

**WW 301 for further details**

## Capacitors

A range of miniature metalized plastic-film capacitors designated type MKM are manufactured by Siemens. Components are cut from a "mother" capacitor of known value, in this way a uniformity of electrical characteristics is achieved. Ratings are 0.01 to 0.68μF at 100V d.c., and 0.1, 0.15 and 0.22μF at 250V d.c. LST Electronic Components Ltd., Victoria Road, Chelmsford, Essex.

**WW 311 for further details**

## Magnetic cartridge

Condor Electronics are now marketing the Tenorel T2001 magnetic cartridge. This is a low priced unit (£5.45 excluding VAT) which is claimed to equal the performance of cartridges such as the Shure M75/B, the Philips GP400, and the Goldring G820. Manufacturers specifications for the device are: frequency response 15Hz to 25kHz; separation more than 25dB at 1kHz; output 5.5mV at 1kHz and 5cm/s; tip mass 1mg; and a playing weight of between 1½ and 3 grammes. Condor Electronics Ltd, 100 Coombe Lane, London SW20 0AY.

**WW 314 for further details**

## Logic-state analyzers

The model 1600A is a self-contained analyzer incorporating a c.r.t. which can display a 16-channel sequence of data in word form using the 1 and 0 format. A model 1607A does not have a c.r.t., but provides both analogue and digital outputs. These analogue outputs can be used to convert most oscilloscopes, with d.c. coupled X, Y and Z inputs, into an analyzer display. If the two models are combined a 32-channel display can be achieved with both units capable of operating at clock speeds up to 20MHz. If used separately, the instruments may operate with different clock rates and the two displays can be compared using an exclusive-OR comparison. Hewlett-Packard Ltd, King Street Lane, Winnersh, Wokingham, Berks RG11 5AR.

**WW 315 for further details**

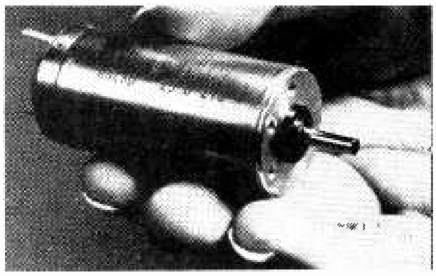
## F.m. intercom

A frequency-modulated intercom system provides speech communication by transmitting through the 240V a.c. mains supply lines. Once the stations are located and connected to the supply the system will transmit up to distances of around 1 km provided that both stations are plugged into the same power line. Hadley Sales Services, 112 Gilbert Road, Smethwick, Warley, West Midlands B66 4PZ.

**WW 313 for further details**

## Transient generator

The model 510 is a transient generator which produces signals that comply with the I.E.E.E. standards for surge



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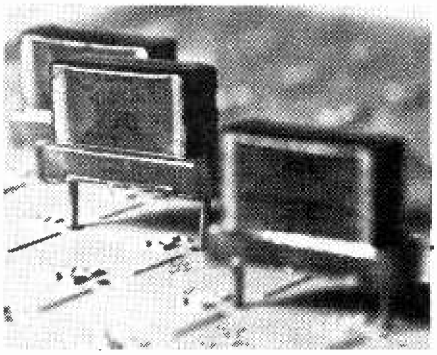

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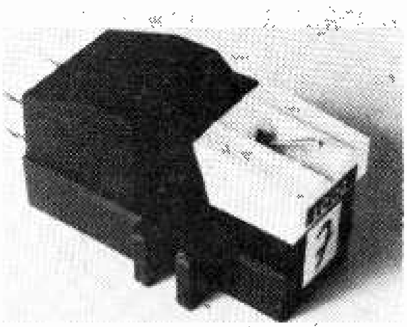

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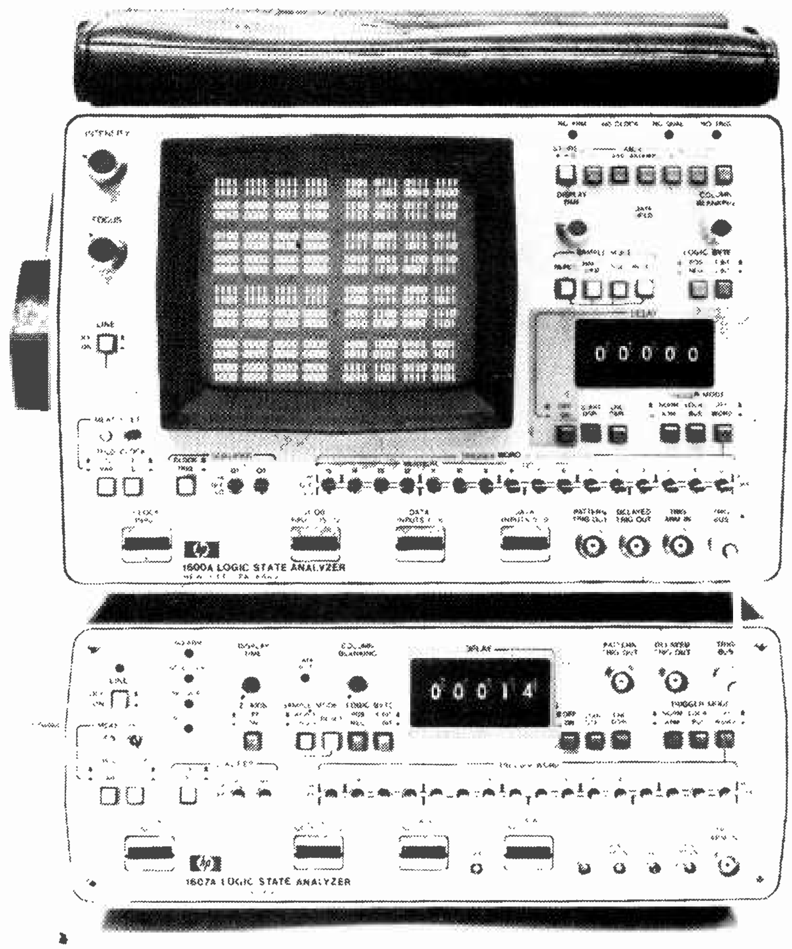



WW315

capability tests. The instrument provides bursts of damped sine waves with amplitudes adjustable up to 2.5kV and 50% decay times around 6μs. The bursts can be single-shot, free running, or synchronized to mains frequency. Nominal frequency of the sinewave oscillator is 1.25MHz and the output is available at selectable impedances of 100, 150, 600 or 1200 ohms. Euro Electronic Instruments Ltd, 27 Camden Road, London NW1 1YE.
**WW 306 for further details**

## Circular-chart recorder

A circular-chart recorder that offers radial recording of information has a 10in diameter chart and can be equipped with up to three pens. The recorder is fitted with a stepping-motor servo system which is claimed to provide high accuracy without overshoot. Rotational speeds of the instrument are one revolution every 8, 12 or 24 hours. Full scale response is 0.8s from any input between 50 and 300mV and any direct current from 100μA to 100mA or alternating current from 250μA to 500mA, selectable by plug-in cards. These ranges may be extended by means of external shunts/current transformers. Boyle Industrial Gauging Systems Ltd, Burch Road, Northfleet, Kent DA11 9NE.
**WW 307 for further details**

## Low-current scanner

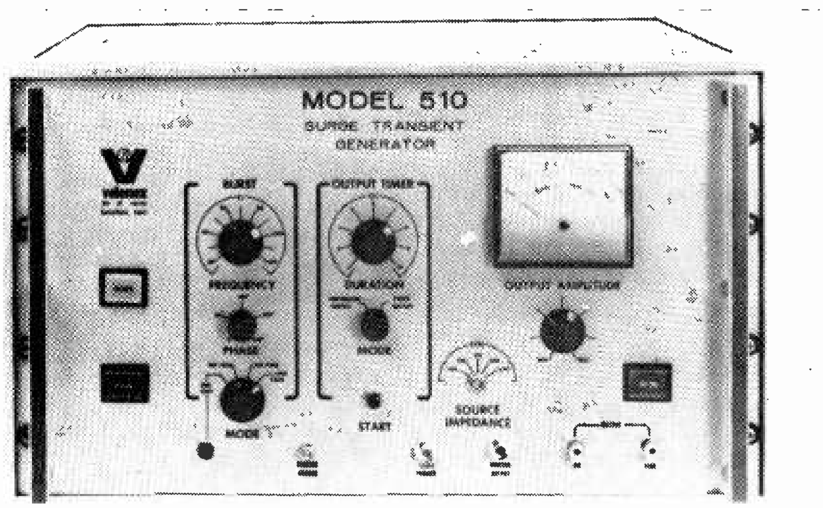
Keithley Instruments have introduced a low-current scanner designed for switching currents from picoamperes to tens of milliamperes. The unit provides ten channels of single-pole switching; channels not connected to the output are grounded to complete current paths. Front panel controls of the scanner permit either manual channel selection or automatic sequential scanning. The automatic scan rate is variable from 10 channels per second to 1 channel per ten second. Keithley Instruments Ltd, 1 Boulton Road, Reading, Berks.
**WW 316 for further details**

## Batteries

The range of batteries known as Wonder Top are individually stamped with the stated shelf-life which is up to two years at 19°C. The batteries have a plastic cap and a protective cover over the positive terminal. The cap can be unscrewed for testing and overscrewed, breaking off the cover, for installation. The batteries, which are suitable for instrumentation, are priced at between 9 and 25p depending on quantity and type, and are available from West Hyde Developments Ltd, Ryefield Crescent, Northwood, Middx HA6 1NN.
**WW 308 for further details**

## Microphone calibrator

A high pressure microphone calibrator, type 4221, consists of a pressure exciter with piston, a high-pressure coupler and a low-frequency coupler. It provides a frequency range up to 1kHz and down to 0.001Hz with the two couplers respectively. Due to a high ratio between the mass of the exciter body and the mass of the moving element (150:1) and the small piston amplitude the vibration level at the microphone is small which, say the manufacturers, can be an important feature. B & K Laboratories Ltd, Cross Lances Road, Hounslow, Middlesex.
**WW 312 for further details**




WW306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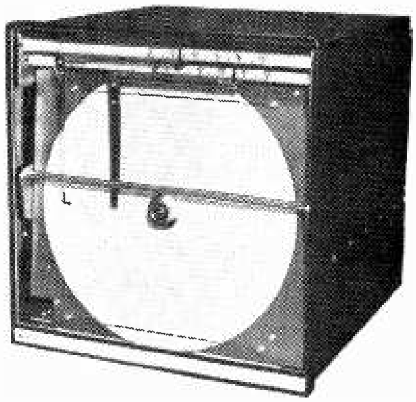
WW308



WW307

# Solid State Devices

**Names of suppliers of devices in this section are given in abbreviation after each entry and in full at the end of the section.**

## Vertical deflection i.c.

All the functions of a colour TV receiver vertical deflection system — oscillator, voltage ramp generator, pre-amplifier and power amplifier — are available from the TDA 1270 i.c. The chip is housed in a 12-pin dual in-line package and operates from supplies up to 40V.

**WW351 for further details** **SGS ATES**

## Microcomputer

A p-channel single m.o.s.-chip microcomputer contains an 8192-bit read-only memory programming, a 256-bit random-access memory for data storage, and a 4-bit binary arithmetic and logic unit. The chip, TMS1000, also has an oscillator activated by an external resistor and capacitor which, at a nominal frequency of 500kHz, provides an instruction cycle time of 12$\mu$ s.

**WW352 for further details** **Texas**

## Blue/u.v. photodetectors

A new series of photodiodes offer a spectral response between 250 and 550nm. The three devices in the range are planar diffused, oxide passivated silicon diodes with a response time of 0.5$\mu$s.

**WW353 for further details** **Techmation**

## Variable shift register

The MC14557CP is a 1 to 64 bit c.m.o.s. variable length shift register that can be used for variable digital delay lines or to produce an odd length shift register. The device can operate at 8MHz from a 10V supply in the temperature range —40 to +85°C.

**WW354 for further details** **GDS**

## Hall-effect switches

Two Hall-effect solid state switches designated ULN3006 and UL3006T are now available housed in transistor packages. The devices consist of a silicon Hall generator, amplifier, trigger and output stage integrated with a voltage regulator on a monolithic chip. The former device has an operating temperature range from 0 to +70°C while the latter switch operates in the range from -40 to +150°C.

**WW355 for further details** **Sprague**

## Variable frequency source

The MC14411 c.m.o.s. generator provides 16 clock frequencies which are available simultaneously. The device contains a crystal oscillator, a programmable rate-select circuit, and divider chains. When connected to a 1.8432MHz ±0.05% crystal, 14 frequencies from 75Hz to 9600Hz are produced. The oscillator frequency and a signal at half the crystal frequency provide the other two outputs.

**WW356 for further details** **Motorola**

## Interface i.c.

AMI Microsystems have introduced the S1883 — a single chip m.o.s./l.s.i. universal asynchronous receiver/transmitter. The device is capable of transmitting and receiving in full duplex mode at data rates up to 12.5k baud.

**WW357 for further details** **AMI**

## 240V transistor

The type BUX80 power transistor is designed for use in high-frequency switched-mode power supplies operating from a 240V mains supply. A glass passivation construction is used in the transistor which is rated at 100W with a $V_{CEO}$ of 400V.

**WW358 for further details** **Mullard**

## 16K r.o.m.

The RO-3-8316A is a high yield 8-bit word read-only memory which costs about £6 and is for use with microprocessors. The device operates from a single 5V supply and offers an access time of 850ns with a power dissipation of around 200mW.

**WW359 for further details** **G.I.**

## Fast recovery rectifiers

A range of axial lead silicon power rectifiers from Semtech offer a 30ns reverse recovery time. The devices are claimed to be 98.5% efficient and are available with current ratings from 0.5 to 10A and p.i.v. ratings up to 150V.

**WW360 for further details** **Bourns**

## 275V f.e.ts

A new family of junction f.e.ts with interchangeable sources and drains have a guaranteed minimum breakdown voltage of 275V.

**WW361 for further details** **Siliconix**

## Audio amplifier

An audio amplier packaged in a SOT32 type case will deliver 10W into 4Ω with a distortion figure of under 1% at 7W. The circuit incorporates frequency compensation and requires one external capacitor for complete stability.

**WW362 for further details** **Texas**

## Count/display i.c.

Ferranti have recently added the 2N1040E to their range of i.cs. This device is a universal count/display circuit that can be adapted to drive most types of display. The chip uses the collector diffusion isolation technique and can count from 0 to 5MHz in a forward or reverse direction.

**WW363 for further details** **Edmundson**

## Telephone i.cs

Plessey Semiconductors has introduced two i.cs for telephone applications, the MP9100 push-button telephone dialler and the MP9200 repertory telephone store. The 9100 is a p-channel low threshold m.o.s. circuit containing the logic required to interface between a standard keyboard and a Strowger type telephone system.

The 9200 uses a similar construction and contains the logic and storage capability to form a self-contained repertory telephone number store of up to ten 22-digit numbers. The two devices can be used together to form a complete repertory dialling system.

**WW364 for further details** **Plessey**

**SGS-ATES (UK) Ltd,** Planar House, Walton Street, Aylesbury, Bucks, HP21 7QN.
**Texas Instruments Ltd,** Manton Lane, Bedford.
**Techmation Ltd,** 58 Edgware Way, Edgware, Middx HA8 8JP.
**GDS Sales Ltd,** Michaelmas House, Salt Hill, Bath Road, Slough, Bucks.
**Sprague Electric (UK) Ltd,** 159 High Street, Yiewsley, West Drayton, Middx.
**Motorola Ltd,** Semiconductor Products Division, York House, Empire Way, Wembley, Middx.
**AMI Microsystems Ltd,** 108A Commercial Road, Swindon, Wiltshire.
**Mullard Ltd,** Mullard House, Torrington Place, London WC1.
**General Instrument Microelectronics Ltd,** 57 Mortimer Street, London W1N 7TD.
**Bourns (Trimpot) Ltd,** Hodford House, 17 High Street, Hounslow, Middx TW3 1TE.
**Siliconix Ltd,** 30a High Street, Thatcham, Berks RG13 4JG.
**Edmundson Electronic Components Ltd,** 30 Ossory Road, London SE1 5AN.
**Plessey Semiconductors,** Cheney Manor, Swindon, Wilts SN2 2QW.

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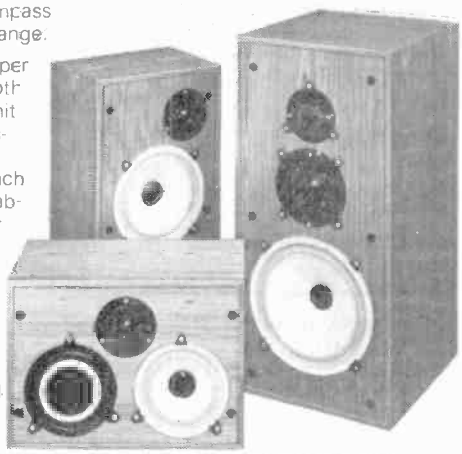

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WW—097 FOR FURTHER DETAILS W3

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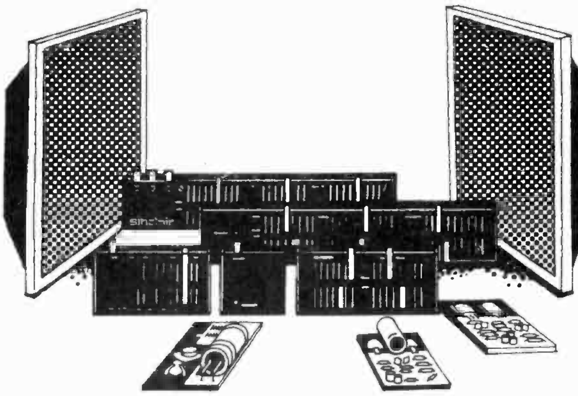
# Sinclair Project 80



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| CA3048 | 2.11 | CD4049 | 0.81 | SL620C | 2.60 | SN7460 | 0.16 | SN74164 | 2.01 |
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| CA3090Q | 4.23 | LM308 | 2.50 | SL640C | 3.10 | SN7473 | 0.36 | SN74174 | 1.25 |
| CD4000 | 0.36 | LOO5TL | 1.50 | SN7400 | 0.16 | SN7474 | 0.36 | SN74175 | 0.90 |
| CD4001 | 0.36 | LM380 | 1.10 | SN7401 | 0.16 | SN7475 | 0.50 | SN74176 | 1.44 |
| CD4002 | 0.36 | LM381 | 2.20 | SN7401AN | 0.38 | SN7476 | 0.35 | SN74180 | 1.40 |
| CD4006 | 1.58 | LM702C | 0.75 | SN7402 | 0.16 | SN7480 | 0.50 | SN74181 | 1.95 |
| CD4007 | 0.36 | LM709 | 0.38 | SN7403 | 0.16 | SN7481 | 1.25 | SN74190 | 2.30 |
| CD4008 | 1.63 | 8DIL | 0.45 | SN7404 | 0.19 | SN7482 | 0.75 | SN74191 | 2.30 |
| CD4009 | 1.18 | 14DIL | 0.40 | SN7405 | 0.19 | SN7483 | 0.95 | SN74192 | 1.15 |
| CD4010 | 1.18 | LM710 | 0.47 | SN7406 | 0.45 | SN7484 | 0.95 | SN74193 | 1.15 |
| CD4011 | 0.36 | LM723C | 0.90 | SN7407 | 0.45 | SN7485 | 1.25 | SN74196 | 1.60 |
| CD4012 | 0.36 | LM741C | 0.40 | SN7408 | 0.19 | SN7486 | 0.32 | SN74197 | 1.58 |
| CD4013 | 0.66 | 8DIL | 0.40 | SN7409 | 0.22 | SN7490 | 0.45 | SN74198 | 2.25 |
| CD4014 | 1.72 | 14DIL | 0.38 | SN7410 | 0.16 | SN7491 | 0.85 | SN74199 | 2.25 |
| CD4015 | 1.72 | LM747 | 1.05 | SN7411 | 0.25 | SN7492 | 0.45 | SN76003N | 2.92 |
| CD4016 | 0.66 | LM748 | 0.60 | SN7412 | 0.28 | SN7493 | 0.45 | SN76013N | 1.95 |
| CD4017 | 1.72 | LM14DIL | 0.73 | SN7413 | 0.35 | SN7494 | 0.82 | SN76023N | 1.60 |
| CD4018 | 2.55 | LM3900 | 0.70 | SN7416 | 0.35 | SN7495 | 0.72 | SN76033N | 2.92 |
| CD4019 | 0.86 | LM7805 | 2.00 | SN7417 | 0.35 | SN7496 | 0.75 | TAA263 | 1.10 |
| CD4020 | 1.91 | LM7812 | 2.50 | SN7420 | 0.16 | SN74100 | 1.25 | TAA300 | 1.80 |
| CD4021 | 1.72 | LM7815 | 2.50 | SN7423 | 0.29 | SN74107 | 0.36 | TAA350A | 2.10 |
| CD4022 | 1.66 | LM7824 | 2.50 | SN7425 | 0.29 | SN74118 | 1.00 | TAA550 | 0.60 |
| CD4023 | 0.36 | MC1303L | 1.50 | SN7427 | 0.29 | SN74119 | 1.92 | TAA611C | 2.18 |
| CD4024 | 1.24 | MC1310P | 2.59 | SN7430 | 0.16 | SN74121 | 0.37 | TAA621 | 2.03 |
| CD4025 | 0.32 | MC1330P | 0.90 | SN7432 | 0.28 | SN74122 | 0.50 | TAA661B | 1.32 |
| CD4027 | 0.43 | MC1351P | 0.80 | SN7437 | 0.35 | SN74123 | 0.60 | TBA641B | 2.25 |
| CD4028 | 1.50 | MC1352P | 0.80 | SN7438 | 0.35 | SN74141 | 0.85 | TBA651 | 1.69 |
| CD4029 | 3.50 | MC1466L | 3.50 | SN7440 | 0.16 | SN74145 | 0.90 | TBA800 | 1.40 |
| CD4030 | 0.87 | MC1469R | 2.75 | SN7441AN | 0.85 | SN74150 | 1.50 | TBA810 | 1.40 |
| CD4031 | 5.19 | NE555V | 0.70 | SN7442 | 0.65 | SN74151 | 0.85 | TBA820 | 1.15 |
| CD4037 | 1.93 | NE556 | 1.30 | SN7445 | 0.90 | SN74153 | 0.85 | TBA920 | 4.00 |
| CD4041 | 1.86 | NE560 | 4.48 | SN7446 | 0.95 | SN74154 | 1.50 | DIL sockets | 0.17 |
| CD4042 | 1.38 | NE561 | 4.48 | SN7447 | 0.95 | SN74155 | 1.50 | | |

## BRISTOL

10% discount for callers at our new shop at 1 Straits Parade, Fishponds, Bristol BS16 2LX during August. Tele: Bristol 654201/2.

