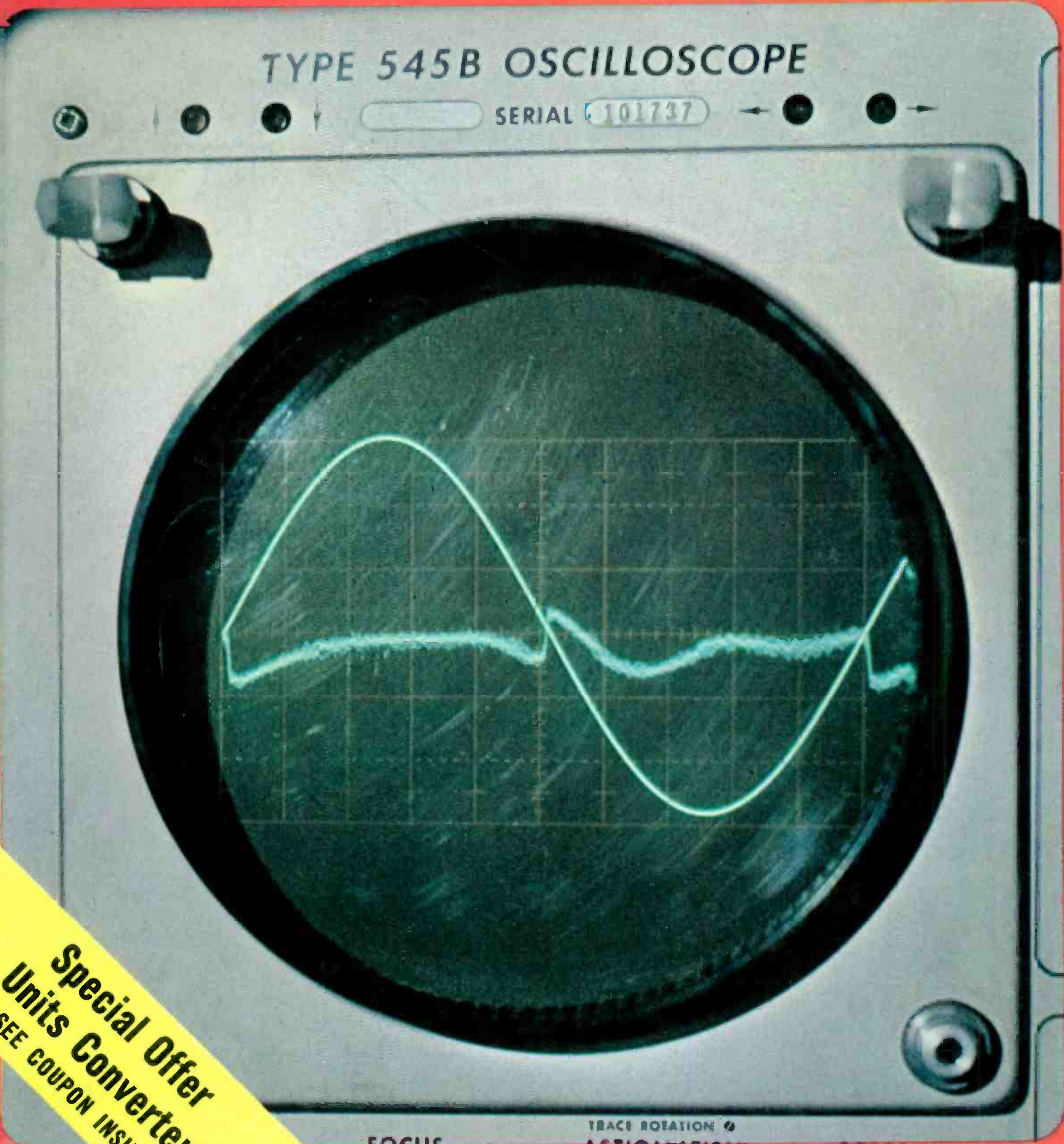
# Wireless World

June 1969 Three Shillings

## F.M. tuner using integrated circuits

## Selecting an audio amplifier

21 MAY 1969




**Special Offer
Units Converter
SEE COUPON INSIDE**

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# ALL POINTS FAVOUR VERSATILE KEYSWITCH TAILOR-MADE RELAYS

There are more than a million variations of the 10 basic Keyswitch relays illustrated here; at least one of them will suit your particular requirements.

They're all top-quality and top-performance, as demonstrated by an impressive list of 'approvals' that includes Post Office, Atomic Energy Authority, NATO, National Coal Board, British Rail and Central Electricity Generating Board. And every Keyswitch 'tailor-made' is also available in plug-in form. So when you need the best relays, at competitive prices and delivered on time, contact Keyswitch Relays Ltd, Cricklewood Lane, London NW2 (01-452 3344; telex 262754)

**KEYSWITCH RELAYS**

1 MIL mechanically interlocked pair, operating A releases B
2 P33 plug-in version of P.O. 3000, at least 30m operations
3 600 compact version of P.O. 3000, up to 10A contacts
4 KTR replaces two P.O. 3000's in space of one, 30% cheaper
5 DA33 two independent armatures and contact assemblies
6 KR31 remanent latching, holds indefinitely
7 MRL latches mechanically, releases electrically, up to 8 contacts
8 K700 miniature contactor, very sensitive coils, up to 30A contacts
9 P.O. 3000 meets full GPO specs, up to 30A contacts
10 MSW any of these relays fitted with up to 8 microswitches


KEYSWITCH RELAYS – WHERE THE ACTION IS – KEYSWITCH RELAYS

WW—001 FOR FURTHER DETAILS


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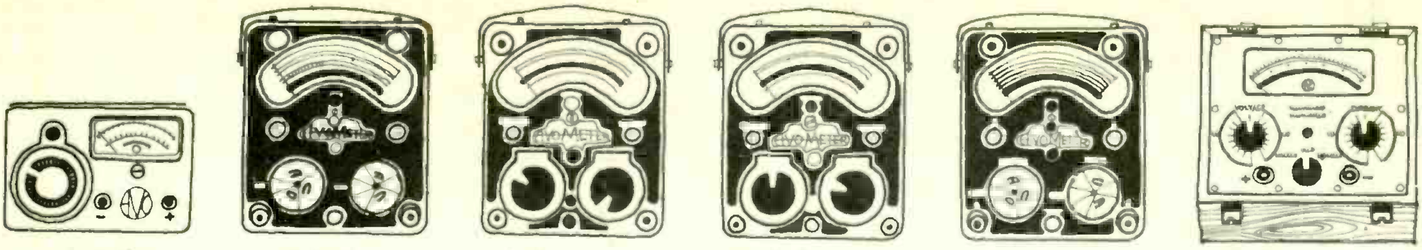


**Multiminor** – inexpensive, pocket-sized for the service engineer or hobbyist.

**Model 7** – for the electrical engineer, general purpose use 50 ranges.

**Model 8** – for the electronic, radio and TV engineer

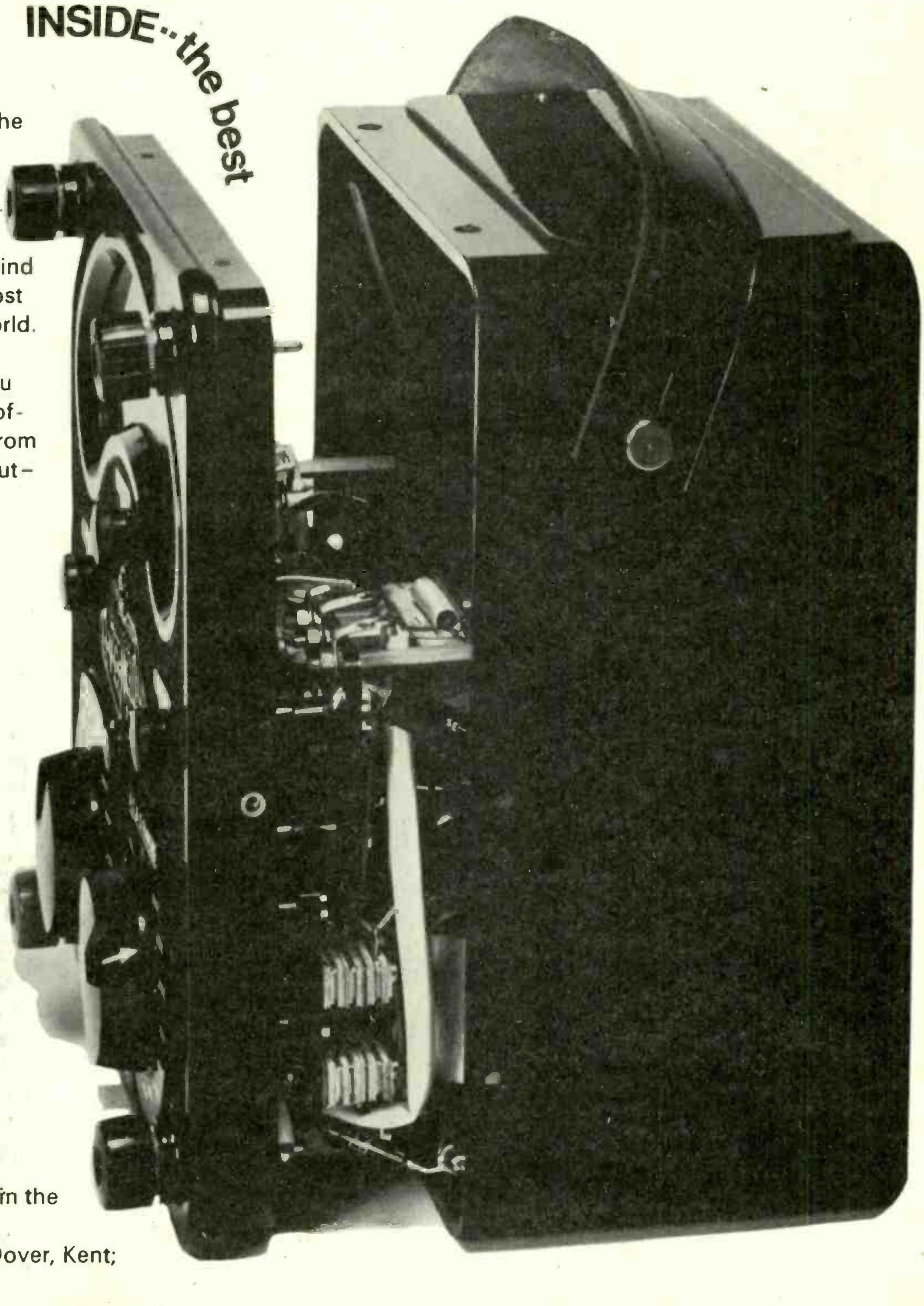
**Model 9** – similar to model 8 but controls marked with graphical symbols.

**Model 40** – for the power engineer, extra robust 40 ranges.

**Precision Avometer** – high accuracy for the laboratory engineer.

# OUTSIDE··the lot

# INSIDE··the best



On the outside, Avometers haven't changed much over the years. But inside every genuine Avometer – right across the range from pocket-size Multiminors to 0.3% Precision Avometers – you'll find the up-to-date guts of the most famous multimeters in the world. Outside – the same familiar functional case and knobs you grew up on. Inside the state-of-the-art circuitry you'd expect from the world leader. Inside and out – multimeters to meet every laboratory, test and servicing requirement.

AVO

THORN

Full details and specifications in the Avo Short Form Catalogue.
Avo Limited, Avocet House, Dover, Kent; Dover 2626; Telex 96283



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# C&S Antennas

## provide a complete aerial service LF to Microwave

**Point to Point**
**Broadcasting**
**Radio Relay**
**Ground to Air**
**Navigational Aids**
**Business Radio**

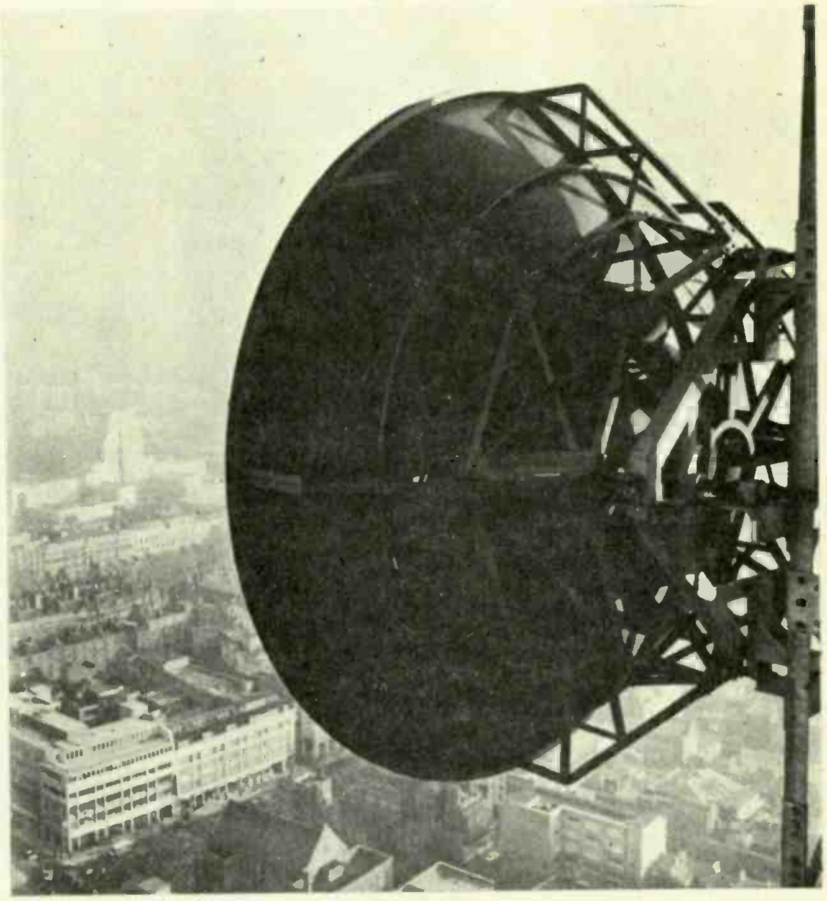
### Design
Site layouts
Aerial System Design

### Aerials
**LF** 'T' and 'L' Aerials,
Mast Radiators,
**HF** Dipoles, Quadrants,
Rhombics, Log Periodics,
Vertical Incidence Arrays,
Conicals, Biconicals
**VHF & UHF** Yagis, Helices,
Ground Planes, Colinears,
Whips, Marine Aerials,
Television Arrays to 100kW e.r.p
**MICROWAVE** Passive Reflectors,
Dishes 3" to 60 ft. dia.

### Supporting Structures
Self-supporting Towers,
Tubular and Lattice Masts,
Telescopic Masts

### Accessories
Coaxial and open wire Feeders,
Filters, Aerial Switches,
Lead-in panels, Earth Systems.
Air-cooled Transmitter Loads.
Termination Networks

### Installation
World Wide Service



# C&S Antennas Ltd

Wentworth House, Eastern Avenue, Ilford, Essex, England.
Telephone: 01-554-0102 Telex: 25850 Cables: Antennas Ilford (England)

WW—007 FOR FURTHER DETAILS

CS16A

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# EEV thyratrons- for better high speed switching

EEV glass and ceramic hydrogen thyratrons are extensively used to provide more precise and efficient high speed switching. Here are some of the reasons why:

1 Their short anode delay time of between 20 and 120 nanoseconds depending on triggering method.

2 Low jitter generally of 1 to 2 nanoseconds but down to less than ½ nanosecond depending on heater supply.

3 The negligible change in anode delay time—typically only 10 nanoseconds over a long period of use.

4 A high peak inverse voltage capability of 20kV immediately following pulse.

5 The low trigger power required.

6 The wide operating voltage range of 1kV-120kV with four tubes.

7 The ability to control anode delay time and rise time of current, using reservoir.

8 The wide reservoir range for maintenance of gas pressure typically 4.5V to 5.7V.

The standard range plus EEV's ability to meet special requirements means that virtually any high speed switching application can be met. Here are a few:

**Radar modulators** with a system output power of 10kW – 10MW.

**Medical linear accelerators** with RF accelerating powers up to 15MW.

**Particle linear accelerators** with RF accelerating powers up to 50MW. They may also be used in first-stage particle beam choppers.

**Particle beam benders** where a network of stored energy needs to be discharged into a deflection coil or other device somewhere on the accelerating ring.

**Spark chambers**

**For pulsing light shutters** such as Kerr or Pockel cells.

**Electronic crowbars and energy diverters**


Brief data on some of the ceramic types available.

| Type | Peak power output max (MW) | Heating Factor (V.A.p.p.s.) | Peak forward voltage max (kV) | Peak anode current max (A) | Mean anode current max (A) |
|---|---|---|---|---|---|
| CX1154 | 50.0 | $30 \times 10^9$ | 40 | 2500 | 3.0 |
| CX1157 | 3.5 | $7 \times 10^9$ | 20 | 350 | 0.35 |
| CX1168 | 100.0 | $70 \times 10^9$ | 80 | 2500 | 2.5 |
| CX1171 | 150 | $70 \times 10^9$ | 120 | 2500 | 2.5 |
| CX1174 | 120 | $60 \times 10^9$ | 40 | 6000 | 6.0 |
| CX1175 | 200 | $140 \times 10^9$ | 80 | 5000 | 6.0 |
| CX1180 | 12.5 | $9 \times 10^9$ | 25 | 1000 | 1.25 |

Send for full details of the complete range of EEV thyratrons.

**English Electric Valve Co Ltd**
Chelmsford Essex England Telephone: 61777
Telex: 99103 Grams: Enelectico Chelmsford

I am particularly interested in using a thyratron with the following parameters:

Application

Peak power output

Peak forward voltage

Peak anode current

Please send me full data on your complete range of glass and ceramic hydrogen thyratrons

NAME POSITION

COMPANY

ADDRESS

TELEPHONE NUMBER EXTENSION

WW17

AP 359



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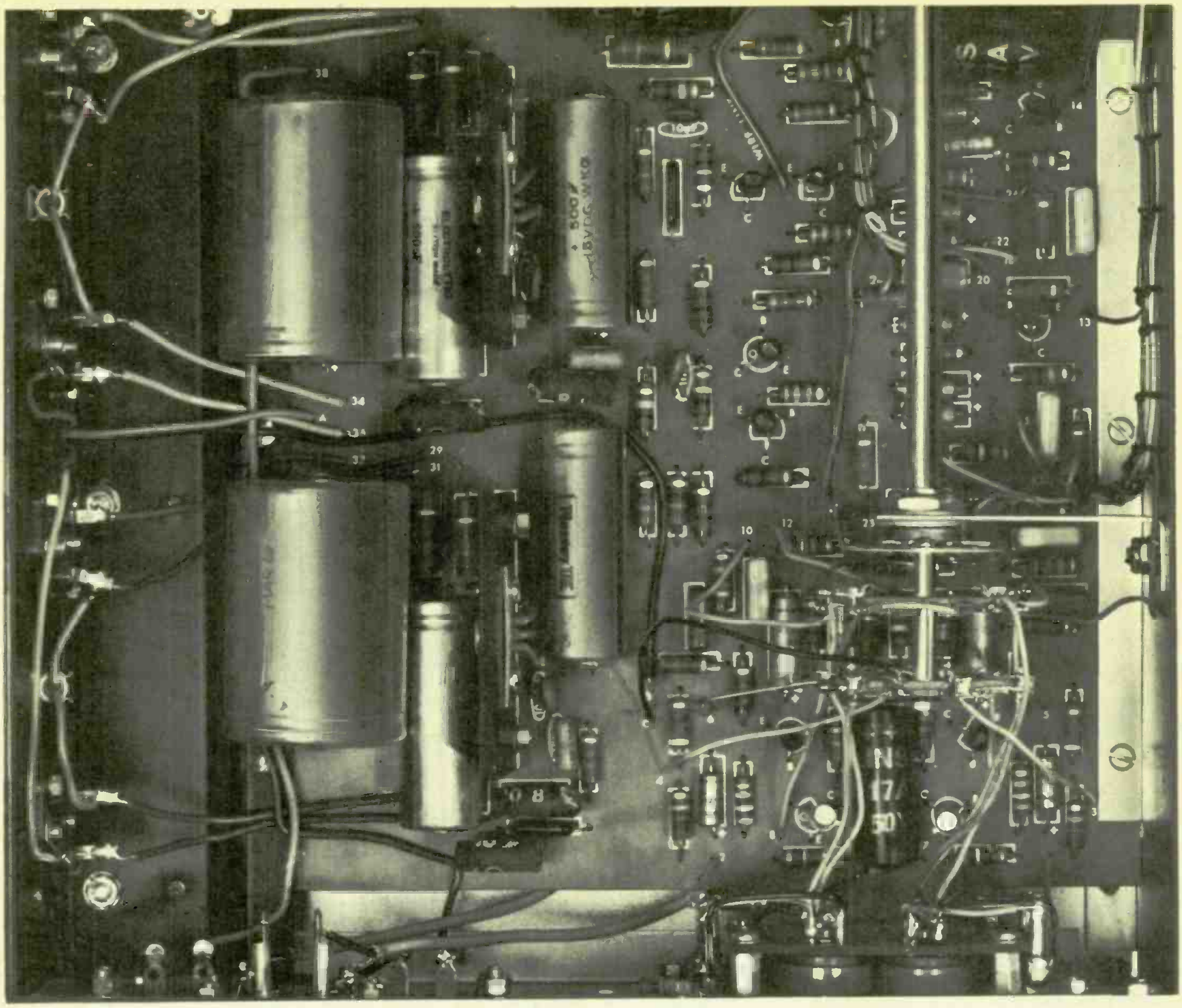

# Heathkit & the power game

It isn't a game any more — the time has come when the public should be told exactly who is behind the idea that high-quality test instruments can be within the reach of everyone. Heathkit can remain in the shadows no longer — it is time for some plain talking. In Heathkit construction manuals that is exactly what you get — instructions clear enough to enable anyone to build their own equipment, thereby cutting costs by up to 50%.

Heathkit's expert technical staff will provide the answers to any queries you may have regarding any of the models to be found in the 1969 catalogue.

HEATHKIT **DAYSTROM LTD.**, Gloucester GL2 6EE England
Tel. Glos. 29451. Telex 43216.

Please send me your fully-detailed catalogue immediately
Daystrom Limited, Gloucester GL2 6EE, England
NAME ..................
ADDRESS ..................
WW100

**WW—009 FOR FURTHER DETAILS**

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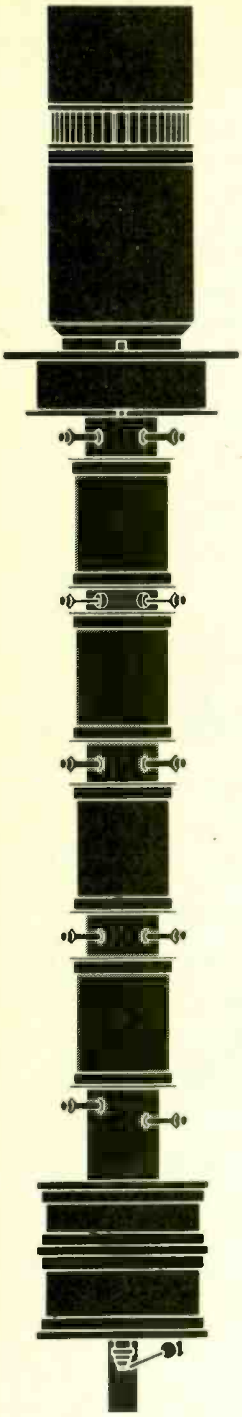

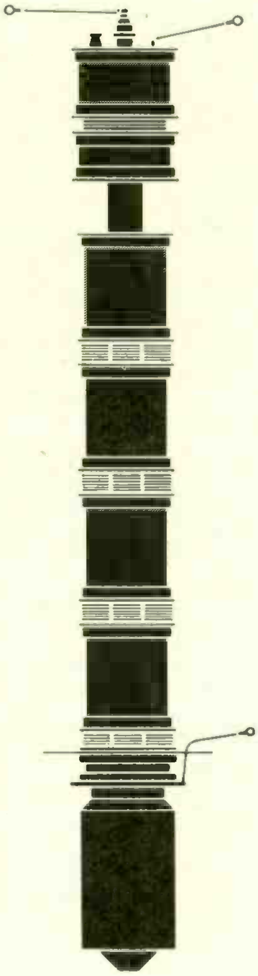

# EEV klystrons – a wide and flexible range for UHF TV

5 7 10 25 40 kW

EEV make amplifier klystrons for UHF TV at power levels 5, 7, 10, 25 and 40kW into the aerial. Their reliability is established, their operating efficiency is good and their design provides a high degree of operational flexibility. A 40kW tube can, for example, be operated at the same efficiency at any power level between 20kW and 40kW. When operated at 40kW the tube needs only 135kW d.c. input.

Send for full details of the complete range of EEV amplifier klystrons.

**English Electric Valve Co Ltd**
Chelmsford Essex England Telephone: 61777
Telex: 99103 Grams: Enelectico Chelmsford

Please send me full details of your range of UHF TV amplifier klystrons.
I am interested in a klystron with the following parameters:

Frequency Range Bandwidth Power Level

NAME POSITION

COMPANY

ADDRESS

TELEPHONE NUMBER EXTENSION WW18

AP 354


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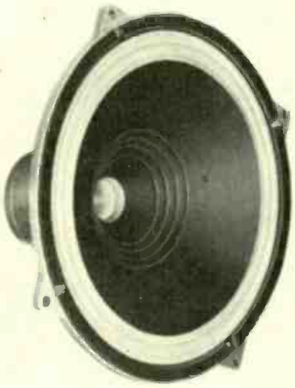
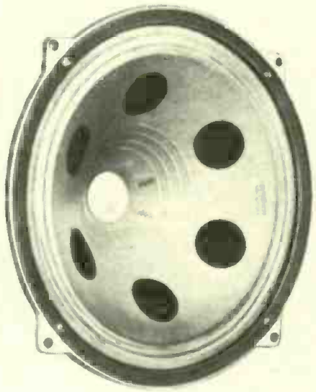
# WHITELEY ELECTRICAL RADIO CO. LTD.

## *Stentorian* HIGH FIDELITY UNITS

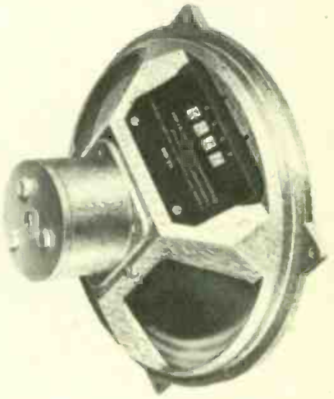
HF.1016 Major



HF.1216

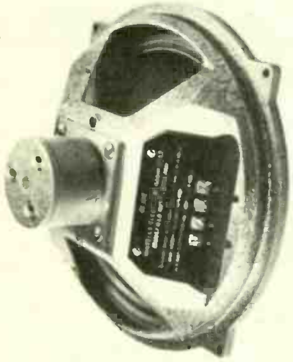


HF.1214

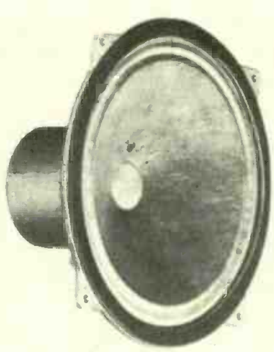


HF.1016

HF.1012

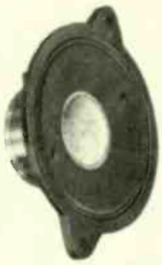


HF.816



T816

P2.585



| Type | Dimensions Depth | Dimensions Dia. | Flux Density Gauss | Pole Dia. In. | Total Flux Maxwells | Imp. ohms | Handling Capacity Watts | Bass Res. c/s | Frequency Response c/s | Weight lb. | Weight oz. | Price* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| HF.816 | 4.218" | 8" | 16,000 | 1.0 | 63,000 | U | 6 | 63 | 50—15 K | 4 | 8 | £8.15.0 |
| HF.1012 | 4 19/32" | 10" | 12,000 | 1.0 | 47,400 | U | 10 | 35 | 30—14 K | 4 | 4 | £6.8.0 |
| HF.1016 | 4 61/64" | 10" | 16,000 | 1.0 | 63,000 | U | 10 | 35 | 30—15 K | 5 | 13 | £10.4.2 |
| HF.1016 Major | 5 1/4" | 10" | 16,000 | 1.0 | 63,000 | 15 | 10 | 39 | 30—16 K | 6 | 0 | £13.1.11 |
| HF.1214 | 6 1/2" | 12" | 14,000 | 1.5 | 106,000 | 15 | 15 | 39 | 25—14 K | 9 | 10 | £14.0.7 |
| HF.1216 | 7 1/2" | 12" | 16,000 | 1.5 | 121,140 | 15 | 15 | 37 | 20—16 K | 13 | 0 | £21.10.3 |
| T.816 | 4 1/4" | 8" | 16,000 | 1.0 | 63,000 | 15 | 15 | — | 1500—17 K | 4 | 8 | £8.5.9 |
| P2.585 | 11/12" | 2 1/2" | 8,500 | 0.375 | 6,400 | 3 | 0.3 | 330 | 250—9 K | — | 3 | £1.10.6 |

* Includes 10% P.T. surcharge

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Whiteley Stentorian Speakers incorporate 40 years of development in acoustic technology. Their frequency response is exceptionally wide, and their overall performance outstanding. Few speakers can equal, and none can excel the superb reproduction of the high fidelity speakers in the Whiteley Stentorian range.

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MANSFIELD · NOTTS · ENGLAND
Telephone: Mansfield 24762
LONDON OFFICE: 109 KINGSWAY, W.C.2. Telephone: 01-405 3074



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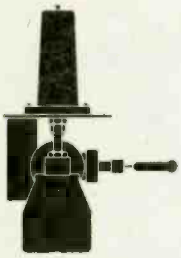
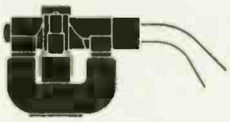
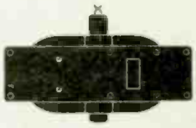
# Be safe...use EEV magnetrons in your marine radar

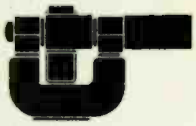
Brief data on some of the many types available. The complete range covers S-Band and X-Band types from 3-80kW.

| Type | Frequency Range (MHz) | Peak Output Power (kW) (Typical Operation) | Equivalents (not complete) |
|---|---|---|---|
| M5063 | 3025-3075 | 50 | 2J70B |
| 2J42 | 9345-9475 | 8 | ME1101, CV3676, MAG3, M526 |
| BM1002 | 9415-9465 | 21 | JP9-15B |
| M513B | 9345-9405 | 22 | JP9-15, YJ1110 |
| M515 | 9380-9440 | 25 | YJ1120 |
| M597 | 9380-9440 | 10 | |
| M598B | 9380-9440 | 22 | |
| 599A/B | 9415-9475 | 3 | JP9-2.5D, JP9-2.5E, 7028 |
| M5022 | 9415-9475 | 30 | YJ1121 |
| M5031 | 9345-9405 | 9 | |
| M5043 | 9380-9440 | 5.8 | |
| M5039 | 9345-9405 | 22.5 | |


M5063


M515


M599A/B


M513B

Send for full details of EEV marine magnetrons.

**English Electric Valve Co Ltd**
Chelmsford Essex England Telephone: 61777
Telex: 99103 Grams: Enelectico Chelmsford

Please send me full data on your range of marine magnetrons.
I am particularly interested in using a marine magnetron with the following parameters.

| Frequency Range (MHz) | Peak Output Power (kW) | Pulse Length (µs) | Pulse Repetition Rate (p.p.s.) |
|---|---|---|---|
| | | | |

NAME POSITION

COMPANY

ADDRESS

TELEPHONE NUMBER EXTENSION

WW19
AP 356



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# NOW...
# Guarantee your audience's listening comfort




**Our Automatic Loudness Controller delivers the sound that's right for every ear. Automatically eliminates excessive loudness. Unconditionally guaranteed!**

No doubt about it. Other devices can control volume and modulation levels. That's what they're for.

But only one instrument can analyze and automatically control loudness levels.

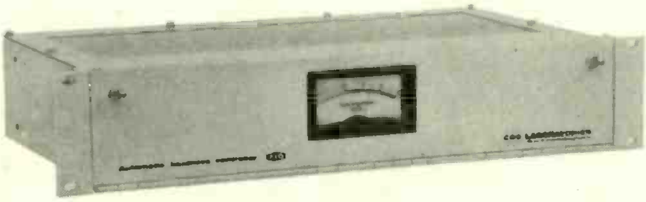
Ours.

Reason? We designed it "from human ears". At CBS laboratories, we tested every conceivable sound sensation: Frequency content. Peak factors. Ballistic response. Combinations of complex signals. All the characteristics that affect even the most sensitive ear.

Result? An instrument so "humanly" perceptive it automatically keeps loudness levels under control. And does it inaudibly. Keeps your audience in their chairs . . . listening comfortably. No constant jumping up and down to flip the dial. They enjoy continuous listening pleasure.

Why not let your audience hear you at your best? Install this remarkable instrument in your studio. You *will* believe your ears. It's guaranteed. Unconditionally.

For further information, write:



PROFESSIONAL PRODUCTS
CBS LABORATORIES
Stamford, Connecticut 06905
A Division of Columbia Broadcasting System, Inc.



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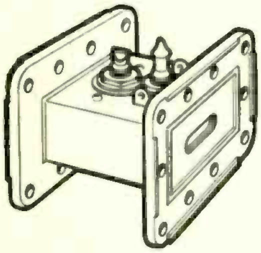
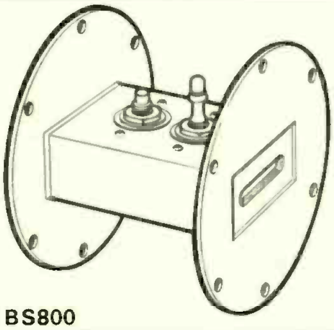
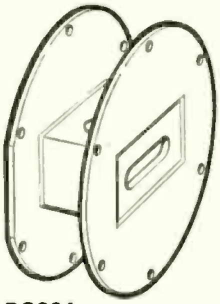
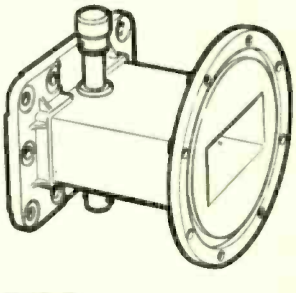
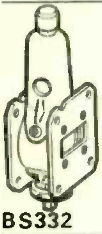
# Choose your duplexer devices from EEV's extensive range

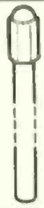

BS390

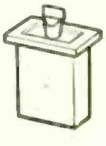

BS800

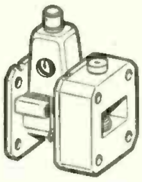

BS824

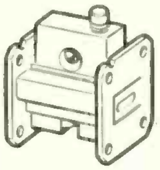

BS802

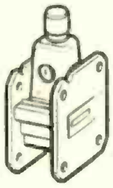

BS332

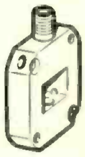

BS834


BS310


BS814


BS458


BS452


BS460

Brief data on some of the many types available.

| Product | Type No | Band | Frequency range (MHz) | Peak power (kW) |
|---|---|---|---|---|
| Pre TR cells | BS834 | — | 2000-12000 | 2500 |
| | BS870 | — | 1240-1365 | 2500 |
| TR cells | BS390 | S | 2925-3075 | 1250 |
| | BS800 | S | 2840-3100 | 1250 |
| | BS824* | S | 2700-3100 | 250 |
| | BS156 | X | 9000-9600 | 200 |
| | BS452 | X | 9310-9510 | 100 |
| | BS810 | X | 9250-9550 | 75 |
| | BS850 | X | 9300-9500 | 50 |
| TB cells | BS310 | X | 9375 | 5-200 |
| TR limiter cells | BS814 | X | 9000-9700 | 200 |
| | BS828 | X | 9325-9425 | 50 |
| Solid state microwave switches | BS392 | S | 2925-3075 | 0.5 |
| | BS460 | X | 8500-12000 | 0.5 |

*For protection of travelling waveguide amplifiers

Send for this booklet giving full details of the complete range of EEV duplexer devices and waveguide switches.

**English Electric Valve Co Ltd**
Chelmsford Essex England Telephone: 61777
Telex: 99103 Grams: Enelectico Chelmsford


Please send me a copy of "Duplexer Devices". I am interested in a tube with the following parameters:

Frequency range Power Type of cell

NAME POSITION

COMPANY

ADDRESS

TELEPHONE NUMBER EXTENSION

WW 20
AP 365

WW—014 FOR FURTHER DETAILS

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**HIGH FIDELITY MOVING COIL STEREO HEADPHONES (TYPE LS43) Now available from DAYSTROM LTD. GLOUCESTER**

WW—015 FOR FURTHER DETAILS

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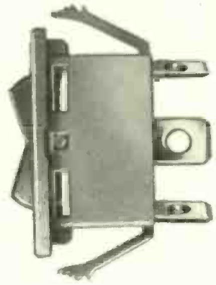
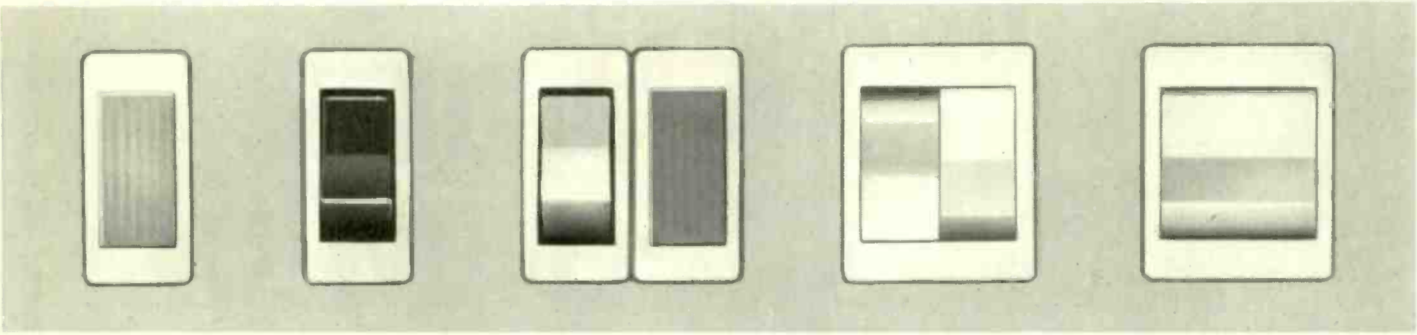
# MY VITAL STATISTICS ARE

# 1·181"x·551"x1·213"
# 250V 10 AMP A.C.
# SINGLE POLE
# SNAP-IN FIXING



## now meet the family



1109 1100 1100/1109 1100 twins 1110

Being a snappy little 1100 rocker who is getting around fast, I am often asked about my family. Now, having managed to persuade them to have their photograph taken with me, I have much pleasure in introducing them.

1109—often seen around with me, is a most illuminating little pilot light with a variety of colour lenses. At times we are very close and can often be seen working together very harmoniously on a wide range of appliances and equipment.

The 1100 twins are going to be very popular and you can expect to see them on many companies' panels soon.

1110, the fat one, is double pole and the clever member of the family, he can operate two circuits at a time.

Like to know more about us? Give us a ring at 01-574 2442, we would certainly like to meet *YOU* some time. P.S. I have just been awarded my BS.3955 approval certificate.

**ARROW**

ARROW ELECTRIC SWITCHES LTD · BRENT ROAD · SOUTHALL · MIDDX · 01-574 2442

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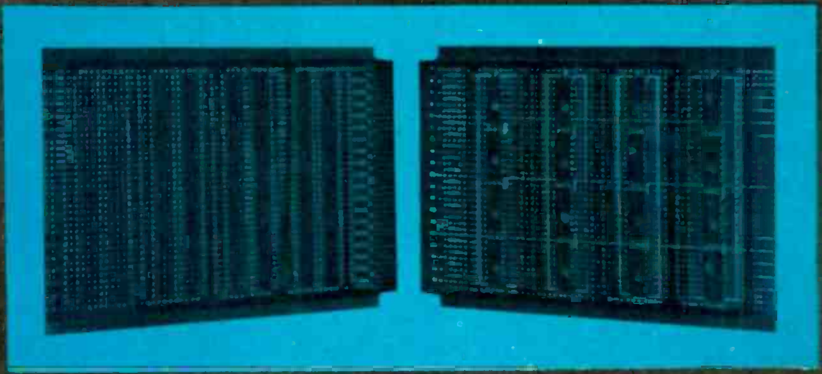

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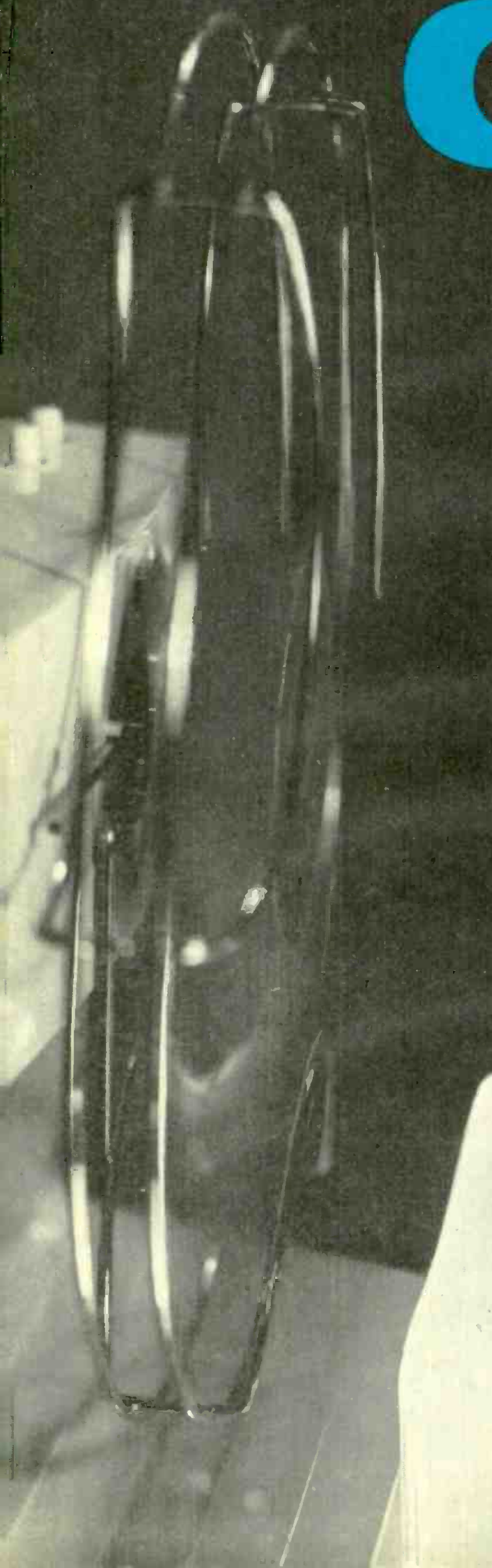

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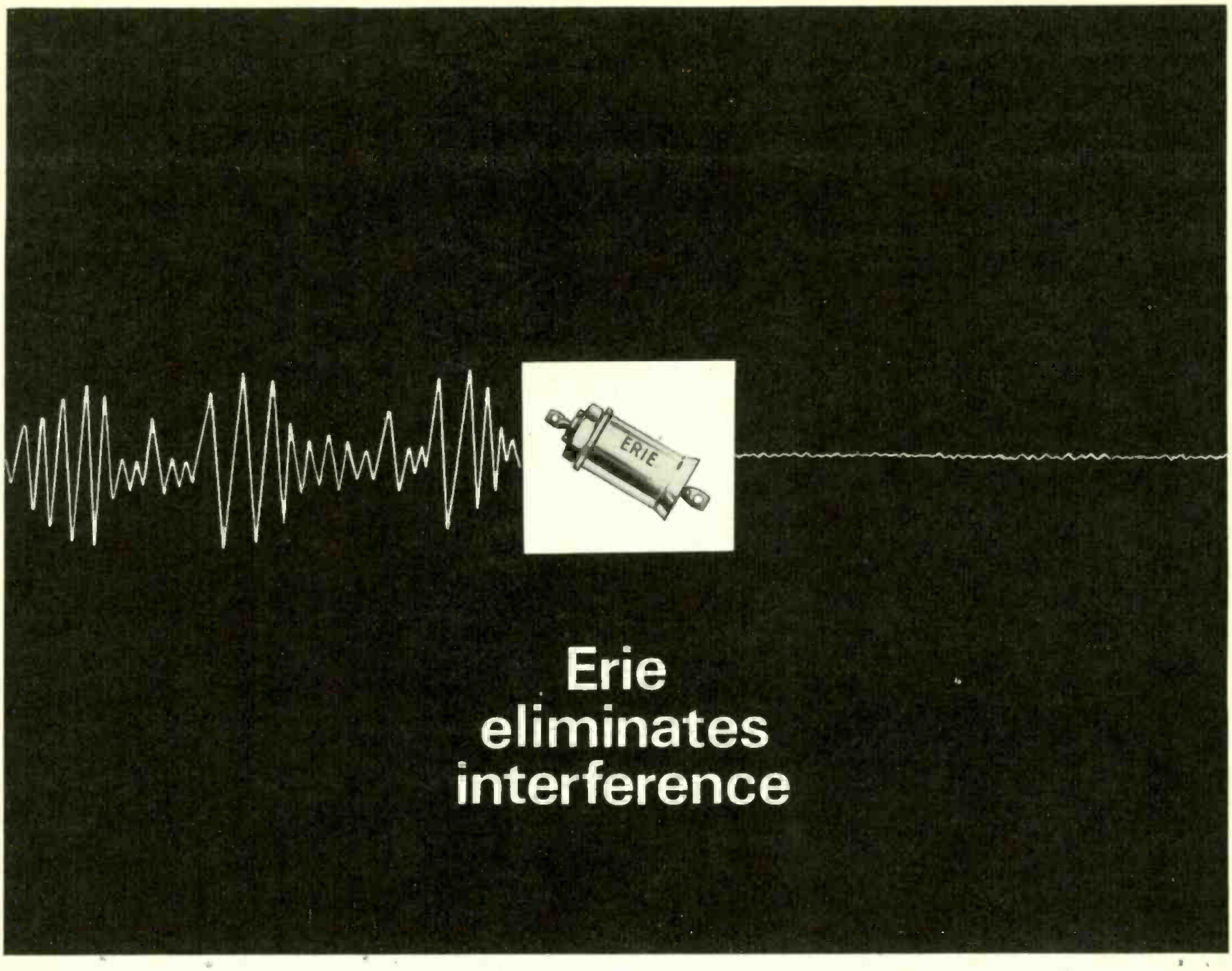


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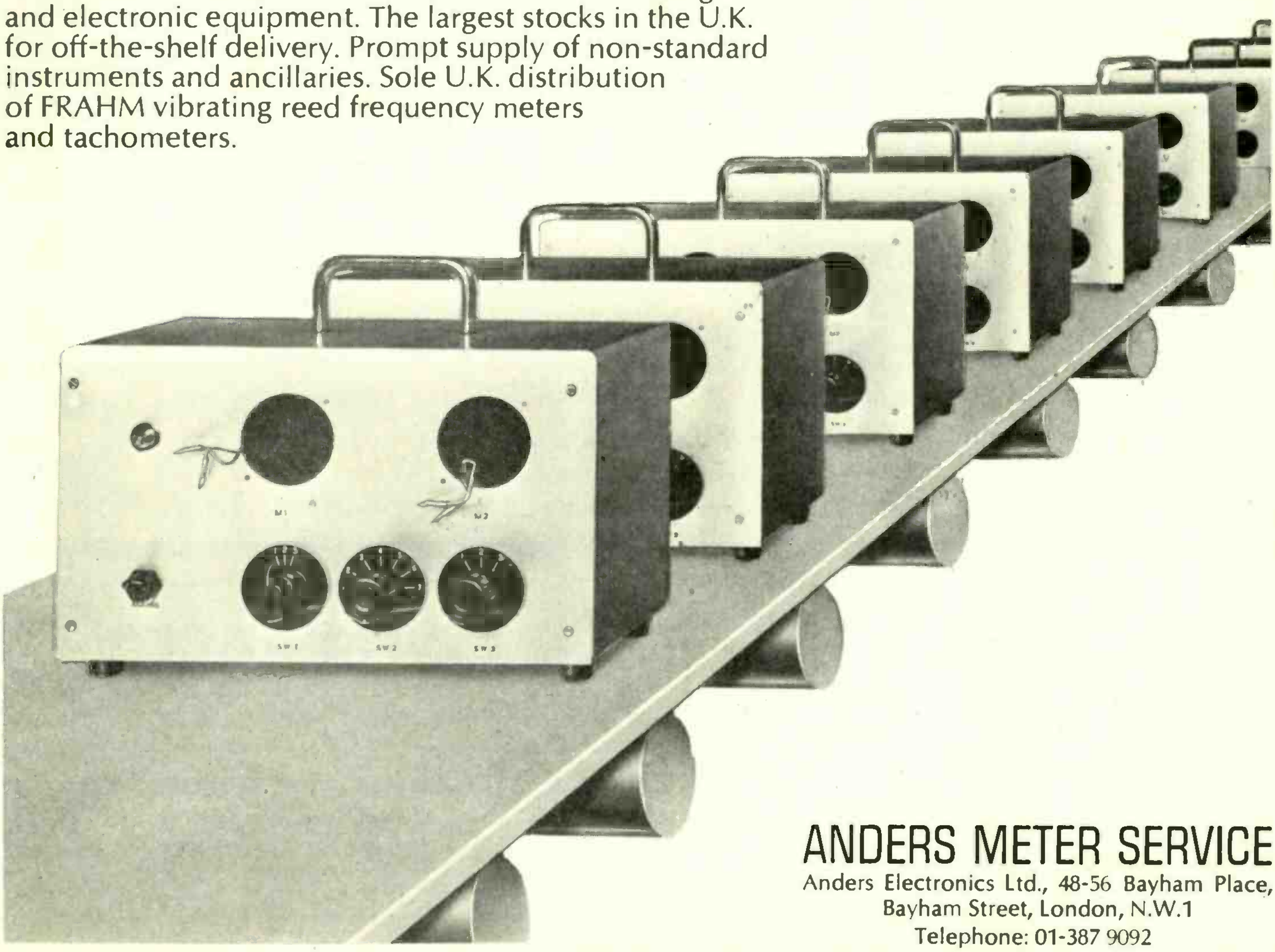

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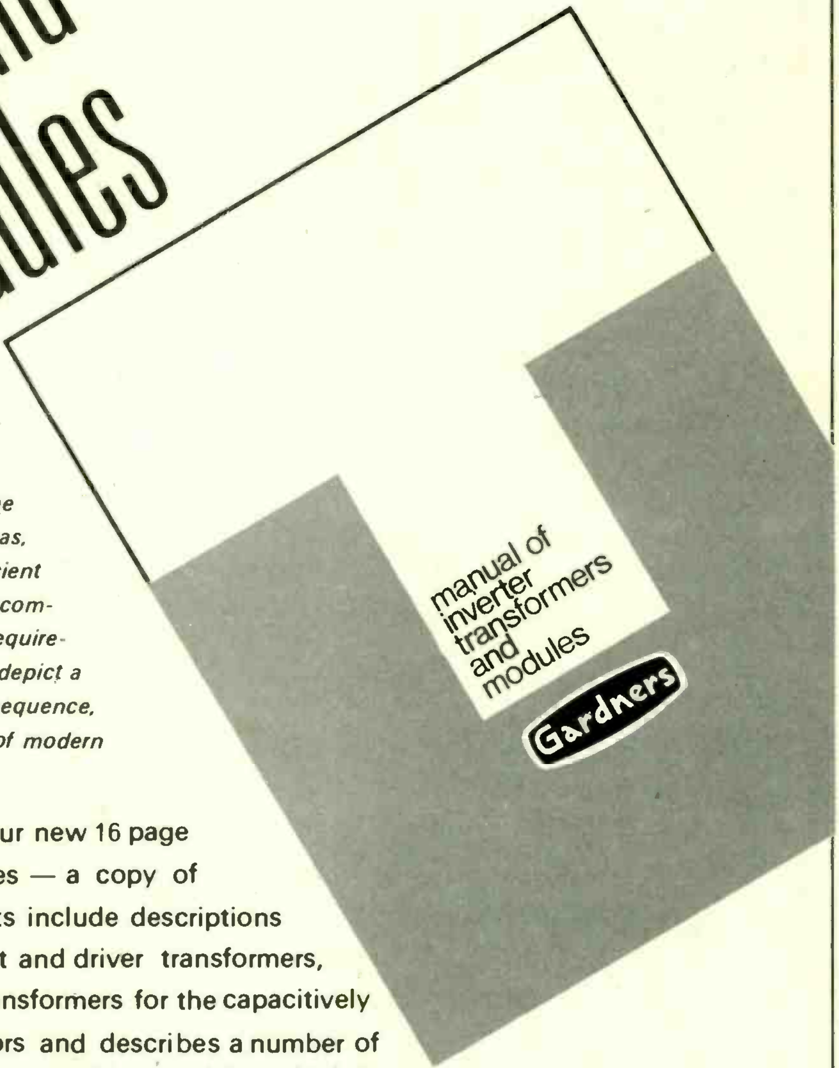
# inverter transformers and modules




*"The freedom to choose suitable line voltages for the operation of different types of electronic circuits has, for many years, enabled engineers to produce efficient electronic equipment comprising many individual components having different optimum power supply requirements . . ." "The centre two pages of this brochure depict a series of basic circuit diagrams which, if taken in sequence, provide an historical survey of the development of modern inverter and converter systems".*

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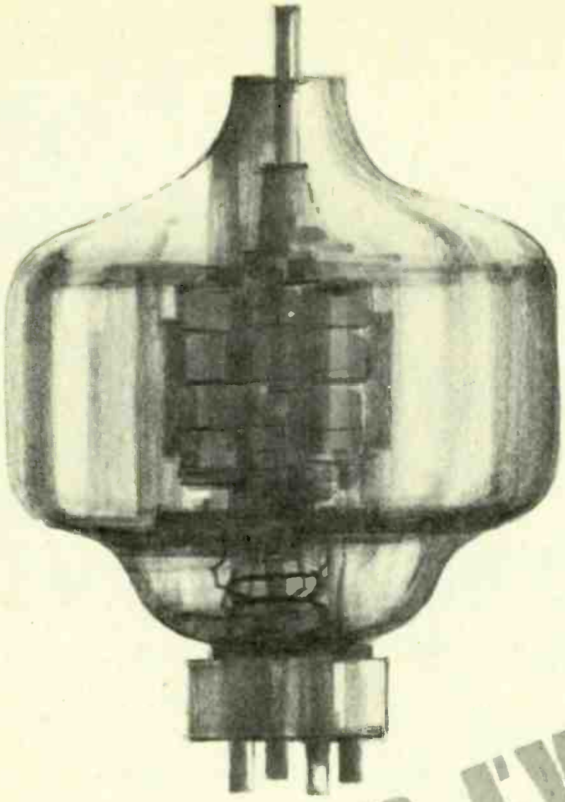

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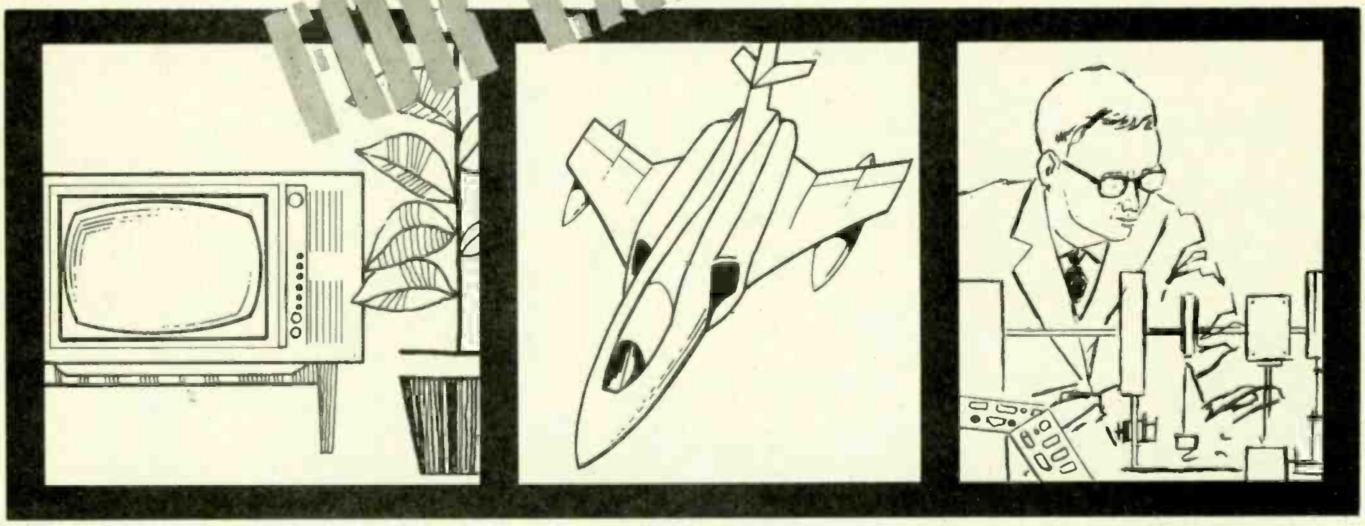

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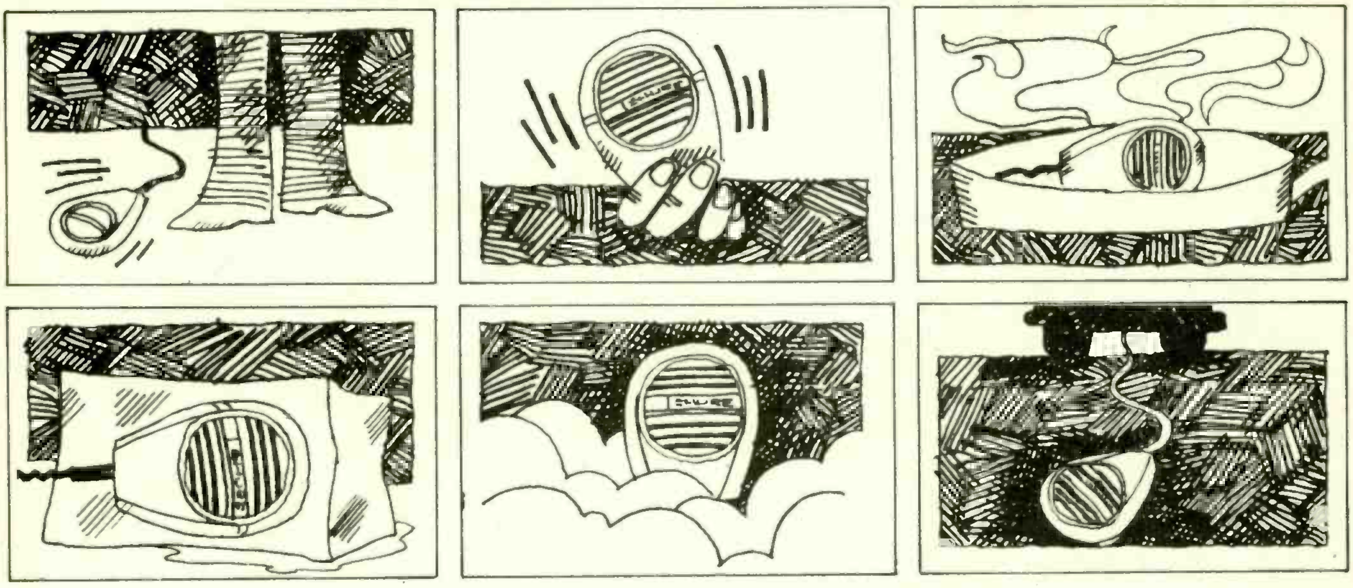

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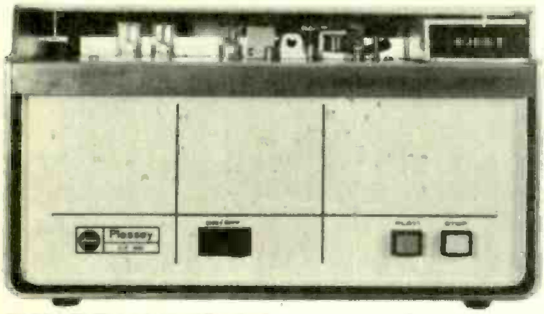

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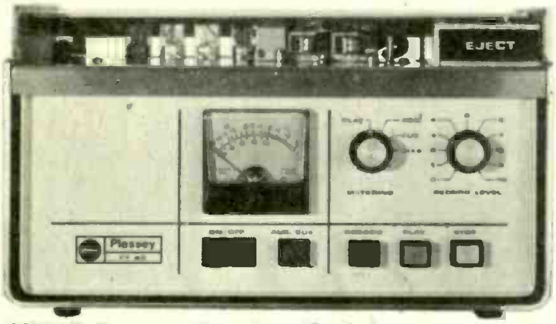


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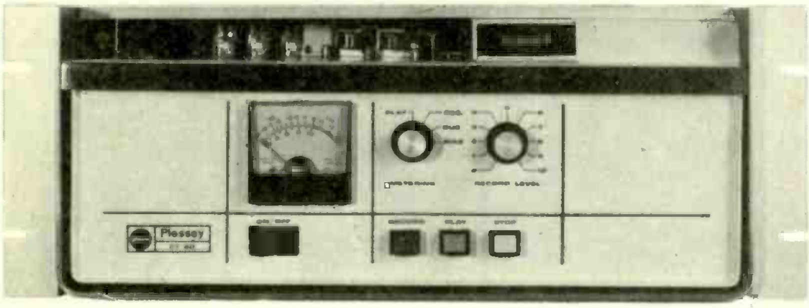

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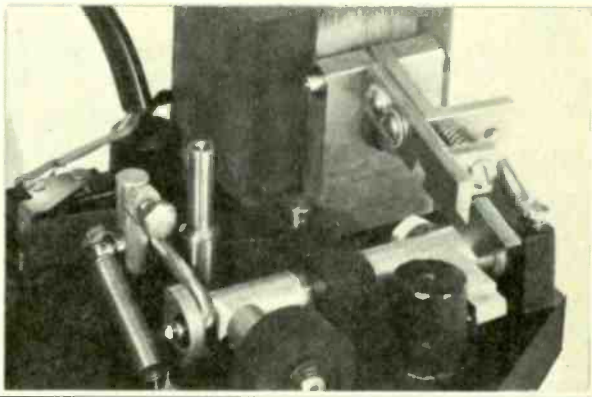

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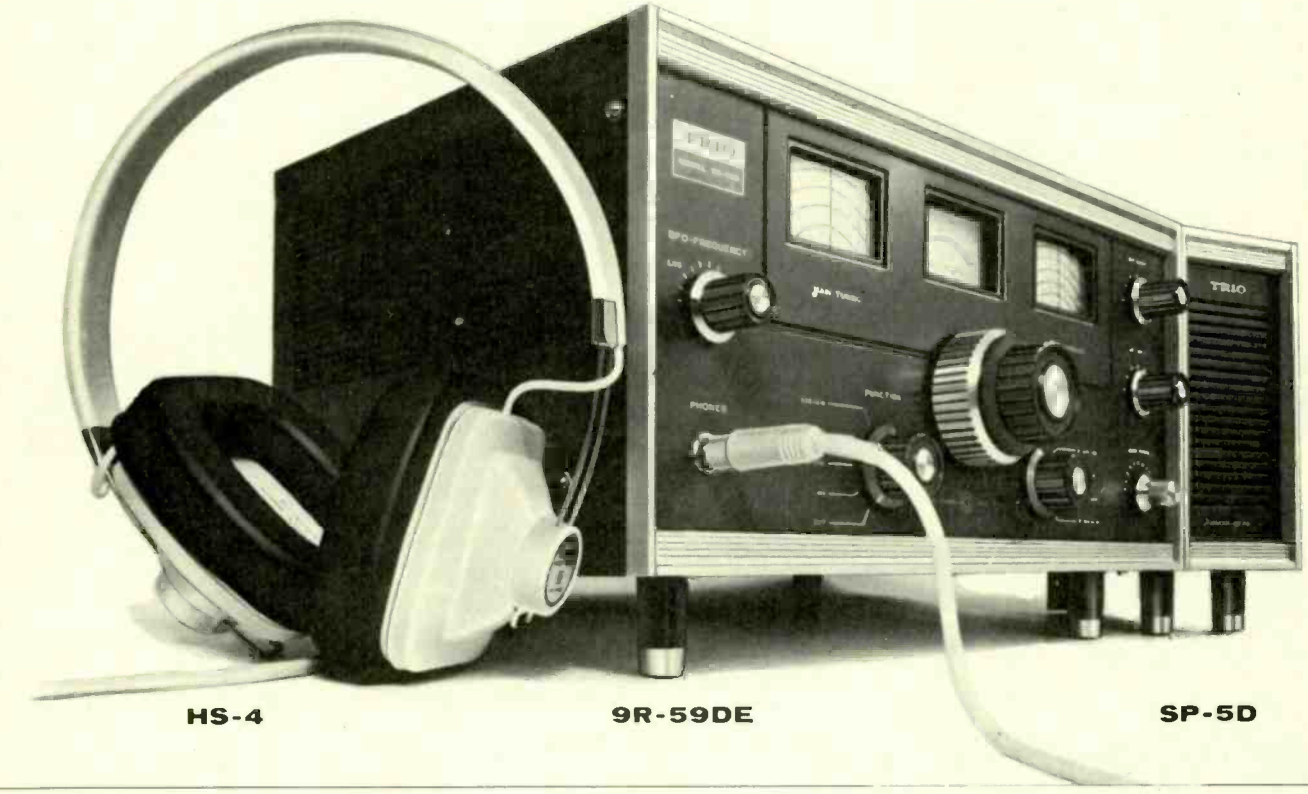


HS-4 9R-59DE SP-5D

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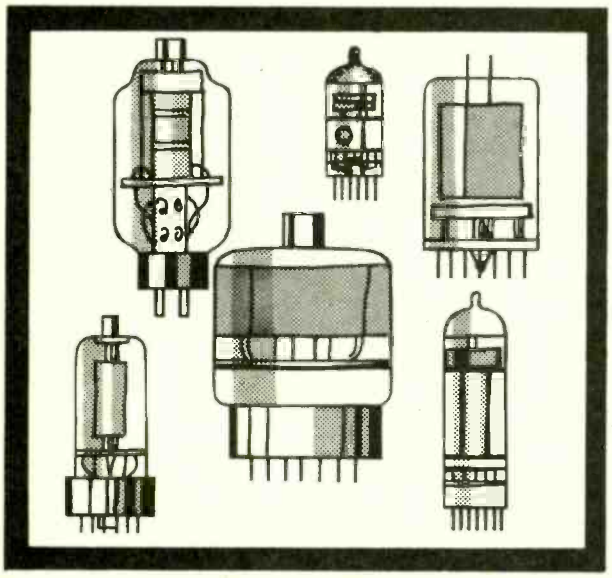

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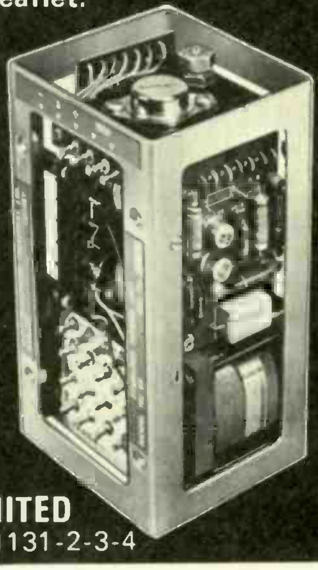

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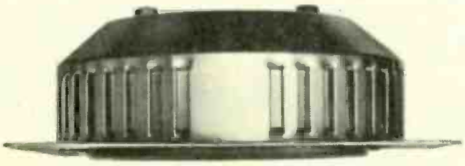

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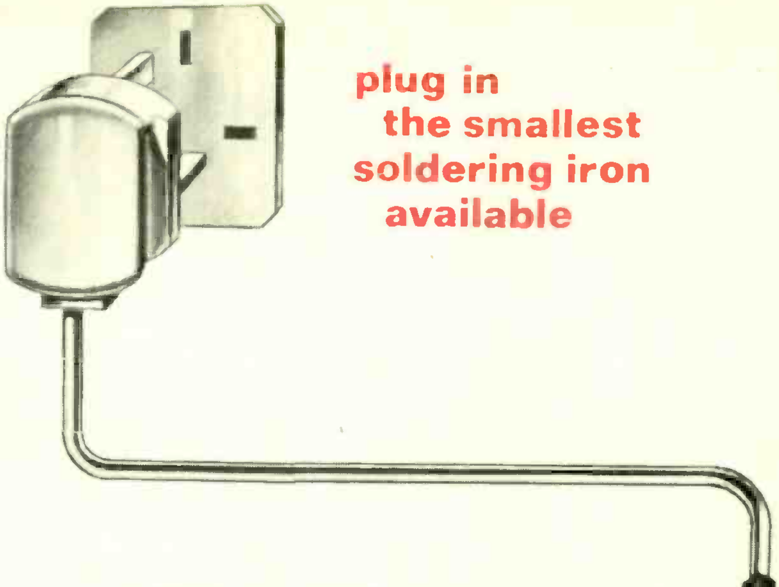
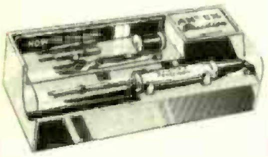


plug in
the smallest
soldering iron
available

## Complete precision soldering kit



This kit—in a rigid plastic "tool-box" — contains everything you need for precision soldering.

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From Electrical and Radio Shops or direct from Antex. **49/6**

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CN 15 watts. Ideal for miniature and micro miniature soldering. 18 interchangeable spare bits available from .040" (1mm) up to $\frac{3}{16}$". For 240, 220, 110, 50 or 24 volts.
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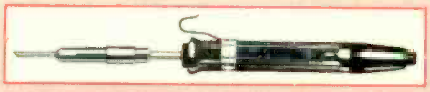
**ACTUAL SIZE**



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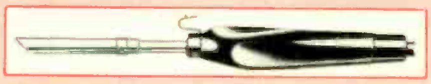

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## Loudspeakers for all Public Address Systems

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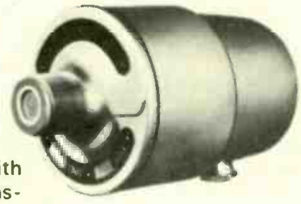
These Horns are capable of delivering a highly concentrated beam of sound over long distances. They are recommended for recreation centres, noisy factories and workshops and all indoor and outdoor locations where a high noise level has to be overcome.



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Pressure type units are available with or without tapped 100V line transformers. The following 'built-in' features are on all models—High Sensitivity, Weatherproof, Phase Equalising Throat and Self-centring Diaphragm Assembly.

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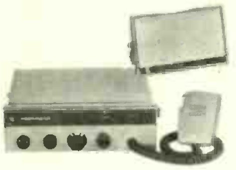

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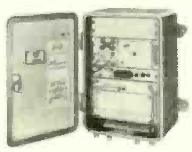

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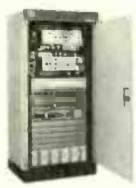

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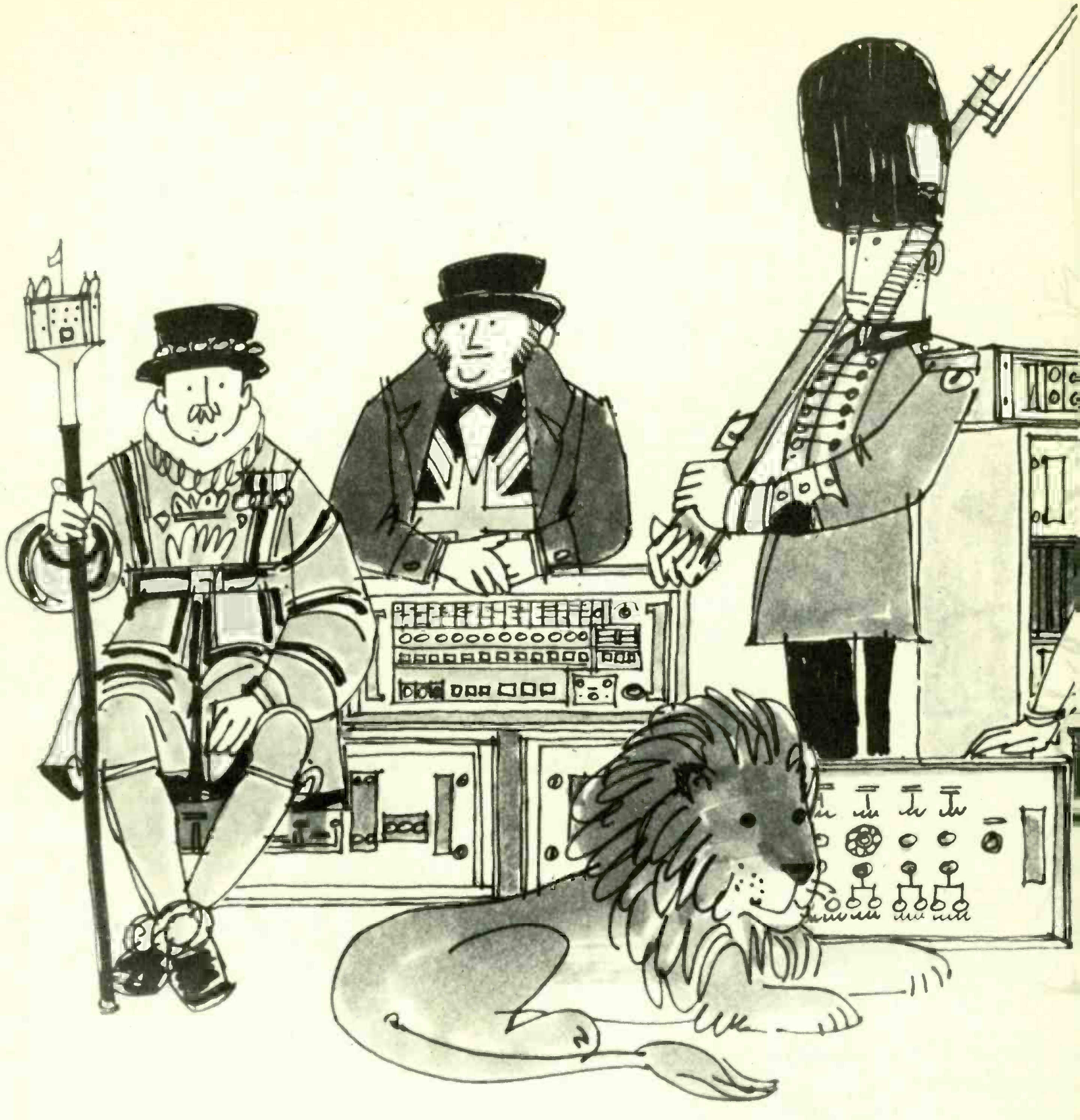

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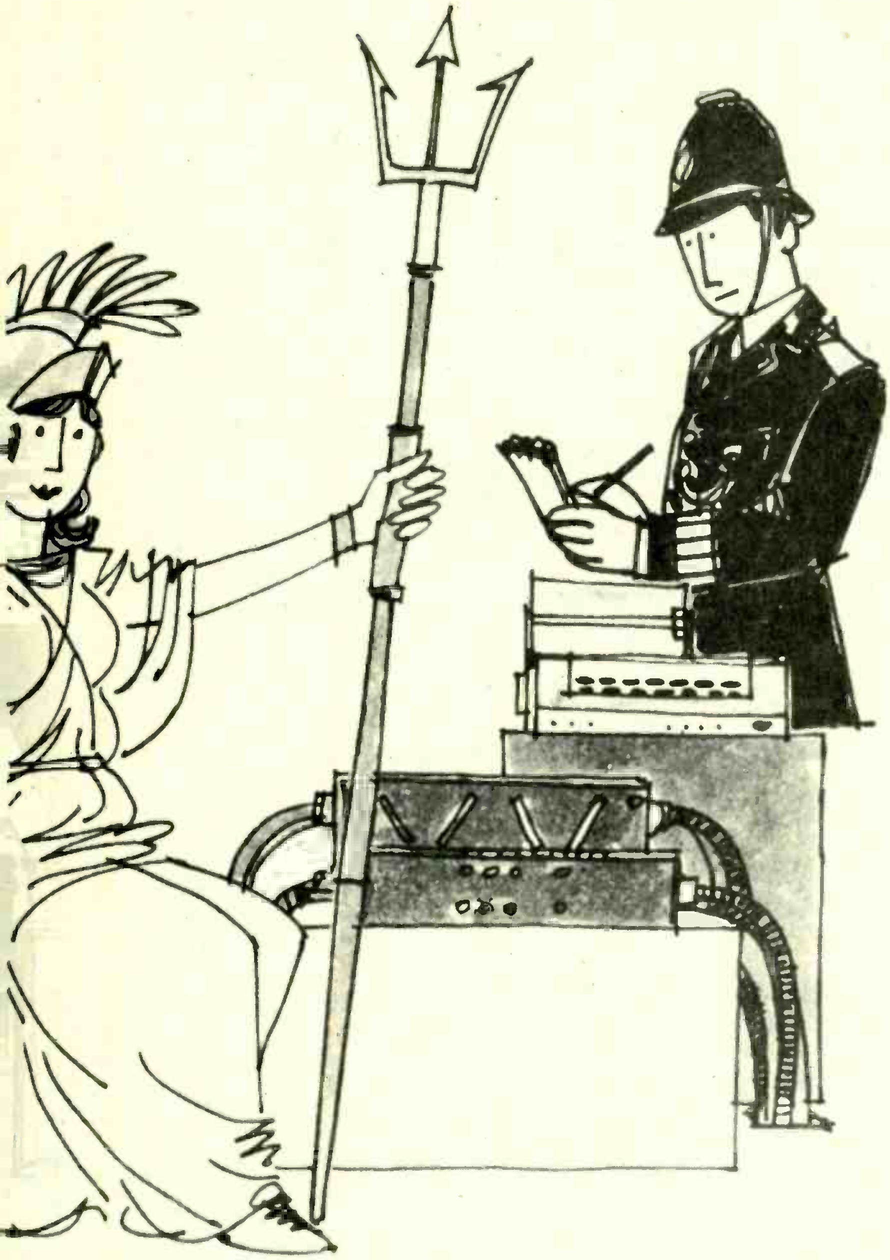

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**SYNCHRONOUS MOTOR & CLUTCH**
**Matchbox size frontal area. Automatic re-set.**

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★RANGES: 10 SECS. TO 36 MINS.

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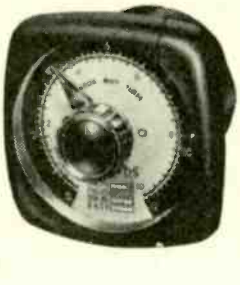

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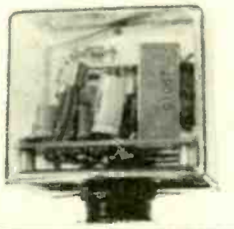

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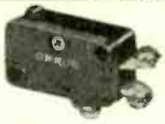

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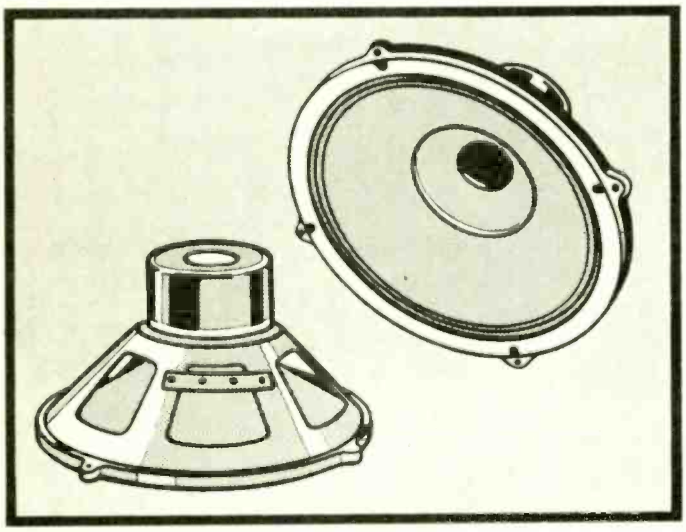

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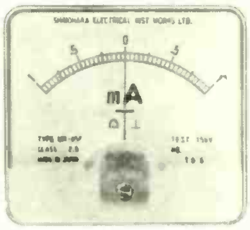


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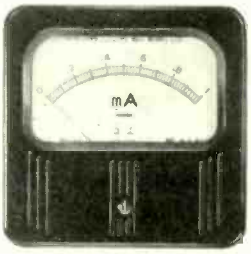


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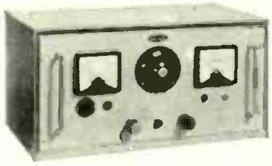

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★Radio telephone transmitter/receivers.