### POPULAR SEMICONDUCTORS

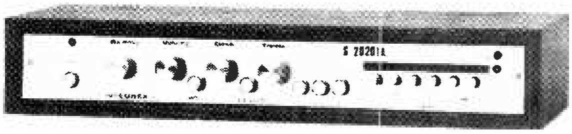
| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 2N696 | 0.22 | 2N3906 | 0.27 | AF139 | 0.65 | BD139 | 0.71 | MPSA56 | 0.31 |
| 2N697 | 0.16 | 2N4037 | 0.42 | AF239 | 0.65 | BD140 | 0.87 | OC28 | 0.765 |
| 2N698 | 0.82 | 2N4036 | 0.67 | AF240 | 0.90 | BF115 | 0.36 | OC35 | 0.60 |
| 2N699 | 0.59 | 2N4058 | 0.18 | AF279 | 0.70 | BF117 | 0.55 | OC42 | 0.50 |
| 2N706 | 0.14 | 2N4062 | 0.15 | AF280 | 0.79 | BF154 | 0.20 | OC45 | 0.32 |
| 2N708 | 0.17 | 2N4289 | 0.34 | AL102 | 1.00 | BF159 | 0.27 | TIP29A | 0.49 |
| 2N916 | 0.28 | 2N4920 | 1.10 | BC107 | 0.14 | BF180 | 0.35 | TIP29C | 0.58 |
| 2N918 | 0.32 | 2N4921 | 0.83 | BC108 | 0.14 | BF181 | 0.36 | TIP31A | 0.62 |
| 2N1302 | 0.185 | 2N4923 | 1.00 | BC109 | 0.14 | BF184 | 0.30 | TIP32A | 0.74 |
| 2N1304 | 0.26 | 2N5245 | 0.47 | BC147B | 0.14 | BF194 | 0.12 | TIP33A | 1.01 |
| 2N1306 | 0.31 | 2N5294 | 0.48 | BC148B | 0.15 | BF195 | 0.12 | TIP34A | 1.51 |
| 2N1308 | 0.47 | 2N5296 | 0.48 | BC149B | 0.15 | BF196 | 0.13 | TIP35A | 2.90 |
| 2N1711 | 0.45 | 2N5457 | 0.49 | BC157A | 0.16 | BF197 | 0.15 | TIP36A | 3.70 |
| 2N2102 | 0.60 | 2N5458 | 0.46 | BC158A | 0.16 | BF198 | 0.18 | TIP42A | 0.90 |
| 2N2147 | 0.78 | 2N5459 | 0.49 | BC167B | 0.15 | BF244 | 0.21 | TIP2955 | 0.98 |
| 2N2148 | 0.94 | 2N6027 | 0.45 | BC168B | 0.15 | BF257 | 0.47 | TIP3055 | 0.50 |
| 2N2218A | 0.22 | 3N128 | 0.73 | BC169B | 0.15 | BF258 | 0.53 | TIS43 | 0.28 |
| 2N2219A | 0.26 | 3N140 | 1.00 | BC182 | 0.12 | BF259 | 0.55 | ZTX300 | 0.13 |
| 2N2220 | 0.25 | 3N141 | 0.81 | BC182L | 0.12 | BFS61 | 0.27 | ZTX301 | 0.13 |
| 2N2221 | 0.18 | 3N200 | 2.49 | BC183 | 0.12 | BFS98 | 0.25 | ZTX500 | 0.15 |
| 2N2222 | 0.20 | 40361 | 0.40 | BC183L | 0.12 | BFR39 | 0.24 | ZTX501 | 0.13 |
| 2N2369 | 0.20 | 40362 | 0.45 | BC184 | 0.13 | BFR79 | 0.24 | ZTX502 | 0.18 |
| 2N2646 | 0.55 | 40406 | 0.44 | BC184L | 0.13 | BFX29 | 0.30 | 1N914 | 0.07 |
| 2N2904 | 0.22 | 40407 | 0.35 | BC212A | 0.16 | BFX30 | 0.27 | 1N3754 | 0.15 |
| 2N2905 | 0.25 | 40408 | 0.50 | BC212LA | 0.16 | BFX84 | 0.24 | 1N4007 | 0.10 |
| 2N2906 | 0.19 | 40409 | 0.52 | BC213LA | 0.15 | BFX85 | 0.30 | 1N4148 | 0.07 |
| 2N2907 | 0.22 | 40410 | 0.52 | BC214LB | 0.18 | BFX88 | 0.25 | 1N5404 | 0.22 |
| 2N2924 | 0.20 | 40411 | 2.00 | BC237B | 0.16 | BFY50 | 0.225 | 1N5408 | 0.30 |
| 2N2926G | 0.12 | 40594 | 0.74 | BC238C | 0.15 | BFY51 | 0.23 | AA119 | 0.08 |
| 2N3053 | 0.25 | 40595 | 0.84 | BC239C | 0.15 | BFY52 | 0.205 | BA102 | 0.25 |
| 2N3054 | 0.60 | 40636 | 1.10 | BC257A | 0.16 | BRY39 | 0.48 | BA145 | 0.18 |
| 2N3055 | 0.75 | 40673 | 0.73 | BC258B | 0.16 | ME0402 | 0.20 | BA154 | 0.12 |
| 2N3391 | 0.28 | AC126 | 0.20 | BC259B | 0.17 | ME0412 | 0.18 | BA155 | 0.12 |
| 2N3392 | 0.15 | AC127 | 0.20 | BC301 | 0.34 | ME4102 | 0.11 | BB103B | 0.23 |
| 2N3393 | 0.15 | AC128 | 0.20 | BC307B | 0.17 | MJ480 | 0.96 | BB104B | 0.45 |
| 2N3440 | 0.59 | AC151 | 0.27 | BC308A | 0.15 | MJ481 | 1.20 | BY126 | 0.12 |
| 2N3442 | 1.40 | AC152 | 0.49 | BC309C | 0.20 | MJ490 | 1.05 | BY127 | 0.15 |
| 2N3638 | 0.15 | AC153 | 0.35 | BC327 | 0.23 | MJ491 | 1.45 | BYZ11 | 0.51 |
| 2N3702 | 0.12 | AC176 | 0.30 | BC328 | 0.22 | MJ2955 | 1.00 | BYZ12 | 0.51 |
| 2N3703 | 0.13 | AC187K | 0.35 | BCY70 | 0.17 | MJE340 | 0.48 | OA47 | 0.06 |
| 2N3704 | 0.15 | AC188K | 0.40 | BCY71 | 0.22 | MJE370 | 0.65 | OA81 | 0.18 |
| 2N3706 | 0.15 | AD143 | 0.68 | BCY72 | 0.15 | MJE371 | 0.75 | OA90 | 0.06 |
| 2N3708 | 0.14 | AD161 | 0.50 | BD121 | 1.00 | MJE520 | 0.60 | OA91 | 0.06 |
| 2N3714 | 1.38 | AD162 | 0.50 | BD123 | 0.82 | MJE521 | 0.70 | WO21A200 | 0.32 |
| 2N3716 | 1.80 | AF106 | 0.40 | BD124 | 0.67 | MJE2955 | 1.20 | BY164 | 0.57 |
| 2N3771 | 2.20 | AF109 | 0.40 | BD131 | 0.40 | MJE3055 | 0.75 | ST2 diac | 0.20 |
| 2N3773 | 2.65 | AF115 | 0.35 | BD132 | 0.50 | MP8113 | 0.47 | 40669 | 1.00 |
| 2N3789 | 2.06 | AF116 | 0.35 | BD135 | 0.43 | MPF102 | 0.39 | TIC44 | 0.29 |
| 2N3819 | 0.37 | AF117 | 0.35 | BD136 | 0.47 | MPSA05 | 0.25 | C106D | 0.65 |
| 2N3820 | 0.64 | AF118 | 0.35 | BD137 | 0.55 | MPSA06 | 0.31 | ORP12 | 0.60 |
| 2N3904 | 0.27 | AF124 | 0.30 | BD138 | 0.63 | MPSA55 | 0.31 | | |

Prices correct at July, 1975, but all exclusive of V.A.T. **Post & Package 25p**

# S-2020TA STEREO TUNER/AMPLIFIER KIT

NEW PRODUCT

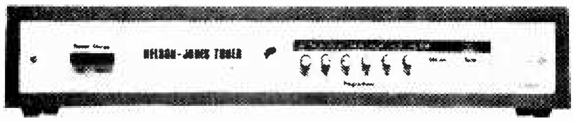
*A high-quality push-button FM Varicap Stereo Tuner combined with a 20W r.m.s. per channel Stereo Amplifier.*



SOLID MAHOGANY CABINET

**Brief Spec.** Amplifier: Low field Toroidal transformer, Mag. input, Tape In/Out facility (for noise reduction unit, etc). THD less than 0.1% at 20W into 8 ohms. All sockets, fuses, etc, are PC mounted for ease of assembly. Tuner section: uses Mullard LP1186 module requiring no RF alignment, ceramic IF, INTERSTATION MUTE, and phase-locked IC stereo decoder. LED tuning and stereo indicators. Tuning range 88–104MHz. 30dB mono S/N @ 1.8μV.THD typ. 0.4%.

**PRICE: £47.95 + 99p p&p + VAT.**



# NELSON-JONES STEREO FM TUNER

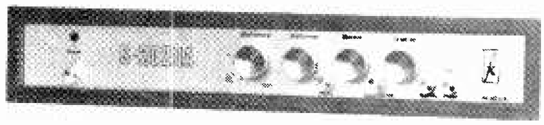
*A very high performance tuner with dual gate MOSFET RF and Mixer front end, triple gang varicap tuning, and dual ceramic filter/dual IC IF amp.*

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

**PRICE: Mono £25.46 + 85p p&p + VAT;**
**With Portus-Haywood Decoder £31.96 + 85p p&p + VAT;**
**With ICPL Decoder £29.73 + 85p p&p + VAT.**

NEW PRODUCT

# S-2020A AMPLIFIER KIT



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

**Typ. Spec.** 20 + 20W r.m.s. into 8-ohm load at less than 0.1% THD. Mag. PU input S/N 60dB. Radio input S/N 72dB. Headphone output. Tape In/Out facility (for noise reduction unit, etc). Toroidal mains transformer.

**PRICE: £29.95 + 99p p&p + VAT.**

# STEREO MODULE TUNER

*A low-cost Stereo Tuner based on the Mullard LP1186 RF module requiring no alignment. The IF comprises a ceramic filter and high-performance IC. Variable INTERSTATION MUTE. PLL stereo decoder IC.*

**Typ. Spec.** Sens. 30dB S/N mono @ 1.8μV. Tuning range 88–104MHz. LED sig. strength indicator. LED Stereo indicator. THD typically 0.4%.

**PRICE: Stereo £26.32 + 85p p&p + VAT. Mono £22.40 + 85p p&p + VAT.**

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

# SUB ASSEMBLIES

### BASIC NELSON-JONES TUNER

Supplied as a printed circuit board with all components and screening box to build a varicap tuner module. Performance spec as above for complete N-J Tuner. For suitable stereo decoders see below. (Illustrated without screening box.)

**PRICE: £12.88 + 25p p&p + VAT.**

### BASIC MODULE TUNER

Supplied as a printed circuit board with all components and screened Mullard LP1186, to build a mono or stereo tuner module. Performance spec as above for Stereo Module Tuner complete kit.

**PRICE: Mono £11.11 + 25p p&p + VAT; Stereo £13.89 + 25p p&p + VAT.**

### PORTUS-HAYWOOD PHASE-LOCKED STEREO DECODER

Mk II version of this design (WW Sept. 1970). The lowest distortion phase-locked stereo decoder kit available (Typ. 0.05% @ N-J Tuner O/P level). Separation 40dB up to 15KHz.
Complete kit comprises PCB and all components, inc. stereo LED.

**PRICE: £7.68 + 25p p&p + VAT.**

### PHASE-LOCKED IC DECODER

Integrated circuit phase-locked stereo decoder based on the MC1310. THD typically 0.3%. Separation 40dB @ 1KHz.

**PRICE: £4.27 + 20p p&p + VAT.**

### PUSH-BUTTON UNIT

The six-position push-button unit used in our tuners and tuner/amp. Each track has the required diode law for stability of tuning. There are approx. 40 turns on each button and there are six separate moving pointers. An AFC disable switch is incorporated with each button. The unit is finished in black with red pointers.

**PRICE: £3.00 + 20p p&p + VAT.**

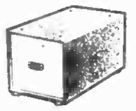
*Please send SAE for complete lists and specifications.*

**INTEGREX LIMITED,** Portwood Industrial Estate, Church Gresley, Burton-on-Trent, Staffs, DE11 9PT. Tel. Swadlincote (0283 87) 5432. Telex 377106.

WW—075 FOR FURTHER DETAILS

# TRANSFORMERS

## CASED TRANSFORMERS



Housed in smart resin coated steel cases with 3 core power cable and outlet socket, fused primary winding. Isolation types are fitted with 3-pin outlet sockets and are available with 110 volt or 240 volt output (Please state). Auto types are fitted with 2-pin flat style sockets up to 500 VA. 3-pin sockets from 750 to 3000 VA. See Auto and Isolation sections for prices. Plugs extra.

## SAFETY ISOLATING

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

| VA (WATTS) | REF No. | PRICE Cased £ | PRICE Plugs 2 Pin + 1 Earth £ | PRICE Open £ | Post £ |
|---|---|---|---|---|---|
| 60 | 149 | 8.35 | 0.88 | 4.37 | 0.56 |
| 100 | 150 | 9.15 | 0.88 | 4.90 | 0.64 |
| 200 | 151 | 11.45 | 0.88 | 8.14 | 0.80 |
| 250 | 152 | 12.90 | 0.88 | 9.80 | 0.88 |
| 350 | 153 | 15.50 | 0.88 | 11.88 | 0.95 |
| 500 | 154 | 17.25 | 0.88 | 13.62 | 1.13 |
| 750 | 155 | 27.10 | 1.10 | 20.59 | O.A. |
| 1000 | 156 | 35.40 | 1.10 | 29.15 | O.A. |
| 1500 | 157 | 42.00 | 1.10 | 33.37 | O.A. |
| 2000 | 158 | 49.75 | 2.64 | 37.10 | O.A. |
| 3000 | 159 | 73.15 | 2.64 | 58.55 | O.A. |

## MINIATURE & EQUIPMENT

Primary 240V with Screen

| VOLTS Sec. 1 | VOLTS Sec. 2 | MILLIAMPS Sec. 1 | MILLIAMPS Sec. 2 | TYPE No. | PRICE £ | Post £ |
|---|---|---|---|---|---|---|
| 3-0-3 | – | 200 | – | 238 | 1.50 | 0.25 |
| 0-6 | 0-6 | 500 | 500 | 234 | 1.38 | 0.25 |
| 0-6 | 0-6 | 1000 | 1000 | 212 | 1.90 | 0.47 |
| 9-0-9 | – | 100 | – | 13 | 1.40 | 0.25 |
| 0-9 | 0-9 | 330 | 330 | 235 | 1.50 | 0.25 |
| 0-8-9 | 0-8-9 | 500 | 500 | 207 | 1.93 | 0.34 |
| 0-8-9 | 0-8-9 | 1000 | 1000 | 208 | 2.75 | 0.47 |
| 15-0-15 | – | 40 | – | 240 | 1.35 | 0.25 |
| 0-15 | 0-15 | 200 | 200 | 236 | 1.38 | 0.25 |
| 20-0-20 | | 30 | – | 241 | 1.35 | 0.25 |
| 0-20 | 0-20 | 150 | 150 | 237 | 1.38 | 0.25 |
| 0-15-20 | 0-15-20 | 500 | 500 | 205 | 2.73 | 0.56 |
| 0-20 | 0-20 | 300 | 300 | 214 | 1.93 | 0.47 |
| 0-20 | – | 3500 | No Screen | 1116 | 3.30 | 0.64 |
| 20-12-0 12-20 | – | 700 (D.C.) | – | 221 | 2.20 | 0.47 |
| 0-15-20 | 0-15-20 | 1000 | 1000 | 206 | 3.50 | 0.56 |
| 0-15-27 | 0-15-27 | 500 | 500 | 203 | 3.00 | 0.56 |
| 0-15-27 | 0-15-27 | 1000 | 1000 | 204 | 3.85 | 0.56 |

## 12 and 24 VOLTS PRIMARY 200-240 Volts

| 12V | 24V | TYPE No. | PRICE £ | Post £ |
|---|---|---|---|---|
| 0.3 | 0.15 | 242 | 1.58 | 0.34 |
| 0.5 | 0.25 | 111 | 1.38 | 0.34 |
| 1 | 0.5 | 213 | 1.74 | 0.47 |
| 2 | 1 | 71 | 2.30 | 0.47 |
| 4 | 2 | 18 | 2.96 | 0.56 |
| 6 | 3 | 70 | 4.18 | 0.56 |
| 8 | 4 | 108 | 4.56 | 0.64 |
| 10 | 5 | 72 | 5.20 | 0.72 |
| 12 | 6 | 116 | 5.51 | 0.72 |
| 16 | 8 | 17 | 7.00 | 0.80 |
| 20 | 10 | 115 | 10.42 | 0.88 |
| 30 | 15 | 187 | 13.25 | 1.01 |
| 40 | 20 | 232 | 14.85 | O.A. |
| 60 | 30 | 226 | 16.83 | O.A. |

## 30 VOLTS

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

| AMPS | Ref. No. | Price £ | Post £ |
|---|---|---|---|
| 0.5 | 112 | 1.90 | 0.47 |
| 1 | 79 | 2.40 | 0.56 |
| 2 | 3 | 3.50 | 0.56 |
| 3 | 20 | 4.50 | 0.64 |
| 4 | 21 | 5.15 | 0.72 |
| 5 | 51 | 6.40 | 0.72 |
| 6 | 117 | 7.16 | 0.88 |
| 8 | 88 | 9.55 | 0.95 |
| 10 | 89 | 9.67 | 0.95 |

## 50 VOLTS

PRIMARY 200/240V
SECONDARY 19, 25, 33, 40, 50V

| AMPS | Ref. | Price | Post |
|---|---|---|---|
| 0.5 | 102 | 2.58 | 0.47 |
| 1 | 103 | 3.48 | 0.56 |
| 2 | 104 | 5.03 | 0.64 |
| 3 | 105 | 5.81 | 0.72 |
| 4 | 106 | 7.58 | 0.88 |
| 6 | 107 | 12.30 | 0.95 |
| 8 | 118 | 13.20 | 1.13 |
| 10 | 119 | 17.02 | O.A. |

## 60 VOLTS

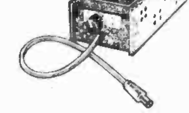
PRIMARY 200/240V
SECONDARY 24, 30, 48, 60V

| AMPS | Ref. | Price | Post |
|---|---|---|---|
| 0.5 | 124 | 2.30 | 0.56 |
| 1 | 126 | 3.41 | 0.56 |
| 2 | 127 | 5.09 | 0.72 |
| 3 | 125 | 7.52 | 0.80 |
| 4 | 123 | 8.75 | 0.95 |
| 5 | 40 | 9.75 | 0.95 |
| 6 | 120 | 11.20 | 1.01 |
| 8 | 121 | 15.00 | 1.19 |
| 10 | 122 | 18.20 | O.A. |
| 12 | 189 | 18.50 | O.A. |

## BRIDGE RECTIFIERS

| | Price |
|---|---|
| **ONE AMP** | |
| 50 P.I.V. | 0.20 |
| 100 P.I.V. | 0.20 |
| 200 P.I.V. | 0.28 |
| 600 P.I.V. | 0.30 |
| **FOUR AMP** | |
| 100 P.I.V. | 0.55 |
| 200 P.I.V. | 0.59 |
| 400 P.I.V. | 0.65 |
| 600 P.I.V. | 0.75 |
| **TWO AMP** | |
| 50 P.I.V. | 0.35 |
| 100 P.I.V. | 0.40 |
| 200 P.I.V. | 0.45 |
| 400 P.I.V. | 0.50 |
| **SIX AMP** | |
| 50 P.I.V. | 0.65 |
| 100 P.I.V. | 0.70 |
| 200 P.I.V. | 0.08 |
| 400 P.I.V. | 0.90 |

## POWER UNIT TYPE CC12-05



Output switched 3, 4.5, 6, 7.5, 9 and 12 Volts at 500 mA D.C. Operates from 240 V mains, suitable for Radios, Tape Recorders, Record Players, etc. Size 7.5 × 5.0 × 14.0 cm. Price £3.95 Post 25p.

## AUTO TRANSFORMERS

| VA (Watts) | Ref. No | PRICE Cased | PRICE Plugs 2 & 3 pin £ | PRICE Open £ | Post £ |
|---|---|---|---|---|---|
| Tapped at 115, 220, 240 Volts | | | | | |
| 20 | 113 | 3.85 | 0.20 | 1.71 | 0 47 |
| Tapped at 115, 200, 220, 240 Volts | | | | | |
| 150 | 4 | 6.38 | 0.20 | 4.12 | 0.56 |
| 200 | 65 | 7.04 | 0.20 | 4.95 | 0.64 |
| 300 | 66 | 8.00 | 0.20 | 5.81 | 0.72 |
| 500 | 67 | 10.99 | 0.20 | 8.85 | 0 88 |
| 750 | 83 | 13.82 | 0.85 | 10.80 | 0.95 |
| 1000 | 84 | 17.27 | 0.85 | 13.68 | 1.13 |
| 1500 | 93 | 21.87 | 0.85 | 18.31 | O.A. |
| 2000 | 95 | 33.11 | 1.60 | 24.25 | O A. |
| 3000 | 73 | 47.94 | 2.10 | 35.10 | O A |

## NEW! 2" AND 4" PANEL METERS

**2"** SIZE: 60mm Wide × 45mm High × 40mm Deep.

| Movement | I.R. Ohms |
|---|---|
| 0-50 micro A. | 1250 |
| 0-100 micro A. | 580 |
| 0-500 Micro A | 170 |
| 0-1 mA | 170 |
| 0-5 mA | 170 |
| 0-10mA | 6 |
| 0-50 mA | 0.5 |
| 0-100 mA | 0.5 |
| 0-500 mA | 0.5 |
| 0-1 AMP | 0.5 |
| 0-2 AMP | 0.5 |
| 0-25 Volt | 15K |
| 0-50 Volt | 50K |
| 0-300 Volt | 300K |
| "g" Meter | 170 |
| VU Meter | 9250 |

**4"** SIZE: 110mm Wide × 82mm High × 43mm Deep.

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|---|---|
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| 0-100 micro A | 730 |
| 0-500 micro A | 200 |
| 0-1 mA | 200 |
| 0-5mA | 200 |
| 0-10 mA | 6 |
| 0-50 mA | 0.5 |
| 0-100 mA | 0.5 |
| 0-500 mA | 0.5 |
| 0-1 AMP | 0.5 |
| 0-2 AMP | 0.5 |
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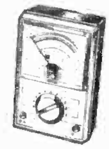

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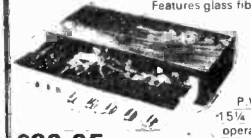

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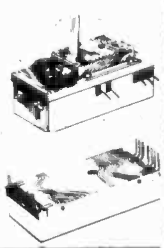

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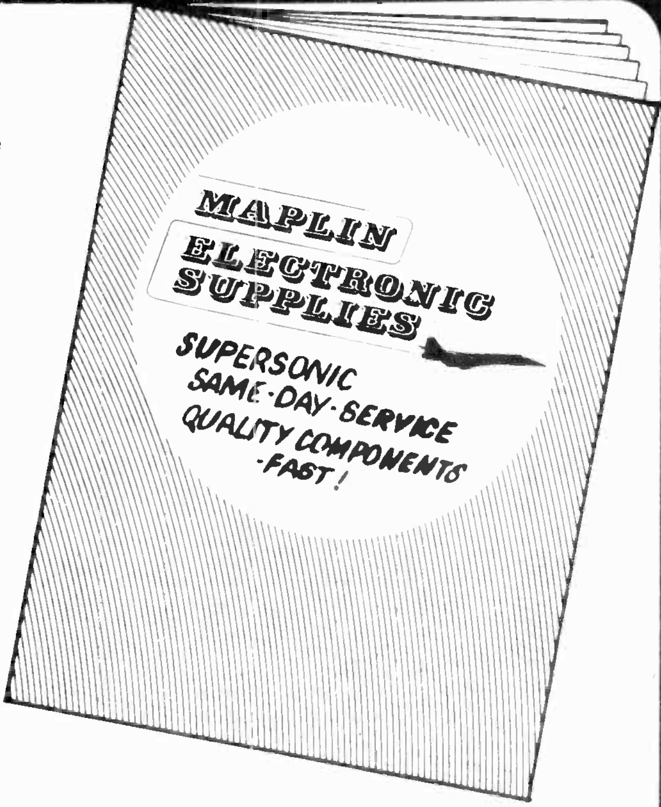


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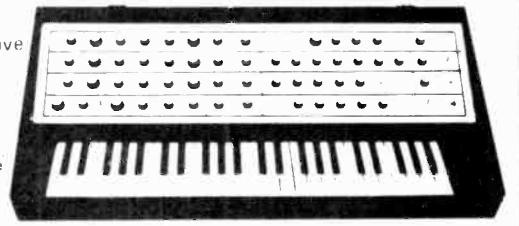

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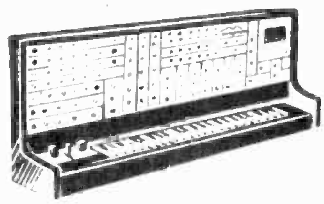

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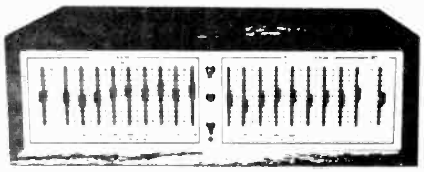

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| TCA830S | £1.04 |
| TCA940 | £2.25 |
| TDA1054 | £1.50 |
| TDA1200 | £2.43 |
| TDA1405 | 80p • |
| TDA1412 | 80p • |
| TDA1415 | 80p • |
| TDA2010 | £3.00 |
| TDA2020 | £3.75 |
| ULN2111A | £1.52 |
| ZN414 | £1.26 |

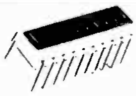
## MINITRON

Minitron Filament Display bi-directional 0.36"
3015F 0-9 L/H d.pr.
3015G ± 1 £1.08 •

## SIEMENS LCD's

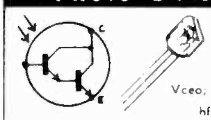
LIQUID CRYSTAL DISPLAY complete with socket and removable reflective backing, Ref AN4132R 13mm character height. Can be directly driven by National Semiconductors Alarm Clock chip MM5316. £13.99 •


## LINE-O-LIGHT



NEW LED Linear Cursors each device contains 10 light emitting diodes in a 20pin dual-in-line package. Ideal for solid state analogue meters or dials.
Type 101 RED £2.26 •

## PHOTO-DARLINGTON



**2N5777**
Vceo; Vcbo 25v, Vebo 8v
Vceo; Vcbo 25v, VEBO 8v
hfe 2500, Ic 250 mA **35p.**

SPECIAL PURCHASE

enables
LIT707 0.3" 90p; • LIT747 0.6" £1.99 •

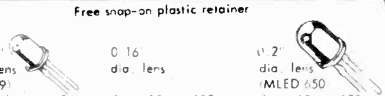
**I.C. SOCKETS**

| | Dual-in-line | | | | | | | TO5 | |
|---|---|---|---|---|---|---|---|---|---|
| Pins | 8 | 14 | 16 | 24 | 28 | 36 | 40 | 8 | 10 |
| • Price | 13p | 15p | 15p | 26p | 30p | 39p | 44p | 31p | 35p |

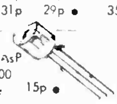
NEW
Litronix Double Digit Displays 0.5"; Common Anode ± 2 R/H D.P.'s
DL721 gives ± 1.9
DL727 gives 0.0. to 9.9
Suitable for Clocks; Instruments; T.V. Channel Indicator
Our Price £4.75 each. •

## L.E.D.'s

Free snap-on plastic retainer



| | 0.125" dia. lens (TIL209) 1+ | 10+ | 100+ | 0.16" dia. lens 1+ | 10+ | 100+ | 0.2" dia. lens (MLED 650) 1+ | 10+ | 100+ |
|---|---|---|---|---|---|---|---|---|---|
| Red | 16p | 15p | 13p • | 27p | 24p | 22p • | 18p | 16p | 14p • |
| Green | 27p | 24p | 22p • | 33p | 30p | 27p • | 30p | 27p | 25p • |
| Orange | 27p | 24p | 22p • | 33p | 30p | 27p • | 30p | 27p | 25p • |
| Yellow | 34p | 31p | 29p • | 35p | 32p | 29p • | 35p | 33p | 30p • |



Low Cost Red GaAsP Motorola MLED 500 in a T092 package 15p •

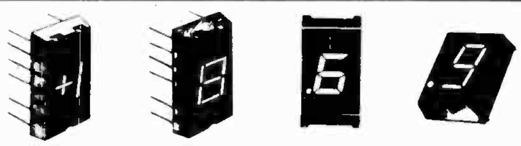
NEW Opto-isolators ILI (4N25 or TIL116) 6 pin industry standard package 2.5KV isolation £1.00 •

NOTICE
Postage & Packing Charges

With the recent increase in postal charges and a continuing increase in packaging costs we have been forced to review our policy.
Henceforward
1. Orders valued at £5 or more will be post free.
2. All U.K. 'small package' orders will go first class mail.
3. Minimum postage & packing charge will increase to 20p.

## SEVEN SEGMENT DISPLAYS

litronix
Xciton
Monsanto



| | | COMMON ANODE R/H Dec. Pt. | COMMON ANODE L/H Dec. Pt. | COMMON ANODE ± 1 | COMMON CATHODE R/H Dec. Pt. | Our Price |
|---|---|---|---|---|---|---|
| | RED | DL707R | DL707 | DL701 | DL704 | £1.82 • |
| 0.3" | GREEN | MAN51 | MAN52 | MAN53 | MAN54 | £1.82 • |
| | RED | MAN71 | MAN72 | MAN73 | MAN74 | £1.82 • |
| | YELLOW | MAN81 | MAN82 | MAN83 | MAN84 | £1.82 • |
| | ORANGE | MAN3610 | MAN3620 | MAN3630 | MAN3640 | £1.82 • |
| | GREEN | XAN51 | XAN52 | - | XAN54 | £1.49 • |
| | RED | XAN71 | XAN72 | - | XAN74 | £1.49 • |
| | YELLOW | XAN81 | XAN82 | - | XAN84 | £1.49 • |
| 0.4" | GREEN | MAN4510 | MAN4520 | MAN4530 | MAN4540 | £2.32 • |
| | RED | MAN4710 | MAN4720 | MAN4730 | MAN4740 | £2.32 • |
| | YELLOW | MAN4810 | MAN4820 | MAN4830 | MAN4840 | £2.32 • |
| | ORANGE | MAN4610 | MAN4620 | MAN4630 | MAN4640 | £2.32 • |
| | | C.A. L/H Dec. Pt. | C.A. ± 1 | C.C. L/H Dec. Pt. | C.C. ± 1 | |
| 0.6" | RED | DL747 | DL746 | DL750 | DL749 | £2.42 • |

NOTE: MAN4000 series pinouts are 14 pin dil the same as MAN50;70 & 80 series.

**VAT INCLUDED**

Items marked with a • include 8% VAT
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ADVERT. No.1. of Series B.

**CALLERS WELCOME**

# HERE'S A 'LOGICAL' SHOPPING LIST YOU CAN'T AFFORD TO MISS

## 7400 Series TTL

| | 1 | 25 | 100+ |
|---|---|---|---|
| SN7400 | 0.14 | 0.13 | 0.12 |
| SN7401 | 0.14 | 0.13 | 0.12 |
| SN7402 | 0.14 | 0.13 | 0.12 |
| SN7403 | 0.14 | 0.13 | 0.12 |
| SN7404 | 0.15 | 0.14 | 0.13 |
| SN7405 | 0.15 | 0.14 | 0.13 |
| SN7406 | 0.30 | 0.29 | 0.28 |
| SN7407 | 0.30 | 0.29 | 0.28 |
| SN7408 | 0.15 | 0.13 | 0.12 |
| SN7409 | 0.15 | 0.13 | 0.12 |
| SN7410 | 0.14 | 0.13 | 0.12 |
| SN7411 | 0.23 | 0.22 | 0.21 |
| SN7412 | 0.19 | 0.18 | 0.17 |
| SN7413 | 0.30 | 0.29 | 0.28 |
| SN7414 | 0.71 | 0.70 | 0.69 |
| SN7415 | 0.30 | 0.29 | 0.27 |
| SN7416 | 0.28 | 0.27 | 0.26 |
| SN7417 | 0.28 | 0.27 | 0.26 |
| SN7420 | 0.14 | 0.13 | 0.12 |
| SN7421 | 0.95 | 0.94 | 0.93 |
| SN7422 | 0.25 | 0.24 | 0.23 |
| SN7423 | 0.26 | 0.25 | 0.22 |
| SN7425 | 0.26 | 0.25 | 0.22 |
| SN7426 | 0.26 | 0.25 | 0.22 |
| SN7427 | 0.26 | 0.25 | 0.22 |
| SN7428 | 0.39 | 0.38 | 0.37 |
| SN7430 | 0.14 | 0.13 | 0.12 |
| SN7432 | 0.25 | 0.24 | 0.22 |
| SN7433 | 0.36 | 0.35 | 0.34 |
| SN7437 | 0.27 | 0.26 | 0.22 |
| SN7438 | 0.27 | 0.26 | 0.22 |
| SN7439 | 1.10 | 1.08 | 1.06 |
| SN7440 | 0.14 | 0.13 | 0.12 |
| SN7441 | 0.70 | 0.69 | 0.66 |
| SN7442 | 0.63 | 0.60 | 0.53 |
| SN7443 | 1.00 | 0.99 | 0.90 |
| SN7444 | 1.08 | 1.07 | 1.05 |
| SN7445 | 0.85 | 0.83 | 0.70 |
| SN7446 | 1.03 | 1.00 | 0.85 |
| SN7447 | 1.03 | 1.00 | 0.85 |
| SN7448 | 0.85 | 0.83 | 0.70 |
| SN7450 | 0.14 | 0.13 | 0.12 |
| SN7451 | 0.14 | 0.13 | 0.12 |
| SN7453 | 0.14 | 0.13 | 0.12 |
| SN7454 | 0.14 | 0.13 | 0.12 |
| SN7455 | 0.40 | 0.39 | 0.38 |
| SN7460 | 0.14 | 0.13 | 0.12 |
| SN7462 | 0.45 | 0.44 | 0.42 |
| SN7464 | 0.45 | 0.44 | 0.42 |
| SN7465 | 0.45 | 0.44 | 0.42 |
| SN7470 | 0.30 | 0.27 | 0.25 |
| SN7471 | 0.60 | 0.59 | 0.58 |
| SN7472 | 0.25 | 0.24 | 0.21 |
| SN7473 | 0.30 | 0.27 | 0.26 |
| SN7474 | 0.31 | 0.29 | 0.26 |
| SN7475 | 0.40 | 0.39 | 0.38 |
| SN7476 | 0.31 | 0.29 | 0.26 |
| SN7478 | 0.65 | 0.63 | 0.61 |
| SN7480 | 0.43 | 0.41 | 0.36 |
| SN7481 | 1.00 | 0.95 | 0.90 |
| SN7482 | 0.75 | 0.70 | 0.62 |
| SN7483 | 0.81 | 0.80 | 0.68 |
| SN7484 | 0.90 | 0.86 | 0.85 |
| SN7485 | 1.25 | 1.15 | 1.00 |
| SN7486 | 0.31 | 0.28 | 0.25 |
| SN7489 | 3.50 | 3.20 | 3.00 |
| SN7490 | 0.45 | 0.42 | 0.35 |
| SN7491 | 1.00 | 0.95 | 0.90 |
| SN7492 | 0.45 | 0.42 | 0.35 |
| SN7493 | 0.45 | 0.42 | 0.35 |
| SN7494 | 0.48 | 0.45 | 0.40 |
| SN7495 | 0.60 | 0.56 | 0.50 |
| SN7496 | 0.70 | 0.67 | 0.60 |
| SN7497 | 0.70 | 0.69 | 0.68 |
| SN74100 | 1.35 | 1.30 | 1.25 |
| SN74104 | 0.31 | 0.29 | 0.26 |
| SN74105 | 0.31 | 0.29 | 0.26 |
| SN74107 | 0.31 | 0.29 | 0.26 |
| SN74109 | 1.00 | 0.97 | 0.95 |
| SN74110 | 0.55 | 0.50 | 0.45 |
| SN74111 | 0.81 | 0.80 | 0.76 |
| SN74114 | 1.00 | 0.97 | 0.95 |
| SN74115 | 1.00 | 0.97 | 0.95 |
| SN74118 | 1.00 | 0.95 | 0.90 |
| SN74121 | 0.31 | 0.29 | 0.25 |
| SN74122 | 0.44 | 0.41 | 0.37 |
| SN74123 | 0.62 | 0.58 | 0.50 |
| SN74125 | 0.70 | 0.65 | 0.60 |
| SN74126 | 0.75 | 0.70 | 0.65 |
| SN74128 | 1.40 | 1.35 | 1.30 |
| SN74132 | 2.10 | 2.05 | 2.00 |
| SN74136 | 0.95 | 0.90 | 0.85 |
| SN74140 | 2.50 | 2.45 | 2.40 |
| SN74141 | 0.75 | 0.70 | 0.62 |
| SN74145 | 1.15 | 1.10 | 1.05 |
| SN74147 | 2.95 | 2.90 | 2.85 |
| SN74148 | 2.30 | 2.25 | 2.20 |
| SN74150 | 1.35 | 1.30 | 1.25 |
| SN74151 | 0.68 | 0.62 | 0.55 |
| SN74152 | 1.55 | 1.50 | 1.45 |
| SN74153 | 0.68 | 0.62 | 0.55 |
| SN74154 | 1.55 | 1.50 | 1.45 |
| SN74155 | 0.68 | 0.62 | 0.55 |
| SN74156 | 0.68 | 0.62 | 0.55 |
| SN74157 | 0.90 | 0.85 | 0.80 |
| SN74158 | 1.50 | 1.45 | 1.40 |
| SN74160 | 0.95 | 0.90 | 0.80 |
| SN74161 | 0.95 | 0.90 | 0.80 |
| SN74162 | 0.95 | 0.90 | 0.80 |
| SN74163 | 0.95 | 0.90 | 0.80 |
| SN74164 | 1.60 | 1.55 | 1.50 |
| SN74165 | 1.60 | 1.55 | 1.50 |
| SN74166 | 1.40 | 1.30 | 1.15 |
| SN74170 | 2.40 | 2.30 | 2.20 |
| SN74173 | 1.65 | 1.60 | 1.55 |
| SN74174 | 1.15 | 1.10 | 1.00 |
| SN74175 | 0.97 | 0.90 | 0.80 |
| SN74176 | 1.10 | 1.05 | 1.00 |
| SN74177 | 1.10 | 1.05 | 1.00 |
| SN74180 | 1.10 | 1.05 | 1.00 |
| SN74181 | 3.50 | 3.45 | 3.35 |
| SN74182 | 1.10 | 1.05 | 1.00 |
| SN74184 | 1.60 | 1.55 | 1.50 |
| SN74185 | 2.30 | 2.25 | 2.20 |
| SN74188 | 4.90 | 4.85 | 4.80 |
| SN74190 | 1.75 | 1.70 | 1.65 |
| SN74191 | 1.70 | 1.65 | 1.60 |
| SN74192 | 1.25 | 1.05 | 1.00 |
| SN74193 | 1.25 | 1.05 | 1.00 |
| SN74194 | 1.10 | 1.05 | 1.00 |
| SN74195 | 0.90 | 0.85 | 0.80 |
| SN74196 | 1.05 | 1.00 | 0.95 |
| SN74197 | 1.05 | 1.00 | 0.95 |
| SN74198 | 2.05 | 2.00 | 1.70 |
| SN74199 | 2.05 | 2.00 | 1.70 |
| SN74200 | 6.00 | 5.95 | 5.80 |
| SN74221 | 1.80 | 1.75 | 1.70 |
| SN74251 | 1.80 | 1.75 | 1.70 |
| SN74278 | 3.00 | 2.90 | 2.80 |
| SN74279 | 1.20 | 1.15 | 1.10 |
| SN74293 | 1.00 | 0.95 | 0.90 |
| SN74298 | 2.60 | 2.55 | 2.50 |

## C-MOS Types

| | 1 | 25 | 100+ |
|---|---|---|---|
| 4000AE | 0.24 | 0.19 | 0.16 |
| 4001AE | 0.24 | 0.19 | 0.16 |
| 4002AE | 0.24 | 0.19 | 0.16 |
| 4004AE | 4.90 | 4.80 | 4.70 |
| 4006AE | 1.55 | 1.50 | 1.45 |
| 4007AE | 0.24 | 0.19 | 0.16 |
| 4008AE | 1.60 | 1.55 | 1.50 |
| 4009AE | 0.35 | 0.34 | 0.30 |
| 4010AE | 0.50 | 0.48 | 0.46 |
| 4011AE | 0.24 | 0.19 | 0.16 |
| 4012AE | 0.24 | 0.19 | 0.16 |
| 4013AE | 0.59 | 0.47 | 0.39 |
| 4014AE | 1.65 | 1.33 | 1.10 |
| 4015AE | 1.65 | 1.33 | 1.10 |
| 4016AE | 0.62 | 0.50 | 0.41 |
| 4017AE | 1.62 | 1.31 | 1.08 |
| 4018AE | 2.45 | 2.40 | 2.30 |
| 4019AE | 0.62 | 0.50 | 0.41 |
| 4020AE | 1.82 | 1.46 | 1.21 |
| 4021AE | 1.65 | 1.33 | 1.10 |
| 4022AE | 1.65 | 1.33 | 1.10 |
| 4023AE | 0.24 | 0.19 | 0.16 |
| 4024AE | 1.13 | 0.91 | 0.75 |
| 4025AE | 0.24 | 0.19 | 0.16 |
| 4026AE | 6.50 | 6.40 | 6.30 |
| 4027AE | 0.42 | 0.41 | 0.40 |
| 4028AE | 1.41 | 1.14 | 0.94 |
| 4029AE | 1.95 | 1.57 | 1.30 |
| 4030AE | 0.62 | 0.50 | 0.41 |
| 4033AE | 2.80 | 2.70 | 2.60 |
| 4035AE | 1.71 | 1.38 | 1.14 |
| 4040AE | 1.82 | 1.46 | 1.21 |
| 4041AE | 0.90 | 0.85 | 0.80 |
| 4042AE | 1.00 | 0.90 | 0.80 |
| 4043AE | 1.00 | 0.90 | 0.80 |
| 4044AE | 1.00 | 0.90 | 0.80 |
| 4047AE | 1.50 | 1.45 | 1.40 |
| 4048AE | 1.30 | 1.25 | 1.20 |
| 4049AE | 0.54 | 0.44 | 0.36 |
| 4050AE | 0.54 | 0.44 | 0.36 |
| 4051AE | 1.77 | 1.43 | 1.18 |
| 4052AE | 2.00 | 1.90 | 1.80 |
| 4053AE | 2.70 | 2.60 | 2.50 |
| 4055AE | 2.60 | 2.50 | 2.40 |
| 4056AE | 1.35 | 1.09 | 0.90 |
| 4060AE | 2.25 | 1.82 | 1.50 |
| 4066AE | 0.95 | 0.90 | 0.85 |
| 4069AE | 0.38 | 0.30 | 0.25 |
| 4071AE | 0.34 | 0.27 | 0.23 |
| 4076AE | 1.45 | 1.40 | 1.35 |
| 4081AE | 0.34 | 0.27 | 0.23 |
| 4510AE | 1.75 | 1.70 | 1.65 |
| 4516AE | 1.76 | 1.42 | 1.18 |
| 4518AE | 2.17 | 1.75 | 1.45 |
| 4520AE | 1.65 | 1.60 | 1.50 |
| 4901AE | 0.37 | 0.35 | 0.33 |
| 4911AE | 0.37 | 0.35 | 0.33 |

## LOW-POWER SCHOTTKY TTL

| | 1 | 25 | 100+ |
|---|---|---|---|
| SN74LS00 | 0.58 | 0.56 | 0.54 |
| SN74LS01 | 0.58 | 0.56 | 0.54 |
| SN74LS02 | 0.58 | 0.56 | 0.54 |
| SN74LS03 | 0.58 | 0.56 | 0.54 |
| SN74LS04 | 0.63 | 0.61 | 0.59 |
| SN74LS05 | 0.63 | 0.61 | 0.59 |
| SN74LS08 | 0.58 | 0.56 | 0.54 |
| SN74LS09 | 0.58 | 0.56 | 0.54 |
| SN74LS10 | 0.58 | 0.56 | 0.54 |
| SN74LS11 | 0.58 | 0.56 | 0.54 |
| SN74LS15 | 0.58 | 0.56 | 0.54 |
| SN74LS20 | 0.58 | 0.56 | 0.54 |
| SN74LS21 | 0.58 | 0.56 | 0.54 |
| SN74LS22 | 0.58 | 0.56 | 0.54 |
| SN74LS27 | 0.64 | 0.62 | 0.60 |
| SN74LS30 | 0.58 | 0.56 | 0.54 |
| SN74LS32 | 0.64 | 0.62 | 0.60 |
| SN74LS51 | 0.58 | 0.56 | 0.54 |
| SN74LS54 | 0.58 | 0.56 | 0.54 |
| SN74LS55 | 0.58 | 0.56 | 0.54 |
| SN74LS73 | 0.92 | 0.90 | 0.88 |
| SN74LS74 | 0.92 | 0.90 | 0.88 |
| SN74LS76 | 0.92 | 0.90 | 0.88 |
| SN74LS78 | 0.92 | 0.90 | 0.88 |
| SN74LS107 | 0.92 | 0.90 | 0.88 |
| SN74LS109 | 0.92 | 0.90 | 0.88 |
| SN74LS112 | 0.92 | 0.90 | 0.88 |
| SN74LS113 | 0.92 | 0.90 | 0.88 |
| SN74LS114 | 0.92 | 0.90 | 0.88 |
| SN74LS138 | 2.38 | 2.32 | 2.26 |
| SN74LS139 | 2.38 | 2.32 | 2.26 |
| SN74LS151 | 2.10 | 2.05 | 2.00 |
| SN74LS153 | 2.38 | 2.32 | 2.26 |
| SN74LS157 | 2.10 | 2.05 | 2.00 |
| SN74LS158 | 2.40 | 2.33 | 2.27 |
| SN74LS160 | 2.70 | 2.62 | 2.54 |
| SN74LS161 | 2.70 | 2.62 | 2.54 |
| SN74LS170 | 5.92 | 5.80 | 5.60 |
| SN74LS174 | 3.02 | 2.92 | 2.82 |
| SN74LS175 | 2.90 | 2.82 | 2.74 |
| SN74LS181 | 3.72 | 3.62 | 3.52 |
| SN74LS251 | 2.55 | 2.49 | 2.40 |
| SN74LS253 | 3.05 | 3.00 | 2.85 |
| SN74LS260 | 0.58 | 0.56 | 0.54 |

## SCHOTTKY TTL

| | 1 | 25 | 100+ |
|---|---|---|---|
| SN74S00 | 0.45 | 0.43 | 0.39 |
| SN74S02 | 0.80 | 0.75 | 0.70 |
| SN74S03 | 0.75 | 0.71 | 0.68 |
| SN74S04 | 0.75 | 0.71 | 0.68 |
| SN74S08 | 0.80 | 0.75 | 0.70 |
| SN74S10 | 0.75 | 0.71 | 0.68 |
| SN74S11 | 0.65 | 0.63 | 0.61 |
| SN74S20 | 0.80 | 0.75 | 0.70 |
| SN74S30 | 0.80 | 0.75 | 0.70 |
| SN74S32 | 0.80 | 0.75 | 0.70 |
| SN74S40 | 0.80 | 0.75 | 0.70 |
| SN74S51 | 0.80 | 0.75 | 0.70 |
| SN74S64 | 0.80 | 0.75 | 0.70 |
| SN74S74 | 1.30 | 1.25 | 1.20 |
| SN74S85 | 6.10 | 6.00 | 5.80 |
| SN74S86 | 2.70 | 2.65 | 2.58 |
| SN74S112 | 2.20 | 2.10 | 2.00 |
| SN74S113 | 1.50 | 1.45 | 1.40 |
| SN74S132 | 3.60 | 3.50 | 3.25 |
| SN74S133 | 0.90 | 0.87 | 0.84 |
| SN74S138 | 2.40 | 2.30 | 2.20 |
| SN74S139 | 2.40 | 2.30 | 2.20 |
| SN74S140 | 0.90 | 0.87 | 0.84 |
| SN74S151 | 2.40 | 2.30 | 2.20 |
| SN74S153 | 2.40 | 2.30 | 2.20 |
| SN74S157 | 2.40 | 2.30 | 2.20 |
| SN74S158 | 2.40 | 2.30 | 2.20 |
| SN74S160 | 4.70 | 4.60 | 4.40 |
| SN74S161 | 4.70 | 4.60 | 4.40 |
| SN74S174 | 3.30 | 3.20 | 3.10 |
| SN74S175 | 3.30 | 3.20 | 3.10 |
| SN74S181 | 10.20 | 9.70 | 9.00 |
| SN74S189 | 5.10 | 4.90 | 4.70 |
| SN74S194 | 3.30 | 3.20 | 3.10 |
| SN74S195 | 3.30 | 3.20 | 3.10 |
| SN74S251 | 2.40 | 2.30 | 2.20 |
| SN74S253 | 2.40 | 2.30 | 2.20 |
| SN74S257 | 2.40 | 2.30 | 2.20 |
| SN74S258 | 2.40 | 2.30 | 2.20 |
| SN74S260 | 0.90 | 0.87 | 0.84 |
| SN74S280 | 5.70 | 5.50 | 5.20 |