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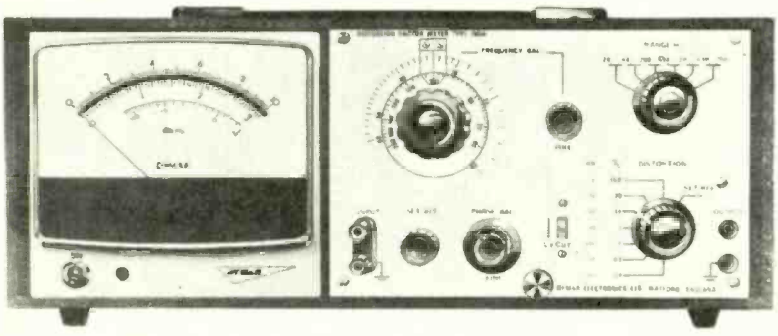

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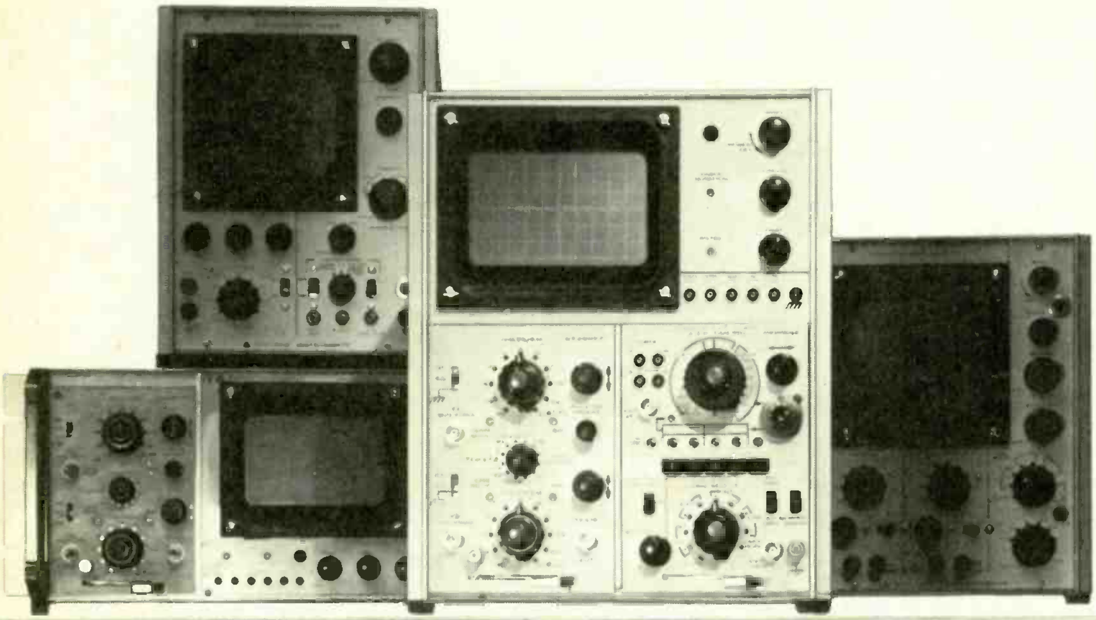
# Advance make over 10(



Advance oscilloscopes give a choice from the simple OS 12 which was designed for educational and industrial monitoring applications at a cost of only £30, to the portable solid state OS2000/OS2100 range. The OS2100 has a bandwidth of 25MHz at a maximum sensitivity of 10mV/cm. The main frame accepts a choice of X & Y plug-ins including the most versatile sweep delay unit currently available.
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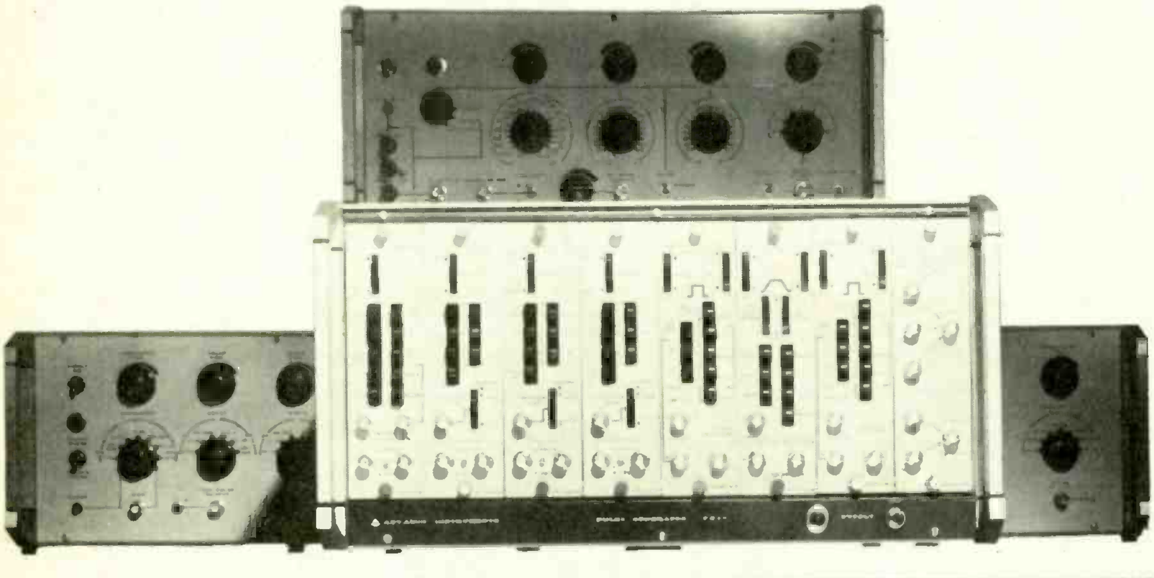
**OSCILLOSCOPES £30-£425**



Advance is the leading British manufacturer of Pulse Generators. Most versatile is the PG 52 Modular Pulse Generator System, which can be assembled from five signal generating and processing units to produce a wide variety of complex waveforms. Other models include the general purpose PG 56 and high power PG 55A. Ask for details.

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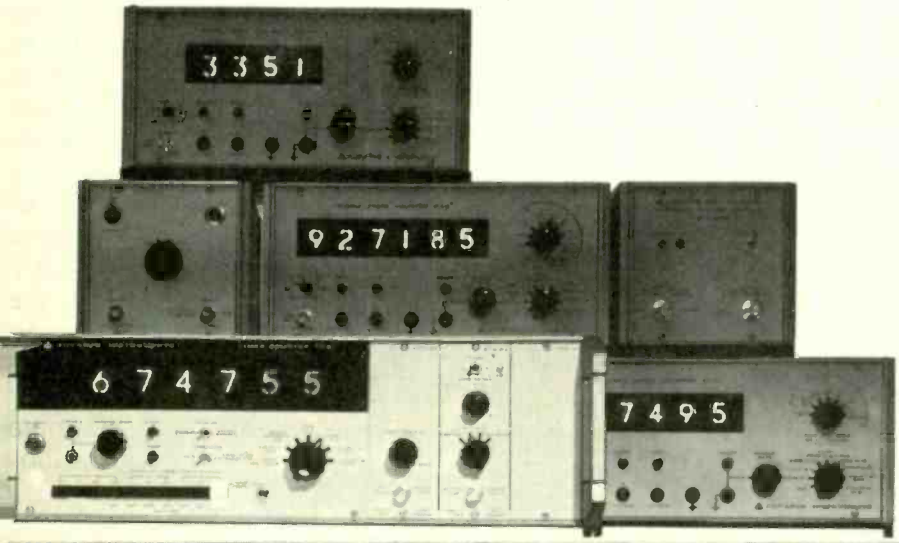
# measuring & test instruments

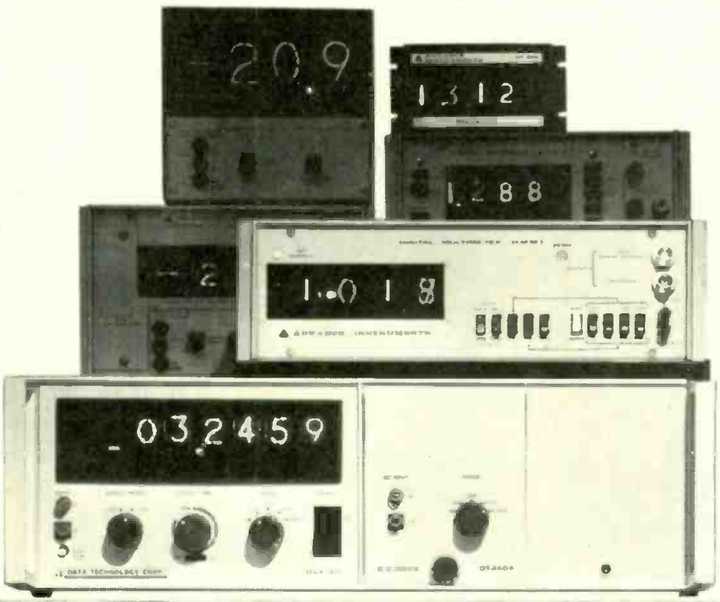
## Generous in specification, realistic in cost.




Advance make a range of compact and versatile timer counters for the measurement of frequency, period, time, and phase angle.

One of the most recent additions to the range, the TC8 system, is a modular time counter which can be assembled in a wide variety of combinations to give the user an instrument precisely meeting his specification. The main frame accepts a choice of factory fitted units for a display of four to seven digits and five input modules capable of measuring frequencies of up to 500 MHz. Other new counters include the 32MHz TC9 and 15MHz TC11 and TC12.

**TIMER COUNTERS £80 - £800**




The Advance digital multimeter DMM1, combines all the measurement capabilities of a conventional analogue multimeter with the undoubted advantages of a digital instrument at a cost of only £175. It gives completely non-ambiguous reading of AC and DC voltages, currents and resistance.

The latest model, the DVM4, is a small dual slope integrating DC digital voltmeter with a 4 digit non-blink display, accurate to within 0.1% of reading.

There are ten digital and analogue voltmeters made by Advance plus a range of digital panel meters. Ask for details.

**DIGITAL VOLTMETERS £99 - £1000**

*Please let me have full data sheets on the following advertised instruments.*

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I am interested as a Buyer/Engineer/Student.

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For information on products from other divisions of Advance Electronics Limited, please tick the appropriate box.

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**AKG C-451**
Quality condenser microphone with new CK1 capsule (interchangeable with other AKG microphones). Other capsules are available built into wind-shield with 'rifle' tube attachment. Supplied with battery power unit and/or mains unit which can feed two microphones.

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Dynamic miniature microphone— the smallest Lavalier on the market. High-quality reproduction compares well with others costing several times more. With 60 or 200 Ohm impedance. 3 metres cable. Use it wherever a mike is to be heard but not seen— interviewing, films, conferences, etc.

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**AKG microphones**

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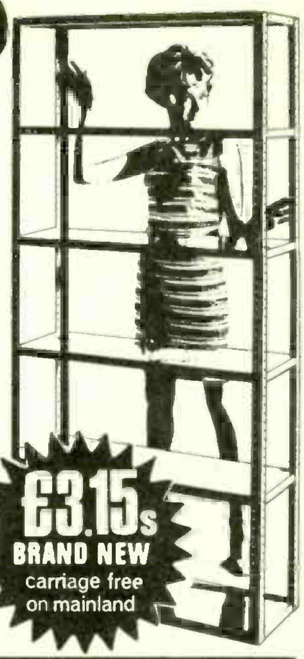

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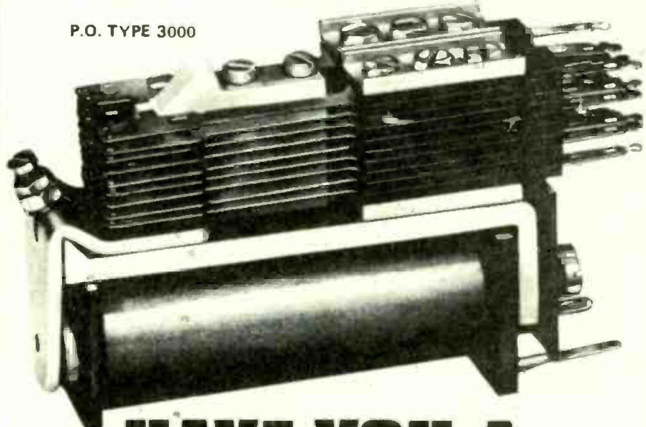

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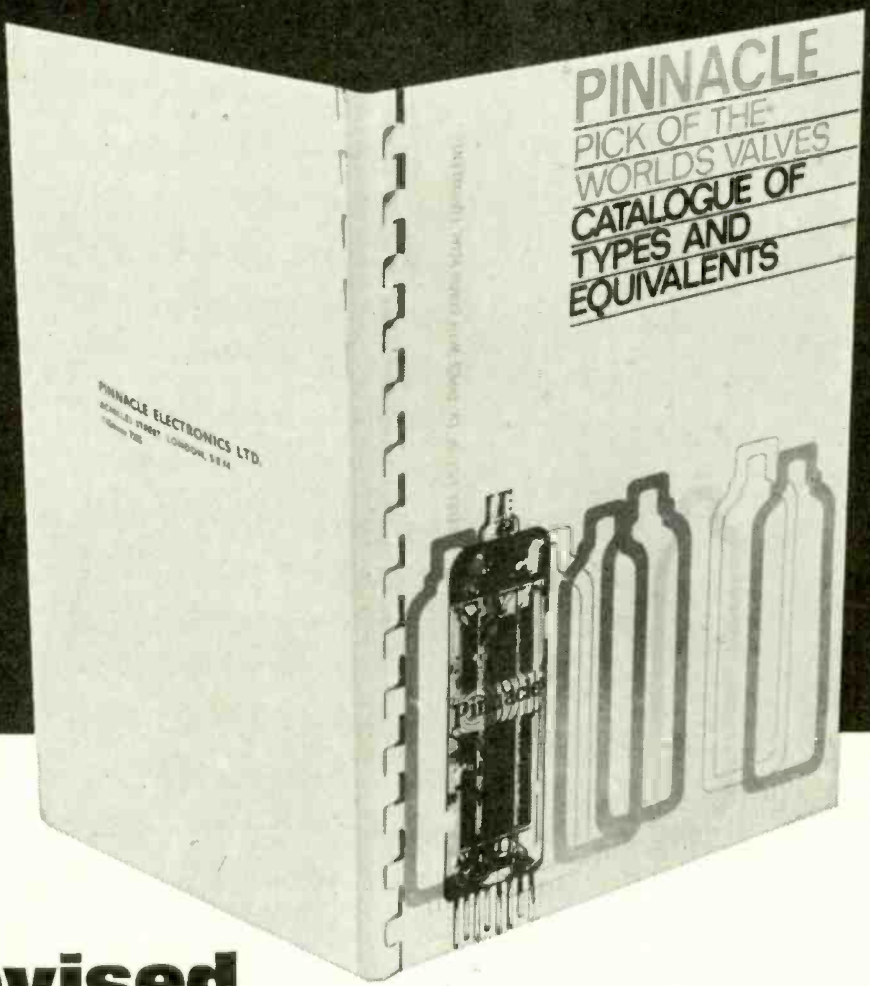


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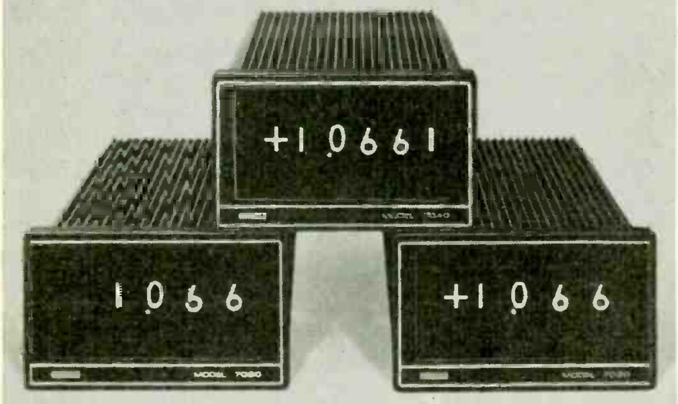
# Thinking Panel Meters Think Fairchild




## Panel mounting digital meters making good products better

Fairchild instrumentation provides a comprehensive line of digital panel meters with Models 7020, 7030 and 7040. These are compact, low cost, quality, panel mounting units designed for easy access and use in system and OEM applications. All offer non-blinking digital display that is accurate, fast, and simple, utilizing the reliable Dual Slope integration technique,
The 7020 is a single range, single polarity, digital meter with three readout tubes and an overrange digit (1), accuracy of ±0·1%, 1mV resolution over the standard 1·500V F.S. range, and operates at 3 readings per second.
The 7030 and 7040 both offer the advantages of dual polarity and optional ratio capability in the same compact aluminium casting as the 7020. The 7030 is a three digit meter with overrange digit; accuracy of ±0·1%, reads at a speed of 6 readings per second. Faster reading speeds are available on special order. The 7040 provides four digits with overrange, increased accuracy at ±0·05% at a speed of 6 readings per second.

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# Valradio ELECTRONIC AC to AC POWER FREQUENCY CHANGERS

Type FCB230/200V

Will change 50Hz to 60Hz or any other frequency. Primarily intended for operating and testing 50Hz equipment from non-standard frequencies or for operating and testing 60Hz equipment from a 50Hz supply. The range comprises 100w and 200w units working from any input voltage and providing almost any output voltage required. The conversion principle is static and noiseless in operation. Special units to provide 400 to 10 000Hz for testing marine and aircraft equipment can be supplied to order.

**APPLICATIONS**
* Operating small 400Hz motors from 50Hz Mains.
* Operating 60Hz tape recorders, cine cameras, etc., from 50Hz Mains.
* Replay 50Hz sound and film recordings from 60Hz supply.
* For sound effects recordings.

**FEATURES**
* Static conversion
* Noiseless
* Compact
* Frequency Stability better than ±1%.
* Output Frequency 60Hz or 50Hz.
(40 to 10 000Hz to order.)

**Type FCA230/100V. Input Volts 200/250 AC. Output 115/250 100W. £32.6.9.**
**Type FCB230/200V. Input Volts 200/250 AC. Output 115/250 200W. £52.0.0.**

*Send for leaflet:*
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# H. F. MANPACKS

# RACAL RANGE BROADENS

The RACAL manpack family is being constantly expanded to meet customer demand for manpack, vehical, maritime and static operation. The latest addition is the TRA.922 'COMCAL' which offers 20 watts p.e.p. with 49 crystal-controlled channels. A wide range of ancillaries, common to the whole RACAL range, offers a choice of audio equipment, power units and antennas.

## 'Squadcal'

This world-famous 5 watt p.e.p. manpack weighs only 18 lb. in operational state, provides 29 crystal-controlled channels between 2 and 7 MHz, is simple to operate and maintain, waterproof and very robust. Compatible a.m., s.s.b. and c.w. operation is available, from dry or Ni-Cad batteries, d.c. or a.c. power units. Low cost with high reliability, wide range of ancillaries.

New

## 'Comcal'

Low-cost 20 watt and 5 watt p.e.p. output, weighing merely 23 lb., and providing 49 crystal-controlled channels 2 - 8 MHz. Case and carrying haversack identical to 'Squadcal', and all ancillaries common. Equally suitable for manpack, vehicle, or static operation; c.w., u.s.b. l.s.b. and full d.s.b. operation available; suitable for use with low-stability a.m. networks, and effectively offering 98 s.s.b./c.w. channels.

## 'Syncal'

6,000 synthesizer-controlled channels, 2 - 8 MHz, with 20 watt and 5 watt p.e.p. output. Case, haversack and ancillaries common to 'Squadcal'. U.s.b., l.s.b., c.w. and full d.s.b. operation. Compatible with low-stability a.m. networks. Simple operation and maintenance with high reliability. Lightweight, robust and waterproof. Beta-light control illumination, weight only 23 lb.

'Syncal' in common with other manpacks in the range can be used as static or vehicle installations. Suitable power supply units incorporating amplifier/loudspeakers are available.

RACAL

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# There's much more to a PHILIPS microphone

# than meets the ear

It's the sound quality that really counts although impeccable appearance is certainly an asset. In fact, *every* aspect of microphone manufacture is covered by the makers of ten million of them—Philips. What's more, Philips make an unrivalled range of compatible equipment—amplifiers, loud-speakers, tape-recorders, record players and much more—for complete sound systems. All backed up by the finest service organisation in the country. Please ask for full information.

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## SOLID STATE, CONSTANT VOLTAGE HIGH POWER FLOAT BATTERY CHARGERS WITH AUTOMATIC CURRENT LIMITING

- ★ Will charge batteries and feed external DC loads such as telemetry, logic, instrumentation, data processing.
- ★ Wide range of units, up to 400V. and 1000 amp.
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Typical Transireg with accumulator space.

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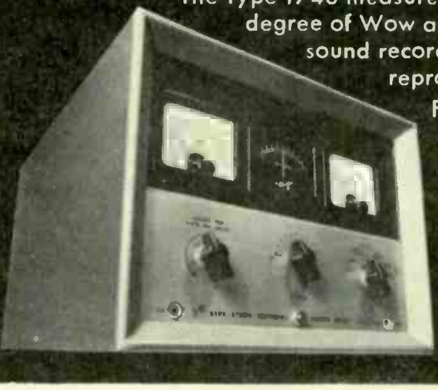
# WOW!

## And how to stop it

First, measure it—on the Rank Studio Flutter Meter. The Type 1740 measures accurately the degree of Wow and Flutter on sound recorders and reproducers.



For more information write to:

**RANK STUDIO EQUIPMENT**
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Shepherds Bush,
London, W.12.
Tel. 01-743 2050

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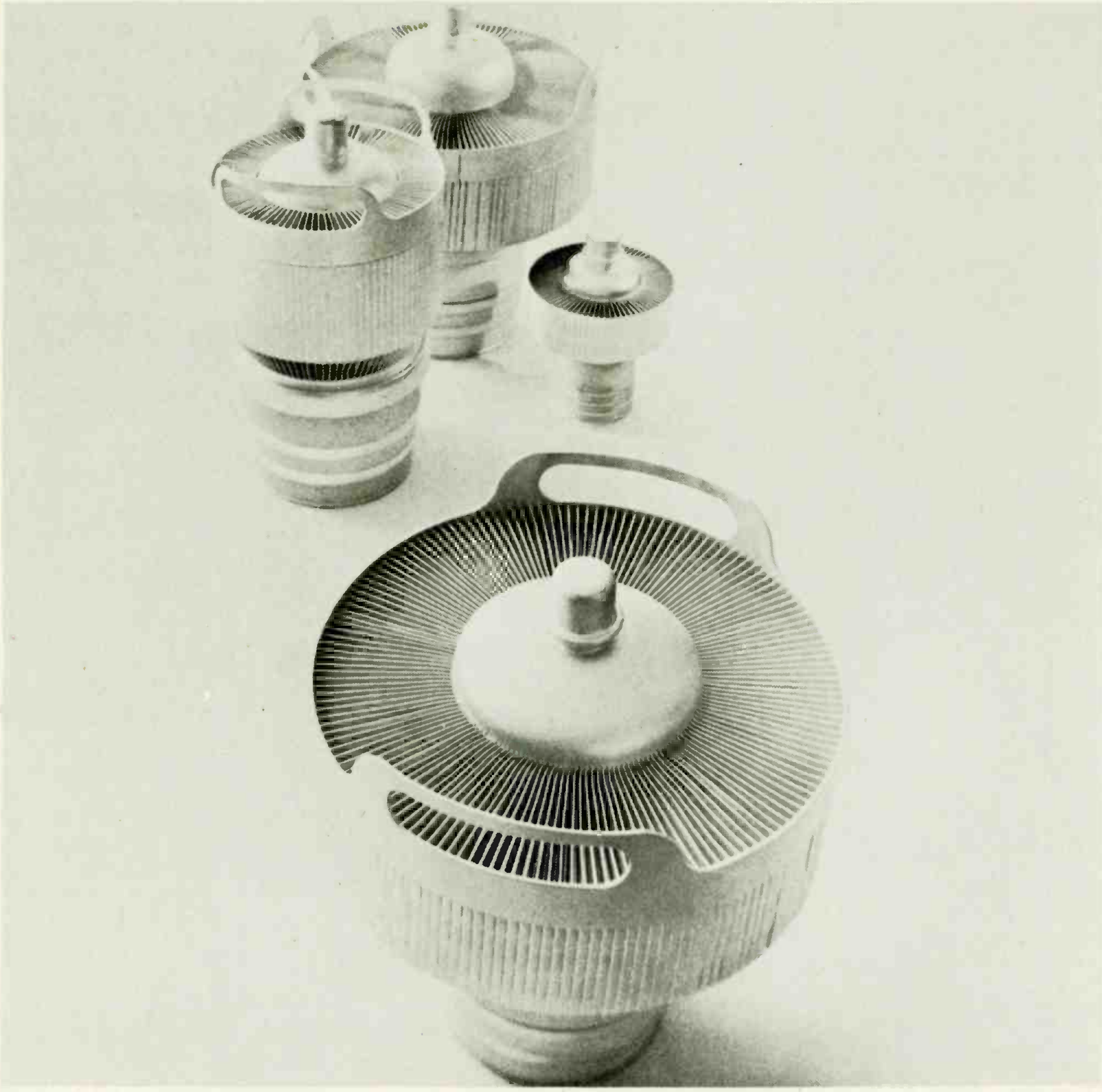

# No tetrodes with higher linearity

In the power tetrode field we're defining the state of the art by demonstrating intermodulation distortion better than any other known tubes. In 1966 we introduced the 4CX1500B, a 1.5 kW tetrode with the highest linearity then known: better than —40 dB 3rd order IM distortion. Since then we produced the 4CX600J, a 600 watt tube with —45 dB 3rd order IM products — without feedback — and later a 5 kW tetrode with the same figure. Now the latest tetrode in our program, a 15 kW tube, exhibits —40 dB 3rd order IM products. We can show IM distortion improvements from 10 to 20 dB in a practical quiescent plate current range.

Other tetrodes now under development will deliver up to 40 kW with linearity as high as —45 dB IMD, according to preliminary data. Such performance advances are part of a long range program employing computer-assisted design studies to optimize internal tube geometry — all part of our plan to insure you get state of the art products every time you buy from Eimac.

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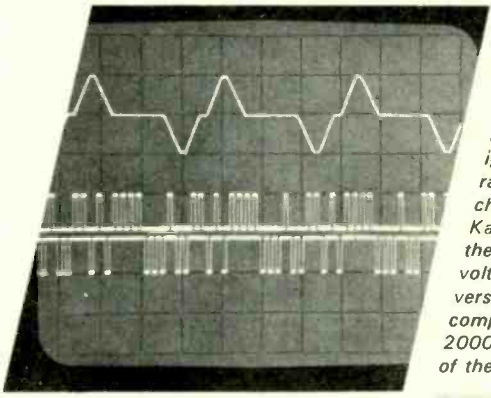
E 27-UK

# Exploring the Hewlett-Packar Universe of Electronic Instrumentation

*... it keeps expanding to reveal new solutions to your measuring problems.*

1 Multi-function pulse generator
2 A bestselling voltmeter
3 X-Y recorders
4 What ICs can do to counter prices
5 Free book on power supplies



## 2 The man who thinks we are the voltmeter specialists

He is the chap who repairs automobile ignition systems in Karachi, or works on a radio production line in Copenhagen, or checks out household appliances in Kansas City. To him, Hewlett-Packard are the people who make the finest analogue voltmeters money can buy—accurate, versatile, reliable and sturdy. And our computers, multi-channel analyzers and 2000 other instruments? He's never heard of them.

Our reputation with him rests on instruments like the 427A, an all-solid-state multifunction meter. It measures AC over ten ranges, DC over nine, and resistance over seven.

The AC voltage range extends from 10 mV to 300 Vrms full scale (10 Hz - 1 MHz). DC voltage range: 100 mV to 1000 V full scale. Accuracy for both ranges is ± 2%. Resistance, from 10Ω to 10 MΩ is measured with ± 5% accuracy (mid-scale). Designed for broad laboratory, production line and service department application, indoors and out the 427A operates off battery or (optional) mains. hp 427A (battery operated): £102 excluding duty.

## 1 How many generators did it take to produce these?

The hp 8005 produces wave forms single-handedly. It is both function generator and pulse generator. And, with appropriate gating signals, a word generator as well. We call it a multi-function pulse generator, the idea being that a single, sensibly priced instrument should be able to do the job of a whole battery of specialized pulse generators.

Hence the wide ranges of repetition ranges, pulse widths and pulse delays—all combined with DC offset for both positive and negative output channels (they are available simultaneously). In the double pulse mode, you can even simulate a 20 MHz repetition rate. Variable rise and fall times extend from 10ns to 2s. Add the possibility of combining both output channels in the output terminal while DC offset remains available. Add simultaneous and seperate gating, asynchronous as well as synchronous.

And the result? Three generators—pulse, function and word—in one.
hp 8005A: £417 excluding duty.

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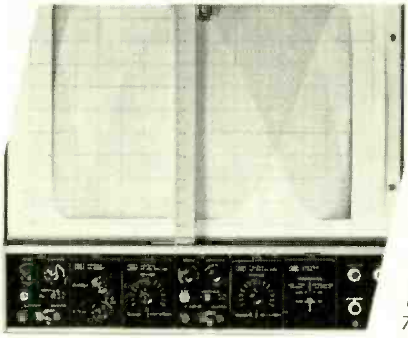
## 3 8 plug-ins make these the most versatile x-y recorders you can own.



*However exacting your recording needs, the 7004A and 7034A can cope. Merely change plug-ins to make X-Y, Y-T or X-T plots... something hitherto impossible. Yet plug-in versatility is only the beginning.*

*Consider their high dynamic performance. Input range is continuously variable from 0,5 mV/in. to 25 V/in. (0.25 mV/cm to 12.5 V/cm). Acceleration is better than 1200 in/sec$^2$ (3000 cm/sec$^2$) and slewing speed is 30 in/sec. (75 cm/sec).*

*Common electronics are located in the frame to eliminate circuitry duplications and reduce the cost of the plug-ins.*

*Plug-ins now available include dc coupler, dc amplifier, null detector, dc offset, filter, time base, and dc attenuator. With the new scanner plug-in, you can plot two dependent variables vs. one independent variable.*

*7004A (11" x 17") chart size £ 641 excluding duty*

*7034A (81/2" x 11") chart size £548 excluding duty*

*Your hp field engineer can assist you in selecting the plug-ins best suited to your work. Why not give him a call?*

## 4 Lucrative application for ICs: scaling down price of your next counter

***21A 4, 5, 6 digit readouts available***

*not only prices were affected when ɟrated circuits were added. Both size and weight of our new counters were reduced and reliability was increased. Readout storage and zero blanking became possible.*

*hp 5321A. 5 Hz – 10 MHz counter with power line time base. Ideal for totalizing and measuring frequency and simple time intervals. Input sensitivity: 100 mV. Gate times: 0.1 and 1.0 sec. If you want BCD output, 5-digit readout, 0.01 and 10 sec gate times, and crystal time base, choose the hp 5321B at £ 354 excl. duty.*

*hp 5216A is a high-performance counter. It measures multiple period average, frequency ratio, multiple ratio, frequency and time interval. Input sensitivity: 10 mV. Frequency range: 3 Hz – 12.5 MHz. 7-digit readout. Feature for feature, the price of £ 449 excl. duty, will strike you as improbably low. Ask for data sheets and "hp Counter Selection Guide".*

## 5 Easiest way to pick the right DC power supply from among 113 models

**Order this free book, and hp and your postman will do the rest.**

*When you make as many power supplies as we do—113 models as we go to press—you run into a problem, namely how to match each customer's requirements against all those power supplies.*

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Regd. Trade Mark

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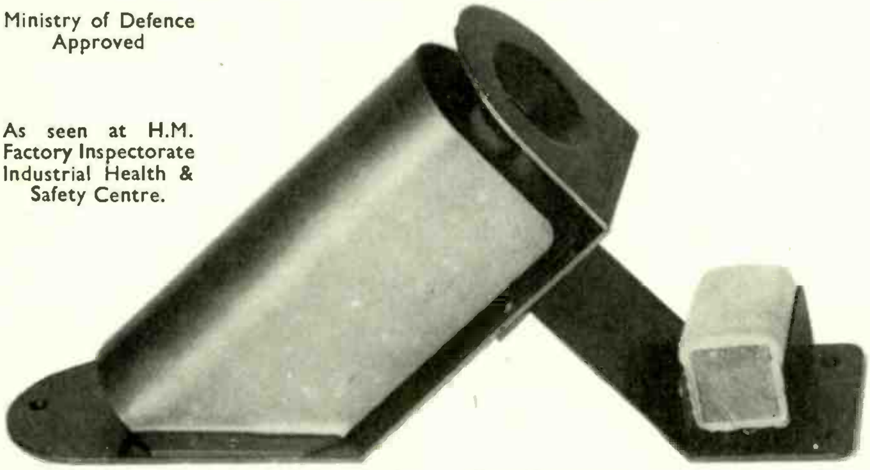

Regd. Design No. 913799. Patent No. 1055352

FINISH: RED ANODISED ALUMINIUM Scale: ½ Size

Aperture normally supplied .5 inch. Available .625 inch.

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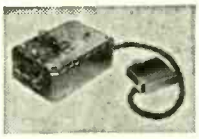

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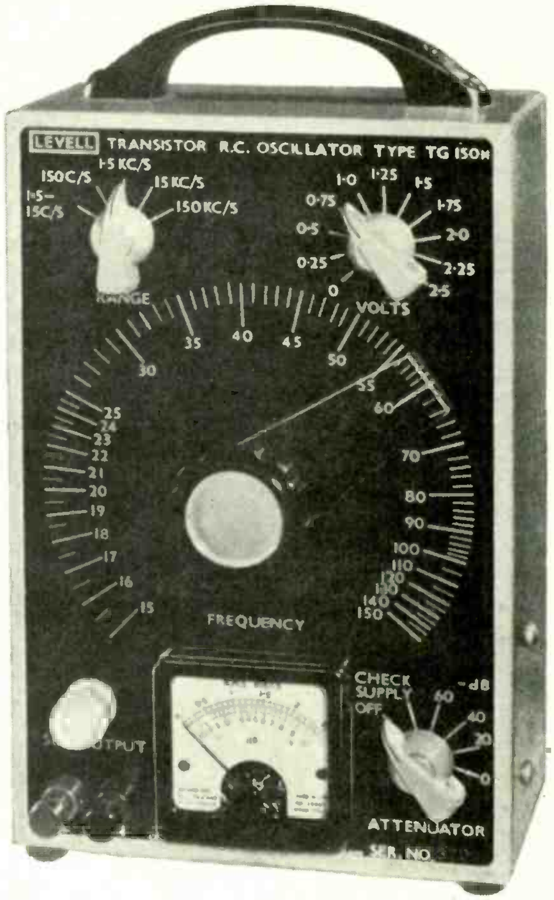
# R. C. OSCILLATORS


## With DIGITAL or ANALOGUE frequency calibration

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| ACCURACY | ± 0.02 Hz below 6 Hz<br>± 0.3% from 6 Hz to 100 kHz<br>± 1% from 100 kHz to 300 kHz<br>± 3% above 300 kHz | | ± 3% ± 0.15 Hz | | | |
| DISTORTION | <0.15% from 15 Hz to 15 kHz<br><0.5% at 1.5 Hz and 150 kHz | | <0.1% at 1 kHz, <0.3% from 50 Hz to 15 kHz,<br><1.5% below 50 Hz and above 15 kHz. | | | |
| SINE WAVE OUTPUT | Source voltage variable from 30μV to 5V. Output impedance 600Ω at all settings. | | Source voltage variable from 250μV to 2.5V, Output impedance <250Ω above 250mV, 600Ω below 250mV. Less than 1% variation of amplitude throughout frequency range. | | | |
| SQUARE WAVE OUTPUT | None | | None | | Variable up to 2.5V peak. Rise time 1% of period + 0.2μS. | |
| OUTPUT METER | Expanded voltage scales and −2dB to +4dB. Scale length 3.5″ | | None | 0 to 2.5V and −10dB to +10dB | None | 0 to 2.5V and −10dB to +10dB |
| POWER SUPPLY | 4 type PP9 batteries, life 400 hours, or, A.C. Mains when:<br>selected by panel control | batteries re-placed by Power Unit | 2 type PP9 batteries, life 400 hours, or, A.C. Mains when batteries are replaced by Levell Power Unit. | | | |
| SIZE | 7″ × 10¼″ × 7″ Weight 12 lb. | | 10″ high × 6″ wide × 4″ deep. Weight 6 lb. | | | |
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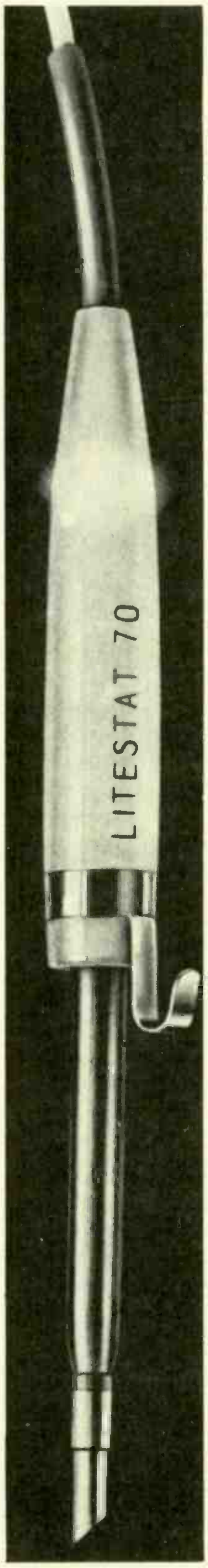


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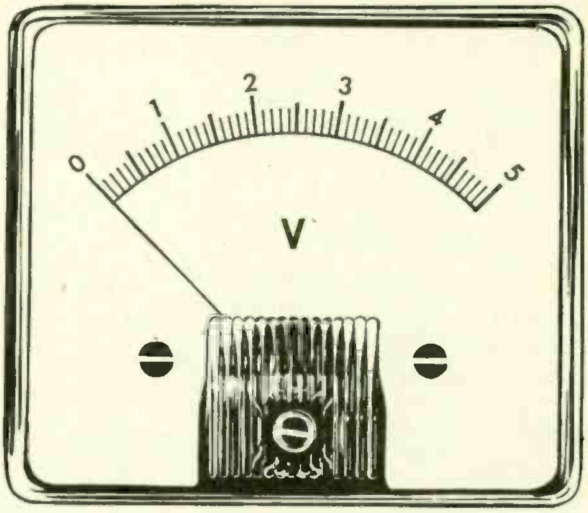


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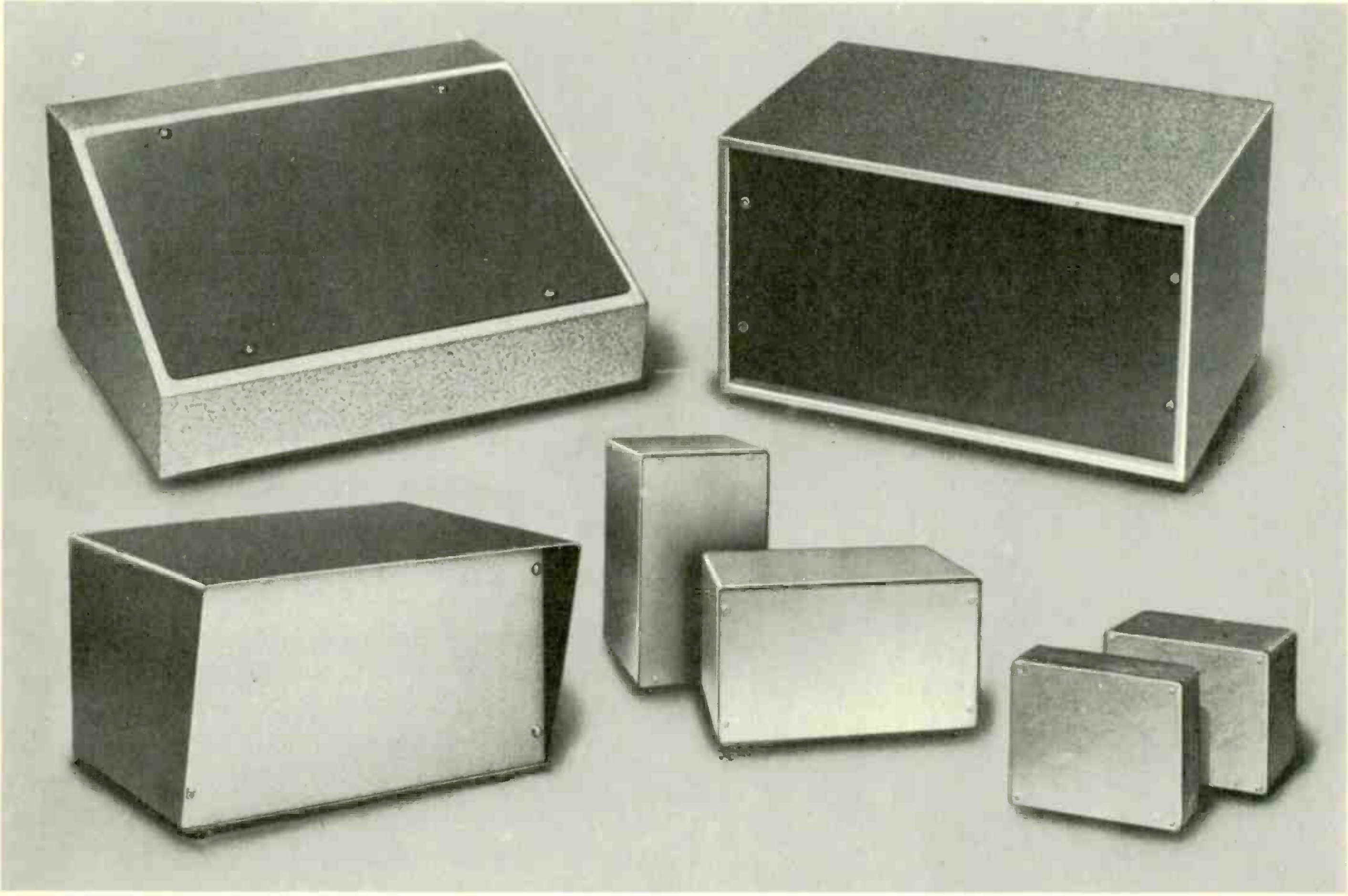

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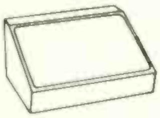
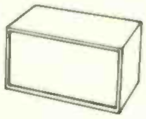
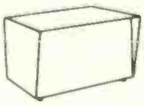


**DF CASES**
DF 126: Overall Size:
$12\frac{7}{8}$ x $6\frac{3}{16}$ (at back) x $8\frac{29}{32}$ ins.
Other widths $16\frac{1}{4}$, $19\frac{1}{4}$, $24\frac{1}{4}$ ins.



**DA CASES**
DA 3U126: Overall Size: $12\frac{5}{8}$ x $6\frac{7}{8}$ x $7\frac{3}{32}$ ins.
Also $16\frac{5}{8}$ x $8\frac{5}{8}$ x $9\frac{3}{32}$ ins.



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DJ 696: Overall Size: 9 x 6 x $6\frac{1}{2}$ ins. (base)
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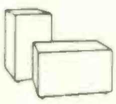

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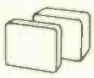

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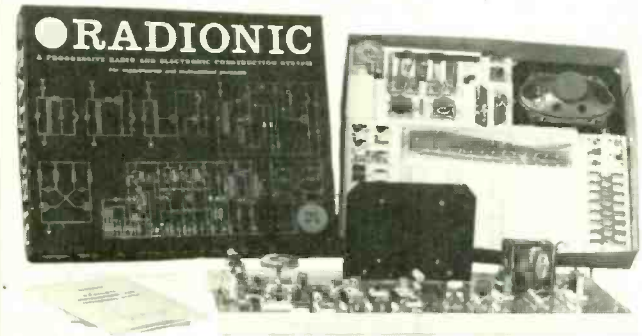


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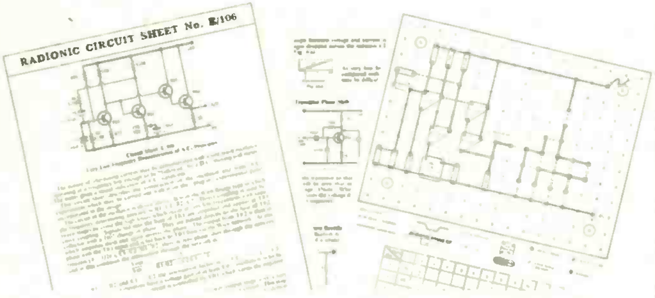


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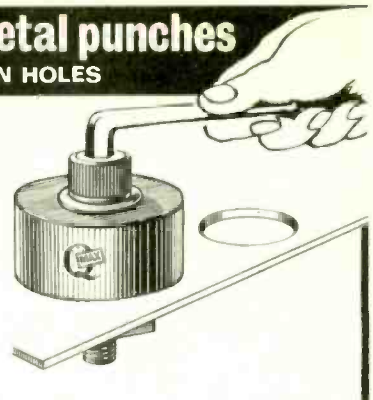

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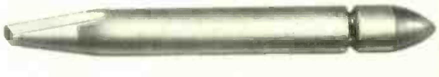

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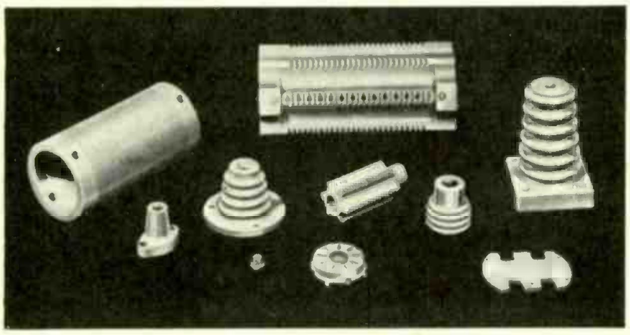
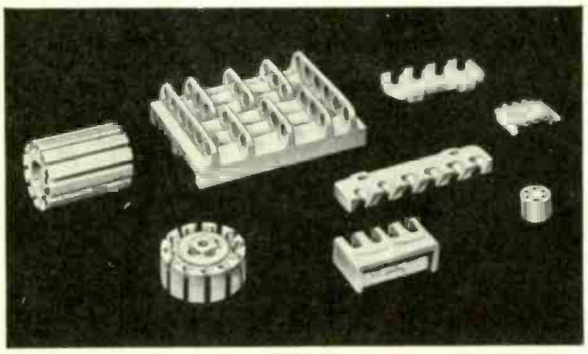
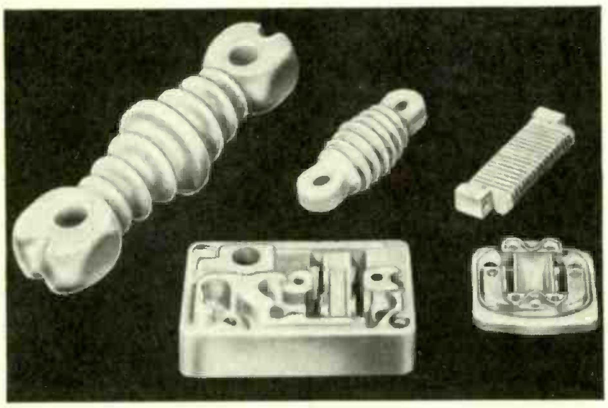


Frequelex—for high-frequency insulation.



Refractories for high-temperature insulation.



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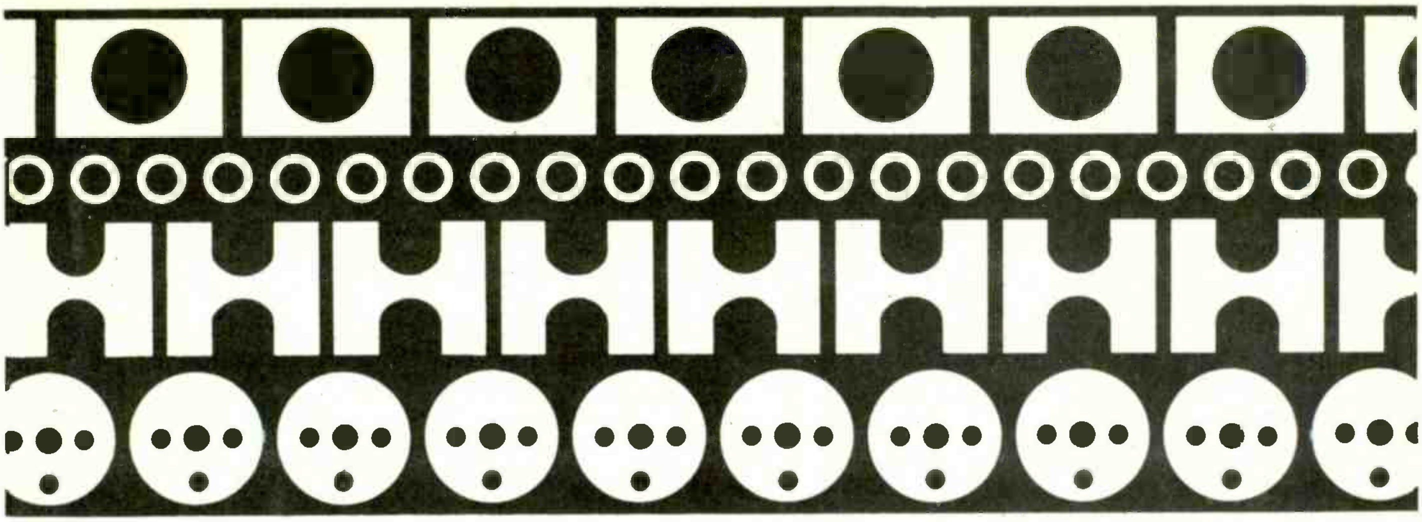


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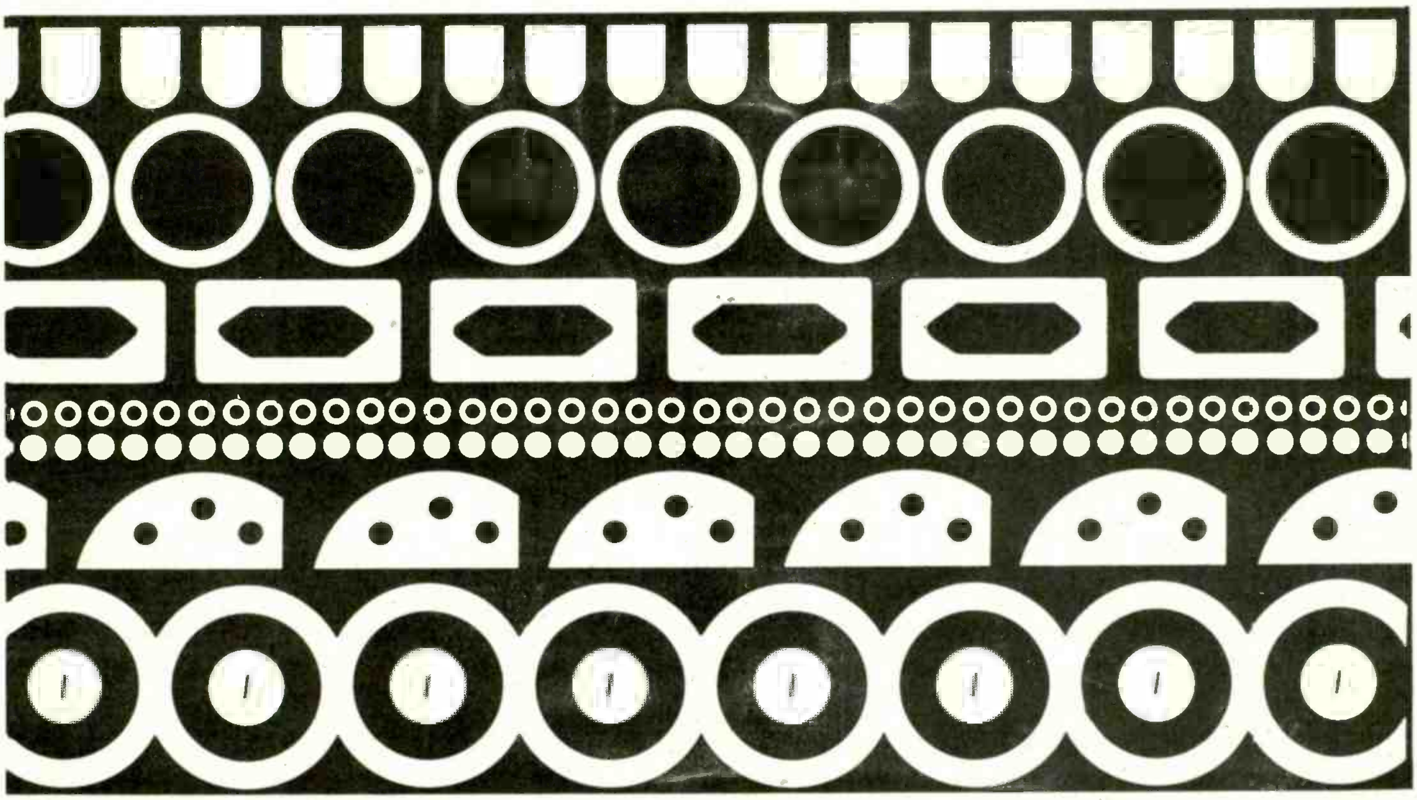



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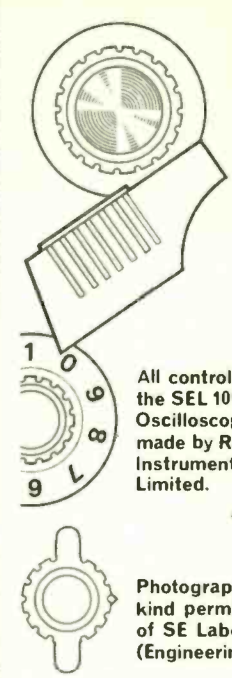


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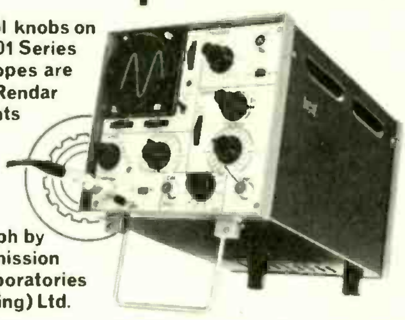

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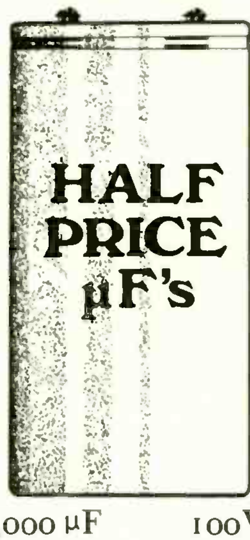


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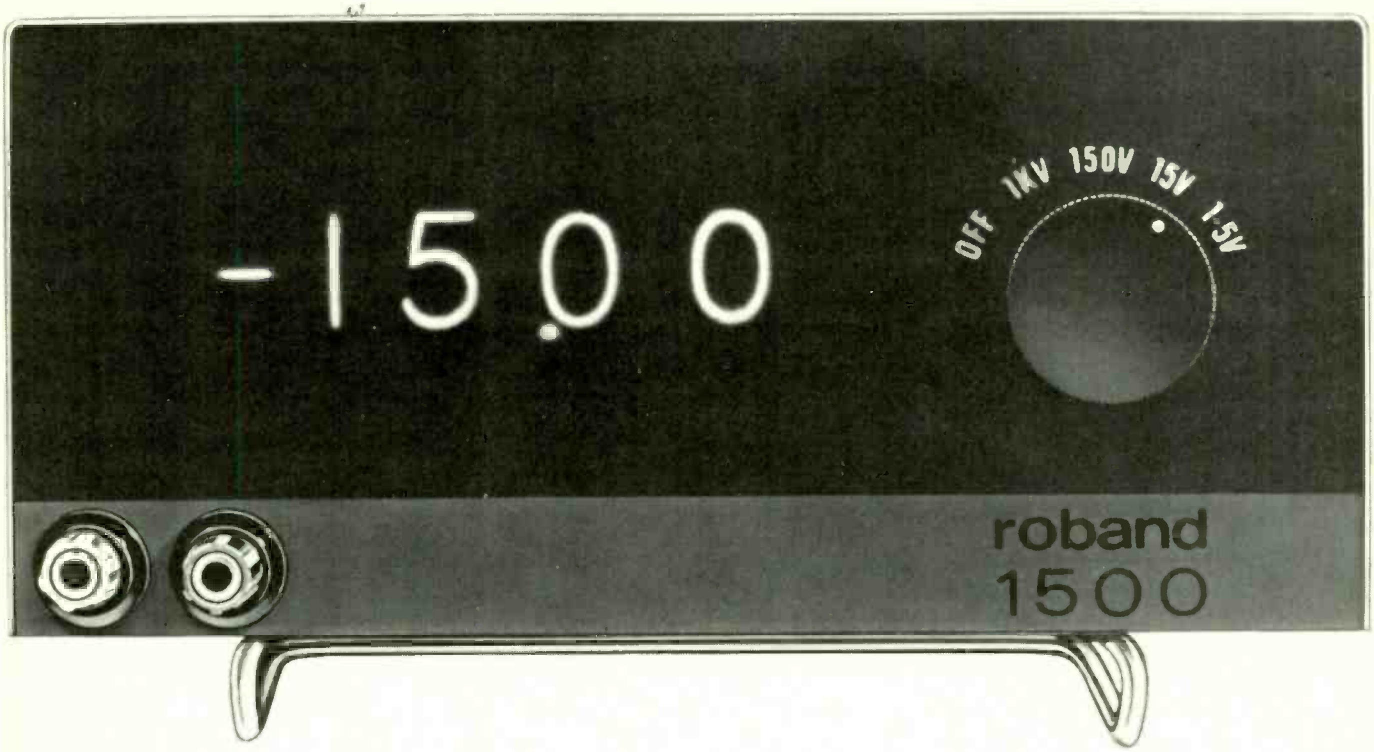


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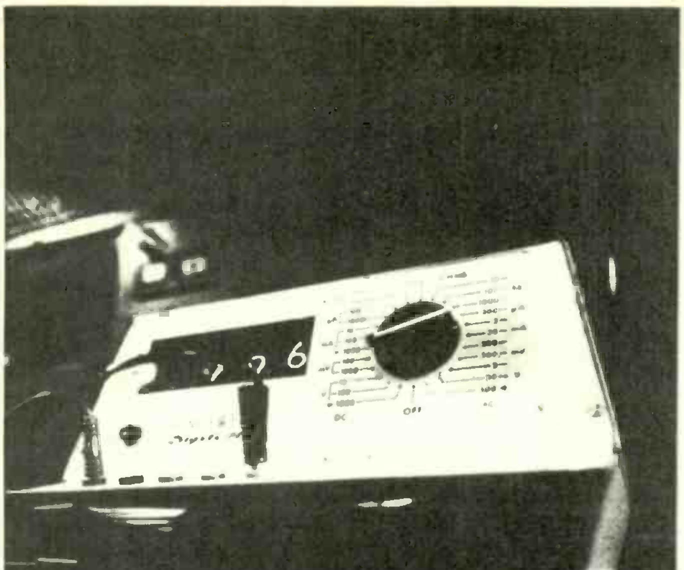

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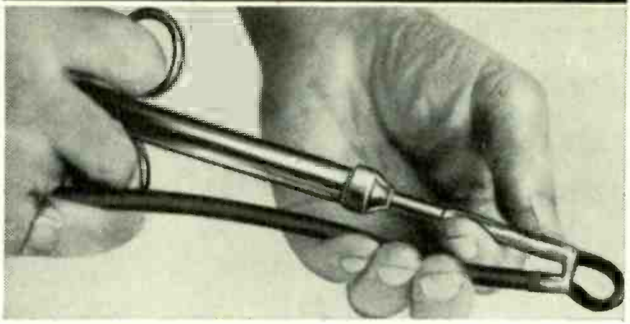

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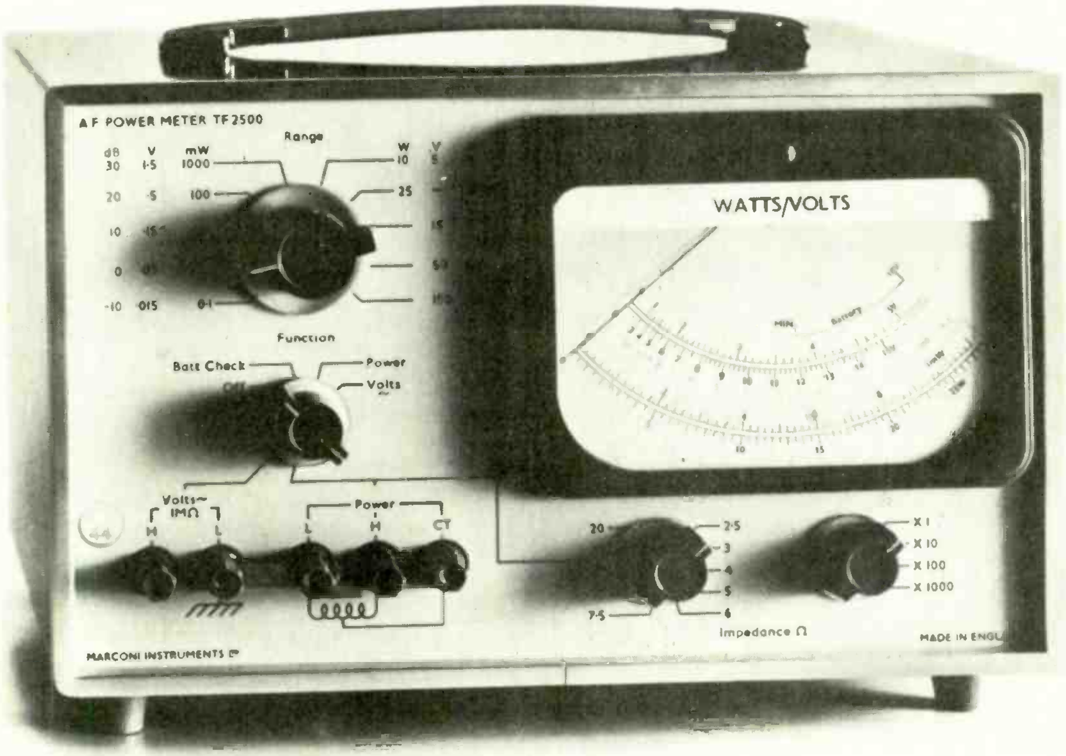


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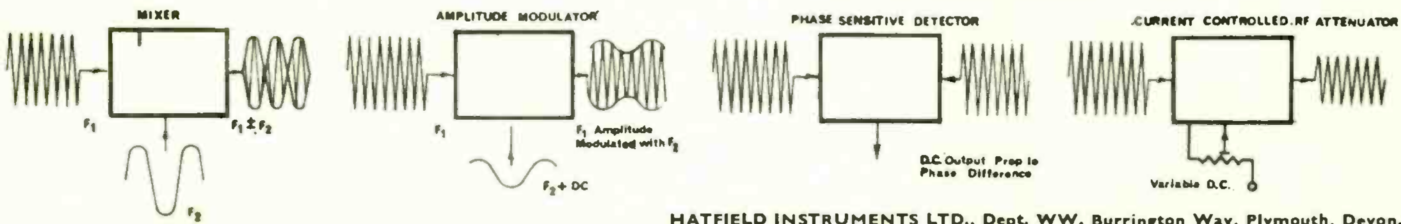


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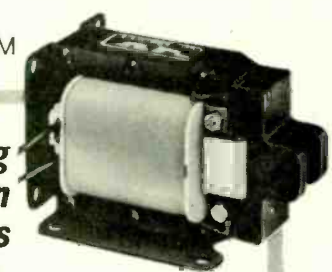

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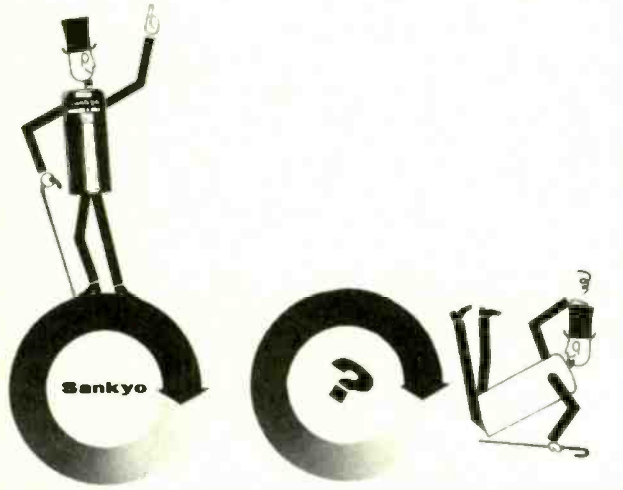


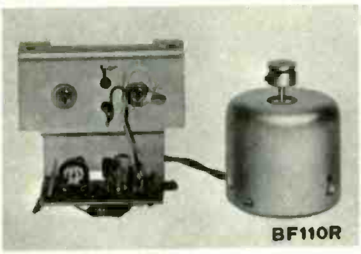



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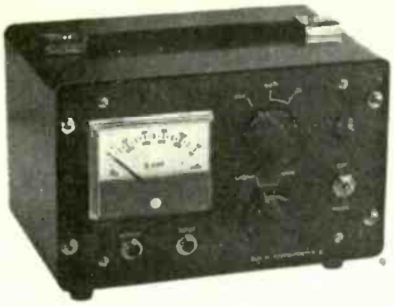

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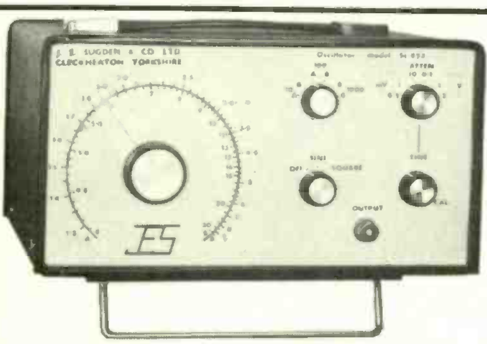

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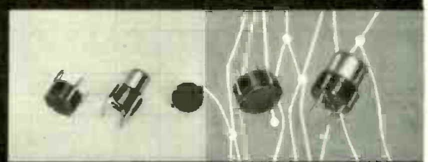

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# Wireless World

**Electronics, Television, Radio, Audio**

*Fifty-ninth year of publication*

**June 1969** **Volume 75 Number 1404**


**This month's cover picture** shows crossover distortion occurring in a class B output stage. The low-level high-order harmonics contained in the apparently clean sinusoid are quite audible although amounting to less than 0.1% distortion.

# Contents



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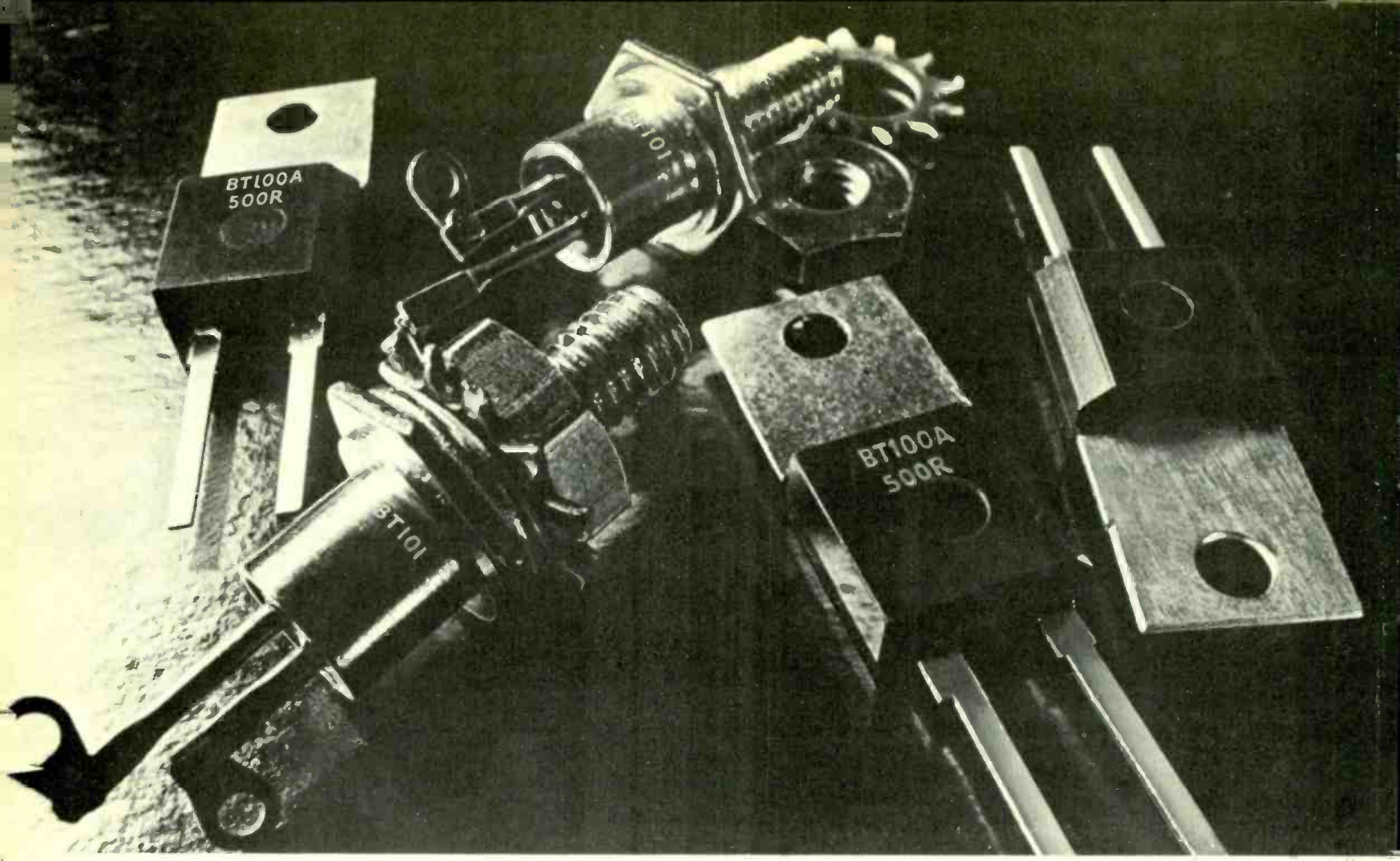


# How we made thyristors a commercial proposition for consumer products

Three years ago a Mullard design team was given the problem of developing thyristors for motor speed control in washing machines and drills. Thyristors offered important advantages over conventional power control methods, but at that time, production was confined to relatively expensive industrial devices. The high unit cost was essentially due to specialist production techniques.

**Two Requirements** The Mullard team set about designing inexpensive thyristors, together with triggering devices, for use on domestic mains supplies. Two current handling capabilities were identified as being necessary to meet the range of applications—6.5A for washing machines and other heavy current loads, and 2A for drills and lighter loads.

Within six months two consumer type thyristors, BT101 and BT102, had been developed for 6.5A applications, and they were soon in mass production. Now these devices, in the TO-64 stud-mounted metal encapsulation, are well established.

**Low-cost Plastic** After further design work, a new *plastic* device, the BT100A, was introduced to meet the lower current requirements. Plastic power device technology is highly specialised, and only intensive effort over many years has resulted in the highly automated manufacturing techniques which ensure extremely good reliability.

**Computer Testing** To cope with the necessary high rate of production, computer techniques were introduced to record test results and to allow automatic grading. The testing cycle was significantly shortened by the use of high-current pulses for directly heating the thyristor crystal. This is one of the best automated methods of testing breakdown voltages at the highest junction temperatures.

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Wireless World

# Components, complaints and complacency

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We are constantly receiving letters from private individuals who are finding it impossible to obtain supplies of certain components and whose pleas to manufacturers and distributors are met with stony silence. Even the small company, not in the electronics field, which requires a special component for a one-off job—and which has the advantage of a company letter heading—sometimes receives the same treatment.

One of our correspondents, who was starting a small company, claimed he was asked for two trade references and the name of his bankers, and that was only in order to receive a catalogue!

However, component supply is the result and not the cause of the problem, the whole attitude of the electronics industry towards the private experimenter and the amateur is one of non-co-operation to the point of scorn. Why is this, when many of yesteryear's major innovations in radio and electronics emanated from the results of work carried out on a kitchen table?

In those days the amateur and the professional (often one and the same person) were working on similar problems and there was a mutual respect. The technology has advanced in leaps and bounds since then and industry is staffed with people who more than likely do not have an amateur background and who have no appreciation of the problems and frustrations that can face anyone trying to work on his own for interest, self-education or amusement.

Because of the great amount of publicity given to electronics, and the aura of mystery surrounding it in the eyes of the layman, more people are taking a practical interest. This has led to manufacturers and distributors being bombarded with letters requesting the solution to private electronic problems, many of which are nonsensical or frivolous, and others could have been answered easily if the writer had shown a little initiative or visited a good library. To answer all these queries would cost a company a great deal and what would they get in return? Perhaps an order for two or three components, the value of which may be less than the cost of the handling.

By making their components generally available on the retail market, to be bought by people who may not be qualified to use them, a company feels that it is inviting the sort of costly correspondence mentioned. The reason for the reticence in this respect can be understood.

All this has led to the present ultra-low status of the amateur in the eyes of industry and the reluctance of many concerns to accept small orders.

The industry does, however, have a responsibility to the public, even if it is only to maintain its own image, and attempts must be made to give assistance in genuine cases. Refusals because of a couldn't-care-less attitude can never be justified and small losses should be accepted at times.

Manufacturers could easily set up machinery to ensure that their products can be sold on the retail market through a distributor. Because of the difficulty in assessing the possible quantities required perhaps some sort of sale or return arrangement could be operated with the distributor. At the present time many components are completely unobtainable on the retail market.

In addition, all private individuals seriously interested in electronics should put their own house in order, and as a first step may well think of joining a club. If there is not one in the area—start one. The answer to nearly all the problems likely to trouble the experimenter could be found amongst a group of people with a common aim. Particularly difficult problems could be made club projects. Benefits could be reaped in terms of central facilities, pooled test equipment, tools and literature.

A great deal of useful work can be done by a well-run organization of this nature and the local community can benefit. For instance, club projects could aid local handicapped people, small electronic systems for local firms could be designed and constructed (power supplies, control systems, photo-electric switches etc.). Often these firms can advantageously use electronic equipment, but, because only a one-off is required, it is uneconomic to employ professionals to do the job.

The companies who supply components would, we feel sure, be more than willing to assist such organizations so long as things were done on a business-like basis. A good example of the sort of co-operation that can be achieved is to be seen in the components list for the Logic Display Aid in this issue.

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# F.M. Tuner using Integrated Circuits

## Non-critical mono design with no i.f. and discriminator coils

*by G. J. Newnham,* A.M.I.E.E.*

The tuner described has been developed primarily for sound distribution systems but is also suited to home construction. For sound distribution systems reliability is of great importance since operation may be for up to 24 hours per day and service calls are expensive. This tuner has been designed to maximize reliability by eliminating the major causes of previous failure and drift in f.m. tuners. To achieve a high reliability factor in any electronic equipment the components themselves must be stable. The most unstable components in conventional f.m. tuners, apart from the valves, are the i.f. and discriminator coils. Thus, even if crystal control of the local oscillator is used, realignment will be required after a time. Now that integrated circuits with an indefinite life are available, if the i.f. and discriminator coils can be eliminated the reliability should be improved considerably.

With this philosophy in mind the design objectives aimed for were as follows:

(1) The requirement for servicing should be negligible, even after lengthy periods of continuous operation.

(2) The circuit should be non-critical such that if wired correctly it will work "first time".

(3) The assembly and alignment should require very little specialized knowledge.

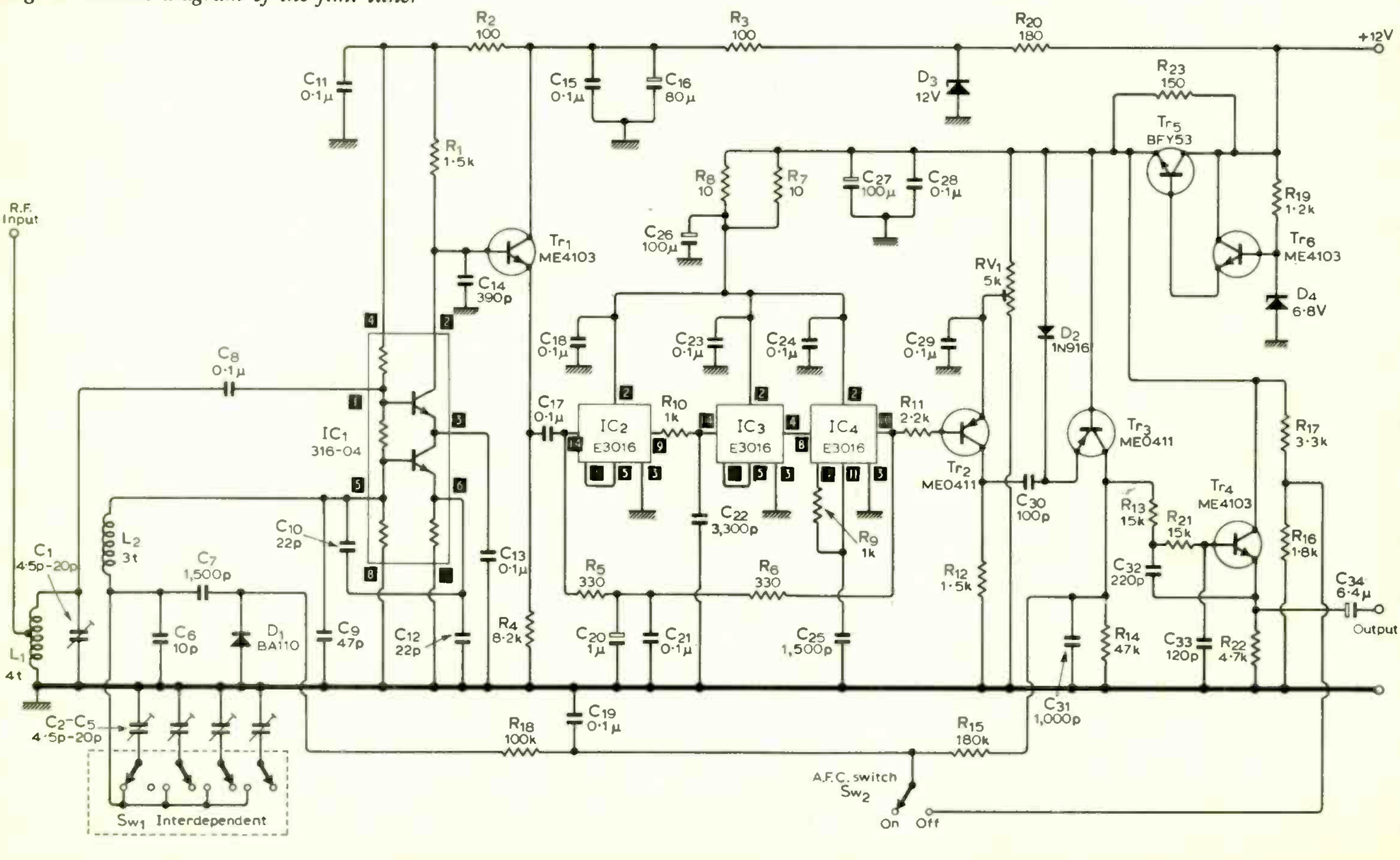
(4) The circuitry should be the most up to date consistent with commercial economics.

(5) The electrical performance of the tuner should not be sacrificed in order to achieve the other objectives.

In accordance with these aims four integrated circuits are incorporated, but it is noticeable from the circuit diagram, Fig. 1, that a large number of discrete components is still necessary. This is because the i.cs are being used here as "powerful" discrete components and were not specifically designed as f.m. tuner circuits. The next step in the advance of integration, as production becomes cheaper and more efficient, will be an i.c. with a more specific system function, i.e. multiple functions per chip or package. There are signs of this already but such i.cs will still

*Marconi-Elliott Microelectronics Ltd.

*Fig. 1. Circuit diagram of the f.m. tuner*

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require some discrete components to enable them to have a useful function. After this, or even alongside it, will come total integration of a complete electronic system such as an f.m. tuner, but it will be some time before it is a commercial practicality, even though the technical ability is available now.

The basis of the present design is a low frequency i.f. amplifier centred on 160kHz, using three Marconi-Elliott E3016 monolithic dual differential amplifiers, followed by a pulse rate discriminator. This principle has been used in previous designs published in *Wireless World*[1,2,3] and enables the conventional i.f. and discriminator coils to be dispensed with. The front end employs a Marconi-Elliott 316-04 cascode amplifier as a mixer with built-in oscillator, and has a broad tuned input circuit. Automatic frequency control is applied to the oscillator to ensure and maintain accurate tuning, allowing reliable push-button programme selection. This is all that is really required on v.h.f. and, as with crystal control, the human error involved every time the received station is changed is also eliminated. No r.f. amplifier stage is used.

## Front end

The front end of a v.h.f. tuner is often the cause of poor performance owing to critical layout and adjustment; however, the rather unconventional approach used here has been found very uncritical and stable. The 316-04 i.c. (Fig. 1) is a multi-chip circuit providing useful power gains to frequencies in excess of 200MHz and as such is being used well within its limits in this application. The lower transistor of the cascode pair in $IC_1$ is used as a grounded-collector Clapp oscillator at the fundamental frequency, 160kHz away from the wanted signal. Owing to the nature of the a.f.c. characteristics the oscillator is always on the low side, but with a.f.c. off, the signal can be tuned in equally well either side. This oscillator configuration is basically stable because the already small transistor junction capacitances are not effectively magnified by voltage gain in the circuit and are therefore easily swamped by the tuned circuit capacitance. Crystal control can be used but crystals are expensive and would have to be specially made for each desired station. Measurements show that without the a.f.c. diode this oscillator moved less than 100kHz at 100MHz, when its supply voltage was increased from 10 to 20 volts. This shift is too small to lose a station which is correctly tuned in at 20 volts. A convenient point to monitor the oscillator output, if a valve voltmeter or sufficiently fast oscilloscope is available, is at pin 6 of $IC_1$ as it is at relatively low impedance. Approximately 80mV should be measured at 90MHz at this pin.

Fundamental as distinct from harmonic mixing was chosen as it gave the best and most consistent conversion gain of 16dB at 100MHz. Assuming that correctly set-up switched preset tuning is used, as is advocated with this design, no interference is experienced by adjacent tuners tuned to the same or different programmes.

The upper transistor of the i.c. acts as a mixer, being supplied at pin 1 with a signal from the broad tuned input circuit and local oscillator injection via the internal bias chain. Capacitor $C_{13}$ on pin 3 serves both to ground the collector of the oscillator and to decouple the emitter circuit of the mixer at the i.f. frequency; its value affects the lower 3dB point of the i.f. bandwidth. A 75-ohm coaxial feeder is matched to the mixer by $L_1$, resonated by $C_1$ and the input capacitance at pin 1. The coupling capacitor $C_8$ serves also to decouple the base of the mixer, which would otherwise tend to pick up strong low frequency interference. Capacitor $C_{14}$ serves to cut the residual mixing products other than the difference frequency desired, and is used also to tailor the i.f. upper frequency limit. An input signal as high as 100mV does not affect operation of the mixer, but protection against voltage transients on the aerial is no less necessary than with any other transistor input stage. As can be seen from the layout (Fig. 3), station selection is achieved with four preset trimmer capacitors selected with a printed circuit mounted push-button switch.

## I.F. section

The i.f. section of the tuner amplifies signals centred on 160kHz and has the advantage that its bandwidth can be defined by *RC*

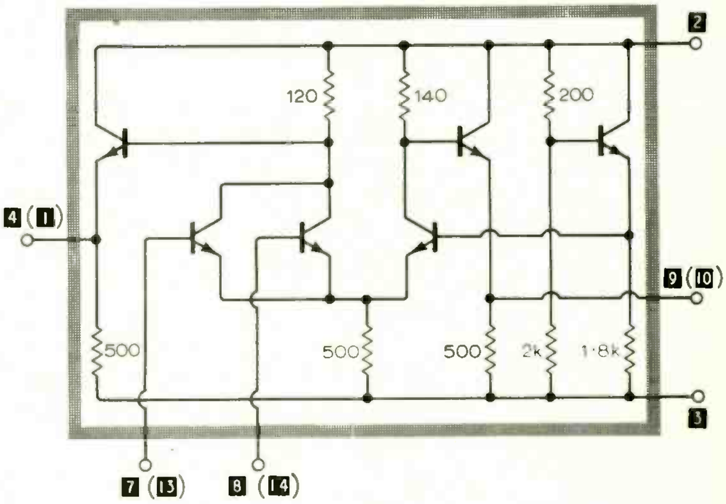
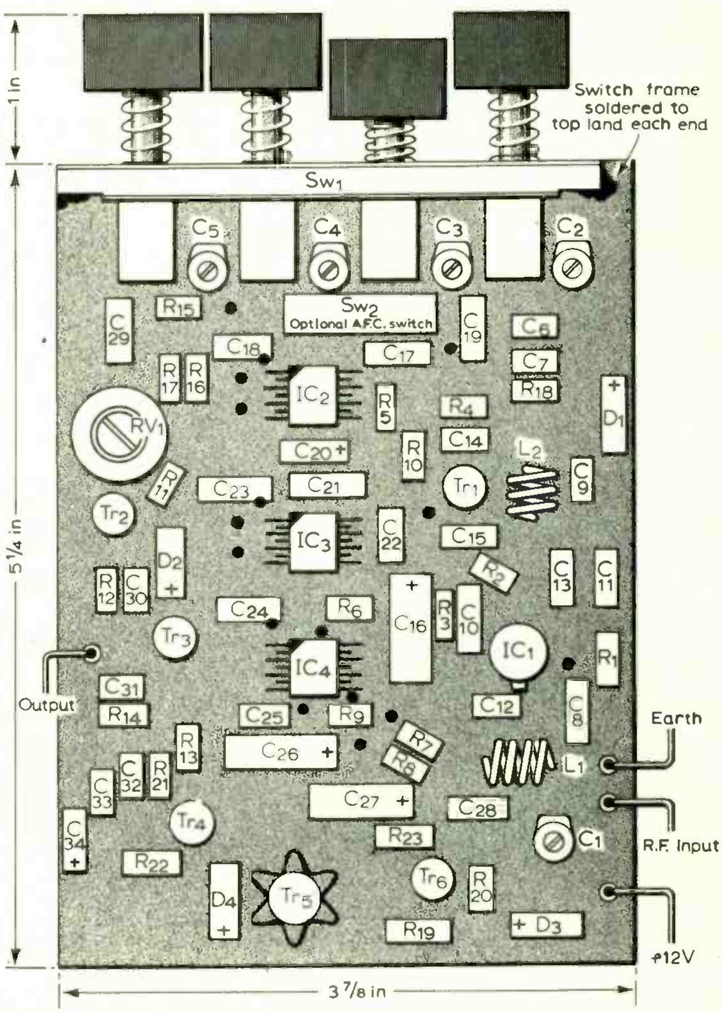



*Fig. 2. Circuit of the type E3016 i.c. used in the i.f. section of the tuner*

*Fig. 3. Component layout on the printed circuit board supplied by General Avionic Associates Ltd.*

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networks rather than by $LC$ tuned circuits. A further advantage is that a pulse rate discriminator[4,5] can be used which provides a useful output voltage of excellent linearity without the necessity for alignment. An additional feature of this discriminator is that a direct voltage is available for a.f.c. purposes. A disadvantage of this system is that two tuning points occur per station, although only one is apparent with a.f.c. on. This makes it difficult to search for weak stations among strong ones, but where preset tuning is used this is of no consequence. Another disadvantage is intermodulation whistles, easily produced if the bandwidth is not tailored sharply enough and aggravated if the transfer characteristic does not produce symmetrical limiting. This design ensures a sharp cut-off by using three isolated $RC$ networks, and a symmetrical limiting characteristic is ensured by using a differential amplifier (Fig. 2) for each stage. The use of differential amplifiers also eases the supply decoupling problem, which is important with an overall i.f. gain, including the interface stage $Tr_2$ of some 110dB. Impedances in the i.f. chain are low, minimizing the likelihood of instability and spurious pick-up. As shown on the circuit diagram (Fig. 1) each i.c. is decoupled by a capacitor adjacent to the package.