## 7-SEGMENT DISPLAYS

| TYPE | EP27 | 1 | 25 | 100+ |
|---|---|---|---|---|
| 0.3" | DIL | 0.90 | 0.80 | 0.75 |

Comm. Anode. 14-pin DIL. Red LED EQUIV: MAN 7, DL707, SLA7; 5082-7730

## LOW-POWER TTL

| | 1 | 25 | 100+ |
|---|---|---|---|
| SN74L00 | 0.34 | 0.33 | 0.30 |
| SN74L02 | 0.34 | 0.33 | 0.30 |
| SN74L03 | 0.39 | 0.37 | 0.34 |
| SN74L04 | 0.39 | 0.37 | 0.34 |
| SN74L10 | 0.34 | 0.33 | 0.30 |
| SN74L20 | 0.39 | 0.37 | 0.34 |
| SN74L42 | 1.62 | 1.58 | 1.50 |
| SN74L51 | 0.34 | 0.33 | 0.30 |
| SN74L73 | 0.74 | 0.71 | 0.68 |
| SN74L74 | 0.89 | 0.87 | 0.80 |
| SN74L90 | 1.62 | 1.58 | 1.50 |
| SN74L93 | 1.74 | 1.71 | 1.65 |
| SN74L95 | 1.62 | 1.58 | 1.50 |
| SN93L00 | 1.50 | 1.45 | 1.40 |
| SN93L01 | 1.60 | 1.55 | 1.50 |
| SN93L08 | 3.20 | 3.10 | 2.90 |
| SN93L09 | 1.80 | 1.75 | 1.70 |
| SN93L10 | 2.80 | 2.75 | 2.65 |
| SN93L11 | 4.20 | 4.10 | 3.90 |
| SN93L12 | 1.80 | 1.75 | 1.70 |
| SN93L14 | 1.70 | 1.65 | 1.60 |
| SN93L16 | 3.20 | 3.10 | 2.95 |
| SN93L21 | 1.50 | 1.46 | 1.42 |
| SN93L22 | 1.80 | 1.76 | 1.70 |
| SN93L24 | 2.80 | 2.72 | 2.60 |
| SN93L28 | 3.70 | 3.60 | 3.42 |
| SN93L34 | 4.00 | 3.70 | 3.50 |
| SN93L38 | 4.20 | 4.10 | 3.90 |
| SN93L40 | 6.50 | 6.30 | 5.90 |
| SN93L41 | 6.50 | 6.30 | 5.90 |
| SN93L60 | 3.00 | 2.90 | 2.70 |
| SN93L66 | 2.70 | 2.65 | 2.55 |

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|---|---|---|---|
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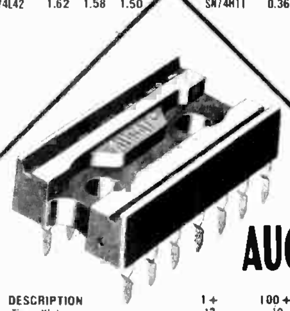
| SN74H01 | 0.34 | 0.33 | 0.30 |
| SN74H04 | 0.38 | 0.37 | 0.34 |
| SN74H05 | 0.37 | 0.36 | 0.33 |
| SN74H08 | 0.40 | 0.39 | 0.37 |
| SN74H10 | 0.36 | 0.35 | 0.33 |
| SN74H11 | 0.36 | 0.35 | 0.33 |
| SN74H20 | 0.36 | 0.35 | 0.33 |
| SN74H21 | 0.36 | 0.35 | 0.33 |
| SN74H22 | 0.36 | 0.35 | 0.33 |
| SN74H30 | 0.36 | 0.35 | 0.33 |
| SN74H40 | 0.36 | 0.35 | 0.33 |
| SN74H50 | 0.36 | 0.35 | 0.33 |
| SN74H51 | 0.36 | 0.35 | 0.33 |
| SN74H52 | 0.36 | 0.35 | 0.33 |
| SN74H53 | 0.36 | 0.35 | 0.33 |
| SN74H54 | 0.36 | 0.35 | 0.33 |
| SN74H55 | 0.36 | 0.35 | 0.33 |
| SN74H60 | 0.36 | 0.35 | 0.33 |
| SN74H61 | 0.36 | 0.35 | 0.33 |
| SN74H62 | 0.36 | 0.35 | 0.33 |
| SN74H71 | 0.80 | 0.78 | 0.75 |
| SN74H72 | 0.74 | 0.73 | 0.70 |
| SN74H73 | 0.90 | 0.88 | 0.85 |
| SN74H74 | 0.87 | 0.85 | 0.81 |
| SN74H76 | 0.90 | 0.88 | 0.85 |
| SN74H101 | 0.80 | 0.78 | 0.75 |
| SN74H102 | 0.80 | 0.78 | 0.75 |
| SN74H103 | 1.10 | 1.09 | 1.05 |
| SN74H106 | 0.95 | 0.93 | 0.90 |



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| PART NO. | DESCRIPTION | 1+ | 100+ | 500+ | 1000+ |
|---|---|---|---|---|---|
| 308-AG370 | Tin – Kink | 13 | 10 | 9 | 8 |
| 308-AG380 | Gold – Kink | 17 | 15 | 13 | 12 |
| 308-AG390 | Tin – No Kink | 13 | 10 | 9 | 8 |
| 308-AG400 | Gold – No Kink | 17 | 15 | 13 | 12 |
| 314-AG370 | Tin – Kink | 15 | 13 | 12 | 9 |
| 314-AG380 | Gold – Kink | 24 | 21 | 18 | 15 |
| 314-AG390 | Tin – No Kink | 15 | 13 | 12 | 9 |
| 314-AG400 | Gold – No Kink | 24 | 21 | 18 | 15 |
| 316-AG370 | Tin – Kink | 16 | 14 | 12 | 10 |
| 316-AG380 | Gold – Kink | 28 | 23 | 20 | 17 |
| 316-AG390 | Tin – No Kink | 16 | 14 | 12 | 10 |
| 316-AG400 | Gold – No Kink | 28 | 23 | 20 | 17 |
| 318-AG370 | Tin – Kink | 17 | 15 | 13 | 11 |
| 318-AG380 | Gold-Kink | 30 | 25 | 22 | 18 |
| 318-AG390 | Tin – No Kink | 17 | 15 | 13 | 11 |
| 318-AG400 | Gold – No Kink | 30 | 25 | 22 | 18 |

Contacts are Beryllium Copper. Tin or Gold plated. Sockets with kinked leads are self-retaining in 0.035" holes: sockets with straight leads are suitable for holes down to 0.0025"

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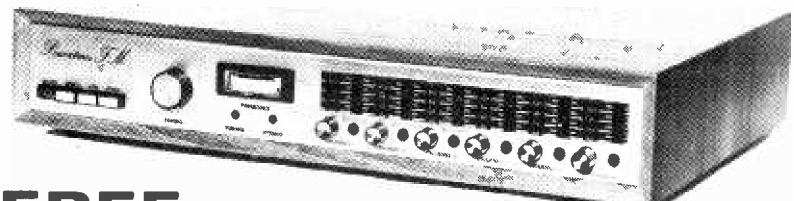
| 2 | Set of metal oxide resistors, thermistor, capacitors, cermet preset for mounting on pack 1 | £4.80 |
| 3 | Set of transistors, diodes, LED, integrated circuits for mounting on pack 1 | £6.25 |
| 4 | Pre-aligned front end module, coil assembly, three-section ceramic filter | £8.80 |
| 5 | Fibreglass printed circuit board for stereo decoder | £1.10 |
| 6 | Set of metal oxide resistors, capacitors cermet preset for decoder | £2.60 |
| 7 | Set of transistors LED, integrated circuit for decoder | £3.45 |
| 8 | Set of components for channel selector switch module including fibreglass printed circuit board, push-button switches, knobs, LEDs preset adjusters, etc. | £8.30 |

| Pack | | Price |
|---|---|---|
| 9 | Function switch, 10 turn tuning potentiometer, knobs | £5.30 |
| 10 | Frequency meter, meter drive components, fibreglass printed circuit board | £8.60 |
| 11 | Toroidal transformer with electrostatic screen, Primary: 0–117V–234V | £4.45 |
| 12 | Set of capacitors, rectifiers, voltage regulator for power supply | £2.95 |
| 13 | Set of miscellaneous parts, including sockets, fuse holder, fuses, inter-connecting wire, etc. | £1.50 |
| 14 | Set of metal work parts including silk screen printed facia panel, acrylic silk screen printed tuning indicator panel insert, internal screen, fixing parts, etc. | £6.50 |
| 15 | Construction notes (free with complete kit) | £0 25 |
| 16 | Teak cabinet | £9 85 |
| | One each of packs 1–16 inclusive are required for complete stereo FM tuner. | |
| | Total cost of individually purchased packs | £76 85 |

## NOVEL STEREO FM TUNER

In the April and May issues of *Wireless World* there was published a novel design for an f m. tuner which combines consistent high performance with the elimination of the critical setting-up procedure required by too many earlier tuners. This original circuit has been developed further and is used as the basis for our new slimline unit. The front end is a ready built pre-aligned module which then feeds an amplifier driven screened three section ceramic filter leading to an integrated circuit five-stage limiting amplifier providing excellent a.m. rejection. This is followed by a single coil integrated balanced demodulator from which the audio output may be taken. Temperature compensated varicap tuning allows stations to be selected either by a ten-turn tuning potentiometer or by a choice of six preset push-button controls. Each of the preset controls can be adjusted on the front panel with the settings being indicated by six LED lamps behind an acrylic silk screen printed facia panel insert. Additional circuitry includes temperature compensated AFC restricted to less than station spacing, inter-station muting, a single-lamp LED tuning indicator and a linear scale frequency meter. The stereo decoder, built on a separate board, is based on a well-proven integrated circuit phase-locked-loop to which has been added active filters to remove sub-carrier harmonics and 'birdies'. The power supply, to ensure station holding stability, uses an integrated circuit voltage regulator which is powered via a low-hum field specially designed TOROIDAL TRANSFORMER.



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# NEW! FROM POWERTRAN ELECTRONICS

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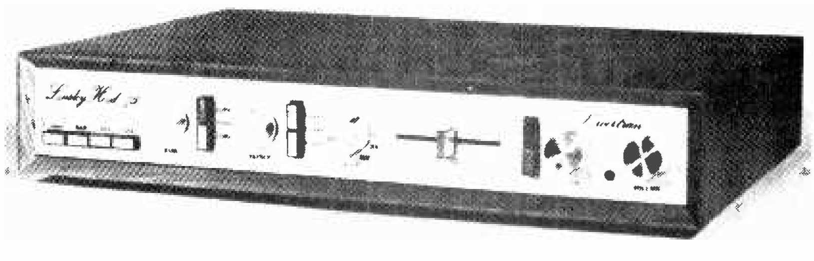
## DESIGNER APPROVED KIT

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



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

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| 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 |

| Pack | | Price |
|---|---|---|
| 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 | £9 85 |
| | 2 each of packs 1–7 inclusive are required for complete stereo system | |
| | Total cost of individually purchased packs | £72 25 |

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| AC126 | 0.16 | BC159 | 0.13 | CV7594 | 0.25 | 2G306 | 0.44 |
| AC127 | 0.16 | BC171 | 0.16 | CV7648 | 0.30 | 2G345A | 0.18 |
| AC128 | 0.12 | BC172 | 0.16 | CV8762 | 0.40 | 2G402 | 0.25 |
| AC138 | 0.20 | BC173 | 0.16 | MOS33 | 0.30 | 2N526 | 0.16 |
| AC141 | 0.20 | BC184 | 0.18 | ME4102 | 0.12 | 2N697 | 0.15 |
| AC142 | 0.20 | BC208 | 0.12 | MJE2021 | 0.85 | 2N715 | 0.35 |
| AC153 | 0.22 | BC209 | 0.13 | MJE2955 | 0.95 | 2N726 | 0.25 |
| AC154 | 0.22 | BC212L | 0.14 | MJE3055 | 0.60 | 2N753 | 0.55 |
| AC167 | 0.21 | BC213L | 0.12 | NKT162 | 0.25 | 2N1303 | 0.16 |
| AC168 | 0.27 | BC214L | 0.14 | NKT164 | 0.25 | 2N1304 | 0.19 |
| AC169 | 0.16 | BC301 | 0.30 | NKT212 | 0.20 | 2N1305 | 0.19 |
| AC176 | 0.15 | BC337 | 0.15 | NKT221 | 0.17 | 2N1309 | 0.25 |
| AC176) | MP | BCZ11 | 0.28 | NKT224 | 0.15 | 2N1754 | 0.20 |
| AC128) | 0.25 | BD131 | 0.40 | NKT270 | 0.15 | 2N2484 | 0.30 |
| AC177 | 0.26 | BD132 | 0.40 | NKT278 | 0.15 | 2N2923 | 0.16 |
| AC178 | 0.25 | BD131) | MP | OC22 | 0.50 | 2N2924 | 0.18 |
| ACY17 | 0.28 | BD132) | 0.75 | OC28 | 0.50 | 2N2925 | 0.15 |
| ACY18 | 0.22 | BD139 | 0.70 | OC35 | 0.45 | 2N2926G | 0.14 |
| ACY19 | 0.22 | BD140 | 0.70 | OC36 | 0.55 | 2N2926Y | 0.12 |
| ACY20 | 0.20 | BD243 | 0.85 | OC44 | 0.17 | 2N2926R | 0.11 |
| ACY21 | 0.18 | BD244 | 0.85 | OC45 | 0.14 | 2N2926O | 0.11 |
| ACY27 | 0.20 | BF167 | 0.24 | OC70 | 0.11 | 2N2926B | 0.11 |
| ACY28 | 0.22 | BF181 | 0.33 | OC71 | 0.11 | 2N3053 | 0.19 |
| AD140 | 0.53 | BF182 | 0.40 | OC72 | 0.15 | 2N2054 | 0.50 |
| AD142 | 0.53 | BF183 | 0.40 | OC81 | 0.17 | 2N3055 | 0.50 |
| AD149 | 0.55 | BF194 | 0.12 | OC200 | 0.28 | 2N3702 | 0.12 |
| AD161 | 0.43 | BF195 | 0.30 | OC201 | 0.32 | 2N3703 | 0.12 |
| AD162 | 0.43 | BF196 | 0.15 | OC202 | 0.27 | 2N3704 | 0.14 |
| AD161) | MP | BF197 | 0.16 | OC203 | 0.29 | 2N3705 | 0.13 |
| AD162) | 0.85 | BF200 | 0.50 | OC204 | 0.28 | 2N3707 | 0.14 |
| AF115 | 0.26 | BF274 | 0.39 | OC445K | 0.20 | 2N3710 | 0.10 |
| AF116 | 0.26 | BU105 | 2.00 | SGS26920 | .15 | 2N3711 | 0.10 |
| AF124 | 0.33 | BFX29 | 0.28 | SGS26942 | .14 | 2N3713 | 1.20 |
| AF125 | 0.31 | BFX84 | 0.33 | SGS26949 | .15 | 2N3094 | 0.33 |
| AF178 | 0.50 | BFX85 | 0.33 | SGS27022 | .18 | 2N3905 | 0.31 |
| ASY51 | 0.26 | BFY50 | 0.20 | SU203 | 0.65 | 2N3905 | 0.31 |
| ASY52 | 0.22 | BFY51 | 0.16 | TK100 | 0.75 | 2N3906 | 0.30 |
| BC107 | 0.11 | BFY52 | 0.20 | TIS90M | 0.33 | 2N4058 | 0.13 |
| BC108 | 0.11 | BFY81 | 0.65 | TIS91M | 0.33 | 2N4059 | 0.15 |
| BC109 | 0.11 | BSY38 | 0.20 | T6217 | 0.30 | 2N4287 | 0.20 |
| BC142 | 0.30 | BSY39 | 0.20 | V405A | 0.25 | 2N4289 | 0.20 |
| BC143 | 0.30 | BSY40 | 0.31 | V10/50 | 0.40 | 2N4291 | 0.22 |
| BC147 | 0.10 | BSY41 | 0.31 | Z116 | 0.75 | 2N4293 | 0.19 |
| BC148 | 0.10 | C111 | 0.50 | ZTX107 | 0.12 | 2S322 | 0.46 |
| BC149 | 0.10 | C111E | 0.55 | ZTX302 | 0.17 | 2S712 | 0.46 |
| BC157 | 0.11 | CV5441 | 0.20 | ZTX502 | 0.17 | 2S745 | 0.45 |

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| | | | | | | | |
|---|---|---|---|---|---|---|---|
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| AA119 | 0.06 | BY127 | 0.12 | OA202 | 0.07 | IN4003 | 0.05 |
| 2/AA119 | 0.09 | BY164 | 0.38 | IN34A | 0.08 | IN4004 | 0.06 |
| AAZ15 | 0.11 | BYX38/300 | | IN202 | 0.09 | IN4005 | 0.07 |
| BA90 | 0.10 | | 0.46 | IN252 | 0.10 | IN4006 | 0.08 |
| BA111 | 0.18 | BYZ213 | 0.28 | IN914 | 0.06 | IN4007 | 0.09 |
| BA112 | 0.16 | BZY95 | 0.15 | IN984B | 0.10 | IN4151 | 0.06 |
| BAX78/1 | 0.10 | OA10 | 0.12 | IN1124 | 0.09 | IN4148 | 0.04 |
| BAY31 | 0.14 | OA47 | 0.10 | IN3064 | 0.10 | IN4244 | 0.07 |
| BAY74 | 0.12 | OA81 | 0.08 | IN4001 | 0.05 | IS3036A | 0.15 |

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| SN7402 | 0.14 | SN7417 | 0.29 | SN7460 | 0.15 | SN7494 | 0.80 |
| SN7403 | 0.14 | SN7423 | 0.40 | SN7472 | 0.30 | SN74121 | 0.49 |
| SN7404 | 0.14 | SN7425 | 0.39 | SN7473 | 0.41 | SN74122 | 0.70 |
| SN7405 | 0.15 | SN7430 | 0.14 | SN7474 | 0.40 | SN74123 | 0.70 |
| SN7406 | 0.39 | SN7432 | 0.39 | SN7476 | 0.42 | SN74151 | 1.05 |
| SN7407 | 0.37 | SN7433 | 0.40 | SN7480 | 0.16 | SN74153 | 0.95 |
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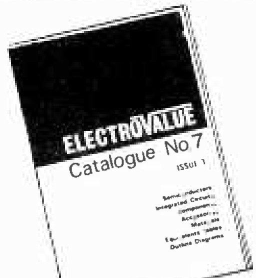


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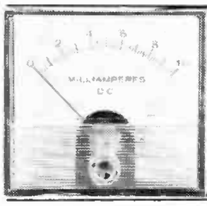


### TYPE TAD

| Dims in mm | 48 x 42 | 66 x 50 | 85 x 70 | 118 x 106 | 150 x 110 |
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| 50 μA | £3.63 | £3.81 | £4.00 | £4.90 | £5.46 |
| 500 μA | £3.34 | £3.51 | £3.72 | £4.62 | £5.32 |
| 1mA | £3.27 | £3.44 | £3.64 | £4.53 | £5.23 |
| 15vDC | £3.30 | £3.49 | £3.67 | £4.57 | £5.26 |
| 300vAC | £3.47 | £3.66 | £3.84 | £4.73 | £5.30 |

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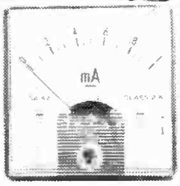
| 500 μA | £3.21 | £3.28 | £3.53 | £3.76 |
| 1mA | £3.11 | £3.18 | £3.43 | £3.72 |
| 15vDC | £3.15 | £3.22 | £3.50 | £3.76 |
| 300vAC | £3.39 | £3.46 | £3.67 | £3.92 |

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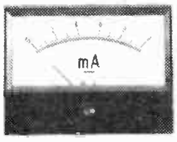


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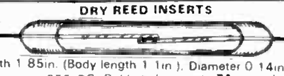

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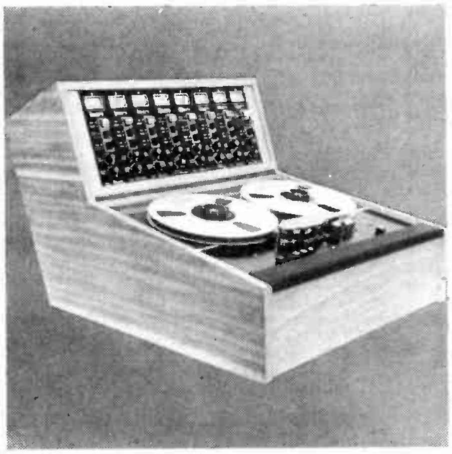

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|---|---|---|---|---|---|---|---|---|---|---|
| | ONE | 10 | ONE | 10 | ONE | 10 | ONE | 10 | ONE | 10 |
| C60 | £0.38 | £3.70 | £0.71 | £6.90 | £0.61 | £6.00 | £0.84 | £8.30 | £0.43 | £4.25 |
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| 5" 900' | £1.55 | £15.00 | £1.84 | £17.90 | £1.34 | £12.90 | £1.22 | £12.10 |
| 5¾" 1200' | £1.78 | £17.50 | £2.40 | £22.76 | — | — | £1.60 | £15.00 |
| 7" 1800' | £2.32 | £23.00 | £2.60 | £25.50 | £2.10 | £20.50 | £2.18 | £21.00 |
| DOUBLE PLAY | ONE | 10 | ONE | 10 | ONE | 10 | ONE | 10 |
| 5" 1200' | £1 80 | £17.75 | £2.40 | £22.76 | £1.48 | £14.00 | £1.52 | £14.49 |
| 5¾" 1800' | £2.57 | £25.00 | £3.00 | £28.52 | — | — | £2.20 | £21.00 |
| 7" 2400' | £2.85 | £28.00 | £3.35 | £32.50 | £2.60 | £25.00 | £2.60 | £25.50 |
| TRIPLE PLAY | ONE | 10 | ONE | 10 | ONE | 10 | ONE | 10 |
| 5" 1800' | £2.52 | £25.00 | £3.00 | £28.52 | — | — | £2.30 | £22.20 |
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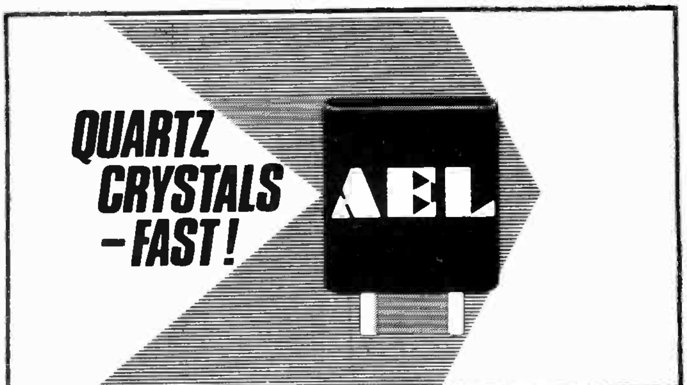


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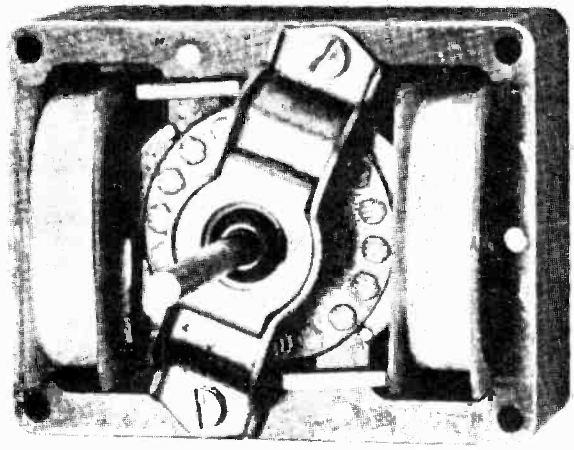

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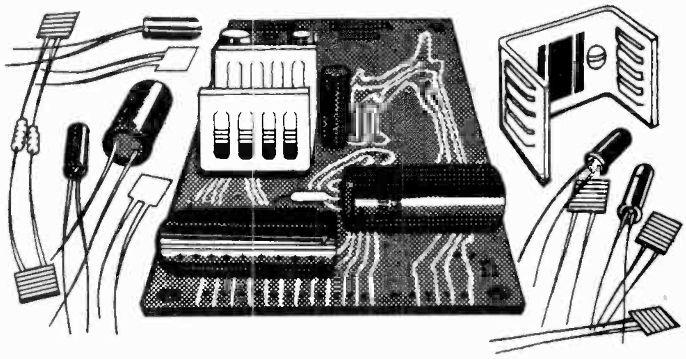

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| AC125 | 0.18 | BC177 | 0.19 | BSX19 | 0.16 | 2N744 | 0.20 |
| AC126 | 0.18 | BC178 | 0.19 | BSX20 | 0.16 | 2N914 | 0.15 |
| AC127 | 0.19 | BC179 | 0.19 | BSY25 | 0.16 | 2N918 | 0.31 |
| AC128 | 0.19 | BC180 | 0.25 | BSY26 | 0.16 | 2N929 | 0.21 |
| AC132 | 0.15 | BC181 | 0.25 | BSY27 | 0.16 | 2N930 | 0.31 |
| AC134 | 0.15 | BC182 | 0.15 | BSY28 | 0.16 | 2N1131 | 0.20 |
| AC137 | 0.15 | BC182L | 0.15 | BSY29 | 0.16 | 2N1132 | 0.22 |
| AC141 | 0.19 | BC183 | 0.15 | BSY38 | 0.19 | 2N1302 | 0.15 |
| AC141K | 0.30 | BC183L | 0.15 | BSY39 | 0.19 | 2N1303 | 0.15 |
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| AC142K | 0.26 | BC184L | 0.20 | BSY41 | 0.29 | 2N1305 | 0.18 |
| AC151 | 0.16 | BC186 | 0.29 | BSY95 | 0.13 | 2N1306 | 0.21 |
| AC154 | 0.20 | BC187 | 0.29 | BSY95A | 0.13 | 2N1307 | 0.21 |
| AC155 | 0.20 | BC207 | 0.11 | BU105 | 2.04 | 2N1308 | 0.24 |
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| AC167 | 0.20 | BC214L | 0.17 | C425 | 0.51 | 2N1890 | 0.46 |
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| AC180K | 0.30 | BC460 | 0.37 | MAT101 | 0.20 | 2N2217 | 0.22 |
| AC181 | 0.20 | BCY30 | 0.25 | MAT120 | 0.19 | 2N2218 | 0.20 |
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| AC188 | 0.22 | BCY34 | 0.26 | MJE3055 | 0.57 | 2N2222 | 0.20 |
| AC188K | 0.23 | BCY70 | 0.15 | MJE3440 | 0.51 | 2N2368 | 0.18 |
| ACY17 | 0.26 | BCY71 | 0.20 | MPF102 | 0.43 | 2N2369 | 0.15 |
| ACY18 | 0.20 | BCY72 | 0.15 | MPF104 | 0.38 | 2N2369A | 0.15 |
| ACY19 | 0.20 | BCZ10 | 0.20 | MPF105 | 0.38 | 2N2411 | 0.25 |
| ACY20 | 0.20 | BCZ11 | 0.26 | OC19 | 0.36 | 2N2412 | 0.25 |
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| ACY22 | 0.17 | BD115 | 0.63 | OC22 | 0.47 | 2N2711 | 0.21 |
| ACY27 | 0.19 | BD116 | 0.81 | OC23 | 0.49 | 2N2712 | 0.21 |
| ACY28 | 0.19 | BD121 | 0.61 | OC24 | 0.57 | 2N2714 | 0.21 |
| ACY29 | 0.36 | BD123 | 0.67 | OC25 | 0.39 | 2N2904 | 0.18 |
| ACY30 | 0.29 | BD124 | 0.70 | OC26 | 0.30 | 2N2904A | 0.21 |
| ACY31 | 0.29 | BD131 | 0.51 | OC28 | 0.51 | 2N2905 | 0.21 |
| ACY34 | 0.21 | BD132 | 0.61 | OC29 | 0.51 | 2N2905A | 0.21 |
| ACY35 | 0.21 | BD133 | 0.67 | OC35 | 0.43 | 2N2906 | 0.16 |
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| ACY40 | 0.18 | BD137 | 0.46 | OC41 | 0.20 | 2N2907 | 0.20 |
| ACY41 | 0.19 | BD138 | 0.51 | OC42 | 0.25 | 2N2907A | 0.22 |
| ACY44 | 0.36 | BD139 | 0.56 | OC44 | 0.16 | 2N2923 | 0.15 |
| AD130 | 0.39 | BD140 | 0.61 | OC45 | 0.13 | 2n2924 | 0.15 |
| AD140 | 0.49 | BD155 | 0.81 | OC70 | 0.10 | 2N2925 | 0.15 |
| AD142 | 0.49 | BD175 | 0.61 | OC71 | 0.10 | 2N2926G | 0.13 |
| AD143 | 0.39 | BD176 | 0.61 | OC72 | 0.15 | 2N2926Y | 0.11 |
| AD149 | 0.51 | BD177 | 0.67 | OC74 | 0.15 | 2N2926O | 0.10 |
| AD161 | 0.36 | BD178 | 0.67 | OC75 | 0.16 | 2N2926R | 0.10 |
| AD162 | 0.36 | BD179 | 0.71 | OC76 | 0.16 | 2N2926B | 0.10 |
| AD161 & | | BD180 | 0.71 | OC77 | 0.26 | 2N3091 | 0.71 |
| AD162(MP) | 0.69 | BD185 | 0.67 | OC81 | 0.16 | 2N3011 | 0.15 |
| ADT140 | 0.51 | BD186 | 0.67 | OC81D | 0.16 | 2N3053 | 0.18 |
| AF114 | 0.25 | BD187 | 0.71 | OC82 | 0.16 | 2N3054 | 0.47 |
| AF115 | 0.25 | BD188 | 0.71 | OC82D | 0.16 | 2N3055 | 0.42 |
| AF116 | 0.25 | BD189 | 0.77 | OC83 | 0.20 | 2N3319 | 0.15 |
| AF117 | 0.25 | BD190 | 0.77 | OC139 | 0.20 | 2N3391A | 0.15 |
| AF118 | 0.36 | BD195 | 0.87 | OC140 | 0.20 | 2N3392 | 0.15 |
| AF124 | 0.31 | BD196 | 0.87 | OC169 | 0.26 | 2N3393 | 0.15 |
| AF125 | 0.31 | BD197 | 0.92 | OC170 | 0.26 | 2N3394 | 0.15 |
| AF126 | 0.29 | BD198 | 0.92 | OC171 | 0.26 | 2N2295 | 0.18 |
| AF127 | 0.29 | BD199 | 0.98 | OC200 | 0.26 | 2N3402 | 0.21 |
| AF139 | 0.31 | BD200 | 0.98 | OC201 | 0.29 | 2N3403 | 0.21 |
| AF178 | 0.51 | BD205 | 0.81 | OC202 | 0.29 | 2N3404 | 0.29 |
| AF179 | 0.51 | BD206 | 0.81 | OC203 | 0.26 | 2N3405 | 0.34 |
| AF180 | 0.51 | BD207 | 0.98 | OC204 | 0.26 | 2N3414 | 0.16 |
| AF181 | 0.51 | BD208 | 0.98 | OC205 | 0.36 | 2N3415 | 0.16 |
| AF186 | 0.51 | BDY20 | 1.02 | OC309 | 0.41 | 2N3416 | 0.29 |
| AF239 | 0.38 | BF115 | 0.25 | OCP71 | ★0.44 | 2N3417 | 0.29 |
| AL102 | 0.68 | BF117 | 0.46 | ORP12 | ★0.44 | 2N3525 | ★0.77 |
| AL103 | 0.68 | BF118 | 0.71 | ORP60 | ★0.41 | 2N3614 | 0.69 |
| ASY26 | 0.26 | BF119 | 0.71 | ORP61 | ★0.41 | 2N3615 | 0.76 |
| ASY27 | 0.31 | BF121 | 0.46 | P20 | ★0.51 | 2N3616 | 0.76 |
| ASY28 | 0.26 | BF123 | 0.51 | P346A | 0.20 | 2N3646 | 0.09 |
| ASY29 | 0.26 | BF125 | 0.46 | P397 | 0.43 | 2N3702 | 0.12 |
| ASY50 | 0.26 | BF127 | 0.51 | ST140 | 0.13 | 2N3703 | 0.12 |
| ASY51 | 0.26 | BF152 | 0.56 | ST141 | 0.18 | 2N3704 | 0.13 |
| ASY52 | 0.26 | BF153 | 0.46 | TIP29 | 0.44 | 2N3705 | 0.12 |
| ASY54 | 0.26 | BF154 | 0.46 | TIP30 | 0.52 | 2N3706 | 0.12 |
| ASY55 | 0.26 | BF155 | 0.71 | TIP31A | 0.56 | 2N3707 | 0.13 |
| ASY56 | 0.26 | BF156 | 0.49 | TIP32A | 0.68 | 2N3708 | 0.08 |
| ASY57 | 0.26 | BF157 | 0.56 | TIP41A | 0.68 | 2N3709 | 0.09 |
| ASY58 | 0.26 | BF158 | 0.56 | TIP42A | 0.81 | 2N3710 | 0.09 |
| ASY73 | 0.26 | BF159 | 0.61 | TIS43 | ★0.31 | 2N3711 | 0.09 |
| ASZ21 | 0.41 | BF160 | 0.41 | UT46 | ★0.28 | 2N3819 | 0.29 |
| BC107 | 0.08 | BF162 | 0.41 | ZN414 | 1.11 | 2N3820 | 0.51 |
| BC108 | 0.08 | BF163 | 0.41 | 2G301 | 0.19 | 2N3821 | 0.36 |
| BC109 | 0.08 | BF164 | 0.41 | 2G302 | 0.19 | 2N3823 | 0.29 |
| BC113 | 0.10 | BF165 | 0.41 | 2G303 | 0.19 | 2N3903 | 0.29 |
| BC114 | 0.16 | BF167 | 0.22 | 2G304 | 0.25 | 2N3904 | 0.31 |
| BC115 | 0.16 | BF173 | 0.22 | 2G306 | 0.41 | 2N3905 | 0.29 |
| BC116 | 0.16 | BF176 | 0.36 | 2G308 | 0.36 | 2N3906 | 0.28 |
| BC117 | 0.19 | BF177 | 0.36 | 2G309 | 0.37 | 2N4058 | 0.12 |
| BC118 | 0.10 | BF178 | 0.31 | 2G339 | 0.20 | 2N4059 | 0.10 |
| BC119 | 0.31 | BF179 | 0.31 | 2G339A | 0.17 | 2N4060 | 0.12 |
| BC120 | 0.81 | BF180 | 0.31 | 2G344 | 0.19 | 2N4061 | 0.12 |
| BC125 | 0.12 | BF181 | 0.31 | 2G345 | 0.17 | 2N4062 | 0.12 |
| BC126 | 0.19 | BF182 | 0.41 | 2G371 | 0.17 | 2N4284 | 0.18 |
| BC132 | 0.12 | BF183 | 0.41 | 2G371B | 0.12 | 2N4285 | 0.18 |
| BC134 | 0.19 | BF184 | 0.26 | 2G373 | 0.18 | 2N4286 | 0.18 |
| BC135 | 0.12 | BF185 | 0.31 | 2G374 | 0.18 | 2N4287 | 0.18 |
| BC136 | 0.16 | BF187 | 0.28 | 2G377 | 0.31 | 2N4288 | 0.18 |
| BC137 | 0.16 | BF188 | 0.41 | 2G378 | 0.17 | 2N4289 | 0.18 |
| BC139 | 0.41 | BF194 | 0.12 | 2G381 | 0.17 | 2N4290 | 0.18 |
| BC140 | 0.31 | BF195 | 0.12 | 2G382 | 0.17 | 2N4291 | 0.18 |
| BC141 | 0.31 | BF196 | 0.15 | 2G401 | 0.31 | 2N4292 | 0.18 |
| BC143 | 0.31 | BF197 | 0.15 | 2G414 | 0.31 | 2N4293 | 0.18 |
| BC145 | 0.46 | BF200 | 0.46 | 2G417 | 0.26 | 2N5172 | 0.12 |
| BC147 | 0.10 | BF222 | 0.98 | 2N388 | 0.36 | 2N5194 | 0.56 |
| BC148 | 0.10 | BF257 | 0.46 | 2N388A | 0.56 | 2N5294 | 0.56 |
| BC149 | 0.12 | BF258 | 0.61 | 2N404 | 0.20 | 2N5296 | 0.56 |
| BC150 | 0.19 | BF259 | 0.87 | 2N404A | 0.29 | 2N5457 | 0.32 |
| BC151 | 0.20 | BF262 | 0.56 | 2N524 | 0.43 | 2N5458 | 0.32 |
| BC152 | 0.18 | BF263 | 0.56 | 2N527 | 0.50 | 2N5459 | 0.41 |
| BC153 | 0.29 | BF270 | 0.36 | 2N598 | 0.43 | 2N6122 | 0.69 |
| BC154 | 0.31 | BF271 | 0.31 | 2N599 | 0.46 | 2S301 | 0.51 |
| BC157 | 0.19 | BF272 | 0.81 | 2N696 | 0.13 | 2S302A | 0.43 |
| BC158 | 0.12 | BF273 | 0.36 | 2N697 | 0.14 | 2S302 | 0.43 |
| BC159 | 0.12 | BF274 | 0.36 | 2N698 | 0.25 | 2S303 | 0.56 |
| BC160 | 0.46 | BFW10 | 0.61 | 2N699 | 0.36 | 2S304 | 0.71 |
| BC161 | 0.51 | BFX29 | 0.28 | 2N706 | 0.08 | 2S305 | 0.80 |
| BC167 | 0.12 | BFX84 | 0.22 | 2N706A | 0.09 | 2S306 | 0.80 |
| BC168 | 0.12 | BFX85 | 0.31 | 2N708 | 0.12 | 2S307 | 0.80 |
| BC169 | 0.12 | BFX86 | 0.22 | 2N711 | 0.31 | 2S321 | 0.75 |
| BC170 | 0.12 | BFX87 | 0.25 | 2N717 | 0.36 | 2S322 | 0.43 |

## ★ 74 SERIES T.T.L. I.C.'s

BI-PAK STILL LOWEST IN PRICE. FULL SPECIFICATION GUARANTEED. ALL FAMOUS MANUFACTURERS

| Type | Quantities 1 | 25 | 100+ | Type | Quantities 1 | 25 | 100+ |
|---|---|---|---|---|---|---|---|
| 7400 | 0.14 | 0.13 | 0.12 | 7486 | 0.32 | 0.31 | 0.30 |
| 7401 | 0.14 | 0.13 | 0.12 | 7489 | 3.70 | 3.47 | 3.24 |
| 7402 | 0.14 | 0.13 | 0.12 | 7490 | 0.60 | 0.58 | 0.56 |
| 7403 | 0.14 | 0.13 | 0.12 | 7491 | 1.02 | 0.97 | 0.93 |
| 7404 | 0.14 | 0.13 | 0.12 | 7492 | 0.69 | 0.66 | 0.59 |
| 7405 | 0.14 | 0.13 | 0.12 | 7493 | 0.69 | 0.66 | 0.59 |
| 7406 | 0.36 | 0.31 | 0.29 | 7494 | 0.79 | 0.76 | 0.69 |
| 7407 | 0.36 | 0.31 | 0.29 | 7495 | 0.79 | 0.76 | 0.69 |
| 7408 | 0.23 | 0.22 | 0.21 | 7596 | 0.89 | 0.86 | 0.80 |
| 7409 | 0.23 | 0.22 | 0.21 | 74100 | 1.39 | 1.34 | 1.30 |
| 7410 | 0.14 | 0.13 | 0.12 | 74104 | 0.56 | 0.54 | 0.51 |
| 7411 | 0.23 | 0.22 | 0.21 | 74105 | 0.56 | 0.54 | 0.51 |
| 7412 | 0.26 | 0.25 | 0.24 | 74107 | 0.41 | 0.39 | 0.37 |
| 7413 | 0.30 | 0.29 | 0.28 | 74110 | 0.56 | 0.51 | 0.46 |
| 7416 | 0.28 | 0.27 | 0.26 | 74111 | 0.83 | 0.81 | 0.78 |
| 7417 | 0.28 | 0.27 | 0.26 | 74118 | 0.93 | 0.88 | 0.83 |
| 7420 | 0.14 | 0.13 | 0.12 | 74119 | 1.39 | 1.30 | 1.20 |
| 7422 | 0.28 | 0.27 | 0.26 | 74121 | 0.46 | 0.44 | 0.41 |
| 7423 | 0.37 | 0.36 | 0.35 | 74122 | 0.65 | 0.63 | 0.60 |
| 7425 | 0.37 | 0.36 | 0.35 | 74123 | 0.69 | 0.68 | 0.65 |
| 7426 | 0.37 | 0.35 | 0.33 | 74141 | 0.79 | 0.76 | 0.73 |
| 7427 | 0.37 | 0.35 | 0.33 | 74145 | 1.20 | 1.16 | 1.11 |
| 7428 | 0.42 | 0.39 | 0.37 | 74150 | 1.39 | 1.30 | 1.20 |
| 7430 | 0.14 | 0.13 | 0.12 | 74151 | 1.02 | 0.97 | 0.93 |
| 7432 | 0.37 | 0.35 | 0.33 | 74153 | 0.93 | 0.88 | 0.83 |
| 7433 | 0.39 | 0.37 | 0.35 | 74154 | 1.57 | 1.43 | 1.48 |
| 7437 | 0.32 | 0.30 | 0.28 | 74155 | 1.11 | 1.06 | 1.02 |
| 7438 | 0.32 | 0.30 | 0.28 | 74156 | 1.11 | 1.06 | 1.02 |
| 7440 | 0.14 | 0.13 | 0.12 | 74157 | 0.93 | 0.88 | 0.83 |
| 7441 | 0.69 | 0.66 | 0.59 | 74160 | 1.30 | 1.25 | 1.20 |
| 7442 | 0.69 | 0.66 | 0.59 | 74161 | 1.30 | 1.25 | 1.20 |
| 7443 | 1.11 | 1.06 | 1.02 | 74162 | 1.30 | 1.25 | 1.20 |
| 7444 | 1.11 | 1.06 | 1.02 | 74163 | 1.30 | 1.25 | 1.20 |
| 7445 | 1.48 | 1.44 | 1.39 | 74164 | 1.67 | 1.62 | 1.55 |
| 7446 | 1.11 | 1.06 | 1.02 | 74165 | 1.67 | 1.62 | 1.55 |
| 7447 | 1.02 | 0.99 | 0.97 | 74166 | 1.48 | 1.44 | 1.39 |
| 7448 | 1.02 | 0.99 | 0.97 | 74174 | 1.48 | 1.44 | 1.39 |
| 7450 | 0.14 | 0.13 | 0.12 | 74175 | 1.02 | 0.97 | 0.93 |
| 7451 | 0.14 | 0.13 | 0.12 | 74176 | 1.16 | 1.11 | 1.06 |
| 7453 | 0.14 | 0.13 | 0.12 | 74177 | 1.16 | 1.11 | 1.06 |
| 7454 | 0.14 | 0.13 | 0.12 | 74180 | 1.16 | 1.11 | 1.06 |
| 7460 | 0.14 | 0.13 | 0.12 | 74181 | 3.66 | 3.56 | 3.47 |
| 7470 | 0.30 | 0.27 | 0.25 | 74182 | 1.16 | 1.11 | 1.06 |
| 7472 | 0.30 | 0.27 | 0.25 | 74184 | 1.67 | 1.62 | 1.55 |
| 7473 | 0.38 | 0.36 | 0.32 | 74190 | 1.81 | 1.76 | 1.71 |
| 7474 | 0.38 | 0.36 | 0.32 | 74191 | 1.81 | 1.76 | 1.71 |
| 7475 | 0.56 | 0.54 | 0.52 | 74192 | 1.81 | 1.76 | 1.71 |
| 7476 | 0.41 | 0.40 | 0.39 | 74193 | 1.81 | 1.76 | 1.71 |
| 7480 | 0.56 | 0.54 | 0.51 | 74194 | 1.20 | 1.16 | 1.11 |
| 7481 | 1.02 | 0.97 | 0.93 | 74195 | 1.02 | 0.97 | 0.93 |
| 7482 | 0.83 | 0.79 | 0.74 | 74196 | 1.11 | 1.06 | 1.02 |
| 7483 | 1.11 | 1.06 | 1.02 | 74197 | 1.11 | 1.06 | 1.02 |
| 7484 | 0.93 | 0.90 | 0.88 | 74198 | 2.55 | 2.50 | 2.45 |
| 7485 | 1.48 | 1.44 | 1.39 | 74199 | 2.31 | 2.21 | 2.11 |

Devices may be mixed to qualify for quantity price (TTL 74 series only) data is available for the above series of I.C.'s in booklet form. PRICE 35p

## ★ D.T.L. 930 SERIES

| Type | Quantities 1 | 25 | 100+ | Type | Quantities 1 | 25 | 100+ |
|---|---|---|---|---|---|---|---|
| BP930 | 0.14 | 0.13 | 0.12 | BP948 | 0.28 | 0.26 | 0.23 |
| BP932 | 0.15 | 0.14 | 0.13 | BP951 | 0.65 | 0.60 | 0.56 |
| BP933 | 0.15 | 0.14 | 0.13 | BP962 | 0.14 | 0.13 | 0.12 |
| BP935 | 0.15 | 0.14 | 0.13 | BP9093 | 0.42 | 0.40 | 0.38 |
| BP936 | 0.15 | 0.14 | 0.13 | BP9094 | 0.42 | 0.40 | 0.38 |
| BP944 | 0.15 | 0.14 | 0.13 | BP9097 | 0.42 | 0.40 | 0.38 |
| BP945 | 0.28 | 0.26 | 0.23 | BP9099 | 0.42 | 0.40 | 0.38 |
| BP946 | 0.14 | 0.13 | 0.12 | | | | |

Devices may be mixed to qualify for quantity price. Larger quantity prices on application. (DTL 930 Series only).