The emitter follower stage $Tr_1$ is necessary in order to maintain the conversion gain of the mixer, which would otherwise be reduced when working into the low input impedance of the i.f. amplifier. The resistors $R_5$ and $R_6$ provide a d.c. negative feedback path over the three E3016 stages. Capacitors $C_{20}$ and $C_{21}$ prevent a.c. feedback except at very low frequencies and hence, together with $C_{17}$, contribute to the low frequency cut-off of the i.f. response. The high frequency cut-off is determined by the $RC$ networks $R_1/C_{14}$, $R_{10}/C_{22}$ and $R_9/C_{25}$.

A symmetrically limited waveform of approximately 0.8V peak to peak appears at pin 10 on $IC_4$ and to drive the discriminator this is increased to 5V peak-to-peak by the interface stage $Tr_2$. The d.c. working point of this stage can be adjusted with $RV_1$ to suppress noise when a signal is not being received (see "Alignment procedure" section). It was not found convenient to plot the overall i.f. response because the amplification is such as to cause limiting on noise. However, on an oscilloscope frequencies from 20kHz to 350kHz were observable as a c.w. signal was tuned through (with a.f.c. off).

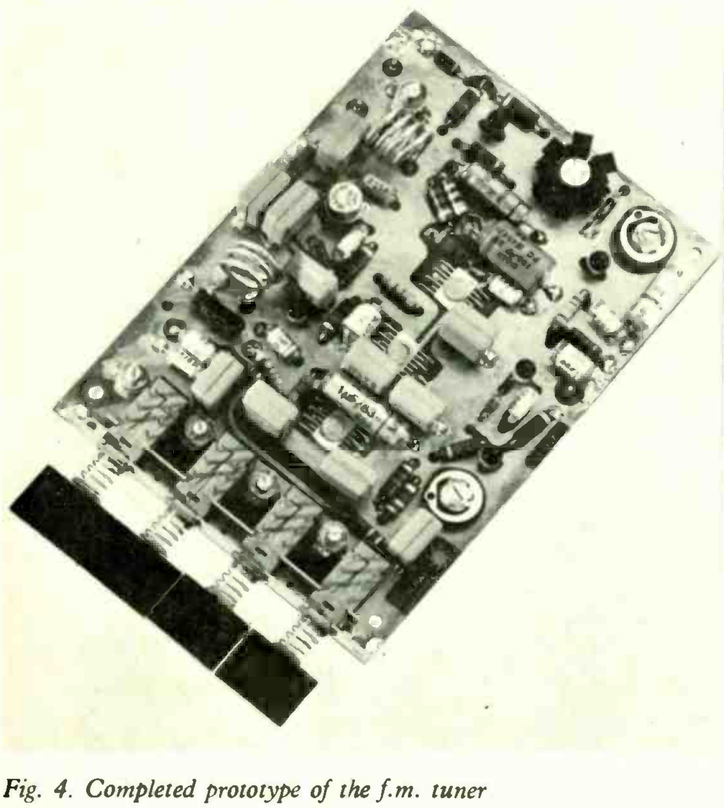

*Fig. 4. Completed prototype of the f.m. tuner*

## Discriminator

The discriminator is a conventional pulse rate type [6], the operation of which has been fully discussed in earlier issues of *Wireless World*, but its function basically is to produce a d.c. voltage output (across $C_{31}$) proportional to the frequency of the input signal. With suitable component values it can do this very linearly over wide frequency ranges and it has a certain amount of inherent de-emphasis. It is very important that the circuit be loaded correctly with a high impedance, otherwise reduced output and frequency-response distortion will result. For this reason and also to ensure that any length of screened lead may be used on the output without degrading the frequency response, an emitter-follower buffer stage has been included. In conjunction with $C_{32}$, $C_{33}$, $R_{13}$ and $R_{21}$ this serves also as a low-pass filter to further attenuate residual 160kHz i.f. output without attenuating frequencies up to 50kHz by more than 1dB.

The a.f.c. voltage is applied to the variable capacitance diode $D_1$ via $R_{15}$ and $R_{18}$, the capacitor $C_{19}$ ensuring closed-loop stability. The effectiveness of the a.f.c. can be increased or decreased by respectively decreasing or increasing these resistors, but care must be taken not to load the discriminator or make $C_{19}$ too small. One effect of the latter can be to reduce bass response. The effect of the a.f.c. switch in the off position is to supply a fixed bias to the diode of the same value as it would receive from the discriminator when correctly tuned, thus simplifying setting up.

## Construction

The double-sided printed-circuit board as illustrated (Fig. 4) together with all the necessary components are available, by mail order only, from General Avionic Associates Ltd, 9 Wimpole Street, London, W.1. The complete kit including i.cs and instructions costs £9 19 6d and is perhaps the most straightforward form of construction for the amateur. Before mounting any components make certain that all the holes have been drilled, and insert the eyelets where indicated to join the two sides of the circuit board. If eyelets are not used it can be difficult to solder both sides, particularly with the i.c. leads. If all the components as listed are mounted with careful respect for polarity where capacitors, diodes, transistors and i.cs are concerned, and earth points are soldered both sides of the board, no trouble should be experienced. The board can be mounted such that the push buttons are accessible through a front panel. Use of an earthed metal cabinet is recommended and, if hum troubles are experienced, better supply smoothing may be required.

With some arrangements of the final system (tuner, p.s.u., amp., etc.) 50Hz hum was experienced and traced to the a.f.c. line. This trouble was entirely eliminated by using in place of $R_{18}$ an r.f.c. (0.6$\mu$H) consisting of 20 turns of 26 s.w.g. enam. wire close wound on a 10M$\Omega$ $\frac{1}{2}$W resistor body. Also $C_{19}$ was increased to 1$\mu$F. These modifications had the additional effect of increasing the low frequency response and appeared to reduce interference from electrical apparatus in close proximity to the tuner.

For those who wish to make their own layout there should be few problems as long as an 'earth plane' form of construction is used. This is very important, and ensures that different parts of the circuit that require to be earthed are earthed through the lowest common impedance possible. A convenient method of achieving this form of construction is to use a plain piece of single-plated printed-circuit board. Then, having decided on the component layout, drill holes where the component leads should go, arranging that the components sit on the same side as the copper. [illegible] board with a continuous copper sheet on one side,

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## COMPONENTS LIST

**Resistors**

| | | | | |
|---|---|---|---|---|
| $R_{1, 12}$ | 1.5k | carbon film | ⅛W | 5% |
| $R_{2, 3}$ | 100Ω | .. .. | .. | .. |
| $R_4$ | 8.2k | .. .. | .. | .. |
| $R_{5, 6}$ | 330Ω | .. .. | .. | .. |
| $R_{7, 8}$ | 10Ω | .. .. | .. | .. |
| $R_{9, 10}$ | 1k | .. .. | .. | .. |
| $R_{11}$ | 2.2k | .. .. | .. | .. |
| $R_{13, 21}$ | 15k | .. .. | .. | .. |
| $R_{14}$ | 47k | .. .. | .. | .. |
| $R_{15}$ | 180k | .. .. | .. | .. |
| $R_{16}$ | 1.8k | .. .. | .. | .. |
| $R_{18}$ | 100k | .. .. | .. | .. |
| $R_{19}$ | 1.2k | .. .. | ½W | .. |
| $R_{20}$ | 180Ω | .. .. | ½W | .. |
| $R_{22}$ | 4.7kΩ | .. .. | ⅛W | .. |
| $R_{23}$ | 150Ω | .. .. | ½W | .. |
| $RV_1$ | 5kΩ | preset | | |

**Capacitors**

| | |
|---|---|
| $C_{1, 2, 3, 4, 5}$ | 4.5—20pF ceramic trimmers |
| $C_6$ | 10pF polystyrene |
| $C_{7, 25}$ | 1,500pF polystyrene |
| $C_{8, 11, 13, 15, 17, 18, 19, 21, 23, 24, 28, 29}$ | 0.1μF metallized polyester |
| $C_9$ | 47pF polystyrene |
| $C_{10, 12}$ | 22pF polystyrene |
| $C_{14}$ | 390pF polystyrene |
| $C_{16}$ | 80μF electrolytic, 16V |
| $C_{20}$ | 1μF electrolytic, 6.4V |
| $C_{22}$ | 3,300pF polystyrene |
| $C_{26, 27}$ | 100μF electrolytic, 6V |
| $C_{30}$ | 100pF polystyrene |
| $C_{31}$ | 1000pF polystyrene |
| $C_{32}$ | 220pF polystyrene |
| $C_{33}$ | 120pF polystyrene |
| $C_{34}$ | 6.4μF electrolytic, 6.4V |

**Coils**

| | |
|---|---|
| $L_1$ | 4 turns 16 s.w.g. tinned copper 0.4in dia. 0.5in long tapped 3 turns from earth. |
| $L_2$ | 3 turns 16 s.w.g. tinned copper 0.4in dia. 0.3in long. |

**Integrated circuits**

| | |
|---|---|
| $IC_1$ | 316-04 cascode amplifier, Marconi-Elliott Microelectronics. |
| $IC_{2, 3, 4}$ | E3016 dual differential amplifier, Marconi-Elliott Microelectronics. |

(Available separately from General Avionic Associates Ltd if required.)

**Transistors**

| | |
|---|---|
| $Tr_{1, 4, 5}$ | ME4103, BC107 |
| $Tr_{2, 3}$ | ME0411, BCY70 |
| $Tr_6$ | BFY53, BFY50, 2N3053 |

**Diodes**

| | |
|---|---|
| $D_1$ | BA110, S.T.C. |
| $D_2$ | IN916 silicon |
| $D_3$ | 12V zener |
| $D_4$ | 6.8V zener |

**Sundries**

Double-sided circuit board
Push-button switch assembly, A.8. Metal Products Ltd
A.f.c. switch (not supplied in kit)
Transistor and diode mounting pads and clips
Heat sink for $Tr_6$

rather than copper strips, is ideal as it saves drilling holes. Where the component leads are not required to be earthed the copper can be cleared away from these holes with a small twist drill and the leads fed through to the other side for wiring up. Wiring can be done with the leads themselves for the most part, but where cross-overs do occur an insulated wire link should be used. Where a component has one lead earthed, this can be done direct to the earth plane, no earth wiring being required. Using this system various layouts have been tried and all worked well.

Remote tuning by means of a d.c. voltage is easily achieved should it be required, but in order to obtain a sufficiently wide tuning range, some circuit modifications must be made. Fig. 5 shows the tuning voltage (0-6V) applied to the a.f.c. diode from preset potentiometers remote from the board, $C_6$ having been removed and $L_2$ increased to 5 turns. Resistors $R_{15}$ and $R_{18}$ have been increased to 1MΩ, and if a 1MΩ resistor is connected across the a.f.c. switch no trouble should be experienced when switching between stations. For maximum tuning range it is recommended that the supply to $R_3$ be taken from the top of $D_4$, and a 1kΩ resistor be connected from pin 6 of the 316-04 to ground. $R_{20}$ and $D_3$ are no longer required and only one trimmer capacitor is needed for setting the tuning range instead of $C_2$ to $C_5$.

A voltage tuned version of the tuner designed for sound distribution systems can be obtained from General Avionic Associates Ltd.

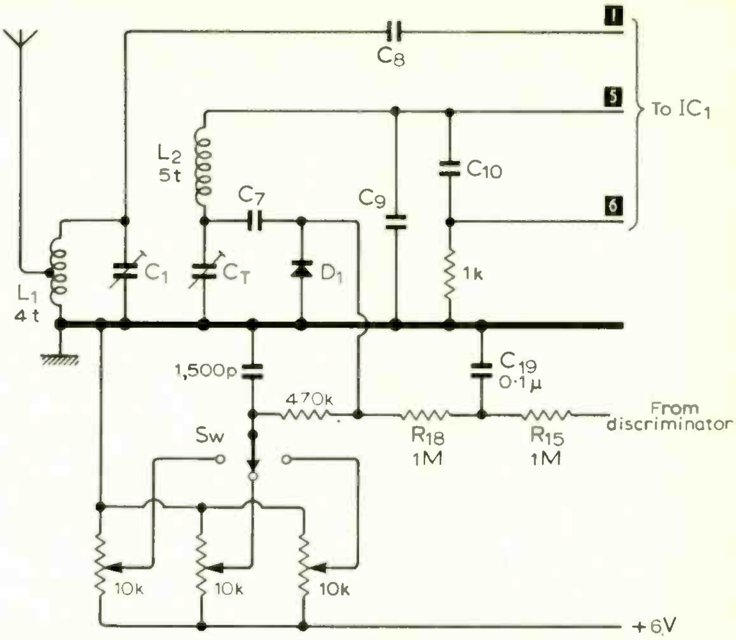


*Fig. 5. Modifications to the circuit to allow electronic tuning to be used*

### Alignment procedure

No test equipment is required for alignment of the tuner but some form of monitoring is needed, either headphones direct on the output or an amplifier and loudspeaker. With the aerial disconnected adjust $RV_1$ for a maximum of rushing noise in the output. Assuming all is well this should occur over a small section of the track; either side of this should be silence. Set $C_1$ about a quarter meshed—it can be peaked later if necessary—and connect an aerial. With a.f.c. switched off it should be possible to tune most of the f.m. band using an insulated trimming tool on any of the trimmers $C_2$ to $C_5$, selected by the appropriate push button. If all of the available stations are not tunable, $L_2$ can be stretched or compressed slightly to alter the coverage. To set a station, it should be approached from the low frequency end of the band, tuned for best output by ear, and then the a.f.c. can be switched on. If when the a.f.c. is switched on the station disappears or becomes distorted, the oscillator must have been set on the wrong side of the station. The best way to check that the oscillator is set correctly is as follows. Having obtained the station and applied a.f.c., take off the aerial and/or switch off the power supply and then reconnect. If the station is still there, all is correct; if not, the trimmer was set outside the a.f.c. locking range. This procedure can be repeated to set any station to any desired push-button. Four are provided, for Radio 2, Radio 3, Radio 4 and a local radio station if available. Once correctly set up the a.f.c. switch should not need to be used again.

### Performance

The tuner has a sensitivity of better than 10μV at 90MHz for i.f. limiting. An audio output of 100mV r.m.s. on an average programme can be expected but programme content varies greatly. Using a good aerial this degree of sensitivity has been found quite adequate in most parts of the country, but a pre-amplifier can be used in difficult areas. In the Chelmsford area of Essex, about 30 miles from the Wrotham transmitter, very good reception is obtained on a short length of wire at ground level, but for minimum pick-up of electrical interference a dipole as high as possible is recommended.

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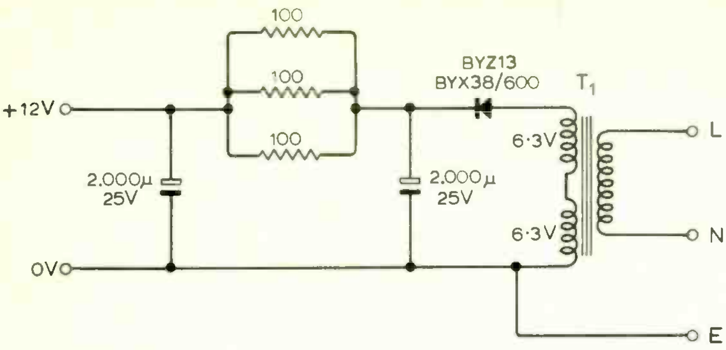



*Fig. 6. A suitable power supply for the tuner. $T_1$ is a Radiospares Ltd "Hygrade" filament transformer*

Current consumption is between 120 and 150mA at 12V which makes the tuner unsuitable for portable use on dry batteries. However, for the majority of applications mains derived supplies are available (see Fig. 6) and if the tuner is used in a car there should be no power consumption problem.

### Performance on stereo

From tests made using a modified Mullard stereophonic decoder it appears that the tuner will not give an adequate performance on stereo broadcasts. The modifications to the decoder were necessary to ensure that the correct impedance and signal levels were obtained. However, channel separation at 440Hz was only 6dB. This result may have been due to a limitation of the decoder, which had no provision for subcarrier phase control, but a more likely reason is that the i.f. frequency of the tuner is too low and the bandwidth inadequate for stereo.

In order to eliminate the possibility of intermodulation whistles in the output caused by mixing of 160kHz with regenerated 38kHz and its harmonics a special filter is required to remove residual i.f. content. The amount of filtering incorporated in the tuner as it stands was found to be insufficient in this respect.

**Acknowledgement.** The author thanks the Managing Director of Marconi-Elliott Microelectronics for permission to publish this article.

### REFERENCES.

1. "Wireless World Crystal-Controlled Transistor F.M. Tuner". *Wireless World*, July 1964.
2. "A Simple Transistor F.M. Tuner" by J. C. Hopkins. *Wireless World*, September 1965.
3. "Pulse counting F.M. Tuner" by E . D. Frost. *Wireless World*, December 1965.
4. "Letters to the Editor" on "The Diode Transistor Pump". *Wireless World*, September 1966.
5. "The Diode Transistor Pump" by D. E. O'N. Waddington. *Wireless World*, July 1966.
6. *ibid.* Fig. 5.

## Conferences and Exhibitions

**LONDON**

June 10-20 — I.M.E., Mark Lane
**Marine and Shipping Conference**
(Institute of Marine Engineers, 76 Mark Lane, London E.C.3)

June 18-27 — Olympia
**Interplas: Plastics Exhibition**
(Iliffe Exhibitions Ltd., Dorset House, Stamford Street, London S.E.1)

**EASTBOURNE**

June 3-5 — Congress Theatre
**Microelectronics Conference**
(I.E.E., Savoy Pl., London W.C.2)

**MANCHESTER**

June 30-July 3 — U.M.I.S.T.
**Computer Science & Technology**
(I.E.E., Savoy Pl., London W.C.2)

**OVERSEAS**

June 1-14 — Chania, Crete
**Growth and Characterization of Electronic Materials**
(E.D. Haidemenakis, 2 rue de Furstenberg, Paris 6e)

June 9-10 — Chicago
**Broadcast and Television Receivers**
(I.E.E.E., 345 E.47th St., New York, N.Y. 10017)

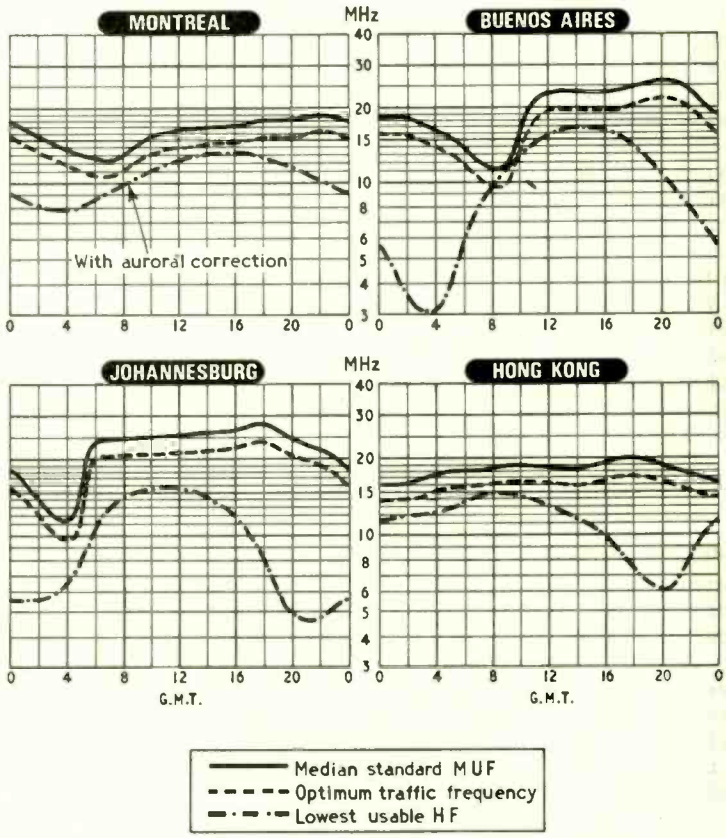
June 9-11 — Boulder
**Communications Conference**
(I.E.E.E., 345 E.47th St., New York, N.Y. 10017)

June 15-22 — Paris
**Navigation Congress**
(Int. Assoc. of Navigation Congresses, Quartier Jordaens (Rez-de-Chaussee), 155 rue de la Loi, Brussels 4)

June 16-21 — Warsaw
**I.F.A.C. Automatic Control Congress**
(U.K. Automation Council, c/o I.E.E., Savoy Pl., London W.C.2)

June 17-19 — Asbury Park, N.J.
**Electromagnetic compatibility Symposium**
(C. Joly, Honeywell Inc., POB 54, Eatontown, New Jersey 07724)

## H. F. Predictions—June




The graphs, which are prepared by Cable & Wireless Ltd, show median standard MUF, optimum traffic frequency and lowest usable frequency (LUF) for reception in this country.

Decreasing solar activity over the past months has lowered MUFs to a greater degree than LUFs; this reduction of usable spectrum will continue for several years with consequent increase in mutual interference problems. Summer conditions, where daytime MUFs are depressed as for Hongkong and Montreal, further aggravate this situation.

Ionospheric and magnetic disturbances have become more frequent of late and can be expected to continue with an occasional complete fade-out.

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# News of the Month

## New training group formed

A working group on scientific and technical manpower has been set up by the Electronic Economic Development Committee (the "little Neddy" for electronics). One of its main tasks will be to determine the future trained manpower needs of the industry and, in doing this it will take into account the findings of earlier studies in this field.

The group will suggest to E.D.C. the methods which they should employ to influence the bodies responsible for training and deploying manpower.

E.D.C. say that the U.K. is spending about £1,000m a year on research (approx. 2.8 per cent of the gross national product); only America and Russia spend more. E.D.C. think that the return from this very large investment is very small in terms of benefit to the community and to the electronics industry, and, when judged by the overall performance of the economy, they feel that the R & D effort has not been adequately reflected in the country's economic growth and productivity.

With this background in mind the group will re-appraise earlier studies of university and industrial deployment of scientists and technologists, with particular reference to the electronics industry.

## Low-cost automation centre

Inexpensive methods of automation will be demonstrated in the West country in a new centre at the Plymouth College of Technology. The centre was opened on April 2nd and was the result of co-operation between the college and the Ministry of Technology. It will provide specialized training and consultancy services for West Devon and Cornwall.

## On weather forecasting and tracking turtles

An equipment being tried for the first time on the satellite Nimbus-3 will interrogate all manner of strategically placed sensors on earth and transmit the total acquired data to a central earth station for processing. The system is called the Interrogation Recording and Location System (I.R.L.S.) and it works in the following manner.

Sensors, and appropriate electronics, are placed at various points on earth along the satellites orbit. These may measure temperature, pressure, water currents, salinity or anything else that can be converted into an electrical quantity. The sensors do not have to be fixed and may be installed on free floating buoys, in balloons, in aircraft, in boats, or on land. It is a feature of the I.R.L.S. to track the sensors and keep a record of their position.

At the start of each polar orbit a ground station (at Alaska or Maryland) commands the satellite to interrogate various sensors at particular times. The times are calculated to ensure that the satellite is within range of the required sensor and are based on predictions based on earlier movements of the sensors.

At the appropriate moment the satellite transmits the address code of the required sensor. The sensor acknowledges by transmitting its address code and the satellite commands the sensor to transmit data on existing conditions which are then stored in the satellites' memory. Also recorded in the memory is the exact time of the interrogation and the satellite-to-sensor range for tracking purposes.

On the next pass over the main command control centre the satellite is instructed to transmit the contents of its memory. After suitable processing the data are available for distribution to users.

Apart from weather forecasting the applications of the I.R.L.S. are numerous; for instance the migratory habits of birds, sea life and animals could be studied. Sensors attached to the backs of giant sea turtles, which regularly migrate across the Atlantic from the Caribbean to Africa, would enable their exact course to be plotted.

The I.R.L.S. which has been developed by Radiation Incorporated of America, fitted to Nimbus-3, will interrogate up to 20 sensor stations in one polar orbit. Under a 3M dollar development contract awarded to Radiation by the N.A.S.A. Goddard Space Flight Center an advanced I.R.L.S. is to be built for Nimbus-D (due for launching in 1970) which will interrogate as many as 370 sensors in a single orbit.

## Television awards

The first recipient of the Gold Medal of the Royal Television Society is Douglas Birkinshaw "for his outstanding contributions to television during his service with the B.B.C. television from 1932-68". Mr. Birkinshaw, who received the medal at the Society's annual ball on May 9th, was engineer-in-charge at Alexandra Palace for the opening of the B.B.C. television service in 1936 and at the

*In the background the B.B.C. advanced field store standards converter, and in the foreground members of the two teams from the B.B.C's Research and Design Departments who were responsible for developing the converter. They are (left-to-right, back row) Eric Rout, David Kitson and Robert Harvey; (front row) George Hunt, Stanley Edwardson, Robin Davies and Peter Rainger*

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time of his retirement a year ago was general assistant to the director of engineering.

The Society's Geoffrey Parr Award was presented by Mrs. Parr to Eric Rout, head of electronics group, B.B.C., and his team' 'for their outstanding work in the development of the advanced field-store television standards converter". The team has also received the Queen's Award to Industry for this project. The system enables 525-line, 60-field N.T.S.C. colour signals to be converted to European 625-line 50-field PAL or SECAM standards. The equipment is now in regular use by the B.B.C. The inventor of the system, Robin Davies, received the Pye travelling scholarship, worth 1000 guineas, plus a trophy "for the most significant technical contribution during the year to the development of colour television". Mr. Davies, who is 34, joined the B.B.C. Research Department in 1958, and transferred to the Department's Television Group in 1963. He described the converter in our January 1969 issue.

The Baird Travelling Scholarship, worth £350 and financed by Radio Rentals, was received by Christopher Jeggo at present studying for a degree of philosophy at the Clarendon Laboratory, Oxford University Physics Department where he is engaged in research in non-linear optics.

## The Emley Moor Saga

March 19th, 1969: Tubular steel mast (1250ft) collapses; much speculation as to the economic consequences, some sources predict that Yorkshire Television will also collapse because of lost advertising revenue.

March 23rd, 1969: zip-up reduces embarrasment; Yorkshire TV once again on the air serving a reduced number of viewers thanks to a hurriedly installed 200ft zip-up aerial. Coverage quickly further increased due to the rapid commissioning of a relay station in Sheffield.

March 29th, 1969: first sections of a 675ft mast supplied by Sweden arrive at Manchester Airport. March 30th, 1969; Remainder of new aerial shipped into Hull.

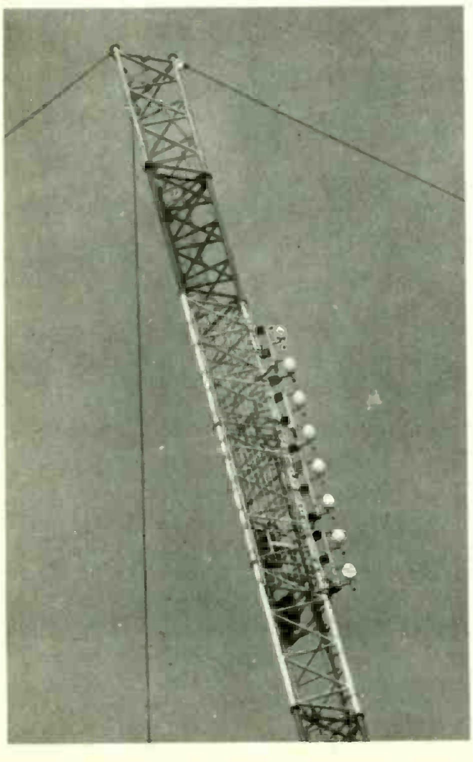
April 16th 1969: Y.TV. back on the air to all its viewers, "give or take a few hundred".

The precise cause of the failure of the original mast has still not been officially announced as an independent inquiry committee is still investigating.

The old mast, which was fully insured, cost about £300,000. The new mast, when it is fully equipped with u.h.f. aerials will cost something like £100,000. Studies are being carried out to determine the best ways of ensuring full u.h.f. coverage of the area.

Our comment; A darn good performance by all concerned!

*The business end of the new 675-ft mast. The aerial, consisting of full-wave dipole panels, was built and erected by E.M.I. in only 20 days.*



## Electronic page composing system

A great deal of the text in *Wireless World* is set on a photo-typesetter at our printers, Southwark Offset. Basically the text is translated to a digital form on a punched paper tape. This tape is fed into a computing system; which holds such details as column width, type size and other relevant information; and which produces another punch tape containing in addition to the text, control information for a photo-typesetter. The photo-typesetter responds to this tape and produces a film containing the text set to column width.

This film, together with film containing the photographs and drawings, is assembled on acetate sheets from which the printing plates for the offset press are produced using a photo-chemical process.

A system has just been devised by R.C.A. which enables the drawings as well as the text to be handled in digital form. This means that text and drawings (not photographs) can be assembled by a computing system and a film of a complete page can be produced in one go.

The text and drawings are digitized and reproduced on a high-resolution c.r.t. (1,800 lines per inch) and projected on to the film. The equipment, which is known as the Video Text 70/840, will also produce a microfilm of a complete page for storage purposes. Text is set at 6,000 characters per second.

A software package that can be used with the system enables computer tapes, originally intended to be reproduced by a standard line-printer, to be produced with various sized types (4 to 96 point) with bold headings, sub-headings, capitals or small letters and with footnotes.

## Integrated circuit lecture tour

This year's Mullard lecture tour, which will visit 76 centres in the U.K., deals with the use of integrated circuits in domestic appliances—radio, TV, cameras, cars, etc., and prophesies that each car built by 1975 will contain about 100 integrated circuits.

The Mullard lectures, intended for service technicians, have been going on now for nearly 15 years and it is expected that attendance this year will approach the quarter-of-a-million mark. The present session started in Southampton on May 5th.

## As components shrink companies expand

Following their recent acquisition of the Controls and Communications group of companies, Racal Electronics Ltd, have been doing some internal re-organization. Racal Communications have been brought together with BCC Ltd in a new company, Racal-BCC Ltd, that will be responsible for marketing for the three group companies concerned with radio communications (Racal-BCC Ltd Racal-Mobilcal and BCC). The new company will operate from premises at Bracknell.

Airmec Instruments Ltd has been amalgamated with Racal Instruments Ltd to operate as the Airmec division of that company.

In order to control central services used by members of the group, and to introduce new services as they are required, a new company, Racal Group Services Ltd, has been formed.

A sales office in Singapore, previously handling work for Racal Communications, has now been made into a company, Racal Electronics (Asia) Private Ltd. This is an addition to other Racal companies now existing in Australia, Canada, Germany, S. Africa and U.S.A.

## Space centre at Bristol

The Guided Weapons Division of the British Aircraft Corporation is building a centre at Bristol which will be used for the construction and testing of satellites and space systems. The first job to be undertaken at the new establishment is the building and testing of two Intelsat-4 communication satellites.

## I.R.D. and Imperial College collaborate

With the aid of a grant from the Science Research Council of £62,338 the International Research and Development Company and the plasma physics group of the Physics Department, Imperial College, London, are embarking on a study of non-equilibrium phenomena in a steadily flowing plasma.

One of the objects of the programme is to substantially increase the effective conductivity of a flowing plasma so that a strong interaction between the moving gaseous conductor and a magnetic field can occur.

Some of this work will be done using I.R.D's continuously flowing magnetohydrodynamic plasma apparatus in which very pure helium is circulated at velocities ap-

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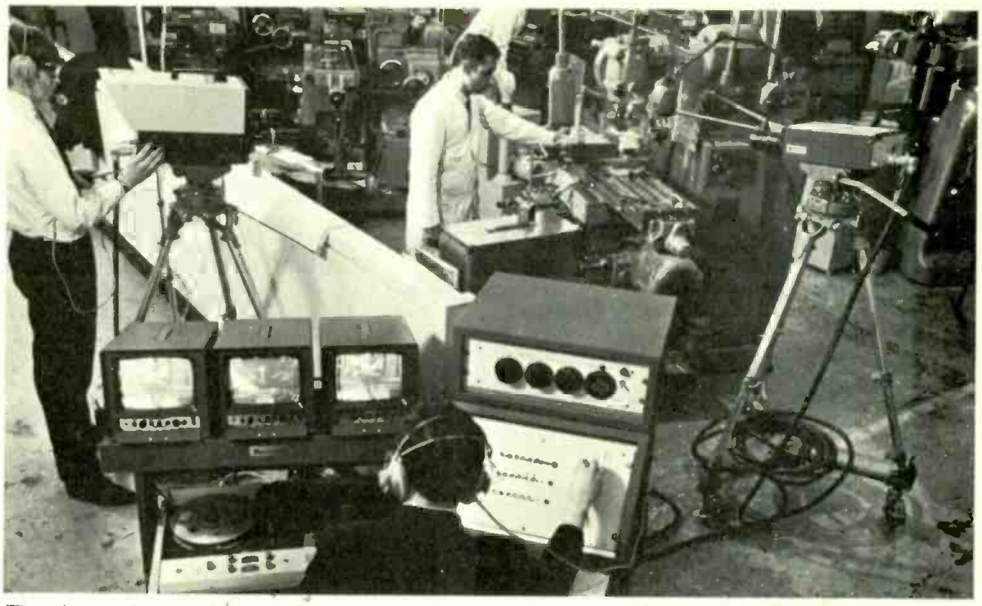
proaching Mach 1 at temperatures up to 2,000°K. The gas is "seeded" with a small amount of caesium vapour which partially ionizes to form an electrically conducting plasma.



*The picture shows a Marconi portable television recording unit (shown at ITEX 69) recording an industrial training film.*

## Solved! or instant jargon

It can now be revealed how some manufacturers and most public relations consultants (particularly American) manage to baffle us all with page after page of high-sounding-incomprehensible-text. They use the new Honeywell "Buzzphrase generator" which will produce a suitable sentence if fed a four digit word. For instance:— 7026 gives:— "Based on integral subsystem considerations a primary interrelationship between system and/or subsystem technologies maximizes the probability of project success and minimizes the cost and time required for the evolution of specifications over a given time period." Which might just as well be applied to a rabbit hutch or a computer.

## Appleton memorial lecture

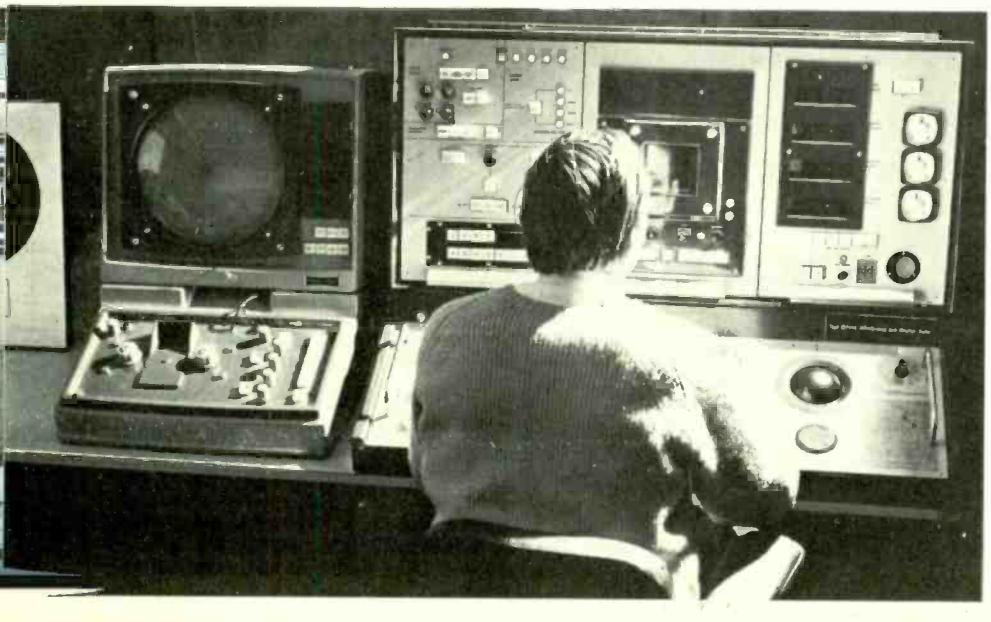
The Royal Society's British National Committee for Radio Science has proposed that at the triennial General Assemblies of the International Union of Radio Science an Appleton Memorial Lecture be delivered by a leading scientist working in the field of ionospheric physics. The lecture is to commemorate the work of the late Sir Edward Appleton, one of this country's foremost radio physicists and a pioneer in the field of ionospheric research, and particularly his long association with the International Union of which he was president from 1934 to 1952. The Royal Society is providing the honorarium to be awarded to the lecturer.

The first lecturer will be Professor W. I. Axford, of the University of California, distinguished for his contributions to upper atmospheric physics including his wind-sheer theory of the sporadic-E layer of the ionosphere. He will deliver his lecture at the General Assembly of the Union in Ottawa in August 1969.

## British companies at WESCON

Under the auspices of the Electronic Engineering Association, and within the Board of Trade joint venture scheme, fourteen British companies will be participating in the Western Electronics Show (WESCON) to be held at San Francisco in August. The firms are, A.E.I., AVO., B.P.L., Ekco, Ferranti, Hawker Siddeley Dynamics, Hellerman, Jermyn Industries, L.C.R. Components, M-O Valve, Racal, Rank, Redifon, and Stow Electronics.

*An order for close on £1M has been received by Plessey from the Commonwealth Bureau of Meteorology for 12 type WF44 meteorological radars. The photograph shows the control panel of one of the WF44 equipments.*



# Announcements

**"Microelectronics for the Circuit Designer"** is the title of a six-day residential course to be held at the University of Surrey from September 24th to October 1st. Details are obtainable from the Course Organizer, Department of Electrical and Control Engineering, University of Surrey, Guildford, Surrey. Fee £54.

**A.S.E.E.** The Association of Supervising Electrical Engineers has adopted the revised title "The Association of Supervisory and Executive Engineers" and membership will no longer be restricted to electrical engineers.

The Ministry of Technology, on behalf of the Ministry of Defence, has placed an order worth almost £400,000 with the Solartron Electronic Group Ltd, for an **Air Electronics Trainer** for the Royal Air Force.

**G.E.C. Electronic Tube Co. Ltd** has been formed to unite the activities of M-O Valve Co. Ltd and English Electric Valve Co. Ltd. Both M-OV and E.E.V. will continue to manufacture and market under their existing trade names.

Siliconix Incorporated of California, designers and suppliers of field-effect transistors, have announced a new wholly owned British subsidiary based in South Wales. The British company, **Siliconix Ltd,** will manufacture a similar line of products and will be responsible for marketing throughout Europe and the Commonwealth.

General Instrument Corporation of Delaware, U.S.A., has acquired **Vitality Bulbs Ltd,** of Bury St. Edmunds, Suffolk, manufacturers of miniature and sub-miniature electric bulbs.

The Plessey Company have acquired 49% of the equity in **Electroprints Ltd,** a wholly owned subsidiary of Painton & Co. Ltd. The joint company will continue as Electroprints Ltd, manufacturing flexible printed wiring for the electrical and electronics industry.

Ultra Electronics (Components) Ltd have acquired Ward Brooke & Co. Ltd as part of their expansion programme. The sales office for connector, terminal and wire-wrapping products will operate from **UECL/Ward Brooke Ltd,** Fassetts Road, Loudwater, Bucks.

**Technograph Printed Circuits Ltd,** of Fleet, Hants, have changed the name of the company to Technograph Ltd.

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# Wireless World Logic Display Aid

## 2: Details of the digital-to-analogue converters and some general information

*designed by B. S. Crank**

Last month a general outline description of the instrument was given and now the time has come to look at the individual circuits themselves. The first circuits to be studied will be the digital-to-analogue converters which produce the staircase X and Y waveforms mentioned last month.

The digital-to-analogue converters employ a current summing principle. Taking the Y dian as an example, each bistable in the counter controls a constant current generator via a buffer amplifier. The amount of current each constant current generator produces is directly related to the decimal weighting of the bistable that controls it. The counters operate in the natural binary code, which is sometimes known as the 1, 2, 4, 8 code. The constant current generators produce outputs of about 1, 2, 4 and 8mA.

Referring to Fig. 15, which illustrates the operating principles of the dians, it will be seen that all the constant current generators in a particular dian share a common load resistor. The voltage drop across this resistor will of course be directly proportional to the current flowing through it and as the resistor has a value of 1kΩ a current of 1mA will produce a drop of 1V.

In Fig. 15 the action of the bistables is simulated by switches. One of the constant current generators is connected directly to the negative line and will always have a current flowing through it; this is arranged to be 2mA. Therefore, with all the switches open the potential at the output will be 2V below the supply line voltage i.e. 25V.

If switches 2 and 4 are closed, as would be the case if the counter held 0110 ($=6_{10}$), an additional 6mA would flow through the load resistor, causing a voltage change at the output of 6V. If the switches are replaced by a counter it

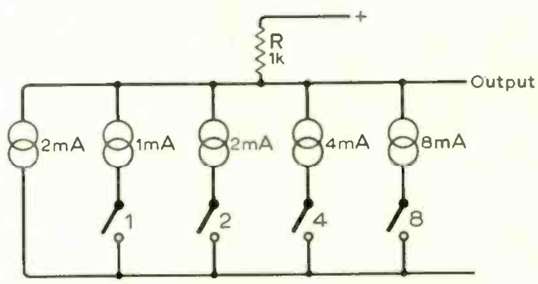



*Fig. 15. Demonstrating the principle employed in the dians.*

can be seen that the voltage output of the dian will be directly proportional to the contents of the counter and the output will alter 1V for each input pulse to the counter.

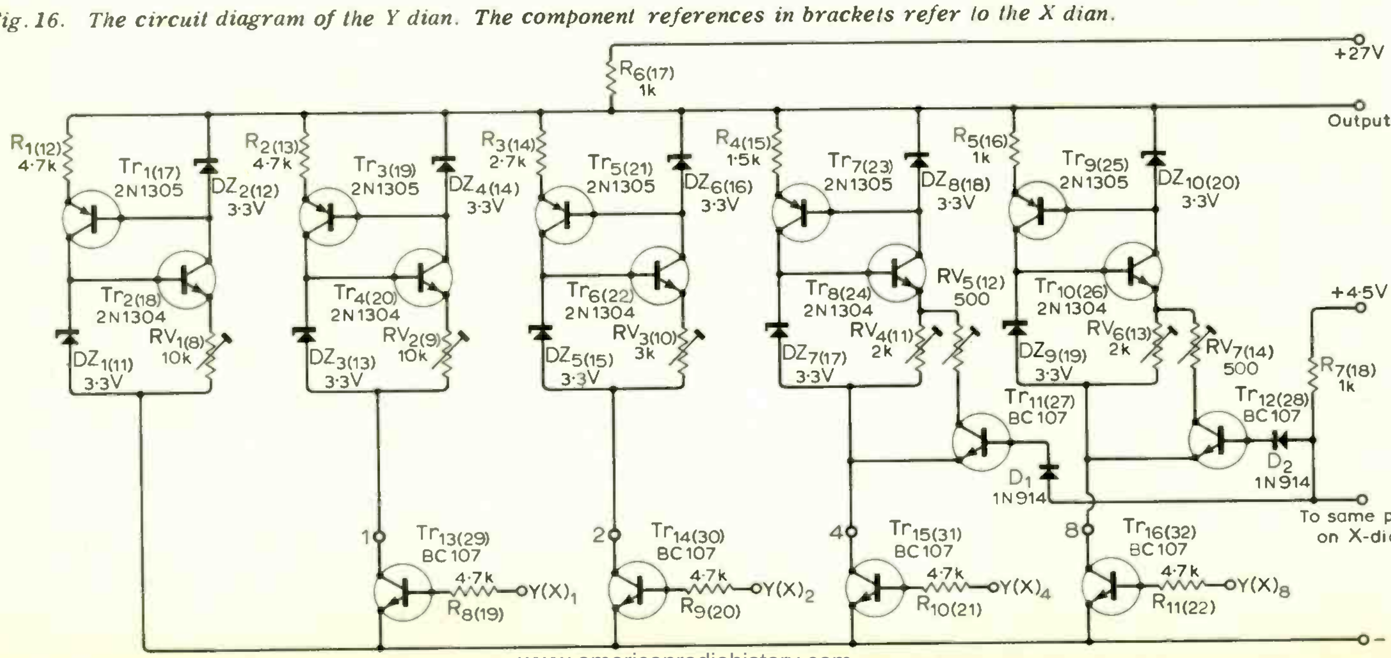
The constant current generator circuits were originally described in a Letter to the Editor, written by Peter Williams, which appeared in the September 1966 issue of *Wireless World*.

The complete circuit of the Y dian is shown in Fig. 16. The component reference numbers in brackets refer to the X dian, the circuit of which is identical.

The four switches of our example have been replaced by the BC107 transistors $Tr_{13-16}$ which are buffer amplifiers between the bistables in the counter and the

*Assistant Editor, *Wireless World*

*Fig. 16. The circuit diagram of the Y dian. The component references in brackets refer to the X dian.*

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constant current generators.

The five constant current generators, each consisting of a 2N1304 and 2N1305 complementary pair, can easily be identified. The variable resistors $RV_{1-3 \text{ and } 4-6}$ serve to adjust the precise current values.

Some additional circuitry; $Tr_{11,12}$, $D_{1,2}$ and $R_7$; has been incorporated and is associated with the 4 and 8mA constant current generators. The purpose of this is to modify the output of the dian to obtain the matrix raster shown in Fig. 13 last month to separate the characters in the Truth table and Karnaugh map modes of operation.

During Venn operation the bottom end of $R_7$ is connected directly to the negative line. $Tr_{11}$ and $Tr_{12}$ will be switched off and the dian will operate as previously described. For Truth table and Karnaugh operation the earth is removed from $R_7$ with the result that both $Tr_{11}$ and $Tr_{12}$ switch on by virtue of the current that will flow from the +4.5V line. The variable resistor $RV_5$ will be connected in parallel with $RV_4$ and $RV_7$ will be connected in parallel with $RV_6$. The effect of this will be to increase the current through 4 and 8mA constant current generators. In other words, when switched on, the once 4 and 8mA constant current generators will cause a voltage drop of more than 4 or 8V across the load resistor $R_6$. The dian now follows a 10, 5, 2, 1, law, as can be seen in Table 2.

**Table 2**

| Decimal Contents of counter | Venn mode Volts | Karnaugh/Truth mode Volts |
|---|---|---|
| 0 | 0 | 0 |
| 1 | 1 | 1 |
| 2 | 2 | 2 |
| 3 | 3 | 3 |
| 4 | 4 | 5 |
| 5 | 5 | 6 |
| 6 | 6 | 7 |
| 7 | 7 | 8 |
| 8 | 8 | 10 |
| 9 | 9 | 11 |
| 10 | 10 | 12 |
| 11 | 11 | 13 |
| 12 | 12 | 15 |
| 13 | 13 | 16 |
| 14 | 14 | 17 |
| 15 | 15 | 18 |

The effect on the output waveform is shown in Fig. 17. The steps in the staircase waveform when the counter holds 4, 8 or 12 are higher than the other steps. The dots on the matrix raster will be wider spaced at these points, which is what is required.

Some readers will consider that the circuit of the dian is over elaborate and may suggest that a resistive ladder network and amplifier should have been used. In defence of the circuit employed one must point out that it is accurate, stable, provides a high level of output and, most important, does not employ any difficult-to obtain precision components.

At one time during the development it was suggested that f.e.ts should be employed as the constant current sources; however, after some thought the idea was not used because f.e.ts would have had to be specially selected for particular values of $I_{DSS}$.

The form of construction employed is very clearly illustrated in Fig. 18. The base-board material is 0.15 inch pitch Veroboard. It is recommended that the dians are built as shown, as it will be found, later on in this series, that when built to this size the dians will fit in very nicely with the mechanical layout as a whole. An idea of this can be gained from Fig. 19 which shows the single

*Fig. 17. How the staircase waveforms are modified in the Truth table and Karnaugh map modes of operation.*

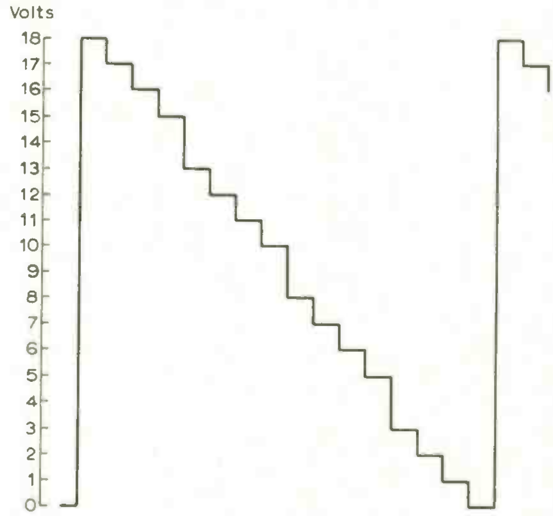



*Fig. 18. Physical layout of one dian. The base material is 0.15in unclad Veroboard.*

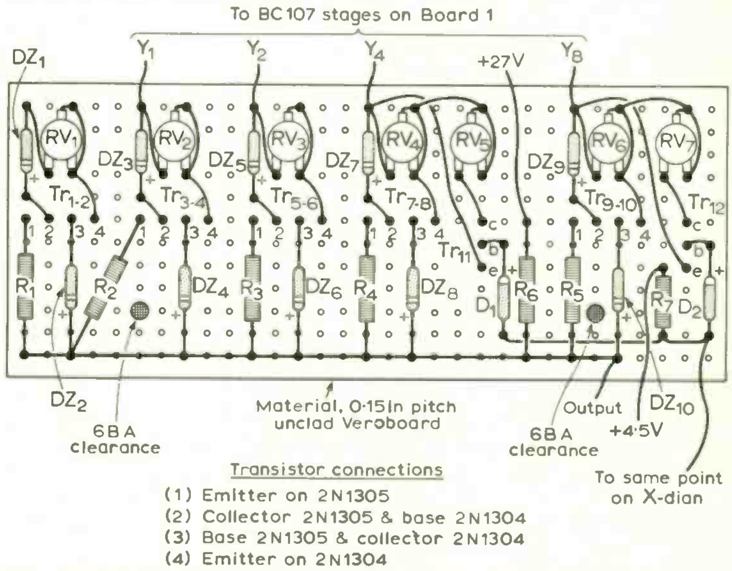
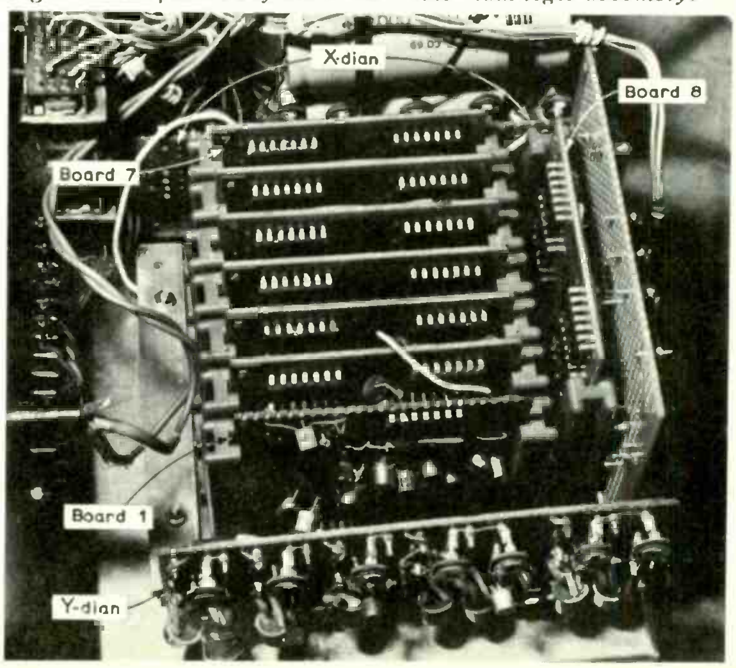



*Fig. 19. The position of the dians on the main logic assembly.*

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base board which holds both dians and the whole of the logic circuit for the rest of the instrument. A photograph of a completed dian is shown in Fig. 20.

There is only one point in the construction that requires particular attention. This arises from the fact that the cans of the transistors used are common to the collector lead. In order to prevent needless short-circuits it is recommended that the transistor cans be insulated in

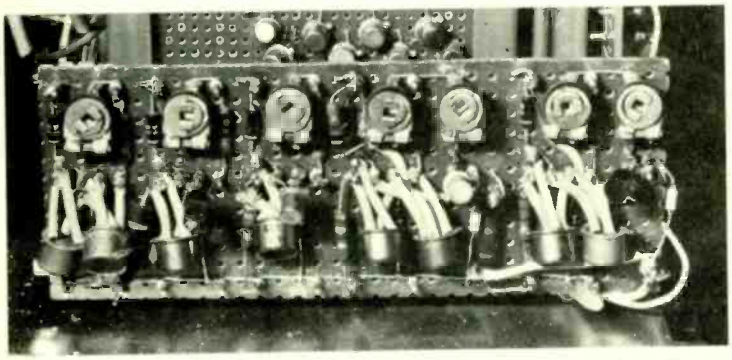

*Fig. 20. A completed dian. Sharp-eyed readers may notice that one of the transistors has been substituted for a different type. This was only because we ran out of stock of the specified type.*

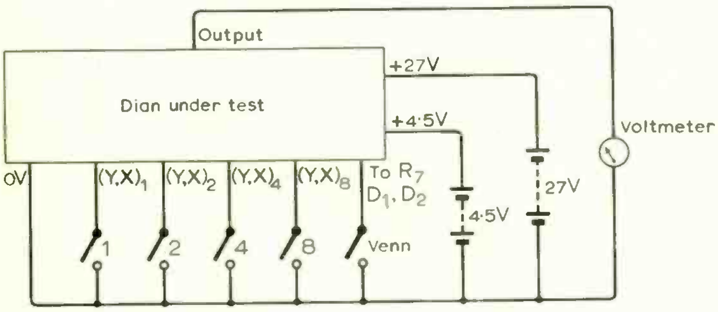


*Fig. 21. A dian test circuit.*

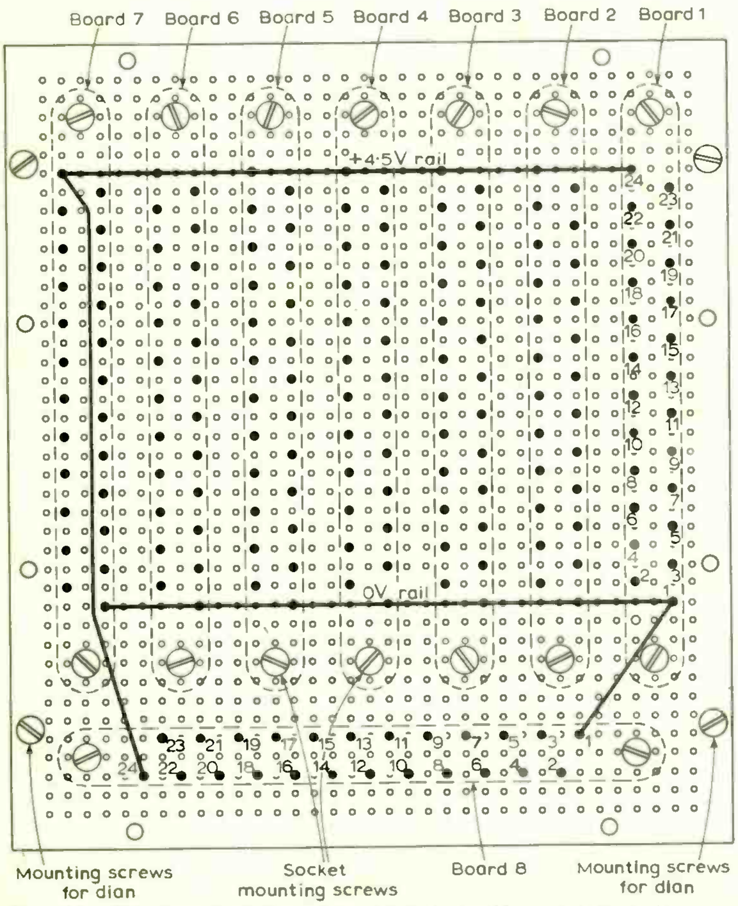


*Fig. 22. The layout of the circuit board sockets in the main logic unit.*

some way, say with a plastic or rubber sleeve or even with a turn or two of Sellotape. It will be noticed that the buffer amplifiers, $Tr_{13-16}$ and associated resistors are not included on the dian boards. These are located elsewhere and their description will be given later.

### Adjusting the dians

The dians are connected as shown in Fig. 21 *after turning all variable resistors to their maximum value*. The 27V can be supplied from three 9V batteries in series—PP9s are ideal—and the 4.5V can be supplied by a single battery. The switches 1, 2, 4 and 8 are connected to the points in the circuit with the same numbering (the BC107 collectors). The switch that has been labelled "Venn" is connected to the bottom end of resistor $R_7$, or $R_{18}$ in the case of the X dian. Go through the sequence of operations listed below.

(1) Open switches 1, 2, 4 and 8.

(2) Close Venn switch.

(3) Adjust $RV_{1(8)}$ to make meter read 25V.

(4) Close switch 1.

(5) Adjust $RV_{2(9)}$ to make meter read 24V.

(6) Open switch 1.

(7) Close switch 2.

(8) Adjust $RV_{3(10)}$ to make meter read 23V.

(9) Open switch 2.

(10) Close switch 4.

(11) Adjust $RV_{4(11)}$ to make meter read 21V.

(12) Open switch 4.

(13) Close switch 8.

(14) Adjust $RV_{6(13)}$ to make meter read 17V.

(15) Open Venn switch.

(16) Adjust $RV_{7(14)}$ to make meter read 15V.

(17) Open switch 8.

(18) Close switch 4.

(19) Adjust $RV_{5(12)}$ to make meter read 20V.

This setting up procedure is completed when it has been applied to both of the dians. The effect of combinations of switches being closed can be tried to illustrate the way in which the circuit works. This is best done with the Venn switch closed.

### General construction

The next job is to mount the sockets that will eventually take the various circuit boards. The sockets are screwed to a single sheet of perforated s.r.b.p. sheet (Lektrokit part no. LK-141). The positions of the sockets are given in Fig. 22 which shows the lower side of the board. Care must be taken to mount the sockets the right way round.

The boards containing the dians are attached to the edges of the main mounting board using four small metal brackets. Meccano brackets were used in the prototype. The exact positions of the dians can be seen in Fig. 19.

### Buffer amplifiers

The eight transistors, $Tr_{13-16}$ and $Tr_{29-32}$, are mounted on a piece of 0.1-inch pitch clad Veroboard which is called "board one". The Veroboard is cut to size using one of the integrated circuit mounting cards as a template. Care must be taken to ensure that the copper strips line-

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up accurately with the contacts of the socket when the board is plugged in.

The eight transistors and the eight associated 4.7kΩ resistors are mounted on the board as shown in Fig. 23. This drawing also shows the connections between socket one and the X and Y dians; these should be made at this stage.

It is possible that the settings of the variable resistors in the dians will have been upset during the assembly work. To check this and to check the operation of the buffer amplifiers wire up the circuit shown in Fig. 24 and repeat the dian setting-up procedure given earlier.

We will now proceed with a discussion of the circuit boards and the more general aspects of the integrated circuits used before going on to the logic design of the display aid next month.

### Circuit boards

A word or two about the plug-in boards would not be out of order at this stage. The numbering of the board input connections is shown in Fig. 25. With the printed side of the board towards you and the input side to the right the input pins are numbered from one to 24 from bottom to top. The printed conductors are used for the power supplies. The top line, from pin 24 is always the positive line and is connected to pin 14 of each integrated circuit without exception. The lower line is always the negative supply and is connected to pin seven of every integrated circuit, again without exception. Connection to the power supply lines is made by bending the appropriate integrated circuit pins over and soldering them directly to the printed power lines. This serves to hold the integrated circuits in position and prevents them from falling off the board.

In Fig. 25 and Fig. 26 it will be seen that each integrated circuit station on the board has been referenced with a number between one and six; this referencing holds good for every board. An integrated circuit may have the circuit reference IC4/B3. This is read as integrated circuit number four on board three. In the same way P12/B4 would indicate board input socket pin number 12 of board four. Finally, P12/IC4/B3 means pin 12 of integrated circuit number four on board three. It is important to recognise the difference between an integrated circuit input pin reference number and a board input pin reference number.

Wiring the boards is a task that deserves some thought on the part of the constructor as the reliability of the finished instrument depends on it. In the prototype 22 s.w.g. tinned copper wire was used and found to be excellent for the job. The type of sleeving used depends on the preferences of the individual constructor. In the prototype 0.5mm bore silicon rubber sleeving obtained from Radiospares was employed and was found to be pleasant to handle. Some readers may consider that the 1mm outside bore of this sleeving is a little on the large side.

The pins on the integrated circuits are only 2.54mm (0.1 inch) apart and can easily be bent. After one has wrapped a wire (or several) round each pin and applied the solder the clearance between pins is very much reduced. The moral is obvious—neat joints, with the minimum amount of solder consistent with a reliable connection.

The constructor is faced with the prospect of interconnecting on each board, with dozens of wires, six integrated circuits, each with 14 pins, and the 24 input pins of the wiring board. There are no "landmarks" in the form of unusually shaped resistors or capacitors to guide the way. Errors are easily made. Be warned!

The approach adopted with the prototype was to complete the inter-gate wiring first, followed by the circuit inputs and finishing with the outputs. In each case the pins to be interconnected can be identified with a small pencil

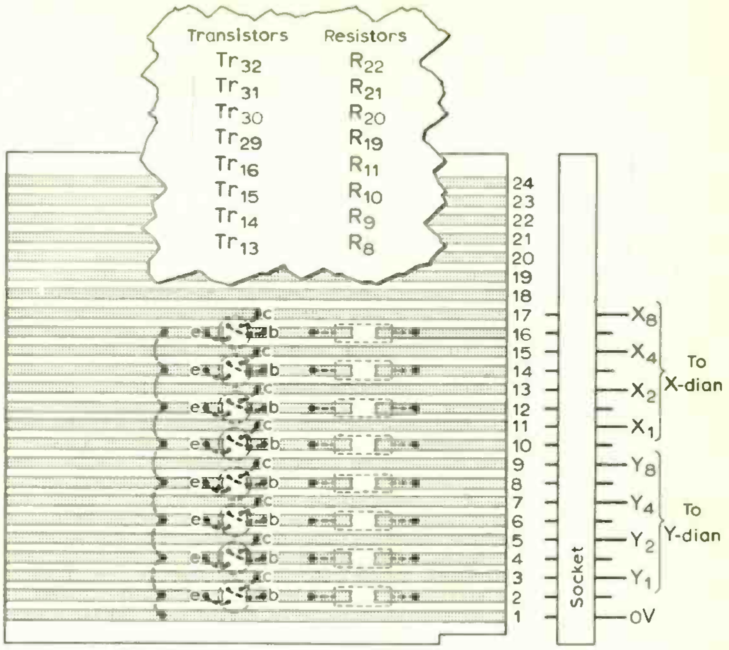


*Fig. 23. Construction of board 1 containing the buffer amplifiers. The vacant space will be used for other components later on in the construction.*

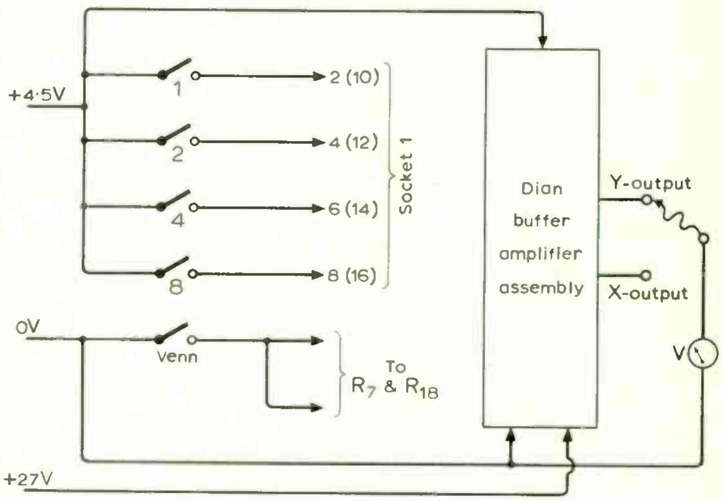


*Fig. 24. Buffer amplifier/dian test circuit.*

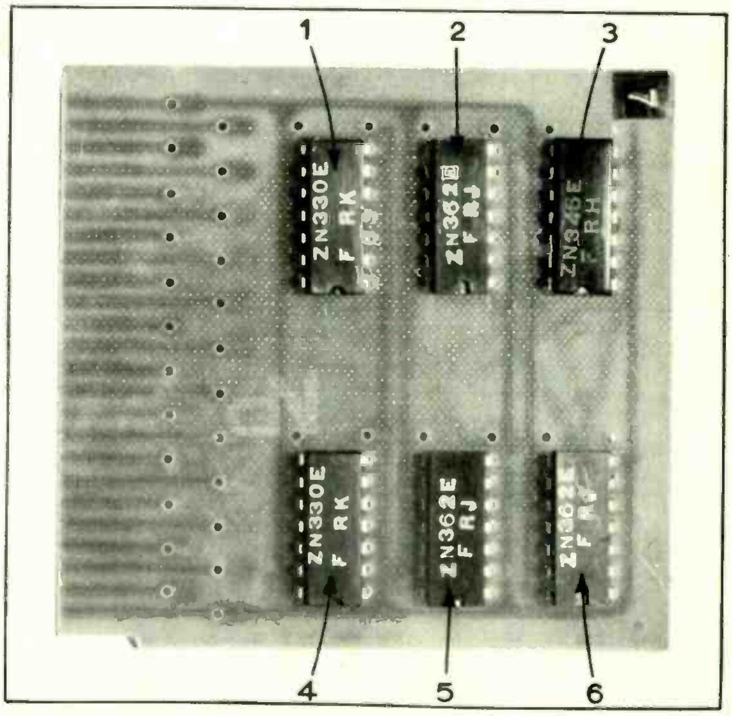


*Fig. 25. The component side of one of the circuit boards.*

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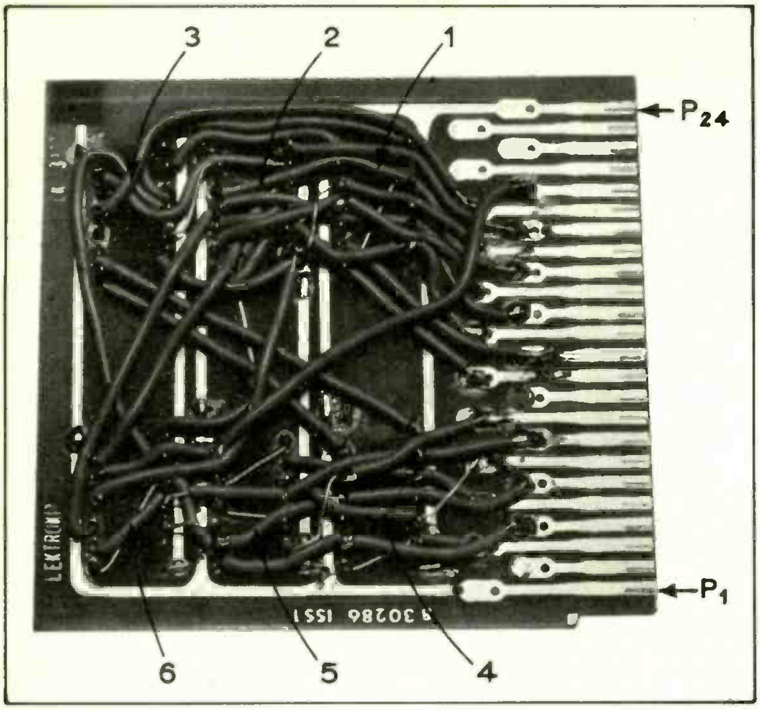
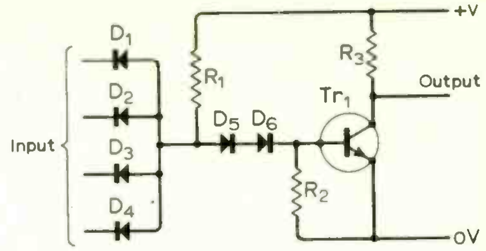



Fig. 26. The circuit side of one of the component boards. This is in fact board 7 which has less wiring than most of the other boards.

*Fig. 27. A conventional d.t.l. NAND gate.*



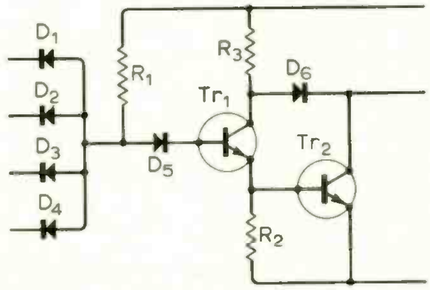




*Fig. 28. Circuit of a Micronor-2 NAND gate.*

mark on the board adjacent to the required pins. The best route for the wire to take, consistent with neatness, is then planned and the relevant connections made. As each connection is dealt with it is good practice to mark the fact with a tick on the circuit diagram. In this way wires should not be omitted.

### Integrated circuits

The use of integrated circuits is more than justified in amateur constructional projects even if one forgets the performance advantages and works only on the cost. Each gate consists of two transistors, four diodes and three resistors. The constructor would not be able to produce a similar circuit at an equivalent price in discrete components. And of course, when using integrated circuits, one has the advantage of a guaranteed performance and small size.

The integrated circuits are from the Ferranti Micronor—2 family of diode-transistor logic. As discussed earlier, in the introductory article, the basic gate performs the positive logic NAND function.

The circuit of the basic gate used in Micronor-2 departs slightly from the conventional NAND circuit and is worthy of mention. A conventional d.t.l. NAND gate is shown in Fig. 27. With all the input diodes at a potential around 4V, the normal logical 1, $Tr_1$ is switched on by the current flowing through $R_1, D_5, D_6$ and the base emitter junction of $Tr_1$. The output therefore, will be at earth potential or at logical 0. The drive to the transistor is limited by $R_1$. Thus to achieve high fan-out, that is the number of gates that can be driven from the output, over the operating temperature range the output transistor must be a high-gain device. This is not only undesirable in terms of process yield but additionally generates excess stored charge in the low fan-out condition, severely limiting operating speed.

When one of the input diodes is earthed the base emitter junction of $Tr_1$ is effectively short circuited and the transistor switches off. The diodes $D_5$ and $D_6$ act as voltage level shifters to cancel out the effect of the small voltage developed across the now conducting input diode.

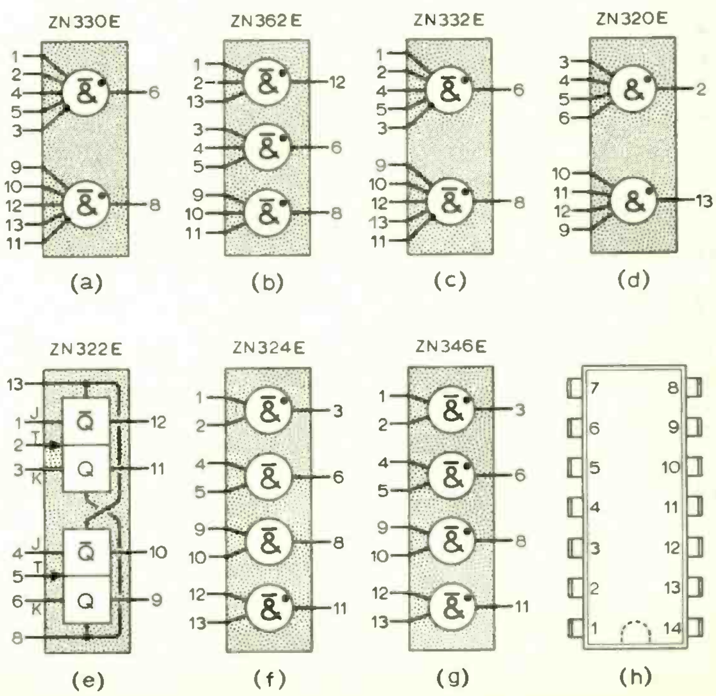
The circuit is modified slightly in Micronor-2 as shown in Fig. 28. Additional drive to the output transistor $Tr_2$ is provided by replacing one of the original level shifting diodes by the transistor $Tr_1$. When the output is unloaded the current flowing through $R_3$ is shared equally through two essentially identical impedance paths. Half the current flows through the saturated collector emitter junction of $Tr_2$. Under these conditions base drive to $Tr_2$ is at a minimum resulting in low propagation delays at low fan-out.

When the output is fully loaded, the flow of load current into $Tr_2$ sets up an additional voltage drop across the saturation resistance of $Tr_2$, providing maximum base drive.

Thus the circuit functions in a feedback manner and correctly proportions the base drive to suit the particular load current. This allows the use of a much lower gain output transistor and aids operating speed.

The basic gate has a fan-out of eight and a propagation delay of the order of 15ns. Two different power gates are used when a fan-out of more than eight is required; one performs the NAND function and the other the AND function (described as OR in the literature). The power gates have a fan-out of 25. Both types of gates can be supplied with or without an internal load resistor. Where no load resistor is used the gate output is intended to be connected directly to the output of another gate so that they

Fig. 29. Pin connection details of the i.cs used in the instrument. A dot in a gate denotes that it contains a load resistor.

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### Components list for basic instrument

The majority of the components are divided into kits for ease of ordering. The prices quoted have been specially negotiated by *Wireless World* and represent extremely good value for money. It is important to note that these prices apply at the time of going to press and only for complete kits.

**Kit LDA/A. Integrated circuits**
Price £33-15-0 Ferranti Ltd., Gem Mill, Chadderton, Oldham, Lancs.

| board | IC reference number | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| 1 | ZN330E | — | — | — | — | — |
| 2 | ZN324E | ZN324E | ZN324E | ZN324E | ZN322E | ZN330E |
| 3 | ZN320E | ZN324E | ZN322E | ZN320E | ZN332E | ZN322E |
| 4 | ZN332E | ZN320E | ZN346E | ZN324E | ZN322E | ZN346E |
| 5 | ZN346E | ZN362E | ZN346E | ZN346E | ZN362E | ZN362E |
| 6 | ZN330E | ZN362E | ZN346E | ZN330E | ZN362E | ZN346E |
| 7 | ZN330E | ZN362E | ZN346E | ZN330E | ZN362E | ZN362E |
| 8 | ZN330E | ZN362E | ZN346E | ZN330E | ZN362E | ZN346E |

**Kit LDA/E. Resistors and Hardware**
Price £9-10-0 Home Radio (Components) Ltd., London Rd., Mitcham, Surrey.

**Lektrokit**

| qty. | | part no. |
|---|---|---|
| 7. | P.C. Board Cardic 6 | LK3111 |
| 8. | Gard guide (pair) | LK2281 |
| 9. | Edge connector | LK2271 |
| 1. | Chassis plate | LK141 |

**Resistors** (variable)
The prefix *RV* has been omitted in the list below. All values in ohms.

| | | | | | |
|---|---|---|---|---|---|
| 1. | 10k | 6. | 2.5k | 11. | 2.5k |
| 2. | 10k | 7. | 500 | 12. | 500 |
| 3. | 5k | 8. | 10k | 13. | 2.5k |
| 4. | 2.5k | 9. | 10k | 14. | 500 |
| 5. | 500 | 10. | 5k | 15. | 100 |

All variable resistors are type VR100A except $RV_{15}$ which is type VR25.

**Kit LDA/B. Semiconductors**
Price £11-10-0 LST Electronic Components Ltd., 7 Coptfold Rd., Brentwood, Essex.

The reference numbers for all the transistors are prefixed *Tr*, this has been left off below for the sake of clarity

| | | | | | |
|---|---|---|---|---|---|
| 1. | 2N1305 | 13. | BC107 | 25. | 2N1305 |
| 2. | 2N1304 | 14. | BC107 | 26. | 2N1304 |
| 3. | 2N1305 | 15. | BC107 | 27. | BC107 |
| 4. | 2N1304 | 16. | BC107 | 28. | BC107 |
| 5. | 2N1305 | 17. | 2N1305 | 29. | BC107 |
| 6. | 2N1304 | 18. | 2N1304 | 30. | BC107 |
| 7. | 2N1305 | 19. | 2N1305 | 31. | BC107 |
| 8. | 2N1304 | 20. | 2N1304 | 32. | BC107 |
| 9. | 2N1305 | 21. | 2N1305 | 33. | BC108 |
| 10. | 2N1304 | 22. | 2N1304 | 34. | BF179 |
| 11. | BC107 | 23. | 2N1305 | 35. | 2N3404 |
| 12. | BC107 | 24. | 2N1304 | 36. | 2N3055 |

**Diodes**

| | |
|---|---|
| $Dz_{1-20}$ | 3.3V, 250mW, zener diodes |
| $D_{1-2}$ | 1N914, or anly small silicon diode |
| $D_{3-4}$ | BXY10, Mullard |
| $D_5$ | SJ103 |

**Kit LDA/C. Miscellaneous**
Price £4-10-0 G.W. Smiths (Radio) Ltd., 3 Lisle St., London, W.C.2.

| qty. | |
|---|---|
| 2 | Radio press button unit 3 button, 3 pole C/O |
| 2 | Terminal unit SLT4 |
| 2 | Terminal unit SLT2 |
| 3 | Coaxial plug L1465/FP |
| 3 | Coaxial socket L1465/CS |
| 1 | Transformer type MT103AT |
| 1 | Heat sink |
| 1 | Toggle switch (TS1) |

**Kit LDA/D. Cabinet**
Price £8-19-0 Bedco Ltd., Datumn Division, Colne Way Trading Estate, Watford, Herts.

Cabinet DA 3U12/6 (mushroom top)

Chassis SC3126

**Resistors** (fixed)
The reference number of all resistors is prefixed *R*, this has been left off below for the sake of clarity. All values in ohms.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1. | 4.7k | 7. | 1k | 13. | 4.7k | 19. | 4.7k |
| 2. | 4.7k | 8. | 4.7k | 14. | 2.7k | 20. | 4.7k |
| 3. | 2.7k | 9. | 4.7k | 15. | 1.5k | 21. | 4.7k |
| 4. | 1.5k | 10. | 4.7k | 16. | 1k | 22. | 4.7k |
| 5. | 1k | 11. | 4.7k | 17. | 1k | 23. | 150 |
| 6. | 1k | 12. | 4.7k | 18. | 1k | 24. | 180 |

All resistors ¼W with the exception of $R_{24}$ which is 2W

**Capacitors**
The prefix *C* has been omitted in the list below

| | | | |
|---|---|---|---|
| 1. | 0.05μF, 12V | 5. | 500μF, 50V |
| 2. | 0.05μF, 12V | 6. | 0.01μF, 50V |
| 3. | 100μF, 100V | 7. | 10μF, 50V |
| 4. | 100μF, 100V | 8. | 5,000μF, 25V |

**Thick film power supply**
Price £6-13-6 Beckman Instruments Ltd., Glenrothes, Fife, Scotland.
type 809-V27

operate in parallel. This type of connection is called "Wired OR" and will be discussed in more detail in the section on NAND logic which follows.

It is not proposed to discuss the J-K flip-flop in any detail at all here. In the display aid the J-K facility is not employed and the flip-flops are only used as standard toggle bistables. In the article the term bistable will be used in preference to flip-flop.

The different types of integrated circuits used, together with the pin connection details are shown in Fig. 29.

### NAND logic

If two variables A and B are fed to the input of a NAND gate the output, as we saw in the section on positive and negative logic, is false when the condition AB exists. This of course is the negative of the AND function.

If the two input variables are $\bar{A}$ and $\bar{B}$ then the output is given by $\bar{A}\,\bar{B}$:

$$X = \overline{\bar{A}\,\bar{B}}$$

$$= \bar{\bar{A}} + \bar{\bar{B}} \text{ (De Morgan's Theorem)}$$

$$= A + B \text{ (double negatives)}$$

In other words the OR function is performed. Consider the circuit of Fig. 30. The output of gate (a) will be $\bar{A}B$ and the output of gate (b) will be $A\bar{B}$. These will be combined in gate (c) to produce:

$$X = \overline{\overline{\bar{A}\,B}.\overline{A\,\bar{B}}}$$

$$= \overline{\overline{\bar{A}\,B}} + \overline{\overline{A\,\bar{B}}} \quad \text{(De Morgan's Theorem)}$$

$$= \bar{A}\,B + A\,\bar{B}$$

In general, when using NAND logic, the first stage of gating performs the AND function and the second stage gives OR. Subsequent odd stages give AND and even stages give OR.

From the earlier example gates (a) and (b), Fig. 31, will produce the functions AB + CD and EF + GH. The expressions will be combined in gate (c) to give:

$$\overline{(AB + CD)\,(EF + GH)}$$

Gate (d) will merely invert this to give:

$$(AB + CD)\,(EF + GH)$$

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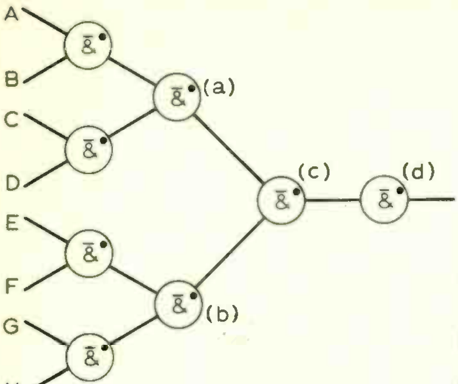


Fig. 31

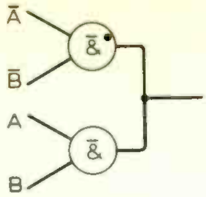


Fig. 30

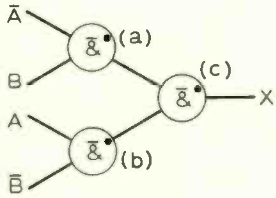


Fig. 32

*Fig. 30. A typical NAND circuit.*
*Fig. 31. Another NAND circuit described in the text.*
*Fig. 32. The wired OR connection.*

In the section on integrated circuits it was stated that some of the gates were supplied without an integral load resistor so that the "wired OR" function could be performed. In the logic diagrams the presence of a load resistor in a particular gate is denoted by a dot in the circle representing the gate.

The "wired OR" connection is performed by connecting gate outputs in parallel as shown in Fig. 32. Gates without load resistors are paralleled with a gate with a load resistor. A moment's thought will show that the output of such a combination cannot be "up" until the outputs of all the gates in parallel are "up". The function performed by the circuit of Fig. 32 can be written as:

$$\overline{\bar{A}\,\bar{B} + A\,B}$$

Now:

$$\overline{\bar{A}\,\bar{B} + A\,B} = \overline{\bar{A}\,\bar{B}}.\overline{A\,B} \quad \text{(De Morgan's Theorem)}$$

$$= (\bar{\bar{A}} + \bar{\bar{B}})\,(\bar{A} + \bar{B}) \quad \text{(De Morgan's Theorem)}$$

$$= (A + B)\,(\bar{A} + \bar{B}) \quad \text{(double negatives)}$$

$$= A\,\bar{B} + \bar{A}\,B$$

This is the same result that was achieved with the circuit of Fig. 30; however, one gate fewer was used. "Wired OR", therefore, can result in fewer gates being needed to perform a particular function.

An expression in AND/OR form can easily be converted into NAND form by repeated use of De Morgan's theorem:

$$(A\,B\,C + D\,E\,F)\,(G\,H\,I + J\,K\,L) + (M\,N\,O + P\,Q\,R)$$

$$= \overline{\overline{A\,B\,C}.\overline{D\,E\,F}}.\overline{\overline{G\,H\,I}\;\overline{J\,K\,L}} + \overline{\overline{M\,N\,O}.\overline{P\,Q\,R}}$$

$$= \overline{\overline{\overline{\overline{A\,B\,C}\;\overline{D\,E\,F}}\;\overline{\overline{G\,H\,I}\;\overline{J\,K\,L}}}\;\overline{\overline{\overline{M\,N\,O}\;\overline{P\,Q\,R}}}}$$

which reduces to:

$$\overline{\overline{\overline{\overline{A\,B\,C}\;\overline{D\,E\,F}}\;\overline{\overline{G\,H\,I}\;\overline{J\,K\,L}}}\;\overline{\overline{M\,N\,O}\;\overline{P\,Q\,R}}}$$

**Next month:** The logic design and construction of the counter and code converter.

# Wireless World Reprints

In response to the demand for issues of *Wireless World* which are now out of print we have prepared reprints of several of the more popular constructional articles. This service will be particularly useful to new readers or those who, not having a regular order for *Wireless World*, have found that, by the time they hear that a certain issue contains something of interest to them, it is out of print. Reprints of articles of educational interest, enable instructors to have enough copies to distribute round the class, and of course when a series is involved it is much handier to have all the information together in one booklet. Readers who have already built the equipment will find the booklets useful as manuals—especially if it is intended to sell the equipment at a later date. The reprints are listed below and may be obtained from the Trade Counter, Dorset House, Stamford Street, London S.E.1. Prices include postage and packing

No. 1. **High-fidelity Amplifiers** by A. R. Bailey (Nov. and Dec. 1966, and May, June and Nov. 1968). *This reprint is still in preparation and an announcement will be made as soon as it is available.* It will contain articles on 20- and 30-W amplifiers; a pre-amplifier; and an article on output transistor protection plus modifications relevant correspondence.

No. 2. **Stereo Decoder and Simulator** by D. E. O'N. Waddington, (Jan. and Oct. 1967). Describes the construction of a stereo decoder for positive or negative power supplies and contains details of an instrument for producing a stereo multiplex signal. Price 3s.

No. 3. **Portable 1-MHz Frequency Standard** by L. Nelson-Jones (Feb. 1968). Presents a design for a frequency standard which is phase locked to the 200kHz Light Programme transmissions. Price 3s.

No. 4. **Wide-range General Purpose Signal Generator** by L. Nelson-Jones (April 1968). Range 150kHz to 120MHz in five bands; output attenuator range 100dB in 20dB steps ($\pm$0.5dB); modulation depth 0 to 50% (can be set to within $\pm$5% of meter indication); max. output 100mV (from 75Ω). Price 3s.

No. 5. **Low-cost High-quality Loudspeaker** by P. J. Baxandall (Aug. and Sept., 1968). Can be built for a few pounds! Excellent performance above 100Hz but is improved if used with a woofer for the low frequencies. Price 5s.

No. 6. **Wireless World Crosshatch and Dot Generator** (Sept. 1968). A pocket sized instrument using digital integrated circuits. Price 3s.

In addition, the following reprints from earlier issues are still available:

**Wireless World Oscilloscope:** Main frame, X amplifier, E.H.T. unit (March June, July and August 1963), price 5s; No. 1. (audio) Y amplifier (Apri 1963), price 2s 6d; No. 1. (audio) Timebase Unit (May 1963), price 2s 6d Calibration—Alternative E.H.T. Unit (Feb. and Oct. 1964), price 2s 6d; anc Wide-band Amplifier (April 1964), price 2s 6d.

**Wireless World Audio Signal Generator** (Nov. and Dec. 1963). Price 3s.

**Wireless World Crystal-controlled F.M. Tuner** (July 1964). Pulse countin type not suitable for stereo. Price 3s.

**Transistor High-quality Audio Amplifier** by J. Dinsdale, (Jan and Feb. 19 Very popular 10W design. Price 5s.

**Wireless World Computer** (Aug. to Dec. 1967). Eight-bit digital machine for instructional purposes. Price 10s.

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# Quasi-complementary Output Stage Modification

## A single diode used to overcome distortion at low listening levels

*by I. M. Shaw**

The quasi-complementary output stage (Fig. 1) has differing input impedances for its upper and lower halves. This is because there are two emitter-base junctions in series in the upper half, but only one in the lower half. In the configuration of Fig. 2 it can be seen that the lower has an input impedance consisting of one emitter-base junction and one forward-biased diode in series, which in practice should approximate to two emitter-base diodes in series. Thus it should be possible to construct a low distortion transformer-less output stage using one pair of low-current complementary transistors and one pair of identical output transistors.

An amplifier with an output stage similar to that in Fig. 1 was constructed, and the distortion levels measured down to 2mW output at quiescent currents of 7mA, 20mA and 80mA. The distortion was measured using a wave analyser (Marconi TF2330) and a low distortion generator (Marconi TR2100/1M1).

The results of the measurements are given in Fig. 3. From these it can be seen that at the normal quiescent current for class B operation (20mA) the total harmonic distortion rises to approximately 1% at 15mW output from 0.1% at full output. This distortion is clearly well above the accepted limit for high-quality reproduction and it can be seen to reduce as the quiescent current is increased towards class A conditions.

An amplifier was constructed with Fig. 2 as a basis, the complete circuit of which is given in Fig. 4. This second amplifier, which had the same amount of negative feedback as the previous amplifier, gave the results indicated in Fig. 5 at 20mA quiescent current.

*Wellbrook Engineering Electronics Ltd.

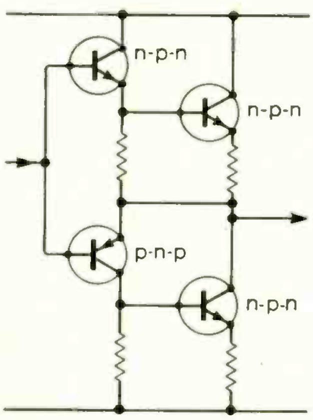


*Fig. 1. Typical quasi-complementary output stage.*

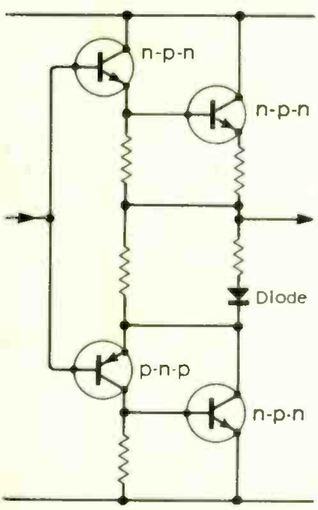


*Fig. 2. Modified quasi-complementary output stage.*

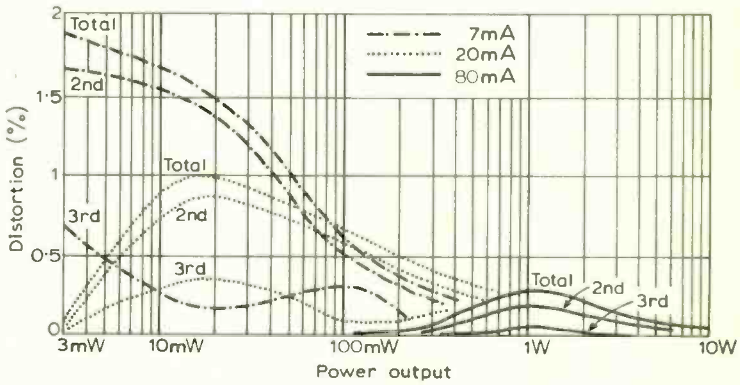


*Fig. 3. Distortion characteristics of conventional amplifier with 7mA, 20mA, and 80mA quiescent current.*

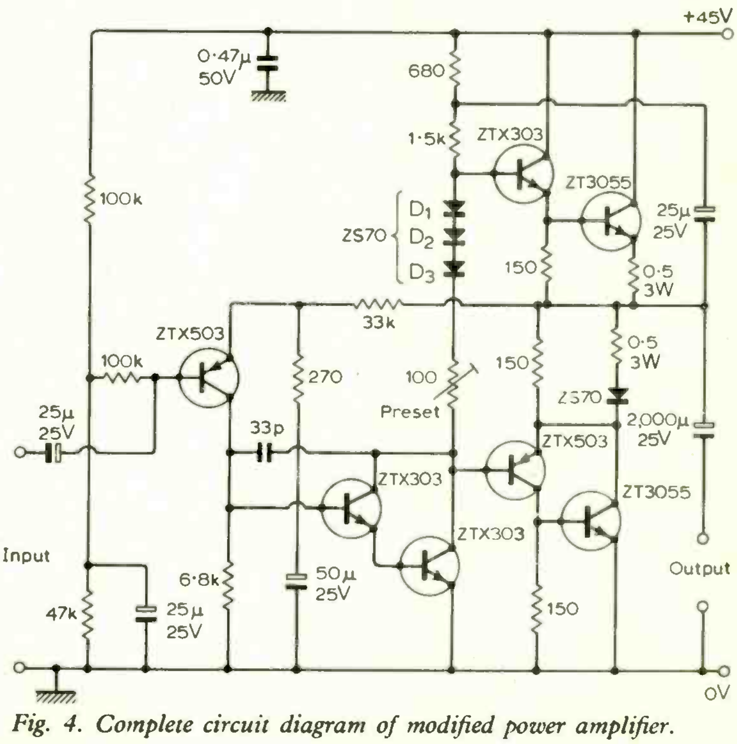


*Fig. 4. Complete circuit diagram of modified power amplifier.*

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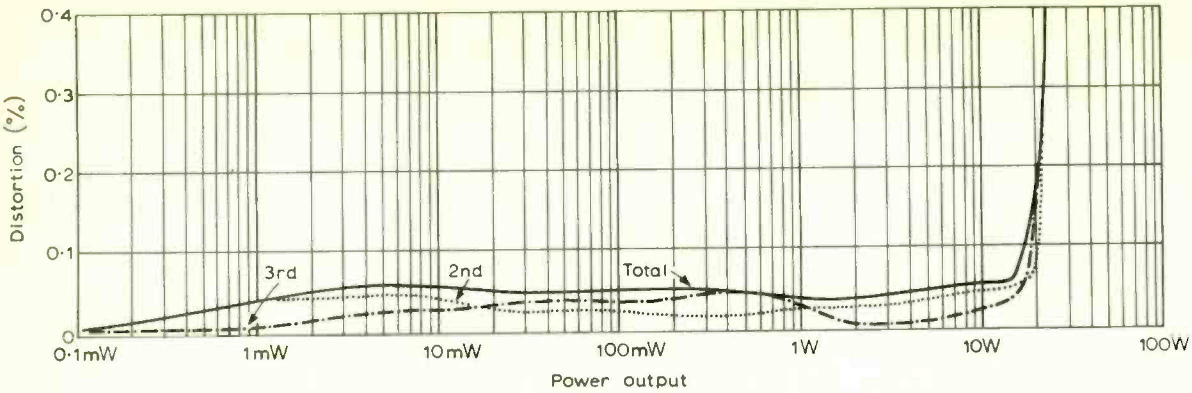


*Fig. 5. Distortion characteristics of modified amplifier at 20mA quiescent current.*

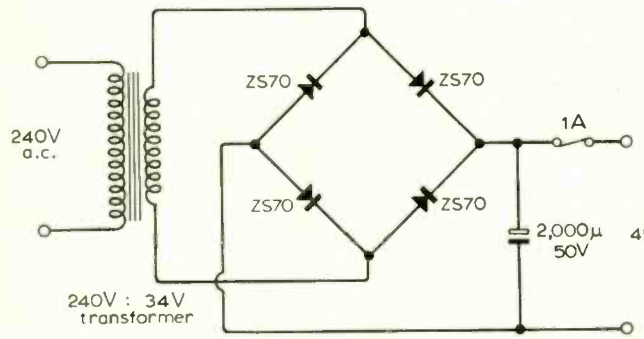


*Fig. 6. Simple power supply used with amplifier.*

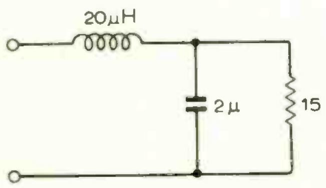


*Fig. 7. Test circuit equivalent to Quad electrostatic speaker.*

The amplifier was operated from a simple unstabilized power supply (Fig. 6), and the d.c. level at the output was set below half of the supply voltage so that the output voltage at full output would not be clipped due to the ripple-limited positive rail.

It can be seen from Fig. 5 that the distortion level does not rise, down to a measured output of 100μW, thus showing that the extra diode has equalized the input impedances giving a fourth and cheap alternative output stage for true high-quality reproduction.

The amplifier has successfully driven a Quad electrostatic loudspeaker without any instability and tests were carried out with the latter and with the simulated circuit (Fig. 7) which is the salient part as regards high frequency instability.

Above 15W output the supply rails clip the output voltage giving rise to a large increase in the harmonic distortion levels, but up to this point the distortion level is extremely low.

# Literature Received

### CATALOGUES

**Connector Catalogue.** The Electronics Division of Greenpar Engineering Ltd., Station Works, Harlow, Essex, have produced a large catalogue devoted to various types of coaxial, twin-axial, and tri-axial connectors. In all variations on eight basic patterns are described and performance data given. **WW 400** for further details.

**"SGS Linear Microcircuits"** is a catalogue published by Quarndon Electronics (Semiconductors) Ltd, Slack Lane, Derby, which gives brief technical data, prices and application notes for a range of SGS devices including operational amplifiers, current sources, comparators, A/D and D/A converters. **WW 401** for further details.

**"Lemosa Cable Connector Catalogue"** gives details of a range of multi-contact, coaxial, tri-axial, bulkhead and thermocouple connectors which have a spring locking action. The catalogue contains an offer whereby you send them a cable and they will send you a connector to suit it. Lemosa Ltd, Box 306, Shoreham-by-Sea, Sussex. **WW 402** for further details.

**"He-Ne Lasers".** The Ferranti range of d.c. excited Helium-Neon lasers are described in this publication which is available from Ferranti Ltd, Laser Sales, Dunsinane Avenue, Dundee, DD2 3PN. **WW 403** for further details.

**"$CO_2$ Lasers"**, also from Ferranti, are described in a leaflet available from the above address. **WW 404** for further details.

**"Catalogue of Used Scientific Equipment"** includes second-hand vacuum equipment, laboratory instruments, etc., available from V. N. Barrett and Co. Ltd, 1 Mayo Rd, Croydon, CRO 2QP. **WW 405** for further details.

Supplement No. 3 to the ITT (S.T.C.) Electronic Services **components catalogue** has been published and lists the International Rectifier range of semiconductors. ITT Electronic Services, Edinburgh Way, Harlow, Essex. **WW 406** for further details.

**"ISEP-ITT Standard Equipment Practice"** is an 80-page booklet, available from the above address, which shows how numerous cabinets and equipment racking systems can be made up from ISEP. **WW 407** for further details.

### GENERAL INFORMATION

**"Consumer Electronics"** is the title of a new quarterly magazine from Mullard. It covers radio and television and the use of electronics in other appliances: electric blankets, washing machines, toys, watches, etc. C.I.H./C.M.S. Dept., Mullard Ltd, Mullard House, Torrington Place, London W.C.1. **WW 408** for further information.

**BS 4421:1969**, "Digital input/output interface for data collection systems" is a development of a system devised by the National Physical Laboratory to enable their measuring and data processing devices to be easily set-up and connected for any particular application. Copies are available from BSI Sales Branch, 101/113 Pentonville Road, London N.1, price 12s.

**"Export Markets for Electronics—E.F.T.A."** is a 57-page booklet which has been produced by the Economic Development Committee for the Electronics Industry. It contains a great deal of interesting statistical information covering the market for electronic products and scientific instruments in E.F.T.A. countries. The Library, National Economic Development Office, 21/24 Millbank, London S.W.1. **WW 409** for further details.

Choice of careers booklet No. 66—**"Radio and Television Servicing"** has been produced by the Department of Employment and Productivity. It is available from H. M. Stationery Office, price 1s 9d.

**"Become an Apprentice Technician with NATCS"** is the title of a pamphlet produced by the Board of Trade for the National Air Traffic Control Service's Technician Apprenticeship Scheme. It can be obtained from T. H. Mallett, Board of Trade (Civil Aviation Dept) Room 705, The Adelphi, John Adam St, London, W.C.2.

In last month's Literature Received we inadvertently gave the address of the advertising agents for Vitality Bulbs. Requests for information should be sent to:—Beetons Way, Bury St. Edmunds, Suffolk.

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# Wireless World Units Converter

## An aid to radio and electronics calculations

Available to readers of this issue (see coupon below) is a "slide rule" units converter specially designed by *Wireless World's* technical staff as an aid to calculation in radio and electronics work. Produced for us by the slide-rule manufacturers Blundell Harling Ltd, the instrument has 20 conversion scales, and other data, clearly engraved in rigid p.v.c., a plastic noted for its good mechanical stability and hard wearing quality. The scales are sufficiently expanded to give the degree of reading accuracy normally needed in each case (typically 0.5% of full scale), but the converter is small enough ($7\frac{1}{2}$in long, 3in wide) to be carried in a jacket pocket. The laws and limits of the scales have been decided on the basis of practical experience in various calculations. At the price of 12s 6d the converter is substantially cheaper than it would be if sold retail. In fact there is no equivalent instrument available on the market.

The converter provides the following facilities:

**Wavelength/frequency.** Two pairs of $\log_{10}$ scales, one pair ranging from 10m to 10,000m, the other from 1cm to 10m.

**Frequency/angular frequency.** Linear scales for conversion between cycles per second ($f$) and radians per second ($\omega = 2\pi f$). Range for $f$: 1.0 to 10.0.

**Peak/r.m.s. values** (voltage, current, power) of a sinusoidal signal. Linear scales, peak values ranging from 1.0 to 14.14.

**Musical pitch/frequency.** Linear/$\log_2$ scales giving frequencies (in Hz) of notes in the equally tempered chromatic scale. Range: two octaves above middle C.

**Loudness, phons/sones.** Linear/$\log_2$ scales relating loudness level (phons) to auditory impression of loudness (sones). Range: 20.0 to 120.0 phons.

**Power ratio/decibels.** Two pairs of $\log_{10}$/linear scales: one pair, expanded scales, ranging from 0 to 10dB; the other pair, compressed scales, ranging from 10 to 100dB.

**Percentage/decibels** ($\log_{10}$/linear scales). Can be used, for example, to convert harmonic distortion between a percentage and dB below a fundamental; or to convert between voltage or pressure ratios (expressed as %) and dB. Range: 0.03% to 100%.

**Frequency (Hz)/period(s)** relationship of a periodic signal. Two pairs of $\log_{10}$ scales: one pair, compressed, ranging from 1Hz to 100GHz; the other pair, expanded, with $f$ ranging from 1.0 to 10.

**Magnetic field strength,** oersted to ampere/metre (SI unit) conversion. Two pairs of scales: one, $\log_{10}$, ranging from 1 milli-oersted to 10,000 oersteds; the other, linear, ranging from 1.0 to 10.0 oersteds.

**Heat sink size** for semiconductors. Scales giving area of $\frac{1}{8}$-inch aluminium sheet needed to secure the temperature/power dissipation ratio (°C/W) permitted by the semiconductor. Range: 2in to 12in side of square.

**Gas pressure** conversion between torr (mm mercury) and N/m$^2$ for low pressure or evacuation work. $\text{Log}_{10}$ scales. Range: $5 \times 10^{-8}$ to $2 \times 10^{-1}$ torr.

**Inches/millimetres.** Linear scales; range 0 to 12in.

**Feet/metres.** Linear scales; range 0 to 50ft.

**Sq.inches/sq.centimetres.** $\text{Log}_{10}$ scales, range 1.0 to 100.0in$^2$.

**Temperature, °F/°C.** Linear scales, range −20°F to +320°F.

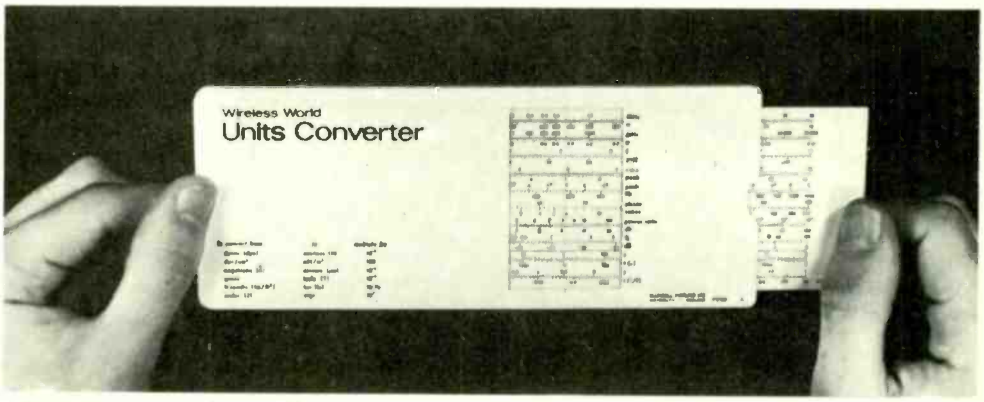
**Ounces/grammes.** Linear scales, range 0 to 8oz.

**Pounds/kilogrammes.** $\text{Log}_{10}$ scales, range 1.0 to 100.0lb.

**Tabulated "easy" conversion factors,** all powers of 10 (or nearly); for dynes/newtons; dyn/cm$^2$ to mN/m$^2$; angstroms/microns; gauss/tesla; ft candles/lux; joules/ergs.

**L and C values, resonance and reactance.** Table of widely used frequencies with the $L$ and $C$ (preferred) values required for resonance. Also the corresponding reactances ($\Omega$) and $LC$ products ($\mu$H-pF).

**Waveband names.** $\text{Log}_{10}$ edge scales of the electromagnetic spectrum, marked in wavelength and giving waveband names. Range 10$\mu$m to 100,000m.




*The units converter in use. The conversion scales are engraved on the slider and are read through a window carrying a "cursor" line.*

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# Mono into "Stereo"

## Techniques being used to make pseudo-stereo gramophone records from mono masters

*by Sean Davies**

The first half of 1969 has seen the virtual disappearance of new classical records in mono form, although light and popular issues will probably continue in mono and stereo for some time. This process will produce a climate in which the classical record buyer refuses anything which does not bear the magic word 'stereo'. Unfortunately many performances of great aesthetic value were recorded in mono only, so we have the increasingly familiar mono record processed into a stereo reissue—welcomed by some, despised by others.

Let us be clear on one point: given a complex single channel signal it is not possible to derive therefrom two separate signals bearing the correct temporal and spatial relationships characteristic of true stereo information. What *is* possible is a lessening of the point-source effect of a mono signal—in essence not too difficult, but there is one rather large fly in the ointment: for the present (and immediate future) the sales office demands that the record should be playable on mono apparatus without loss of quality. This rules out some of the methods of obtaining a spread of information, e.g. if a mono signal is fed equally to two loudspeakers the sound appears central, but if a portion of the signal is injected in antiphase the image will be spread. However, if the two signals are now combined, the anti-phase relationship will prevent a satisfactory mono summation. In practice, a limited amount of phase difference is introduced in parts, usually confined to selected bands of frequencies, and the result is checked by comparing the mono and stereo results on an A-B basis.

Two other means of separation are frequency division and selective reverberation. In its simplest form frequency division consists of feeding low frequencies to one and high to the other: this has the disadvantage that the harmonics of an instrument such as the cello appear on the opposite side from the fundamentals, while the player may seem to be dashing from loudspeaker to loudspeaker according to the note being played. Nevertheless, selected bands of frequencies may be divided as long as care is used. Reverberation can be added so that the ambience appears to come from an area other than the direct source point. Two possible methods are: (i) The mono signal is fed to a common drive unit on the echo device (chamber or plate), while two separate pick-up units give an apparently random mixture of return signals, which may be filtered before remixing with the direct signal. (ii) Two separate echo systems may be used, fed from different portions of the mono spectrum, the outputs being cross mixed, or a portion of the output of one being fed to the other in order to spread the effect.

It will be appreciated that any system of division is likely to suit one passage of music more than another, so in order to ensure the optimum conditions at any instant there must be an engineer with good reflexes and a complex control system following the score. An alternative system showing good promise allows the programme content to control the division systems. For instance, two filter networks may have their active elements controlled by a voltage (derived from the mono programme) serving also to determine the relative reverberation and phase conditions. A subsequent cross-mixing of low frequencies ensures that the bass remains in position (often central) and assists good conditions for playback tracking. A further advantage of this system is that the active elements in the two channels may be balanced relative to one another so that at no instant is any part of the mono signal totally excluded from the outputs.

Actual figures for frequency spectra and levels used in division vary from disc to disc and from one company to another, but some general patterns may be noted. Brass instruments may be separated by a peak boost of some 6-10dB at 5 to 6kHz (which often improves the quality of the brass sound), although if strings are present this may not be possible as it lends a distinct edge to the violins. A very good concert hall ambience is obtained by setting the echo device (if adjustable) to a reverberation time of 3.5 seconds and delaying its input signal by a few milliseconds in order that the first echo shall not arrive too soon and destroy the overall effect.

*General Recording Services

*The space below has been left to avoid readers removing text when cutting out the coupon on the previous page for the Units Converter.*

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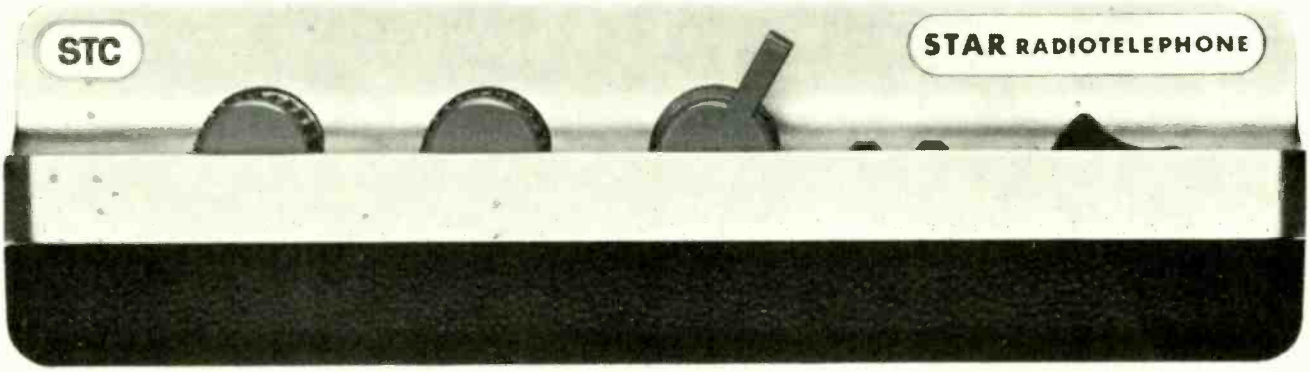


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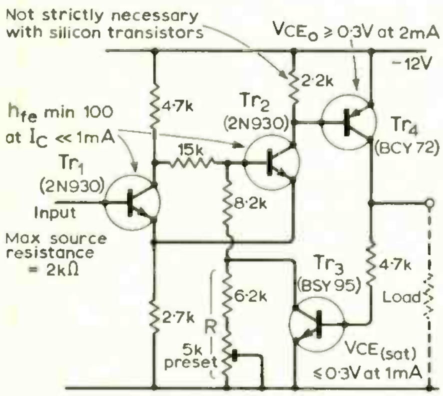
# Circuit Ideas

### Schmitt trigger with "zero" backlash

To the conventional Schmitt circuit ($Tr_1$ and $Tr_2$) is added a level shifter $Tr_3$, and an electronic switch $Tr_4$. The circuit has two stable states. When the input signal is




*Schmitt trigger with "zero" backlash.*

above the upper trip-point $Tr_1$ is on, $Tr_2$, $Tr_3$, and $Tr_4$ off and $R$ is in circuit. When the input signal is below the lower trip-point $Tr_1$ is off, $Tr_2$, $Tr_3$ and $Tr_4$ on and $R$ shorted. Lowering the value of $R$ will reduce backlash to zero. It is possible to go below zero "backlash" and cause the circuit to oscillate.

A. E. CRUMP,
Broadstone,
Dorset

### Linear scale power meter

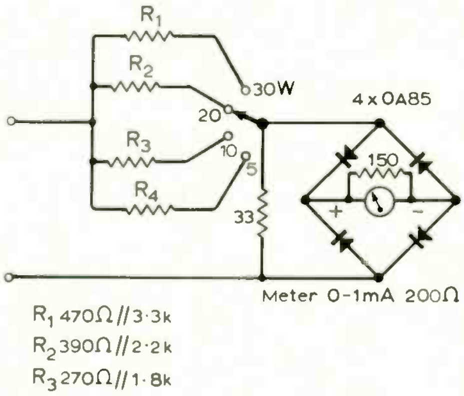
A usually undesirable property of semi-conductor diodes — curvature of the $I/E$ characteristic at low forward voltages — is exploited in this circuit. The curvature approximates a square law for most diodes so that $I_{diode} \propto E^2$ while for power in a resistive circuit, $P \propto I^2$ or $E^2$. Thus if a suitable fraction of the voltage across the load is used to feed a diode and meter then:

Meter indication $\propto I_{diode} \propto E_L^2 \propto P$

i.e. the meter scale will be linear.

Type OA85 diodes were chosen as their characteristics closely follow a square law up to 1.3–1.4V.

The circuit illustrated has 30, 20, 10 and 5 watt full-scale ranges at an impedance of 15 ohms, but by changing the input resistors




*Power meter*

$R_{1, 2, 3, 4}$, it may be adapted for other impedances and powers, provided that no more than 1.4V is applied to the bridge input.

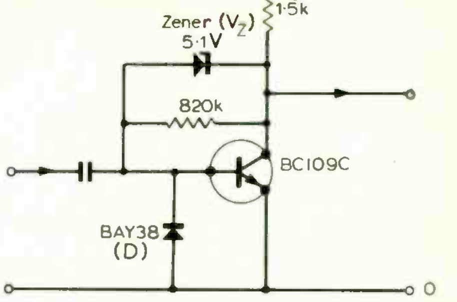
K. D. JAMES,
Fiji Broadcasting Commission.

### A non-blocking limiting amplifier

The need arose for a simple capacitance-coupled amplifier to amplify small signals (about 1mV) without blocking after receiving a train of large signals (a few volts).

In the circuit shown, the zener diode conducts when the signal tries to turn the transistor off. The transistor remains conducting until

*Non-blocking limiting amplifier*




the current from the signal source exceeds a value of about $(V_{CC}-V_Z)/R_C$; the transistor is then cut off. Diode $D$ prevents the negative part of the signal waveform being passed on to the next stage through the zener diode.

Two such amplifier stages together were used in a design for a microwave Doppler radar speed meter.

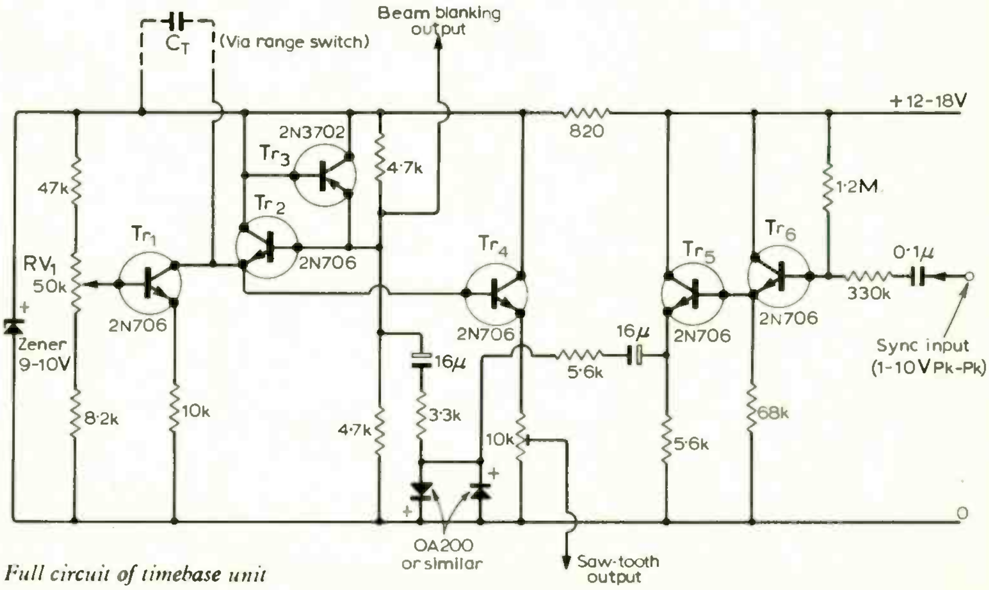
F. HIBBERD,
The University College,
Dar es Salaam,
Tanzania.

### Synchronized oscilloscope timebase generator

This unit gives a perfectly linear saw-tooth output that can be varied over the frequency range 1Hz to 150kHz. The synchronization circuit incorporated has an input impedance of 1MΩ and is easily locked to low-level 'Y' amplifier signals. A beam-blanking output pulse is also available. $Tr_3$ is connected 'upside-down' in the bistable to eliminate leakage problems. Linear charging of the tuning capacitor, $C_T$, is achieved by using $Tr_1$ as a constant current source. Frequency is altered by $R_{V_1}$ and the different ranges obtained by altering the value of $C_T$ as follows:

| Frequency range | $C_T$ | |
|---|---|---|
| 1Hz— 15Hz | 20μF | reversible tantalum |
| 10Hz— 150Hz | 2μF | |
| 100Hz— 1.5kHz | 0.2μF | mylar |
| 1kHz— 15kHz | 0.02μF | |
| 10kHz—150kHz | 0.002μF | |

R. M. MARSTON,
London E.7.




*Full circuit of timebase unit*

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# Operational Amplifiers

## 5. Applications

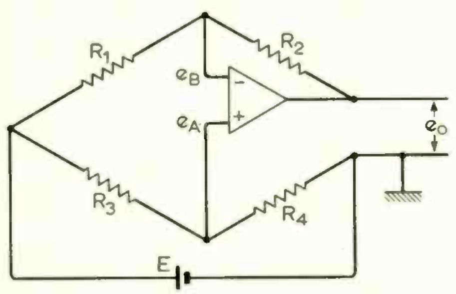
*by G. B. Clayton,** B.Sc., A.Inst.P.

### Bridge Amplifiers

In instrumentation systems using resistive transducers the transducers are normally included in the arms of a balanced bridge. Changes in the physical variable to which the transducer is sensitive cause an unbalance in the bridge, the extent of the unbalance being used to measure the change in the physical variable. Thermistor bridges for temperature measurement and bridges using resistive strain gauges are examples of such systems. Op. amps. are well suited for application in such balanced bridge circuits.

The most suitable configuration depends upon the particular application. Here are some of the points that have to be considered in choosing a particular circuit: earthed or floating bridge voltage supply; earthed or floating unknown resistor; output voltage linearly related to changes in the unknown resistor for both large and small changes; sensitivity of the arrangement dependent on the bridge impedance level (this will determine whether or not the circuit is affected by temperature changes affecting all the arms).

Bridge supply earthed (no amplification).




$$e_B = e_0 + \frac{(E - e_0)R_2}{R_1 + R_2}$$

$$e_A = E\frac{R_4}{R_3 + R_4}$$

But $e_A = e_B$

Substitution and rearrangement gives

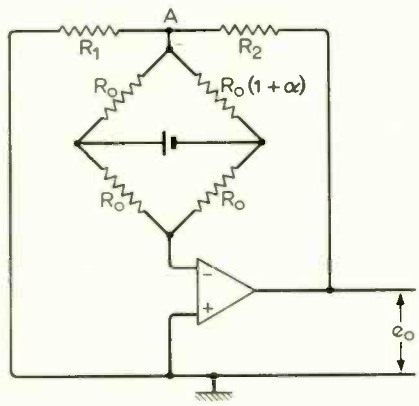
$$e_0 = \left[\frac{R_4 - \frac{R_2}{R_1}R_3}{R_4 + R_3}\right]E$$

**Features.** The circuit is basically an application of the adder subtractor amplifier previously discussed. It may be used in two ways.

(a) Make $R_1 = R_o$, and $R_2 = R_x = R_0(1 + \alpha)$ the unknown; make $R_3 = R_4 = R$. Substituting these values in the expression for the output voltage gives $e_0 = \alpha.E$. Used in this way the circuit gives an output voltage which is linearly dependent upon $(R_x - R_o)$, the difference between the unknown and standard. This linearity is maintained even for large deviations. The output is independent of bridge impedance levels. The circuit does not provide amplification and the measurement of small resistance changes may necessitate the addition of another amplifier to increase sensitivity. The unknown resistor is floating.

(b) If it is required to earth one end of the unknown and to perhaps drive quite large currents through it then we put it in another arm of the bridge. Make $R_3 = R_o$, $R_4 = R_x = R_o(1 + \alpha)$ and $R_1 = R_2 = R$. Used in this way the amplifier does not need to carry the current passing through $R_o$ and $R_x$ and it is practicable to use large currents. The output voltage is now $e_0 = (\alpha/[2 + \alpha])E$. The output is now linear only for small deviations in the unknown ($\alpha \ll 2$). In both arrangements the maximum common-mode voltage for the particular op. amp. in use must not be exceeded.

Amplification with Bridge Supply Floating.




The feedback circuit forces the amplifier to develop a voltage at the point A which is equal and opposite to the unbalance voltage developed across the bridge. The bridge unbalance voltage is

$$\frac{E}{2} - \frac{E}{R_0 + R_0(1 + \alpha)}R_0 = E\frac{\alpha}{4\left(1 + \frac{\alpha}{2}\right)}$$

The voltage developed at A by $e_0$ is

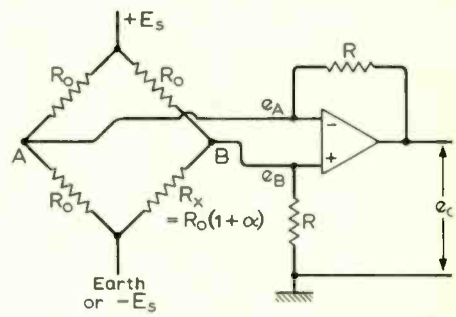
$$e_0\frac{R_1}{R_1 + R_2}$$

Equating and rearranging gives.

$$e_0 = \left\{1 + \frac{R_2}{R_1}\right\}\frac{E}{4}\frac{\alpha}{\left(1 + \frac{\alpha}{2}\right)}$$

**Features.** The circuit is basically a adaptation of the inverting amplifier and a such has no common-mode voltage limita tions. The output does not depend o bridge impedance levels; it is linear for sma deviations in the unknown $\left(\frac{\alpha}{2} \ll 1\right)$. Th bridge unbalance voltage is amplified b $(1 + R_2/R_1)$. The necessity for a floatin bridge supply may sometimes be a di advantage.

Amplification with Earthed or Floating Supply.




Feedback maintains the opposing corners of the bridge at equal potential; the amplifier output voltage establishes the differential current needed to balance the bridge. Using a single supply with the lower end of the bridge earthed:

Summing currents at A

$$\frac{E_s - e_A}{R_0} - \frac{e_A}{R_0} + \frac{e_0 - e_A}{R} = 0$$

Summing currents at B

$$\frac{E_S - e_B}{R_0} - \frac{e_B}{R_0(1 + \alpha)} - \frac{e_B}{R} = 0$$

Equating $e_A = e_B$ and rearranging gives

$$e_0 = \frac{R}{R_0}E_S\,\alpha\frac{1}{(1 + \alpha)\left(1 + \frac{R_0}{R}\right) + 1}$$

**Features.** This circuit may be used with a earthed bridge supply but the sensitivity dependent on bridge impedance levels.

* Liverpool College of Technology

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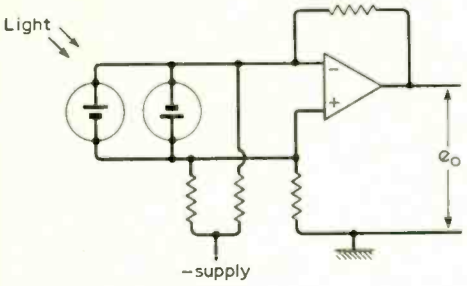
linear output is obtained for small deviations ($\alpha \ll 1$). The amplifier type used should be insensitive to the possibly quite large common-mode voltage level at the input.

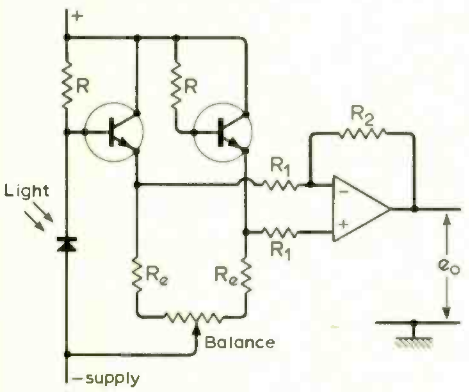
Solar Cell Amplifier.




**Features.** In the circuit shown the polarity of the output voltage is dependent on the relative intensity of the light falling on the two cells. Circuits of this type are useful in measuring small deflections of a beam of light.

### Photodiode Amplifier

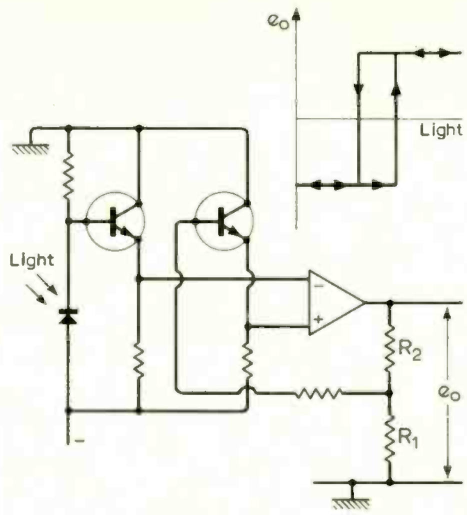
A photodiode is essentially a reverse biased p-n junction, the reverse leakage current through the junction being dependent on the illumination falling on the junction. In use the diodes are connected in series with a high value resistor, but the input resistance of a




general purpose op. amp. is normally not high enough to allow it to be connected directly to this circuit. A transistor capable of operating at low currents and acting as an emitter follower can be used to increase the input resistance. A balanced input stage is used to reduce temperature drift. The gain of the amplifier is set by the choice of $R_2/R_1$.

### Light Level Detector

A variation of the photodiode amplifier employing positive feedback can be arranged so that when the light intensity falling on the cell reaches some fixed level the amplifier output switches between saturation states. With no light falling on the photodiode the phase inverting terminal of the op. amp. is positive with respect to its other input terminal and the amplifier is in negative saturation. Light falling on the cell causes the potential of the phase-inverting terminal to fall, and when the amplifier comes out of saturation positive feedback applied via $R_1$ and $R_2$ causes a regenerative switching action which drives the amplifier to positive

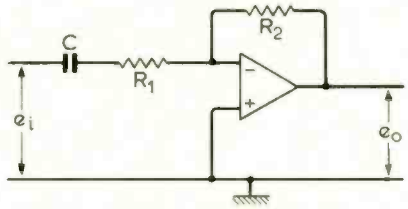



saturation. If the light intensity is reduced a regenerative action returns the amplifier to its negative saturation value. The circuit exhibits hysteresis.

### A.C. Amplifiers

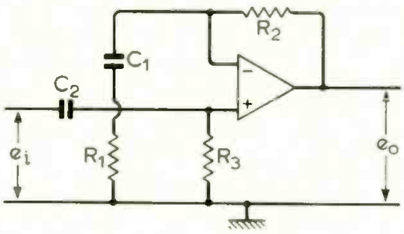
Op. amps. are basically high-gain d.c. amplifiers, but they are equally suitable for applications not requiring a d.c. response. In such cases d.c. blocking capacitors are used in the signal path, and it is often possible to operate the amplifiers with a single power supply and a split zener biasing or resistive network divider technique, thus reducing the requirement for separate positive and negative supplies.

Phase Inverting A.C. Amplifier.



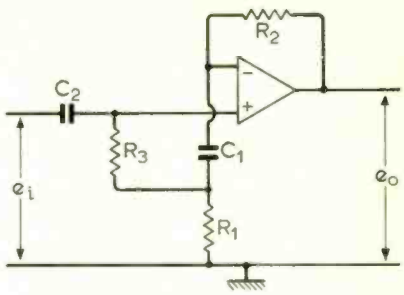

The basic inverter amplifier with capacitor $C$ in series with the input. The gain of the amplifier is $R_2/R_1$ with the low frequency 3 dB fall in gain occuring at a frequency $1/(2\pi CR_1)$. The upper frequency limit of the amplifier will be dependent on the loop gain and the compensated open-loop frequency response (see March article). The input resistance is $R_1$.

Non Inverting A.C. Amplifier.




Basically the follower with gain with the addition of blocking capacitors and the d.c. bias path $R_3$. The gain of the amplifier is $(1 + R_2/R_1)$ with low frequency 3 dB frequency determined by the shorter of the two time constants $C_1R_1$, $C_2R_3$. The input resistance is $R_3$.

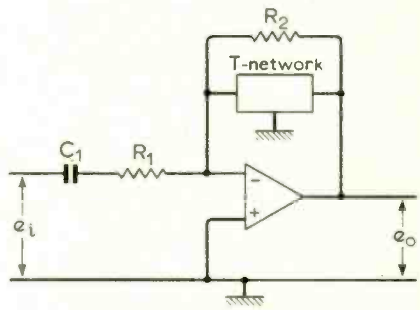
High Input Impedance A.C. Amplifier.

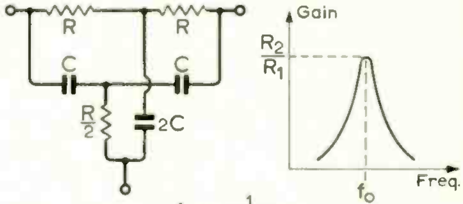



The non-inverting amplifier, being a voltage follower, is intrinsically capable of providing a high input impedance, but this is reduced in the simple follower by the d.c. biasing path $R_3$. In this circuit positive feedback is applied from the output via $R_2$ $C_1$ and $R_1$ to the lower end of $R_3$. This results in a large effective input impedance. The technique of raising the apparent value of an impedance by driving its low potential end with a voltage in phase with, and almost as large as, the voltage at its high potential end is known as 'bootstrapping'. The gain of the amplifier is $1 + R_2/R_1$ and the effective input impedance is increased by a factor equal to the loop gain; e.g. if the closed-loop gain is, say, 20 and the open-loop gain of the amplifier is 4,000, the effective value of $R_3$ is increased 200 times.

### Frequency Selective Amplifier

This is a bandpass amplifier employing a twin-T filter. The circuit uses the inverting feedback configuration, and in order to develop a specific frequency response characteristic the feedback path is made to




$$f_o = \frac{1}{2\pi CR}$$

Choose $C_1$ so that $C_1 R_1 > CR$

$$\text{Peak gain} \simeq \frac{R_2}{R_1}$$

Input impedance $\simeq R_1$

include a frequency selective network—a twin-T network in this case. The twin-T is a rejection filter and has a high impedance at its characteristic frequency; the feedback is thus a minimum and the gain of the amplifier a maximum at this frequency.

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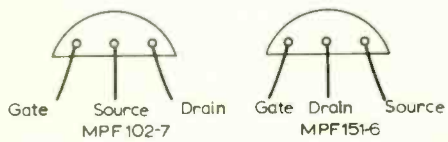
# Letters to the Editor

*The Editor does not necessarily endorse opinions expressed by his correspondents*

## Base-connections of f.e.ts

It has come to my notice that various suppliers of field effect transistors are publishing misleading information in their catalogues regarding the arrangement of the lead connections of these devices. The compilers of these catalogues have assumed that the manufacturers have followed the logical arrangement of: collector = drain; base = gate; and emitter = source.

Unfortunately this is not so—even particular makes vary. The following examples from the Motorola range illustrate the point:




Several colleagues and I have spent many hours attempting to get MPF 102s to function—following the connections given in the retailer's catalogue, only to find that this information was wrong and that the devices had probably "gone down the drain"!

If nothing can be done by the makers to identify the leads, either on the device or in the packet, would you please give this letter the widest publicity as we feel sure that other users are also being misled.

T. N. LLOYD (G3SL),
Hounslow,
Middx.

## Labelling components

I should like to back up Mr. Short's suggestion that *Wireless World* adopts, what he calls the Continental practice of abbreviating component values in circuit diagrams, but I should also like to point out the inconsequence in mentioning only the resistors and omitting the capacitors (and the coils for that matter).

It seems obvious that the safety in reading resistance values, which is certainly gained by the adoption of the "Continental" practice of replacing the decimal point by the multiplier abbreviation, has even more bearing on the labelling of capacitors.

Surely, it necessitates the further adoption of a couple of multiplier abbreviations to which many British and American engineers seem somehow adverse, namely "m" for $10^{-3}$ and more important "n" for $10^{-9}$. It seems to me that the ease gained in reading and pronunciation justifies the necessary effort to get used to it. Here are a few examples:

for 0.0016 μF write 1n6,
for 0.027 μF write 27n,
for 0.68 μF write 680n,
for 1000 μF write 10m.

Exactly the same applies to the coils, these also often having values of fractions of the unit.

MOGENS P. MÜLLER,
Copenhagen,
Denmark.

## Improper oscillations in transistors

D. B. Pitt describes "improper" oscillations on page 20 of the January, 1969 issue. Relaxation-type signals are obtained with an n-p-n planar silicon transistor in a simple *RC* circuit.

Some years ago, I carried on similar experiments with p-n-p germanium transistors. See Fig. 1, which has two unusual features: (a) the base is *not connected* (b) the output is a *sine wave*—about 0.5 V at 7 kHz!

As $R_2$ is decreased to raise the current, an oscilloscope across $R_1$ or the transistor will indicate a sinusoid at approximately 0.4 to 0.6 mA. If the current is increased further, the sine wave will disappear. Not all transistors tested gave this unusual result. I used 2N112 and CK768 (Raytheon) transistors. My experiments were described in *Radio-Electronics*, August, 1959.

More recently, I found that various n-p-n silicon types seem to generate *saw-tooth* or *pulse* signals, and at much lower currents. I used Fig. 1 with reversed polarity. In all cases, the voltage across the transistor tends to remain at a peak value as $R_2$ is varied. For a 2N112 this is approximately 20 volts, so a 22½ volt battery may be used. For a 2N2501, it is about 26 volts, and for a 2N2712 it is about 48 volts.

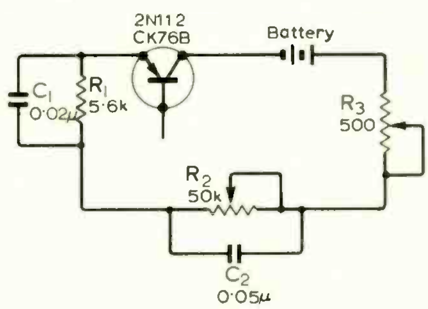



Fig. 1

I. QUEEN,
*Radio-Electronics*,
New York,
U.S.A.

## Do manufacturers really want to sell?

I am currently an undergraduate in electrical engineering and a radio amateur. One day, after graduation, I will perhaps be required to obtain some component or assembly in quantity for my employer. Because of my past experience I know even now to whom I shall turn. The odd thing is —almost all such places I can think of are American.

Example: A casual request for some information on a component resulted in the whole catalogue, plus reply-paid cards should I need more information on anything else, being sent to my home address. I was not once asked if I were in business. The company was American.

An even more modest request for a pamphlet, to an English firm resulted in my being told that this prized document was not really available to the general public, however, a special case would be made if I were prepared to pay 6d plus postage.

These are not one-off examples, nor am I prejudiced (yet) but the facts are where public relations are concerned the Americans are our tutors and we are unwilling pupils.

Okay, so you can't supply the British Isles with firelighters—but you don't have to. All you have to do is generate goodwill, not only to your immediate market but also to the public at large.

Subsidies and tariff controls are like penicillin, one can become immune and trade protection is then lost, and it is then too late to "get your finger out" because somebody will have cut off your hand.

L. KENNEDY,
Southport,
Lancs.

'Vector' makes several points in his March article about 'Jim Bandstop', but at least Jim was able to start his business and doubtless Jim himself would agree wholeheartedly about the structuring of companies. Now as far as the structure of his own company was concerned, he at least had some choice. What is, however, quite intolerable is the degree of external interference from such people, for instance, as Vector mentions, the Inland Revenue.

Even these people, and all the other multitudinous Government agents, have at least the defence that they have no vested interest in the success of the business. Quite incomprehensible from any point of view is the attitude taken by the component suppliers in whose interests it surely must be that any business thrives.

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May I relate my own experiences in starting a small business in my spare time, as most businesses start.

I have dealt direct with several manufacturers or agents, sometimes for single orders in the £50-£60 region and have had no suggestion of any difficulty in opening an account, with no preliminaries such as giving references. All bills have been paid within two weeks of receipt.

Not so happy however have been my dealings with the component wholesalers. Radiospares flatly refused to allow me to open an account unless I had a Registered Office open at least six hours a day.

Finally, I forwarded a 'cut-out coupon' from one of your advertisements for C.E.S. applying for a catalogue, and received in reply a duplicated letter, unsigned, asking me to give two trade references and the name of my bankers, so that, if my premises are correctly rated, I may receive a *catalogue*. What they would require if I wished to open an account, I hate to think!

As I mentioned earlier, my business is at present only part time. It does not seem to have occurred to any of these companies that I also have control of ordering thousands of pounds worth of goods for the company I am employed by.

J. C. TAYLOR,
Heywood,
Lancs.

## Negative feedback and hum

Whilst I must congratulate Mr. G. W. Short on his extremely ingenious circuit for reducing hum in class B single-ended push-pull output amplifiers (March issue), I suggest it is better to attack the problem at its root. This particular amplifier (Fig. 1) produces hum on its output because the negative rail is used as the input "earth", and the positive rail as the output "earth". Since the liberal negative feedback ensures that there is negligible ripple on the output terminal, *with respect to the negative rail*, it follows that virtually the whole of the supply voltage ripple appears between the output terminal and the positive terminal. Fortunately it is very easy to redesign this amplifier so that the same rail is used for both input and output earth (positive), thus eliminating this problem (Fig. 2). If a negative earth amplifier is required, it is necessary merely to "invert" the circuit, using the same transistors in different positions (Fig. 3).

D. AUSTIN,
Birmingham, 24.

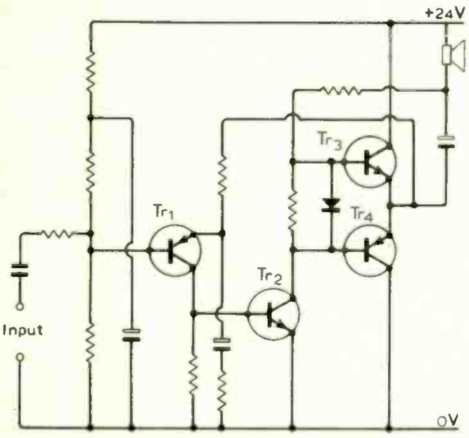

*Fig. 1. G. W. Short's original amplifier*

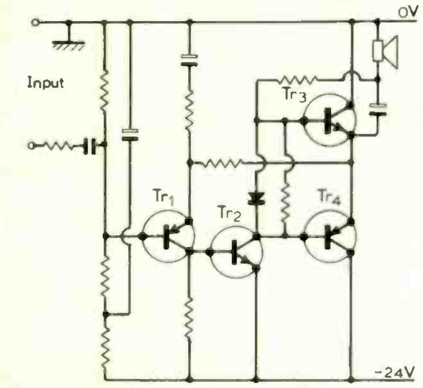

*Fig. 2. Amplifier re-designed for common positive earth line*

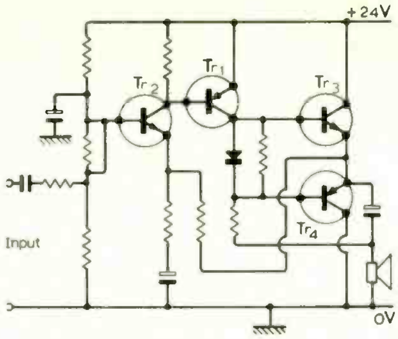

*Fig. 3. Negative earth amplifier*

*The author replies:*

The most elegant solution to the hum problem is certainly to use a circuit which doesn't have it. One of my purposes in writing about my experiences with a particular amplifier circuit was to warn others of the problem, so that they could take avoiding action. When one gets down to actual cases, however, the solution may not be quite as simple as Mr. Austin's circuits suggest. For one thing, it is quite likely that the amplifier will be used with a pre-amp in a 'negative earth' configuration, in which case his Fig. 2 will be a non-starter. For another, it may not be permissible to swap $Tr_1$ and $Tr_2$ around to make possible Fig. 3. My own amplifier used a low-level p-n-p planar transistor type 2N4058 in the input stage and a medium power n-p-n planar type BFY51 as driver. Swapping these types around is not possible, because the 2N4058 won't handle the current needed in the driver stage, while the low gain of the BFY51 makes it unattractive as an input transistor. This may seem a mere quibble, but when one looks for a p-n-p driver equivalent to the BFY51 one discovers that it is expensive. If an extra smoothing capacitor can be obtained cheaply (they are much easier to find on the 'surplus' market than good p-n-p silicon driver transistors) then the 'swinging diode' smoothing circuit may be the most economical solution after all.

There is a further snag about Mr. Austin's circuits. This is that they may be found to exhibit an unexpectedly high hum level! Inspection of Figs. 1 and 2 shows that they both offer an entry point for ripple from the supply line. This is the emitter of the driver transistor, which goes straight to the unearthed side of the supply in each case.

Some readers have enquired about diode types for the smoothing circuit. Any silicon rectifier which will handle the current will serve. The reverse-voltage rating is of no importance. Selenium rectifiers will also work: they start to conduct at about the same forward voltage but may have a greater forward drop at full current. A selenium bridge can be connected so as to be equivalent to two diodes in series.

G. W. SHORT

## High-quality TV sound

With regard to the comments in the April issue about high-quality television sound, I would agree entirely with Mr. Dinsdale about the position of the sound source.

Due to space considerations, anyone watching my set has to sit between it and the hi-fi speaker I use for the sound, thus the sound comes from behind the viewer. Everyone who has watched it has been quite amazed at the way the sound seems to come from the screen when actually watching it.

As regards extracting a high-quality sound signal, I simply earth all my equipment to the neutral side of the mains and take the sound from the output of the post detector stage as one would do with an ordinary radio. This is not as dangerous as it might appear since all the mains plugs are three pin and thus cannot be plugged in the wrong way round.

The quality of the sound thus obtained, when fed through a normal domestic hi-fi system can be surprisingly good. Although not as good as that of the Band II f.m. transmissions, it compares very favourably with that of the monitors used at the B.B.C. and I.T.A. transmitting stations I have visited.

On tape recordings made in this manner it is just possible to hear the 405- and 625-line scan whistles, but they are not normally noticeable.

I have tried this method of sound extraction with two sets and found in both cases that mains hum could be troublesome due to the slight voltage drop in the TV mains feeder. The cure for this is to connect the TV chassis direct to the hi-fi amplifier's earth. Also, a significant improvement in treble response was obtained on removing the sound interference limiters on both sets.

B. POLLARD (aged 18),
Sheffield 10.

## Groove jumping on records

On both sides of the Atlantic one reads that a gramophone record has a "jumping groove", although what presumably is meant is that the cartridge needle jumps. The more important question is whether it is correct to speak at all of a "jumping" needle. Does the needle actually jump—that is, more correctly, is it thrown by the one groove wall over the opposite groove wall?—or does the groove wall, over which the needle is said to "jump", in fact pass under the needle? Or, again, is it sometimes the one, sometimes the other, and sometimes both occurring simultaneously? When I say that the groove wall passes under the needle—to me, the more likely cause of a needle missing one spiral of a groove—I mean that the one groove wall can undergo so violent an excursion that the groove moves out from under the needle, which inertia and insufficient compliance hold more or less rooted to its original position.

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It would seem that where the skating force is exactly neutralized, a needle should miss a spiral as often in the one direction as in the other, the only determining factor being (assuming that the needle, suspension, and damping material have exactly symmetrical characteristics in all directions of movement) whether the excursion causing the needle to miss moves towards or away from the centre of the disc. In the past, of course, owing to the skating force, it was usually the next groove inwards that came to be occupied by the needle.

Can any reader support or demolish my speculations?

RONALD KLETT,
Loerrach,
W. Germany.

## Folded exponential horn loudspeaker

I was delighted to read the abstract of J. Jecklin's article in February's *Wireless World.*

I do not feel, however, that Mr. Jecklin's high frequency arrangements represent the most satisfactory system. The power handling capacity of two Axiom 80s is far in excess of any domestic requirement and suitable arrangements give satisfactory distribution of sound from a single speaker.

My suggestion is to fit the high-frequency driver into a simple horn, mounted so as to reflect the sound off the corner of the room, or, if the ceiling be low, the ceiling. The horn loading restricts the movement of the cone ensuring negligible out-of-phase sound output from the rear of the cone. With Mr. Jecklin's arrangement this out-of-phase signal could be reflected off the walls to produce irregular response.

A further improvement, which I have made to my own speakers, is to cross over from the Lowther speaker at 4 kHz into a Decca-Kelly ribbon DK30 using the crossover details of which are given in Fig. 1 and the scheme of connection in Fig. 2. The crossover provides a transformer function increasing the drive to the ribbon to bring its apparent sensitivity into line with the rest of the system. The ribbon unit is readily mounted on the outside of the horn of the mid-range speaker and similarly aimed so that its output too is reflected and dispersed. The Kelly acoustic lens should not be used in this arrangement.

The inclusion of the ribbon unit is well worthwhile as transient performance is improved and the smooth response minimizes listener fatigue, and background noise. For really noisy programme material the ribbons may be switched off—a filter far more effective than that in the amplifier.

Since Mr. Jecklin wrote his original article development has taken place in electrostatic mid-range speakers and readers should bear them in mind as a possible advantageous replacement for the p.m. unit. Mr. Peter Belt (Duode Ltd, Leeds) is marketing electrostatic speakers in which the matching transformer is replaced with advantage by a valve amplifier which also makes up for the lack of sensitivity of the electrostatic speaker. I have, however, found it necessary to retain the ribbon but to feed the h.f. range into the electrostatic panels and to feed the ribbon using the crossover as a high-pass filter-transformer only (see Fig. 3).

With the suggested arrangements the 16-ohm resistor can come out of Mr. Jecklin's crossover and the efficiency of the system rises to circa 40%. This now gives rise to important considerations concerning the amplifier, a matter of milliwatts making a very pleasant sound level in a small room. The sizeable sum of money spent on the speaker can now be recouped on the amplifier.

The appended 2 × 2 watt circuit (Fig. 4) provides the audibly faultless quality and unconditional stability found only in the best professional studio amplifiers. Heat dissipation of 70 W is no greater than a large valve table radio and cost should not exceed £8. It has not been found possible to reduce the heat dissipation without degrading the sound but suggestions are very welcome as users of insensitive speakers would like to build more powerful versions that are not at the same time central heating systems.

Readers having no constructional facilities might consult Mr. C. Telfer, Caverton, Kelso, Roxburghshire, Scotland, who specializes in horn speaker construction.

I. G. ABELSON,
London N.14.

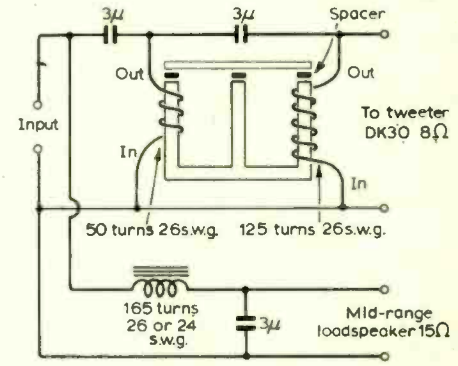


*Fig. 1. Crossover circuit supplied by Stanley Kelly. Cores: Mullard FX 1007 (E) and FX 1107 (I). Spacer 0.036 in.*

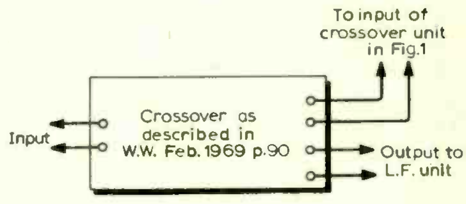


Fig. 2

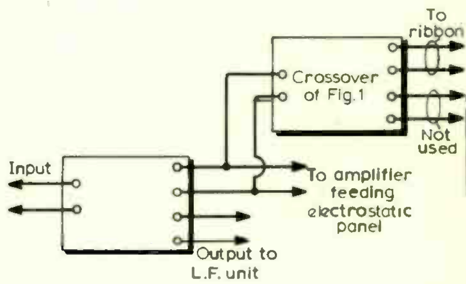


Fig. 3

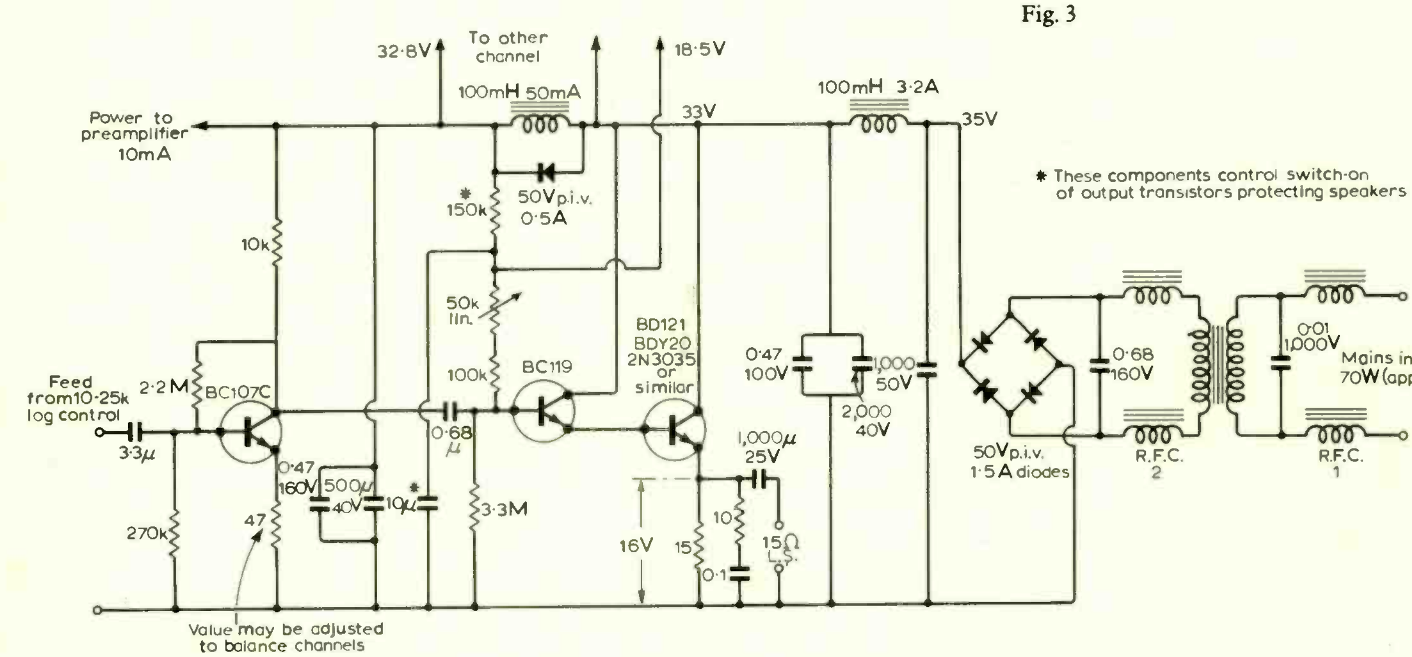


*Fig. 4 One channel and power supply for 2-watt amplifier. $RFC_1$ = Radiospares 1A television suppressor choke; $RFC_2$ = 2A version.*

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# Modified Treble Filter for Bailey Pre-amplifier

In the pre-amplifier described by the author in the December 1966 edition of *Wireless World*, the presence of the treble filter affected the performance of the tone control in that the full boost and cut ranges were not available. In addition, ferrite-cored inductors of high "Q" value gave unwanted ringing in the circuit.

These defects have only recently become clear, and a modified filter circuit has been designed to overcome them. This is shown in Fig. 1. The cut-off frequency of the filter is now dependent on only one capacitor, in that the cut-off frequency can be varied from 4 to 11 kHz merely by changing the value of the output terminating capacitor. The values given in Fig. 1 represent the limiting values of common usage, capacitor values between these limits giving intermediate values of cut-off frequency.

The inductor is damped by the series resistor to such an extent that variations in inductor "Q" have little effect on the performance. Equally with the filter in the "out" position it is now removed completely from circuit and does not affect the amount of treble boost available. The overall transient response of the filter is quite satisfactory as can be seen from the square-wave response photograph shown in Figs. 3 and 4.

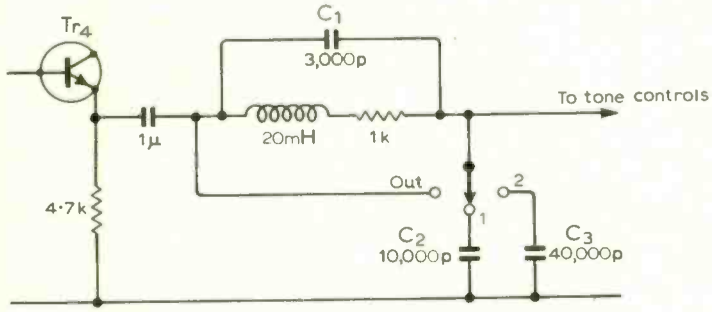


*Fig. 1. Modified treble-filter circuit.*

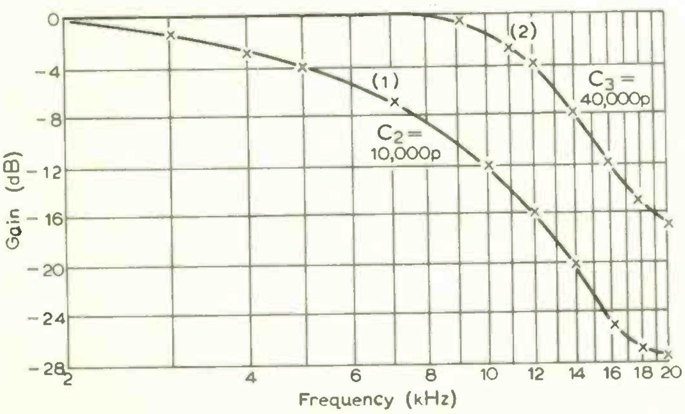


*Fig. 2. Performance of modified circuit.*

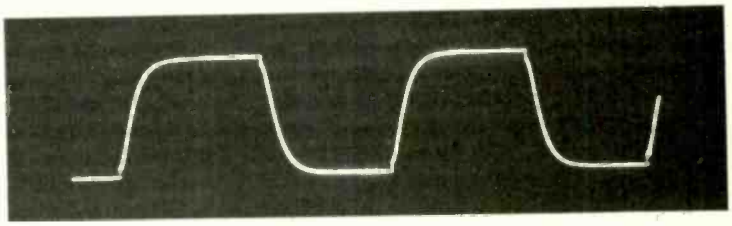

*Fig. 3. Response to 1 kHz square-wave with 40,000 pF capacitor*

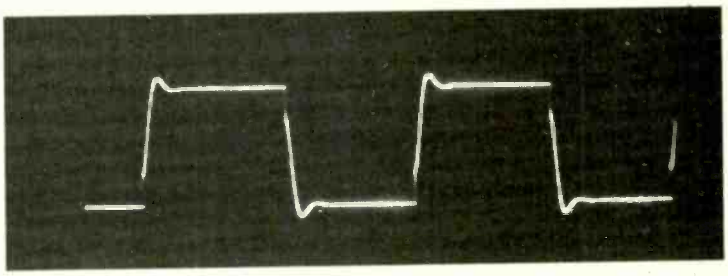

*Fig. 4. As Fig. 3 but with 10,000 pF terminating capacitor*

The inductor size was maintained identical to that in the original circuit so that modification entails a minimum expense.

A.R.B.

# Books Received

**Solid State Electronics** by G. Fournet, edited by S. Chomet. This book, translated from the French, investigates the laws governing the motion of electrons in a crystalline medium. It falls into four parts. The first part is a thorough treatment of quantum theory, from first principles, which should be followed without difficulty by anyone with no more than a grounding in the ideas of quantum physics. The second part deals more specifically with the theory of electrons in metals. The third and longest section deals with semi-conductors, and with the detailed theory of the working of diodes and transistors. The last section is a discussion of magnetic phenomena including ferro- and anti-ferro-magnetism, and ferri-magnetism. Typical numerical examples are worked out to show what magnitudes may be expected in practice. Pp.308. Prices 70s hard-back and 38s limp. Iliffe Books Ltd., 42 Russell Square, London W.C.1.

**Management of Research Development and Design in Industry** by T. S. McLeod. The author is Company Technical Co-ordinator with the Plessey Company and responsible for the inauguration and control of much of their research. The creed of this book is that expenditure on research and development is wasted without planning and control and that the design process itself must be properly managed. Guidance is given in setting up objectives for industrial research. Details of budgeting, staffing and day-to-day control are described in practical terms. The book ends with four detailed case studies of research, development and design management in action. Pp.260. Price £3. Gower Press Ltd., 13 Bloomsbury Square, London W.C.1.

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# Computer Aided Design

## A short interpretation

Computers have been used in engineering design ever since they became available to engineers, which has been for about twenty years. Why, then, all the excitement about this apparently new subject called "Computer Aided Design" (or "CAD" as it has become known, perhaps because it is not the gentleman's way of doing things)? It could be, of course, that those responsible for organizing conferences and publishing books and journals—the professional communicators—have only recently discovered what has been going on. Another reason may be that what started in a fragmentary way twenty years ago has only now gathered sufficient body to become autarkic. Yet another explanation could be that computers have suddenly become human, in the sense that the engineer can now conduct a "conversation" with them with the aid of verbal or graphical peripheral equipment.

The c.a.d. conference at Southampton Un - I.E.E. provided a good opportunity to see what is being done in electronics design (the conference was concerned with computer aided design of almost anything, but electrical and electronic products were predominant). There seem to be three main areas of application: (1) circuit analysis and synthesis—using computing techniques to find the circuit values necessary to achieve optimum or specified performance or production yield; (2) physical layout—achieving the optimum spatial arrangements of circuit elements and connections in printed circuits, i.c. and l.s.i. devices, thin or thick film sub-assemblies, or conventional electronic equipment; (3) system design by simulation or testing—using the computer as a model on which to try out a likely system before construction, or to test a system already built.

In almost all c.a.d. projects the computer used is a digital machine. Analogue computers although particularly well adapted to certain jobs, such as system simulation in "real time", are restricted in range of ability because each piece of their hardware can perform only one specific operation (e.g. adding, multiplying, integrating).

What is perhaps rather mystifying is how a machine for handling numbers can deal with spatial and topological information, as in printed-circuit layouts or electronic circuit configurations. With spatial patterns the principle is simple: any point in space can be specified numerically in terms of Cartesian or polar co-ordinates within some arbitrary frame of reference; thus numerical descriptions of points, lines, areas and volumes are possible. With electronic circuit topology the transformation is usually done by the use of nodes—that is, all the common connection points, or nodes, in a circuit are labelled with code numbers, then the position of each component in the circuit is specified by the code numbers of the nodes to which it is connected. This process, of course, can also be applied to the nodes of equivalent-circuit "models" of single devices such as the transistor. Branches (the paths containing components between nodes) are also used and similarly numbered.

By such techniques the computer can be made to do what the engineer normally does with diagrams and drawings in the design process, repeatedly recording and modifying. With straightforward calculations, e.g. using Ohm's or Kirchhoff's laws in circuits, the computer does essentially the same as the engineer with his slide rule—but more of it. Correct or optimum design is a matter of trying a succession of different arrangements in a systematic manner that approaches the desired result by degrees—very tedious and perhaps impractical for an unaided engineer to do exhaustively. Mathematically, however, it is an iterative, convergent process and therefore very suitable for handling by a mathematical machine such as a digital computer, which is ideal for repeating a given calculation with different sets of numerical values. For example, a typical electronics design process might call for calculating the steady-state response of a circuit at numerous frequencies for every possible value of every component in the circuit.

The following short descriptions of papers from the Southampton conference give some idea of current activity in c.a.d. as applied to electronic engineering.

**Circuit analysis and synthesis.** Computer programme to solve the currents and voltages in a transistor-resistor network under steady applied voltage conditions (A. M. MacSwan). Determining circuit element nominal values and maximum allowable tolerances to achieve responses within specified constraints (G. J. Herskowitz, M. A. Murray-Lasso). A general d.c. analysis programme for non-linear circuits: allows the user to take the model provided or build up his own model (H. M. Davison). Worst-case a.c. analysis using signal-flow graphs (G. W. Zobrist). Specifying a circuit with the aid of an alpha/numeric/graphical display: the requirements of a given circuit analysis programme are automatically met as the engineer is guided in a sequence of actions by instructions from the computer itself (J. A. Weaver). Obtaining optimum yield in production: finding the set of nominal component parameters, with given probability density functions, that gives the maximum number of satisfactory circuits (F. Jensen). Taking account of non-idealities of active devices in circuit analysis and applying corrections (J. I. Sewell, C. Nightingale).

**Physical layout.** Computer programming language for specifying layouts for i.c. masks: takes advantage of redundancies arising from parallel sides of shapes, repeated shapes in one circuit, patterns common to a range of circuits (J. Wood, *et. al.*). Programmes for designing layouts of circuit modules in large equipments (computers) to achieve minimum functions of the wiring, e.g. minimum total length of wire (J. Houghton). Trial layouts of thin-film microcircuits: programme deals with component dimensions, placement and interconnections and displays result on a digital incremental plotter (W. J. Cullyer *et. al.*). Programme using graphical display to allow intervention by the designer for semi-automatic design of printed circuit boards: placement of packages and arrangement of interconnections (D. F. A. Leevers). C.r.t. display and pattern-generating computer programme as an aid to designing i.c. masks: when a design is completed dimensional information is stored on magnetic tape to control a mask cutting machine (J. Atiyah). Programmes for automatic design of l.s.i. two-layer interconnection patterns (P. E. Radley).

**System design by simulation.** Programme for simulating a digital processor of a doppler radar system (J. H. Blythe *et. al.*). "Conversational" programme for simulating logic sub-systems on a time-sharing computer: circuit description, input and required output are fed in as data and can be modified at will while the programme is running (J. S. Reynolds). Logic simulation programme capable of being expanded and modified according to experience with practical examples: includes TTL74 and DTL900 series of i.cs (P. C. Gorton, S. P. O'Byrne). Testing logic networks by simulation: system being developed is designed to reduce computing costs (A. A. Kaposi).