## ★ THYRISTORS

| PIV | 0.6A TO18 | 0.8A TO92 | 1A TO5 | 3A TO66 | 5A TO66 | 5A TO64 | 7A TO48 | 10A TO48 | 16A TO48 | 30A TO48 |
|---|---|---|---|---|---|---|---|---|---|---|
| 10 | 0.13 | 0.15 | — | — | — | — | — | — | — | — |
| 20 | 0.15 | 0.18 | — | — | — | — | — | — | — | — |
| 30 | 0.19 | 0.22 | — | — | — | — | — | — | — | — |
| 50 | 0.22 | 0.28 | 0.20 | 0.25 | 0.36 | 0.36 | 0.48 | 0.51 | 0.54 | 1.18 |
| 100 | 0.25 | 0.30 | 0.25 | 0.25 | 0.48 | 0.48 | 0.51 | 0.57 | 0.58 | 1.43 |
| 150 | 0.31 | 0.38 | — | — | — | — | — | — | — | — |
| 200 | 0.38 | 0.44 | 0.25 | 0.30 | 0.50 | 0.50 | 0.57 | 0.62 | 0.62 | 1.63 |
| 400 | — | — | 0.30 | 0.39 | 0.55 | 0.57 | 0.62 | 0.71 | 0.77 | 1.79 |
| 600 | — | — | 0.39 | 0.48 | 0.69 | 0.69 | 0.78 | 0.99 | 0.90 | — |
| 800 | — | — | 0.58 | 0.65 | 0.81 | 0.81 | 0.92 | 1.22 | 1.39 | 4.07 |

## LINEAR I.C.'s

| Type | Quantities 1 | 25 | 100+ | Type | Quantities 1 | 25 | 100+ |
|---|---|---|---|---|---|---|---|
| 72702 | 0.46 | 0.44 | 0.42 | TAA350A | 1.71 | 1.67 | 1.57 |
| 72709 | 0.23 | 0.21 | 0.19 | uA703C | 0.26 | 0.24 | 0.22 |
| 72709P | 0.19 | 0.18 | 0.17 | uA709C | 0.19 | 0.18 | 0.17 |
| 72710 | 0.32 | 0.31 | 0.28 | uA711C | 0.32 | 0.31 | 0.28 |
| 72741 | 0.28 | 0.27 | 0.26 | uA712C | 0.32 | 0.31 | 0.28 |
| 72741C | 0.26 | 0.25 | 0.24 | uA723C | 0.45 | 0.43 | 0.40 |
| 72741P | 0.28 | 0.27 | 0.26 | 76003 | 1.39 | 1.34 | 1.30 |
| 72747 | 0.79 | 0.74 | 0.61 | 76023 | 1.39 | 1.34 | 1.30 |
| 72748P | 0.35 | 0.33 | 0.31 | 76660 | 0.88 | 0.86 | 0.83 |
| SL201C | 0.46 | 0.42 | 0.37 | LM380 | 0.93 | 0.90 | 0.88 |
| SL701C | 0.46 | 0.42 | 0.37 | NE555 | 0.45 | 0.43 | 0.40 |
| SL702C | 0.46 | 0.42 | 0.37 | NE556 | 0.88 | 0.86 | 0.83 |
| TAA263 | 0.74 | 0.65 | 0.56 | TBA800 | 1.39 | 1.34 | 1.30 |
| TAA293 | 0.93 | 0.88 | 0.83 | ZN414 | 1.11 | — | — |

## SILICON RECTIFIERS

| PIV | 300mA (DO7) | 300mA (SO16) | 750mA Plastic | 1A (SO16) | 1.5A (SO10) | 3A (SO10) | 10A | 30A (TO48) |
|---|---|---|---|---|---|---|---|---|
| 50 | 0.05 | 0.06 | 1N4001 | 0.05 | 0.07 | 0.14 | ★0.19 | ★0.56 |
| 100 | 0.05 | 0.07 | 1N4002 | 0.06 | 0.09 | 0.16 | ★0.21 | ★0.69 |
| 200 | 0.06 | 0.09 | 1N4003 | 0.07 | 0.12 | 0.20 | ★0.23 | ★0.93 |
| 400 | 0.07 | 0.14 | 1N4004 | 0.08 | 0.14 | 0.28 | ★0.35 | ★0.25 |
| 600 | 0.08 | 0.16 | 1N4005 | 0.09 | 0.16 | 0.33 | ★0.42 | ★1.76 |
| 800 | 0.11 | 0.18 | 1N4006 | 0.10 | 0.18 | 0.35 | ★0.51 | ★1.94 |
| 1000 | 0.13 | 0.28 | 1N4007 | 0.11 | 0.23 | 0.44 | ★0.60 | ★2.31 |
| 1200 | | 0.32 | | | 0.28 | 0.54 | ★0.69 | ★2.88 |

## ★ TRIACS

| | Case | 100V | 200V | 400V |
|---|---|---|---|---|
| 2 Amp | TO5 | 0.31 | 0.51 | 0.7 |
| 6 Amp | TO66 | 0.51 | 0.61 | 0.77 |
| 10 Amp | TO48 | 0.77 | 0.92 | 1.12 |

## SUPER UNTESTED PAKS

| Pak No. | Description | Price |
|---|---|---|
| U 1 | 120 Glass Sub-min. G.P. Germ. diodes | 0.60 |
| U 2 | 50 Mixed Germanium transistors AF/RF | 0.60 |
| U 3 | 75 Germ. gold bonded sub-min like OA47 | 0.60 |
| U 4 | 30 Germ. transistors like OC81, AC128 | 0.60 |
| U5 | 60 200mA sub-min. silicon diodes | 0.60 |
| U 6 | 30 Sil. trans. NPN like BSY95A, 2N706 | 0.60 |
| U 7 | 16 Sil. rect. 750mA up to 1000 | 0.60 |
| U 8 | 50 Sil. diodes DO-7 250mA like OA200/202 | 0.60 |
| U 9 | 20 Mixed voltages, 1 Watt Zener Diodes | 0.60 |
| U10 | 20 BAY50 charge storage diodes DO-7 | 0.60 |
| U11 | 20 PNP Sil. trans. TO-5 like 2N1132, 2N2904 | 0.60 |
| U13 | 30 PNP-NPN Sil. trans. OC200 & 2S104 | 0.60 |
| U14 | 150 Mixed silicon and germ. diodes | 0.60 |
| U15 | 20 NPN Sil. trans. TO-5 like 2N696 | 0.60 |
| U16 | 10 3Amp Sil. rect. stud up to 1000 PIV | 0.60 |
| U17 | 30 Germ. PNP AF trans TO-5 like ACY17-22 | 0.60 |
| U18 | 8 6 Amp sil rect. BYZ13 type up to 600 PIV | 0.60 |
| U19 | 20 Silicon NPN trans. like BC108 | 0.60 |
| U20 | 12 1.5 Amp sil. rect. top hat up to 1000 PIV | 0.60 |
| U21 | 30 AF. Germ. trans. 2G300 series & OC71 | 0.60 |
| U23 | 25 MADT's like MHz series PNP series | 0.60 |
| U24 | 20 Germ. 1 Amp rect. GJM up to 300 PIV | 0.60 |
| U25 | 25 300MHZ NPN sil. trans. 2N708, BSY27 | 0.60 |
| U26 | 30 Fast switching sil. diodes like IN914 | 0.60 |
| U29 | 10 1 Amp SCR's TO-5 up to 600 PIV | ★1.20 |
| U32 | 25 Zener diodes 400mW DO-7 3-33 volts mixed | 0.60 |
| U33 | 15 Plastic 1Amp sil. rect. IN4000 series | 0.60 |
| U34 | 30 Sil. PNP trans. TO-5 BCY26 2S302/4 | 0.60 |
| U35 | 25 Sil. trans. PNP TO-18 2N2906 | 0.60 |
| U36 | 20 Sil NPN trans. TO-5 BFY50/51/52 | 0.60 |
| U37 | 30 Sil. trans. SO-2 PNP OC200. wS322 | 0.60 |
| U38 | 30 Fast switch sil. trans. NPN 400MHz | 0.60 |
| U39 | 30 RF.Germ. PNP trans. 2N1301/5 TO-5 | 0.60 |
| U40 | 10 Dual trans. 6 lead TO-5 2N2060 | 0.60 |
| U43 | 25 Sil. trans. plastic TO-18 BC113/114 | 0.60 |
| U44 | 20 Sil. trans. plastic TO-5 BC115 | 0.60 |
| U45 | 7 3A SCR. TO66 up to 600 PIV | ★1.20 |
| U46 | 20 Unijunction trans. similar to TIS43 | ★0.60 |
| U47 | 10 TO220AB plastic triacs 50V 6A | ★1.20 |
| U48 | 9 NPN sil. power trans. like 2N3055 | 1.20 |
| U49 | 12 NPN sil. plastic power 60W like 2N5294 | 1.20 |

Code Nos. mentioned above are given as a guide to the type of device in the pak. The devices themselves are normally unmarked.

## QUALITY TESTED PAKS

| Pak No. | | Price £ p |
|---|---|---|
| Q 1 | 20 Red spot transistors PNP | 0.60 |
| Q 2 | 16 White spot R.F. transistors PNP | 0.60 |
| Q 3 | 4 OC77 type transistors | 0.60 |
| Q 4 | 6 Matched transistors OC44/45/81/81D | 0.60 |
| Q 5 | 4 OC75 transistors | 0.60 |
| Q 6 | 5 OC72 transistors | 0.60 |
| Q 7 | 4 AC128 transistors PNP high gain | 0.60 |
| Q 8 | 4 AC126 transistors PNP | 0.60 |
| Q 9 | 7 OC81 type transistors | 0.60 |
| Q10 | 7 OC71 type transistors | 0.60 |
| Q11 | 2 AC127/128 Compmentary pairs PNP/NPN | 0.60 |
| Q12 | 3 AF116 type transistors | 0.60 |
| Q13 | 3 AF117 type transistors | 0.60 |
| Q14 | 3 OC171 H.F. type transistors | 0.60 |
| Q15 | 7 2N2926 Sil. Epoxy transistors mixed colours | 0.60 |
| Q17 | 5 NPN 2 x ST141 & 3 x ST140 | 0.60 |
| Q18 | 4 MADT's 2 x MAT100 & 2 x MAT120 | 0.60 |
| Q19 | 3 MAT's 2 x MAT101 & 1 x MAT121 | 0.60 |
| Q20 | 4 OC44 Germanium transistors A.F. | 0.60 |
| Q21 | 4 AC127 NPN Germanium transistors | 0.60 |
| Q22 | 20 NKT transistors A.F. R.F. coded | 0.60 |
| Q23 | 10 OA202 Silicon diodes sub-min | 0.60 |
| Q24 | 8 OA81 diodes | 0.60 |
| Q25 | 15 IN914 Silicon diodes 75PIV 75mA | 0.60 |
| Q26 | 8 OA95 Germanium diodes sub-min IN59 | 0.60 |
| Q27 | 2 10A 500 PIV Silicon rectifiers IS425B | ★0.60 |
| Q28 | 2 Silicon power rectifiers BYZ13 | ★0.60 |
| Q29 | 4 Sil. transistors 2 x 2N696, 1 x 3N697, 1 x 2N698 | 0.60 |
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| Q35 | 3 Silicon PNP TO-5 2 x 2N2904 & 1 x 2N2905 | 0.60 |
| Q36 | 7 2N3646 TO-18 plastic 300 MHz NPN | 0.60 |
| Q37 | 3 2N3053 NPN Silicon transistors | 0.60 |
| Q38 | 5 PNP transistors 3 x 2N3703, 2 x 2N3702 | 0.60 |
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| Q40 | 5 NPN transistors 3 x 2N3707, 2 x 2N3708 | 0.60 |
| Q41 | 3 Plastic NPN TO18 2N3904 | 0.60 |
| Q42 | 5 BC107 NPN transistors | 0.60 |
| Q44 | 5 NON transistors 3 x BC108, 2 x BC109 | 0.60 |
| Q45 | 3 BC113 NPN TO-18 transistors | 0.60 |
| Q46 | 3 BC115 NPN TO-5 transistors | 0.60 |
| Q47 | 4 NPN high gain transistors 2 x BC167, 2 x BC168 | 0.60 |
| Q48 | 3 BCY70 PNP transistors TO-18 | 0.60 |
| Q49 | 3 NPN transistors 2 x BFY51, 1 x BFY52 | 0.60 |
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| Pak no | Contents |
|---|---|
| UIC00 | = 12x7400 |
| UIC01 | = 12x7401 |
| UIC02 | = 12x7402 |
| UIC03 | = 12x7403 |
| UIC04 | = 12x7404 |
| UIC05 | = 12x7405 |
| UIC06 | = 8x7406 |
| UIC07 | = 8x7407 |
| UIC10 | = 12x7410 |
| UIC13 | = 8x7413 |
| UIC20 | = 12x7420 |
| UIC30 | = 12x7430 |
| UIC40 | = 12x7440 |
| UIC41 | = 5x7441 |
| UIC42 | = 5x7442 |
| UIC43 | = 5x7443 |
| UIC44 | = 5x7444 |
| UIC45 | = 5x7445 |
| UIC46 | = 5x7446 |
| UIC47 | = 5x7447 |
| UIC48 | = 5x7448 |
| UIC50 | = 12x7450 |
| UIC51 | = 12x7451 |
| UIC53 | = 12x7453 |
| UIC54 | = 12x7454 |
| UIC60 | = 12x7460 |
| UIC70 | = 8x7470 |
| UIC72 | = 8x7472 |
| UIC73 | = 8x7473 |
| UIC74 | = 8x7474 |
| UIC75 | = 8x7475 |
| UIC76 | = 8x7476 |
| UIC80 | = 5x7480 |
| UIC81 | = 5x7481 |
| UIC82 | = 5x7482 |
| UIC83 | = 5x7483 |
| UIC86 | = 5x7486 |
| UIC90 | = 5x7490 |
| UIC91 | = 5x7491 |
| UIC92 | = 5x7492 |
| UIC93 | = 5x7493 |
| UIC94 | = 5x7494 |
| UIC95 | = 5x7495 |
| UIC96 | = 5x7496 |
| UIC100 | = 5x74100 |
| UIC121 | = 5x74121 |
| UIC141 | = 5x74141 |
| UIC151 | = 5x74151 |
| UIC154 | = 5x74154 |
| UIC193 | = 5x74193 |
| UIC199 | = 5x74199 |
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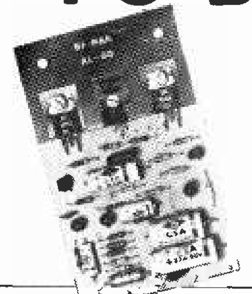
| | 1 | 25 | 10 |
|---|---|---|---|
| TSO 14 14 pin type | 0.31 | 0.28 | 0 |
| TSO16 16 pin type | 0.35 | 0.32 | 0 |
| TSO24 24 pin type | 0.69 | 0.64 | 0 |
| BPS8 8 pin type (low cost) | 0.14 | 0.12 | 0 |
| BPS14 14 pin type (low c | 0.15 | 0.13 | 0 |
| BPS16 16 pin type (low c | 0.16 | 0.14 | 0 |

## DIODES

| | | | |
|---|---|---|---|
| AA119 | 0.08 | BYZ16 | 0. |
| AA120 | 0.08 | BTZ17 | 0. |
| AA129 | 0.08 | BYZ18 | 0. |
| AAY30 | 0.09 | BYZ19 | 0. |
| AAZ13 | 0.10 | CG62 | |
| BA100 | 0.10 | (OA91Eq) | 0. |
| BA116 | 0.21 | CG651 | |
| BA126 | 0.22 | (OA70-OA79) | |
| BA148 | 0.15 | | 0. |
| BA154 | 0.12 | OA5 Short | |
| BA155 | 0.15 | Leads | 0. |
| BA165 | 0.14 | OA10 | 0. |
| BA173 | 0.15 | OA47 | 0. |
| BB104 | 0.15 | OA70 | 0. |
| BY100 | 0.16 | OA79 | 0. |
| BY101 | 0.12 | OA81 | 0. |
| BY105 | 0.18 | OA85 | 0. |
| BY114 | 0.12 | OA90 | 0. |
| BY124 | 0.12 | OA91 | 0. |
| BY126 | 0.15 | OA95 | 0. |
| BY127 | 0.16 | OA200 | 0. |
| BY128 | 0.16 | OA202 | 0. |
| BY130 | 0.17 | SD10 | 0. |
| BY133 | 0.21 | SD19 | 0. |
| BY164 | 0.51 | IN34 | 0. |
| BYX38 30 | 0.43 | IN34A | 0. |
| BYZ10 | 0.36 | IN914 | 0. |
| BYZ11 | 0.31 | IN916 | 0. |
| BYZ12 | 0.31 | IN4148 | 0. |
| BYZ13 | 0.26 | IS021 | 0. |
| | | IS951 | 0. |

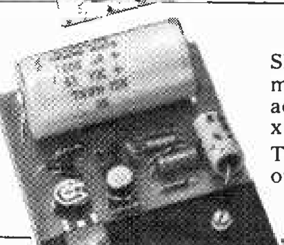
# PO BOX 6 WARE HERTS



## AL 60 ONLY £3.95

### 50w. PEAK (25w. R.M.S.)

● Max Heat Sink temp 90°C ● Frequency Response 20Hz to 100K Hz ● Distortion better than 0.1 at 1KHz ● Supply voltage 15-50 volts ● Thermal Feedback ● Latest Design Improvements ● Load — 3, 4, 5 or 16 ohms ● Signal to noise ratio 80dH ● Overall size 63mm x 105mm x 13mm. Especially designed to a strict specification. Only the finest components have been used and the latest solid state circuitry incorporated in this powerful little amplifier which should satisfy the most critical A.F. enthusiast.

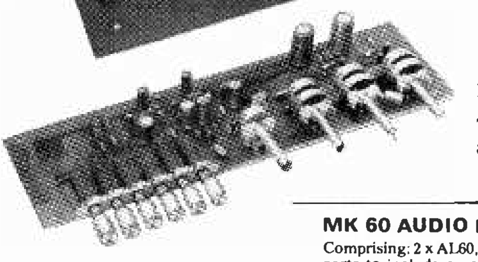


## STABILISED POWER MODULE SPM80

SPM80 is especially designed to power 2 of the AL60 Amplifiers, up to 15 watt (r.m.s.) per channel simultaneously. This module embodies the latest components and circuit techniques incorporating complete short circuit protection. With the addition of the Mains Transformer BMT80, the unit will provide outputs of up to 1.5 amps at 35 volts. Size: 63mm x 105mm x 30mm.

These units enable you to build Audio Systems of the highest quality at a hitherto unobtainable price. Also ideal for many other applications including:—Disco Systems. Public Address Intercom Units, etc. Handbook available 10p.

**TRANSFORMER BMT80 £2.60** **PRICE £3.00**



## STEREO PRE-AMPLIFIER TYPE PA100

Built to a specification and NOT a price, and yet still the greatest value on the market, the PA100 stereo pre-amplifier has been conceived from the latest circuit techniques. Designed for use with the AL50 power amplifier system, this quality made unit incorporates no less than eight silicon planar transistors, two of these are specially selected low noise NPN devices for use in the input stages.

Three switched stereo inputs, and rumble and scratch filters are features of the PA100 which also has a STEREO/MONO switch, volume, balance and continuously variable bass and treble controls.

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**MK 60 AUDIO KIT**

Comprising: 2 x AL60, 1 x SPM80, 1 x BTM80, 1 x PA100, 1 front panel, 1 kit of parts to include on-off switch, neon indicator, stereo headphone sockets plus instruction booklets.

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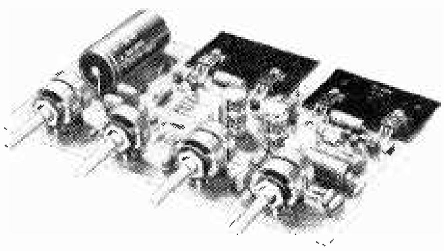
**TEAK 60 AUDIO KIT**

Comprising: Teak veneered cabinet size 16¾" x 11½" x 3¾", other parts include aluminium chassis, heatsink and front panel bracket, plus back panel and appropriate sockets, etc.

KIT PRICE: **£9.20** plus 45p postage.



## STEREO 30 COMPLETE AUDIO CHASSIS

### 7 + 7 WATTS R.M.S.

The Stereo 30 comprises a complete stereo pre-amplifier, power amplifiers and power supply. This with only the addition of a transformer or overwind, will produce a high quality audio unit suitable for use with a wide range of inputs, i.e. high quality ceramic pickup, stereo tuner, stereo tape deck, etc.

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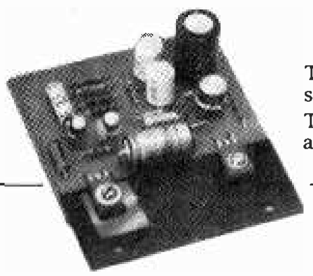

## AL 10/AL 20/AL 30

The AL10, AL20 and AL30 units are similar in their appearance and in their general specification. However, careful selection of the plastic power devices has resulted in a range of output powers from 3 to 10 watts R.M.S.

The versatility of their design makes them ideal for use in record players, tape recorders, stereo amplifiers and cassette and cartridge tape players in the car and at home.

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njoy the quality of a magnetic cartridge with our existing ceramic equipment using the new i-Pak M.P.A.30 which is a high quality re-amplifier exist for the use of ceramic artridges only.

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upplied with full, easy to follow instructions.

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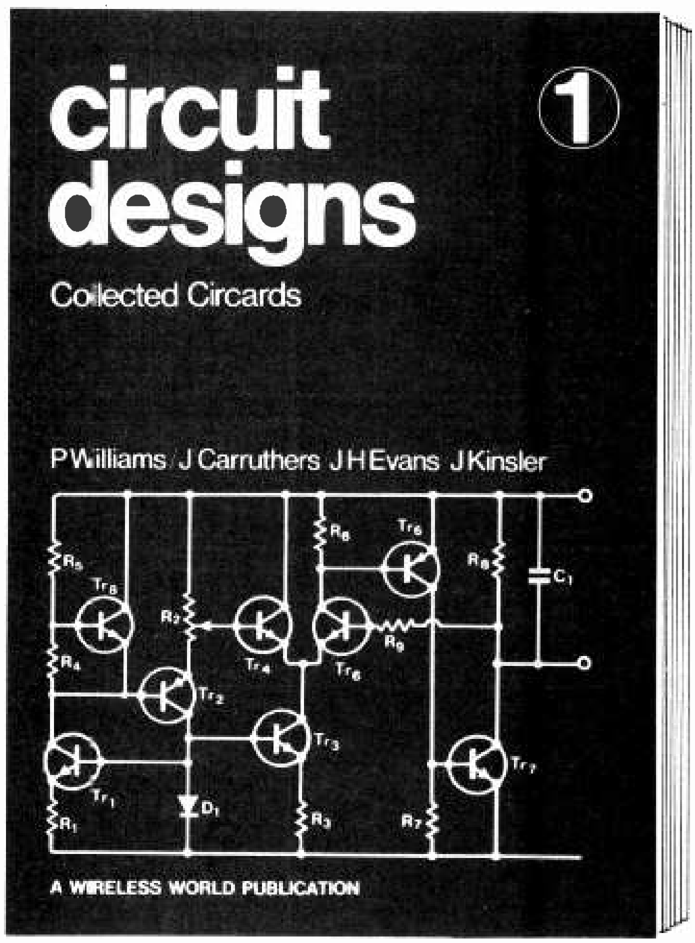


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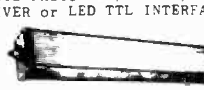

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| 1 | 2 | 1 | 2.29 | 38 |
| 8 | 4 | 2 | 2.86 | 38 |
| 0 | 6 | 3 | 4.12 | 45 |
| 108 | 8 | 4 | 4.56 | 45 |
| 2 | 10 | 5 | 5.14 | 53 |
| 1 6 | 12 | 6 | 5.52 | 53 |
| 7 | 16 | 8 | 7.28 | 60 |
| 1 5 | 20 | 10 | 10.39 | 73 |
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| 226* | 60 | 30 | 16.83 | BRS |

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| Ref. No. | Amps | £ | P&P p |
|---|---|---|---|
| 112 | 0.5 | 1.81 | 30 |
| 79 | 1.0 | 2.40 | 38 |
| 3 | 2.0 | 3.49 | 38 |
| 20 | 3.0 | 4.53 | 45 |
| 21 | 4.0 | 5.13 | 53 |
| 51 | 5.0 | 6.41 | 53 |
| 117 | 6.0 | 7.16 | 60 |
| 88 | 8.0 | 9.87 | 67 |
| 89 | 10.0 | 9.90 | 73 |

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SECONDARY TAPS
0-19-25-33-40-50

| Ref. No. | Amps. | £ | P&P p |
|---|---|---|---|
| 102 | 0.5 | 2.58 | 30 |
| 103 | 1.0 | 3.38 | 38 |
| 104 | 2.0 | 4.68 | 45 |
| 105 | 3.0 | 5.81 | 53 |
| 106 | 4.0 | 7.60 | 67 |
| 107 | 6.0 | 12.10 | 67 |
| 118 | 8.0 | 12.98 | 85 |
| 119 | 10.0 | 16.99 | BRS |

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SECONDARY TAPS
0-24-30-40-48-60

| Ref. No. | Amps | £ | P&P p |
|---|---|---|---|
| 124 | 0.5 | 2.33 | 38 |
| 126 | 1.0 | 3.41 | 38 |
| 127 | 2.0 | 5.08 | 45 |
| 125 | 3.0 | 7.52 | 60 |
| 123 | 4.0 | 8.75 | 67 |
| 40 | 5.0 | 9.75 | 73 |
| 120 | 6.0 | 11.30 | 85 |
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| Ref. No. | VA (Watts) | AUTO TAPS | £ | P&P p |
|---|---|---|---|---|
| 113 | 20 | 0-115-210-240 | 1.67 | 30 |
| 64 | 75 | 0-115-210-240 | 2.90 | 38 |
| 4 | 150 | 0-115-210-220-240 | 4.12 | 45 |
| 66 | 300 | " " | 5.82 | 53 |
| 67 | 500 | " " | 8.82 | 67 |
| 84 | 1000 | " " | 13.68 | 91 |
| 93 | 1500 | " " | 18.11 | BRS |
| 95 | 2000 | " " | 24.20 | BRS |
| 73 | 3000 | " " | 35.09 | BRS |