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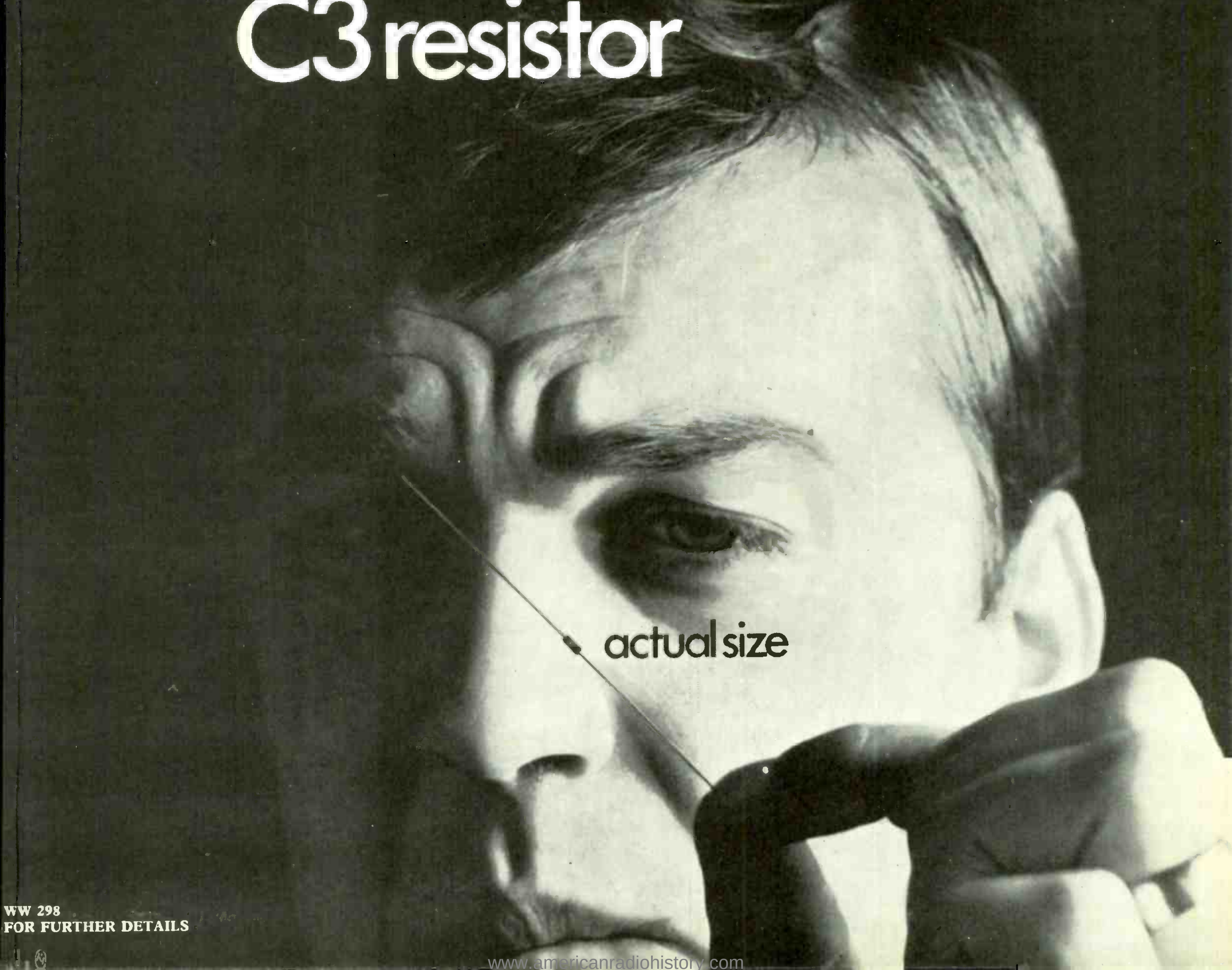





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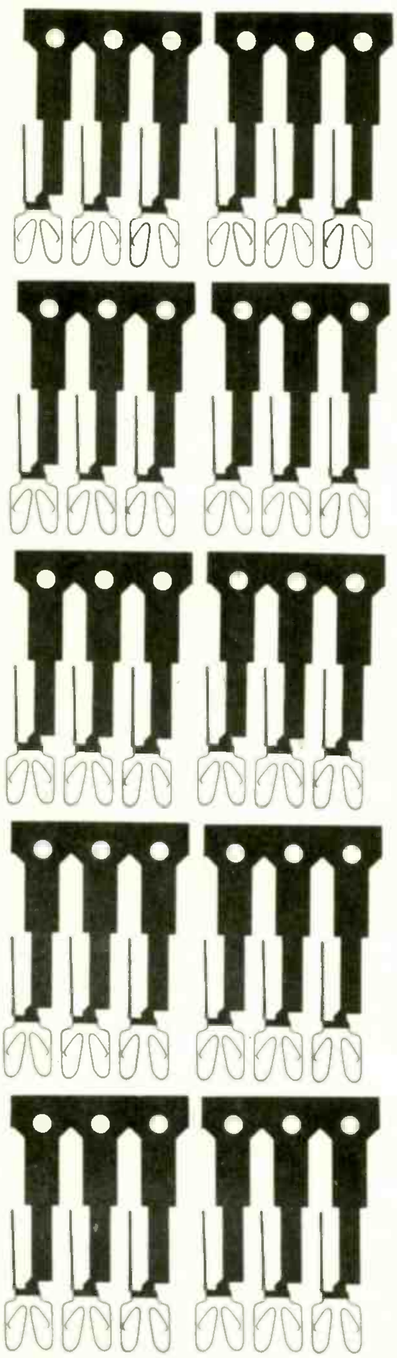

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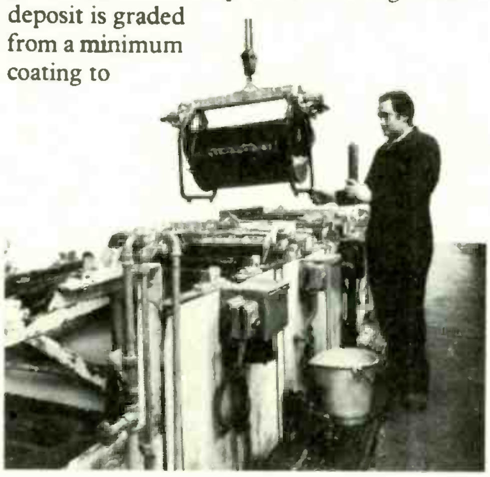

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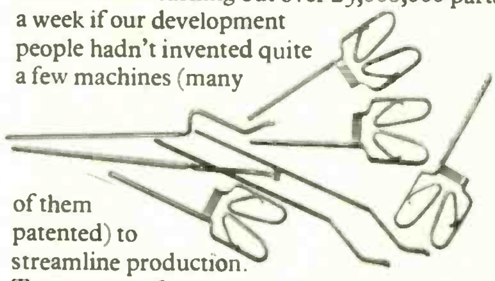

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# Personalities

**Group Captain E. Fennessy,** C.B.E., is the new chairman of the National Industrial Space Committee set up by the Society of British Aerospace Companies, the Electronic Engineering Assoc., and the Telecommunication Engineering & Manufacturing Assoc. Grp. Capt. Fennessy is managing director of Plessey Electronics Group which he joined in 1965 after 20 years with the Decca organization, latterly as managing director of Decca Radar Ltd. The N.I.S.C. is responsible for co-ordinating the views of this country's industries involved in space vehicles and associated control and communications systems.

**Douglas H. Bolton,** M.B.E., who is 48 and joined Newmark Instruments Ltd 3½ years ago as chief project engineer, is appointed manager of the company's Control Engineering Division. He was with Elliott Automation as a technical manager for eight years on development of aircraft/missile control systems prior to which he was from 1956 to 1958 chief systems engineer with Sanders Roe Ltd on "Black Knight" rocket development. During World War II, from 1939 to 1946, Mr. Bolton served in the Army and for 2½ years was a senior lecturer on radar and electronic control equipment at a R.E.M.E. Technical School. After the war he served as a civilian technical officer in the War Department and in 1951 was appointed an M.B.E. for his work on operational performance of radar and control equipment used for the air defence of Great Britain.

*D. H. Bolton*

**K. H. Kreuchen,** O.B.E., D.Phil., F.Inst.P., appointed managing director of the newly formed EMI-Varian Ltd., Hayes, Middlesex, studied physics, chemistry and mathematics at the universities of Kiel and Heidelberg. He started his career as a physicist at what is now the Max Planck Institute at Heidelberg. Five years later he joined the Development Laboratory of the Tube Factory of Siemens and Halske at Berlin—Siemenstadt. After the war, he was asked to come to England where he worked first on a government contract with S.T.C. In 1948 Dr. Kreuchen joined the staff of the Research Laboratories of EMI Limited, and specialized in research and development work on high-power velocity-modulated tubes, particularly klystrons. He has latterly been general manager of the Power Tube Division of EMI Electronics Ltd.

**Walter Marshall,** B.Sc., Ph.D., who is 37, is appointed by the U.K. Atomic Energy Authority director of the Research Group (which includes the Culham Laboratory as well as Harwell). He will continue to be director of the Atomic Energy Research Establishment, Harwell. Dr. Marshall took his B.Sc. in mathematical physics at Birmingham in 1952, and his Ph.D. in 1954. He joined the Atomic Energy Research Establishment at Harwell in that year and from 1957 to 1959 spent two years in the United States at Berkeley and Harvard before returning to Harwell. In 1960 he was appointed head of the Theoretical Physics Division at Harwell, and in 1964 was made a member of the research group management board. In March 1966, Dr. Marshall was appointed deputy director of the A.E.R.E., Harwell, and a year later received the additional appointment of deputy director of the Research Group. He has been director of A.E.R.E., Harwell, since April 1968.

**Michael Wadely,** D.F.H., M.I.E.E., who has been development manager of Newmark Instruments since November 1966, has become chief engineer of the Control Engineering Division. He was with G.E.C. (Electronics) Ltd, at their Applied Electronics Laboratory, Stanmore, as a project leader for 10 years. For the last three years with G.E.C. he was manufacturing manager of the Stanmore and Hemel Hempstead facilities. Mr. Wadely was educated at Brighton College and at Faraday House Electrical Engineering College, London.

*M. Wadely*

The new managing director of Veeder-Root Ltd., the counter and pump computer manufacturers of New Addington, Croydon, is **Lawrence Dilger,** B.Sc., M.I.E.E. He succeeds **B. E. Harry** who is returning to the U.S.A. to take up the position of vice-president international with the parent company in Hartford, Connecticut. Mr. Dilger has been with Veeder-Root for five years, having joined them as technical manager from Honeywell Controls. The company has also announced the appointment of **E. S. Ashford,** M.I.E.E., as technical manager. Mr. Ashford joined the company ten years ago as chief designer from E.M.I. Electronics Ltd. In his new capacity he will be responsible for R & D and design at New Addington.

**R. W. Merrick,** who has completed 41 years with Wright & Weaire Ltd and the Ferrograph Company Ltd, of which he was a founder in 1949, is retiring from active participation in the commercial affairs of Ferrograph, but continues as a member of the board. He will continue to serve as an executive director of the Ferrograph subsidiary, Rendar Ltd. **S. G. Griffiths** has been appointed director of commercial affairs in succession to Mr. Merrick. Mr. Griffiths has been on the staff of Electric and Musical Industries Ltd for 23 years, during the last five of which he has held the position of sales manager with responsibility for product planning and for world-wide marketing of professional tape recorders and associated equipment.

**F. H. Townsend,** a Londoner who has been in N. America since 1957, has been appointed manager, Electronic Tube Division of Canadian Westinghouse Co. Ltd. Prior to joining Canadian Westinghouse, Mr. Townsend served as manager, entertainment equipment sales, for the Westinghouse Electric Corporation, Electronic Tube Division. Mr. Townsend, who is 57, started his career with Cossors in 1931 where he remained in the research department until 1938 when he joined the vacuum laboratory of Pye. From 1946 until he went to the U.S.A. Mr. Townsend was chief vacuum engineer and manager of Cathodeon.

**John Lockyer,** chief designer, British Radio Corporation (Thorn Group), recently retired after 22 years service with the company. He started his career as an apprentice mechanical engineer in 1925 with Western Electric, which later became International Telephone and Telegraph. In 1931 he joined the B.B.C. to work on equipment for installation in the new Broadcasting House and later transferred to the Research Department as head draughtsman. Leaving the B.B.C. in 1946, Mr. Lockyer joined the Ferguson Radio Corporation at Enfield as chief mechanical designer.

**Kenneth F. Gibson,** B.Sc., has been appointed managing director of Computing Devices Company Ltd, London. Mr. Gibson, aged 33 and a graduate of Queen's University, Belfast, joined Computing Devices of Canada Ltd., Ottawa, the London company's parent organization, seven years ago. He became supervisor of the aerophysics department in 1964; manager of space sciences division 1965; and director, research and technology marketing just over a year ago.

**Christopher R. Robinson,** B.Sc., M.Sc., who is 38, has become chief engineer of Computing Devices Company Ltd., London, following the recent death of **Adrian Duguid.** Mr. Robinson took his B.Sc. in electrical engineering at Nottingham University and an M.Sc. at the University of Tennessee. He later lectured in electrical engineering at the Ohio State University before returning to England in 1960 to join Hawker Siddeley Engineering Ltd. After this he was a design engineer with Bendix Electronics Ltd. In 1967 Mr. Robinson joined Computing Devices of Canada Ltd, Ottawa, and has there been engaged on the planning of avionics products.

**Peter Iddon,** who has been with Multicore Solders Ltd for more than ten years, has been appointed U.K. sales manager, consequent upon the resignation of **G. A. Jarvis.**

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# Wireless World Colour Television Receiver

## 13. Chrominance circuit adjustments

Before dealing with the adjustment of the chrominance circuits, it is necessary to complete the description of the colour-difference amplifiers and some other matters which lack of space prevented inclusion in last month's article. The circuit of

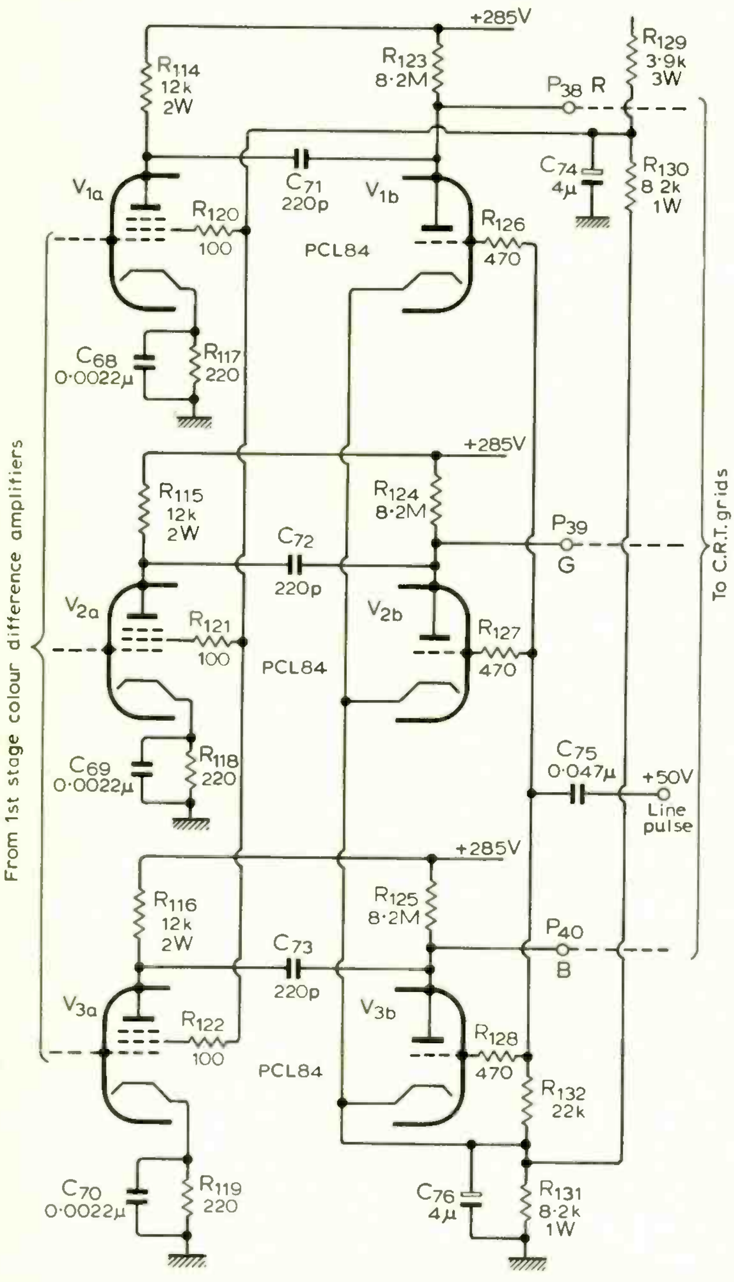


*Fig. 1. Circuit diagram of the output stages of the colour-difference video amplifiers and black-level clamps.*

Fig. 1 shows the colour-difference output stages. The grids of the three pentodes are connected through the resistors $R_{111}$, $R_{112}$ and $R_{113}$ to $P_{35}$, $P_{36}$ and $P_{37}$ on the main chrominance board. These three resistors are connected directly between the three pins of the main board and the pentode grid terminals of the valveholders and are shown dotted in the circuit diagram of Part 12.

The valves used are type PCL84 triode-pentodes; the pentode sections are used as the video amplifiers and the triode sections as black-level clamps. All three stages are identical and are self-biased by cathode resistors, $R_{117}$, $R_{118}$ and $R_{119}$; the by-pass capacitors $C_{68}$, $C_{69}$ and $C_{70}$, have values which give compensation for the effect of shunt capacitance on the anode loads.

Each pentode anode is connected to a triode anode through a capacitor and each triode anode in turn is connected directly to a grid of the colour tube. The triode anode loads are very high, 8.2M $\Omega$ and the triodes are normally non-conductive. During line flyback, however, a 50-V positive-going pulse from the line timebase is applied to each grid and makes each triode conduct. Because of the high anode load the voltage drop between anode and cathode becomes quite small, with the result that the anode potential drops to but little more than the cathode potential, which is set by the voltage divider, $R_{129}$, $R_{130}$ and $R_{131}$.

Because of this the coupling capacitors between the pentode and triode anodes are brought to a fixed charge once per line. The result is thus the same as if the conventional d.c. restorers were used on a normal signal. They cannot be used here, however, because the sync pulses, which normally control a d.c. restorer, are gated out of the signal at an early stage. Control has to be effected by pulses from the timebase, therefore.

The three valveholders are carried by a small metal panel measuring $3\frac{1}{2}$ x 2 inches. The pentode bias resistors and by-pass capacitors are connected directly between the appropriate tags of these holders and the panel.

A second panel of Veroboard measuring $3\frac{1}{2}$ x $2\frac{1}{2}$ inches is screwed to the metal panel with an overlap of $\frac{5}{8}$ inch, and on this are mounted the other resistors and capacitors as shown in the photographs of Fig. 5. Three 2 B.A. clearance holes are drilled through both panels and the composite panel is screwed to the top of the framework holding the other boards. It is convenient to tap the holes in the framework, since nuts would be rather inaccessible. Spacers are needed to stand off the board from the frame and these can conveniently be a pair of 0 B.A. full nuts.

Fig. 2 shows the interconnections between the two main boards. Notice particularly that the connection between $P_6$ and $P_{26}$ is made by a 0.0022 $\mu$F capacitor.

Coil-winding details are given in the table, and a second table gives typical no-signal voltages.

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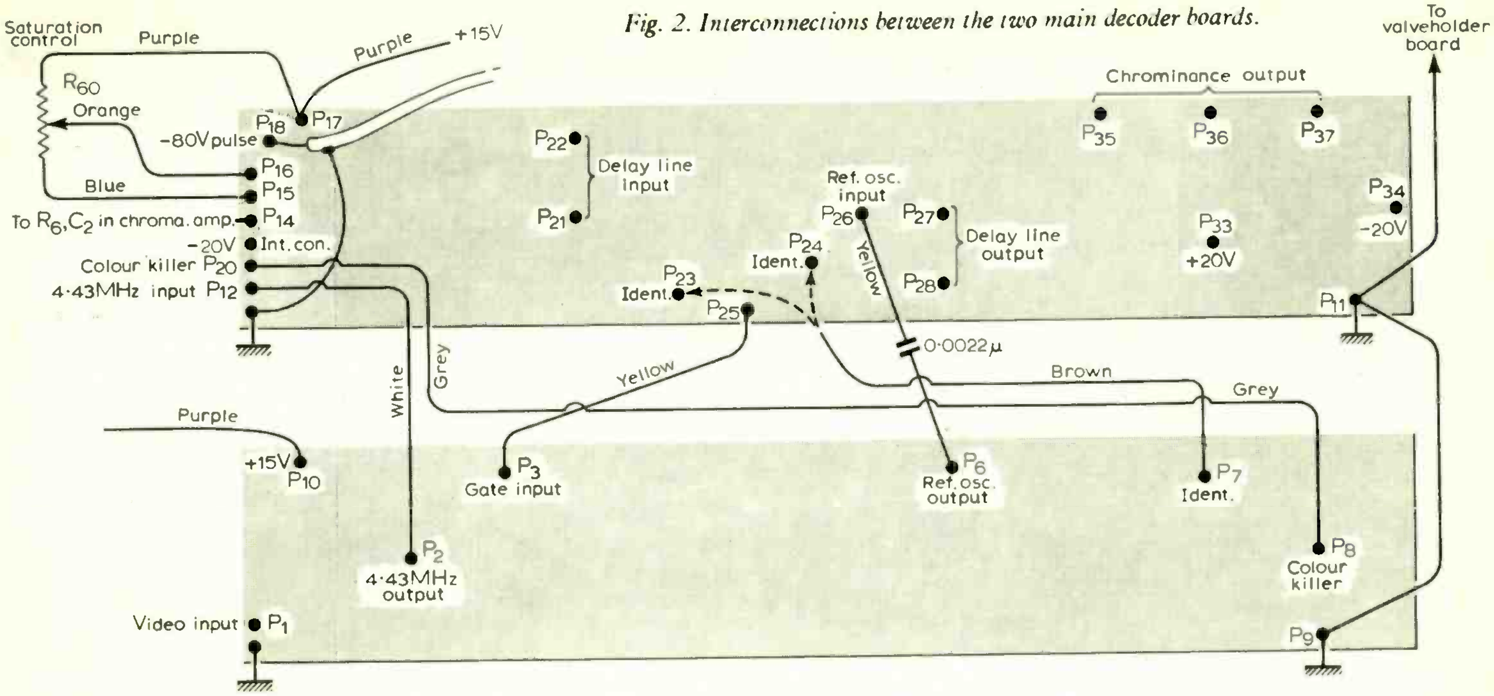


*Fig. 2. Interconnections between the two main decoder boards.*

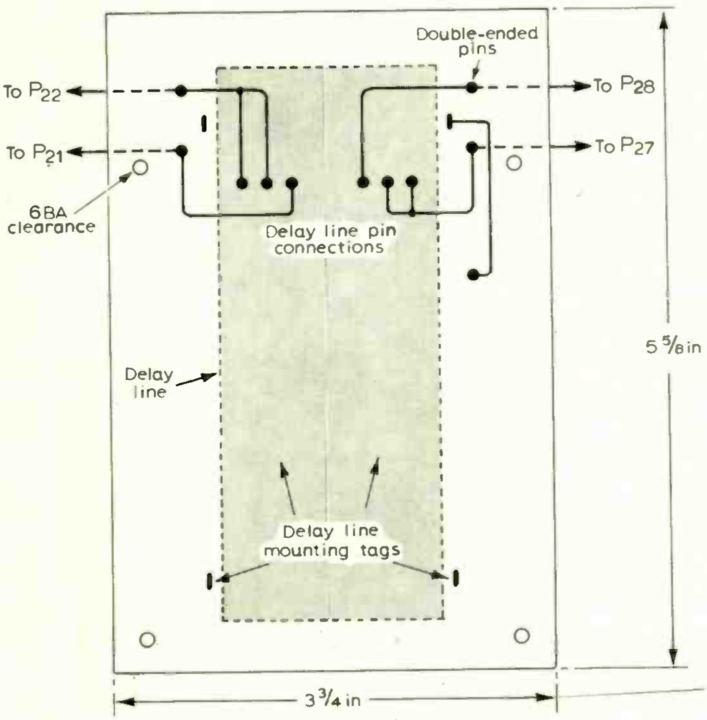


*Fig. 3. Details of the delay-line mounting board are given here, viewed from the rear. This is for the original model of the Mullard delay line.*

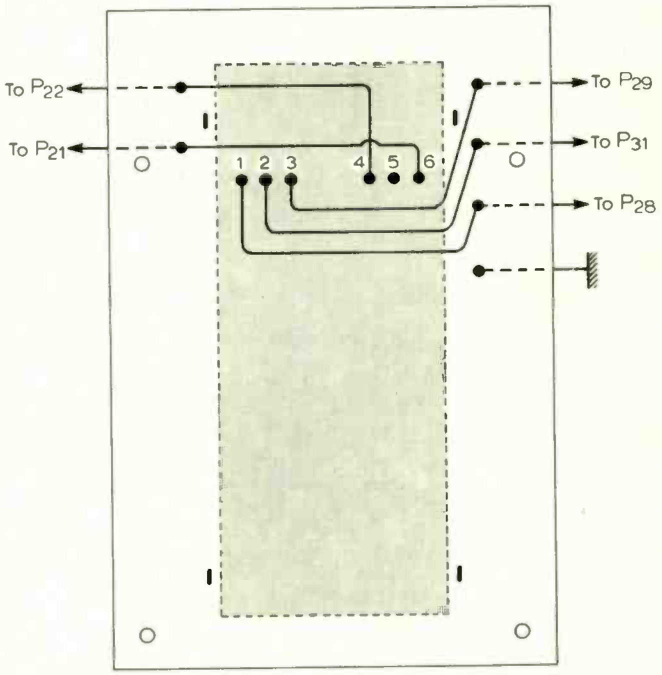


*Fig. 4. This drawing shows the details of the board for the current Mullard-type DL1E delay line. With this line $T_7$ is not required and $R_{72}$ and $R_{95}$ should be changed to 100 ohms.*

**COIL WINDING DETAILS**

| Coil | Turns | Winding | Frequency (MHz) | Lmin (μH) | Lmax (μH) | Rdc (Ω) | Core |
|---|---|---|---|---|---|---|---|
| $L_1$ | 60 | single-layer | 4.43 | 11 | 29 | 2.35 | short |
| $L_2$ | 120 | scramble | — | 52 | 133 | 4.6 | long |
| $L_3$ | 55 | single-layer | 4.43 | 9.25 | 25.8 | 1.6 | long |
| $L_4$ | 1700 | scramble | | 17.000 | 70.000 | 90 | Ferroxcube |
| $L_5$ | 250 | scramble | | 204 | 475 | 10.2 | long |
| $L_6$ | 70 | scramble | 4.43 | 15 | 40 | 2.8 | long |
| $L_7$ | 90 | scramble | 6 | 24.2 | 65 | 3.1 | short |
| $L_8$ | 30 | single-layer | 4.43 | 2.8 | 7.1 | 0.85 | long |
| $L_9$, $L_{10}$ | 120 | scramble | 4.43 | 57.5 | 139 | 5 | short |

Except for $L_4$, all coil formers are Neosid type 722/1 with cans 7100, and terminal bases 5027. The long cores are Neosid 4×0.5×12.7 and the short cores Neosid 4×0.5×6/900. For $L_4$ an Aladdin former is used of $\frac{1}{4}$-inch diameter and $2\frac{3}{8}$-inches long with a can $\frac{3}{4}$-inch square by $2\frac{3}{8}$-inch long. All coils which are scramble-wound have cheeks fitted $\frac{1}{4}$-inch apart. All coils are wound with No. 42 gauge wire, which can be enamel or enamel-silk covered. The core of $L_4$ is Ferroxcube FX1068, wrapped with Sellotape to be an easy fit in the former.

**LINE VOLTS 14.5 WITH NORMAL SIGNAL**

| Stage | Base | Emitter | Collector | Stage | Anode | Cathode |
|---|---|---|---|---|---|---|
| $Tr_1$ | 0.65 | 0 | 12.9 | $D_1$ | −10 | 0 |
| $Tr_2$ | 1.05 | 0.7 | 14.1 | $D_2$ | −6.1 | 0.7 |
| $Tr_3$ | 0.45 | 0.5 | 14.25 | $D_3$ | 0.7 | 8 |
| $Tr_4$ | 0.6 | 0.2 | 8.6 | $D_4$ | 0 | 10.9 |
| $Tr_5$ | 2.7 | 2.1 | 11.6 | $D_5$ | 0 | 3.9 |
| $Tr_6$ | 3.5 | 2.95 | 11.6 | $D_6$ | 4 | 6.7 |
| $Tr_7$ | 2.4 | 2.7 | 13.2 | $D_7$ | 0 | 5.3 |
| $Tr_8$ | 4 | 4 | 13.3 | $D_8$ | 2.4 | 2.4 |
| $Tr_9$ | 2.2 | 1.6 | 13 | | | |
| $Tr_{10}$ | 5.2 | 4.6 | 12.5 | | | |
| $Tr_{11}$ | 0 | 0 | 5.5 | | | |
| $Tr_{12}$ | 0 | 0 | 5.5 | | | |
| $Tr_{13}$ | 0 | −0.65 | 15 | | | |
| $Tr_{14}$ | 0 | −0.6 | 17.6 | | | |
| $Tr_{15}$ | 0 | −0.65 | 13.5 | | | |

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Fig. 3 shows an under view of the board which carries the delay line and its connections. The delay line includes tuned circuits which are factory adjusted and should not be touched. There are in existence two types of line which can be distinguished with an ohmmeter. The connecting tags are in two groups of three and in the original pattern of line the outer pair of each three must be joined together, as shown in Fig. 3. An ohmmeter test between the tags of each pair before they are joined will show an open circuit. In the later model the test will show an internal connection between these tags. They must not then be joined together, but the connections shown in Fig. 4 must be adopted. This newer model, the Mullard type DL1E, has built-in auto-transformers at each end instead of plain coils. As a result, a push-pull output can be obtained directly from it and $T_7$ of Part 12 should not be used with it. At the input two different impedance levels are available. The higher impedance input provides a greater output and if this should be needed it is necessary to change $R_{72}$ to 390 ohms. However, normally the lower impedance is suitable and $R_{72}$ and $R_{95}$ should be each 100 ohms instead of the 150 ohms needed for the earlier model.

There are a good many adjustments needed in the chrominance circuits but nothing very complicated in the way of apparatus is needed. A signal generator and an oscilloscope will do most things. It is advisable to use an isolating mains transformer, not merely to protect oneself, but to protect the test equipment. In addition a 0.002-$\mu$F capacitor should be in series with the signal generator output.

The procedure is as follows:

1. Apply the output of the signal generator between the decoder input terminal, $P_1$, and chassis.
2. Set the saturation control $R_{60}$ to maximum.
3. Short-circuit $D_8$ (to render the colour-killer inoperative) and $R_{30}$ (to render the local oscillator inoperative).
4. Connect the oscilloscope to the base of $Tr_{10}$.
5. With an input at 6MHz tune $L_7$ for minimum output.
6. With an input of 4.43MHz tune $L_6$ for maximum output.
7. Remove short-circuit from $D_8$ leaving that to $D_{30}$ in place.
8. Disconnect the inter-unit lead from $P_3$.
9. Join $P_3$ to the junction of $R_{48}$ and $R_{49}$ and also connect it to the chassis through 0.01 F.
10. Connect the oscilloscope to the cathode of $D_1$.
11. With an input of 4.43MHz tune $L_1$ for maximum output.
12. Replace the connections altered under (8) and (9) to normal.
13. Connect the signal generator across $C_{59}$ and the oscilloscope

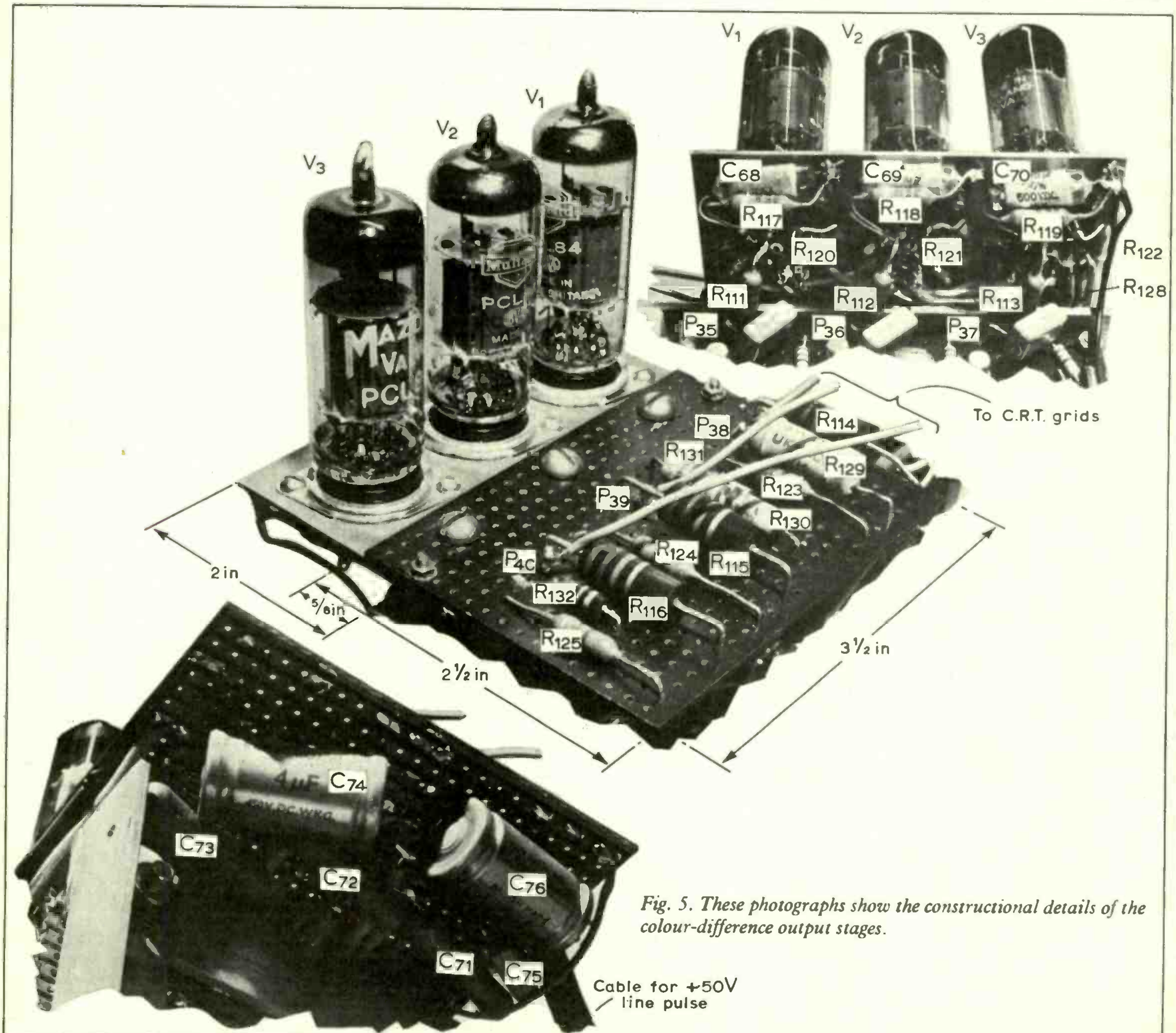


*Fig. 5. These photographs show the constructional details of the colour-difference output stages.*

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across $R_{96}$.
14. At 4.43MHz adjust $L_9$ for minimum output.
15. Connect the signal generator across $C_{61}$ and the oscilloscope across $R_{97}$.
16. At 4.43 MHz adjust $L_{10}$ for minimum output.
17. Disconnect the signal generator and oscilloscope.
18. Connect the oscilloscope between $P_6$ and chassis.
19. Remove the short-circuit from $R_{30}$.
20. Adjust $L_3$ for maximum output which should be about 5.4V p-p.
21. If possible, examine the waveform and if necessary re-adjust $L_3$ to make it more nearly sinusoidal. This will usually entail screwing in the slug a little. An output of 5V p-p of good waveform should be obtainable.
22. Connect the oscilloscope to $C_{61}$.
23. Adjust $L_8$ for minimum output.
24. Connect the oscilloscope to $P_6$ and chassis, and take a separate lead from $P_6$ to the 'external sync' terminal of the oscilloscope.
25. Use a 1-$\mu$s sweep range and carefully lock the oscilloscope to the wave. Adjust the X-shift so that the top of a half cycle is exactly on a vertical line of the oscilloscope graticule.
26. Connect the oscilloscope to the junction of $R_{90}$ and $C_{57}$, but leave the 'external sync' terminal still joined to $P_6$.
27. Adjust $C_{57}$ so that the graticule line, which previously coincided with the top of a half cycle, now coincides with a zero of the sine wave. If this cannot be reached with $C_{57}$ at maximum, add $C_{56}$ of perhaps 20pF. (Note. If a double-beam oscilloscope is available and it has the same phase shift in both channels, the two inputs can be connected simultaneously to $P_6$ and across $T_6$. Then $C_{57}$ can be adjusted for 90° phase angle between the two traces.)
28. Restore all connections to normal.
29. Tune in a signal and lock line and field timebases to it. With saturation at minimum adjust for a good black and white picture. Adjust the tuning from a position of poor picture detail to one which is just short of the setting at which sound-channel interference appears.
30. Connect the 'external sync' terminal of the oscilloscope to a convenient point on the line timebase (a wire within a few inches of the line output valve will usually give enough pick-up).
31. Connect the oscilloscope input to $P_1$ and check that there is a colour burst on the waveform. If not, readjust the tuning, which may be critical.
32. Disconnect the lead from $P_3$ and connect the oscilloscope to $P_3$.
33. Adjust the X-shift to centre the colour burst on a vertical line of the graticule.
34. Connect the oscilloscope to $P_{25}$.
35. The trace should be a damped sinewave of perhaps three or four noticeable cycles. Adjust $L_5$ so that the first positive half cycle is centred on the vertical line of the graticule on which the colour burst was previously aligned. (Note. If a double-beam oscilloscope is available connect it to display the burst on one trace and the damped sinewave on the other.) The amplitude of the first positive half cycle should be about 3.5V.
36. Replace all connections to normal.
37. Set $R_{19}$ and $R_{25}$ at a little below maximum.
38. Remove the link between $P_4$ and $P_5$.
39. Short-circuit $D_8$.
40. Connect Model 8 Avometer on 25-V range between chassis and the collector of $Tr_4$ (i.e., $P_4$).
41. Adjust $R_{19}$ and $R_{25}$ so that the meter reads 7V, and so that by adjustment of $R_{25}$ only the voltage can be varied from nearly zero to 12V. This fixes the setting of $R_{19}$. Then set to 7V by $R_{25}$.
42. Turn up saturation. Horizontal colour bars should appear. Adjust for a moderate intensity of colour.
43. Adjust $L_2$ for a colour lock if possible; if not for the slowest movement of the bars.
44. Replace the link between $P_{24}$ and $P_{25}$.
45. Adjust $R_{25}$ for a colour lock. This means that the horizontal bars will disappear and that the colour will be properly distributed over the picture. The colours, however, may be the wrong ones, but at this stage do not worry about this.
46. Adjust $R_4$ so that the setting of $R_{25}$ for a colour lock is not too critical.
47. Remove the short-circuit from $D_8$. If the colour killer is operating correctly this should have no effect.
48. Connect the oscilloscope across $R_{44}$. An approximate sinewave of 7.8kHz should appear. Adjust $L_4$ for the best sinewave.
49. Readjust the tuning. It will now be critical for colour. With quite small mistuning all colour should disappear, but at the proper setting not only should traces of colour appear but the reference oscillator should lock-in without any other adjustment.
50. Adjust saturation for a reasonable depth of colour. Avoid turning it up too much for this will produce colour streaking.
51. Examine the actual colours obtained. Test Card F is best for this. On this the background should be a pale blue and the girl should have a red dress with brown hair and the doll should be green. If the colours are wrong or nearly all wrong, transfer the lead to $P_{24}$ to $P_{23}$, thus changing the phase of the bistable. All colours should now be substantially correct, but may not be precisely right. Thus, reds should be red, greens green, and blues blue, but some may be too vivid and others too pale, while other colours, which are a mixture of these may have considerable errors of hue.
52. The controls $R_{98}$, $R_{106}$ and $R_{108}$ have now to be adjusted to put this right. The $R-Y$ channel gain is fixed, but the relative gain of the other two is adjustable as is also the matrixing of the $G-Y$ channel by $R_{98}$. Fortunately, these controls are not very critical. Adjustments are initially best carried out on the colour bar test pattern which is usually broadcast several times a day during the trade test transmissions. There is little that can be said about these adjustments beyond saying that they are done a little at a time until all colours look right.
53. Since the delay line has not yet been brought into use the receiver is operating in the simple PAL mode. Under conditions of good reception it should give a good colour picture which at normal viewing distance may satisfy many people. Its main defect will be that in close viewing (how close depends on individual eyesight) alternate lines in a large area of colour may be of slightly different shades and the lines appear to move vertically. This is because in simple PAL the integration of successive lines is performed by the eye, and the eye cannot do this when it is too near the picture.
54. With the receiver tuned to a signal so that the reference oscillator remains locked, connect up the delay line. Disconnect the lead to $P_{12}$ and disconnect the lead from $P_6$. Connect $P_6$ to $P_{12}$ through 10k$\Omega$.
55. Disconnect the links $P_{29}$ to $P_{30}$ and $P_{31}$ to $P_{32}$.
56. Connect the oscilloscope to $P_{31}$. It will display the 4.43-MHz output from the reference oscillator. Adjust $R_{75}$ for a minium. If no minimum setting can be found, transfer the oscilloscope to $P_{29}$. If there is now a definite minimum setting for $R_{75}$, reverse the leads to one end of the delay line. There should now be a definite minimum setting with the oscilloscope connected to $P_3$.
57. Ideally the minimum output should be zero. In practice, it is not. If it is not very small indeed, however, compared with the output at $P_{29}$, try adding capacitance across $R_{76}$ or $R_{77}$, across one there will be a phase lead and across the other a phase lag. Values of from 25-100pF should be tried.
58. Replace connections to normal and check on a picture. The crawling-line effect on areas of solid colour should now have disappeared. If it has not, slight readjustment of $R_{75}$ should make it do so.

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This completes the adjustments to the chrominance circuits. The list appears to be a very formidable one, but in actual fact the adjustments are not at all difficult to carry out. No serious difficulty is likely to arise unless there is some gross defect. Unfortunately, the symptoms of a fault in the colour circuits can be very different from what one is inclined superficially to expect. Thus, for example, suppose that there is some defect which renders the B−Y channel inoperative. One's first reaction is to expect that there will be no blue in the picture, but this is quite wrong. There will be too much blue! It is important to remember that this is a colour difference channel. For a fully-saturated blue signal, the B–Y channel carries a signal of which the Y component is supposed to cancel the Y signal applied to the cathode and leave the B signal to operate the gun. However, if there is no signal at all applied to the blue grid there is still the Y signal applied to the cathode and this will operate the blue gun to produce blue.

The quickest way of checking in such cases is, of course, to use the oscilloscope to make sure that signals are in fact being applied to each grid of the tube. However, if it is necessary to diagnose from the symptoms the waveforms of Fig. 5, Part 10 will be found very helpful.

From this it can be seen, for instance, that on a blue signal the Y signal is quite small and that the R–Y and G–Y signals are equal and opposite so that they cancel out to give no total signal on the red and green guns; the B−Y signal is large, but its complete absence leaves the small Y signal on the blue gun.

If the R−Y channel were to fail, then with the same blue signal the cancelling signal on the red grid would be absent and the Y signal on the cathode would operate the red gun when it should be inoperative. The net result would be to give the blue a magenta cast.

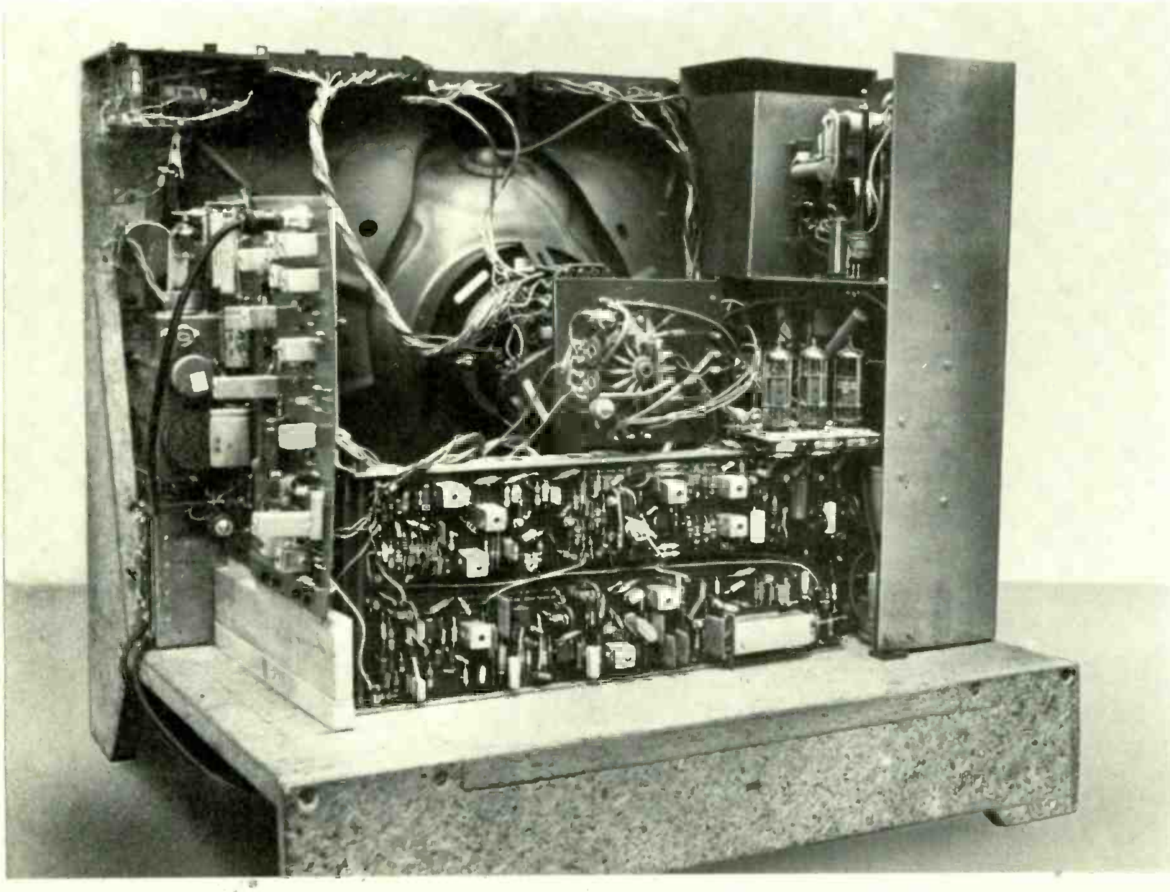
It is possible to adopt this procedure in diagnosing colour troubles when the signal is the colour-bar test pattern for the colours are then known ones and include pure red, green and blue. It is almost impossible to do so on a general picture where the precise colours are unknown and where pure primary colours are fairly rare.

In the development quite a number of colour faults were found and some of them through inexperience took quite a time to trace. In the end, however, they all proved to be simple electrical faults. Some, like reversed connections to a transformer winding or to the delay line, were a little puzzling at first. One which had devastating effects on the colours was a failure in the G−Y channel. This was localized quickly enough for there was full h.t. voltage on the pentode anode, indicating that it was taking no current. A further check showed it to have no $g_2$ voltage and the problem then was, why? This took some time to find for the fault was a very rare one, an invisible break in a copper strip on the Veroboard! Once found, a touch with the soldering iron put matters right.

It may seem a statement of the obvious to point out that in order to obtain a colour picture one must have the proper chrominance input to the decoder, including the colour burst. This depends upon the bandwidth of the i.f. amplifier and they will not be obtained if this is insufficient.

In monochrome inadequate bandwidth does no more than reduce the horizontal definition and can pass unnoticed by the uncritical. In colour it may reduce the amplitude of the burst so much that a colour lock is difficult or impossible to obtain, but traces of colour and, in particular, horizontal colour bars, may still be evident. The chrominance signals are transmitted vestigial sideband below the sub-carrier in frequency. The higher modulation-frequency components of the chrominance signal may thus be within the i.f. pass-band even if the sub-carrier frequency itself is just outside it.

It is the normal current practice to make the −6-dB points of the i.f. amplifier 39.5MHz and 35MHz; the burst comes at 35.17MHz and so is attenuated only slightly less than 6dB. As transmitted, the peak-to-peak amplitude of the burst is the same as that of a sync pulse. At the detector output of the receiver it will rarely be greater than one-half of this. It does



*Rear view of the complete recei with the complete decoder in its closed position at the rear.*

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not take much misalignment of the i.f. amplifier to reduce the colour burst to a level which is inadequate for locking the reference oscillator properly.

Mistuning the receiver one way brings the vision carrier below 39.5MHz, the upper modulation frequencies are cut-off, the definition becomes poor and, as the colour burst is cut-off, there is no colour. Mistuning the other way brings the vision carrier above 39.5MHz, the upper modulation-frequency response is improved but a strong interference pattern from the sound channel occurs.

It might be thought that a bandwidth at 6dB of 4.5MHz is rather small when the transmitted bandwidth is 5.5MHz. In practice, however, the results are good. It is not impossible to obtain a 5.5MHz bandwidth but it is very difficult to do so and obtain the drop in response of at least 30dB on a further 0.5MHz change of frequency, which is necessary for sound-channel rejection. A bandwidth of 5MHz is more practicable but even then the cut-off needed for proper sound-channel rejection is hard to obtain.

**Transient response**

In television it is not so much the frequency response which is important as the transient response, and what is really required is a very short rise time without overshoot. A flat frequency response with a sharp cut-off, which is inevitable if the bandwidth is large, may give short rise time, but it inevitably produces overshoot. It is desirable for the response to fall off gradually towards and beyond the edge of the passband and so the edge is usually taken as the 6-dB point.

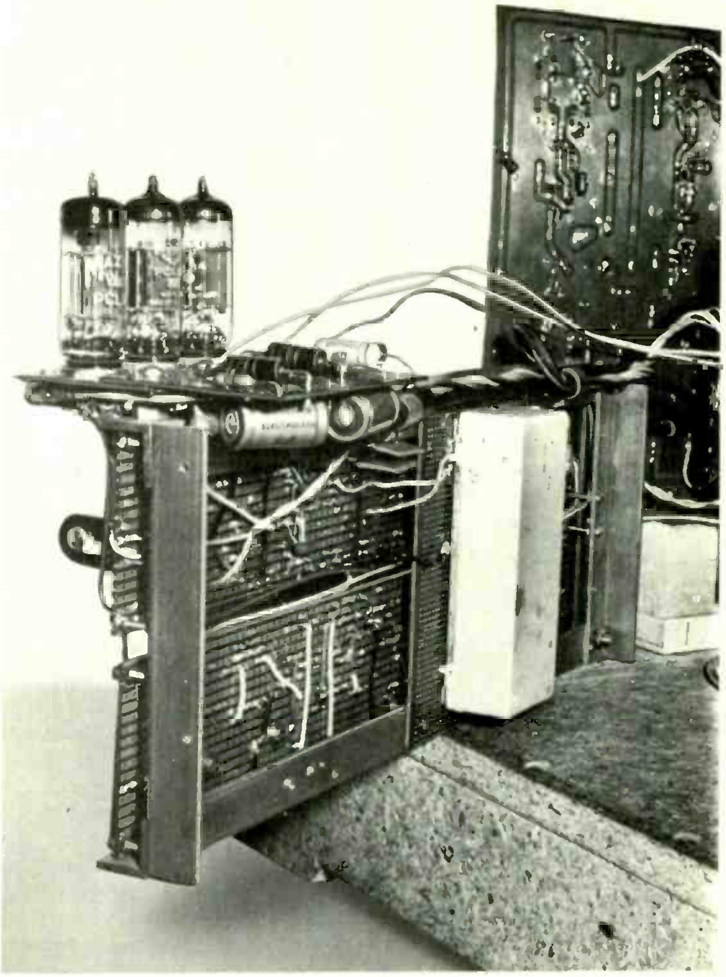
The nearer this point is to the sound channel the more likely it is that objectionable overshoot will occur and the more difficult it is to secure adequate rejection of the sound channel.

There are two matters involved in deciding just where to place the cut-off point. One is performance and the other is cost. Current practice places it at 35MHz and this is certainly the lowest practicable bandwidth and it is cheapest. To place it at 34MHz would certainly greatly increase the cost of the i.f. amplifier and might make it too difficult to adjust and keep in adjustment. A limit at 34.5MHz is certainly practicable but it is still a moot point as to whether it is desirable. The basic definition would certainly be improved; there would probably be more overshoot but it is not thought that this would be serious. However, the increased amplitude of the chrominance components around 4.43MHz would certainly increase colour patterning effects and the net result might well be worse.

So much work has been involved in the development of this equipment that it has not been possible to explore all of the finer points of design. As a result we do not know just what is the optimum bandwidth when little regard is paid to cost. We have no doubt that for a monochrome *transmission* it should be at least 5MHz but we are very doubtful whether with a colour transmission the increase of patterning would not more than offset the improvement in definition.

It is a very fortunate circumstance that colour improves the apparent definition and this in spite of the fact that the colour signals themselves are transmitted in a very narrow bandwidth and the true definition is produced by a monochrome signal, the Y signal. The reason is, of course, that the change between adjacent objects in the picture is not merely one of light and shade, as in monochrome, but of colour as well. This becomes obvious when it is remembered that two objects which are adjacent and of different colours are readily distinguished in a colour picture even when they are of precisely the same luminance, whereas in monochrome reproduction they could not then be distinguished at all whatever the bandwidth.

In conclusion, we should mention that there has been a change in the A.B. Metal Products tuner. It is basically the same as the earlier model referred to in Part 7, but it no longer



*The decoder section opened out and showing the PAL delay line.*

has the printed-circuit board shown in Fig. 2, Part 8. Certain resistors are now mounted internally and have different values; also the case is now connected to the negative of the supply instead of being isolated from it.

In the i.f. board $R_{32}$ must be changed to $590\Omega$ ($120\,\Omega + 470\Omega$) and $R_{33}=0$. On the tuner itself $R^{11}$ between the positive and negative supply terminals remains unchanged at $2.2\text{k}\Omega$. The other resistor ($R^1 = 470\,\Omega$) is now fitted internally and has the value of $1\text{k}\,\Omega$.

The chassis of the tuner will be at $-20$ V to all other chassis in the equipment and must be appropriately insulated. The aerial feeder can be connected as before through $0.001$–$\mu$F capacitors shunted by 1–M $\Omega$ resistors. The outer of the cable connecting the tuner to the i.f. board, however, must not be connected directly to the tuner case, but through $0.001\mu$F. The coupling capacitor $C^1$, Fig. 2, Part 8, is still required and can be connected to the tuner case.

There is no longer an emitter connection of the mixer externally accessible to which a signal generator can be connected for alignment. The cover of the tuner is easily removable, however, by bending up two metal tags, one at each end of the cover. The mixer is at the shaft end and the emitter is joined to a 1–k $\Omega$ resistor shunted by 150pF and is reasonably accessible.

**This article concludes the series on the *Wireless World* colour television receiver. It is intended to reprint the whole series in booklet form and an announcement will be made when supplies are available.**

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# Test Your Knowledge

*Series devised by L. Ibbotson,** *B.Sc., A.Inst.P., M.I.E.E., M.I.E.R.E.*

## 13. Frequency Modulation

1. A sinusoidal carrier has an unmodulated frequency of 90MHz. A particular modulating signal causes the carrier frequency to vary between 89.99 and 90.01MHz 1000 times per second. If the amplitude of the modulating signal is doubled
(a) the carrier frequency will still vary between 89.99 and 90.01MHz 1000 times per second
(b) The carrier frequency will vary between 89.99 and 90.01Mhz 2000 times per second
(c) the carrier frequency will vary between 89.98 and 90.02MHz 1000 times per second
(d) the carrier frequency will vary between 89.98 and 90.02MHz 2000 times/sec.

2. A sinusoidal carrier is frequently modulated in turn by two signals of the same amplitude, one having a frequency of 100Hz, the other 1000Hz. The amplitude of the phase variation of the carrier is
(a) zero in both cases
(b) the same for both signals
(c) larger for the lower frequency signal
(d) larger for the higher frequency signal.

3. A frequency modulated transmitter is radiating a modulated carrier, the modulation index being 2 radians. The amplitude of the modulating signal is doubled. As a result the total power radiated
(a) remains unchanged
(b) is doubled
(c) increases by 50%
(d) increases by a factor of $\sqrt{2}$.

4. The amplitude of the carrier frequency component of the spectrum of a frequency modulated carrier is always
(a) the same as the amplitude of the unmodulated carrier
(b) less than the amplitude of the unmodulated carrier
(c) greater than the amplitude of the unmodulated carrier
(d) zero.

5. The spectrum of a carrier, frequency modulated with wide deviation by a single sinusoid, contains many side-frequency components. The number of components with significant amplitudes (assuming maximum deviation) is
(a) the same whatever the modulating frequency
(b) smaller the higher the modulating frequency
(c) larger the higher the modulating frequency
(d) greatest when the modulating frequency is equal to the square root of the deviation.

6. The carrier frequency of a f.m. signal may be increased either by multiplication or heterodyning. The result is
(a) no change in the frequency deviation in either case
(b) an increase in the frequency deviation in both cases
(c) an increase in the frequency deviation when multiplication is used; no increase when heterodyning is used
(d) an increase in the frequency deviation when heterodyning is used; no increase when multiplication is used.

7. The Armstrong method of generating a f.m. signal is based upon the generation of a pair of amplitude modulation sidebands (using a balanced mixer) and the subsequent addition of a carrier frequency signal lagging by $/_2$ radians on the phase which the a.m. carrier would have had. The basic signal so produced is effectively
(a) frequency modulated with a wide frequency deviation
(b) f.m. with a narrow frequency deviation
(c) phase modulated with a large phase deviation
(d) phase modulated with a small phase deviation.

8. It is possible for a f.m. radio set to receive two transmissions within the bandwidth of its r.f. stage and, provided the amplitude of the unmodulated carrier of the stronger is at least twice that of the weaker, only respond to the stronger signal with negligible interference from the weaker. This effect can only occur if
(a) the maximum modulation index of the stronger signal is at least several radians at the highest modulating frequency
(b) the modulation index of the weaker signal is not greater than 0.5 radian at the lowest modulating frequency
(c) the two carriers are not closer together than the sum of the highest modulating frequencies of both
(d) the r.f. tuned circuit cuts off most of one sideband of the undesired signal.

9. The B.B.C. f.m. broadcasting system uses a maximum frequency deviation of 75kHz and transmits an audio bandwidth of 15kHz. The i.f. bandwidth of a receiver should be at least
(a) 30kHz
(b) 90kHz
(c) 105kHz
(d) 180kHz.

10. If the i.f. bandwidth of a f.m. receiver is much narrower than it should be the main effect is
(a) removal of the higher audio frequencies from the output signal
(b) non-linear distortion in the output signal
(c) a large increase in the noise output from the receiver
(d) a reduction in the interference rejection effect.

11. Communications f.m. systems generally use a much narrower r.f. bandwidth than that required by the B.B.C. broadcast system; restriction of the a.f. bandwidth allows a much smaller maximum frequency deviation to be used. In addition to allowing more channels in a given frequency band, the result is that for a given transmitter power
(a) the service range is increased
(b) the output signal to noise ratio is improved
(c) the interference between stations broadcasting on adjacent channels is reduced
(d) the receiver i.f. gain required is less.

12. Many f.m. receivers have a stage at the end of the i.f. amplifier which "limits" the amplitude of the signal by cutting off the top and bottom of the waveform (those which do not have this stage use a demodulating circuit which incorporates limiting action). The purpose of limiting is
(a) to prevent the demodulator from being overloaded
(b) to provide a simple a.g.c. action
(c) to remove amplitude variations due to noise
(d) to improve the demodulator action by supplying it with a square waveform.

13. If we represent the signal presented to the demodulator in a f.m. receiver as:
$V \sin[\omega_c t + \phi(t)]$, the demodulator must produce an output voltage which is
(a) directly proportional to $\phi(t)$
(b) inversely proportional to $\phi(t)$
(c) directly proportional to $d\phi(t)/dt$
(d) inversely proportional to $d\phi(t)/dt$

14. Following the demodulator in a receiver for the B.B.C. f.m. broadcasts is a circuit which consists of a resistor and capacitor arranged as a potential divider, the output being taken across the capacitor. The time constant of this circuit is specified as 50μs. Its purpose is
(a) to correct for frequency distortion which all f.m. demodulators introduce into the audio signal
(b) to correct for frequency distortion deliberately introduced into the audio signal at the transmitter
(c) to attenuate the higher audio frequencies because the receiver output stages cannot handle them
(d) to filter out any remaining carrier-frequency component in the output signal.

**Answers and comments, page 295.**

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# A Transistor Multiplier Circuit

## A multiplier circuit and how it may be employed for modulation, mixing, detecting, a.g.c. and a.a.c. A circuit for a high-performance audio signal generator is described.

*by A. F. Newell, M.I.E.R.E.*

Many electronic circuits are basically nultipliers; some examples are detectors, requency changers, modulators, square aw voltmeters and analogue computer nultipliers. The physical realization of the nultiplication function can take many forms anging from a simple non-linear element uch as a diode, to the fairly complex ircuits used in analogue computers. In ome circuits there is only one pair of input erminals, and the output consists of many omponents besides the product of the nputs. While in other circuits separate erminals are available for each input, and he output is the product of the two inputs.

In this article a circuit will be described in vhich separate terminals are available for he inputs, and in which the output can be ither:

$$k_1 A + k_2 AB$$

or:

$$kAB$$

vhere $A$ and $B$ are the two inputs and the $k$s re constants which depend on circuit alues. Several examples will be given to how how the circuit may be used to erform different functions.

### Basic circuit

The basic circuit, Fig. 1, consists of a long-ailed pair, the emitter current of which is upplied by a simple amplifier.

The linearity of the multiplier will of ourse be determined by the linearity of the two amplifiers. The linearity of $Tr_3$ is determined mainly by the ratio of the constant resistor $R_3$, and the varying emitter resistance of the transistor, which is approximately:

$$r_e = 25/I_E \;(I_E \text{ in mA})$$

Now:

$$I_E = V_E/R_3$$

therefore:

$$R_3/r_e = V_E/25 \text{ with } V_E \text{ in mV}$$

This shows that if $V_E$ is large compared with 25 mV then the total emitter resistance is nearly constant, and the linearity is good. But at low emitter current where $V_E$ becomes comparable with 25 mV the linearity becomes poor. In practice this means that if the input $V_2$ is a.c. then it is possible to restrict the signal to the linear part of the amplifier characteristic. But if the input is d.c., additional circuitry will be required to linearize the characteristic.

To determine the linearity of the long-tailed pair, a simplifying assumption will be made. This is that the relationship between the base-emitter voltage and emitter current of the two transistors is given by the diode equation:

$$I = I_o[\exp(qV/KT) - 1]$$

This is a good approximation provided that $r_b/h_{fe}$ is small, which is usually the case for a transistor with a high gain working at currents of a few milliamperes or less.

It is easy to select transistors which most nearly satisfy this requirement by using the circuit of Fig. 2. If the relationship holds, then, when the emitter current is switched by a factor of ten, the change in $V_{BE}$ should be the same whether the switch is from 10 $\mu$A to 100 $\mu$A, or from 100 $\mu$A to 1 mA.

Assuming that:

$$I_E = I_{EBS}[\exp(qV/KT) - 1]$$

then:

$$V_{BE} = (KT/q)\log_e(I_E/I_{EBS}) \ldots \quad \text{for } I_E \gg I_{EBS}$$

$$V_1 = V_{BE_1} - V_{BE_2}$$

and:

$$= 0{\cdot}025 \log_e(I_{E1}/I_{E2})$$

From this equation the curve of $I_{E1}$ and $I_{E2}$ against $V_1$ can be drawn (Fig. 3). It can be seen that between ±10 and ±15 mV the relationship has good linearity, but beyond these points it is increasingly non-linear.

It is now possible to see how the circuit acts as a multiplier. From Fig. 3 the relationship between $I_{E1}$ and the total emitter current $I_E$ over the linear part of the curve is:

$$I_{E1} = \frac{I_E}{2}\left(1 + \frac{V_1}{V_{1max}}\right)$$

where $V_{1max}$ is the voltage for $I_{E1} = I_E$.

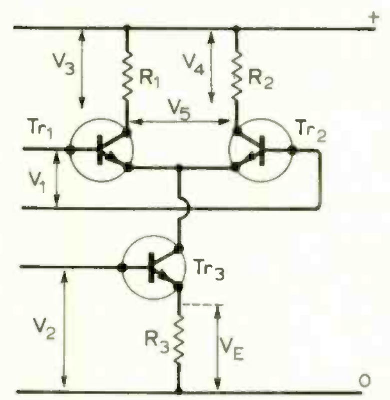



Fig. 1. The basic circuit of the multiplier.

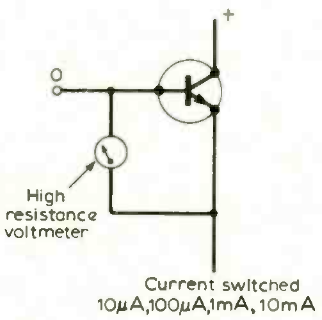
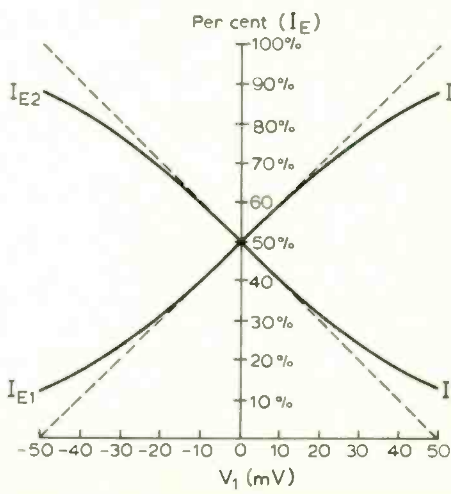



Fig. 2. The test circuit employed.




(Right) Fig. 3. Characteristics of the long-tailed pair.

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Now $V_{1max} = 50$ mV $= 1/20$ of a volt which makes:

$$I_{E1} = \frac{I_E}{2}(1 + 20\,V_1)$$

$$= \frac{I_E}{2} + 10\,V_1 I_E \quad \ldots (1)$$

similarly:

$$I_{E2} = \frac{I_E}{2} - 10\,V_1\,I_E \quad \ldots (2)$$

and:

$$I_{E1} - I_{E2} = 20\,V_1\,I_E \quad \ldots (3)$$

but:

$$I_E \approx \frac{V_2}{R_3}$$

$$\therefore \quad I_{E1} \approx \frac{V_2}{2R_3} + \frac{10\,V_1\,V_2}{R_3} \quad \ldots (4)$$

$$I_{E2} \approx \frac{V_2}{2R_3} - \frac{10\,V_1\,V_2}{R_3} \quad \ldots (5)$$

$$I_{E1} - I_{E2} \approx 20\,\frac{V_1\,V_2}{R_3} \quad \ldots (6)$$

If the output is taken across $R_1$:

$$V_{out} \approx \frac{R_1}{2R_3}\,V_2 + \frac{10R_1}{R_3}\,V_1\,V_2 \quad \ldots (7)$$

If the output is taken across $R_2$:

$$V_{out} \approx \frac{R_2}{2R_3}\,V_2 - \frac{10R_2}{R_3}\,V_1\,V_2 \quad \ldots (8)$$

If the output is taken between the collectors, assuming that $R_1 = R_2$, then:

$$V_{out} \approx \frac{20R_1}{R_3}\,V_1\,V_2 \quad \ldots (9)$$

The graph of Fig. 3 was checked experimentally (at $I_{E1} + I_{E2} = 1$ mA) with transistors selected using the circuit of Fig. 2, and confirmed within the limits of measurement accuracy.

### Temperature dependence

Equations 1 to 9 and Fig. 3 are based on the assumption that $KT = 25$ mV which is correct for 17°C (= 290°K). The temperature coefficient of $V_1$ in the region of 17°C is 1/290 = 0·00345. In some circuits it may be desirable to compensate for this by using a resistance between the bases, which has a similar temperature coefficient.

### Zero drift due to differential power dissipation

If the long-tailed pair is unbalanced (as will happen, for example, if the input is d.c.) then there will be a difference in power dissipation between the two transistors which will result in unequal junction temperatures.

To minimize this effect the thermal resistance between the transistors, and the dissipation in them, should be as small as possible.

For a given mean dissipation, the differential dissipation can be minimized by designing the circuit so that the mean collector to emitter voltage is equal to the mean voltage across the collector resistor. In this case an unbalance in collector currents will reduce the dissipation in both transistors by the same amount.

### Frequency dependence

The linearity of Fig. 3 for $V_1$ between about $\pm 15$ mV depends on the $h_{fe}$ of the transistor being so large that the base resistance (internal and external) can be neglected. The cut off frequency of $h_{fe}$ is approximately $f_1/h_{fe}$, and at frequencies above this distortion may become apparent. Also the impedance presented by the long-tailed pair at the base terminals will decrease and cease to be resistive at frequencies of the order of $f_1/h_{fe}$ and above. However with high frequency transistors the circuit should be usable up to several MHz.

### Modulation

Amplitude modulation is a process whereby the amplitude of a carrier is made to vary in accordance with the modulating signal.

Consider the case of a carrier ($V_c \sin \omega_c t$) applied between the bases of $Tr_1$ and $Tr_2$ in Fig. 1, and a modulating signal:

$$(V_{dc} + V_m \sin \omega_m t)$$

applied to the base of $Tr_3$: then from equation (7):

$$V_3 = \frac{R_1 V_{dc}}{2R_3} + \frac{R_1 V_m}{2R_3}\sin \omega_m t + \frac{10R_1 V_{dc} V_c}{R_3}\sin \omega_c t + \frac{10R_1 V_m V_c}{R_3}\sin \omega_m t \sin \omega_c t$$

$$= \frac{R_1 V_{dc}}{2R_3} + \frac{R_1 V_m}{2R_3}\sin \omega_m t + \frac{10R_1 V_{dc} V_c}{R_3}\sin \omega_c t + \frac{5R_1 V_m V_c}{R_3} \times [\cos(\omega_c - \omega_m)t - \cos(\omega_c + \omega_m)t] \quad \ldots (10)$$

The output $V_3$ thus consists of a d.c. component, a component at modulation frequency, the carrier and the upper and lower sidebands. A simple $CR$ coupling can be used to eliminate the d.c. and modulation-frequency components, provided that there is a sufficient difference between carrier and modulation frequency.

The output $V_4$ is the same as $V_3$ except that the polarity of the carrier and the sidebands is reversed. $V_5$ which is the difference between $V_3$ and $V_4$ is therefore:

$$V_5 = \frac{20R_1 V_{dc} V_c}{R_3}\sin \omega_c t + \frac{10R_1 V_m V_c}{R_3} \times [\cos(\omega_c - \omega_m)t - \cos(\omega_c + \omega_m)t]$$

i.e. just the carrier and the two sidebands.

It is sometimes necessary to suppress the carrier leaving only the two sidebands, one of which may then be filtered out to give single-sideband transmission. A method of achieving carrier suppression is shown

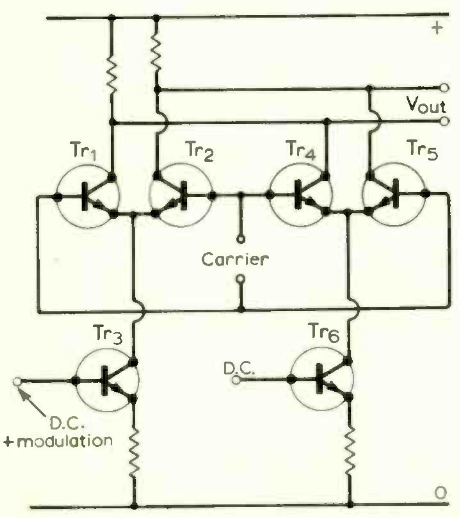


*Fig. 4. Modulator with suppression of carrier and modulation frequencies.*

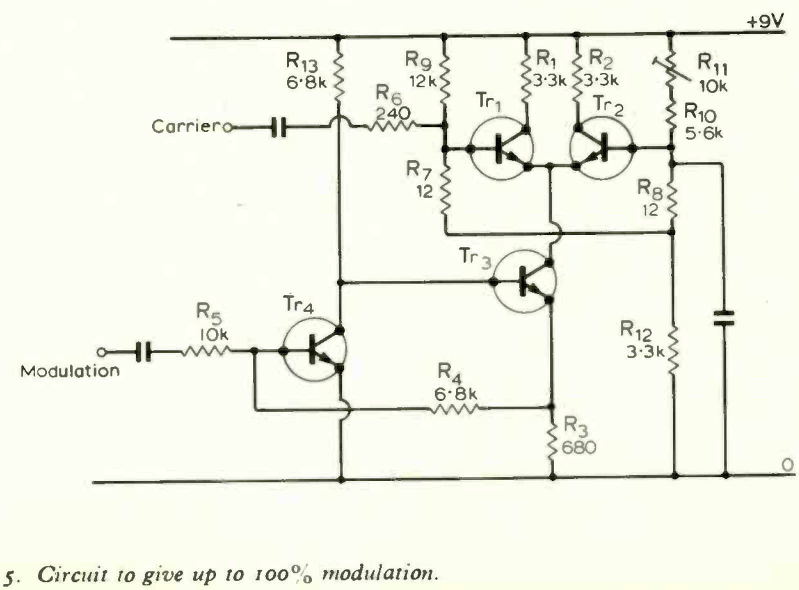


*Fig. 5. Circuit to give up to 100% modulation.*

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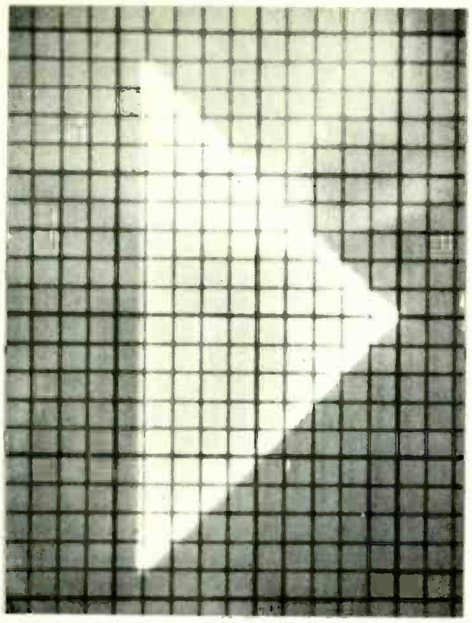

*Fig. 6. Output of Fig. 5 versus modulating waveform.*

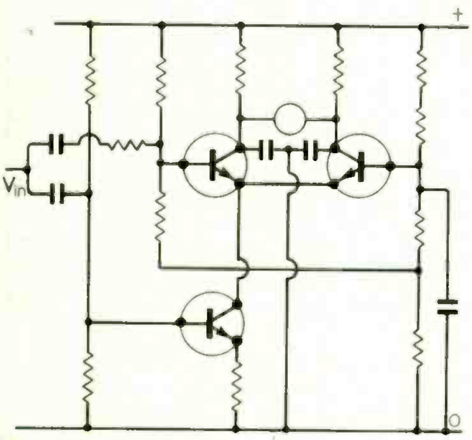


*Fig. 7. Square law voltmeter.*

schematically in Fig. 4. Provided that the collector current of $Tr_6$ is the same as the d.c. component of $Tr_3$ current, then the carrier frequency component due to $Tr_1$ and $Tr_2$ is cancelled by that of $Tr_4$ and $Tr_5$. The sideband components appear only in the output of $Tr_1$ and $Tr_2$ and are therefore not cancelled. By having a small unbalance in d.c. currents in $Tr_3$ and $Tr_6$ it is possible to leave a small component of carrier frequency, which may sometimes be required.

The curve of Fig. 3 shows that good linearity is obtained up to about $\pm 15$ mV, and the carrier input should be restricted to this value if the following circuits are simple amplifiers. However if the amplifiers are tuned so that harmonics will be rejected, a larger input is permissible.

As stated earlier the linearity of a simple amplifier, such as $Tr_3$ in Fig. 1, is quite good provided that the maximum input signal does not cause the emitter current to approach zero. This means that it is suitable for modulation depths up to, say, 80%. But if good linearity is required with modulation depths of near 100% then a circuit such as Fig. 5 should be used. A current feedback pair, $Tr_3$ and $Tr_4$, is used in place of $Tr_3$ in Fig. 1. The current amplification of the circuit is quite accurately given by $(R_3 + R_4)/R_3$, provided that the actual gain is not too large.

The biasing network of $Tr_1$ and $Tr_2$ is arranged so that the preset resistor $R_{11}$ can be used to balance the long-tailed pair. The carrier voltage developed across the bases of $Tr_1$ and $Tr_2$ is

$$(R_7 + R_8)/(R_6 + R_7 + R_8)$$

times the input. The value of $R_7 + R_8$ should be small if the assumption of an exponential relationship between the base-emitter voltage and the emitter currents is to be a good approximation.

A circuit was constructed using the values shown in Fig. 5, and with BC107 transistors. Fig. 6 shows the output waveform (between the collectors) with nearly 100% modulation, and with the modulation waveform applied to the X input, to check linearity.

### Detectors and mixers

The use of the multiplier circuit as a detector or mixer is similar to its use as a modulator, and therefore need not be considered at length.

By applying the signal to one input and an oscillation of carrier frequency to the other, the circuit can be used as a synchrodyne, homodyne or single-sideband detector.

### Square law voltmeter

Multiplier circuits can be used to give the square, cube or higher power of an input. A practical application would be an a.c. voltmeter with an indication proportional to the square of the input. Such a voltmeter is useful because it indicates the true r.m.s. value regardless of waveform; also a doubling of the reading corresponds to a change of 3 dB.

Fig. 7 shows one form of circuit. It has the advantage of simplicity; but since the long-tailed pair operates with a standing current, and the f.s.d. of the meter can only be a fraction of this, there may be difficulty in maintaining a stable zero. Also unless the meter is very sensitive, it may have a comparatively small ratio of (peak)/(r.m.s.) before distortion occurs. A high ratio is desirable if the voltmeter is used to measure noise, or other "peaky" waveforms.

Since the main drawback of the circuit of Fig. 7 is due to the standing current, a better alternative would be to effectively rectify the input to give the modulus. In this case no standing current is required.

### Analogue multiplier, reciprocal and divider circuits

With analogue circuits it is usually desirable that all inputs should be referred to the same zero level. Fig. 8 shows how this may be done, in the case of the multiplier circuit. The diodes $D_1$ and $D_2$ compensate for the base-emitter voltages of the transistors $Tr_3$ and $Tr_5$, so that with the input voltages at zero the emitter current of $Tr_4$ is zero and the emitter current of $Tr_6$ is that required to balance the long-tailed pair. The use of current feedback pairs ensures good linearity.

The linearity of the analogue multiplier circuit is determined almost entirely by the characteristic of the long-tailed pair (see Fig. 3). The two input amplifiers use considerable amounts of negative feedback and are thus very linear.

With the circuit values shown in Fig. 8, the maximum departure from linearity was about 3% (corresponding to $V_1 = 15$ mV). It would be possible to improve on this by restricting $V_1$ to a lower value. Another method, using feedback is shown schematically in Fig. 9. An additional long-tailed pair is used to provide negative feedback. The characteristics of the long-tailed pairs are the same, so that the non-linearity caused by the feedback tends to cancel the non-linearity of the multiplier.

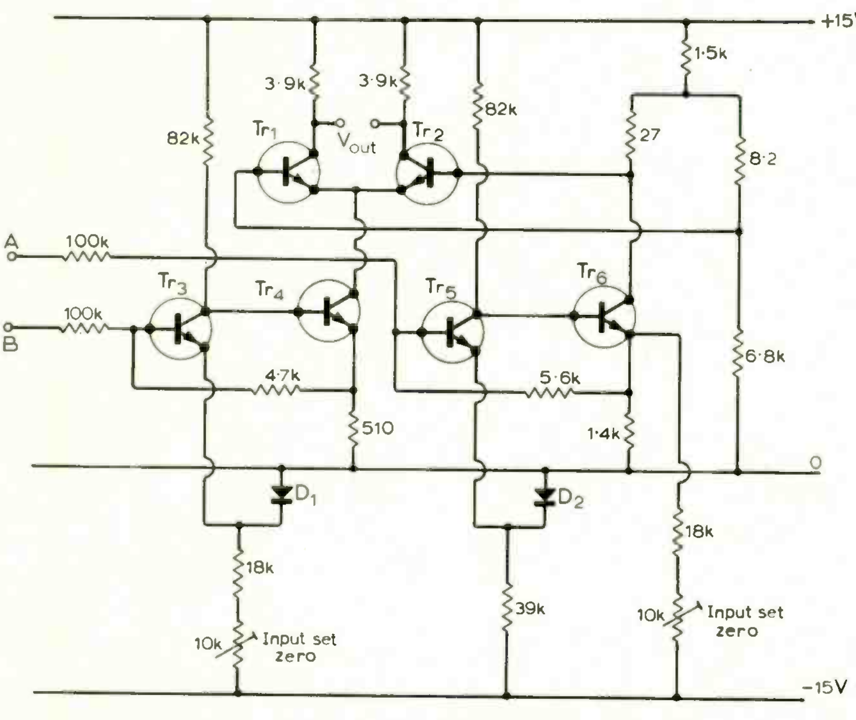


*Fig. 8. An analogue multiplier.*

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The quotient $A/B$ may be obtained by multiplying together $A$ and $1/B$. A circuit for obtaining an output proportional to the reciprocal of an input is shown at the left of Fig. 10, this together with the multiplier circuit at the right of the figure forms a divider circuit.

The reciprocal circuit consists of a multiplier circuit, $Tr_{1,2,3 \text{ and } 8}$, a feedback amplifier, $Tr_{4 \text{ and } 5}$, and constant current sources $Tr_{6 \text{ and } 7}$. The tendency of the constant current source $Tr_7$ to unbalance the collector voltages of $Tr_1$ and $Tr_2$ will be compensated by the feedback circuit; this will result in the collector voltages being nearly in balance, and a voltage between the bases to give:

$$I_{c2} - I_{c1} = I_{c7}$$

It has already been shown (Fig. 3) that, over the range of about $\pm 15$ mV, the voltage between the bases is related to the collector currents by the expression:

$$\frac{I_{c1} - I_{c2}}{I_{c1} + I_{c2}} \propto V_1$$

But $I_{c_1} - I_{c_2}$ in Fig. 10 is a constant and $I_{c_1} + I_{c_2}$ is proportional to the input, therefore $V_1$ is proportional to the reciprocal of the input.

The characteristics of Fig. 3 show that as the divisor input in Fig. 10 is reduced the voltage $V_1$ will depart from the relationship above, and the more the input is reduced the greater will be the discrepancy. However this non-linearity is exactly that required to cancel the non-linearity of the multiplier $Tr_9$ and $Tr_{10}$. So the permissible minimum value of divisor input is fixed by limiting in $Tr_9$ and $Tr_{10}$ rather than by non-linearity in $V_1$. It is of course not possible to obtain useful results with the divisor input near zero, as the reciprocal of zero is infinity.

The relationship between divisor input and $V_o$ was checked for inputs between 1 and 10 V (at intervals of 1 V), it was not possible to detect any departure from the relationship $V_o \propto 1/V_{in}$. The input was then reduced to 0·4 V, the departure from the correct relationship was then about 1%. At an input of 0·2 V the discrepancy was about 2%, no further reduction in input was possible because of limiting in $Tr_9$, $Tr_{10}$.

## Automatic amplitude control and automatic gain control

The controls a.a.c. and a.g.c. are virtually the same thing; in both cases the gain of an amplifier is controlled. In a.a.c. the amplifier is part of an oscillator. The gain is controlled so that the amplifier is linear and a constant amplitude output is obtained, without the distortion that would result from limiting on a non-linear part of the characteristic. On the other hand a.g.c. is used to keep the output of an amplifier approximately constant for a changing input, or to make the output change in proportion to the logarithm of the input.

Fig. 11 shows schematically how a.a.c. and constant output a.g.c. may be achieved. For low inputs where $V_o$ is less than $V_d$ $Tr_2$ is cut off, and the full gain is available. When the rectified voltage across $C_2$ approaches $V_d$ current starts to flow in $Tr_2$ thus reducing the gain in proportion to the reduction of current in $Tr_1$.

By eliminating the delay voltage (connecting the anode of $D_2$ to the base of $Tr_1$) and compensating for the diode voltages, the output can be made approximately proportional to the logarithm of the input.

## Wien network signal generator with a.a.c.

With $RC$ oscillators some form of amplitude control is virtually essential as the effective $Q$ of $RC$ networks is very small, and reliance on non-linearity to limit the amplitude would result in considerable distortion.

The circuit of a Wien network signal generator with a.a.c. is shown in Fig. 12. The amplifier used in the oscillator $Tr_1$ and $Tr_2$ is a current feedback pair which is particularly suitable because it has a current output to feed the long-tailed pair, and, because the input impedance is very low (about 10 Ω with the values shown), it has negligible effect on the frequency. Also the gain is dependent on the ratio of resistors, and is virtually independent of transistor parameters and supply voltage.

The output amplifier $Tr_5$ and $Tr_7$ is also a feedback pair. The current output to the attenuator is useful as it ensures that the output resistance of the generator is a known and constant value. Also since the input resistance is low and the input terminal is at about the same d.c. potential as the emitter of $Tr_2$, it is possible to use direct coupling as shown.

The use of a buffer amplifier $Tr_6$ to feed the control rectifier ensures that distortion of the output waveform due to non-linear loading does not occur. Another possible source of distortion is ripple between the bases of $Tr_3$ and $Tr_4$. The capacitor $C_4$ is charged up by the positive peaks of the waveform at the collector of $Tr_6$, for the rest of the cycle it is discharged by the base current of $Tr_4$ and the leakage of $D_1$ and $C_4$. The distortion should therefore only be apparent at the lowest frequencies, and can be minimized by using a high gain transistor for $Tr_4$ and low leakage devices for $D_1$ and $C_4$. $C_4$ should have a high value of capacitance.

If the capacitance value required for $C_4$ is inconveniently high, an additional amplifier (Fig. 13) can be used to make the base of $Tr_3$ vary in sympathy with the base of $Tr_4$. Thus very much reducing the ripple between the bases, and reducing distortion in proportion.

The signal generator has a range of from 15 Hz to 150 kHz. The variation of output with supply voltage was $\pm 0{\cdot}5\%$ for $\pm 1$ volt, so that a simple voltage stabilizer is advisable. The variation of output over the frequency range was less than 0·5%.

No difficulty was experienced in reducing frequency to 1·5 Hz with another position on the range switch. A further reduction to 0·15 Hz was possible, but it was found necessary to use the amplifier shown in Fig. 13; an alternative would have been to use a larger capacitor for $C_4$, but this would have made the response of the generator very sluggish. No attempt was made to go below 0·15 Hz, because of the high values of capacitance which would have been required.

It was also found possible to extend the range up to 1·5 MHz, but it was first necessary to cure a tendency to "squeg". The cause of this squegging, or intermittent behaviour, has been described by Edson.[1] The output of a squegging oscillator is an amplitude-modulated sine wave. If a circuit is such that the modulating frequency is phase shifted by 180° when the loop gain falls to unity then squegging will occur. An oscillator such as Fig. 12 will produce a

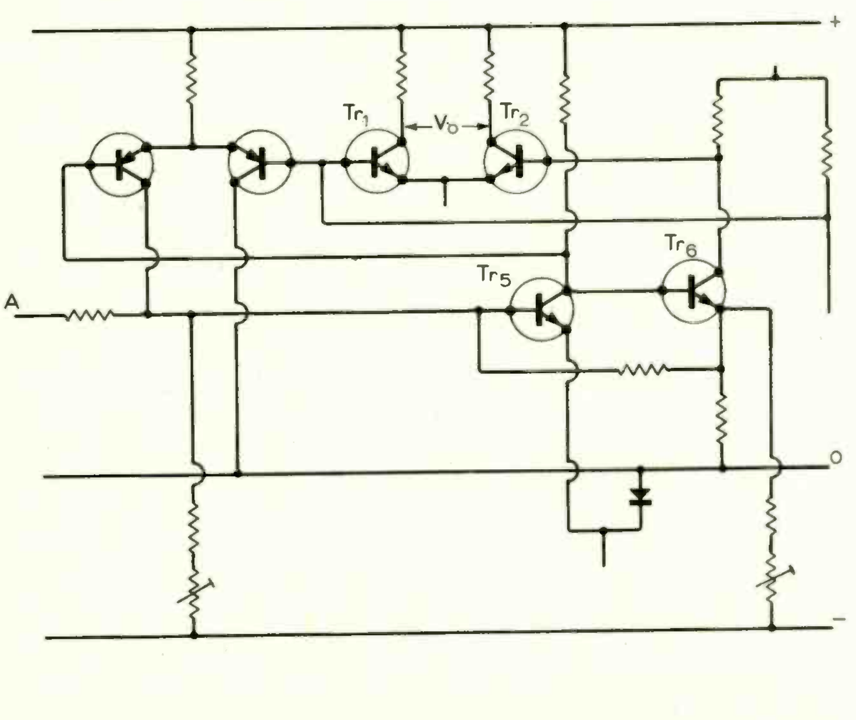


*Fig. 9. Adding negative feedback to the multiplier circuit.*

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maximum phase shift of 90° in the modulating frequency and a single time constant smoothing circuit will cause a maximum shift of another 90°. But these shifts will occur at zero gain, so that it would seem that squegging would be avoided. However at high frequencies there are stray impedances, which are not shown in the circuit diagram, and these may provide sufficient extra phase shift to cause the 180°, unity gain condition to be met.

One way of curing the squegging is to switch to a low value of $C_4$ on the highest range. This will still give good smoothing of the oscillator frequency, but the phase shift of the possible modulating frequencies will be sufficiently low to prevent squegging.

The circuit of Fig. 12 has been kept simple, as its purpose is to show how the multiplier can be used to provide automatic amplitude control. However additional facilities may easily be provided. For example, by placing a resistor in the collector circuit of $Tr_4$ a constant amplitude output may be obtained, which may be used to synchronize an oscilloscope or feed a frequency meter. A square wave may be obtained by feeding a limiter or trigger circuit from the collector of $Tr_6$, as a constant load at this point will not affect the amplitude stability. An antiphase output may be obtained by feeding a current-feedback pair from the emitter of $Tr_7$.

### Reference

1. W. A. Edson, "Intermittent Behaviour in Oscillators", *Bell System Technical Journal*, *Vol.* 24, *No.* 1, *Jan.* 1945.

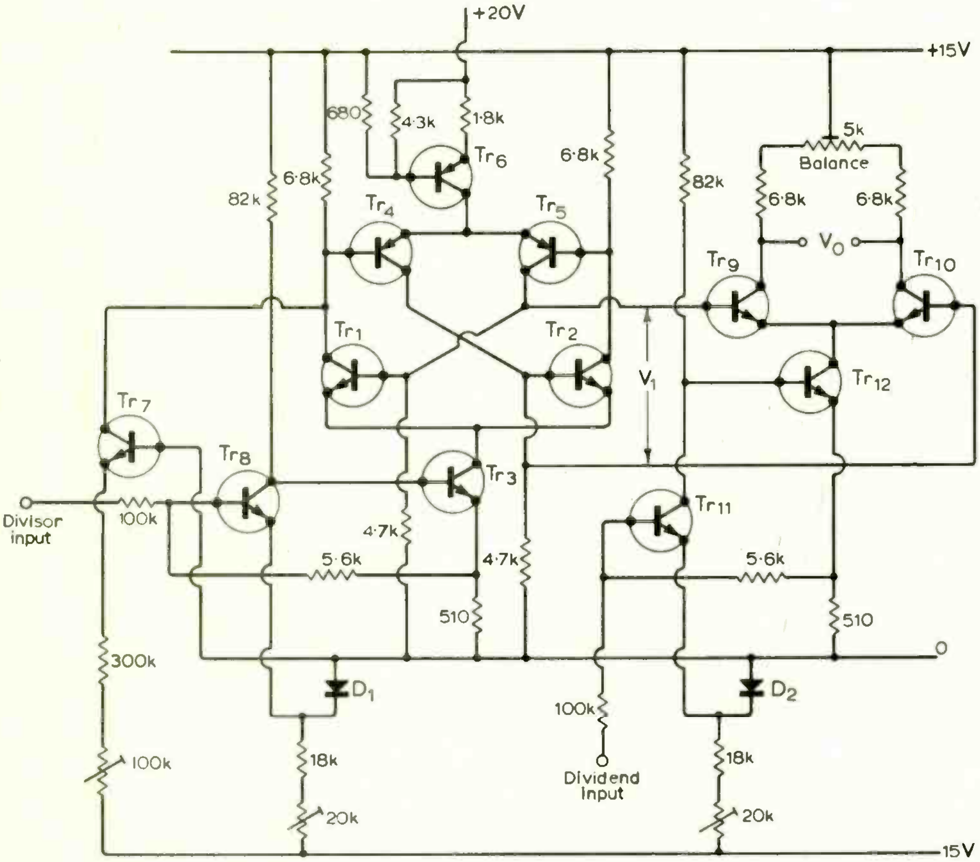


*Fig. 10. An analogue divider circuit.*

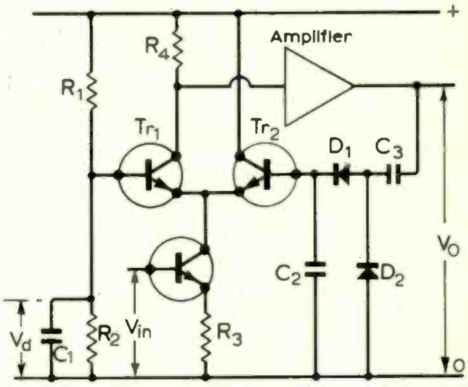


*Fig. 11. Automatic gain control.*

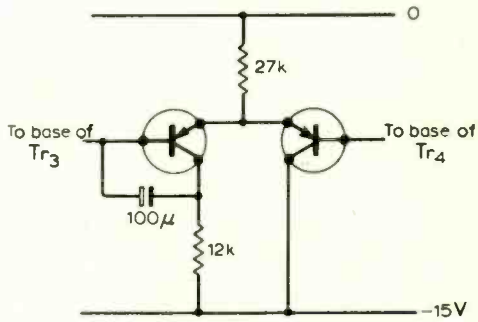


*Fig. 13. Amplifier to reduce effect of rectifier ripple in Fig. 11.*

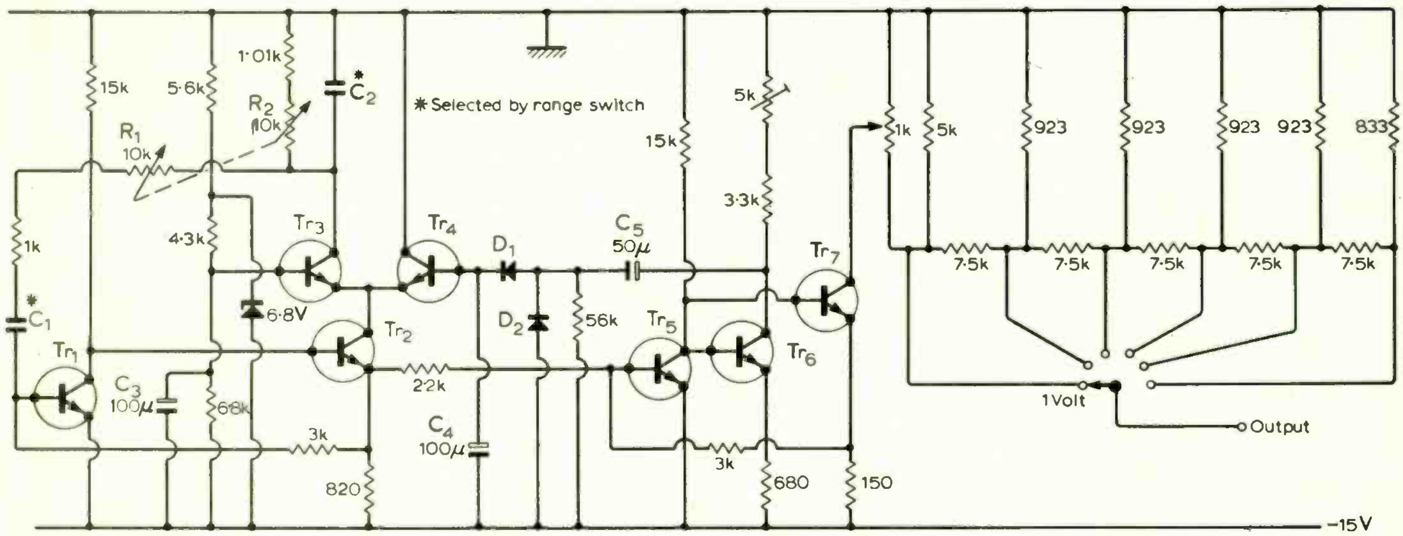


*Fig. 12. Wien network signal generator with a.a.c.*

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# Letter from America

When commenting on last year's I.E.E.E. Show in New York I questioned whether the handful of British exhibitors was really representative of Britain's electronics capability. This year (Mar. 24-27) there were 31 British exhibitors—a big improvement.

As usual the Show spread over four floors in the Coliseum Building although the total floor space was 4% down on the 1968 Show. More important was the absence of some of the larger firms like Raytheon, Philco and the semiconductor companies. The number of exhibitors was 720 minus 1 (which I will explain later). Probably the most significant development (at least I thought so) was the enormous increase in automated test systems. As Abraham Bluestone, sales manager of Teradyne, put it "While the number of leads on a device has grown linearly, the number of tests has grown exponentially. The diode, first semiconductor, has two leads and requires about four tests. The transistor with its three leads requires about nine or ten tests. After transistors, the industry started making i.cs and now large arrays with many, many leads and the number of tests that have to be performed have grown enormously. A human operator could not perform them all quickly and efficiently."

Automated i.c. test systems were shown by many companies. The Microdyne automatic i.c. tester is quite compact measuring some 19in by 20in deep and only 7in high. When the instrument is set up the operator merely inserts the i.c. devices and watches pass or reject lamps. A third lamp gives an indication if proper connections are not being made. This go-no-go instrument will test d.t.l., h.n.i.l., m.e.c.l., r.t.l. and t.t.l. logic, gates, flip-flops, binary counters, etc. Programming is performed by a plug-in matrix card and it is stated that upwards of 5,000 devices can be tested in a day. The Model 1000 test system made by AAI is much more complex featuring computer operation with built-in analogue-to-digital convertor, testing with a.c., d.c., pulse, r.f. and thermal conditions. It can test all kinds of microcircuits, thin or thick film devices, analogue, linear and non-linear logic devices. Provision is made for a data logging option which allows the operator to arrange test results under programme control and log them on a teletypewriter. Modular construction is used and the test rate is quoted as 180 double limit tests per second. Another tape-programmed i.c. tester is Aviens Model 2400 which comes in the form of a fairly large console. All tests and measurements are on Mylar tape 82-bits wide and it is claimed that 3000 i.cs can be tested per day. Performance can be tested, measured, displayed and recorded under a wide range of conditions. Failures can be analysed in detail and data logging can be made of each measurement or switched to record failures only.

General Radio had an automatic capacitor bridge which selects range, balances capacitance and loss simultaneously, generates coded digital output data and displays the measured values on illuminated indicators—all in half a second or so! This is Model 1680 and the useful range is 1pF to 1000$\mu$F. Accuracy is quoted as 0.1% and the 1680 can also measure parallel conductance from 1 nanomho to 1 mho.

How about the other test equipment—oscilloscopes, generators, meters—and the computers? Well, it would probably take more than one complete issue of *Wireless World* to do justice to the vast array of equipment displayed so I will mention just a few of those I found interesting. For example, Wavetek had several unusual instruments on show—all well styled with an eye to function. Model 141 is a voltage controlled generator which can provide sine, square or triangular waveforms from 0.5Hz to 5MHz. External frequency control is possible over a 1000-1 range and there is an audio sweep option to cover the range from 20Hz to 20kHz. Overall accuracy is very high and the output is 10 volts peak-to-peak into 50 ohms. Model 710 is a Dialomatic Herzmeter and this instrument measures frequency from 5Hz to 100MHz with an accuracy of 0.1%. It combines the resolution of a digital device with differential voltmeter circuitry and crystal control. Exact Electronics were showing what they claimed to be the smallest multiple waveform generator on the market. This was Model 100 and it measures just under 7½in by 3in by 8½in and has a continuously variable frequency range from 0.001Hz to 3MHz. It features a choice of nine different waveforms and is very moderately priced at $445 (£145). I liked the new Krohn-Hite variable bandpass filter unit which has independently controlled low and high cut-off frequencies.

Telephone facsimile transmitters have been available for some time and there is now a wide choice of equipment. Among those shown was the Dex I made by Graphic Sciences. It is an attractively styled machine and it can transmit photographs, letters, documents, etc., up to 11in by 8in via any telephone. Transmission time is six minutes. No electrical connection is made to the telephone lines—coupling is purely acoustical. I was quite impressed with the clarity and definition obtained with the Dex I (88 lines per inch). Printing is non-contact and no chemicals are used.

CSI had an 'Acoustic Data Coupler' which is another device for use with a telephone. This one is intended for computer links and only frequencies in the 1–2kHz range are used.

Colour TV cameras and equipment were well in evidence. Sony were demonstrating a two-tube camera which employs what is called a 'Colour dissector optical system' to separate luminance and chrominance components. Also being demonstrated were TV sets using the controversial 'Trinitron' tube which has three beams and a single gun with a common electron lens system. A pair of electron 'prisms' give colour convergence. Also shown were Trinitron systems combined with an 'Aperture Grille' which is said to give twice the brightness of conventional shadow-mask tubes. I understand Panosonic were showing their new flat television receiver, which uses an electroluminescent image display system, but unfortunately I missed this exhibit.

One stand that did intrigue me had the splendid title of "The Orient International (USA) Inc.". This turned out to be a tailor's business and here two cheerful Chinese gentlemen could be seen busily measuring up diffident but smiling engineers for Hong Kong suits! I understand the stand had to close down the next day as the organizers had misunderstood the precise business of Orient International (USA) Inc.; hence my reference earlier to 720 minus 1 stands! I only hope they made enough to pay the expenses!

G. W. TILLETT

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# New Products

## Uni-junction Transistor

A low-voltage device for pulse triggering voltage and current sensing circuits, tuning circuits, flip-flops and pulse timers has been announced by Motorola. It is a silicon uni-junction transistor type 2N5431 which is constructed by the surface-passivated, diffused annular process giving high uniformity and improved characteristics. Peak point current is only 0.4$\mu$A at a $V_{B2B1}$ of 25V and 4$\mu$A at 4V, critical parameters in long-time-delay, low leakage circuits. The very low emitter leakage current of 10nA is claimed by the makers to be 100 times better than cube-alloy uni-junctions. Maximum emitter voltage is 30V, maximum emitter current 50mA r.m.s., power dissipation 300mW, and maximum emitter saturation voltage 3V. The 2N5431 is hermetically sealed in a TO-18 case. Motorola Semiconductors Ltd., York House, Wembley, Middlesex.

**WW 328 for further details**

## Double-beam Oscilloscope with Signal-delay

Philips PM3231, marketed by Pye Unicam, is a double-beam oscilloscope employing signal-delay lines on both inputs. It is a d.c. to 15MHz general-purpose instrument but is specially suitable for the pulse measurements required when checking low- and medium-speed computers and desk calculators. The vertical amplifier's sensitivities are adjustable from 10mV/div using 1:2:5-sequence switches with continuous adjustment between settings by vernier controls. Sensitivity can be extended to 1mV/div via a × 10 switch but on this setting the bandwidth is reduced to 5MHz. Measurement accuracy on all ranges is 3%. The inputs are protected against overloads up to 500V d.c., and d.c. drift is 0.5div/24 hours. Triggering can be either automatic or continuously variable level triggering. Sweep speeds cover 0.2$\mu$s/div to 0.5s/div with continuous adjustment of setting. Sweep can be expanded up to five times. The input selector switch features a "0" position which earths the Y amplifier input enabling the d.c. reference level to be found without disconnecting the probe. Pye Unicam Ltd., York Street, Cambridge.

**WW 313 for further details**

## Coaxial Attenuator Kit

A versatile attenuator kit available in both 75 and 50 Ω impedance has been introduced by Greenpar Engineering of Harlow. The kit comprises seven attenuators of 1, 2, 3, 6, 10, 14 and 20dB. These are made with "T" rod and disc networks designed to accept Greenpar inter-series adaptors allowing the user to fit

the required coaxial interfaces. A male and female series "N" interface is supplied with the kit and when this is used in conjunction with the attenuators the specification is as follows: Frequency range d.c. to 4GHz; resistance tolerance ±1% or 0.1dB (whichever is least); v.s.w.r. less than 1.05 at 1GHz (1.2 at 4GHz); maximum power 1W continuous. Price of the 50-Ω version (GE83500) or the 75-Ω version (GE83700) is £48.3s (£48.15). Greenpar Engineering Ltd., Station Works, Harlow, Essex.

**WW 338 for further details**

## Aero-band Monitor

A crystal-controlled monitor, model 60SS, for a.m. 25 or 50kHz channelling on frequencies between 118 and 156MHz is announced by Park Air Electronics. Six-channel capability is provided with dual-gate f.e.ts for r.f. amplifier and mixer circuits, and linear i.cs for the i.f. amplifier. Each circuit function occupies a separate printed circuit sub-assembly, interconnected by plug and socket. Single-frequency conversion is employed and the i.f. is the standard 10.7MHz. Sensitivity at 130MHz is 2$\mu$V for 2W audio output power, and signal-to-noise ratio with 2$\mu$V input is > 15dB. Rejection at 50kHz (adjacent channel) is −80dB. Suitable 3rd overtone crystals are supplied with the equipment, each crystal being individually trimmed to frequency. Frequency stability is 0.003% in the temperature range −10° to +50°C.

Details of a.g.c. performance state that for a change of input from 2$\mu$V to 200mV it will produce a change of output not greater than 3dB with reference to 1W. Operation is from a.c. mains 100-115V and 200-250V. Size is 407 × 305 × 178mm. A number of optional extras are available including interchangeable block filters for changing channel spacing. Park Air Electronics Ltd., Red Lion Square, Stamford, Lincs.

**WW 315 for further details**

## Conductive Tapes

Two new pressure-sensitive tapes introduced by the 3M Company are claimed to provide low-cost shielding against electromagnetic and r.f. interference. These two additions to the range of Scotch electrical tapes are type X-1181, a copper foil-backed tape and type X-1170, which is aluminium foil-backed. Both employ an electrically conductive adhesive which allows the tapes to be, what the makers call "three-dimensionally conductive", with no corrosive reaction between the adhesive and the material to which the tape is applied. Conductivity and adhesion is said to remain good in conditions of high ambient temperature and humidity. 3M Company, Wigmore Street, London W.1.

**WW 318 for further details**

## Switch without Contact Bounce

A push-type switch incorporating a t.t.l. flip-flop was shown at the recent Paris components exhibition by SECME. The switch, which provides a true and a complementary output, has two modes of operation: asynchronous or synchronous. In the asynchronous mode the equipment operates when the button is pushed and released. In the synchronous mode the equipment switches on at the first clock pulse after the button is pressed and switches off on the clock pulse following the button's release. Société d'Etudes et de Construction de Matériel Electronique, 13 bis, rue des Envierges, Boite Postale 26, Paris 20e.

**WW 335 for further details**

## S.S.B. Communications Receiver

Model LSR8-B by Labgear is a single sideband a.m./c.w. receiver which provides instant sideband selection on eight crystal-controlled channels within the 2-20MHz band. Normally operated from a 100-240V a.c. mains supply, the receiver can be powered from a 12V battery; the change-over from mains to battery in the event of mains

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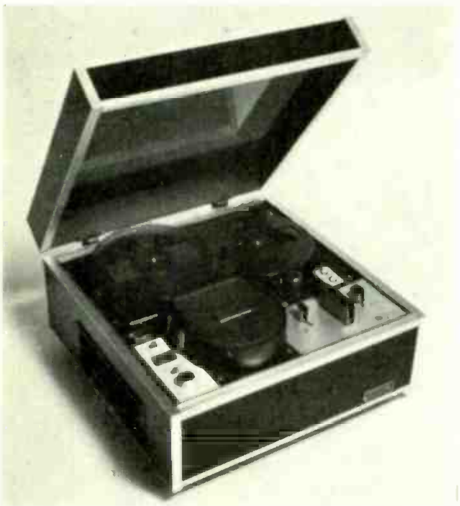
failure is automatic. Any aerial with a 75 Ω transmission line may be employed with the receiver or a long wire in conjunction with an aerial tuning unit. A socket is provided for the connection of headphones or an external loudspeaker. When this facility is in use the internal loudspeaker is muted. A second socket terminated at 600 Ω allows an a.f. signal to be fed to external equipment such as an amplifier or teleprinter. Price £190. Labgear Ltd., Cromwell Road, Cambridge.
**WW 301 for further details**

## Portable Colour V.T.R.

A portable colour video tape recorder developed by the Victor Company of Japan will be available for export later this year. In the U.S.A. it will cost $2000. The technique employed is called d.f.c. (direct and f.m. combined) system and, although the recorder is designed to accept N.T.S.C. colour signals, the system can be applied to any broadcasting standards. When recording, the video signal is divided into two bands of low and high frequencies. The l.f. component is frequency modulated and the f.m. signal is then combined with the h.f. component and recorded on the tape. On playback, the f.m. signal is demodulated and added to the h.f. component to reproduce the original signal. By adopting this method the makers



claim to make the bandwidth 50% wider than a normal v.t.r. Tape width is 12.7mm and its length 915m. Speed is 240mm/s. Two video heads are used and horizontal resolution is 350 lines for black and white; 250 lines for colour. The recorder measures 480 × 480 × 250mm and weighs 25kg. Victor Company of Japan Ltd., 12,3-chome, Moriyacho, Kanagawa-ku, Yokohama, 221, Japan.
**WW 332 for further details**

## Transducer Scanners

Low-level transducer scanner modules designed specifically for data logging and alarm scanning applications have been announced by IDM Electronics, of Reading. Costing from £325, three


models in the range are 25-, 50-, and 100-channel units each with three alternative rates of scanning provided by an internal clock. Flexibility of design allows the connection of different types of equipment. Use with an existing digital voltmeter provides multi-channel measurement and the addition of a printer will give complete data logging facilities. A visual indication of the channel being sampled is provided by neon number tubes and a b.c.d. output is supplied for printout purposes. Internally generated thermal e.m.fs are less than 1μV in normal operating conditions. All of the modules are self-contained and mains-operated. The 25- and 50-channel units are 133mm high and 241mm wide; the 100-channel unit is 482mm wide. IDM Electronics Ltd., Arkwright Road, Berkshire, RG2 0LH.
**WW 311 for further details**

## Solid-state Relays

Solid-state relays that can operate at frequencies up to several hundred MHz using photon coupling are announced by Mullard. They can be used in a range of applications varying from simple on/off switches to r.f. modulators and demodulators. Complete electrical isolation exists between input and output stages thus allowing the devices to be used as coupling elements between circuits at different voltage levels but still allowing the transfer of d.c. signals. Each relay comprises a gallium arsenide diode and photo-transistor or photo-diode inside the same encapsulation. When a forward current flows through the gallium arsenide diode, it emits infrared radiation that applies a bias to the other diode or transistor so that current in the g.a. diode controls the conducting state of the output diode. Unlike mechanical relays, the output is proportional to the input making the photo-relays suitable for use as noiseless automatic or manual volume controls. The transfer ratio (input current to output current) is typically 10:1. Rise and fall times for the output current are 1ns. The two semiconductors in a relay are linked only by the infrared radiation: the voltage breakdown rating can be as high as 20kV between input and output stages. Mullard Ltd., Torrington Place, London W.C.1.
**WW 303 for further details**

## P.C. Edge Connectors

Connectors for printed circuit boards with contacts pitched at 3.96mm are announced by Ultra Electronics. The type of construction enables any length of connector to be specified by the circuit designer within the range 5-62 contacts per side, and the contacts can be single-sided or double-sided as required. Phosphor-bronze contacts are gold-plated and set in diallyl-phthalate mouldings which are claimed to provide high physical and dielectric strength. High conductivity is obtained at low contact pressure. The new series, type 5124, is offered with a full range of ancillaries including nylon or metal mounting clips, terminations for solder and solderless connections and polarizing and reference keys. Ultra Electronics (Components) Ltd., 419 Bridport Road, Greenford, Middlesex.
**WW 307 for further details**

## Advance Timebase Module

A sweep delay plug-in for their OS2000 and OS2100 oscilloscopes has been introduced by Advance Electronics. When used with either of these normal sweep, variable delay sweep or gated delay sweep modes of operation can be selected. Twin timebases and special triggering characteristics are featured. Timebase A has 19 calibrated sweep speeds from 200ms/cm to 0.μs/cm and a continuously variable 3:1 fine control which provides the sweep for normal and "A intensified by B" modes of operation. It is also used together with

a 10-turn calibrated potentiometer to provide the delay of 0.2μs to 2s. Timebase B, with 18 calibrated sweep speeds from 100ms/cm to 0.2μs/cm provides the sweep in the delay mode. The gate and ramp waveforms from timebases A and B are available at sockets on the front panel. A ×5 magnifier expands the sweep length to effectively five screen diameters and provides a maximum sweep speed of 40ns/cm. Advance Electronics Ltd., Roebuck Road, Hainault, Essex.
**WW 327 for further details**

## Fibre-Optic Vidicon

E.E.V. has introduced a new vidicon camera tube with a fibre-optic faceplate. Essentially the same as the EEV type P831 ruggedized vidicon, which has separate mesh construction, magnetic deflection and focusing; the P831F has a 25mm diameter faceplate constructed from 9-micron diameter fibres. When used with a 7735B type photosurface and 10.8lux illumination on the faceplate, a signal current of at least 0.15μA is

attainable with the target voltage set to produce 0.02μA dark current. This new fibre-optic vidicon is ideal for applications involving coupling to other devices having fibre-optic window outputs, such as image intensifiers. By using fibre-optic windows on both devices and coupling them together in direct optical contact, the optical efficiency can be improved by as much as 50 times compared with a normal lens system. English Electric Valve Co. Ltd., Chelmsford, Essex.
**WW 319 for further details**

## Lightweight Accelerometers

Miniature piezo-electric accelerometers for vibration and shock measurements have been introduced by Environmental Equipments Ltd. Measuring 11mm in diameter and 9.5mm high the accelerometers weigh 4.5g and have a charge sensitivity of 3.5pC/g. The two basic types in the

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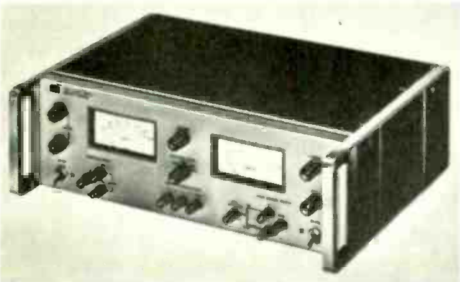
range are designed for adhesive mounting, or fixing by means of an integral mounting stud. All models in the range have a flat response from 0.05Hz to 12kHz, a resonant frequency of 60kHz, and an operating temperature range of $-75°$ to $+250°$C. These devices are constructed from either stainless steel or titanium and the use of adhesives is avoided in the crystal assembly to prevent problems at high temperature. Environmental Equipments Ltd., Denton Road, Wokingham, Berkshire.
**WW 337 for further details**

## Power Supply for Valve Circuits

While most solid-state power supplies described in these columns are designed to power semiconductor circuits, Hewlett-Packard has brought out a new power supply unit which, although in itself is solid-state, its purpose is to power valve circuits. The new unit, model 712C, provides a variable output 0 to +500V d.c., 200mA max.; a fixed output of $-300$V d.c., 50mA max.; a variable bias output of 0 to $-150$V d.c., 5mA max.; and a heater supply output of 6.3V a.c. centre-tapped,



10A max. The output voltage changes less than 0.1% +5mV with a change from no load to full load and the transient recovery time is such that the output returns to within 25mV of the selected voltage within 50$\mu$s of the step change from no load to full load or vice versa. Dimensions: 16 × 42 × 33mm. Weight: 10kg. Price: £240. Hewlett-Packard Ltd., 224 Bath Road, Slough, Bucks.
**WW 322 for further details**

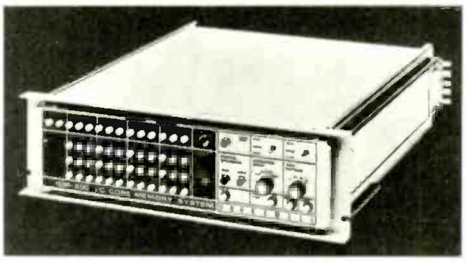
## Variable Filter

Barr & Stroud variable filter consists of two similar active low-pass/high-pass sections which can be used separately and together to give high-pass, low-pass, band-pass and band-stop facilities. The low-pass range is in five decades from 0-100kHz with lowest cut-off at 0.1Hz. The high-pass range is in five decades from 0.1Hz-500kHz with highest cut-off at 100kHz. In all modes the pass-band insertion loss of each filter is low and the stop-band attenuation is at least 36dB/octave. Critical damping can be switched in for pulse and step waveforms. A narrow band amplifier mode can be selected with a voltage gain of 20dB. The input impedance is nominally 1M $\Omega$ in parallel with 30pF capacitance while the output impedance

is approximately 5 $\Omega$ The case measures 320 × 225 × 245mm. Barr & Stroud Limited, Kinnaird House, 1 Pall Mall East, London S.W.1.
**WW 329 for further details**

## I.C. Memory System

A family of 500-600ns core memories with all the electronic functions performed by integrated circuits is announced by Honeywell. The new ICM-500 system is designed for use as main or



auxiliary memory within standard or custom digital systems. It has a 600ns full cycle-time and an access time under 300ns. Capacities range from 4,096 to 32,768 words. The i.c. replaces a number of discrete transformers and transistors and it performs both current switching and logic functions in the system. In a typical 8,192-word capacity memory of 24-bit words, 112 flat-packs perform the functions formerly requiring 2,000 discrete components. Honeywell Ltd., Great West Road, Brentford, Middlesex.
**WW 309 for further details**

## Hall Probe Magnetometer

Model D11 magnetometer by Scientifica & Cook Electronics is a self-contained instrument with internal cells supplying the power requirements. It has four ranges of 0.1, 0.3, 1 and 3 tesla full scale with manual selection by front panel switch. The same switches also provide battery check and polarity reversal. Additional controls are for "zero" and "calibration" with a coaxial socket output for

recorder operation. Supplied with the magnetometer is a calibration magnet and two Hall probes; one for transverse field and the other for axial field measurement. Accuracy is quoted as ±2%. The unit measures 229 × 152 × 127mm and weighs 1.95kg. Price £98. Scientifica & Cook Electronics Ltd., 40-48 High Street, Acton, London W.3.
**WW 314 for further details**

## Temperature Controllers

A new range of temperature controllers by SK Instruments combines in one mode the features of three-term control (proportional, reset and rate control) without complications. These controllers employ a form of non-linear proportional mode control which the makers describe as deviation dependent sensitivity or d.d.s. In operation, the correction force derived from deviation is linearly proportional for small values but at the limits of deviation the control loop is de-sensitized logarithmically. This results in a narrow proportional band operating around the control point which, at large deviations, operates smoothly to an almost infinite proportional band. This overcomes several disadvantages inherent with proportional control. Series-nine controllers are available for operation with resistance thermometers and with thermocouples with integral cold junction compensation. Common mode a.c. rejection is up to 250V, and series mode up to 50mA. Operation is from 240V 50-60Hz single phase supply with optional ratings of 8, 12 or 24A. The front panel measures 92 × 92mm and it contains a scale with a calibration accuracy within 1%. SK Instruments Ltd., Greenhey Place, Gillibrands, Skelmersdale, Lancashire.
**WW 325 for further details**

## Double-beam Storage Oscilloscope

Featuring double-beam storage facilities the Telequipment oscilloscope, model D53S, costs £495. It offers a choice of three display modes: as a normal oscilloscope; as a long-persistence instrument with a continuously variable persistence of

more than a minute; and as a storage oscilloscope capable of storing traces for periods of up to ten minutes. Variable sweep delay is also provided and a choice of plug-in Y amplifiers is available. Display area is 6 × 10cm and 22 calibrated sweep speeds range from 5s to 0.5$\mu$s/cm. Telequipment Ltd., 313 Chase Road, Southgate, London N.14.
**WW 336 for further details**

## Compact D.C. Supply

A power supply measuring only 38 × 76 × 50mm can provide up to four output rails with a total capability of 30V at up to 40mA. It is Adretta's model P1015, initially developed as a stabilized d.c. source to drive this company's tuning fork oscillator/tuning units and now marketed as a product in its own right. Operation can be from 100-125V or 200-250V 50-60Hz mains supplies without adjustment. Up to four outputs can be provided in series if required, provided that the sum of the output voltages should not exceed 30V and the current 40mA. The zero volt connection may be earthed or isolated as required and a second screen may be connected to minimize spurious noise when an isolated supply is required. Prices range from £8 16s (£8.80) to £12 according to quantity. Adretta Ltd., Station Approach, Fleet, Hampshire.
**WW 302 for further details**

## Character-generating C.R.T.

A 30mm electrostatic character-generating monoscope for use in data display units, in which a c.r.t. is used to provide input and output information for a computer, or for displaying remotely printed information initiated on a typewriter keyboard, is announced by E.M.I. Designated Printicon Tube 9788, it provides up to 64 charac-

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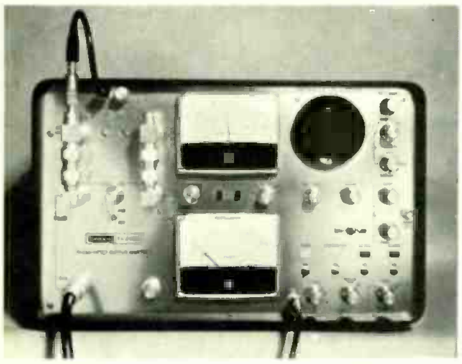
ters in an 8 × 8 array. The number and style of symbols can be changed to meet users' requirements. Principal feature is all-electrostatic operation giving fast access to any character. E.M.I. Electronics Ltd., Hayes, Middlesex.
**WW 308 for further details**

## Low Output, High Input Impedance Potentiometer

The limitations of precision potentiometers when circuit designers require low output impedance and high input impedance are met by a new potentiometer introduced by Computer Instruments Corp. which incorporates a solid-state isolation circuit. The low output impedance means that low-impedance devices such as meters and sensitive relays requiring high current levels can be directly driven. Any load from infinity to 1kΩ, fixed or variable in magnitude up to 30mA, can be driven by a standard unit. Wiper current is virtually eliminated providing improved noise performance and, with the need for impedance matching removed, the potentiometer can be treated as a simple shaft-to-voltage converter. Standard model 202-30 is available with terminal resistance of 10kΩ or 25kΩ and maximum output impedance of 0.5Ω. Electrical function angle is 350°. The applied voltage can be from 10 to 30V d.c. (polarity must be observed) and the permitted power dissipation at 25°C is 2W. Computer Controls Ltd., 19 Buckingham Street, London W.C.2.
**WW 333 for further details**

## Transmitter Analyser

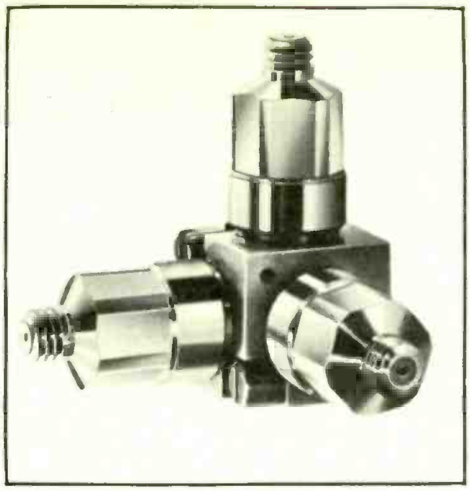
A transmitter output analyser, model TG2400 by Green E.C.E. Ltd., features an oscilloscope which displays directly the r.f. modulation envelope at any frequency up to 500MHz. Absorption load units of 50Ω and 75Ω contained in the analyser can handle up to 1kW mean r.f. power at any frequency between 2 and 500 MHz. The absorption load units are connected to a wattmeter with full scale ranges of 10, 30, 100, 300 and 1000W mean, and an accuracy of 5%. Indicators of v.s.w.r. are



included. Single- and two-tone signals are provided for driving the microphone input of a.m. and s.s.b. transmitters. Price £290. Green Electronic and Communication Equipment Ltd., 79-91 Braemar Road, London N.15.
**WW 304 for further details**

## Shock Accelerometer

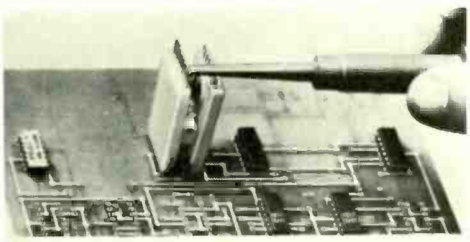
A transducer for use in very high *g* shock applications has been announced by Kistler Instruments. It is the quartz shock accelerometer type 805A which has a resonant frequency of 60kHz and is suitable for the measurement of shock accelerations up to 100,000*g*. Deviation is only 5% at 12kHz and the low lower frequency limit allows measurements of long duration shocks to be made. A tri-axial accelerometer (see illustration) comprises three shock accelerometers mounted on a special adaptor with which accelerations up



to 20,000*g* in three axes can be measured. Kistler Instruments Ltd., The Ridges, 2 Clockhouse Road, Farnborough, Hampshire.
**WW 323 for further details**

## I.C. Test Clip

A device comprising a spring-loaded test clip and a "contact comb" has been introduced by Guest Electronics for testing dual-in-line integrated circuits. The comb can be attached to 14- or 16-lead packages where it functions as an attachment



guide and prevents the short-circuiting of adjacent leads. The test probe can then be clipped to the comb. The makers claim that this solves oscilloscope probe attachment problems and facilitates testing. Gold-plated contacts are employed and the capacitance effects on h.f. transitions are quoted as negligible. Price £2 10s (£2.50) each with reductions for quantity. Guest Electronics Ltd., Nicholas House, Brigstock Road, Thornton Heath, Surrey, CR4 7JA.
**WW 317 for further details**

## Power Frequency Changers

Although the primary purpose of power frequency changers by Valradio is to allow operation of 50-Hz equipment from non-standard frequencies, or for operating 60-Hz equipment from a 50-Hz supply, the range comprises 100-W and 200-W

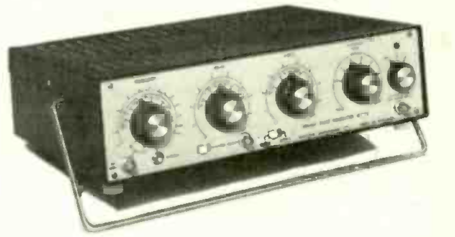
units working from any input voltage and providing a variety of output voltages. The conversion principle is static and noiseless in operation. Frequency stability is claimed to be better than ±1%. The two types available are FCA230/100W at £32.6s.9d. (£32.34) and FCB230/200W at £52. Special units providing 400-1000Hz for testing marine and aircraft equipment can be supplied to order. Valradio Ltd., Browell's Lane, Feltham, Middx.
**WW 331 for further details**

## Short-circuit Detector

Rapid location of short-circuits in telephone and signalling cables, distribution wires and power cables is the claim made for the Swiss-made ITT short-circuit detector now available in the U.K. from ITT Electronic Services, of Harlow. The instrument also enables particular cables to be identified from among others, concealed wiring to be traced and the run of cable pairs to be followed even through concrete to a depth of 300mm. Two separate units are employed: one comprising a probe, amplifier and headphones and the other an oscillator unit generating a fixed frequency at about 1.4kHz. The short-circuited cable is first energized by the oscillator, then the probe is moved along the cable. Initially a tone is heard in the headphones which falls to a minimum when the short-circuit is reached. Price is £25 17s 6d (£25.87½) for the detector and £12 12s (£12.60) for the oscillator. ITT Electronic Services, Edinburgh Way, Harlow, Essex.
**WW 316 for further details**

## Pulse Generator

A general purpose pulse generator, type TF2010, has been introduced by Marconi Instruments. It provides positive and negative outputs, single or double pulse. Double pulse outputs are delivered from 2.5Hz to 2MHz and single pulse outputs up to 2.5MHz. Features include continuously variable amplitude up to 20V, variable pulse width from 100ns to 10ms, and 10ns rise time. Internal or external triggering may be used; the internal trigger frequency is adjustable over the range 2.5Hz to 2.5MHz. External triggering can be



achieved by the application of a sine, square or pulse waveform. In addition to the main output waveform, a positive or negative "pre-pulse" is delivered from a separate socket. Dimensions of the instrument are 100 × 360 × 270mm deep. Price: £135. Marconi Instruments Ltd., St. Albans, Hertfordshire.
**WW 326 for further details**

## Magnetic Memory

Utilizing a miniature reed switch and designed for printed circuit mounting, a compact memory element announced by F. R. Electronics is suitable for applications such as the retention of information in the event of power failure, or the replacement of conventional relays in portable equipment. Designated type RSC68, the memory is small (35.6 × 17.8 × 16.5mm) and has good vibration and shock characteristics. Price is about £1 10s (£1.50). F. R. Electronics, Wimborne, Dorset.
**WW 321 for further details**

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# Answers to "Test Your Knowledge"—13

## Questions on page 284

1. (*c*). The amplitude of the modulating signal determines the frequency deviation of the carrier, the frequency of the modulating signal determines the number of cycles of variation of the carrier frequency per second.

2. (*c*). Mathematical analysis shows that if a carrier $A \sin \omega_c t$ has its frequency varied by a signal of the form $\cos \omega_m t$ so that the frequency deviation (maximum frequency excursion) is $\Delta f$, then the modulated carrier can be written $A \sin (\omega_c t + \frac{\Delta f}{f_m} \sin \omega_m t)$.

3. (*a*). The mean power output of a frequency modulated transmitter is constant whatever the modulation.

4. (*b*). It must be so since the mean power output is unchanged.

5. (*b*). The number of components with significant amplitude decreases as the modulating frequency increases, but the frequency separation between components increases so that the total bandwidth required to include all significant side frequencies is about the same for all modulation frequencies.

6. (*c*). A combination of the two is used in transmitters where it is most convenient to generate f.m. of small deviation at a low carrier frequency and then increase the carrier output and the deviation to those required at the output.

7. (*d*). In phase modulation the modulation index (or phase deviation) is independent of modulating frequency; in frequency modulation it is inversely proportional. Hence in the Armstrong system the modulating signal is first passed through a network which produces attenuation proportional to frequency before it is applied to the balanced mixer. This method cannot produce a phase deviation greater than about $\frac{1}{2}$ radian without introducing significant distortion.

8. (*a*). The weaker signal modulates the phase of the stronger signal (amplitude variations are removed by the receiver limiting action). The phase variation of the stronger signal due to this cause cannot exceed 0.46 radian, whatever the carrier frequency or modulation index of the weaker signal.

9. (*d*). The "rule of thumb" for wide frequency deviation systems is that a range of frequencies equal to the maximum deviation plus maximum audio frequency on either side of the carrier must be passed.

10. (*b*). For a sinusoidal modulating signal the carrier phase at the output of the i.f. amplifier will not vary sinusoidally.

11. (*a*). Provided that limiting still occurs in the receiver the extent of the service range is determined by the distance from the transmitter at which the unmodulated carrier amplitude is about twice the mean noise amplitude. With a narrower bandwidth system the mean noise amplitude will be smaller.

12. (*c*). a.g.c. is usually incorporated as well

13. (*c*). For a sinusoidal modulating signal $\phi(t) = \frac{\Delta f}{f_m} \sin \omega_m t$, $\Delta f$ being proportional to the modulating signal amplitude.

Hence $\frac{d\phi(t)}{dt} = 2\pi \Delta f \cos \omega_m t$.

14. (*b*). Since with f.m. the noise suppression is least at the highest audio frequencies, components of the input signal at these frequencies are deliberately "pre-emphasised" at the transmitter. The circuit referred to is the "de-emphasising" circuit.



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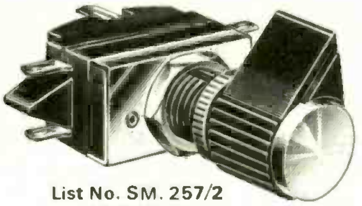
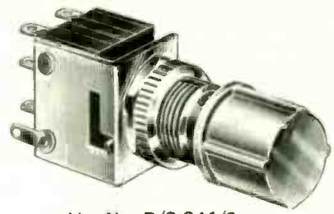
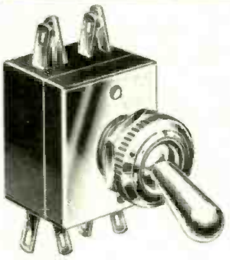

List No. SM. 257/2 + K.515 Knob

Latest addition to the new range of D.P.C.O. Moulded Switches. Semi-rotary operation 2A. 250V. A.C. N.I. rating.


List No. D/S 941/2

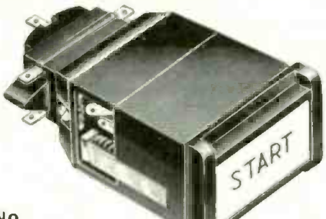
A Switched Signal Lamp with lockable biased action. L.E.S. lamp, one or two switches as desired rated 8A. 250V. A.C.


List No. SM. 277/2

A Moulded body toggle operated D.P.C.O. 8 contact switch for double pole alternative circuit switching. Replacing the popular laminated body type S.277 to which it has dimensional conformity but improved performance.

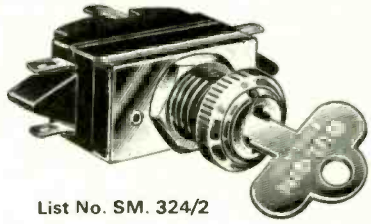
Two, three pole side entry jack plugs. The 'third 'Ring' contact between the 'Sleeve' and 'Tip' can serve as a guard-ring or as a third pole, or 'Sleeve' can carry screening continuity of 2 pole +screen cable. The design matches that of our popular model P.535-6.


List No. P. 537 Chrome
P. 538 Gold



List No.
D/S 890/SA. 2432/2.

Switched legend indicator unit with D.P.C.O. switch rated 2A. 250V. A.C. and holders accepting L.E.S. lamps. Legending to order.


List No. SM. 324/2

Further addition to the D.P.C.O. Moulded Switch range. Key operated rated at 2A. 250V. A.C. N.I.


List No. K. 556/Legend

Knob dial and escutcheon assembly, dial legending is only visible through 'window' in escutcheon and is carried out to customers' requirements. Whole unit is collet fixing to ¼" dia. shafts.

Unique seven pole +earth shrouded connector with positive polarity keying, 6A. 250V. A.C. rating and safety conscious design. To pre-arranged orders special pin and socket arrangements can be supplied.


List No. P. 550.

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# World of Amateur Radio

### Direct-conversion "Homodyne" Receivers

Increasing interest is being shown by amateurs in the development of relatively low-cost receivers in which the incoming signal is heterodyned directly, by means of a balanced linear detector, to audio frequency. This form of "straight" receiver was described, in a valve version, by James White, (W2WBI) of Princeton, N.J., in *QST*, May 1961, but has attracted more attention since it was revived, using transistors, by the Dutch amateur K. Spaargaren (PA0KSB) in *Electron* (Jan. 1967) and by *R.S.G.B. Bulletin*. An interesting design, in which the linear detector comprises four hot-carrier (Schottky) diodes using wideband ferrite toroid transformers, has also attracted considerable attention.

The basic requirements for such direct conversion or simple synchrodyne receivers are a well-balanced linear detector, a stable variable-frequency-oscillator on the signal frequency, an audio filter and a high-gain, low-noise a.f. amplifier. The oscillator can also form the basis of a simple transceiver. For the reception of broadcast or other a.m. transmissions, the oscillator requires to be phase-locked to the incoming signal as in the Tucker synchrodyne, but this refinement is unnecessary for the reception of s.s.b. or c.w. signals, for which the current receivers are generally intended. Provided that the detector is linear and accurately balanced, selectivity can effectively be determined by the characteristics of the audio filter without incurring cross-modulation or blocking. The use of hot-carrier diodes or beam deflection valves (types 7360 or 6JH8 etc) can result in excellent noise figures without requiring any r.f. stage. An inherent problem—unless a more complex phasing type detector were used—is the presence of the audio "image" which can be eliminated by the i.f. selectivity of single-signal superheterodyne receivers. Nevertheless, good audio selectivity can minimize this disadvantage. Several simple receivers of this general type, using either semiconductors or valves, are known to have been built by British amateurs, with generally satisfactory results.

### Ionospheric "Openings" on 50 MHz

Despite the earlier belief that Solar Cycle 20 was already on the decline, 50MHz conditions this year appear better than at any other time during the current sunspot cycle. M. Waters, G3JVL, of Portsmouth, heard the south-west African station, ZS3B, at very good strength for $1\frac{1}{2}$ hours from 13.50 G.M.T. on April 4th, almost certainly due to F2 layer ionospheric propagation. Don Hayter, G3JHM, of Worthing, similarly recieved the 40-watt Rhodesian beacon station ZE1AZC from 16.30 to 17.15 G.M.T. on April 14th, with signals peaking RST99. One suggestion, being mooted in amateur circles, is that Solar Cycle 20 may be following precedents in having two main peaks, spaced roughly one year apart, and offering the prospect that higher maximum usable frequencies may occur this year, than those of 1968.

### "Top Band" DX

The current world "wanderings" of Gus Browning, W4BPD, have brought several new countries briefly on to "Top Band" (1.8 MHz). His expedition to Rodriguez, in conjunction with VQ8CC, however, resulted in only one two-way contact being made on this band; this was with the British station G3XAQ. Gus Browning's 1.8MHz operation as ZD3A produced no two-way contacts, though his signals were heard in the U.K., and he heard veteran top-bander, Stewart Perry, W1BB. Incidentally, Stewart Perry recently achieved his DXCC (100 confirmed countries) on this band following a contact with HK0TU, Malpelo Islands—despite trouble, during the contact, with his coaxial feeder. He later lifted his total worked to 104 countries with a contact with VP2KK, the St. Kitts' expedition.

### Chordal Hop Theories Gaining Support

There is a growing feeling among some British amateurs that throughout the h.f. and v.h.f. spectrum (and possibly also at m.f.) long distances are often covered by means of "chordal hop" and related modes not requiring intermediate ground reflection points. The chordal hop theory, now attracting increasing attention in professional research and communications, was originally put forward by Hans Albrecht, following the careful measurements made by him and a large number of other Australian amateurs in the early 1950s, on 3.5, 7 and 14MHz signals received in Australia from amateurs in West Europe. Albrecht subsequently returned to Europe and suggested the name "chordal hop" to explain his idea that signals could be reflected more than once from ionospheric layers without returning to earth each time. The apparent absence of intermediate ground reflection points is now also recognized as occurring during transequatorial (TE) propagation, which was first investigated as a result of amateur long-distance openings on 50MHz, at times when this band should have been well above the maximum usable frequency. Such mechanisms have more recently been suggested by M. Hall of the Radio and Space Research Station, Ditton Park, Slough, as playing a significant role in v.h.f. propagation. Possibly as a result of ionosperic tilts and/or "whispering gallery" layer entrapment, it now seems likely that many of the amateur DX contacts, previously thought to be due to conventional multi-hop F2 propagation, are in fact made without intermediate ground reflection, accounting for the low path losses and high m.u.f. often observed. More precise knowledge of such propagation modes could have considerable importance for radio communication and broadcasting.

### National Field Day

The R.S.G.B. National Field Day, with all participating stations operated from tents by amateur radio clubs and R.S.G.B. groups, is being held this year over the period 17.00 G.M.T. June 7th to 17.00 G.M.T. June 8th. For many years, this event—first held in June 1933—has been the most keenly contested of all British portable events, and involves the largest number of operators. At the first event, 34 stations were operated by 18 groups; last year, when Cannock Chase Amateur Radio Society gained the coveted shield, some 150 stations were entered by about 100 groups and clubs. Contacts, on c.w., can be on any three bands from 1.8 to 28 MHz.

### Other June Events

A mobile rally organized by the Amateur Radio Mobile Society is being held on June 1st at the Shuttleworth Aircraft Museum, Biggleswade.

The Bristol R.S.G.B. Group, assisted by the Bristol Amateur Radio Club, are organizing for June 29th the Longleat Mobile Rally at Longleat Park, near Warminster.

A Midlands VHF/UHF Convention and Dinner—including a lecture on "a new approach to vhf/uhf receiver design" is being held at Wolverhampton on June 14th (details from P. G. Wright, 20 James Road, Kidderminster, Worcester, enclosing foolscap stamped addressed envelope).

**In Brief:** A new beacon station, GB3SU, operating on 70.695 MHz is located at the University of Sheffield . . . Latest F.C.C. figures put the number of amateur operators in the United States at 256,546, down very slightly on a year ago . . . A.R.R.L. reports its full membership down 1% to 80,012 with worldwide membership given as 97,678 . . . Membership of the International Amateur Radio Union, following the admission of societies representing Mauritius and Surinam, now stands at 80 . . . U.S. amateurs, as a result of changes in the Bell System telephone regulations, can now legitimately operate "phone patches" connecting overseas stations to telephone subscribers.

PAT HAWKER, G3VA

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# AMPLIFIER SUPPLEMENT

## The Vital Statistics of an Audio Amplifier

*by R. Williamson*

A definition of the term "high fidelity" would be a logical opening to a discussion on high-quality amplifiers (yes, I'm sufficiently old fashioned to prefer high quality to the imported term—but high fidelity, or "hi-fi", is here to stay and I have no intention of starting a revolution to change it back again). A precise definition is quite impossible, since there is no clearly defined boundary at which "low fidelity" *(sic)* ends and high fidelity begins.*

In the final analysis, a purely subjective judgement by the listener will decide one way or the other and so long as the human element is involved in assessing reproduced sound quality, the boundaries will continue to remain blurred. I much regret that in recent years there has been no real progress towards a more precise definition. Anyone may slap a label "high fidelity" on an amplifier despite a frequency response which, if reproduced graphically, would look something like the hind leg of an arthritic donkey.

The amplifier is the "heart" of any sound reproducing system and I intend to discuss its vital statistics, to examine the facilities one expects to find and finally, to draw attention to typical and particularly interesting design features.

### Distortion level and distortion figures

At the head of my list of vital statistics for good sound quality is the degree of non-linear distortion up to the maximum rated output. By non-linear distortion I mean any spurious harmonic and intermodulation products in the amplified signal. For these to be negligible the dynamic input/output transfer characteristic should be linear within clearly defined limits up to maximum output at all frequencies within the accepted audible range.

In the U.S.A. intermodulation products are often quoted and although some authorities might justifiably attach equal or even greater weight to this information, the practice of quoting i.m. products is not usual in the U.K.

It is here that it might be worthwhile examining a very thorny problem—that of evaluating the figures quoted. Just prior to the transistor amplifier era, valve designs had reached a very high standard, and at levels up to the rated power generated harmonics were at a very low level, and usually of a low order. The magical figure was a total harmonic distortion (t.h.d.) of below 0.1% and one could literally assume that with the best on the market, the amplifier was the strongest link in the reproducing chain. Almost, one might say—and here I cannot resist quoting my favourite advertising blurb—a "straight wire with gain".

When the change to transistors began, and using the germanium devices available at that time, designers were to some extent obliged to take advantage of the high efficiency possible with them. Not only were the early circuits virtually "transistorized" valve amplifiers, but class B output stages came back, too, sometimes with driver transformers which had long since disappeared from the valve amplifier scene! Small wonder, then, that soon there were complaints that not only was the sound "different" to the best valve amplifiers, but that in most cases it was very much inferior.

However, the rapid development of semiconductor technology began to yield its own circuit techniques, and, following the concept of complementary symmetry and the publication of the well-known circuit by H. C. Lin in 1956,† transistor amplifiers began to improve. But the so-called "transistor" sound persisted and it began to be appreciated that it was primarily due to minute amounts of crossover distortion arising from the inherent asymmetry of a quasi-complementary output stage operating in the class B mode. A new generation of designers and listeners were re-discovering that there are two kinds of harmonic distortion; the even harmonic (nice) sort and the odd harmonic (nasty) sort; furthermore, the nasty sort could be extremely objectionable when caused by even minute discontinuities in the transfer characteristic at the transition point and consisted of very high order odd harmonics. It had been well understood for some time that these high order harmonics can provoke a degree of discomfort and have an unpleasant aural effect out of all proportion to their actual level in ratio to the fundamental, even though as low as the long accepted 0.1%. At least one manufacturer has suggested that this type of distortion must be as low as 0.003% if the "transistor" sound is to be eliminated.

### Frequency response

An audio amplifier is required to handle the audible spectrum from say 20Hz to 20kHz. Wait! Before the "let's entertain the bats as well" fraternity rush for their pens and paper, let me make a plea for sweet reason in this. We are, after all, considering high quality sound reproduction in the home and there isn't the slightest doubt that for you and me, the programme sources that are available are going to have bandwidths that are very much less than this for most of the time. Limits to the bandwidth are being imposed all along the chain to the listener's loudspeaker, and wasn't it Capt. P. P. Eckersley who wisely remarked, apropos audio bandwidth that "the wider you open the window, the more the dirt flies in!"?

Fortunately, in the present state of the art of amplifier design, an acceptable bandwidth at normal power levels presents no problem and our specification can easily be met within $\pm 1$dB and with no more than 3dB loss at an octave above and below the prescribed limits.

### Power bandwidth

Rather more important is power bandwidth; the amplifier must be able to handle comfortably this frequency range at or near full power without measurable degradation of the signal. This

* Does "fidelity" need qualifying? Fidelity or infidelity!—ED.

† H.C.Lin, "Quasi-Complementary Transistor Amplifier," *Electronics*, Sept. 1956.

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requirement is not quite so stringent at the extreme high end of the passband, and in a practical amplifier it would be acceptable for the power bandwidth to fall above 15kHz. A typical specification will indicate the limits of power bandwidth at $-3$dB points. Again, with modern design techniques, this modest requirement should be met without difficulty and in a typical product, the $-3$dB points will be well beyond these limits—although some early germanium designs might fall short of these standards.

### Transients

The ability of an amplifier to handle without degradation wavefronts with a fast rise time is referred to as its "transient" response and will be related to the upper limits of its frequency response and inherent stability. The rise time of a modern transistor design is likely to be very much faster than that occurring in the waveforms of programme sources accessible to the domestic user.

### Damping factor

For good frequency response and transient handling ability the speaker system must be well damped electrically. Movement of the cone of a moving-coil loudspeaker is restricted by its suspension stiffness and resistance, by air loading and electromechanical damping. While it could be argued that with a modern 'infinite baffle' speaker the inherent damping of the system is already very high and that further electromechanical damping would be superfluous, I would suggest that it is still of importance because of the large number of speaker systems that do not fall neatly into this category.

Typically, in a modern feedback amplifier, the source impedance will be a fraction of an ohm and substantially resistive. The damping factor is usually derived by dividing the actual source *Z* into the nominal load *Z*. Values of quoted damping factor vary from 20 to 150, although there is little point in deliberately aiming for values as high as this, since the speakers own resistance has to be taken into account and is effectively in series. In fact, there are good grounds for suggesting that a damping factor of not less than 15 is adequate for all practical purposes. Nevertheless, one must deplore the increasing practice of actually adding quite large amounts of passive resistance in series with the speaker circuit on some recent commercial designs, ostensibly to limit the current in the output stage when low-impedance speaker systems are used. One such model recently reviewed had a measured source Z of nearly 5 ohms at the 4- ohm speaker terminals. The measured frequency response was markedly degraded.

### Power rating

It is perfectly true that a mere one watt of power into an efficient speaker will generate a very healthy noise and probably more than enough for most domestic users. However, commercial speakers seem to get less and less sensitive as designers trade efficiency for quality. It is a purely personal view that to take this into account, and yet to preserve at all times the capacity of the system to handle the maximum possible dynamic range, the power rating should not be less than 10 watts per channel in a stereo system.

And this is, I feel, an opportune moment to discuss the highly deplorable bandying about of figures that seems to be the current advertising practice when referring to power handling ability. Almost any subterfuge goes, it seems, if that highly important figure in watts can be inflated. We have peak watts, music power and I.H.F. rating to mention but three popular methods of enchancing the power, and no doubt these ratings would carry some validity if everyone fully understood what they meant; unhappily, the vast majority of the lay public haven't the faintest idea what they mean.

I have one such advertisement before me at this moment and by virtue of what it omits to say it is quite misleading. The product is variously described as a 12-watt amplifier, with 24 watts peak power, 15 watts music power and 30 watts peak (music?) power. We are also furnished with the information that power requirements can be met by using batteries if so desired.

This juggling with figures can only but utterly confuse the less knowledgeable reader, who is likely to purchase the product, attempt to use it with an inefficient 15-ohm loudspeaker and a 6-V battery supply and then wonder why it sounds like his younger sister's transistor portable with its honest 500mW power rating. One can only hope that recent legislation will offer some means of regulating this sort of advertising.

I would suggest that a straightforward measurement of the power dissipated in a specified load under continuous sine wave input and taken at the onset of symmetrical clipping, has the merit of being the least equivocal method of assessing power rating.

### Input sensitivity

The sensitivity of each of the inputs provided on an amplifier is usually expressed as the r.m.s volts "in" for maximum power "out"; but the manner of expressing sensitivity in this way can be a little misleading, as indeed can be the method of quoting the signal-to-noise ratio.

Take, for example, a 10-watt amplifier with a pickup input typically rated at 2mV for maximum output. What will not be obvious to the uninitiated is that a 20-watt amplifier with the same sensitivity and s/n ratio is actually twice as sensitive as, and has a s/n ratio 3dB better than, the 10-watt model. The reason for the increase in sensitivity is probably quite clear (the 20-watt model will need only 1mV to produce the same volume of sound from the same speaker as the lower powered amplifier) but the apparent improvement in s/n ratio might not be quite so obvious. Since the noise generated in an amplifier usually originates in the earlier low-level stages, it follows that for the 20-watt amplifier to produce 10 watts for a 2-mV input, the volume control will have to be adjusted to reduce the signal level by 3dB; and, of course, the generated noise is also attenuated by the same amount.

### Stability

The final requirement one expects of a well-designed amplifier is that it should be unconditionally stable, bearing in mind the complex load conditions presented by some modern speakers, such as those with multiple drive units and crossover networks.

In a feedback amplifier the loop gain must be tailored so that it falls below unity at frequencies where the phase shift reaches 180°. Whilst with silicon planar transistors the unrestricted passband could extend well into the megahertz region, such a range is neither necessary nor desirable.

Such an amplifier could be unduly sensitive to small reactive components in the load and even if not going into sustained oscillation, the performance could be severely degraded if the amplifier were provoked into "ringing" by steep transients in the signal.

### 'Facilities'

What facilities does one expect to find in a modern high-fidelity amplifier? While it is idealistically the aim of amplifier designers as well as the manufacturers of pickups and loudspeakers for their product to have a linear frequency response over the audible range, somewhere in the programme chain, something or somebody will let the side down and there will be introduced some imperfection that will mar the quality of the sound that emerges from the loudspeaker.

Nevertheless, the facilities we have now come to expect as a

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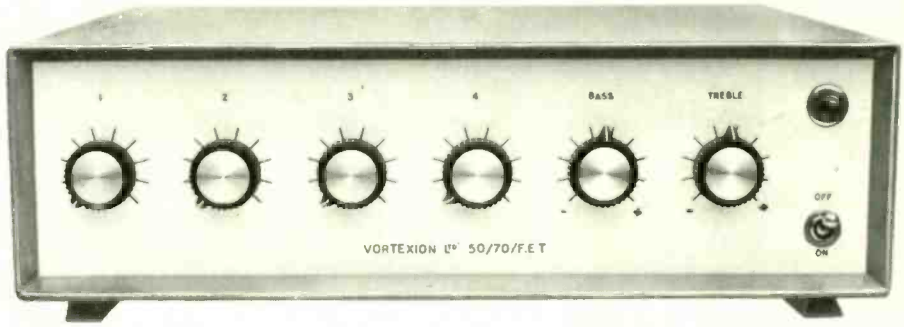
**THE VORTEXION 50/70 WATT ALL SILICON AMPLIFIER WITH BUILT-IN 4 WAY MIXER USING F.E.T.s.**




Size 14" × 11½" x 4½"
100μV on 30/60 ohm mic. input.
100mV to 100 volts on gram/auxiliary input 100KΩ.

Weight 20lb.

**ELECTRONIC MIXERS.** Various types of mixers available. 3-channel with accuracy within 1db Peak Programme Meter. 4-6-8-10 and 12-way mixers. Twin 2,3,4 and 5 channel stereo. Tropicalised controls. Built-in screened supplies. Balanced line mic. input. Outputs: 0.5v at 20K or alternative 1mW at 600 ohms, balanced, unbalanced or floating.

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It hasn't been neglected by Sansui, however.

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Each incorporates a newly developed noise canceler and is capable of handling up to two speaker systems simultaneously. And each features the functional black window design.

For a new look at the middle—or any—power range, see your nearest Sansui dealer soon.

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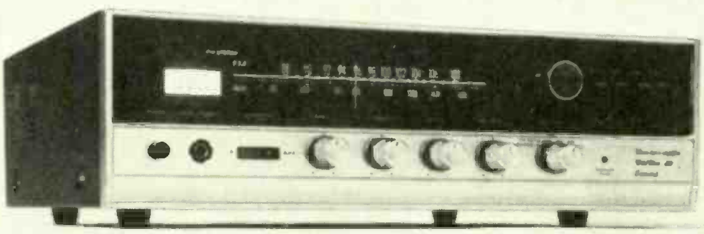

Sansui 350

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permanent feature of a typical high-fidelity amplifier have fallen into a set pattern, and I propose to take each in turn, to describe its function and illustrate with extracts from the circuits of currently available commercial amplifiers.

**The amplifier stages**

Probably the most important stage is the so-called "front end", the point at which the often minute signal from the programme source is amplified to a level which raises it well above the inherent noise of the system. It also carries out one other important function, that of equalizing the signal from the gramophone pickup.

To all intents and purposes, the signal on a modern LP disc is recorded at constant amplitude and with a velocity proportional to frequency. So when the system includes a velocity sensitive pickup, and this means the majority in use today (moving magnet, moving coil and variable reluctance dominating the field) the voltable at its output terminals will be proportional to the frequency on the disc.

The shape of this voltage curve has long been determined to an international standard, and the input stage has to introduce an inverse of this curve within close tolerance. A particular two-transistor circuit has become popular with designers—the d.c. feedback pair which I believe can be accredited to J. Somerset Murray (British Patents 80927 and 83245). Originally developed with germanium transistors to give tight d.c. "sit" points under conditions of varying temperature and using transistors with a wide production "spread" it has passed into use with modern silicon planar types. The input stage of the Heathkit TSA-12 is typical of the many variants of this type of circuit, and not only compensates for the replay curve but provides for a sensible amount of overall gain (Fig. 1).

That the input stage should contribute negligible noise to the signal is a basic requirement generally appreciated, and to this end it is common practice for the first transistor to be run at less than 0.5mA. The second transistor is normally run at a higher $I_{ce}$ and a figure of 1–2mA is again typical. The collector load is chosen to take into account the shunting of the feedback network and a low-noise working condition is here of rather secondary importance. Suffice to say, that in respect of s/n ratio, most modern designs are satisfactory, and on the most sensitive input a –65dB figure or better should be attainable, even using modern low-output magnetic cartridges.

Since it is in overload capability that there is some variation in the standards achieved, let's examine the problem and see what is involved. Consider a typical magnetic pickup with a sensitivity of 1mV/cm/sec, which will generate from the average LP disc a signal in the region of 5mV. Allowing for the dynamic range possible on a modern recording, one must cater for peak velocities of up to 20cm/sec and this means the peak terminal voltage from the pickup may reach 20mV. With a midband overall gain for our "front end" of, say, 150, the peak signal level at the collector of the second stage will be up to 3V. The designer has to ensure that the input stage is able to handle signal levels of this magnitude without distortion, at all frequencies over the audible band and it has come to be accepted that such an input stage must be able to handle not *less* than +20dB over the rated input level and preferably very much more.

An alternative to the simple two-transistor pair, and representative of a sophisticated design philosophy, is that adopted by Radford in their SCA30. Here (Fig.2) an additional buffer stage in the common collector mode has been added to the conventional pair as an impedance conversion device. This offers certain advantages, in that the second common emitter stage can now be tailored for the maximum possible gain, having now been relieved of the loading of the feedback network, and can operate at low $I_{ce}$.

Cambridge Audio bring a highly individual approach to the problems of input stage overload. They have abandoned the traditional concept of a feedback equalizing pair at the input, and substituted instead a straightforward linear amplifying stage with overall variable parallel feedback—the variable element being the volume control. By using a "virtual earth" amplifier in this way, a number of virtues are claimed, including a better than +60dB overload factor and a s/n ratio that is independent of the source *Z* (Fig.3). The function of equalization is delegated to a later stage.

Inputs that are already at a suitably high level and equalized (such as from a tuner) are usually selected by switching, and are injected across the volume control. An alternative is to convert the front end from an equalizing stage to one of fixed linear gain, and feed the high level signal in at the same point via a passive, sometimes variable, attenuator.

On many imported models, and on some British designs conceived with an eye on the healthy export market, the volume control is sometimes replaced by, or can by switching be converted to, the controversial loudness control. This feature is guaranteed to arouse passionate feelings whenever discussed by the true apostles of the hi-fi religion, as readers will be well

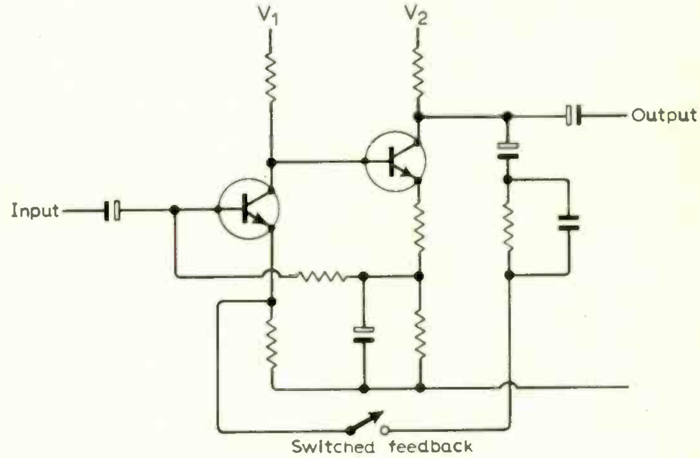


*Fig. 1. Input stage of the Heathkit TSA-12.*

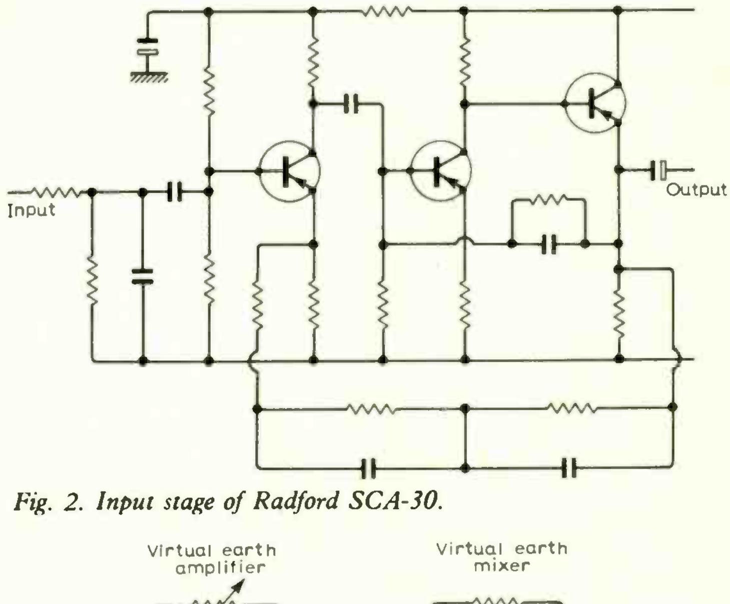


*Fig. 2. Input stage of Radford SCA-30.*

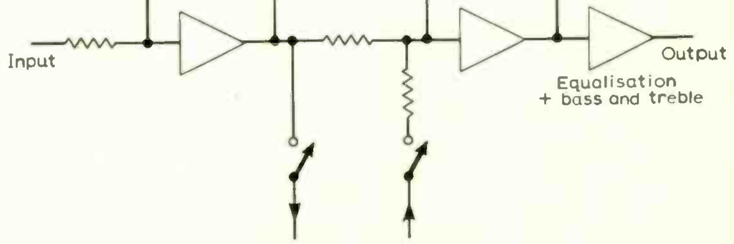


*Fig. 3. Input stage of Cambridge Audio P40 and P80.*

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aware from Letters to the Editor published some months ago. The principles on which the action of the loudness control is based, is that the ear becomes disproportionately less sensitive to low frequencies and, to a lesser degree, high frequencies as the loudness (volume) of the sound source diminishes.

Unfortunately, its staunchest protagonists refuse to recognize the simple fact that it just doesn't always make a low-level sound more natural; for example one has only to listen to the reproduced male voice while manipulating a loudness control.

On the other hand, there is another side of the argument that should be recognized. Hi-fi is no longer the cult of the few but big business, and its products are subject to the dictates of consumer demand and market research. If evidence derived from such sources indicates that the consumer regards some form of loudness control as a desirable feature, then who are our experts and, even more important, British manufacturers to wrinkle a fastidious nose and ignore the demand? Audio amplifiers are going to be used in the home for background music, and the loudness control takes the effort out of making a pleasant noise at low volume level. Foreign competitors are aware of this, and laugh at our conservative attitudes all the way to the bank. . . . If it helps to sell the product, then put the loudness control in, so long as it can be switched out by the pure at heart; and above all, spare us the scientific evidence of its desirability. Fig.4 shows the loudness control in the Sansui AU-777 and is typical.

One expects the well-dressed amplifier to have tone controls, of course. These permit some adjustment to the treble and bass ends of the spectrum relative to a midband point—which may be anywhere from 500Hz to 1kHz. The degree of variation is usually up to ±15dB at 15kHz and of a similar amount at 40Hz. There are, basically, two modes in which these controls operate. Broadly speaking they are related to whether the designer has opted for passive equalization or the adjustment of reactive elements in a feedback network. The feedback type, especially that due to Baxandall, appears to enjoy the greatest popularity and that used in the Leak "Stereo 30 Plus" is a well tailored version (Fig. 5).

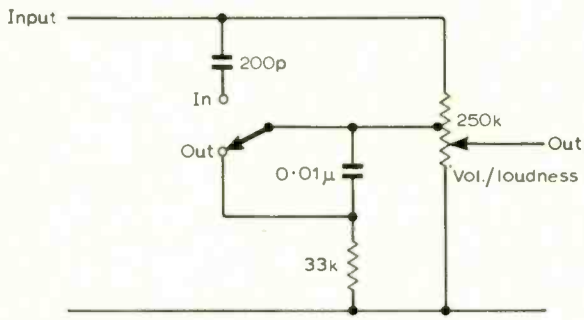


*Fig. 4. Sansui loudness control circuit.*

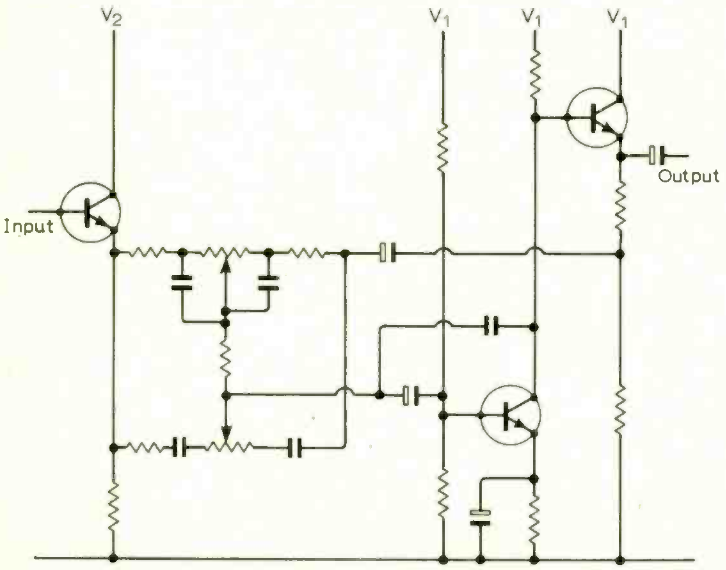


*Fig. 5. Tone control stage of Leak 'Stereo 30 Plus'.*

Whilst tone controls have a maximum slope that does not exceed 6dB/octave, it is frequently desirable, one might say almost essential, to have low-pass filter facilities that operate at a far greater rate than this and particularly at the high end of the spectrum. Objectionable noises and harmonic and intermodulation products are likely to appear in an imperfect signal above, say, 5kHz, and it is useful to be able to attenuate these rapidly. The rate of slope for these steep cut filters should not be less than −12dB/octave and to achieve these higher attenuation rates, designers either adopt a two-section *RC* network or in a more sophisticated approach, will use bridged-T networks in a feedback configuration. Curiously enough, designers seem to fight shy of using combinations of *L* and *C*, although Leak have included a basic half section in their "Stereo 30 Plus" with one switched turnover frequency at 6kHz. Quad, on the other hand, have gone in for a full-blooded version, very comprehensive, with three switched turnover points at 5, 7 and 10kHz (by means of a tapped inductor) and the facility of being able to vary the slope on a calibrated control up to a maximum of 25dB/octave.

It is regrettable that many amplifier manufacturers seem to regard a really effective low-pass filter as less than essential.

At the low end of the spectrum a high-pass filter is either permanently included or switchable, to limit the response below 20 or 30Hz in order to attenuate mechanical noise or "rumble" produced by the record turntable.

Paradoxically, inexpensive amplifiers which might be complemented in a budget system by a turntable of comparable cost, invariably omit this feature and response is likely to be unrestricted down to subsonic levels.

**The power amplifier:** Both at home and abroad, a small number of manufacturers eschew completely the principle of complementary working, possibly because originally, suitable high-voltage complementary pairs of driver transistors were somewhat thin on the ground and carried a price tag that reflected their scarcity. This inhibiting factor applied equally to n-p-n types in the germanium era and later, with silicons, p-n-p's were in short supply and somewhat costly. Rogers, for example, have opted for a driver transformer in both their Ravensbourne and Ravensbrooke. By employing a carefully designed quadrifilar wound component, it is claimed that most of the inherent disadvantages usually associated with transformer drive have been overcome. Incidentally, without exception in my experience, output transformers have disappeared entirely and designers have opted for the series push-pull transformerless output stage, irrespective of the method of phase inversion adopted. But broadly speaking, the quasi-complementary class B transformerless circuit is highly favoured.

However, right from the introduction of the first transistor amplifier, there began to be complaints (and sometimes, even *approval*) of the so-called "transistor sound", and discounting some of the highly subjective reasons advanced one can justifiably argue now that the *main* cause can usually be attributed to the inherent asymmetry of the Lin-type quasi-complementary configuration. The principal "cure" has been, so far, to rely upon the high overall negative feedback that has come to be regarded as almost mandatory with this type of amplifier. During a recent evaluation of a very expensive amplifier there was, at low listening levels, some crossover distortion audible. Yet the reproduced sine wave at approximately the same level, 200mW, showed not the slightest sign of this defect and the sum of the distortion products when measured on a distortion factor meter hardly reached our hitherto acceptable figure of 0.1%.

We are faced, then, with the problem of how to equate the subjective effects with the degree of aural "objectionable-ness" that this form of distortion provokes, and to express it in

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quantitative terms. Fortunately, this is a problem that may be resolved by the adoption of techniques in transistor circuitry that will eliminate once again this particularly objectionable defect. The obvious line of attack is to try to overcome the inherent asymmetry of the orthodox quasi-complementary class B output stage, although there has developed a strong "back to class A" movement as exemplified by the two commercial models produced by the Richard Allan company.

While one cannot deny that a good class A design will eliminate crossover distortion completely, in my view this is design by expediency and metaphorically speaking, simply sweeping the difficulties under the carpet of the R and D department. The many disadvantages of class A working in a transistor amplifier, its low efficiency for example, far outweigh the short-term advantage of freedom from just one aberration in the performance of an audio amplifier.

I emphasize short-term, because already, there is evidence that designers with a more imaginative approach are developing ways to eliminate the asymmetry of the class B stage, the use of complementary "triples" as adopted in the Quad 303 being well to the fore in sophisticated elegance (Fig. 6).

Aside from the technique developed by Quad, the orthodox remedy is likely to be the adoption of full complementary working following the increasing availability of pairs of n-p-n/p-n-p silicon power transistors and whilst they are still not too plentiful, the Radford SCA30 employs this technique. Models P40 and P80 from Cambridge Audio also use a complementary pair of silicon transistors in the output stage with the added refinement of constant current drive. It is claimed that this technique reduces even further the effects of any asymmetry that remains in the complementary output stage.