### SCREENED MINIATURES

| Ref. | MA | Volts | £ | P&P p |
|---|---|---|---|---|
| 238 | 200 | 3-0-3 | 1.54 | 10 |
| 212 | 1A 1A | 0-6, 0-6 | 1.84 | 30 |
| 13 | 100 | 9-0-9 | 1.41 | 13 |
| 235 | 330 330 | 0-9, 0-9 | 1.56 | 19 |
| 207 | 500 500 | 0-8-9, 0-8-9 | 1.92 | 30 |
| 208 | 1A A | 0-8-9, 0-8-9 | 3.30 | 38 |
| 236 | 200 200 | 0-15, 0-15 | 1.43 | 19 |
| 214 | 300 300 | 0-20, 0-20 | 1.93 | 30 |
| 221 | 700 (DC) | 20-12-0-12-20 | 2.17 | 38 |
| 206 | 1A A | 0-15-20, 0-15-20 | 3.46 | 38 |
| 203 | 500 500 | 0-15-27, 0-15-27 | 3.00 | 38 |
| 204 | 1A A | 0-15-27, 0-15-27 | 3.85 | 38 |
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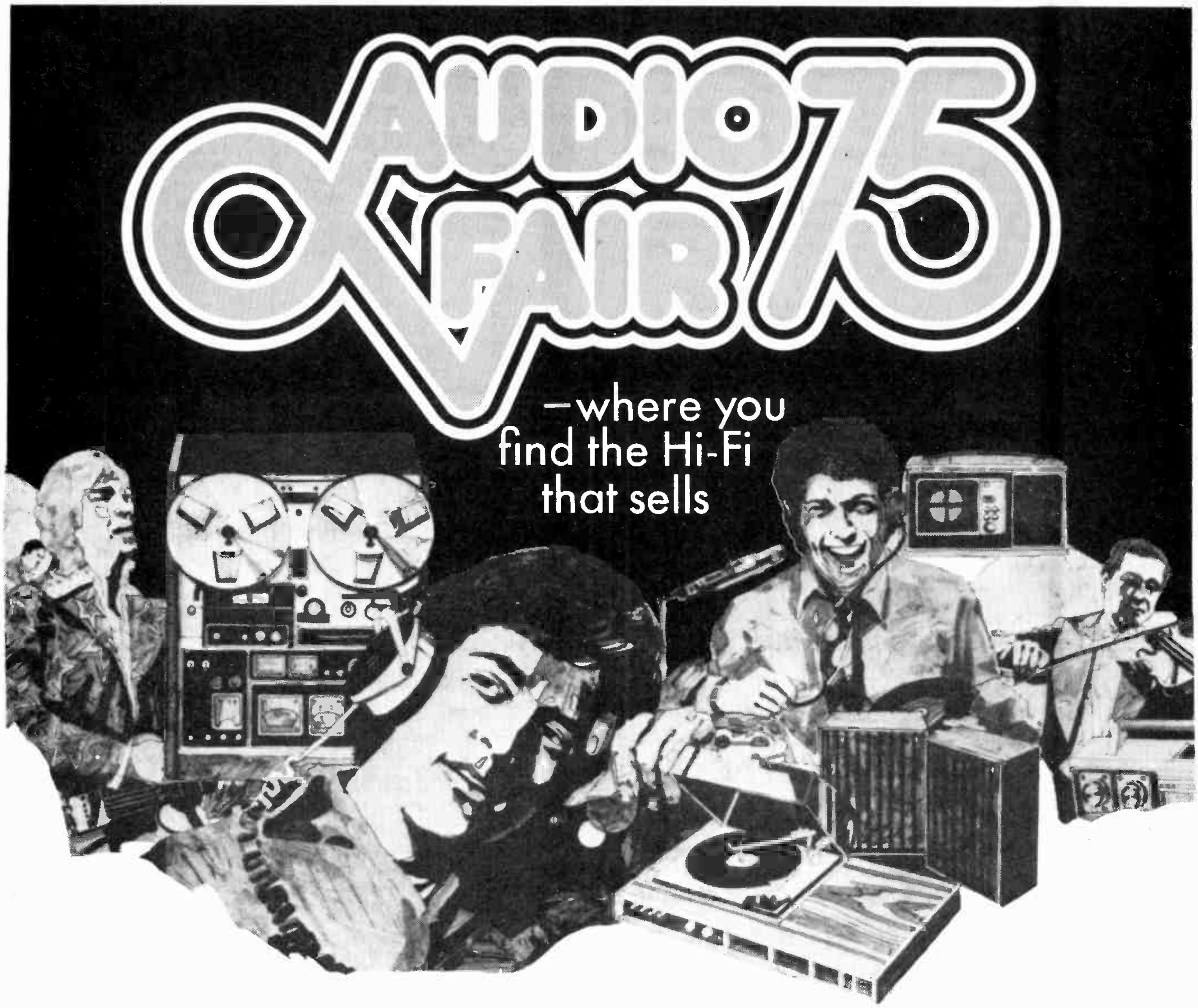


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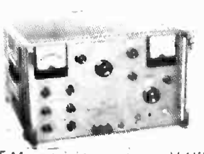

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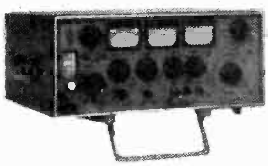

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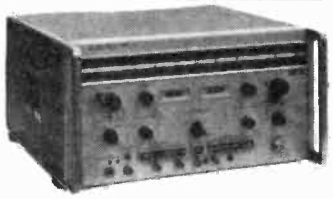
## SWEEP GENERATORS



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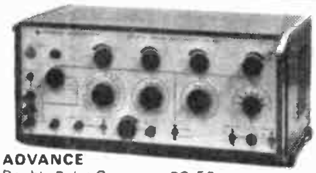
## PULSE GENERATORS



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Pulse Amplitude 0.1V-10V. Sq. wave 0-10V. Rise Time 10nsec. (typically) **£87.50**

Pulse Generator PG 55 P.O.A.

Modular Pulse Generator Advance Type PG.52. System of 5 Signal generating & Processing units. Repetition freqs. up to 20MHz & Output pulses to 20V (50 ohms) Rise & Fall times 5nsec. Its versatility enables the production of complex pulse & ramp waveforms not obtainable from conventional pulse generators **£250**

**MARCONI**

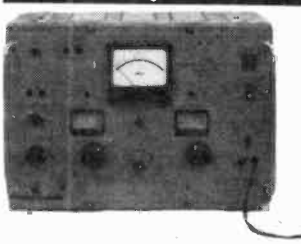
Double Pulse Generator TF 1400/S Min. type CT 434 c/w TM 6600 Sec. Pulse gen Plug In. 10Hz-100KHz 100nsec-100µsec. Negative pulses up to 200V E.M.F. +VE pulses up to 60V E.M.F. & Simultaneous +VE &—VE pulses up to 20V E.M.F. P.O.A.

**SOLARTRON**

Precision Pulse Generator G.O 1377 100V single or double pulses 0.2 amp paraphase outputs. Simultaneous +VE & —VE outputs Square wave to 5MHz 10nsec. Rise time. Pulse repetition freq. — 10Hz-1MHz. Pulse duration 0.1 µsec-100msec **£125**

Pulse Generator OPS 100C P.O.A.

## TELEPHONE TEST EQUIPMENT



Siemens Level Meter 3D 335 10KHz-17MHz Complete system by Siemens. Comprising 3W 518 Level Oscillator, 3D 335 Level Meter, 3W 933 Sweep Attachment, 3D 346 Screen Level Tracing Receiver P.O.A.

Siemens Level Meter 3D 332. 0.3-1200KHz. Level Oscillator 3W 29 0.3-1200KHz P.O.A.

**S.T.C.**

Octave Filter 74143A. 37.5-12,800Hz. For analysing noise and interference on comms. systems, particularly useful with 74142 psophometer P.O.A.

Selective level Measuring Set 74184B 60-1364KHz P.O.A.

Measuring Set 74831A P.O.A.

**A.T.& E.**

Telegraph Distortion Measuring Set. Various types. 5BV, 5BV3, 6BV, 6A P.O.A.

**MURPHY RADIO**

Receiver VHF field strength RX 506 & interference measuring set c/w Power Unit P.O.A.

## OSCILLOSCOPE TEST EQUIPMENT

**TEKTRONIX**

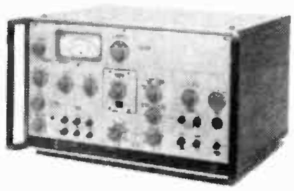
Pulse Generator Type 111. 0.5µsec risetime. Amplitude ± 5V. 30 to 250 nsec. difference between trigger and output pulses **£60**

Time Mark Generator 180A **£85**

Pulse Generator 109 0.25 nsec. Risetime 0-55V Calibrated variable amplitude. Impedance 50 ohms **£35**

Pre-Trigger Pulse Generator 111 **£60**

## T.V. TEST EQUIPMENT



Wandel & Golterman VZM.2 Distortion measuring set for phase & amplitude mod. For multichannel FM Radio Systems up to 12MHz Base bands **£400**

**MARCONI**

Sine Squared Pulse & Bar Generator TF.2905/8 **£225**

**GRESHAM LION**

Waveform Generator 625 lines. Sine squared. Pulse & Bar P.O.A.

Waveform Generator 625 lines staircase P.O.A.

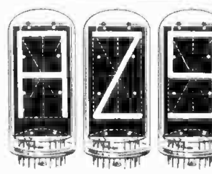
**WANDEL & GOLTERMAN**

Measuring Set VZM 1 **£495**

Generator & Receiver. VZM 83 **£275**

## COMPONENTS

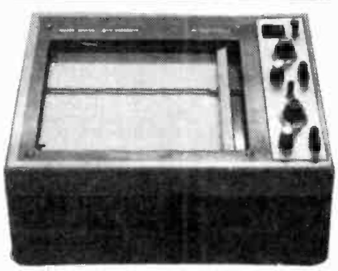
Numeric Tube B.5853 0-9 Digit 1.4" height Brand New **£1.00**



Also Alpha Numeric Nixie Tube

B.7971. Displays alphabet & 0-9 numerals **99p**

## X-Y & U/V RECORDERS



ADVANCE

X-Y Recorder HR 92/1 **£150**

BELL & HOWELL

U.V. Recorder 5/127, without Galvo's **£225**

BRYANS

X-Y Recorder 20021 **£195**

ELECTRONIC ASSOCIATES

Vari-Plotter **£145**

SE3006 UV P.O.A.

## INSULATION TESTERS

EVERSHED & VIGNOLES

Circuit Tester Ohmeter 0-3 ohms 0-39 ohms **£18**

Circuit Tester Ohmeter 0-1000 ohms. 100-200 kohms **£18**

Megger Series + II 250V **£12**

Megger Series III Mk. 3 250V **£20**

Megger 250V **£20**

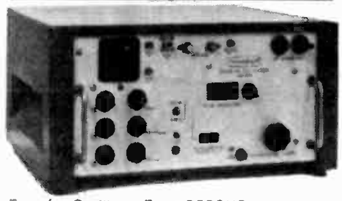
Megger 500V **£37**

Battery Megger 500V **£37**

**PYE**

Insulation Tester 10B 500V **£25**

## MISCELLANEOUS



Transfer Oscillator Type 7580HBy Beckman. DC-15GHz with counter. 7.5MHz-15GHz without counter. Sensitivity 100mV (R.M.S.) **£350**

**MARCONI**

Distortion Factor Meter TF.142F. Fundamental Freq. Range 100Hz-8KHz. Dist. measurement ranges 0-5% & 0-50% **£60**

Portable Receiver Tester TF 888/3. 70KHz-70MHz. Xtal check 500KHz & 5MHz. 1KHz A.F. Oscillator. A.F. Power 10mW, 100mW & 1W **£69**

Wave Analyser TF 455E **£95**

Noise Generator TF 1301 200-1700 MHz **£60**

Amplitude Modulator TF 1102 Basic Carrier Frequency Range 100KHz-300Mhz/500MHz CW or FM output of any conventional signal generator can be amplitude modulated, including sine waves, square waves pulses, picture signals **£25**

**SOLARTRON**

Resolved Component Indicator VP 253.3 **P.O.A.**

Low Freq. Decade Oscillator OS 103.3 **P.O.A.**

**EKCO INSTS**

(Nucleonics)

Ratemeter N.600B **P.O.A.**

**S.T.C.**

Level Measuring Set 74307A **P.O.A.**

**RADIOMETER**

1MHz Capacitance Comparator Type CMB 11bS2 **P.O.A.**

**BELL**

Gaussmeter 120 **P.O.A.**

**CROMPTON PARKINSON**

3 Phase Wattmeter 0-4000 Watts 4 wire Double Element **P.O.A.**

**ADVANCE**

Recorder Calibrator HC.20 **£20**

Printer PR.1 Intended for use with almost any kind of counter. 7 digit display, 2" wide paper print-out **£55**

**B.P.L.**

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"Q" Meter T1 **£75**

Component Comparator CZ457/5 **P.O.A.**

**AIRMEC**

Modulation Meter 210 **£75**

Modulation Meter 210A **£135**

**EDDYSTONE**

Receiver 770R/1 **£285**

**HEWLETT PACKARD**

Microwave Link Analyser 3701/02/03 **£2000**

Distortion Analyser 380C **P.O.A.**

Ratio Meter 416B **P.O.A.**

Univerter 207H (for use with 202H and J Generators) **P.O.A.**

**MUIRHEAD**

Facsimile Transmitter Receiver Type 900 Easily convertible to receive weather pictures from satellite systems **£850**

**SAVAGE**

Amplifier Mark II Star Model 1KM2Z 1 KW output. Freq. 50-10 KHz. Good condition **£1650**

**WAYNE KERR**

Video Noise Level Meter M.131 **£75**

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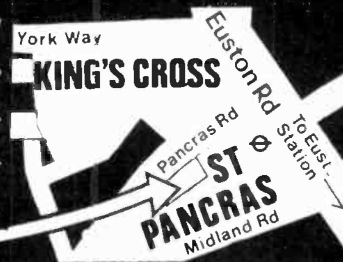
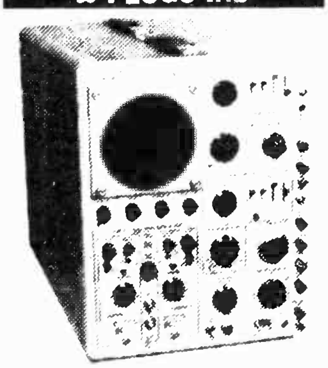



## OSCILLOSCOPES & PLUGS INS



**TEKTRONIX**
The most versatile oscilloscopes ever produced by Tektronix to accept Multi trace, Differential, Sampling, Spectrum Analysers, and special purpose Plug-ins, etc. A few examples offered below
IA1 — DC 50 Meg. 5mV/cm Dual Trace **£125.00**
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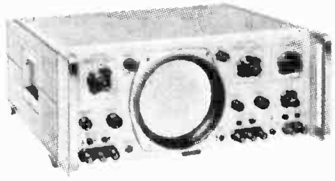
546 Dual time base/Delayed sweep DC 50 Meg **£275.00**
547 Dual time base/Delayed sweep/alternate display DC 50 Meg **£325.00**

**HEWLETT PACKARD**



Model 130C 200µV/cm Oscilloscope. This scope is a versatile all purpose instrument for laboratory, production line, industrial process measurements and medical applications. The outputs of rf detectors, strain gauges, transducers, and other low level devices may be viewed directly without preamplification. The Model 130C is easy to operate even by inexperienced personnel. Specification: Time Base Range — 1 µs/cm to 5 s/cm, 21 ranges in a 1.2.5 sequence, accuracy ± 3%, vernier provides continuous adjustment between steps and extends the 5 s/cm step to at least 12.5 s/cm. Automatic triggering (baseline displayed in the absence of an input signal). Vertical and horizontal amplifiers. Bandwidth: d.c. coupled, dc to 500 KHz; ac coupled (input), 2 Hz to 500 KHz; ac coupled (amplifier), 25 Hz to 500 KHz at 0.2 mV/cm deflection factor **£175**
Sampling Scpe 1858 DC-3.5 GHz **£395**

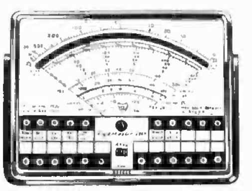
**MARCONI**
Scope TF 2200A/1 c/w TV Differential plug in TM 6457A DC — 30 MHz 50 mV/cm **£190**

**TELEQUIPMENT**
Dual Beam Scope D31R DC-6MHz **£75**
D31 & D31R Dual Beam DC-6MHz 100mV/cm **£75**
S.32A Single Beam **£50**
S.43 Single Beam DC-15MHz @ 100mV/cm DC-1MHz @ 10mV/cm **£70**
D.53 Dual Beam **£120**

**HEATHKIT**
Model 10-12u Assembled 50mV/cm @ 1 KHz ±3dB 3Hz to 4.5MHz. 3 Month Warranty. Suitable for use by electronic service engineer or by radio amateurs. Wide range of facilities e.g. push-pull horizontal & vertical amplifiers with a very wide range, switch selected internal or external sync., & a wide range of time base speeds. The critical parts of the power supply are electronically stabilised **£49**

## MULTIMETERS

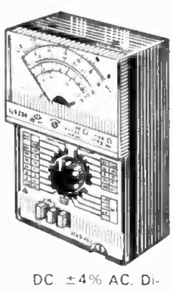
Avo 7 **£29.50**
Avo Ever-ready Carrying Case **£5.50**
Avo Leads, Clips & Probes (New) **£3.95**
U4323 Multimeter/Generator 20,000opv Simple Unit with audio/IF Oscillator, suitable for general receiver tuning **£7.70**



**SUPER-TESTER 680R ICE** 20,000 Ohm per Volt sensitivity. Fully screened against external magnetic fields. Scale width and small case dimensions (128 x 95 x 32mm). Accuracy and stability (1% in D.C., 2% in A.C.) of indicated reading. Simplicity and ease of use and readability. Full ranges of accessories. 1000 times overload. Printed Circuit board is removable without de-soldering. More ranges than any other meter. Ask for free catalogue **£18.50**

Accessories (extra) available to convert Microtest 80 & Supertester 680R into following: SIGNAL INJECTOR, GAUSS METER, ELECTRONIC VOLTMETER, AMPER-CLAMP, TRANSISTOR TESTER, TEMPERATURE PROBE, PHASE SEQUENCE INDICATOR — Send for details

**MORE RANGES FOR LESS MONEY!**
AC/DC Multimeter type U4324 A-DC 0.06-3A — 6 Ranges A-AC 0.3A — 5 Ranges V-DC 0.6-1200V — 9 Ranges V-AC 3-900V — 8 Ranges. Freq. In the range of 45 to 20kHz. Resistance 500 ohm to 5 Mohm — 5 Ranges Decibel —10 to +12dB. Accuracy ±2.5%

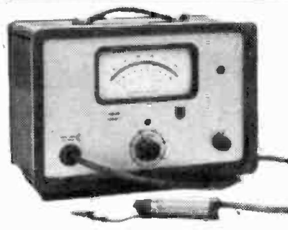


DC ±4% AC. Dimensions 167 x 98 x 63mm
Only **£9.25**

All above Multimeters (except AVO) are brand new

Avo Meter **£29.50** plus Postage & Packing £1.00. All other meters Postage & Packing 50p.

## VOLTMETERS



H.F. Multivoltmeter Philips Type GM 6014. Ranges 1mV-300mV in 6 Ranges. Facility also for 100mV-30V. Meter equipped with dB scale. Accuracy at 30KHz less than 3% F.S.D. Amplitude characteristic flat within ±5% **£55**

**HEWLETT PACKARD**
D.C. Vacuum Tube Voltmeter 412A 1mV-1000V 1% Accuracy. Can also be used as Ohmeter & Ammeter **£75**
VTVM 400D 1mV to 300V FSD. 12 ranges 10Hz to 4MHz. 2% accuracy. Input Impedance 10Mohms **£85**
VTVM 400L Logarithmic version of 400D. Reads RMS value of sine wave. Log. voltage scale 0.3 to 1 & 0.8 to 3. Linear dB scale. Input Impedance 10Mohms **£90**

**MARCONI**
Sensitive Valve Voltmeter TF.1100 100µV-300V AC Freq. coverage 10Hz-10MHz. Meter has dB scale facility **£85**

**ADVANCE**
77B AC Millivoltmeter 50Hz-4.5MHz 0.001V to 300V FSD. Input Impedance 10Mohms **£42**

## DIGITAL VOLTMETERS

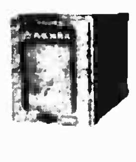
D.C. Digital Voltmeter Solartron Type LM 1420.2 2.5µV-1 KV in 6 Ranges. 0.05% DC Accuracy. 250KHz Counter Facility **£235**

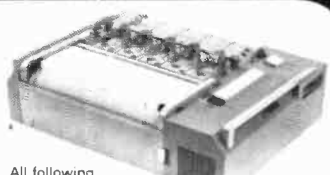
**DYNAMCO**
DM 2022S 10µV-2kV. Max. reading 39999. Accuracy 0.02% **£245**
D.V.M. DM2001 Mk. II **£125**
D.V.M. DM2004 **£95**

**SOLARTRON**
Autoranging Digital Voltmeter LM 1480. Accuracy: 0.005%. 10µV — 2kV DC. Resolution 1 part in 30,000. 20,000 M input resistance. 6 Operating modes. Long term accuracy stability. Suitable for the Standards Room, Laboratory or Industrial uses.

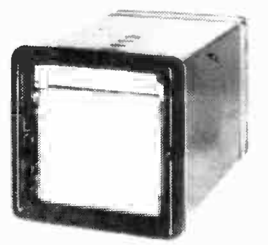
## RECORDERS

**RECORD ELECTRICAL**
Single Pen Recorder. 3" chart sensitivity 1 milliamp chart speed 1 and 6" per hr. Size 8" x 11" x 6". Offered complete with pen assembly. Listed at over £120 — this month's special price due to bulk purchase.
1mA version **£50**
500µ A version **£60**





All following H Series. Brand New
**H3020** 8mA FSD 5Hz 80mm per channel. 0.1-25mm/sec chart drive inc., time and event market **£80, 3 pen £130**
**H327** 8mA FSD 100Hz transistorised amp, as above **£180, 3 pen £310, 5 pen £435**
**H390** AC/DC recorder, 5mA-5 amps, 5-volts-500V. 20-5400mm/hr **£78**

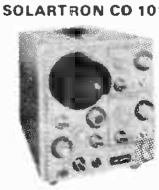


**H30.**Ten channel event recorder **£62**
**RECORD** 500µA single channel 1"/6" per hr **£59**
**RECORD** 1mA version **£49**
**RUSTRACK** 88 1mA

## SPECIAL OFFER

Also available Audio Signal Generator AG9U 10Hz to 100KHz 8 Output ranges, 3mV — 10 volts > 0.1% Distortion (20-20Kcs) **£29.50**
Harmonic Distortion Meter 1M — 58U 20-2,000 Hz — 5 ranges 1 — 100%, 4 voltmeter ranges 1 — 30 volts **£29.50**

**SOLARTRON CO 1014**



Dual beam 5MHz 100mV/cm sensitivity, more sensitive on Y2 Timebase 1µS/cm to 1S/cm
**LIMITED STOCK PRICE £89.50.**

**BRUEL & KJAER**
Bruel & Kjaer Portable Sound Level & Vibration Meter 2203 **£275**

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A member of the EB Group

Carriage and packing charge extra on all items unless otherwise stated.

Please note: All instruments offered are secondhand and tested and guaranteed 12 months unless otherwise stated.

**ADD 8% VAT TO ALL PRICES**

WW—012 FOR FURTHER DETAILS

# Appointments

Advertisements accepted up to 12 noon Wednesday, September 3rd, for the October issue subject to space being available.

**DISPLAYED APPOINTMENTS VACANT:** £6.99 per single col. centimetre (min. 3cm).
**LINE advertisements (run on):** 99p per line (approx. 7 words), minimum three lines.
**BOX NUMBERS:** 40p extra. (Replies should be addressed to the Box numbers in the advertisement, c/o Wireless World, Dorset House, Stamford Street, London SE1 9LU).
**PHONE: Allan Petters on 01-261 8508 or 01-261 8423.**
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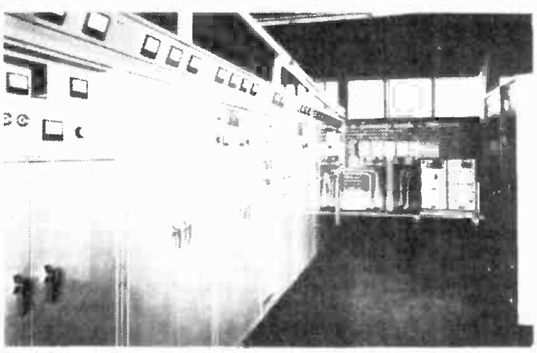
# T.V. Transmitter Systems Engineers.

## Security and opportunity with an international leader in T.V. Broadcast Engineering.



Pye TVT Limited is an international leader in broadcast engineering. We took colour TV to ZANZIBAR – the very first colour service in the whole of Africa. In OMAN we were awarded probably the largest single broadcasting contract ever placed – a complete TV and radio *turnkey* project. TORONTO's giant CN Tower will have one of 14 UHF TV transmitters sold into Canada against stiff American competition. We have other stimulating new projects and can offer professional engineers the kind of opportunities that are rare in 1975. We need men with initiative and a spirit of adventure, capable of leading others – to success. With Pye TVT you can *really* go places.