While the increasing use of silicon devices improved the robustness of high-quality amplifiers under a wide range of expected working conditions, it is an inescapable fact that transistors have not yet the inherent resistance to short-term overload of valves and most leading manufacturers might, in an unguarded moment, admit to some unhappy experiences following an initial attempt to introduce a transistor model.

Possibly the most important problem that designers have had to contend with, is that of "second breakdown" in transistors and principally those of the large chip area power types. This is not just simple voltage breakdown, but a thermally and electrically regenerative process initiated by certain levels of voltage and current being coincident for finite lengths of time, and is produced in the output stage of an audio amplifier by undesirable reactive load conditions. Transistor manufacturers have not been slow to develop chip construction techniques to minimize the possibility of second breakdown, but the problem is still very much with the amplifier designer and some measures of circuit protection are now regarded as essential.

Protection on a short-term basis can only be achieved by comparatively fast operating electronic circuitry. Broadly speaking, the techniques being adopted fall into two categories. First, the latching-type overload trip whereby the power supply to the output stage is cut instantly under conditions of overload and has to be reset manually. This is employed in some Japanese designs, such as the Sony TA1120 and the Sansui AU777.

Most British and European designers, on the other hand, tend to favour non-latching protection and incorporate limiting circuitry into the amplifier and/or the power supply, again employing sensing techniques either with diodes as simple voltage operated switches as in the Quad 303 or as in the Radford SCA 30 which uses transistors to monitor the emitter current of each output transistor.

**Power supplies.** In the low and medium price ranges, the designer has usually to be content with a straightforward silicon diode bridge rectifier, plus a single electrolytic smoothing capacitor. At the other end of the cost spectrum, we have the complex thyristor regulated system of the Radford which even includes a separate zener regulated supply for the pre-amplifier stages (Fig. 7). Power supplies of such sophistication go a long way towards rendering unnecessary any need for the advertising dept. to manipulate the power rating figures. Amplifiers of this calibre are clearly in the "professional" class and invariably carry a price tag to match.

It is safe, at least, to assume that circuit techniques will continue the process of refinement, with the increasing use of integrated circuits and correspondingly fewer discrete components, especially in the small signal stages. Whilst it is an open secret that at least one familiar name in the amplifier field is seriously considering the advantages of an integrated power amplifier and loudspeaker combination, market trends indicate that "separates" in the traditional form of tuner plus pre-amplifier, plus power amplifier are falling out of public favour. Preamp. and power amp. combined, in one unit, are dominating the market and eventually, the stereo receiver—all three in one—will be the favoured choice, as indeed they already are in the U.S.A. and on the Continent.

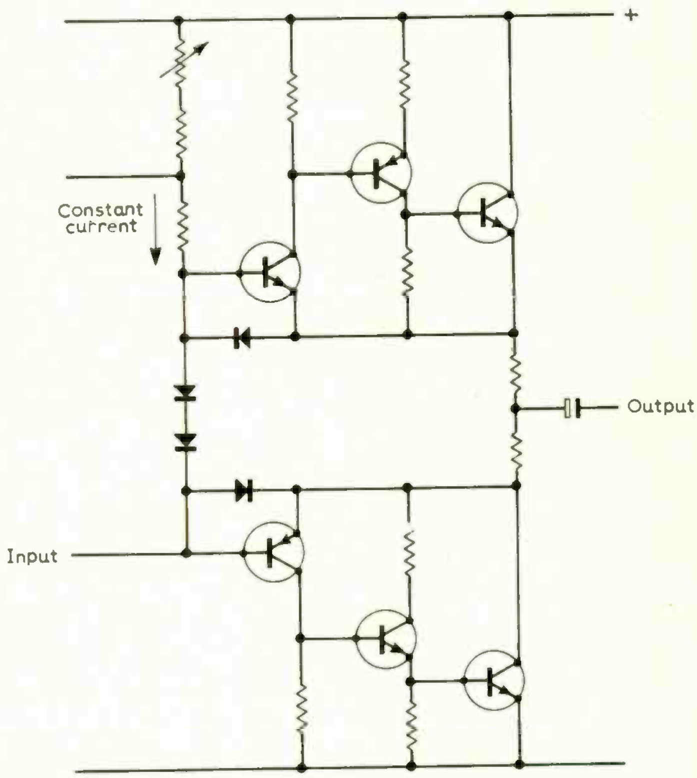


*Fig. 6. Output section of Quad 303 power amplifier.*

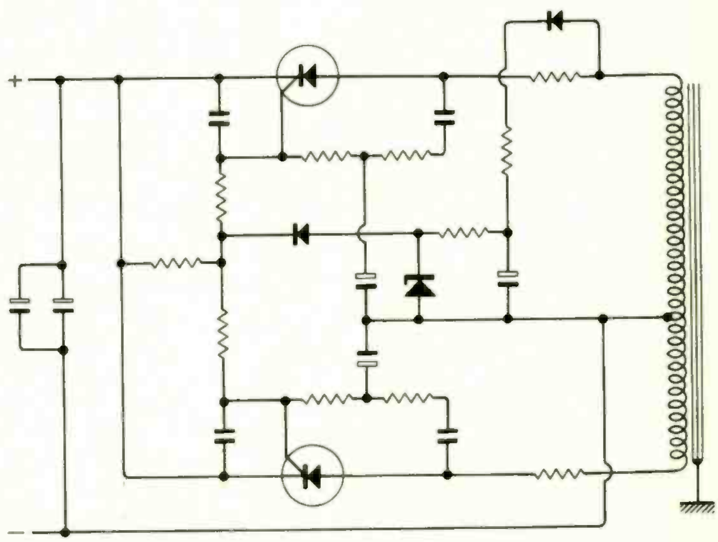


*Fig. 7. One half of the power supply in the Radford SCA-30.*

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# Audio Amplifier Data

This table of data has been drawn up by Wireless World from manufacturers' information to illustrate, by example, the particular facts and figures referred to in Mr. Williamson's survey article. On examining the details given, the reader should be able to draw some useful conclusions. It is particularly hoped that this may be true for those who are worriedly balancing quality and cost in the midst of a bewildering variety.

| Model | Mono or stereo | Valve or transistor | Recommended speaker impedance (Ω) | Maximum r.m.s. power/channel into recommended load (W) | Damping factor | T.H.D. at maximum output power (%) | T.H.D. at 10 mW output (%) | Power bandwidth (±3dB) (Hz-kHz) | Magnetic pickup sensitivity (mV) | Ceramic pickup sensitivity (mV) | High level input sensitivity (mV) | Output for tape-recorder | Built-in f.m. tuner | Dimensions in cm W × D × H | Recommended retail price | Special features |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Arena (Highgate Acoustics, 184-188 Great Portland Street, London, W.1)** | | | | | | | | | | | | | | | | |
| F210 | S | T | 4 | 8 | 20 | — | — | 30–18 | 3 | 500 | — | Yes | No | 26 × 20 × 7 | 33gn | — |
| T1500F | S | T | 4 | 8 | 30 | — | — | 20–20 | 6.5 | 500 | — | Yes | Yes | 35 × 20 × 11 | 61gn | — |
| T1500H | S | T | 4 | 8 | 30 | — | — | 20–20 | 6.5 | 500 | — | Yes | Yes | 74 × 20 × 11 | 69gn | — |
| T2400 | S | T | 4 | 15 | 40 | 0.6 | — | 20–20 | 6.5 | 500 | — | Yes | Yes | — | 79gn | — |
| T2500F | S | T | 4 | 15 | 40 | 0.6 | — | 20–20 | 6.5 | 500 | — | Yes | Yes | 45 × 21 × 15 | 89gn | — |
| T2500H | S | T | 4 | 15 | 40 | 0.6 | — | 20–20 | 6.5 | 500 | — | Yes | Yes | 74 × 21 × 15 | 97gn | — |
| T9000 | S | T | 8 | 15 | 80 | 0.5 | — | 20–20 | 3 | — | — | Yes | Yes | 51 × 30 × 15 | 275gn | — |
| **Armstrong Audio Ltd., Warlters Road, London, N.7** | | | | | | | | | | | | | | | | |
| 521 | S | T | 4–16 | 25 (8Ω) | 10 | < 0.5 | < 0.5 | 15–25 | 3.5 | 60 | 400 & 100 | Yes | No | 29 × 27 × 12 | £52 | These models include switched treble and rumble filters, loudness control, tape-monitor switch, and headphone jack. The 426 also covers m.w. and l.w. bands |
| 425 / 426 | S | T | 4–16 | 25 (8Ω) | 10 | < 0.5 | < 0.5 | 15–25 | 3.5 | 60 | 400 | Yes | Yes | 41 × 27 × 10 | £79 14 9 / £88 19 | |
| **Braun (Fi-Cord International, Charlwoods Road, East Grinstead)** | | | | | | | | | | | | | | | | |
| CSV250 | S | T | 4 | 20 | — | 0.5 | — | 20–40 (±1dB) | 3 | 220 | — | Yes | No | 29 × 31 × 11 | £83 0 3 | Separate bass and treble controls for each channel |
| CSV500 | S | T | 4 to 16 | 40 (4Ω) | — | < 0.5 | — | 10–35 (±1dB) | 6 | 250 | — | Yes | No | 40 × 40 × 11 | £163 11 4 | — |
| CSV1000 | S | T | 4 to 16 | 55 (8Ω) | — | < 0.5 | — | 20–30 (±1.5dB) | 2 | 400 | — | Yes | No | 40 × 31 × 11 | £273 1 10 | Stereo expansion control |
| Regie 500 | S | T | 4 to 16 | 50 (4Ω) | — | < 0.5 | — | 30–30 | 3 | 400 | — | Yes | Yes | 40 × 31 × 11 | £262 6 | Complete with multiplex decoder |
| **Bryan Amplifiers Ltd., 120 Ashley Road, Hale, Altrincham, Cheshire** | | | | | | | | | | | | | | | | |
| 9000 | S | T | 8 or 15 | 18 (8Ω) | 60 | < 0.5 | < 0.5 | 20–30 | 3.0 | 40 | 75 | Yes | No | 34 × 13 × 24 | £48 | — |
| 8000 | S | T | 8 or 15 | 25 (8Ω) | 60 | < 0.1 | < 0.1 | 20–30 | 3.5 | 45 | 80 | Yes | No | 34 × 13 × 24 | £55 | — |
| 6000 | S | T | 8 or 15 | 25 (8Ω) | 60 | < 0.5 | < 0.5 | 20–30 | 3.5 | 45 | 80 | Yes | Yes | 44 × 30 × 14 | £91 7 10 | Stereo radio model available |
| **Cambridge Audio Laboratories Ltd., 6 Queen Street, London, W.1** | | | | | | | | | | | | | | | | |
| P40 | S | T | 8 | 20 | 80 (8Ω) | < 0.1% | < residual noise | 15–20 | 3 | 100 | 400 | Yes | No | 42 × 24 × 5 | £64 10 | Electronic output circuit protection. Unconditionally stable with any load |
| P80 | S | T | 8 | 40 | 80 (8Ω) | < 0.1% | < residual noise | — | 3 | 100 | 400 | Yes | No | 42 × 24 × 5 | £92 15 | |
| **Crown (Carston Electronics Ltd., 71 Oakley Road, Chinnor, Oxon.)** | | | | | | | | | | | | | | | | |
| DC300 | S | T | 4 to 16 | 340 (4Ω) | 200 | < 0.02 | — | 0–35 | — | — | 1.75V | No | No | 47 × 25 × 17 | £297 + £25 duty | D.C. coupled throughout. Hum and noise 100dB below 150W |
| SA30-30 | M or S | T | 4 to 16 | 30 (8Ω) | 200 | 0.5 | — | 10–100 | — | — | 600 | No | No | 47 × 18 × 4 | £110 (S) / £75 (M) | Direct 25-V line output with accessory transformer. Hum and noise 90dB below 30W |
| **Dual Electronics Ltd., Radnor House, London Road, Norbury, London, S.W.16** | | | | | | | | | | | | | | | | |
| CV40 | S | T | 4 | 18 | — | 0.3% | 0.08 (50mW) | 15–40 | 4 | 350 | 350 | Yes | No | 42 × 29 × 11 | £64 10 | "Loudness" contour circuits which can be switched out of circuit |
| **Dulci-Lee Products (G.B.) Ltd., 10-18 Clifton Street, London, E.C.2** | | | | | | | | | | | | | | | | |
| 207 | S | T | 4–15 | 4 (15Ω) | 16 | 1.5 | 2 | 20–25 | — | 100 | — | Yes | No | 34 × 17 × 7 | — | — |
| 207M | S | T | 4–15 | 4 (15Ω) | 16 | 1.5 | 2 | 20–25 | 3.5 | 100 | — | Yes | No | 34 × 17 × 7 | — | — |
| LZ220 | S | T | 4–15 | 17 (4Ω) | 58 | 0.5 | 1 | 18–30 | 3.5 | 35 and 400 | — | Yes | No | 37 × 21 × 11 | — | — |
| **Eagle (B. Adler & Sons (Radio) Ltd., Coptic Street, London, W.C.1)** | | | | | | | | | | | | | | | | |
| TSA60 | S | T | 8 or 16 | 15 (8Ω) | — | < 1 | — | 20–20 | 5 | 100 | 100 | Yes | No | 32 × 24 × 11 | £41 9 6 | — |
| VTA40 | S | T | 8 or 16 | 10 (8Ω) | — | < 1 | — | 20–20 | 3 | 100 | 300 | Yes | No | 11 × 22 × 22 | £41 9 6 | — |
| SA200 | S | V | 4 to 16 | 7.5 (4–16Ω) | — | < 0.5 | — | 40–20 | 5 | 100 | 100 | Yes | No | 31 × 21 × 12 | £31 1 6 | — |
| TSA10C | S | T | 16 | 5 (16Ω) | — | < 2 | — | 40–18 | None | 50 | 100 | No | No | 24 × 18 × 8 | £14 13 6 | — |
| SA100 | S | V | 4 to 16 | 5 (4–16Ω) | — | < 1 | — | 40–20 | 10 | 180 | 180 | Yes | No | 24 × 18 × 11 | £22 11 6 | — |
| TSA20 | S | T | 8 or 16 | 10 (8Ω) | — | < 1 | — | 30–20 | 3 | 100 | 150 | Yes | No | 25 × 20 × 11 | £27 11 3 | — |



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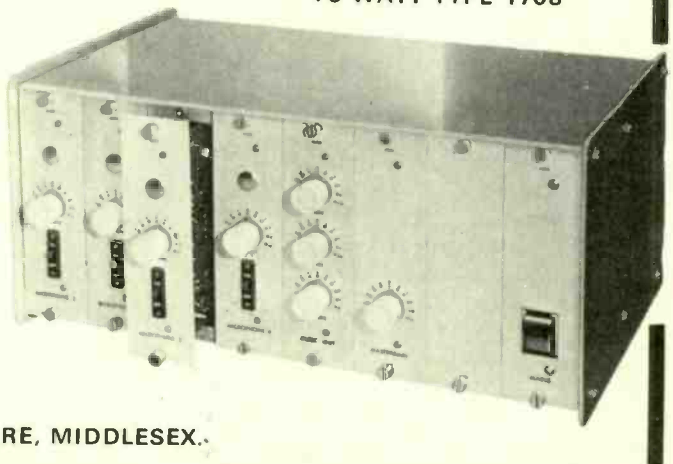

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| Model | Mono or stereo | Valve or transistor | Recommended speaker impedance (Ω) | Maximum r.m.s. power/channel into recommended load (W) | Damping factor | T.H.D. at maximum output power (%) | T.H.D. at 10 mW output (%) | Power bandwidth (±3dB) (Hz-kHz) | Magnetic pickup sensitivity (mV) | [illegible] pickup sensitivity (mV) | [illegible] input sensitivity (mV) | [illegible] for tape-recorder | [illegible] f.m. tuner | [illegible] in cm W×D×H | retail price | Special features |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Goodmans Loudspeakers Ltd., Axiom Works, Lancelot Road, Wembley, Middx.** | | | | | | | | | | | | | | | | |
| Maxamp 30 | S | T | 4 to 16 | 15 (8Ω) | 50 (8Ω) | 0.4 | — | 20–20 (±.5dB) | 3.5 | 50 | 100 | Yes | No | 14×18×27 | £54 | — |
| **Grundig (Great Britain) Ltd., London, S.E.26** | | | | | | | | | | | | | | | | |
| TRV350 | S | T | 5 | 7 | — | 1 | | 40–18 | — | 150 | 150 | Yes | Yes | 55×15×22 | — | AM and FM tuner—decoder fitted |
| RTV600 | S | T | 5 | 20 | 14 | 0.5 | | 20–30 | 3 | 200 | 200 | Yes | Yes | 60×15×31 | — | Electronic overload-protected output stages |
| SV80 M | S | T | 5 | 30 | 20 | 0.5 | < 0.1 (at 250mW) | 10–50 | 4 | 220 | 220 | Yes | — | 41×15×28 | — | Switchable loudness compensation. Scratch and rumble filters |
| SV40 M | S | T | 5 | 15 | 20 | 0.5 | | 10–50 | 3 | 200 | 200 | Yes | — | 41×15×28 | — | Switchable loudness compensation. Scratch and rumble filters |
| SV140 | S | T | 5 | 50 | 20 | 0.5 | | 10–50 | 5 | 250 | 250 | Yes | — | 50×15×31 | — | Switchable loudness compensation. Scratch and rumble filters. Electronic overload-protected output stages |
| **H.H. Electronic, 147 High Street, Harston, Cambridge** | | | | | | | | | | | | | | | | |
| TPA50 | M | T | 8 or 15 | 50 | 25 (8Ω) | < 0.2 | 0.05 | 10–60 | — | — | 770 | No | No | 48×30×9 | £49 | All models stable with any load and short-circuit proof. Bench-standing or rack-mounting models available |
| TPA100 | M | T | 8 or 15 | 100 | 25 (8Ω) | < 0.2 | 0.05 | 10–80 | — | — | 770 | No | No | 48×30×9 | £75 | — |
| TPA25 | M | T | 8 or 15 | 25 | 25 (8Ω) | < 0.2 | 0.05 | 10–60 | — | — | 650 | No | No | 15×24×9 | £42 | — |
| **Korting (Europa Electronics Ltd., Howard Place, Shelton, Stoke-on-Trent, ST1 4NW)** | | | | | | | | | | | | | | | | |
| Stereo 700 | S | T | 4 | 24 | 23 | 2% | 0.1 | 15–40 | 3.5 | 30 | No limit into 470kΩ | Yes | Yes | 63×24×16 | 99gn | — |
| A500 | S | T | 4 | 24 | 23 | 2% | 0.1 | 15–30 | 3.5 | 30 | | Yes | No | 36×23×9 | 39gn | — |
| Stereo 1000L | S | T | 4 | 27 | 23 | 2% | 0.1 | 15–40 | 2.5 | 20 | | Yes | Yes | 63×24×16 | 119gn | — |
| **Lafayette (Barnet Factors Ltd., 4 Lisle Street, London, W.C.2)** | | | | | | | | | | | | | | | | |
| LA-85T | S | T | 4 | 30 | — | 1 | — | 22–20 | 2.5 | — | 270 | Yes | No | 33×24×10 | £49 10 | — |
| LR-500T | S | T | 4 | 20 | — | < 1 | 0.3 (at 1W) | 22–40 | 2.2 | — | 270 and 500 | Yes | Yes | 37×31×12 | £94 9 11 | — |
| LR-99 | S | T | 8 | 10 | — | — | 0.5 (at 1 W) | 40–17 | 3 | 80 | 250 | — | Yes | 35×25×11 | £77 5 10 | Loudness control fitted |
| **H. J. Leak & Co. Ltd., Brunel Road, London, W.3** | | | | | | | | | | | | | | | | |
| Stereo 30 Plus | S | T | 8 | 15 | 20 | 0.1 | 0.1 | 30–20 (±1dB) | 2 and 10 | 30 | 250 and 60 | Yes | No | 34×23×12 | £59 10 | Case or chassis models available. Prices given are for case models |
| Stereo 70 | S | T | 8 | 35 | 20 | 0.1 (at 25W) | 0.1 | 30–20 (±1dB) | 2 and 10 | 30 | 250 and 60 | Yes | No | 34×23×12 | £69 10 | |
| **Quad—The Acoustical Manufacturing Co. Ltd., Huntingdon** | | | | | | | | | | | | | | | | |
| Quad 33 and 303 | S | T | 4–16 | 45 (8Ω) | > 20 (16Ω) | < 0.03 | < 0.03 | 20–35 (−1dB) | 2–5.6 | 100 | 100 | Yes | No | 29×16×9 (Q33) 12×32×16 (Q303) | £98 | Unconditional stability with any load |
| Quad 50E | M | T | 4–200 | 50 | — | < 0.1 | < 0.1 | 30–20 | — | — | 500 | No | No | 12×32×16 | | |
| **Radford Audio Ltd., Ashton Vale Road, Bristol BS3 2HZ** | | | | | | | | | | | | | | | | |
| SCA30 | S | T | 8 or 16 | 45 (8Ω) | 60 | 0.1 | 0.1 | 20–150 (−1dB) | 1.5 (variable) | — | 125 | Yes | No | 32×37×16 | £106 | Complementary symmetry output stage. High overload characteristics |
| STA25 | S | V | 16/8/4 (switched) | 35 | 35 | 0.1 | 0.02 | 20–40 (−1dB) | — | | 500 | No | — | 35×25×21 | £60 | |
| STA100 and STA100B | S | V | 16/8/4 (switched) | 100 | 60 | 0.1 | 0.02 | 20–40 (−1dB) | — | | 500 | No | — | 42×35×24 | £127 £145 (B) | 100B is line input version. |
| **R.A.H. Automation Ltd., 406 Hackney Road, London, E.2** | | | | | | | | | | | | | | | | |
| Vector 24 | S | T | 8 | 12 | 100 | 0.1 | 0.09 | 20–20 (±1dB) | 5 | 100 | 500 | Yes | No | 30×20×9 | 28gn | I.c. pre-amp and driver stage. Short circuit protection for output stage |
| **Revox (C. E. Hammond & Co. Ltd., 90 High Street, Eton, Berks.)** | | | | | | | | | | | | | | | | |
| Revox A50 | S | T | 4 or 8 | 40 | > 20 | — | — | 10–40 | 3 | 230 | 100 | Yes | No | 41×24×16 | 94gn | Adjustable preset pots for each input |
| **J. Richardson Electronics Ltd., 57 Jamestown Road, London, N.W.1** | | | | | | | | | | | | | | | | |
| MA135 | M | V | 4–16 | 30 (16Ω) | — | < 0.1 | — | 30–20 (±.5dB) | — | — | — | — | — | 31×21×17 | £37 10 | — |
| MA200 | M | V | 4–16 (or 100V line) | 75 (16Ω) | — | < 0.1 | — | 30–20 (±.5dB) | — | — | — | — | — | 43×19×17 | £60 | — |
| SA170 matched to | S | V | 4–16 | 30 (16Ω) | — | < 0.1 | — | 30–20 (±.5dB) | — | — | — | — | — | 30×33×17 | £60 | — |
| SCP1 (control unit) | S | T | — | — | — | < 0.02 | — | — | 2 | 50 and 225 | 225 | Yes | No | 36×29×11 | £42 10 | — |
| **Rogers Developments (Electronics) Ltd., Rodevco Works, 4/14 Barmeston Road, Catford, London, S.E.6** | | | | | | | | | | | | | | | | |
| Cadet III | S | V | 3–16 | 10 | — | 0.8 | — | 40–10 (±1dB) | 3.8 | 65 | 100 | Yes | No | 30×28×13 | £37 10 (chassis £33 15) | — |
| Ravensbrook | S | T | 8 and 16 | 10 (15Ω) | — | < 0.1 | — | 20–50 (±3dB) | 2 and 4 | 25 and 50 | 100 | Yes | No | 36×25×13 | £47 10 (chassis £42 10) | — |
| Ravensbourne | S | T | 4–16 | 25 (8 or 15Ω) | 60 | < 0.1 | — | — | 4 and 8 | 50 and 100 | 200 | Yes | No | 37×23×13 | £64 (chassis £59 10) | — |

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| Model | Mono or stereo | Valve or transistor | Recommended speaker impedance (Ω) | Maximum r.m.s. power/channel into recommended load (W) | Damping factor | T.H.D. at maximum output power (%) | T.H.D. at 10 mW output (%) | Power bandwidth (±3dB) (Hz-kHz) | Magnetic pickup sensitivity (mV) | Ceramic pickup sensitivity (mV) | High level input sensitivity (mV) | Output for tape-recorder | Built-in f.m. tuner | Dimensions in cm W×D×H | Recommended retail price | Special features |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sansui (Technical Ceramics Ltd., Thorn Hill, Southampton, SO9 1QX)** | | | | | | | | | | | | | | | | |
| AU222 | S | T | 4 to 16 | 18 (8Ω) | 20 (8Ω) | < 0.8 | — | 20–20 | 2 | 150 | 150 | Yes | No | 29×27×11 | 57gn | — |
| AU555 | S | T | 4 to 16 | 25 (4Ω) | 45 (8Ω) | < 0.5 | — | 20–30 | 2 | 140 | 200 | Yes | No | 38×28×11 | 73gn | Independent pre- and main amplifiers |
| AU777 | S | T | 4 to 16 | 25 (16Ω) | 24 (8Ω) | < 0.5 | — | 20–50 | 2 | 140 | 140 | Yes | No | 43×33×15 | £110 5 | Protection circuit in output stage |
| 250 | S | V | 8 or 16 | 10 (16Ω) | — | 1.5 | — | 35–15 | 3 | 150 | 150 | Yes | Yes | 43×33×15 | £95 3 | Stereo decoder fitted |
| 350 | S | T | 4 to 16 | 18 (8Ω) | 34 (8Ω) | < 1.0 | — | 30–20 | 2.2 | 150 | 150 | Yes | Yes | 40×33×12 | £122 18 11 | — |
| 400 | S | T | 4 to 16 | 20 (8Ω) | 24 (8Ω) | < 1.0 | — | 20–50 | 2.2 | 150 | 150 | Yes | Yes | 41×33×13 | £127 2 11 | Protection circuit in output stage |
| 2000 | S | T | 4 to 16 | 32 (8Ω) | 24 (8Ω) | < 0.8 | — | 20–40 | 2.2 | 150 | 150 | Yes | Yes | 40×33×13 | £154 9 8 | — |
| 3000A | S | T | 4 to 32 | 48 (8Ω) | 15 (8Ω) | < 0.8 | — | 20–40 | 2.5 | 180 | 180 | Yes | Yes | 45×38×18 | £178 10 9 | — |
| 5000 | S | T | 4 to 16 | 55 (8Ω) | 50 (8Ω) | < 0.8 | — | 15–30 | 2.5 | 150 | 150 | Yes | Yes | 43×37×13 | £198 17 | Three speaker system |
| 800 | S | T | 4 to 16 | 22 (8Ω) | 60 (8Ω) | < 0.8 | — | 20–40 | 2.2 | 150 | 150 | Yes | Yes | 39×33×11 | £139 19 6 | — |
| **Sanyo Service and Sales, Marubeni-Iida House, 164 Clapham Park Road, London, S.W.4** | | | | | | | | | | | | | | | | |
| DC434 | S | T | 8 | 18 | 30 | 1 | 1 | 35–30 | 3–5 | — | 100–200 | Yes | Yes | 62×40×30 | £175 9 10 | Built-in turntable. Magnetic pick-up cartridge |
| DC534 | S | T | 8 | 10 | 10 | 5 | 1 | 50–11 | 3–5 | — | 100–200 | Yes | Yes | 62×39×25 | £135 6 3 | As above |
| DC60 | S | T | 8 | 20 | 10 | 1 | 1 | 30–9 | 3.5 | 250 | 100 | Yes | Yes | 46×29×14 | £100 14 7 | — |
| **Sony (U.K.) Ltd., Ascot Road, Bedfont, Feltham, Middx.** | | | | | | | | | | | | | | | | |
| TA1080 | S | T | 8 | 30 | > 40 | < 0.15 | < 0.1 | 30–100 | 2.3 | 2.3 | 120 | — | No | 40×31×14 | £120 | 6 stereo inputs (2 adjustable). |
| TA1120 | S | T | 8 | 50 | > 70 | < 0.1 | < 0.03 | 10–100 | 1.0 | 5 | 200 | — | No | 40×31×14 | £160 | As above with filters and tone-control cancelling switches |
| STR6050FW | S | T | 8 | 30 | > 40 | < 0.2 | < 0.1 | 30–50 | 2.5 | 2.5 | 250 | — | Yes | 44×34×15 | £146 12 | — |
| STR6060FW | S | T | 8 | 45 | > 70 | < 0.2 | < 0.08 | 20–60 | 2.1 | 2.1 | 180 | — | Yes | 44×35×15 | £188 1 6 | — |
| **Tandberg (Elstone Electronics Ltd., Templar Street, North Court, Leeds 2)** | | | | | | | | | | | | | | | | |
| Sølvsuper 1070 | M | Hybrid | 4 | 8 | — | — | — | 30–16 | — | 50 | 50 | Yes | Yes | 53×13×23 | £60 19 | With speaker |
| Sølvsuper 1071 | S | Hybrid | 4 | 6 | — | — | — | 30–16 | 2.4 | 50 | 50 | Yes | Yes | 38×23×13 | £75 18 | — |
| Sølvsuper 1072 | S | Hybrid | 4 | 6 | — | — | — | 30–16 | 2.4 | 50 | 50 | Yes | Yes | 70×23×5 | £82 6 | With speakers |
| Huldra 9 | S | Hybrid | 4 | 15 | — | — | — | 30–16 | 2.7 | 50 | 50 | Yes | Yes | 54×27×13 | £138 10 | — |
| **Telefunken (A.E.G. (Great Britain) Ltd., 27 Chancery Lane, London, W.C.2.)** | | | | | | | | | | | | | | | | |
| Allegro 101 | S | T | 4 | 4 | — | — | — | — | — | 100 | — | Yes | Yes | 50×17×18 | — | — |
| Rondo | S | T | 4 | 4 | — | — | — | | — | 100 | — | Yes | Yes | 63×38×18 | — | — |
| Concertino 101 | S | T | 4 | 10 | — | ≤1 | — | 20–20 (±1.5dB) | — | 100 | — | Yes | Yes | 61×19×17 | — | — |
| V201 | S | T | 4 | 25 | — | ≤1 | — | 17–35 | 7 | 320 | 320 | Yes | No | 46×32×15 | — | — |
| V250 Hi Fi | S | T | 4 | 35 | 30 | 0.5 | — | 10–20 | 4.5 | 300 | 300 | Yes | No | 46×32×13 | — | Output stage protection |
| **Trio (B. H. Morris & Co. (Radio) Ltd., 84-88 Nelson Street, London, E.1)** | | | | | | | | | | | | | | | | |
| Trio KA-4000 | S | T | 8 | 32 | 27.5 | > 0.5 | > 0.3 | 13–30 | 2 | — | 200 | Yes | No | 45×28×13 | £78 | Power transistor protection circuit |
| Trio Supreme I | S | T | 8 | 33 (low) 23 (mid) 15 (high) | 40 | — | — | 20–50 | — | — | — | Yes | No | 42×33×16 | £298 | Each channel employs separate low-, mid-, and high-range amplifiers |
| Trio TK-250T | S | T | 8 | 20 | 20 | 0.8 | — | 18–60 | 2 and 2.5 | — | 150 | Yes | No | 32×25×10 | £52 | — |
| Trio TK-150T | S | T | 8 | 13 | 20 | 0.5 | — | 20–60 | 2.1 | — | 130 | Yes | No | 26×21×10 | £36 | — |
| **Tripletone Manufacturing Co. Ltd., 241a The Broadway, Wimbledon, London, S.W.19** | | | | | | | | | | | | | | | | |
| 8+8 | S | T | 15 | 8 | 40 | < 0.2 | < 0.2 | 30–20 | — | 80 | 200 | Yes | No | 28×19×9 | £29 19 6 | — |
| Hi Fi Major | M | T | 15 | 10 | 40 | < 0.2 | < 0.2 | 30–20 | — | 80 | 200 | Yes | No | 28×19×9 | £19 18 6 | — |
| **Vortexion Ltd., 257/263 The Broadway, Wimbledon, London, S.W.19** | | | | | | | | | | | | | | | | |
| 120/200 watt | M | V | 70/100Ω or 200Ω | 200 (100Ω) | 20+ | 0.1 | < 0.1 | 20–40 | — | — | 1mW 600Ω | — | — | 31 high 48 rack | £135 | — |
| 100 Watt | M | T | 100Ω line | 100 | 20+ | 0.3 | < 0.1 | 40–20 | — | — | 30 | — | — | 30×16×23 | £70 | — |
| 30/50 watt | M | V | 4, 7.5, 15Ω or 100 volt line | 50 | 20+ | 0.15 | < 0.1 | 20–50 | — | — | 80 | — | — | — | — | — |
| S.50 watt | M | V | 15Ω and 100 volt line | 50 | 20 | — | — | — | — | — | — | — | — | — | £76 | Balanced line mic. inputs |
| 50/70 watt | M | T | Bal. 100 volt line | 70 (100 volt line) | 20+ | 0.3 (i.m.d.) | < 0.1 | 30–20 | — | — | 100 | — | — | 35×29×11 | £75 | All f.e.t. inputs |
| CP50 | M | T | 7.5–15Ω and 100V line | 50 | 10 | 1 | < 0.1 | 25–20 | — | — | — | — | — | 45×29×16 | £84 | Mains and automatic 12-volt working on mains failure. Battery kept charged |
| 20/30 watt Mixer/amplifier | M | T | 7.5 and 15Ω | 30 | 30+ | < 0.1 | < 0.15 | 20–20 (±1dB) | — | — | 50 (to 10V) | — | — | 25×20×11 | £35 | All f.e.t. inputs. With 100 volt line output £39 |
| **Welbrook Engineering Electronics Ltd., Brooks Street, Higher Hillgate, Stockport, Cheshire** | | | | | | | | | | | | | | | | |
| | S | T | 8 or 15 | 15 (8Ω) | 30 | 0.1 | < 0.1 | 30–20 (±1dB) | Variable up to 3mV | | 100 | Yes | No | 38×24×11 | £52 | Uncased model £4 less |
| **Whiteley Electrical Radio Co. Ltd., Radio Works, Victoria Street, Mansfield, Notts.** | | | | | | | | | | | | | | | | |
| Stereo 30 | S | T | 3 to 15 | 20 (8Ω) | 100 | 0.2 | < 0.1 | 20–> 20 | 10 | 100 | 200 | Yes | No | 20×26×15 | £63 15 6 | — |
| **Wye Electronics Ltd., Queen Street North, Whittington Moor, Chesterfield** | | | | | | | | | | | | | | | | |
| 500 | S | T | 4 | 10 | — | < 1.5 | 1.0 | 40–30 | — | 50 | 350 | Yes | No | 38×23×9 | £30 9 | — |

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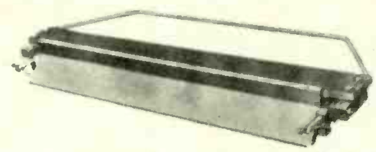

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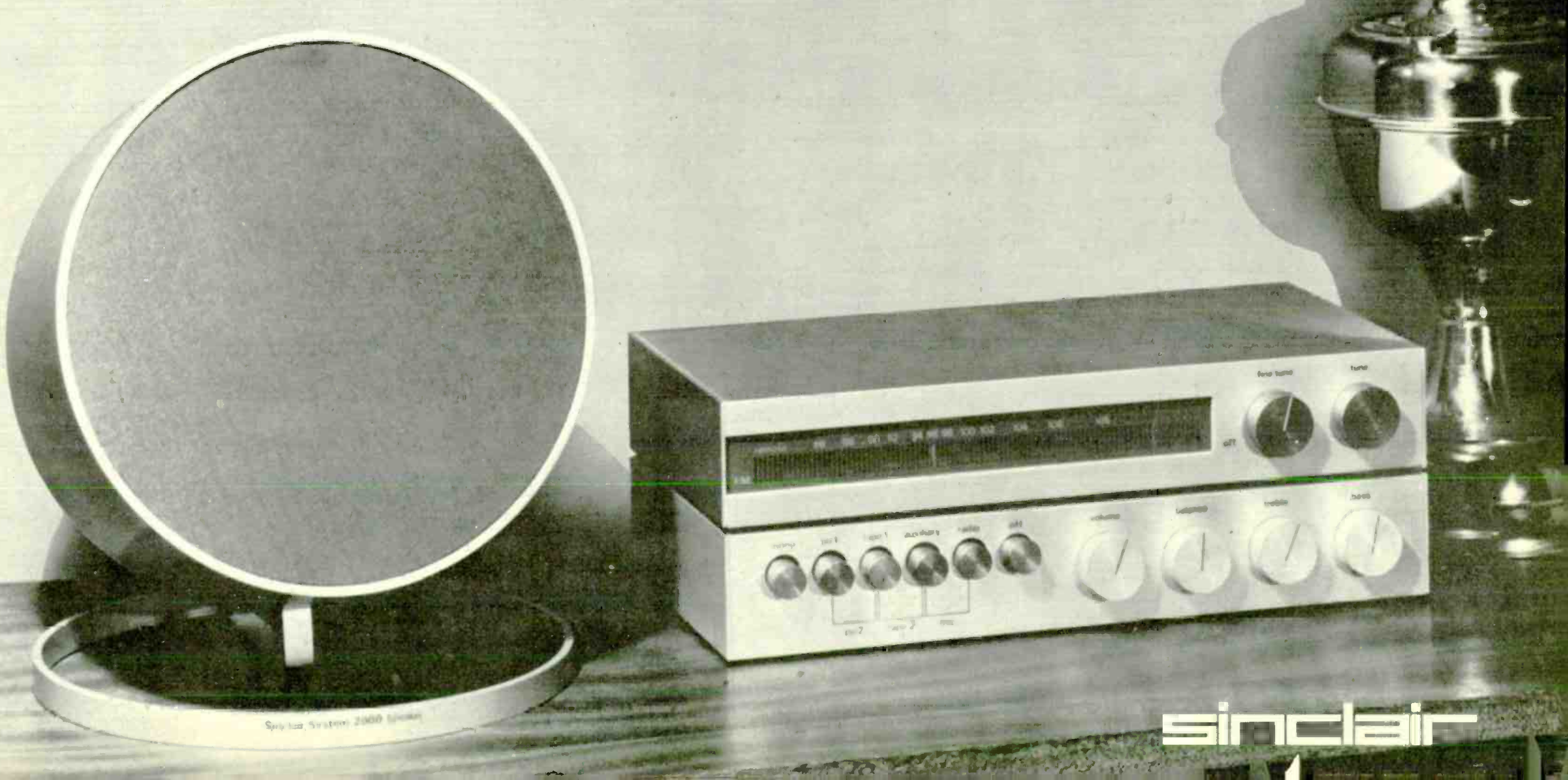




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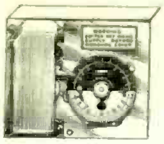
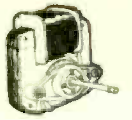


Made by Smiths these are AC mains operated, NOT CLOCKWORK ideal for mounting on rack or shelf or can be built into box with 13A socket. 2 completely adjustable time periods per 24 hours, 5A changeover contacts will switch circuit on or off during these periods. 59/6, post and ins. 4/6. Additional time contacts, 10/- pair.

## MAINS MOTOR



Precision made—as used in record decks and tape recorders—ideal also for extractor fans, blower, heater, etc. New and perfect. Snip at 9/6. Postage 3/- for first one then 1/- for each one ordered. 12 and over post free.

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Small but very powerful mains motor with 6½ in. blades. Ideal for cooling equipment or as extractor. Silent but very efficient. 17/6, post 4/6. Mounts from back or front with 4BA screws

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Made by the famous meter company Chamberlain and Hookham, these have a normal mains 200-240v motor which drives a rachet mechanism so geared to give one rachet action per minute on a wheel with 60 teeth thus a complete revolution of the cam takes place in one hour. The cam operates 4 switches (6 changeover and 2 on/off thus 480 circuit changes per hour are possible). Contacts, rated at 15 amps have been set for certain switch combinations but can, no doubt, be altered to suit a special job. Also other switch wafers or devices can be attached to the shaft which extends approximately one inch. 47/6 p. & ins. 4/6.

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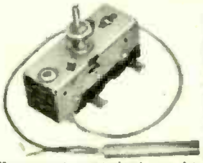
## THERMOSTAT WITH PROBE



This has a sensor attached to a 15A switch by a 14in. length of flexible capillary tubing—control range is 20deg.F. to 150deg.F. so it is suitable to control soil heating and liquid heating especially when in buckets or portable vessels as the sensor can be raised out and lowered into the vessel. This thermostat could also be used to sound a bell or other alarm when critical temp. is reached in stack or heap subject to spontaneous combustion or if liquid is being heated by gas or other means not controllable by the switch. Made by the famous Teddington Co., we offer these at 12/6 each.

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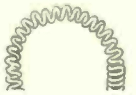

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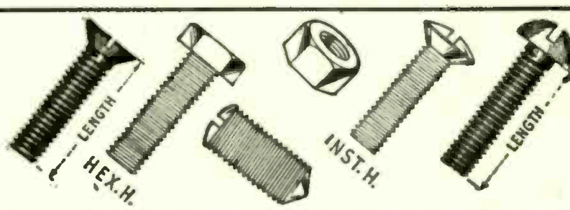


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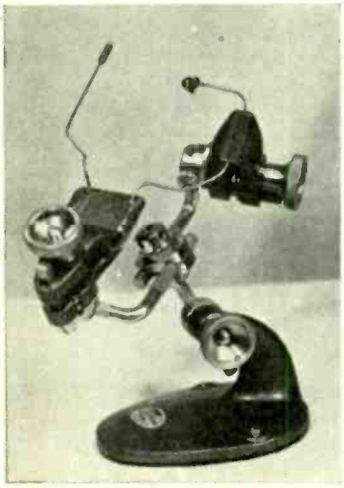
# Your third hand



The ONTOS UNIVERSAL VICE is a new type of multi-purpose, multi-position light engineering vice and stand, fully adjustable for any angle and location in any desired plane. Applications are virtually limitless within its size capacity; i.e. holding P.C. boards for assembly or testing, building up modules, as a micrometer or gauge stand, as a light general purpose vice, in the chemical laboratory, or in fact for all those occasions when you could use a third hand!
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**ONTOS: 67/6**
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**ONTOS TWIN**
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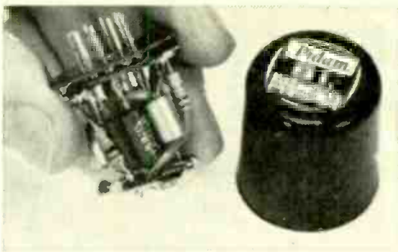

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6 NEW modules—send for free information.

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Prices range per module from 10/- to 28/- and all necessary accessories are supplied. A complete starting kit is only £21 19s. 0d. (normally £24 6s. 0d.).

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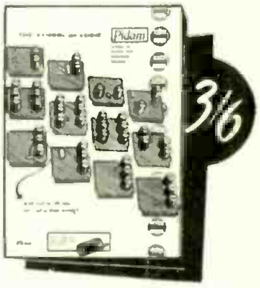
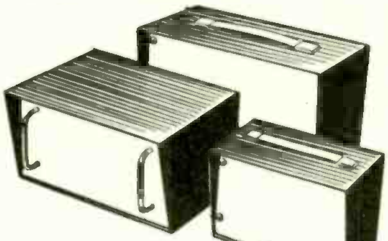
Send for this complete explanatory booklet showing detailed examples and circuit diagrams of all modules. Examples and circuits given include voice-operated switch, alarms, flashers, tachometer, timers, batch counters, etc.




# Contil Cases



Contil cases are mass-produced to give lowest prices yet. In 21-gauge steel. Finished hammer blue, with 18-gauge front panel supplied with easy-to-strip protective covering for easy marking out. For ease of ordering Contil cases are described by their dimensions, i.e. 755 is 7 × 5 × 5. Individually packed, including feet and screws.

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| *Nos. denote size in inches* | 1 | 5 | 10 | 25 | 50 | 100 | 200 |
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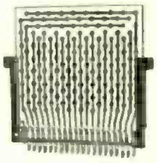
| 867/975 | 45/6 | 44/- | 43/6 | 41/6 | 40/6 | 38/6 | 37/- |
| 1277 white or black panel | 49/6 | 47/- | 46/- | 45/- | 43/6 | 43/- | 41/6 |
| 1277 unpainted | 40/6 | 39/6 | 38/6 | 36/- | 35/- | 32/6 | 31/6 |
| 1277 nylon-coated | 82/6 | 79/- | 77/6 | 76/- | 73/6 | 73/6 | 73/6 |
| 16127 | 96/6 | 94/6 | 92/6 | 91/6 | 89/6 | 88/- | 86/- |
| 16127S | 129/- | 127/- | 125/- | 124/- | 122/- | 119/- | 116/- |
| 191010 | 130/6 | 127/6 | 125/- | 123/- | 122/- | 121/- | 119/- |
| 191010D | 185/6 | 182/6 | 180/- | 178/- | 176/- | 173/6 | 173/6 |

Postage and packing extra

Kit of five cases £11 19s. 0d. including postage and packing extra, normally £14 12s. 0d.



"A" board shown plugged into "M" 20-way connector with "S" board supports.
*Note:* Power supply rails at right angles to signal rails. "A" boards 8/6 each. 20-way "M" connector 9/-. "S" support 3/- pair. Less for quantities.

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| | 1 | 10 | 50 |
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| Standard transistor board "A" | 9/9 | 9/- | 8/6 |
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| .2 Pitch, 18" × 4$\frac{3}{4}$" | 17/7 | 15/9 | 15/- |
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| .1 Pitch, 17" × 3$\frac{3}{4}$" | 16/5 | 14/9 | 14/- |

## ACCESSORIES

Flexible insulated test prods, colour red or black, at 13/- each with fine steel clips at the tip, opened by button on top. High speed resetting counter including bezel and socket with speed of over 40 operations per second 165/-. Plug in octal relay, 24 volts, with two changeovers 17/6.

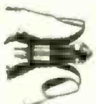
## REED SWITCH

The West Hyde reed switch works up to 2,000 operations per second with a life of up to 50,000,000,000 operations when used in the recommended circuit. The hermetically sealed switch is protected in a brass tube and moulded into a polypropylene block giving accurate placing of the contents in relation to the mounting screws. 30" nominal leads fitted. Used for Rev. Counters, flowmeters, burglar alarms, under and over speed monitors, etc. 1 at 14/-, 10 at 10/6 each, 100 at 9/- each.

## 'Brightlife' NEONS

25,000 hour average life. PC type $\frac{1}{4}$" diameter, 6" leads with resistor inside. Nine different caps available, 160–260 V, 10 at 2/10 each, 100 at 2/6 each, 1,000 at 2/2 each, 10,000 at 2/- each. Also available with 30" leads; 110 volt resistor values. PP type $\frac{1}{4}$" diameter also supplied with 30" leads and 110 volt variants. 10 at 2/10 each, 100 at 2/6 each, 10,000 at 2/2 each, 10,000 at 2/- each. Neon/resistor assemblies, 100 at 9d. each, 10,000 at 8d. each. Neons only, 100 at 9d. each, 10,000 at 6d. each. Neons driven by neon oscillator for 6 to 24 volt input down to 50 mW input. Neons driven by transistors with or without alphanumeric caps.

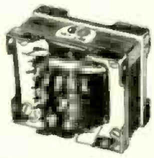
## SUB-MINIATURE NEONS



The smallest yet, type "Q". Overall diameter $\frac{1}{16}$", body .7", resistor mounted externally, medium intensity. Minimum quantity 10 at 3/10 each, 100 at 3/4 each, 500 at 3/2 each.

## TRANSFORMERS

West Hyde have three transformers for transistorised equipment. TRA which provides low voltages at 2 Amps. and high voltages at ·1 Amp. for driving neons or number tubes. TRB which provides 2 Amps. and TRC, a 1 Amp. transformer. The low voltages on TRA, TRB are 6, 10, 15, 18, 30 which can of course be connected to give 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 24 and 30 with 12-0-12 and 15-0-15.



The 1 Amp. transformer gives 6, 10, 18 voltage outputs. The TRA also gives 150-80-0-80-150. TRA at 57/6 each. TRB at 47/- each TRC at 35/6 each.

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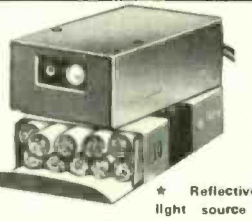

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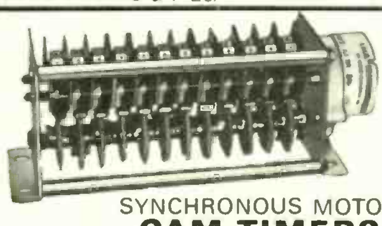

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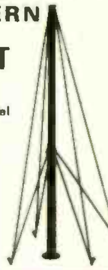

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Listen to the thrills of Aircraft, Pilots, and Airports at work. Also Civil Depts., Fire and Ambulance services. Gas and Electricity Depts. Ideal for receiving 2 metre amateurs. Gives super reception within the range of all transmissions. A fully transistorised receiver covering 97-150mc/s VHF broadcast. Robust attractive finished metal cabinet size approx. 7 × 4 × 4ins. Operates from a 9 volt internal battery. Speaker or earphone output. Simple to use. Available from us at the pre-devaluation price of £8.19.6, carriage and insurance 10/6. CWO or COD.

**SMOOTHING UNITS**
**"CURE YOUR HUM PROBLEMS"**
Beautifully made pieces of equipment. 12 volts or 24 volts d.c. input gives a fully smoothed fully regulated d.c. output. Worth £30 each. Robust metal cabinet with provision for standby battery. Brand new in maker's cartons. Price 65/-, p. & p. 15/-.

**RECTIFIER SALE**
6/12 volt full wave bridged, 4 amps. Brand new manufacturers surplus, only 4/6 each, p. & p. 1/6. Two for 10/-, post free. Four for 15/-, post free. £2 per dozen, post free.

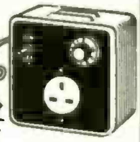

**BATTERY ELIMINATORS AND STABILISED POWER PACKS**

The most economical method of running transistorised equipment from A.C. mains. Power radios, record players, etc. Mark 1 model: replaces all 9 volt batteries. Price only 35/-, p. & p. 5/-. Mark 2 model: output 6, 7½ and 9 V. STABILISED, making it ideal for running Hi-Fi and test gear and cassette type tape recorders. Price only 85/-, p. & p. 5/-.

**RUN YOUR 19 SET TX/RX FROM AC MAINS.** We manufacture a brand new unit ready to operate all 19 set Trans/Rec. direct from the mains. Complete ready to plug in with full connecting instructions. Contained in an attractive steel cabinet. Price £6.10.0. carr. & insur. 10/-. Receiver version only, £4.10.0. carr. & insur. 5/-.

Tannoy Mikes. As new, 9/6 each, p. & p. 3/6. (Heavy duty, ideal for P.A. work.)

**HEAT LIGHT SPEED CONTROL Unit**



An electronic unit capable of controlling electrical equipment up to 3000 WATTS. Full fingertip control of all AC & Universal apparatus. Gives full wave control from zero to full power. Suitable for the control of electric motors of up to 2 hp. Suitable for controlling all types of lighting. Makes an ideal dimmer unit with no loss of power. Will control up to 3 K.W. Heaters. Ideal for fine control of Lathes, Power Tools, Conveyor belts, pumps etc. Contained in a robust metal cabinet, attractively designed, with matching control panel. Size approx. 6 × 5 × 2in. New design makes possible full wave control. Not to be confused with earlier half wave thyristor units. Now employs the latest electronic techniques. Ideal for all industrial applications. Price £9.19.6. Carriage and Insurance 10/-.

**MINIATURE MOVING COIL SPEAKERS**
1½in. diameter. Only 3/6 each, p. & p. 1/6. Two for 8/6 post free. Four for 15/- post free.

**THE LATEST SOLID STATE STABILISED CURRENT LIMITED BENCH P.S.U. Type C/F/HC/11.** Latest circuit design. Zenner reference. Almost no overloading as remarkable transients are employed. 0.5 to 50 volts D.C. Continuous variability of voltage and current settings up to 1 amp. Panel meter displays output voltage or current. Excellently stabilised against load/line variations. Independent on/off switching of mains input and D.C. output. Unparalleled design gives superb performance in a laboratory power supply. Attractive functional case. Due to an excessive demand there is a delay of up to 1 month with this model. Price 29½ gns. Carr. and insur. 15/6. Kindly place your orders as quickly as possible to avoid delay. 2 years guarantee.

**TOP BAND SPECIAL**

These excellent radios were made for Government to high standard spec. Octal valve line-up. Freq. Coverage brings in Top Band Amateurs, Marine Stations, Airports, etc., etc. Slow motion tuning. Built in PSU for 6 volt operation, simply modified for mains. Robust cabinet with high-quality speaker. As new, few only, price £4.19.6. Carr. and insur. 10/6.

**GLOBE SCIENTIFIC LTD**
[illegible] YARD,
MILL STREET, MARSH LANE, LEEDS 9.



# BUILD YOURSELF A QUALITY TRANSISTOR RADIO !

**"NEW LOOK" MELODY SIX MED. AND LONG WAVES. WITH SPEAKER AND EARPIECE.** 6 transistors and 2 diodes. Push-pull output, tuning condenser, high "Q" ferrite rod aerial. 3½in. speaker, and personal earpiece for private listening. 6½ × 4 × 2in. Building Costs 69/6. P. & P. 4/3. Plans and Parts list 2/- (free with parts).

**ROAMER SIX. 6 WAVEBANDS —MW1, MW2, SW1, SW2, LW AND TRAWLER BAND.** 6 transistors and 2 diodes. Ferrite rod and telescopic aerials, speaker. Size 7¼ × 5¼ × 1½in. Building Costs 79/6 P. & P. 4/6. Plans and Parts list 2/- (free with parts). Carrying Strap 1/6 extra.

**POCKET FIVE. MED. AND LONG WAVES & TRAWLER BAND** to approx. 50 metres **WITH SPEAKER AND EARPIECE.** 5 transistors and 2 diodes, ferrite rod aerial, tuning condenser, moving coil speaker, etc. 5¼ × 1¼ × 3½in. Total Building Costs 44/6. P. & P. 3/6. Plans and Parts list 1/6 (free with parts).

**SUPER SEVEN MED. LONG AND TRAWLER BAND.** 7 transistors and 2 diodes. 3in. speaker. 2 R.F. stages push-pull output, etc. 7¼ × 5¼ × 1½in. Total Building Costs 59/6. P. & P. 4/6. Plans and Parts list 2/- (free with parts). Personal Earpiece with switched socket for private listening. 5/- extra.

**TRANSONA FIVE MED. AND LONG AND TRAWLER BAND** to approx. 50 metres **WITH SPEAKER AND EARPIECE.** 5 transistors and 2 diodes. Ferrite rod aerial, moving coil speaker. 6½ × 4½ × 1½in. Total Building Costs 47/6. P. & P. 3/9. Plans and Parts list 1/6 (free with parts).

**ROAMER SEVEN Mk 4. 7 WAVE-BANDS—MW1, MW2, LW, SW1, SW2, SW3, AND TRAWLER BAND.** 7 transistors and 2 diodes. Ferrite rod aerial and telescopic aerial. Socket for car aerial. 7 × 4in. speaker. Airspaced ganged tuning condenser etc. Size 9 × 7 × 4in. Total Building Costs £5/19/6. P. & P. 7/6. Personal earpiece with switched socket for private listening 5/- extra. Plans and Parts list 3/- (free with parts).

**RADIO EXCHANGE CO. LTD. Dept WW. 61 High Street, Bedford. 'Phone 0234 52367**

● Open 10-1, 2.30-4.30, Sat. 9-12.30


www.americanradiohistory.com

# R.S.C. SENSATIONAL HIGH FIDELITY STEREO PACKAGE OFFERS

Matching as recommended for optimum performance. Compare prices with equipment and cabinets purchased individually.

## 'Package 3' 30 Watt Output

★ Goldring Transcription Turntable on Plinth.
★ Shure Magnetic Pick-up Cartridge.
★ Super 30 Amplifier in veneered housing.
★ Pair of Stanton Loudspeaker Units.

Special total price. Four fully wired units ready to "plug-in". Really superb performance. **86 Gns.** Send S.A.E. for leaflet. Carr. 25/-

Illustrated with TFM1 Tuner fitted.

## 'Package 2' 30 Watt Output

★ Garrard SP25 Mk. II Turntable on Plinth.
★ Goldring CS90 Ceramic P.U. Cartridge.
★ Super 30 Amplifier in veneered housing.
★ Pair of Stanton Loudspeaker Units.

Special total price. Four fully wired units ready to "plug-in." **76 Gns.** Carr. 25/-

**Extremely Attractive and Versatile Plinths** finished in Teak or Afrormosia veneer. Tinted Perspex "roll over" cover with satin chrome handle.

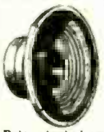
## 'Package 1' 13 Watt Output

★ Garrard SP25 Mk. II 4-speed Player Unit, on plinth.
★ Goldring CS90 Ceramic P.U. Cartridge.
★ TA12 Amplifier in veneered housing.
★ Pair of Dorchester Loudspeaker Units.

Special total price. Perspex cover 3 gns extra. Or Dep. £10 and 9 monthly payments £5.11.0 (Total £59.19.0) **51 Gns.** Carr. 25/-

**BLACKPOOL** AGENT APPOINTED See addresses

## AUDIOTRINE HIGH FIDELITY LOUDSPEAKERS

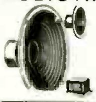


Heavy construction. Latest high efficiency ceramic magnets. Treated Cone surround giving low fundamental resonance. "D" indicates Tweeter Cone providing extended frequency range 40-15,000 c.p.s. Exceptional performance at low cost. Impedance 3 or 15 ohms.

Prices include carriage. PLEASE STATE IMPEDANCE

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| HF 510L | 5" | 10W | 57/9 | HF 120 | 12" | 15W | 69/9 |
| HF 801D | 8" | 8W | 58/9 | HF 120D | 12" | 15W | 79/9 |
| HF 811D | 8" | 10W | £4/4/0 | HF 126 | 12" | 15W | 89/9 |
| HF 102D | 10" | 8W | 59/9 | | | | |
| HF 100D | 10" | 15W | £5/15/0 | HF 126D | 12" | 15W | 5 Gns. |

## AUDIOTRINE HI-FI SPEAKER SYSTEMS



Consisting of matched 12in. 12,000 line 10 watt 15 ohm high quality speaker, cross-over unit and tweeter. Smooth response and extended frequency range ensure surprisingly realistic reproduction. **5 Gns.** Carr. 5/9

Or Senior 15 watt inc. HF 126 15,000 line Speaker 6 Gns. Carr. 6/6.

## HI-FI 'SPEAKER ENCLOSURES

Teak or Afrormosia veneer finish. Modern design. Acoustically lined and ported. Prices inc. carr.

JE8 Size 16 × 11 × 9in. Pressurised. Gives pleasing results with any 8in. Hi-Fi speaker. **4 Gns.**

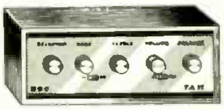
SE8 For optimum performance with any 8in. Hi-Fi 'speaker. Size 22 × 15 × 9in. **5 Gns.**

SE10 For outstanding results with 10in. Hi-Fi speaker. Size 24 × 15 × 10in. **£5.10**

SE12 For high performance with 12in. Hi-Fi speaker and Tweeter. Size 25 × 16 × 10½in. Pressurised. **6 Gns.**

## R·S·C·TA12 13 WATT STEREO AMPLIFIER

FULLY TRANSISTORISED, SOLID STATE CONSTRUCTION HIGH FIDELITY OUTPUT OF 6.5 WATTS PER CHANNEL



Designed for optimum performance with any crystal or ceramic Gram P.U. cartridge, Radio tuner, Tape recorder, 'Mike' etc. ★ 3 separate switched input sockets on each channel ★ Separate Bass and Treble controls ★ Slide Switch for mono use ★ Speaker Output 3-15 ohms ★ For 200-250 v. A.C. mains ★ Frequency Response 30-20,000 c.p.s. —2dB ★ Harmonic Distortion 0.3% at 1000 c.p.s. Hum and Noise —70dB ★ Sensitivities (1) 300 mV (2) 50 mV (3) 100 mV (4) 2 mV ★ Handsome brushed silver finish Facia and Knobs. Output rating I.H.F.M. Complete kit of parts with full wiring diagrams and instructions. 12½ GNS. Carr. 7/9. Factory built with 12 mth. gntee. 16 GNS. Or Dep. £5/2/6 and 9 mthly pymts. 31/6 (Total £19/6/0). Or in Teak or Afrormosia veneer housing 19½ GNS. or Dep. £5/10/6 and 9 mthly. pymts. 39/- (Total £23/1/6.)

## HIGH FIDELITY LOUDSPEAKER UNITS

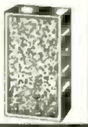
Cabinets of latest styling Satin Teak or Afrormosia veneer. Acoustically lined or filled with woollen damping material. Ported where appropriate. Credit terms available.

**DORCHESTER** Size 16 × 11 × 9in. Appr. Range 45-15,000 c.p.s. Rating 8-10 watts. Fitted High flux 13 × 8in. Dual cone speaker. Impedance 3 or 15 ohms. **£8.19.9** Carr. 7/6

**STANTON IIIS** Size 18 × 11 × 10in. Rating 10 watts. Incorporating Fane 803b speaker with roll rubber cone surround and 15,000 line magnet. High flux tweeter. Handsome Scandinavian design cabinet. Range 30-20,000 c.p.s. Impedance 15Ω. Gives smooth realistic sound output. **16 Gns.**

**GLOUCESTER** Size 25 × 16 × 10in. 12in. High flux 12,000 line speaker. Cross-over unit and Tweeter. Rating 10 watts. Frequency range 40-20,000 c.p.s. Impedance 15 ohms. **12½ Gns.**

## THE 'YORK' HIGH FIDELITY 3 'SPEAKER SYSTEM



• Moderate size approx. 25 × 14 × 10 in. • Range 30-20,000 c.p.s. Impedance 15 ohms. • Performance comparable with units costing considerably more. Consists of (1) 12 in. 15 watt Bass unit with cast chassis. Roll rubber cone surround for ultra low resonance, and ceramic magnet. (2) 3-way quarter section series cross-over system. (3) 8 × 5in. high flux middle range speaker (4) High efficiency tweeter. (5) Measured weight of woollen acoustic damping material. (6) Teak veneered cabinet. (7) Circuit and full instructions. HEAR IT AT ANY BRANCH. Complete kit. **19 Gns.**

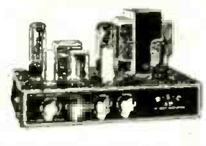
## R.S.C. BATTERY/MAINS CONVERSION UNITS

Type BM1. An all-dry battery eliminator. Size 5½ × 4½ × 2in. approx. Completely replaces batteries supplying 1.5 v. and 90 v. where A.C. mains 200/250 v. 50 c/s. is available. Complete kit with diagram 49/11 or Ready for use 59/11.

**SELENIUM RECTIFIERS**

F.W. Bridged 6/12v. D.C. O/P Input Max. 18v. A.C. 1a.. 3/11. 2a.. 6/11; 3a.. 9/9; 4a.. 12/9; 6a.. 15/9.

## R.S.C. A10 30 WATT ULTRA LINEAR HI-FI AMPLIFIER



Highly sensitive. Push-Pull high output, with Pre-amp./Tone Control Stages. Performance figures: Hum level —70dB. Frequency response ±3dB 30-20,000c/s. Sectionally wound output transformer. All high grade components. Valves EF86, EF86, ECC83, 807, 807, GZ34. Separate Bass and Treble Controls. Sensitivity 36 millivolts. Suitable for High Impedance mic. or pick-ups. Designed for Clubs, Schools, Theatres, Dance Halls or Outdoor Functions, etc. For use with Electronic Organ, Guitar, String Bass, etc. Gram, Radio or Tape. Reserve L.T. and H.T. for Radio Tuner. Two inputs with associated volume controls so that two separate inputs such as Gram and "Mike" can be mixed. 200-250 v., 50 c/s. A.C. mains. For 3 and 15 ohm speakers. Complete Kit parts wiring diags., instructions. Twin-handled perforated cover 27/6. Or factory built with EL34 output valves and 12 months' guarantee for 17 gns. Tech. figs. apply to factory built units. Carr. 12/6 **14 Gns.**
TERMS: Deposit £6 and 9 monthly payments of 32/- (Total £20/8/0. Send S.A.E. for leaflet.

## R.S.C. MAINS TRANSFORMERS

FULLY GUARANTEED. Interleaved and Impregnated. Primaries 200-250 v. 50 c/s. Screened

MIDGET CLAMPED TYPE 2½ × 2½ × 2½in.
250 v., 60 mA, 6.3 v. 2 a. .... 15/11
250-0-250v., 60mA. 6.3v. 2a. .... 16/11

FULLY SHROUDED UPRIGHT MOUNTING
250-0-250v. 60mA., 6.3v. 2a., 0-5-6.3v. 2a. .. 21/9
250-0-250v. 100mA. 6.3v. 4a., 0-5-6.3v. 3a. .. 37/9
300-0-300v. 100mA. 6.3v. 4a., 0-5-6.3v. 3a. .. 37/9
300-0-300v. 130mA. 6.3v. 4a., c.t., 6.3v. 1a.
For Mullard 510 Amplifier .... 45/9
350-0-350v. 100mA., 6.3v. 4a., 0-5-6.3v. 3a. .. 37/9
350-0-350v. 150mA. 6.3v. 4a., 0-5-6.3v. 3a. .. 47/9
425-0-425v. 200mA. 6.3v. 4a. c.t., 5v. 3a .... 69/9
425-0-425v. 200mA. 6.3v. 4a., 6.3v. 3a. 5v. 3a 75/-
450-0-450v. 250mA. 6.3v. 4a., ct., 5v. 3a. .... 87/9

TOP SHROUDED DROP-THROUGH TYPE
250-0-250v. 70mA. 6.3v. 2a., 0-5-6.3v. 2a. .... 21/9
250-0-250v. 100mA. 6.3v. 3.5a. .... 25/9
250-0-250v. 100mA. 6.3v. 2a.. 6.3v. 1a. .... 26/9
350-0-350v. 80mA. 6.3v. 2a., 0-5-6.3v. 2a .... 27/9
250-0-250v. 100mA. 6.3v. 4a., 0-5-6.3v. 3a. 37/9
300-0-300v. 100mA. 6.3v. 4a., 0-5-6.3v. 3a. 37/9
300-0-300v. 130mA. 6.3v. 4a., 0-5-6.3v. 1a.
Suitable for Mullard 510 Amplifier .... 44/9
350-0-350v. 100mA., 6.3v. 4a., 0-5-6.3v. 3a. 37/9
350-0-350v. 150mA., 6.3v. 4a., 0-5-6.3v. 3a. 45/11

FILAMENT or TRANSISTOR POWER PACK Types 6.3 v.1.5a. 7/9; 6.3v. 2a. 8/9; 6.3v. 3a. 10/9; 6.3v. 6a. 21/9; 12v. 1a. 8/9; 12v. 3a. or 24v. 1.5a. 21/9; 0-9-18v. 1½a. 17/9; 0-12-25-42v. 2a. 29/9.

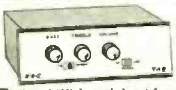
CHARGER TRANSFORMERS 0-9-15v. 1½a. 14/11; 2½a. 17/9; 3a. 19/11; 5a 23/9; 6a. 27/9; 8a 33/9.

AUTO (Step UP/Step DOWN) TRANSFORMERS
0-110/120v.-200-230-250v. 50-80 watts .... 15/9
150 watts, 29/11; 250 watts 49/9; 500 watts 99/9

OUTPUT TRANSFORMERS
Standard Pentode 5,000Ω or 7,000Ω to 3Ω 8/9
Push-Pull 8 watts EL84 to 3Ω or 15Ω 12/9
Push-Pull 10 watts 6V6 ECL86 to 3, 5, 8 or 15Ω 22/9
Push-Pull EL84 to 3 or 15Ω 10-12 watts .... 21/9
Push-Pull Ultra Linear for Mullard 510, etc. 39/9
Push-Pull 15-18 watts, sectionally wound 6L6 KT66, etc., for 3 or 15Ω .... 35/9
Push-Pull 20 watt high quality sectionally wound EL34, 6L6, KT66, etc. to 3 or 15Ω 59/9

SMOOTHING CHOKES
150mA. 7-10H, 250Ω 12/9; 100mA. 10H, 200Ω 10/9; 80mA. 10H, 350Ω. 8/9; 60mA. 10H, 400Ω 4/11.

## R.S.C. TA6 6 Watt HIGH FIDELITY SOLID STATE AMPLIFIER



200-250v. A.C. mains operated Frequency Response 30-20,000 c.p.s. —2dB. Harmonic Distortion 0.3% at 1,000 c.p.s. Separate Bass and Treble 'lift' and 'cut' controls. 3 input sockets for Mike, Gram, Radio or Tape. Input selector switch. Output for 3-15 ohm speakers. Max. sensitivity 5mV. Output rating I.H.F.M. In fully enclosed enamelled case, 9½ × 2½ × 5½in. Attractive brushed silver finish facia plate 10½ × 3½in. and matching knobs. Complete kit of parts with full wiring diagrams and instructions. Carr. 7/6. Or factory built with 12 months' guarantee. £8. 19. 9 **£6.19.9**

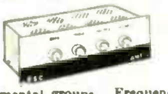
## INTEREST CHARGES REFUNDED

On Credit Sales settled in 3 months.

## R.S.C. COLUMN SPEAKERS

Covered in two-tone Rexine/Vynair. Ideal for vocalists and Public Address. 15 ohm matching. Type C57 15 watts inc. five 7 × 4in. spkrs. £7/19/11. Type C48S, 30 watts. Fitted four 8in. high flux 8 watt speakers. Overall size approx. 42 × 10 × 5in. 16 Gns. Or deposit 67/- and 9 mthly pmts. 34/9 (Total £18/19/9). Carr. 10/-.
Type C412s. 50 watts. Fitted four 12in. 11,000 lines 15 watt speakers. Overall size 56 × 14 × 9in. approx. 24 Gns. Or Deposit £4/13/6 and 9 monthly payments of 52/6 (Total £28/5/-). Carr. 15/-

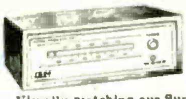
## R.S.C. A11T 15 WATT HIGH FIDELITY AMPLIFIER



DUAL PURPOSE P.A. or HI-FI SOLID STATE CIRCUITRY. ★ 3 input sockets. ★ 2 vol. controls for mixing purposes. ★ Input Selector. ★ Output for speakers between 3 and 15 ohms. ★ Separate Bass and Treble Controls. Suitable for Gram, Radio, Tape, Microphone, or Guitar P.U. For Vocal and Instrumental groups. Frequency Response 20-40,000 c.p.s.—3dB. Hum level —80dB. Harmonic Distortion 0.2% at 10 watts R.M.S. Operation on 200-250v. A.C. mains. Output rating I.H.F.M. Size 9½ × 2½ × 5½in. Complete Kit of parts with comprehensive wiring diagrams and instructions **9 Gns.** Carr. 9/6
Or Factory built with 12 mths. guarantee 13 gns. Carr. 9/6. Terms: Deposit £4/13/6 and 9 monthly payments 25/6 (Total £16/3/0).

## R.S.C. TFM1 SOLID STATE VHF/FM RADIO TUNER

Total cost of parts with detailed wiring diagrams & instructions. Inc. Carr. **14 Gns.** Or factory built 16½ gns. Or in Teak finished cabinet as illustrated 19½ gns. Terms: Deposit £5 and 9 monthly payments £2. Total £23.



★ High-sensitivity ★ 200-250v. A.C. Mains operation. ★ Sharp A.M. Rejection. ★ Drift-free reception. ★ Output ample for any amplifier (approx. 500 m.v.). ★ Simple alignment instructions. ★ Output available for feeding tuning meter. ★ Output for feeding Stereo Multiplexer. ★ Tuner head using silicon Planar Transistors. ★ Designed for standard 80 ohm co-axial input. Visually matching our Super 15 and 30 amplifiers and of the same high standard of performance and reliability. The pre-wired tuning head facilitates speed and simplicity of construction. Printed circuitry. Only high grade transistors and components used. A quality product at considerably less than the cost of comparable units. Stereo version. All parts 20 gns. Inc. Carr. Assembled 22½ gns. Inc. Carr.

## 12in. High Quality LOUDSPEAKERS

In teak veneered cabinets. 15 Watt Model. Gauss 11,000 lines, 3 or 15 ohms. **£5/15/-** Carr. 7/6
20 Watt Model. 15 ohm. Size 18 × 18 × 10in. Gauss 10,000 lines. Rexine covered 10/- extra. **£8/19/9** Carr. 8/9

## TWO-WAY 'PHONE AMPLIFIER

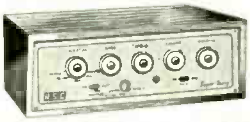
Listen and speak with both hands free. Handsome black case. Battery operated. **59/9**

## R.S.C. SUPER 15 HI-FI AMPLIFIER

SOLID STATE

FULLY TRANSISTORISED 200/250v. A.C. Mains.
OUTPUT 10 WATTS R.M.S. continuous into 15 ohms.
15 WATTS R.M.S. continuous into 3-4 ohms.
TRANSISTORS. 9 current types of high quality by leading manufacturers.
5 POSITION INPUT SELECTOR SWITCH EQUALISATION to Standard R.I.A.A. and C.C.I R. Characteristics for Gram and Tape Heads.
FULL TAPE MONITORING FACILITIES
SENSITIVITIES: Magnetic P.U. 4 mV. Crystal or Ceramic P.U. 400 mV. Microphone 4.5 mV. Tape Head 2.5 mV. Radio/Aux. or Ceramic P.U. 110 mV.
FREQUENCY RESPONSE: ±2 dB 20-20,000 c.p.s.
TREBLE CONTROL: +15dB to —14dB at 10 Kc/s. NEG. FEEDBACK: 52dB.
BASS CONTROL: +17dB to —15dB at 50 c/s. HUM LEVEL: —75dB.
HARMONIC DISTORTION at 10 watts 1,000 c.p.s. 0.2%
Complete Kit of parts with full constructional details and point to point wiring diagrams. Carr. 12/6. **12½ Gns.**
Supplied factory built. 15½ Gns. Carr. 12/6. Terms: Deposit 4 Gns. and 9 monthly payments 31/1 (Total £18/3/9). Or in Teak or Afrormosia veneer housing as ill. 19 Gns.
COMPONENTS ETC. ARE OF A HIGH STANDAR DAND SUPPLIED BY LEADING MANUFACTURERS.

SPECIFICATIONS COMPARABLE WITH UNITS COSTING CONSIDERABLY MORE



## R.S.C.SUPER 30 STEREO AMPLIFIER

A DUAL CHANNEL VERSION OF THE SUPER 15. Employing Twin Printed Circuits. High quality Ganged Pots. Matched Components. CROSS TALK:—52dB at 1,000 c.p.s.
CONTROL: 5 position Input Selector, Bass Control. Treble Control. Volume Control. Balance Control. Stereo/Mono Switch. Tape Monitor Switch. Mains Switch. INPUT SOCKETS (Matched Pairs). (1) Magnetic P.U. (2) Ceramic or Crystal P.U. (3) Radio/Aux. (4) Tape Head/Microphone. Operation of the Input Selector Switch assures appropriate equalisation. Rigid 18 s.w.g. Chassis. Size approx. 12in. wide, 3in. high and 8in. deep. Neon Panel indicator. Attractive Facia Plate and Spun Silver Matching Knobs. Above facilities, etc., except for Ganging and Balance control, apply also to Super 15.

THESE UNITS ARE EMINENTLY SUITABLE FOR USE WITH ANY MAKE OF PICK-UP OR MICROPHONE (Crystal, Ceramic, Magnetic, Moving Coil, Ribbon) CURRENTLY AVAILABLE. SUPERB SOUND OUTPUT QUALITY CAN BE OBTAINED BY USING WITH FIRST RATE ANCILLARY EQUIPMENT. All required parts, point to point wiring diagrams and detailed instructions. Carr. 15/- **21 Gns.**
Unit factory built 28 Gns. or deposit £7/5/- and 9 monthly payments 56/3. (Total £32/13/3). Or in Teak or Afrormosia Veneered housing. 31 Gns. Carr. 15/- or Deposit £7/3/6 and 9 monthly paymts., 64/- (Total £35/19/6). *Send S.A.E. for leaflet*

## Record Playing Units

MONEY SAVING UNITS
Ready to plug into Amplifier

**RP2** Consisting of Garrard SP25 Mk. II (with heavy turntable) fitted Goldring CS90 high compliance ceramic Stereo/Mono cartridge with diamond stylus. Mounted on plinth. Perspex Cover included. Carr. 15/-. **22 Gns.**

**RP3** As above but with Goldring Lenco GL68 Transcription unit and CS90 Cartridge. Cover included. Carr. 21/-. ONLY **£28**

**Various other types** with Magnetic P.U. Cartridges and 'Lift off' or 'Roll over' transparent covers at lowest prices.

## R.S.C. PLINTHS

for Record Playing units. Teak finish cut for Garrard 1000, 2000, 3000, AT6, AT60, SP25 etc. etc. **59/9**

Available with clear Perspex cover as illustrated. Inc. carr. **6 Gns.**

Perspex cover sold separately at 3 Gns. Limited number of covers slightly damaged but repaired by Manufacturer. 39/9 to clear.

**BRADFORD** 10 North Parade (Half-day Wed.). Tel. 25349
**BLACKPOOL** (Agent) O & C Electronics 227 Church St.
**BIRMINGHAM** 30/31 Gt. Western Arcade, opp. Snow Hill Station 021-236 1279. Half-day Wed.
**DERBY** 26 Osmaston Rd. The Spot (Half-day Wed.). Tel. 41361
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**EDINBURGH** 133 Leith St. (Half-day Wed.). Tel. Waverley 5766
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**R·S·C HI-FI CENTRES LTD.**

MAIL ORDERS to: 102-106 Henconner Lane, Bramley, Leeds 13. No C.O.D. under £1. Terms C.W.O. or C.O.D. Postage 4/6 extra under £2. 5/9 extra under £5. Trade supplied S.A.E. with enquiries please. Open all day Sats. Mail orders MUST NOT be sent to shops.

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**LIVERPOOL** 73 Dale St. (Half-day Wed.). Tel. CENtral 3573
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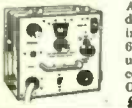
## RACAL RA-17

**First ministry release of these world famous communication receivers. Frequency range 500 Kc/s.-30 Mc/s. Available in excellent condition fully tested and guaranteed. £150** Carr. 40/-.

### CLASS D. WAVEMETERS

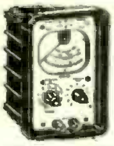


A crystal controlled heterodyne frequency meter covering 1.7-8 Mc/s. Operation on 6 v. D.C. Ideal for amateur use. Available in good used condition £5.19.6 Carr. 7/6. Or brand new with accessories £7.19.6 Carr. 7/6.

### CLASS D WAVEMETERS No. 2

Crystal controlled. 1.2-19 Mc/s. Mains or 12v. D.C. operation. Complete with calibration charts. Excellent condition £12/10/0. Carr. 30/-.

### MARCONI CT44 TF956 AF ABSORPTION WATTMETER

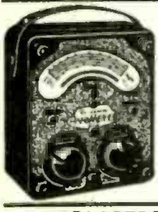


1 u/watt to 6 watts. £20. Carr. 20/-.

### LELAND MODEL 27 BEAT FREQUENCY OSCILLATORS

0-20 Kc/s. Output 5K or 500 ohms. 200/250 v. A.C. Offered in excellent condition. £12/10/-. Carriage 10/-.

### AVOMETERS



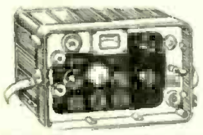
Supplied in excellent condition fully tested and checked. Complete with prods, leads and instructions.

Model 47A £9/19/6 P. & P. 7/6.

### SOLARTRON CD. 1016. OSCILLOSCOPE

Double beam. D.C. To 5 Mc/s. Excellent condition. £55 each. Carr. 20/-.

### AM/FM SIGNAL GENERATORS



Oscillator Test No. 2. A high quality precision instrument made for the Ministry by Airmec. Frequency coverage 20-80 Mc/s. AM/CW/FM. Incorporates precision dial, level meter, precision attenuator 1µV-100Mv. Operation from 12 volt D.C. or 0/110/200/250 v A.C. Size 12 x 8½ x 9in. Supplied in brand new condition complete with all connectors, fully tested. £45. Carr. 20/-.

### GEARED MAINS MOTORS

Parvalux type 8D19 230/250 v. A.C. Reversible. 30 r.p.m. 40 lb. ins. Complete with capacitor. Excellent condition. 99/6. Carr. 10/-.

### AMERICAN RECORDING TAPES

First grade quality American tapes. Brand new and guaranteed. Discounts for quantities. Postage 2/-. Over £3 post paid.

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| 3in. 225ft. L.P. Acetate | 3/6 |
| 3¼in. 600ft. T.P. Mylar | 10/- |
| 5in. 600ft. Std. plastic | 8/6 |
| 6in. 900ft. L.P. acetate | 10/- |
| 5in. 1,200ft. D.P. Mylar | 15/- |
| 5¾in. 1,200ft. L.P. acetate | 12/6 |
| 5¾in. 1,200ft. L.P. Mylar | 16/- |
| 5¾in. 1,800ft. D.P. Mylar | 22/6 |
| 5¾in. 2,400ft. T.P. Mylar | 39/6 |
| 7in. 1,200ft. Std. acetate | 12/6 |
| 7in. 1,800ft. L.P. acetate | 15/- |
| 7in. 1,800ft. L.P. Mylar | 20/- |
| 7in. 2,400ft. D.P. Mylar | 25/- |
| 7in. 3,600 ft. T.P. Mylar | 45/- |

### SINCLAIR EQUIPMENT

Z12. 12 watt amplifier 89/6.
PZ4. Power supply Unit 89/6.
STEREO 25. Pre-amplifier £9/19/6.
Q.14 Speakers £7/19/6.
Micromatic Radio Kit 49/6. Built 59/6.
ALL POST PAID.

SPECIAL OFFER
2 Z12 amps. PZ4 Power Supply. Stereo 25. Preamplifier .......... £22
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NEW SINCLAIR 2000 SYSTEM
35 watt Integrated Amplifier. £29. Carr. 5/-
Self-powered FM Tuner, £25. Carr. 5/-.

### ECHO HS-606 STEREO HEADPHONES

Wonderfully comfortable. Lightweight adjustable vinyl headband, 6ft. cable and stereo jack plug. 25-17,000 cps.. 8Ω imp. 67/6. P. & P. 2/6.

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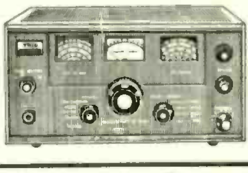
Our new walk around shop is now open at 311 Edgware Road, fully stocked with all Hi-Fi, Communication and Test Equipment. *Call into your nearest shop—Edgware Rd. for all Equipment—Lisle Street for all Equipment and Components.*

### UNR-30 4 BAND COMMUNICATION RECEIVER

Covering 550 Kc/s-30 Mc/s. Incorporates BFO. Built-in speaker and phone jack. Metal cabinet. Operation 220/240 v. A.C. Supplied brand new, guaranteed with instructions. 13gns. Carr. 7/6.