### Senior Installation and Commissioning Engineers

Self reliant engineers capable of working independently, or leading small teams installing and commissioning VHF and UHF TV transmitters. Many projects are outside Europe and the engineers will be required to spend periods abroad. Several years' practical experience in broadcasting is essential. Generous overseas allowances paid in addition to basic salary and subsistence.

### Senior Systems Engineers (Transmitters)

Self motivated engineers capable of aligning complete TV Transmitter systems to customer specifications using modern test equipment. Applicants should be able to locate and rectify complex faults involving the whole system or individual items of equipment, and be able to work with customers' engineers of many nationalities. Ideally the applicants should have had some experience of high power TV transmitters, but relevant experience in UHF and klystrons and/or high power transmitters will be considered.

The appointments are based in Cambridge. Relocation expenses are paid in approved cases in addition to the usual employee benefits.

Applications, giving brief details, should be sent to Mrs J A MacNab, Personnel Manager,

**Pye TVT Limited**

Coldhams Lane, Cambridge CB1 3JU.
Tel: Cambridge (0223) 45115

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# PAPUA NEW GUINEA UNIVERSITY OF TECHNOLOGY

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No. 22

# TECHNICAL INSTRUCTOR OR SENIOR TECHNICAL INSTRUCTOR COMMUNICATIONS ENGINEERING:

To teach technical subjects in the Communications Diploma course of Technician engineering standard, and to assist in the general development of the course, training aids and laboratories.

**QUALIFICATIONS —** Applicants should have wide experience in the telecommunications field and have been actively engaged in telecommunications training at technician engineer level. Qualifications of at least HNC or City and Guilds full technological standard are required. Specialist experience in one or more of the following fields would be an advantage: HF, VHF, Microwave, Tropascatter, Broadcasting.

**GENERAL INFORMATION**

Salaries within the ranges:
Instructor K8,266 range K9,173 per annum
Senior Instructor K9,403 range K12,908 per annum
(K1 = $Aust. 1)

Appointment within these salary ranges will be according to qualifications and experience.
Allowances additional to salary are payable as follows: Married K2,300 per annum. Single K1,300 per annum. In certain circumstances a child allowance of K156 per annum is also payable. An educational allowance and additional fares may be provided for children being educated away from their parents place of residence. Other benefits include furnished housing (hard goods only) supplied at nominal rental, leave fares to place of recruitment every second year and equivalent fares to Canberra, Australia each alternate year and six weeks annual leave. Superannuation benefits apply in most circumstances. Study leave of 6 months will accrue after three years service. Taxation is presently two thirds of that applicable in Australia.

Appointments will be on a contract basis for a maximum of three years in the first instance.

Applications in duplicate should include number of post applied for, particulars of age, nationality, marital status, family if any, qualifications, experience, present post and the names and addresses of three referees from whom confidential enquiries can be made.

The University reserves the right to make no appointment or to make an appointment by invitation at any stage.

Further information will be forwarded to all applicants. Applications are required by **30 September, 1975,** and should be sent to the Registrar, The Papua New Guinea University of Technology, P.O. Box 793, **LAE. PAPUA NEW GUINEA.** An additional copy should be sent to the Association of Commonwealth Universities (Appts), 36 Gordon Square, London WC1H OPF by the same date.

4860


UNIVERSITY OF ST. ANDREWS
DEPARTMENT OF PSYCHOLOGY

## TECHNICIAN GRADE 5 ELECTRONICS

Applications are invited for the above post in the Electronics Workshop of the Psychology Department, tenable from October 1975. Applicants should have a good electronics background together with practical experience in the development and construction of digital equipment and computer interfacing. The person appointed will work together with other members of the technical staff on the development of on-line experimental systems using the Department's Data General Computer facility. The duties will also involve the maintenance and application of other equipment and facilities used in the Department.

Salary on scale £2439-£2895. Applications, with full details of career to date, and the names of two referees, should be sent to the Establishments Officer of the University, College Gate, St. Andrews, Fife, as soon as possible. (4842)

CITY OF LONDON POLYTECHNIC

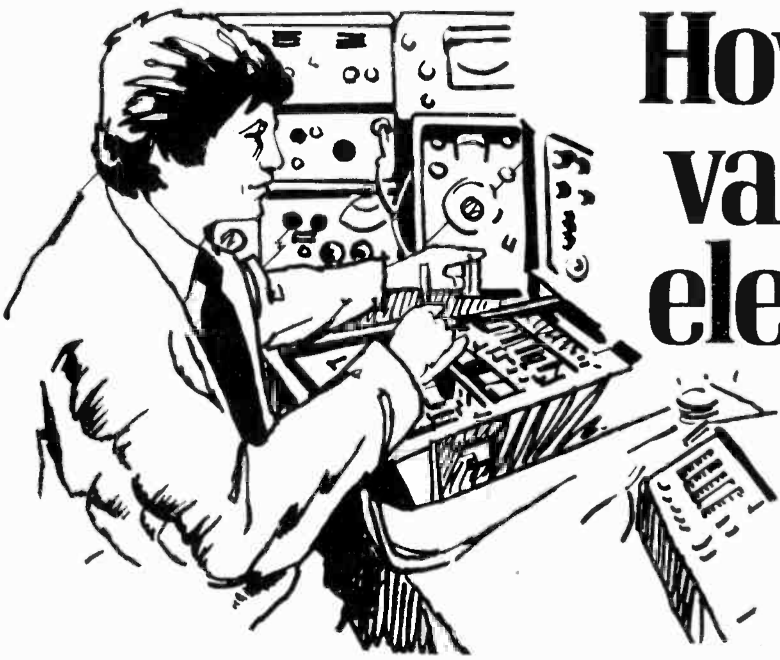
## SENIOR TECHNICIAN GRADE 5 (ELECTRONICS)

required immediately in the Department of Biological Sciences for the maintenance, construction and operation of electronic and other instruments, espeically those used in Neurophysiology. The successful candidate must possess the relevant qualifications at HND/HNC or CGLI level, together with at least seven years' relevant experience (including training period).

Salary: £2850-£3306 including London Weighting.

Apply, in writing, giving full details of qualification, experience, etc., and including the names and addresses of two referees, to the Laboratories Superintendent, Biological Sciences, Calcutta House Precinct, Old Castle Street, London, E1 7NT. (4853)

# Appointments



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Phone or write today to

**Mrs Audrey Darkin**
**Pye Telecommunications Ltd**
**Cambridge Works**
**Elizabeth Way, Cambridge CB4 1DW**
**Tel: Cambridge 58985**

or

**Mrs Cath Dawe**
**Pye Telecommunications Ltd**
**Colne Valley Road**
**Haverhill, Suffolk CB9 8DU**
**Tel: Haverhill 4422**

**Pye Telecommunications Ltd**

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UNIVERSITY OF EXETER

## ELECTRONICS TECHNICIAN GRADE 5

The University of Exeter has a vacancy in the Department of Biological Sciences for an Electronics Technician, Grade 5. Duties include the servicing and repair of a wide range of electronic analytical instrumentation, and the design, construction and modification of electronic units concerned with instruments.

Minimum qualifications: O.N.C. or equivalent. Salary £2,439-£2,895 p.a.

Applications to: The Secretary, University of Exeter, Northcote House, The Queen's Drive, Exeter, Devon. Closing date: 1st September, 1975.

Please quote reference no. 1/75/5055

(4888

CHELSEA COLLEGE
University of London

## TECHNICIAN
GRADE 5

required to be responsible for the running and technical development work of Physics and Electronics Undergraduate Teaching Laboratories in Chelsea, SW3. Salary £2849-£3305 per annum, including London Allowance.

*Further details and application form from Mr. M. E. Cane (5 PET), Chelsea College Department of Physics and Electronics, Pulton Place, London SW6 5PR.* 4872

CHELSEA COLLEGE
UNIVERSITY OF LONDON

## ELECTRONICS/TECHNICIAN

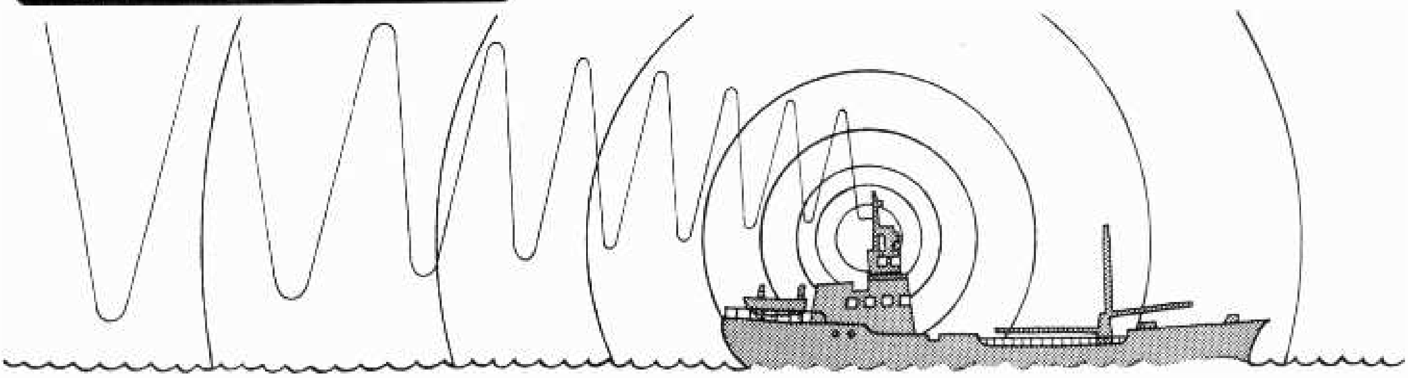
required to take charge of Electronics Workshop for the design and production of prototype electronic equipment for electronics and physics reseach and teaching, and also for the servicing and maintenance of a wide range of commercial electronic equipment. A wide practical experience and a sound theoretical knowledge of electronics is essential. Experience in microwave instrumentation would be an advantage. 5-day 37½-hour week. Salary (Grade 5) £3,254-£3,860 p.a. including London Allowance. Further details and application form from Mr. M. E. Cane (EW6), Chelsea College (University of London), Departments of Electronics and Physics, Pulton Place, Fulham, London SW6 5PR.

(4886

**TELEVISION TECHNICIANS** wanted for Middle East position. Five years heavy maintenance required. Send resumes and copies of certificates to Box WW 4851.

**ELECTRONICS TECHNICIAN** aged 20-30. We are a small Company situated in S.W. London. We require a technician to join our young electronics team working on professional audio equipment. He will be responsible for the alignment, testing and maintenance of digital, analogue and audio circuitry, and should have some practical experience in one of these fields. The company operates a profit sharing scheme. Telephone Mr. Evans at 01-542 1171. (4869)

**STUDIO** IN KENSINGTON AREA requires JUNIOR TECHNICIAN (18-22 years) to assist with maintenance and tape editing. Contact Graham Stephens, 108 Cromwell Road, London SW7. Tel. 01-370 1442. (4887)



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Right now we have vacancies at some of our coastal radio stations, so if you're 19 or over, write to: ETE Maritime Radio Services Division (R/B/9), ET 17.1.1.2., Room 643, Union House, St. Martins-le-Grand, London EC1A 1AR.

**Post Office Telecommunications**

93

## ENGINEER

**£2500-£3100 + car allowance**

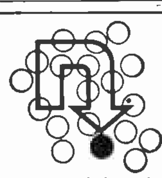
The man appointed will be engaged principally on the maintenance of ITEL automatic typewriters both at our premises and in the field. Applicants should therefore have a working knowledge of the IBM Selectric, and should live in the S.E. London/Kent area.

It is hoped, however, that someone with a wide-ranging interest in electronics and able to work on a variety of other projects will be appointed.

It is anticipated that the post might appeal to a young man to whom an informal and flexible environment is not a disincentive.

Phone: Raymond ffoulkes (Godstone 3106) for details, or write naming two referees:

**COMPUTER APPRECIATION**
**Castle Street, Bletchingley**
**Surrey, RH1 4NX** 4896



*Opportunities in the*
## *ELECTRONICS FIELD*

Men with analogue or digital qualifications / experience seeking higher paid posts in: TEST - SERVICE - DESIGN - SALES.

Phone: Mike Gernat, Ref. W.W.

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## Equipment Dept., Chiswick, W.4.

Interesting work testing new electronic equipment made by the BBC for its colour television and stereo radio services, involving analogue and digital techniques over a frequency range from D.C. to U.H.F.

Qualifications O.N.D., O.N.C. or C. & G. Part II in Telecommunications or Electrical Technician certificate. Initial salary range normally £2,127 to £2,319 rising to £2,952. Good opportunities for promotion to Senior Laboratory and Engineering Technicians with salaries rising to £3,762. Further promotion to Engineer grades is also possible.

Staff will be based at Equipment Department, Chiswick which is within easy reach of British Rail and London Transport services and the M4, North and South Circular roads.

Good club and canteen facilities are available.

The posts are pensionable with four weeks' leave annually.

Requests for application forms to The Engineering Recruitment Officer, BBC, Broadcasting House, London W1A 1AA, quoting reference 75.E.4047/WW. Please enclose an addressed envelope at least 9" x 4" with your application; no stamp required. Closing date for completed application forms is 14 days after publication.

(4877)

**BBC**

# WIRELESS TECHNICIANS

There are vacancies at Home Office Wireless Depots throughout England and Wales for Wireless Technicians to assist with the installation and maintenance of VHF and UHF Systems. Ability to drive a car and possession of a current driving licence is desirable.

**Salary**

is £2010 (at 17), £2450 (at 21) and £2905 (at 25) rising to £3385 a year.

A London Weighting Allowance of up to £410 a year is also payable for staff in London.

**A Secure Future**

with a non-contributory pension scheme, good prospects of promotion and a generous leave allowance. There are opportunities for day release to obtain higher qualifications.

**Qualifications**

Candidates should have good experience in Telecommunications and preferably hold a City and Guilds Intermediate Telecommunications Certificate or equivalent.

**Interested?**

Then write or telephone for further details and application form to:

Mr. C. B. Constable,
Directorate of Telecommunications,
Home Office,
60 Rochester Row,
LONDON SW1P 1JX.
Telephone No. 01-828 9848 (Extension 734).

4871

Home Office

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requires

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Sabah Air
P.O. Box 747
Kota Kinabalu
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(4893

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**THE SPECIALIST IN POWER CONVERSION**

Applicants should have HND or better qualifications, preferably with some Industrial Design experience in transformers from five to several hundred kVA and/or industrial semi-conductor rectifier equipment. Training in the design of the Company's specific products will be given.

Salary commensurate with qualifications and experience and four weeks annual holiday.

Assistance will be given with removal expenses where appropriate.

Please apply in writing to:
Mrs J. Davey, Personnel Services

(4841)

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Manweb

ELECTRICITY

ENGINEERING DEPARTMENT

COMMUNICATIONS AND MEASUREMENT

## FIRST ENGINEER—DESIGN AND APPLICATION

A First Engineer is required for duties in the Technical Section of the Chief Engineer's Department at Manweb Head Office, Sealand Road, Chester.

He should have a sound theoretical knowledge and extensive practical experience in the communications field.

The post involves work on projects in the following branches of communications:

(1) **AUTOMATIC TELEPHONY**
(2) **POST OFFICE TELEPHONY**
(3) **PRIVATE RADIO SYSTEMS**
(4) **DATA TRANSMISSION**
(5) **CARRIER LINE TRANSMISSION**
(6) **COMPUTER PRINCIPLES AND APPLICATIONS**

(A) The First Engineer will be required to share responsibility for the design of extensions to the communications systems and of new applications of computer technology.

(B) To negotiate on engineering design matters with Post Office engineers and manufacturers of communication equipment, and must be able to prepare technical specifications of communication equipment.

(C) And to control development work at a technical workshop close to Head Office and also at a computer terminal located at Head Office and provided with communication links to the Manweb computers and to the private communications systems.

Manweb is operating an extensive communications system linking district offices and depots at the ten districts with Head Office, and the first stage in the provision of links between districts and the Head Office computers has been implemented.

Salary within the range £4630-£6680 per annum + £120 responsibility payment + £229.35 threshold payment.

Applications, giving full details, should be sent to the Secretary (Personnel), Manweb, Head Office, Sealand Road, Chester, to arrive not later than 8th September, 1975. (4840)

UNIVERSITY OF SHEFFIELD

## RESEARCH TECHNICIAN (Grade 3-5)

required for the Space Physics Group within the Department of Physics for an initial period of 2 years. The successful candidate would be primarily concerned with the research, development and construction of pay loads for use with ionospheric sounding rockets. Experience of design and/or construction in one or more of the following areas would be advantageous:

(a) low noise analogue circuitry D.C. - 100 KHz
(b) Radio frequency circuitry 100 MHz - 1500 MHz and modulation methods
(c) Ultra reliable equipment for use in extreme environments and/or prolonged periods of unattended operation.

A current driving licence is essential, the duties may include some travel both within the U.K. and abroad for periods up to several weeks.

Salary scales £2013-£2343 p.a. or £2247-£2628 p.a. or £2439-£2895 p.a.

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**STODDART RADIO INTERFERENCE MEASURING SET.** 3 Units range from 15m/cs to 1000mc/s. In perfect working order. £2,500.00 Hewlett Packard Spectrum Analyser Type 8551A. Not working on suitable for spares £400.00. Telephone evenings only 01-449 6548. (4881

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Natural Environment Research Council

## British Antarctic Survey

**Electronic Engineer** (graduate or H.N.C.) required for maintenance, development and operation of radio-echo sounding equipment. This is a pulsed radar system working at 60 MHz used in aircraft to measure ice thickness in the Antarctic. The same equipment is used on the surface to measure glacier flow.

Candidates should be familiar with radar theory and digital logic, and have experience in design and construction in these fields. The successful candidate will be based in Cambridge (Scott Polar Research Institute) and must be prepared to work in the Antarctic for periods of up to four months.

Salary according to age and experience from £2,012. In addition, a Cost of Living Supplement of £229.68 per annum is payable.

Please write for further details, stating full qualifications to:
The Establishment Officer, British Antarctic Survey, 2 All Saints Passage, CAMBRIDGE CB2 3LS.
Tel: Cambridge (0223) 61188
Please quote reference BAS1. 4883

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We are a young but expanding Electronics Company moving to a modern well-equipped factory. An opening has arisen for an Engineer to join our research and development department.

The successful applicant will be involved in all sides of project engineering and should have experience in both analogue and digital electronics.

The job offers an exciting future with rapid advancement to Senior Management for the right person.

**SALARY £2400 p.a.**

Apply Technical Director
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APPOINTMENTS

**AGRICULTURAL RESEARCH COUNCIL**

**WEED RESEARCH ORGANISATION**

# ELECTRONICS ENGINEER

This new post involves preventive maintenance, repair and development of new electronic devices. Equipment involved includes electronic aspects of controlled environment cabinets and rooms, monitoring instrumentation, general laboratory equipment, and data collection and handling facilities. The engineer will work closely with research staff to apply the potentialities of contemporary electronics to a wide range of research activities. Hence, in addition to general proficiency in electronics, a broad knowledge, inventive ability and capability to communicate with other specialists will all be required.

Minimum qualifications required are ONC or equivalent qualification in Electronics Engineering.

The appointment will be in the grade of Professional and Technology Officer III (£3,450 x 5 to £3,925)

Non-contributory pension scheme.

For further particulars and application form write to The Secretary, Weed Research Organisation, Begbroke Hill, Yarnton, Oxford OX5 1PF, quoting 7/75. Closing date for applications 10th September, 1975

(4875)

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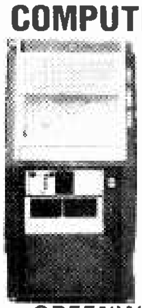

ICL Model P11 Potter MT120 7-track ½" tape deck EC120 PSU MA315 Read & Write Amplifier Unit etc 240V 50Hz operation Size 1.6mx0.78mx0.61m £80 Carriage by arrangement

Also Mullard core store AW661 48 planes each 64x64 £22+£1 carr

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SAE Enquiries

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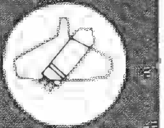

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| PCF80 | 31.5 |
| PCF86 | 39.0 |
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| PCL82 | 39.0 |
| PCL84 | 39.0 |
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| AC154 | 18 |
| AC155 | 18 |
| AC156 | 20 |
| AC176 | 22 |
| AC187 | 19 |
| AC187K | 24 |
| AC188 | 17 |
| AC188K | 26 |
| AD142 | 45 |

| Type | Price Each (p) | Type | Price Each (p) |
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| AD161 | 38 | BD131 | 45 |
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| AF116 | 22 | BD237 | 52 |
| AF117 | 19 | BDX32 | £2.40 |
| AF118 | 50 | BF115 | 20 |
| AF139 | 35 | BF160 | 15 |
| AF178 | 45 | BF167 | 20 |
| AF180 | 45 | BF173 | 20 |
| AF181 | 45 | BF178 | 35 |
| AF239 | 40 | BF179 | 40 |
| AF240 | 60 | BF180 | 31 |
| BC107 | 11 | BF181 | 32 |
| BC108 | 10 | BF184 | 25 |
| BC109 | 14 | BF185 | 25 |
| BC109C | 14 | BF194 | 9 |
| BC113 | 13 | BF195 | 8 |
| BC116A | 19 | BF196 | 10 |
| BC117 | 14 | BF197 | 12 |
| BC125B | 15 | BF198 | 23 |
| BC132 | 25 | BF200 | 25 |
| BC135 | 15 | BF218 | 30 |
| BC137 | 19 | BF224 | 23 |
| BC138 | 26 | BF258 | 34 |
| BC142 | 23 | BF336 | 28 |
| BC143 | 25 | BF337 | 35 |
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| BA148 | 19 |
| BA154/201 | 11 |
| BY126 | 11 |
| BY127 | 12 |
| BY199 | 27 |
| BY206 | 21 |
| BY238 | 25 |
| OA90 | 6 |
| OA202 | 7.5 |
| IN60/OA91 | 5 |

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| TBA540Q | £1.75 |
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| TBA800 | £1.50 |
| TBA920Q | £2.90 |
| TBA990Q | £2.90 |
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| ITN GEC/Sobell | £4.50 |
| 11TAZ GEC 2110 | £4.85 |
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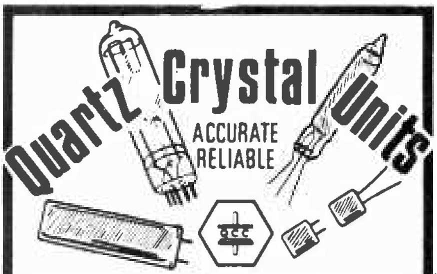


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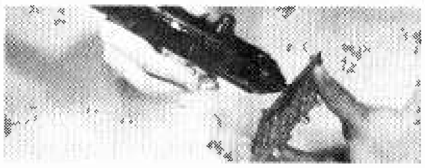

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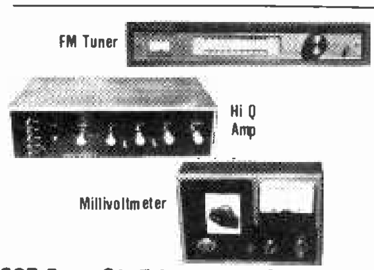


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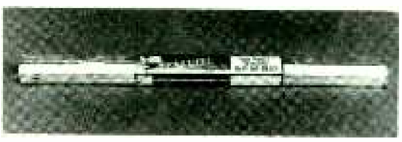

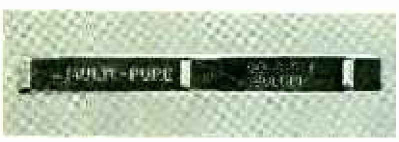

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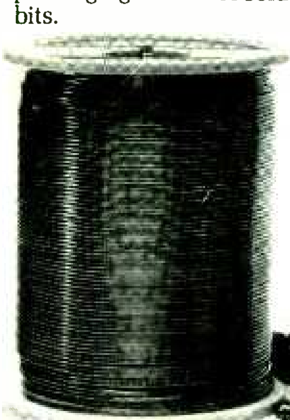

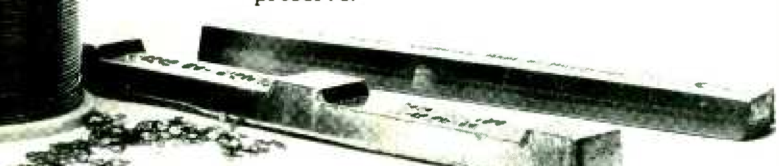

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