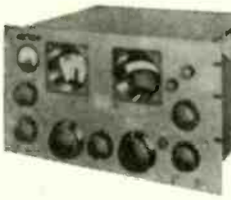
### TRIO COMMUNICATION RECEIVER MODEL 9R-59DE



4 band receiver covering 500 Kc/s to 30 Mc/s. continuous and electrical bandspread on 10-15, 20, 40 and 80 metres. 8 valve plus 7 diode circuit. 4/8 ohm output and phone jack. SSB-CW ● ANL ● Variable BFO ● S meter. ● Sep. Bandspread dial ● IF 455 Kc/s ● audio output 1.5 w. ● Variable RF and AF gains controls. 115/250 v. A.C. mains. Beautifully designed. Size 7 x 15 x 10in. With instruction manual and service data. £42.10.0. Carriage paid. Trio Communication Type Headphones. Normally £5.19.6. Our price £3.15.0 if purchased with above receiver.

### TRIO JR500SE 10-80 METRE AMATEUR COMMUNICATION RECEIVER IN STOCK £69

### HAMMARLUND SP600JX COMMUNICATION RECEIVER



High quality professional dual conversion communication receivers available once again in this country at a reasonable price. Frequency range 540 Kc/s-54 Mc/s in 6 bands, variable tuning or 6 channel crystal controlled. 2.5 watt output into 600 ohms. Input 110/230 v. A.C. 20 valve circuit incorporating: Xtal filter, B.F.O., A.N.L., Xtal calibrator, S meter etc. Size 19 x 12 x 22 in. (List £520). Offered in excellent condition fully tested and checked. £100 each. Few only.

## POWER RHEOSTATS

High quality ceramic construction. Windings embedded in vitreous enamel. Heavy duty brush wiper. Continuous rating. Wide range available ex-stock. Single hole fixing. ¼in. dia. shafts. Bulk quantities available.
25 WATT. 10/25/50/100/250/500/1000/1500/2500 or 5000 ohms. 14/6. P. & P. 1/6.
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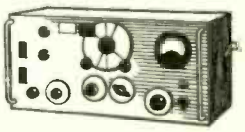
100 WATT. 1/5/10/25/50/100/250/500/1000 or 2500 ohms. 27/6. P. & P. 1/6.

### LAFAYETTE LA-224T TRANSISTOR STEREO AMPLIFIER

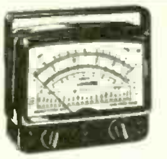
19 transistors, 8 diodes. IHF music power 30 watts at 8 ohms. Res. 30-20,000 ±2 dB at 1 w. Distortion 1% or less. Inputs 3 mV and 250 mV. Output 3-16 ohms. Separate L and R volume controls. Treble and bass controls. Stereo phone jack. Brushed aluminium, gold anodised extruded front panel with metal case. Size 10½in. x 3 ⁵⁄₁₆ in. x 7 ⅞ in. Operation 115/230 volt A.C. £28. Carr. 7/6.

### MARCONI TEST EQUIPMENT Ex-Military Reconditioned.



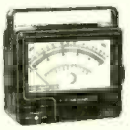
TF 144G Standard Signal Generators, 85 Kc/s-25 Mc/s, £25. Carr. 30/-.
TF 885 Video Oscillator 0-5 m/cs. £45. Carr. 30/-.
TF 195M Beat Frequency Oscillator, 0-40 kc/s, 200/250 v. A.C. £20. Carr. 30/-.
TF 142E Distortion Factor Meter, £20. Carr. 20/-. All above offered in excellent condition, fully tested and checked.
TF 1100 Valve Voltmeter, Brand New. £50.
TF 1267 Transmission Test Set, Brand New, £75.
TF 1371 Wide Band Millivolt Meter, Brand New, £50.

## MULTIMETERS *for EVERY purpose!*

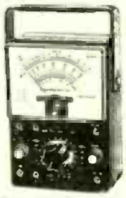


**LAFAYETTE DE-LUXE 100 KΩ/VOLT "LAB TESTER."** Giant 6½in. scale. Built in meter protection, 0/.5/2.5/10/50/250/500/1,000 v. D.C. 0/3/10/50/250/500/1,000 v. A.C. 0/10/100µA/10/100/500 MA/2.5/10 Amp. 0/1K/10K/100K/10M/100M Ω. —10 to 49.4dB. £18/18/-. P. & P. 5/-.

**TE-900 20,000Ω/VOLT GIANT MULTIMETER** Mirror scale and overload protection. 6in. full view meter. 2 colour scale. 0/2.5/10/250/1,000/5,000 v. A.C. 0/.25/12.5/10/50/250/1,000/5,000 v. D.C. 0/50µA/1/10/100/500mA/10 amp. D.C. 0-2K/200K/20 MEG. OHM. £15/-/-. P. & P. 5/-.



**LAFAYETTE 57 Range Super 50K Ω/V. Multimeter.** D.C. volts 125mv—1000v. A.C. volts 1.5v—1000v. D.C. Current 25µA—10 Amp. Ohms 0—10 MegΩ. D.B.—20 to +81 db. Overload protection. £12/10/-. P. & P. 3/6.



**MODEL AS-100D. 100KΩ/Volt. 5in., mirror scale.** Built-in meter protection 0/3/12/60/120/300/600/1,200 v. D.C. 0/6/30/120/300/600 v. A.C. 0/10µA/6/60/300MA/12 Amp. 0/2K/200K/2M/200MΩ. —20 to +17dB. £12/10/-. P. & P. 3/6.

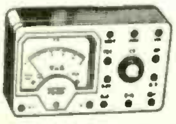
**PROFESSIONAL 20,000 O.P.V. LAB TYPE MULTITESTER.** Automatic overload protection, mirror scale. Ranges 1/10/50/250/500/1,000 v. D.C. and A.C. 0-500µA, 10mA, 250mA, Current: 0/20K. 200K. 2megohm, Decibels:—20 to +22db. £5/19/6. P. & P. 2/6.

**MODEL TE-70. 30,000 O.P.V.** 0/3/15/60/300/600/1,200 v. D.C. 0/6/30/120/600/1,200 v. A.C. 0/30µA/3/30/300mA. 0/16K/160K/1.6M/16 MegΩ. £5/10/-. P. & P. 3/-.

**MODEL TE-90 50,000 O.P.V.** Mirror scale overload protection. 0/3/12/60/300/600/1,200 v. D.C. 0/6/30/120/300/1,200. v D.C. .03/6/60/600 MA. D.C. 16K/160K/1.6/16 MEG Ω. —20 — + 63db. £7/10/0. P. & P. 3/-.

**MODEL TE-12. 20,000 O.P.V.** 0/0.6/6/30/120/600/1,200/3,000/6,000 v. D.C. 0/6/30/120/600/1,200 v. A.C. 0/60µA/6/60/600 mA. 0/6K/600K/6Meg./60 Meg.Ω. 50 PF. .2 MFD £5/19/6. P. & P. 3/6.

**MODEL TE-80. 20,000 O.P.V.** 0/10/50/100/500/1,000 v. A.C. 0/5/25/50/250/500/1,000 v. D.C. 0-50µA. 5/50/500mA. 0/6K/60K/600K/6 meg. £4/17/6. P. & P. 3/-.



**MODEL PT-34.** 1,000 O.P.V. 0/10/50/250/500/1,000V. a.c. and d.c. 0/1/100/500 mA. d.c. 0/100 K Ω 39/6. P. & P. 1/6.

### TO-2 PORTABLE OSCILLOSCOPE

A general purpose low cost economy oscilloscope for everyday use. Y amp. Bandwidth 2 CPS—1 MHZ. Input imp. 2 meg Ω. 25 PF. Illuminated scale. 2" tube. 115 x 180 x 230 mm. Weight 8lbs. 220/240v. A.C. Supplied brand new with handbook. £22/10/-. Carr. 10/-.

**FIELD TELEPHONES TYPE L.** Generator ringing, metal cases. Operate on 2 1.5 v. batteries (not supplied.) Excellent condition. £4.10.0 per pair. Carr. 10/-.

### T.E.40 HIGH SENSITIVITY A.C. VOLTMETER

10 meg. input 10 ranges: .01/.03/.1/.3/1/3/10/30/100/300 v. R.M.S. 4 cps.-1.2 Mc/s. Decibels —40 to +50 dB. Supplied brand new complete with leads and instructions. Operation 230 v. A.C. £17/10/-. Carr. 5/-.

### AUTO TRANSFORMERS

0/115/230v. Step up or step down. Fully shrouded.
150 W. 32/6. P. & P. 3/6
300 W. 47/6. P. & P. 4/6
500 W. £3/10/0. P. & P. 6/6
1,000 W. £5/10/0. P. & P. 7/6
1,500 W. £6/10/0. P. & P. 8/6
7,500 W. £15/10/0. P. & P. 20/-.

### TE22 SINE SQUARE WAVE AUDIO GENERATORS

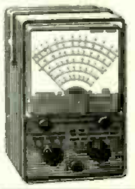
Sine: 20 cps to 200 kc/s. on 4 bands. Square 20 cps to 30 kc/s. Output impedance 5,000 ohms. 200/250 v. A.C. operation. Supplied brand new and guaranteed with instruction manual and leads. £16.10.0. Carr. 7/6.

### RECORDING HEADS

Reuter ¼-track. As fitted to Collaro Mk. IV and Studio Decks. High imp. record playback, low imp. erase. Lower track only. Brand new, 19/6 pair.

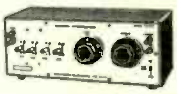
Cosmocord ¼ track heads:
Record/replay. High imp. .......... 65/-
Erase. Low imp. .......... 20/-
Marriott ¼ track heads:
Record/Playback, high imp. .......... 65/-
Erase, low imp. .......... 20/-
Post extra.

### TE-65 VALVE VOLTMETER



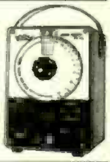
High quality instrument with 28 ranges. D.C. volts 1.5-1,500 v. A.C. volts 1.5-1,500 v. Resistance up to 1,000 megohms. 220/240v. A.C. operation. Complete with probe and instructions £17/10/0. P. & P. 6/-. Additional Probes available; R.F. 35/- H.V. 42/6.

### TE111 DECADE RESISTANCE ATTENUATOR



Variable range 0-111 db. Connections. Unbalanced T and Bridge T. Impedance 600 ohms. Range (0.1 db x 10) + (1 db x 10) + 10 + 20 + 30 + 40 db. Frequency: DC to 200 KHZ (—3db). Accuracy: 0.05 db. + indication db x 0.01. Maximum input less than 4 watts (50 volts). Built in 600 Ω load resistance with internal/external switch. Brand new £27/10/-. P. & P. 5/-.

### TY75 AUDIO SIGNAL GENERATOR



Sine Wave 20 CPS—200 Kc/s. Square Wave 20 CPS—30 Kc/s. High and low impedance output. Output variable up to 6 volts. 220/240 volts A.C. Brand new with instructions. £16. Carr. 7/6. Size 210 x 150 x 120 mm.

### TE-20D RF SIGNAL GENERATOR

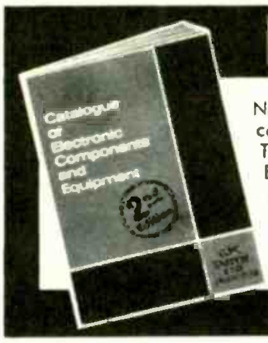
Accurate wide range signal generator covering 120 Kc/s—500 Mc/s on 6 bands. Directly calibrated. Variable RF. attenuator, audio output. Xtal socket for calibration. 220/240V. A.C. Brand new with instructions. £15. Carr. 7/6. Size 140 x 215 x 170 mm.

### FULL RANGE OF

● Components ● Valves ● Semi-Conductors ● Test Equipment ● Receivers ● Hi-Fi AT DISCOUNT PRICES

## G. W. SMITH & Co. (Radio) Ltd.

*ALSO SEE OPPOSITE PAGE*



# NEW CATALOGUE

Nearly 200 pages giving full details of a comprehensive range of COMPONENTS, TEST EQUIPMENT, COMMUNICATION EQUIPMENT and HI-FI EQUIPMENT. Each section greatly enlarged and fully illustrated. Thousands of items, many at bargain prices. FREE DISCOUNT COUPONS VALUE 10/-.

**SEND NOW-ONLY 7'6 P&P 1'-**

# GARRARD

*Full current range offered brand new and guarenteed at fantastic savings*

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| SRP22 Mono | £6.10.0 | •SP25 MKII | £11.19.6 |
| SRP22 Stereo | £6.19.6 | •SL55 | £11.19.6 |
| •1025 Mono | £7.10.0 | A70 MKII | £12.10.0 |
| •1025 Stereo | £7.15.0 | •AT60 MKII | £13.10.0 |
| •2025 Stereo | £7.19.6 | •SL65 | £14.14.6 |
| •2025T/C Mono/ Stereo | £8.17.6 | AP75 | £19. 0.0 |
| •3000 Stereo | £9.19.6 | 401 | £28. 7.6 |
| | | SL75 | £29. 0.0 |
| | | SL95 | £35. 0.0 |

Carriage/insurance 7/6 extra any model.

WB4 Bases £3/19/6. Perspex cover £3/10/0.

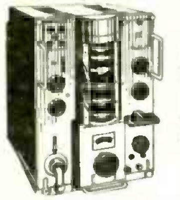
•Special offer base and cover available for these models at £4.15.0. Carr. 5/-.

Full range of Garrard accessories available

## TYPE 13A DOUBLE BEAM OSCILLOSCOPES BARGAIN

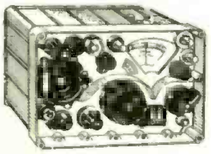
An excellent general purpose D/B oscilloscope. T.B. 2 cps-750 Kc/s. Bandwidth 5.5 Mc/s Sensitivity 33 Mv/cm. Operating voltage 0/110/200/250 v. A.C. Supplied in excellent working condition. £22/10/-. Or complete with all accessories, probe, leads, lid, etc. £25. Carriage 30/-.

## ADMIRALTY B.40 RECEIVERS



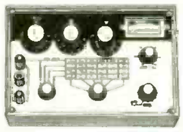
High quality 10 valve receiver manufactured by Murphy. Coverage in 5 bands 650 Kc/s-30 Mc/s. I.F. 500/Kc/s. Incorporates 2 R.F. and 3 I.F. stages, bandpass filter, noise limiter, crystal controlled B.F.O. calibrator I.F. output, etc. Built-in speaker, output for phones. Operation 150/230 volt A.C. Size 19½ × 13½ × 16in. Weight 114lb. Offered in good working condition. £22/10/0. carr. 30/-. With circuit diagrams. Also available B41 L.F. version of above. 15 Kc/s-700 Kc/s. £17/10/-. Carr. 30/-.

## R209 Mk. II COMMUNICATION RECEIVER



11 valve high grade communication receiver suitable for tropical use. 1-20 Mc/s. on 4 bands. AM/CW/FM operation. Incorporates precision vernier drive, B.F.O. Aerial trimmer, internal speaker and 12v. D.C. internal power supply. Supplied in excellent condition, fully tested and checked. £15.0.0 Carr. 20/-.

## TRANSISTORISED L.C.R. A.C MEASURING BRIDGE.



A new portable bridge offering excellent range and accuracy at low cost. Ranges: R. 1Ω—11.1 MEG Ω 6 Ranges ± 1%. L. 1μH—111 HENRIES. 6 Ranges — 2%. C. 10PF ± 1110MFD. 6 Ranges ± 2%. TURNS RATIO 1:1/1000—1:11100. 6 Ranges ± 1%. Bridge voltage at 1,000 CPS. Operated from 9 volts. 100μA. Meter indication. Attractive 2 tone metal case. Size 7½" × 5" × 2". £20. P. & P. 5/-.

## ADVANCE TEST EQUIPMENT

Brand new and boxed in original sealed cartons.
**VM.76. VALVE VOLTMETER.** R.F. measurements in excess of 100 Mc/s and D.C. measurements up to 1000 v. with accuracy of ±2%. D.C. range 300 MV to 1 KV. A.C. range 300 MV to 300 V RMS. Resistance 0.02—500 M. Price £72.
**VM.78. A.C. MILLIVOLT METER.** Transistorised. 1 Mv—300V. Frequency 1 c/s to 1 Mc/s. Price £55.
**VM.79. UHF MILLIVOLT METER.** Transistorised. A.C. range 10 Mv—3V. D.C. current range 0.01/A—0.3 Ma. Resistance 1 ohm—10 megohms. £125.
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**J1B. AUDIO SIGNAL GENERATOR.** 15 c/s—50 Kc/s. Price £30.
**J2B. AUDIO SIGNAL GENERATOR.** As per J1B except fitted with output meter £35.
**TT1S. TRANSISTOR TESTER.** £37/10/-.
Carriage 10/- per item.

## SOLARTRON MONITOR OSCILLOSCOPE TYPE 101

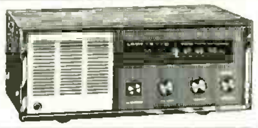
An extremely high quality oscilloscope with time base of 10 μ/sec. to 20 m/sec. Internal Y amplifier Separate mains power supply, 200/250 V. Supplied in excellent condition with cables, probe, etc., as received from Ministry. £8/19/6. Carr. 30/-.

## LAFAYETTE SOLID STATE HA600 RECEIVER

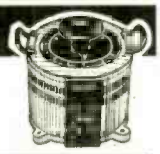
5 BAND AM/CW/SSB AMATEUR AND SHORT WAVE. 150 kc/s-400 Kc/s AND 550 Kc/s-30 Mc/s. F.E.T. front end ● 2 mechanical filters ● Huge dial ● Product detector ● Variable BFO ● Noiselimiter ● S Meter ● 24½in. Bandspread ● 230 v. A.C./12 v. D.C. neg earth operation ● RF gain control. Size 15in. × 9½in. × 8½in. Wt. 18 lbs. EXCEPTIONAL VALUE £45. CARR. 10/-. S.A.E. FOR FULL DETAILS.

## LAFAYETTE PF-60 SOLID STATE VHF FM RECEIVER

A completely new transistorised receiver covering 152-174 Mc/s. Fully tuneable or crystal controlled (not supplied) for fixed frequency operation. Incorporates 4 INTEGRATED CIRCUITS. Built-in speaker and illuminated dial. Squelch and volume controls. Tape recorder output. 75 Ω aerial input. Headphone jack. Operation 230 v. A.C./12 v. D.C. Neg. earth. £37/10/-. Carr. 10/-



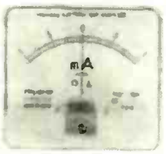
## Variable Voltage TRANSFORMERS



Brand new, guaranteed and carriage paid.
High quality construction. Input 230 v. 50-60 cycles.
Output full variable from 0-260 volts. Bulk quantities available.
1 amp.— £5/10/-; 2.5 amp.— £6/15/-; 5 amp.— £9/15/-;
8 amp.—£14/10/-; 10 amp.—£18/10/-; 12 amp.—£21; 20 amp.—£37

## SEW PANEL METERS

Send S.A.E. for full lists. Other ranges available. Please include postage.
Special quotations for quantities.



CLEAR PLASTIC METERS

**Type MR.38P. 1 21/32in. square fronts.**

| | | | |
|---|---|---|---|
| 50μA | 37/6 | 750mA | 25/- |
| 50-0-50μA | 35/- | 1 amp | 25/- |
| 100μA | 35/- | 2 amp | 25/- |
| 100-0-100μA | 32/6 | 5 amp | 25/- |
| 200μA | 32/6 | 3V. D.C. | 25/- |
| 500μA | 27/6 | 10V. D.C. | 25/- |
| 500-0-500μA | 25/- | 20V. D.C. | 25/- |
| 1mA | 25/- | 100V. D.C. | 25/- |
| 1-0-1mA | 25/- | 150V. D.C. | 25/- |
| 2mA | 25/- | 300V. D.C. | 25/- |
| 5mA | 25/- | 500V. D.C. | 25/- |
| 10mA | 25/- | 750V. D.C. | 25/- |
| 20mA | 25/- | 15V. A.C. | 25/- |
| 50mA | 25/- | 50V. A.C. | 25/- |
| 100mA | 25/- | 150V. A.C. | 25/- |
| 150mA | 25/- | 300V. A.C. | 25/- |
| 200mA | 25/- | 500V. A.C. | 25/- |
| 300mA | 25/- | S meter 1mA | 29/6 |
| 500mA | 25/- | VU meter | 39/6 |

**Type MR.45P. 2in. square fronts.**

| | | | |
|---|---|---|---|
| 50μA | 42/6 | 10V. D.C. | 27/6 |
| 50-0-50μA | 39/6 | 20V. D.C. | 27/6 |
| 100μA | 39/6 | 50V. D.C. | 27/6 |
| 100-0-100μA | 35/- | 300V. D.C. | 27/6 |
| 500μA | 29/6 | 15V. A.C. | 27/6 |
| 1mA | 27/6 | 300V. A.C. | 27/6 |
| 5mA | 27/6 | S meter 1mA | 35/- |
| 10mA | 27/6 | VU meter | 42/6 |
| 50mA | 27/6 | 1 amp. A.C.• | 27/6 |
| 100 mA | 27/6 | 5 amp. A.C.• | 27/6 |
| 500mA | 27/6 | 10 amp. A.C.• | 27/6 |
| 1 amp | 27/6 | 20 amp. A.C.• | 27/6 |
| 5 amp | 27/6 | 30 amp. A.C.• | 27/6 |

**Type MR.52P. 2½in. square fronts.**

| | | | |
|---|---|---|---|
| 50μA | 59/6 | 100-0-100μA | 45/- |
| 50-0-50μA | 49/6 | 500μA | 42/6 |
| 100μA | 49/6 | 1mA | 37/6 |

| | | | |
|---|---|---|---|
| 5mA | 37/6 | 300V. D.C. | 37/6 |
| 10mA | 37/6 | 15 V.A.C. | 37/6 |
| 50mA | 37/6 | 300V. A.C. | 37/6 |
| 100mA | 37/6 | S Meter 1mA | 39/6 |
| 500mA | 37/6 | VU Meter | 59/6 |
| 1 amp | 37/6 | 1 amp. A.C.• | 37/6 |
| 5 amp | 37/6 | 5 amp. A.C.• | 37/6 |
| 10V. D.C. | 37/6 | 10 amp. A.C.• | 37/6 |
| 20V. D.C. | 37/6 | 20 amp. A.C.• | 37/6 |
| 50V. D.C. | 37/6 | 30 amp. A.C.• | 37/6 |

**Type M.R.85P. 4¼in. × 4¾in. fronts.**

| | | | |
|---|---|---|---|
| 50μA | 69/6 | 15 amp. | 49/6 |
| 50-0-50μA | 59/6 | 30 amp. | 49/6 |
| 100μA | 59/6 | 20V. D.C. | 49/6 |
| 100-0-100μA | 59/6 | 50V. D.C. | 49/6 |
| 200μA | 55/- | 150V. D.C. | 49/6 |
| 500μA | 52/6 | 300V. D.C. | 49/6 |
| 500-0-500μA | 49/6 | 15V. A.C. | 49/6 |
| 1mA | 49/6 | 300V. A.C. | 49/6 |
| 1-0-1mA | 49/6 | S Meter 1mA | 55/- |
| 5mA | 49/6 | VU meter | 69/6 |
| 10mA | 49/6 | 1 amp. A.C.• | 49/6 |
| 50mA | 49/6 | 5 amp. A.C.• | 49/6 |
| 100mA | 49/6 | 10 amp. A.C.• | 49/6 |
| 500mA | 49/6 | 20 amp. A.C.• | 49/6 |
| 1 amp. | 49/6 | 30 amp. A.C.• | 49/6 |
| 5 amp. | 49/6 | | |

**Type MR.65P. 3½in. × 3¼in. fronts.**

| | | | |
|---|---|---|---|
| 50μA | 65/- | 20V. D.C. | 39/6 |
| 50-0-50μA | 52/6 | 50V. D.C. | 39/6 |
| 100μA | 52/6 | 150V. D.C. | 39/6 |
| 100-0-100μA | 49/6 | 300V. D.C. | 39/6 |
| 500μA | 45/- | 15V. A.C. | 39/6 |
| 1mA | 39/6 | 50V. A.C. | 39/6 |
| 5mA | 39/6 | 150V. A.C. | 39/6 |
| 10mA | 39/6 | 300V. A.C. | 39/6 |
| 50mA | 39/6 | 500V. A.C. | 39/6 |
| 100mA | 39/6 | S meter 1 mA | 45/- |
| 500mA | 39/6 | VU meter | 65/- |
| 1 amp | 39/6 | 50mA A.C.• | 39/6 |
| 5 amp | 39/6 | 100mA A.C.• | 39/6 |
| 10 amp | 39/6 | 200mA A.C.• | 39/6 |
| 15 amp | 39/6 | 500mA A.C.• | 39/6 |
| 20 amp | 39/6 | 1 amp. A.C.• | 39/6 |
| 30 amp | 39/6 | 5 amp. A.C.• | 39/6 |
| 50 amp | 39/6 | 10 amp. A.C.• | 39/6 |
| 10V. D.C. | 39/6 | 20 amp. A.C.• | 39/6 |
| | | 30 amp. A.C.• | 39/6 |

• Moving iron. all others moving coil

**BAKELITE PANEL METERS** Type MR.65 3½in. square fronts.

| | | | | | |
|---|---|---|---|---|---|
| 25μA | 67/6 | 500mA | 32/6 | 30V. A.C.• | 32/6 |
| 50μA | 45/- | 1 amp. | 32/6 | 50V. A.C.• | 32/6 |
| 50-0-50μA | 42/6 | 5 amp | 32/6 | 150V. A.C.• | 32/6 |
| 100μA | 42/6 | 15 amp. | 32/6 | 300V. A.C.• | 32/6 |
| 100-0-100μA | 42/6 | 30 amp. | 32/6 | 1 amp. A.C.• | 32/6 |
| 500μA | 39/6 | 50 amp. | 32/6 | 5 amp. A.C.• | 32/6 |
| 1mA | 32/6 | 5V. D.C. | 32/6 | 10 amp. A.C.• | 32/6 |
| 1.0 1mA | 32/6 | 10V. D.C. | 32/6 | 20 amp. A.C.• | 32/6 |
| 5mA | 32/6 | 20V. D.C. | 32/6 | 30 amp. A.C.• | 32/6 |
| 10mA | 32/6 | 50V. D.C. | 32/6 | 50 amp. A.C.• | 32/6 |
| 50mA | 32/6 | 150V. D.C. | 32/6 | VU meter | 59/6 |
| 100mA | 32/6 | 309V. D.C. | 32/6 | | |

## TRANSISTOR FM TUNER

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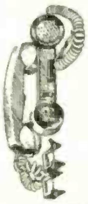
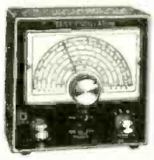
## TRANSISTORISED TWO-WAY TELEPHONE INTERCOM



Operative over amazingly long distances. Separate call and press to talk buttons. 2-wire connection. 1000's of applications. Beautifully finished in ebony. Supplied complete with batteries and wall brackets. £6/19/6 pair. P. & P. 3/6.

## TE-16A TRANSISTORISED SIGNAL GENERATOR



5 Ranges 400 KHZ-30 MHZ. An inexpensive instrument for the handyman. Operates on 9v. battery. Wide easy to read scale. 800 KHZ modulation. 5¼" × 5¼" × 3½". Complete with instructions and leads. £7/19/6. P/P 4/-.

## MODEL ZQM TRANSISTOR CHECKER

It has the fullest capacity for checking on A, B and Ico.
Equally adaptable for checking diodes, etc.
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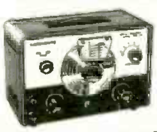
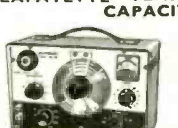
## TE-20RF SIGNAL GENERATOR



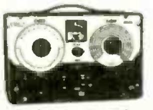
Accurate wide range signal generator covering 120 kc/s-260 Mc/s. on 6 bands. Directly calibrated. Variable R.F. attenuator. Operation 200/240 v. A.C. Brand new with instructions, £15.
P. & P. 7/6. S.A.E. for details.

## LAFAYETTE TE-46 RESISTANCE CAPACITY ANALYSER



2 pf-2,000 mfd. 2 ohms-200 megohms. Also checks impedance turns ratio insulation. 200/250 v. A.C. Brand New, £17.10 Carr. 7/6.

## ARF-100 COMBINED AF-RF SIGNAL GENERATOR



AF. SINE WAVE 20-200,000 cps. Square wave 20-30,000 cps. O/P HIGH IMP. 21 v. P/P 600 Ω 3.8 v. P/P.
R.F. 100 kc/s-300 Mc/s. Variable R.F. attenuation. Int./Ext. Modulation. Incorporates dual purpose meter to monitor. AF output and % mod. on R.F. 220/240 v. A.C. £30. Carr. 7/6.

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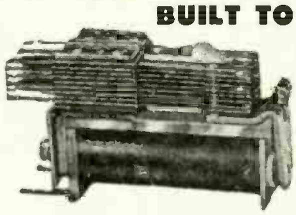

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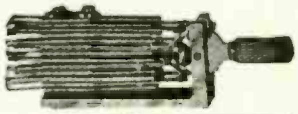

**LEDEX ROTARY SOLENOIDS AND CIRCUIT SELECTORS.** size 5S 4 pole 11 way and off **110/-.** 13 pole 11 way and off **170/-.** 24 pole 11 way and off **210/-.** 54 pole On/Off **150/-.**
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| B77 | 2 | AD161—AD162 NPN/PNP TRANS. COMP. OUTPUT PAIR | 10/- |
| B79 | 4 | IN4007 SIL. REC. DIODES 1000 PIV 1 AMP. MINIATURE | 10/- |
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| B89 | 2 | 5 SP5 LIGHT SENSITIVE CELLS LIGHT RES. 400 Ω DARK 1 M Ω | 10/- |
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| B93 | 5 | GET113 TRANS. EQUIV. TO ACY17-21 PNP GERM. | 10/- |
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Full of Short Lead Semiconductors & Electronic Components, approx. 170. We guarantee at least 30 really high quality factory marked Transistors PNP & NPN, and a host of Diodes & Rectifiers mounted on Printed Circuit Panels. Identification Chart supplied to give some information on the Transistors.

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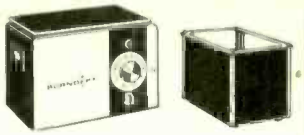
**1. ULTRASONIC CLEANERS**



(Burndept B.E.352) 60 watt model. Supplied Brand New complete with stainless steel tank 9¾ × 6¼ × 4½ in. **£60.** Carr. 20/-.

2. **FAST NEUTRON MONITORS** (Burndept 1407C) for measuring neutrons in the energy range 0.15-15 meV. **£100.**

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S.A.E. for literature. 10% discount for Educational Authorities.

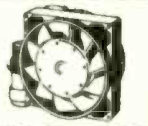
**LARGE CAPACITY ELECTROLYTICS.** 2,000 μF. 30v.; 2,500 μF. 25v.; 2,500 μF. 50v.; 4,000 μF. 90v.; 5,000 μF. 25v.; **7/6** ea. 5,000 μF. 50v.; 10,000 μF. 30v.; 16,000 μF. 10v. **10/-** ea. p.p. 1/-.

**SPEAKER BARGAINS.** E.M.I. 13×8 in. with double Tweeters 15 ohm, **65/-**, P.P. 5/-. As above less tweeters 3 or 15 ohm, **45/-** ea., P.P. 5/-.

**FANE 12 in.** 20 watt (Dual Cone), **£5.** P.P. 5/-.

**CAR RADIO SPEAKER** 7×4 in. 3/5 ohm. 15/- ea. P.P. 2/6

**EXTRACTOR/BLOWER FANS (Papst)**



100 c.f.m. 4½ × 4½ × 2 in. 2800 r.p.m. Wonderful buy at **50**/- ea. 240v. A.C.

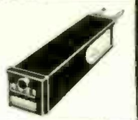
**SPEAKER SYSTEM** (20×10×10 in.). Made to spec. from ¾ in. board. Finished in black leathercloth. 13×8 in. speaker with twin tweeters complete with cross-over. 50c/s-20k/c. **£7.10.** P.P. 10/-.

**PHOTOMULTIPLIERS** 6262 and 6262b. **£15** ea.

**RELAYS** H.D. 2 pole 3 way 10 amp. contacts. 12v.w. **7/6** ea.

**LIGHTWEIGHT RELAYS** (with dust-proof covers) 4 c/o contacts. 12v. 100 ohm. or 24v. 500 ohm **7/6** ea.

**HIGH SPEED MAGNETIC COUNTERS** (4×1×1 in.) 4 digit. 6/12v. 24/48v. (state which), **6/6** ea. P.P. 1/-.



**PYE OHMMETER TYPE 10B.** 500v. test. .3 meg. ohm—20 k. meg. ohm. 200/250v. A.C. Brand new instrument **£30.** P.P. 30/-.

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**50 WAY PLUG & SOCKET** (U.C.L. miniature). Gold plated contacts **20**/- pair. 34 way version **15**/- pair.

**VALVE MILLIVOLTMETER** (Marconi TF899). 0-2v. complete with R.F. probe. **£8/10**/- p.p. 10/-.

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**STEP-DOWN TRANSFORMERS** Prim. 200/250v. Sec. 115v. 1.25 amps. **25/-** ea. P.P. 5/.

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100 Capacitors (latest types) 50pF to .5μF.
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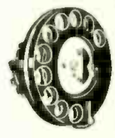

**Amplified TELEPHONE HANDSET** (706) **27/6.** P.P. 2/6.

**EXTENSION TELEPHONE** (Type 706) Black or 2 tone Grey. **65/-.** P.P. 5/-.

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**CONTINUOUS LEVEL MONITORS** (Burndept BE307) complete with Sensing Probe. £25.

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**LEVEL CONTROLLER** (Burndept BE305). £8.

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**BRAND NEW** and in original cases—A.C. mains input. 110V or 250V. Freq. in 6 bands 535 Kc/s-32 Mc/s. Output impedance 2.5-600 ohms. Complete with crystal filter, noise limiter, B.F.O., H.F. tone control, R.F. & A.F. variable controls. Price **£87/10/-** each, carr. £2.

Same model as above in secondhand cond. (guaranteed working order), from £45 to £60, carr. £2.

***SET OF VALVES:** new, **£3/10/-** a set, post 7/6; **SPEAKERS:** new, **£3** each, post 10/-. ***HEADPHONES:** new, **£1/5/-** a pair, 600 ohms impedance. Post 5/-.

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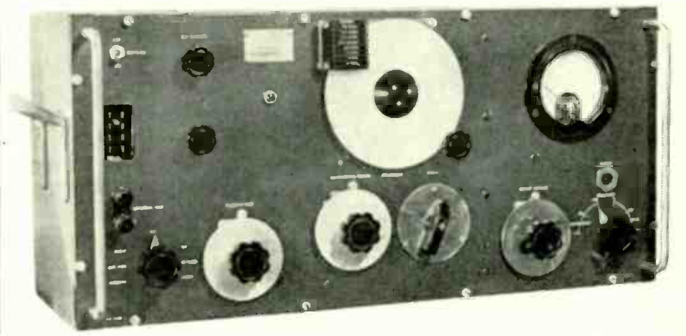
* *Available with Receiver only.*



## MARCONI SIGNAL GENERATORS
## TYPE TF-144G

Freq. 85Kc/s-25Mc/s in 8 ranges. Incremental: +/— 1% at 1Mc/s. Output: continuously variable 1 microvolt to 1 volt. Output Impedance: 1 microvolt to 100 millivolts, 10 ohms 100mV-1 volt-52.5 ohms. Internal Modulation: 400 c/s sinewave 75% depth. External Modulation: Direct or via internal amplifier. A.C. mains 200/250V, 40-100 c/s. Consumption approx. 40 watts. Measurements: 19¼ × 12¼ × 10 in. The above come complete with Mains Leads, Dummy Aerial with screened lead, and plugs. As New, in Manufacturer's cases, £40 each. Carr. 30/-. DISCOUNT OF 10% FOR SCHOOLS, TECHNICAL COLLEGES, etc.

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**COMMAND RECEIVERS;** Model 6-9 Mc/s., as new, price £5/10/- each, post 5/-.

**COMMAND TRANSMITTERS,** BC-458: 5.3-7 Mc/s., approx. 25W output, directly calibrated. Valves 2 × 1625 PA; 1 × 1626 osc.; 1 × 1629 Tuning Indicator; Crystal 6,200 Kc/s. New condition—£3/10/- each, 10/- post.
(Conversion as per "Surplus Radio Conversion Manual, Vol. No. 2," by R. C. Evenson and O. R. Beach.)

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**AVO MULTIRANGE No. I ELECTRONIC TEST SET:** £25 each, carr. £1.

**OSCILLOSCOPE Type 13A,** 100/250 v. A.C. Time base 2 c/s.-750 Kc/s. Bandwidth up to 5 Mc/s. Calibration markers 100 Kc/s. and 1 Mc/s. Double Beam tube. Reliable general purpose scope, £22/10/- each, 30/- carr.
**COSSAR 1035 OSCILLOSCOPE,** £30 each, 30/- carr.

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12 Small American Relays, mixed types £2, post 4/-.

**CALIBRATION TACHOMETER Mk. II:** Maxwell Bridge Type 6C/869, £25 each, £2 carr.

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**HEWLETT PACKARD TYPE 400C:** 115 v./230 v. input 50/60 c/s. Freq. range 20 c/s-2 Mc/s. Voltage range: 1mV-300 v. in 12 ranges. Input impedance 10 megohms. Designed for rack mounting, £30 each, carr. 15/-.

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**AUTOMATIC PILOT UNIT Mk. 2.** This complex unit of diodes and valves, relays, magnetic clutches, motors and plug-in amplifiers, with many other items, price £7/10/-, £1 carriage.

**FOR EXPORT ONLY:** B.44 Trans-ceiver Mk. III. Crystal control, 60-95 Mc/s. **AMERICAN EQUIPMENT:** BC-640 Transmitter, 100-156 Mc/s., 50 watt output. For 110 or 230 v. operation. ARC 27 trans-ceivers, 28 v. D.C. input. Also have associated equipment. BC-375 Transmitter. BC-778 Dinghy transmitter. SCR-522 trans-ceiver. Power supply, PP893/GRC 32A; Filter D.C. Power Supply F-170/GRC 32A: Cabinet Electrical CY 1288/GRC 32A; Antenna Box Base and Cables CY 728/GRC; Mast Erection Kits, 1186/GRC; Directional Antenna CRD.6; Comparator Unit, CM.23; Directional Control CRD.6, 567/CRD and 568/CRD; Azimuth Control Units, 260/CRD. Test Set URM.44, complete with Signal Generator TS.622/U.

**VARIABLE POWER UNIT:** complete with Zenith variac 0-230 v., 9 amps.; 2½in. scale meter reading 0-250 v. Unit is mounted in 19in. rack, £16/10/- each, 30/- carr.

**SOLENOID UNIT:** 230 v. A.C. input, 2 pole, 15 amp contacts, £2/10/- each post 6/-.

**CONTROL PANEL:** 230 v. A.C., 24 v. D.C. @ 2 amps., £2/10/- each, carr. 12/6.

**AUTO TRANSFORMER:** 230-115 v.; 1,000 w. £5 each, carr. 12/6. 230-115 v.; 300VA, £3 each, carr. 10/-.

**OHMITE VARIABLE RESISTOR:** 5 ohms, 5½ amps; or 2.6 ohms at 4 amps. Price (either type) £2 each, 4/6 post each.

**POWER SUPPLY UNIT PN-12B:** 230 v. A.C. input, 395-0-395 v. output @ 300 mA. Complete with two × 9H chokes and 10 mfd. oil filled capacitors. Mounted in 19in. panel, £6/10/- each, £1 carr.

**TX DRIVER UNIT:** Freq. 100-156 Mc/s. Valves 3 × 3C24's; complete with filament transformer 230 v. A.C. Mounted in 19in. panel, £4/10/- each, 15/- carr.

**POWER UNIT:** 110 v. or 230 v. input switched; 28 v. @ 45 amps. D.C. output. Wt. approx. 100 lbs., £17/10/- each, 30/- carr. SMOOTHING UNITS suitable for above £7/10/- each, 15/- carr.

**DE-ICER CONTROLLER MK. III:** Contains 10 relays D.P. changeover heavy duty contacts, 1 relay 4P, C/O. (235 ohms coil). Stud switch 30-way relay operated, one five-way ditto, D.C. timing motor with Chronometric governor 20-30 v., 12 r.p.m.; geared to two 30-way stud switches and two Ledex solenoids, 1 delay relay etc., sealed in steel case (4 × 5 × 7 ins.) £3 each, post 7/6.

**MODULATOR UNIT:** 50 watt, part of BC-640, complete with 2 × 811 valves, microphone and modulator transformers etc. £7/10/- each, 15/- carr.

**ADVANCE TEST EQUIPMENT:** VM76 Valve Voltmeter, £78 each; VM78 A.C. Millivoltmeter (transistorised) £55 each; VM79 UHF Millivoltmeter (transistorised) £125 each; J1B Audio Signal Generator £30 each; TT1S Transistor Tester (CT472) £37/10 each. 10 per cent Discount for schools, colleges, etc. on the above items. Carr. 10/-, extra per item.

**INDICATOR UNIT TYPE CRT.26:** complete with CV1526 Cathode Ray Tube (3EG1). (3 × CV138; 3 × CV329; 1 × CV858; 2 × CV261; 6 × Crystals). Complete with brilliance and focus controls. Suitable for converting into a small oscilloscope (10 × 8 × 6 in., wt. 15 lb.) £5 each. Post 10/-.

**NIFE BATTERIES:** 6 v. 75 amps., new, in cases, £15 each, £1 carr.; 4 v. 160 amps, new, in cases, £20 each, £1 10/- carr. L.R.7 Cells, only 1.2 v. 75 amps., new, £3 each, 12/- carr. The above batteries are low resistance designed to give a heavy surge for starting and can be stored for long periods without any effect to their performance.

**FUEL INDICATOR Type 113R:** 24 v. complete with 2 magnetic counters 0-9999, with locking and reset controls mounted in a 3in. diameter case. Price 30/- each, postage 5/-.

**UNISELECTORS** (ex equipment): 5 Bank, 50 Way, 75 ohm Coil, alternate wipe, £2/5/- each, post 4/-

**FREQUENCY METERS:** BC-221, meter only £30 each, BC-221 complete with stabilised power supply £35 each, carr. 15/-. LM13, 125-20,000 Kc/s., £25 each, carr. 15/-. TS.175/U, £75 each, carr. £1. TS323/UR, 20-450 Mc/s., £75 each, carr. 15/-. FR-67/U: This instrument is direct reading and the results are presented directly in digital form. Counting rate: 20-100,000 events per sec. Time Base Crystal Freq.: 100 Kc/s. per sec. Power supply: 115 v., 50/60 c/s., £100 each, carr. £1

**CT.49 ABSORPTION AUDIO FREQUENCY METER:** freq. range 450 c/s-22 Kc/s., directly calibrated. Power supply 1.5 v.-22 v. D.C. £12/10/- each, carr. 15/-.

**CATHODE RAY TUBE UNIT:** With 3in. tube, colour green, medium persistence complete with nu-metal screen, £3/10/- each, post 7/6.

**APNI ALTIMETER TRANS./REC.,** suitable for conversion 420 Mc/s., complete with all valves 28 v. D.C. 3 relays, 11 valves, price £3 each, carr. 10/-.

**GEARED MOTORS:** 24 v. D.C., current 150 mA, output 1 r.p.m., 30/- each 4/- post. Assembly unit with Letcherbar Tuning Mechanism and potentiometer, 3 r.p.m., £2 each, 5/- post.

**Actuator Type SR-43:** 28 v. D.C. 2,000 r.p.m., output 26 watts, 5 inch screw thrust, reversible, torque approx. 25 lbs., rating intermittent, price £3 each, post 5/-.

**SYNCHROS:** and other special purpose motors available. British and American ex stock. List available 6d.

**MARCONI NOISE GENERATOR TF-987/1;** Used to determine noise factor of a.m. and f.m. receivers. Designed for 230 v. a.c. operation. In used condition, £20 each, carr. £1.

**MARCONI TF-956 (CT.44) AUDIO FREQUENCY ABSORPTION WATTMETER;** Large clear 6in. scale. 1 microW. to 6W. £25 each. Carr. 15/-.

**MARCONI DIVERSITY RECEIVERS;** Consisting of 2 x CR.150's and associated equipment. £175 each. Carr. £5.

**MARCONI DEVIATION TEST SET TF-934:** Freq. 2.5-100Mc/s. Can be extended to 500Mc/s. Deviation range 0-5, 0-25 and 0-65 Kc/s. £35 each, carr. £1

**CANADIAN C52 TRANS/REC.:** Freq. 1.75-16 Mc/s on 3 bands. R.T., M.C.W. and C.W. Crystal calibrator etc., power input 12V. D.C., new cond., complete set £50. Used condition working order £25. Carr. on both types £2/10/-. Transmitter only £7/10/- (few only) Carr. 15/-. Power Unit for Rec., new £3/5/-. Used power units in working order £2/5/-. Carr 10/-.

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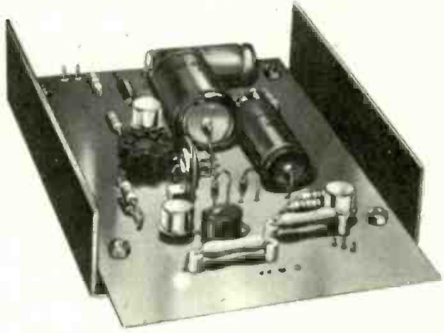

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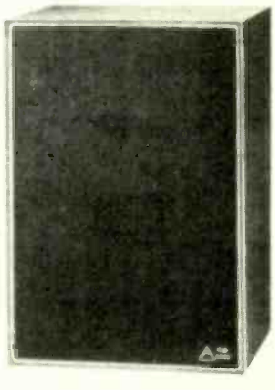
## BAXANDALL SPEAKER
*as described in 'Wireless World'*



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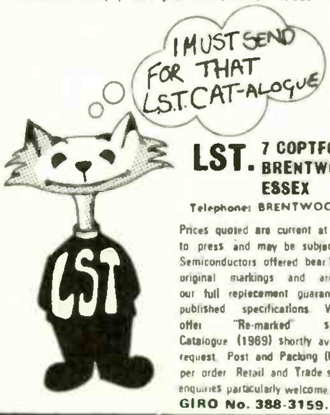


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G/371K 57/6, G1/370K 20/-, G50/2G 20/-, G120/1B 35/-, GM4 45/-, GU50 28/-, GZ32 9/6, GZ34 11/6, H30 3/6, HL23DD 5/-, HL41 4/-, HVR2 9/-, KT8C 32/6, KT63 4/-, KT66 18/6, KT67 45/-, KT71 7/6, KT76 7/-, KT88 27/-, KTZ63 7/-, L63 6/-, MH4 5/-, MH41 8/-, MHLD6 7/6, ML6 6/-, N34 8/-, N78 25/-, OA2 6/-, OB2 6/-, OB3 7/-, OC3 6/-, OD3 6/-, OZ4A 5/-, P41 7/-, PABC80 7/6, PC86 10/3, PC97 9/-, PC900 9/3, PCC84 6/6, PCC89 9/6, PCC189 10/9, PCF80 6/6, PCF82 6/9, PCF84 9/3, PCF86 9/3, PCF801 9/-, PCF802 9/-, PCF805 12/6, PCF806 14/6, PCF808 14/6, PCL81 9/-, PCL82 7/-, PCL83 10/3, PCL84 8/6, PCL85 8/6, PCL86 8/6, PFL200 13/-, PL36 10/9, PL81 8/-, PL82 8/-, PL83 6/9, PL84 6/6, PL500 13/6, PX4 14/-, PX25 12/6, PY33 9/3, PY80 6/-, PY81 5/6, PY82 5/9

PY83 6/6, PY88 7/-, PY800 9/-, PY801 9/-, QQV03-10 19/-, QQV06-40 85/-, QQV06-40A 100/-, QS150-15 7/6, QS95/10 5/-, QS1200 10/-, QS1202 8/-, QV04/7 8/-, QQZ04-15 57/6, R10 17/6, R17 8/6, R19 7/6

U25 14/6, U26 14/6, U27 8/-, U52 4/6, U81 8/-, U191 14/-, U404 6/-, U801 19/6, UABC80 6/-, UAF42 10/6, UBC41 9/3, UBF80 6/6, UBF89 7/-, UCF80 9/6, UCH42 10/-, UCH81 7/-, UCL82 7/6, UCL83 10/3, UF41 10/6, UF80 7/-, UF89 6/9

VR150/30 6/-, VU39 7/-, W118 8/-, W119 9/-, X65 5/-, X66 7/6, X76M 7/-, X118 8/-, X145 8/-, Y63 6/6, Y65 4/-, Z800U 29/-, Z801U 25/-, Z900T 12/-, 1B22 30/-, 1G5GT 6/-, 1D8GT 6/-, 1G6GT 6/-, 1L4 2/6, 1LA6 6/-, 1LC6 7/-

3Q4 8/-, 3Q5GT 6/-, 3S4 5/9, 3V4 6/6, 4D1 4/-, 5A173G 5/-, 5A174G 5/-, 5B251M 40/-, 5B252M 35/-, 5B254M 40/-, 5B/255M 35/-, 5R4GY 9/-, 5T4 7/-, 5U4G 4/6, 5V4G 7/6, 5X4G 8/6, 5Y3GT 5/6, 5Y3WGB 15/-, 5Y3WGTB 9/-

6AM6 3/-, 6AN5 20/-, 6AN8 10/-, 6AQ5 5/6, 6AQ5W 9/-, 6AS6 6/-, 6AS7G 14/-, 6AT6 4/6, 6AU6 5/9, 6AX4 8/-, 6B7 5/6, 6B4G 15/-, 6B8G 2/6, 6BA6 4/6, 6BA7 12/6, 6BE6 5/3, 6BJ6 8/6, 6BJ7 7/-, 6BL7GTA 11/-, 6BQ7A 4/-, 6BR7 9/-

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OC28 12/6, OC29 15/-, OC35 10/-, OC36 12/6, OC38 5/-, OC41 6/-, OC42 5/-, OC44 4/-, OC45 3/6, OC70 4/-, OC71 3/-, OC72 5/-, OC73 6/-, OC75 6/-, OC76 5/-, OC81 5/-, OC81D 3/-, OC81DM 3/-, OC82 5/-, OC82DM 3/-, OC83 5/-, OC83B 3/-, OC84 5/-, OC122 10/-, OC139 7/6, OC140 9/6, OC169 5/-, OC170 5/-, OC171 6/-

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Automatically transfers antenna for TX to RX and vice versa without the use of relay or any moving part. Operates from 3.5 mcs to 28 mcs. No loss of transmitting power and provides gain of 2 6Db in receiving sensitivity, with built-in power supply unit for 220/250v AC. Our own manufacture. Full description and price upon request.

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| No. | SEC. TAPS | AMPS | PRICE | CARR. |
|---|---|---|---|---|
| 1A .. | 25-33-40-50 .... | 15 | £9 10 0 | 10/6 |
| 1B .. | 25-33-40-50 .... | 10 | £6 19 6 | 8/6 |
| 1C .. | 25-33-40-50 .... | 6 | £5 19 6 | 8/6 |
| 1D .. | 25-33-40-50 .... | 3 | £3 12 6 | 7/6 |
| 2A .. | 4-16-24-32 .... | 12 | £6 10 0 | 7/6 |
| 2B .. | 4-16-24-32 .... | 8 | £4 17 6 | 7/6 |
| 2C .. | 4-16-24-32 .... | 4 | £3 5 0 | 6/– |
| 2D .. | 4-16-24-32 .... | 2 | £2 2 6 | 5/– |
| 3A*.. | 25-30-35 ...... | 40 | £14 17 6 | 15/– |
| 3B*.. | 25-30-35 ...... | 20 | £9 7 6 | 9/6 |
| 3C .. | 25-30-35 ...... | 10 | £6 10 0 | 7/6 |
| 3D .. | 25-30-35 ...... | 5 | £3 15 0 | 6/6 |
| 3E .. | 25-30-35 ...... | 2 | £2 15 0 | 6/6 |
| 4A*.. | 12-20-24 ...... | 30 | £11 15 0 | 10/– |
| 4B .. | 12-20-24 ...... | 20 | £7 10 0 | 8/6 |
| 4C .. | 12-20-24 ...... | 10 | £4 15 0 | 7/6 |
| 4D .. | 12-20-24 ...... | 5 | £3 5 0 | 6/6 |
| 5A .. | 3-12-18 ...... | 30 | £8 15 0 | 7/6 |
| 5B .. | 3-12-18 ...... | 20 | £6 10 0 | 7/6 |
| 5C .. | 3-12-18 ...... | 10 | £3 17 6 | 6/6 |
| 5D .. | 3-12-18 ...... | 5 | £2 12 6 | 6/6 |
| 6A .. | 48-56-60 ...... | 2 | £3 5 0 | 5/6 |
| 6B .. | 48-56-60 ...... | 1 | £2 7 6 | 5/6 |
| 7A*.. | 6-12 .......... | 50 | £9 7 6 | 9/6 |
| 7B .. | 6-12 .......... | 20 | £5 10 0 | 7/6 |
| 7C .. | 6-12 .......... | 10 | £3 10 0 | 6/6 |
| 7D .. | 6-12 .......... | 5 | £2 10 0 | 5/6 |
| 8A .. | 12-24 ........ | 1 | £1 9 6 | 5/6 |
| 9A .. | 17-32 ........ | 8 | £5 12 6 | 5/6 |
| 10A*. | 9-15 .......... | 2 | £1 5 0 | 5/6 |
| 11A.. | 6·3 .......... | 15 | £2 5 0 | 5/6 |
| 12A.. | 30-25-0-25-30 .. | 2 | £3 5 0 | 5/6 |

**Note: By using the intermediate taps many other voltages can be obtained.**

Example: No. 1. 7-8-10-15-17-25-33-40-50V.
" 2. 4-8-12-16-20-24-32V.
" 5. 3-6-9-12-15-18V.

**AUTO TRANSFORMERS**

**240v.-110v. or 100v. Completely Shrouded fitted with Two-pin American Sockets or terminal blocks. Please state which type required.**

| *Type* | *Watts* | *Approx. Weight* | *Price* | *Carr.* |
|---|---|---|---|---|
| 1 | 80 | 2½ lb | £1 17 6 | 4 6 |
| 2 | 150 | 4 lb | £2 7 6 | 5 0 |
| 3 | 300 | 6½ lb | £3 7 6 | 6 0 |
| 4 | 500 | 8½ lb | £4 15 0 | 6 6 |
| 5 | 1000 | 15 lb | £6 12 6 | 7 6 |
| 6* | 1750 | 25 lb | £13 10 0 | 10 6 |
| 7* | 2250 | 30 lb | £16 10 0 | 12 6 |

*Completely enclosed in beautifully finished metal case fitted with two 2-pin American sockets, neon indicator, on/off switch, and carrying handle.

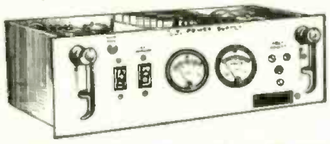
# Samson's

(ELECTRONICS) LTD.

**9 & 10 CHAPEL ST., LONDON, N.W.1**

**01-723-7851 01-262-5125**

**AMERICAN HIGHLY STABILISED POWER SUPPLY UNIT**



Regulation between 7-15 volts D.C. at 20 amps. Fitted 0-30 D.C. ammeter, 0-15 D.C. voltmeter and overload protection switch. Built to a very high specification. Bench or rack mounting. Size 19 × 8 × 17 ins. A.C. input 110v. 50 cycles. Ex equipment but guaranteed in perfect condition. Maker's price in excess of £200. Our price **£25**. Carr. 30/- 240/110 volt, 400 watts, Mains Transformer available if required. £3 extra.

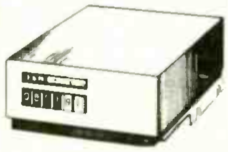
**EX COMPUTER LOW VOLTAGE STABILISED POWER SUPPLY UNITS**

| | | | | | |
|---|---|---|---|---|---|
| 6 volts | 8 amps | **£10** | 20 volts | 15 amps | **£26** |
| 12 volts | 16 amps | **£22** | 30 volts | 7 amps | **£18** |
| 12 volts | 20 amps | **£26** | 30 volts | 4 amps | **£14** |

**Open chassis. Re-conditioned and guaranteed perfect. Choke/capacity transistorised smoothing. Ripple better than 3000:1. Incorporates printed circuit S.C.R. Board for overload protection and overload switch with manual re-set button. Insulation of high standard. Designed for 120/130 volts. A.C. operation, but transformer for 200/240 volts. A.C. mains supply included in list price.**

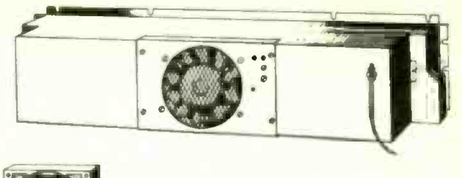
**DIMENSIONS:** 6in. × 6in. square and between 10 in. and 20 in. long according to type. All 12/6 carriage.

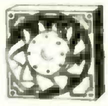
**DIGITAL HOUR METERS**



6 figs inc. 1/10ths, 1/100ths 40v. A.C. but complete with transformer for 240v. A.C. operation. All in plastic case. Size 6½ × 6½ × 3in. Condition as new 45/-. P&P 5/-.

**COMPUTER EXTRACTOR FANS**



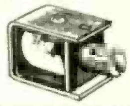


Manufactured by Papst. A.C. 220-240 volts 2800 r.p.m. 100 c.f.m. with fibre glass filter. Ex equipment. Guaranteed in perfect condidition. Size 28 × 5 × 5 ins. **59/6**. Carr 8/6

**FANS ONLY**

Mounted on metal plate. Size 13 × 5 × 3 in. **45/-**. Carr. 5/-.

**MAGNETIC DEVICES SOLENOIDS**



180v. D.C. Approx. ⅜in. pull. Size 1½ × 1½ × 1¼ins. 5s. 0d. P. & P. 1/6. 50v. D.C. **7s. 6d.** P. & P. 1/6.

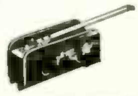
**ELECTRO METHODS 2·3v. A.C. CONTACTORS**

1 Heavy Duty Change-over Contact. Size 2¾ × 1¾ × 1ins. **7s. 6d.** P. & P. 2/-.

**MAGNETIC DEVICES 6v. D.C. CONTACTORS**

1 C.O., 1 H/D Make contacts. Size 2 × 1⅛ × 1ins. **7s. 6d.** P. & P. 2/-.

**MICRO SWITCHES**



Burgess Type CRK2-524. Lever operated. Make or break (3 tags). Three for **12s. 6d.** P. & P. 2/-. Many other types available.

**SELENIUM F.W. BRIDGE RECTIFIERS**

Max. A.C. input 36v., D.C. 8 amps. **29/6**. P. & P. 3/6. Max. A.C. input 18v., D.C. 8 amps, **22/6**. P. & P. 2/6. 4 amps 15/-. P. & P. 2/-. 2½ amps, **9/6**. P. & P. 2/-. Supplied new and guaranteed. Not to be confused with surplus types.

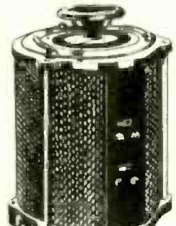
**SMOOTHING CHOKES**

Haddon totally enclosed 12H conservatively rated at 60 M/A. 10/6. P.P. 4/6. Parmeko Neptune Series. 10H 180 M/A. **17/6**. P.P. 5/-. 10H 120 M/A. **12/6**. P.P. 4/6.

*Send 6d. stamp for our latest price list.*

# NO EXCUSES! NO DELAYS! FROM STOCK!

# VARIABLE VOLTAGE TRANSFORMERS



**50 AMPS**

**1 AMP.**

**INPUT 230 v. A.C. 50/60**

**BRAND NEW. Keenest prices in the country. All Types (and spares) from ½ to 50 amp. available from stock.**

| | |
|---|---|
| 0–260 v. at 1 amp. .... | **£5 10 0** |
| 0–260 v. at 2.5 amps. .. | **£6 15 0** |
| 0–260 v. at 4 amps. .... | **£9 0 0** |
| 0–260 v. at 5 amps. .... | **£9 15 0** |
| 0–260 v. at 8 amps. .... | **£14 10 0** |
| 0–260 v. at 10 amps. ... | **£18 10 0** |
| 0–260 v. at 12 amps. ... | **£21 0 0** |
| 0–260 v. at 15 amps. ... | **£25 0 0** |
| 0–260 v. at 20 amps. ... | **£37 0 0** |
| 0–260 v. at 37.5 amps. . | **£72 0 0** |
| 0–260 v. at 50 amps. ... | **£92 0 0** |

**20 DIFFERENT TYPES AVAILABLE FOR IMMEDIATE DELIVERY.**

## Double Wound Variable Transformers

**Fully isolated, low tension Secondary winding. Input 230 v. A.C. OUTPUT CONTINUOUSLY VARIABLE 0-36 v. A.C.**

**0-36 v. at 5 amp. £9.12.6— p. & p. 8/6**

**0-36 v. at 20 amp. £21.0.0— 15/- p. & c.**

**These fully shrouded Transformers, designed to our specifications, are ideally suited for Educational, Industrial and Laboratory use.**

## SPEEDIVAC

**HIGH VOLTAGE HIGH FREQUENCY GENERATOR**

Input 100/110 volts or 200/250 volts AC/DC. Output 19KV variable. Ideal for testing insulation, vacuum, leakage path, gas discharge lamps, neon etc. A useful ozone and HF supply. Manufactured by Edwards High Vacuum Ltd. Brand new in maker's polished wooden carrying case Offered at fraction of maker's price. **£10.0.0** plus 7/6d. p. & p.

## 5Amp.AC/DC VARIABLE VOLTAGE OUTPUT UNIT

Input 230 v. A.C. Output 0-250 v. A.C. Output 0-240 v. D.C. Fitted large scale ammeter and voltmeter. Neon indicator, fully fused. Strong attractive metal case 15in. × 8¾in. × 6in. Weight 24 lb. Infinitely variable, smooth stepless voltage variation over range. Similar in appearance to illustration below.

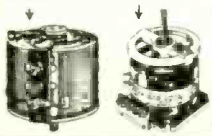
## OPEN TYPES

**Designed for Panel Mounting. Input 230 v. A.C. 50/60 Output variable. 0-260 v.**

| | |
|---|---|
| ½ amp ..... | **£3 10 0** |
| 1 amp. .... | **£5 10 0** |
| 2½ amp. .... | **£6 12 6** |

P. & P. 7/6

**½ AMP. 1 AMP.**



**PORTABLE VARIABLE VOLTAGE TRANSFORMER**

Input 230 v. A.C. Output variable 0-260 v. A.C. at 1.5 amp. Fitted in beautifully finished steel case. Complete with voltmeter, pilot lamp, fuse, switch, carrying handle. **£9/5/-**. P. & C. 10/-. Also 2.5 amp. as above. **£11/7/6**. P. & C. 10/-.

**ADVANCE VOLSTAT**

LT constant voltage Transformer. Input 205/250 volts. Output 6.3 volts. RMS Load 7-10 amps. **£3**. 6/6 p.p.

## CONSTANT VOLTAGE TRANSFORMER

**Input 185-250 v. A.C. Output constant at 230 v. AC.** Capacity 250 watt. Attractive metal case. Fitted red signal lamp. Rubber feet. Weight 17lbs. Price **£11/10/-**, P. & P. 10/-.

## LATEST TYPE SOLID STATE VARIABLE CONTROLLER

Ideal for lighting and heating circuits, compact panel mounting. Built in fuse protection. CONTINUOUSLY VARIABLE.
Input 230v AC output 25-230v AC
5 amp model **£8. 7. 6**
10 amp model **£13. 5. 0**

**INSULATION TESTERS (NEW)**

Test to I.E.E. Spec. Rugged metal construction, suitable for bench or field work, constant speed clutch. Size L. 8in., W. 4in., H. 6in. Weight 6lb. 500 volts, 500 megohms. Price £22 carriage paid. 1,000 volts, 1,000 megohms, **£28** carriage paid.

## 36 volt 30 amp. A.C. or D.C. Variable L.T. Supply Unit

**INPUT**
220/240 v. A.C.
**OUTPUT**
CONTINUOUSLY VARIABLE 0-36 v.

**Fully Isolated. Fitted in robust metal case with Voltmeter, Ammeter, Panel Indicator and chrome handles. Input and Output fully fused. Ideally suited for Lab. or Industrial use. £55 plus 40/- p. & c.**

# SERVICE TRADING COMPANY →

# SERVICE TRADING CO

Postage and Carriage shown below are inland only. For Overseas please ask for quotation. We do not issue a catalogue or list.

### LIGHT SENSITIVE SWITCHES

Kit and parts including ORP.12 Cadmium Sulphide Photocell. Relay Transistor and Circuit. Now supplied with new Siemens High Speed Relay for 6 or 12 volt operations. **Price 25/-**, plus 2/6 P. & P. **ORP 12 and Circuit 10/- post paid.**

**220/240 A.C. MAINS MODEL** incorporates mains transformer rectifier and special relay with 3 × 5 amp. mains c/o contacts. Price inc. circuit **47/6**, plus 2/6 P. & P.

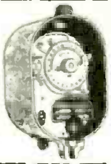
### LIGHT SOURCE AND PHOTO CELL MOUNTING

Precision engineered light source with adjustable lens assembly and ventilated lamp housing to take MBC bulb. Separate photo cell mounting assembly for ORP.12 or similar cell with optic window. Both units are single hole fixing. Price per pair **£2/15/0** plus 3/6 P. & P.

### VAN DE GRAAF ELECTROSTATIC GENERATOR

**VAN DE GRAAF ELECTROSTATIC GENERATOR**, fitted with motor drive for 230 v. A.C. giving a potential of approx. 50,000 volts. Supplied absolutely complete including accessories for carrying out a number of interesting experiments, and full instructions. This instrument is completely safe, and ideally suited for School demonstrations. Price **£7/7/-**, plus 4/- P. & P. L't. on req.

### 200/250 v. AC HORSTMAN 20AMP TIME SWITCH



2 on/off every 24 hrs. at any pre-set time. Fitted in metal case 36 hr. spring reserve. Used but fully tested. Fraction of maker's price. **£3.19.6** plus 4/6d. post and pack. Available with solar dial on request.

### LATEST TYPE SELENIUM BRIDGE RECTIFIERS

30 volt 3 amp., **11/-**, plus 2/6 P. & P.
30 volt 5 amp., **16/-**, plus 2/6 P. & P.

### NICKEL CADMIUM BATTERY

**Sintered Cadmium Type 1.2 v. 7AH. Size: height 3¾in., width 2¾in. × 1$\frac{3}{16}$in. Weight: approx. 13 ozs. Ex-R.A.F. Tested 12/6. P. & P. 2/6.**

## DRY REED SWITCHES

2 × lamp Dry Reeds (makes contacts) mounted in 870 ohm 9-18v coil. Size 3in. × 3¼in. × ½in. New. Price **8/6** per pair. Post Paid.

6 of the above mentioned units (12 Reeds, 6 coils) fitted in metal box. Size 4in. × 3½in. × 1½in. Mfg. by Elliott Bros. New **45/-** each. Post Paid.

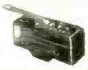
**Telephone Dials (New) 14/6d. Post Paid.**

### SOLAR OIL-FILLED CONDENSER.

240 mfd. for 230 V.A.C. 600 volt D.C. Overall size 14in. × 9in. × 5½in. plus feet. Weight 46 lb. Guaranteed perfect. Manufacturer's packing. Price **£7/10/-**. Carriage 15/-.

**AUTO TRANSFORMERS.** Step up, step down. 110-200-220-240 v. Fully shrouded. New. 300 watt type **£3/10/-** each. P. & P. 4/6. 500 watt type **£4/12/6** each. P. & P. 6/6. 1,000 watt type **£5/15/-** each. P. & P. 7/6.

### LEVER MICRO SWITCH



Brand new lever operated micro switch. 20 amp. A.C. Price **4/6** each plus 1/6 P. & P. 5 for **£1** post paid.

### MOVING COIL HEADPHONE AND MIKE

Soft rubber ear-pieces with M/C Mike fitted 5-way plug as on No. 19 set. New, in maker's packing, **16/6**, plus 3/6 C. & P.

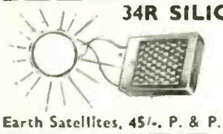
### SEMI-AUTOMATIC "BUG" SUPER SPEED MORSE KEY

7 adjustments, precision tooled, speed adjustable 10 w.p.m. to as high as desired. Weight 2½lb. **£4/12/6** post paid.

### *NEW MODEL* HIGH FREQUENCY TRANSISTORISED MORSE OSCILLATOR

Adjustable tone control. Fitted with moving coil speaker, also earpiece for personal monitoring. Complete with morse key. **45/-** plus 3/6d. p. & p.

### 34R SILICON SOLAR CELL



4 × .5 volt unit series connected, output up to 2 v. at 20 mA. in sunlight. 30 times the efficiency of selenium. As used in power Earth Satellites. **45/-**. P. & P. 1/6d.

### CONDENSERS

New at a fraction of maker's price.

| | | | |
|---|---|---|---|
| 2,500 mfd. 100 v. | 12/6 | 4,000 mfd. 25 v. | 10/- |
| 10,000 mfd. 35 v. | 15/- | 4,000 mfd. 50 v. | 15/- |

### 220/240v. A.C. COOLING UNIT

2,300 r.p.m. 6in. blade size. Smooth powerful motor. All metal construction. Continuously rated. Individually tested. Offered at fraction of maker's price, **£2/15/-**. P. & P. 7/6.

### 100 WATT POWER RHEOSTATS

(NEW) Ceramic construction, winding embedded in Vitreous Enamel, heavy duty brush assembly designed for continuous duty.

**AVAILABLE FROM STOCK IN THE FOLLOWING 11 VALUES:** 1 ohm 10a., 5 ohm 4.7a., 10 ohm 3a., 25 ohm 2a., 50 ohm 1.4a., 100 ohm 1a., 250 ohm 7a., 500 ohm 45a., 1,000 ohm 280mA., 1,500 ohm 230mA., 2,500 ohm .2a. Diameter 3½in. Shaft length ⅝in. dia. ⅜in., **27/6**. P. & P. 1/6.

**50 WATT** 1/5/10/25/50/100/250/500/1,000/1,500/2,500 ohm, **21/-**, P. & P. 1/6.

**25 WATT** 10/25/50/100/250/500/1,000/1,500/2,500 ohm, **14/6**, P. & P. 1/6.

**Black Silver Skirted knob calibrated in Nos. 1-9. 1½ in. dia. brass bush. Ideal for above Rheostats, 3/6 each.**

## STROBE! STROBE! STROBE!

TWO EASY TO BUILD KITS USING XENON WHITE LIGHT FLASH TUBES. SOLID STATE TIMING + TRIGGERING CIRCUITS. PROVISION FOR EXTERNAL TRIGGERING. 230-250v. A.C. OPERATION.

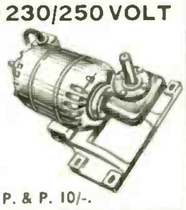
The Strobe is one of the most useful and interesting instruments in the laboratory or workshop. It is invaluable for the study of movement and checking of speeds. Many uses can be found in the psychiatric and photographic fields, also in the entertainment business. It is used a great deal in the motor industry and is a real tool as well as an interesting scientific device.

**EXPERIMENTERS "ECONOMY" KIT.** 1 to 36 Flash per sec. All electronic components including Veroboard S.C.R. Unijunction Xenon Tube + Instructions **£5.5.0** plus 5/- P. & P.

**INDUSTRIAL "ADVANCED" KIT.** 1 to 80 Flash per sec. IDEAL FOR LABORATORY OR SCHOOL USE. Fully isolated from the mains supply by specially wound transformer. 500v. FLASH CIRCUIT and stabilised timing circuit. Higher output flash tube. Price **£8.8.0** plus 7/6 P. & P.

**6½ INCH POLISHED REFLECTOR.** Ideally suited for above Strobe Kits. Price **8/6** post paid. Regret not sold separately.

### PARVALUX TYPE SD19 230/250 VOLT AC REVERSIBLE GEARED MOTORS



**30 r.p.m. 40 lb. ins.** Position of drive spindle adjustable to 3 different angles. Mounted on substantial cast aluminium base. Ex-equipment. Tested and in first-class running order. A really powerful motor offered at a fraction of maker's price. **6 gns.** P. & P. 10/-.

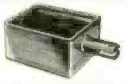
### BODINE TYPE N.C.1 GEARED MOTOR

**(Type 1) 71 r.p.m. torque 10 lb. in.** Reversible 1/70th h.p. 50 cycle.38 amp.
**(Type 2) 28 r.p.m. torque 20 lb. in** reversible 1/80th h.p. 50 cycle .28 amp.

The above two precision made U.S.A. motors are offered in 'as new' condition. Input voltage of motor 115v A.C. Supplied complete with transformer for **230/240v A.C. input**

Price, either type **£2.17.6** plus 6/6 P. & P. or less transformer **£2.2.6** plus 4/6d. P. & P.

These motors are ideal for rotating aerials, drawing curtains, display stands, vending machines etc.



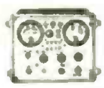
**230/250 v. A.C. SOLENOID** Heavy duty type. Approx. 3lb. pull. **17/6** plus 2/6 P. & P.

**12/24 v. D.C. SOLENOID** Approx. 8 oz. push, **8/6** plus 1/6 P. & P.

### A.C. CONTACTOR

2 make and 2 break (or 2 c/o) 15 amp. contacts. 230/240 v. A.C. operation. Brand new. **22/6** plus 1/- P. & P.

### CT82 NOISE GENERATOR

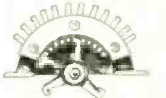


Ideal for alignment of all types of communication and VHF receivers. Self contained audio output meter and mains power supply.
100Kc/s to 160 Mc/s Frequency range
43 ohm or 75 ohm impedance.
Noise figure range to 20 db.
In rugged alloy case with instructions for use. Offered untested but in excellent condition, less mains lead. **£7/19/6**, P. & P. 10/-.

**Latest American. New. Plastic THYRISTOR** 400 P.I.V. 8 amp. Data sheet. **19/6** post paid.

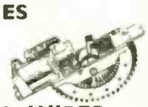
**COPPER LAMINATE PRINTED CIRCUIT BOARD.** Large sheet 15½ × 5¼in. 3 for **10/-** post paid. (3 minimum order).

### MINIATURE UNISELECTOR



3 banks of 11 positions, plus homing bank. 40 ohm coil. 24-36 v. D.C. operation. Carefully removed from equipment and tested. **22/6**, plus 2/6 P. & P.

### UNISELECTOR SWITCHES *NEW* 4 BANK 25 WAY

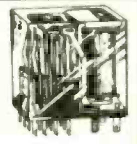


25 ohm coil, 24 v. D.C. operation. **£5/17/6**, plus 2/6. P. & P.

### 8-BANK 25-WAY FULL WIPER

24 v. D.C. operation, **£7/12/6**. Plus 4/- P. & P.

## RELAYS

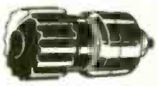


BULK PURCHASE ENABLES US TO OFFER THE FOLLOWING *NEW* **SIEMENS PLESSEY**, etc. MINIATURE PLUG IN RELAYS COMPLETE WITH BASE, AT A FRACTION OF MAKER'S PRICE

| COIL Ω | WORKING VOLTAGE | CONTACTS | PRICE |
|---|---|---|---|
| 280 | 6—12 | 2 c/o | 14/6 |
| 280 | 9—18 | 4 c/o | 15/6 |
| 700 | 12—24 | 2 c/o | 12/6 |
| 700 | 16—24 | 4 c/o | 15/6 |
| 700 | 16—24 | 4M 2B | 12/6 |
| 1250 | 20—40 | 2 c/o Heavy Duty | 12/6 |
| 2500 | 30—50 | 2 c/o Heavy Duty | 12/6 |
| 5800 | 50—70 | 4 c/o | 10/- |
| 9000 | 40—70 | 2 c/o | 10/- |

POST PAID

### INSULATED TERMINALS



Available in black, red, white, yellow, blue and green. New **17/-** per doz. P. & P. 2/-.

### SANGAMO WESTON

Dual range voltmeter. 0-5 and 0-100 v. D.C. FSD 1 mA. In carrying case with tests prods and leads. **32/6.** P. & P. 3/6.

**A.C. AMMETERS** 0-1, 0-5, 0-10, 0-15, 0-20 amp. F.R. 2½in. dia. All at **21/-** each.

**A.C. VOLTMETERS** 0-25 v., 0-50 v., 0-150 v. M.I 2½in. Flush round all at **21/-** each. P. & P. extra.

0-300 v. A.C. Rect. M-Coil 2½in. ........ **29/-**
0-300 v. A.C. Rect. M-Coil 3½in. Type W23 ...... **55/-**

### 'AVO' METER MODEL 7

Supplied fully checked and tested on all ranges and in excellent condition. Complete with batteries and leads. Price **£13/10/-**. P. & P. 7/6d.
Avo Leather Carrying Case **30/-**.
(Regret not sold separately)

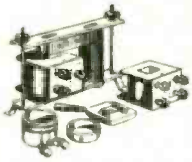
### 'AVO' MODEL 47A

Ex-Admiralty in first class condition, complete with instructions, leads and case. **£9/19/6**, P. & P. 10/-.

### 'AVO' MODEL 48A

Ex-Admiralty in good condition with instructions, leads, plus D.C. Shunts for 120 Amp and 480 Amp. A.C. Transformer for 60 Amp. and 240 Amp. Multiplier for 3600 volt. Complete outfit in fitted case. **£15/0/0**, P. & P. 10/-.

### DEMONSTRATION TRANSFORMER (STENZYL TYPE)



Two removable coils are tapped at 0, 110, 220 volts, and 6, 12, 36 volts respectively. A composite apparatus designed for class demonstration. Electro magnetic induction, jumping ring, induction lamp, relationship between field intensity and ampere turns, induction melting, are just a few of the possible experiments. New modified model. **£14/10/-**. P. & P. 10/-.

### L.T. TRANSFORMERS

All primaries 220-240 volts.

| Type No. | Sec. Taps | Price | Carr. |
|---|---|---|---|
| 1 | 30, 32, 34, 36 v. at 5 amps. | £4 5 0 | 6/- |
| 2 | 30, 40, 50 v. at 5 amps. | £6 5 0 | 6/6 |
| 3 | 10, 17, 18 v. at 10 amps. | £4 10 0 | 4/6 |
| 4 | 6, 12 v. at 20 amps. | £5 17 6 | 6/6 |
| 5 | 17, 18, 20 v. at 20 amps. | £6 12 6 | 6/6 |
| 6 | 6, 12, 20 v. at 20 amps. | £6 5 0 | 7/6 |
| 7 | 24 v. at 10 amps. | £4 15 0 | 5/6 |
| 8 | 4, 6, 24, 32 v. at 12 amps. | £6 10 0 | 6/6 |

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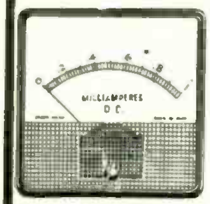
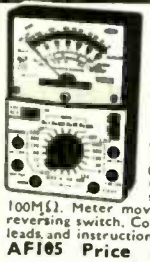
# HR QUALITY COMPONENTS AND EQUIPMENT

## NEW RANGES FOR THE AMATEUR AND PROFESSIONAL USER

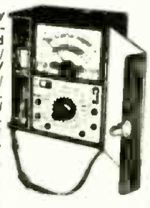


### *QUALITY PANEL METERS

38 Series. Face size 42 x 42mm (1⅝in x 1⅝in). 50µA, 37/6; 100µA, 35/-; 200µA, 32/6; 500µA, 27/6; 1mA, 5mA, 10mA, 50mA, 100mA, 500mA, 25/- each; 10V, 20V, 50V, 100V, 300V and 500V, 25/- each; 1A and 5A, 25/- each. "S" meter, 1mA, 29/6. VU meter, 37/6.
65 Series. Face size 86 x 78mm (3⅜ x 3⅛in). 50µA, 62/6; 100µA, 52/6; 200µA, 47/6; 500µA, 45/-; 1mA, 5mA, 10mA, 500mA, 37/6 each. "S" meter, 1mA, 42/6. Other ranges and sizes available. List on request.



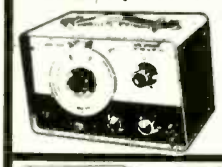
### *50,000 OHMS PER VOLT MULTIMETER



Recommended quality instrument, with mirror scale and overload protection. 0/0.3/3/12/60/120/300/600/1200V d.c. (50KΩ/V); 0/6/30/120/300/600/1200V a.c. (10KΩ/V); 0/30µA/6/60/300mA, 0/12A; resistance 0/10kΩ/1/10/100MΩ. Meter movement 20µA. Polarity reversing switch. Complete with batteries, leads and instructions.

**AF105 Price £8.10.0 p.p. 2/6**
**Leather case 28/6**

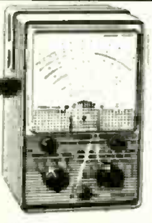
### *SINE/SQUARE WAVE AUDIO GENERATOR



Provides audio output on 4 bands. Sine wave 20c/s to 200kc/s, output up to 7V; square wave 60c/s to 30kc/s, 7V p-p. Distortion under 2%. Output impedance 1kΩ. Variable output amplitude control. Supplied with leads and instructions. A.C. mains operated.

**TE22 Price £16.10.0. p.p. 8/6**

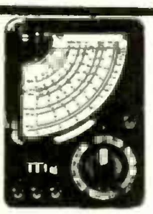
### *VACUUM TUBE VOLTMETER

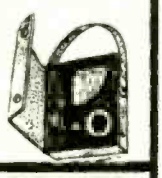


Features low price for such an instrument. Large 6in full view scaled meter. 28 ranges. D.C. volts: 0/1½/5/15/50/150/500/1500. A.C. volts: 0/1½/5/15/50/150/500/1500 r.m.s.: 0/1·4/4/14/40/140/400/1400/4000 p-p. Resistance: R x 10–100–1k–10k–100k–1m–10m. Range 0·2 ohm to 1000MΩ. dB scales: —10 to +65dB. Complete with instructions and leads.

**MODEL TE65**
**£17.10.0 p.p. 7/6**
**HV Probe 50/-**
**R.F. Probe 42/6**

### 20,000 OHMS PER VOLT MULTIMETER

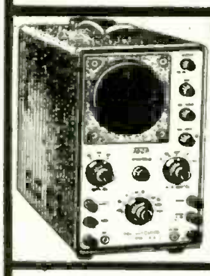




Popular model but with extra scale range. 20,000 ohms per volt. 0/5/25/50/250/500/2500V d.c., 0/10/50/100/500/1000V a.c., 0/50µA, 0/2½/250mA. Resistance 0–6kΩ and 6MΩ. Also dB scales or capacitance.

**Model 200H .. .. 77/6**
**(Leather case, Price 15/-)**

### *PORTABLE OSCILLOSCOPE



Features 3in clear view tube, easy to use controls and good stability. Y amp. Sensitivity. ·1V p-p/CM. Bandwidth 1·5 cps—1·5 MHz. Input imp. 2 meg Ω. 25 PF. X amp sensitivity. ·9V p-p/CM. Bandwidth 1·5 cps—800 KHz. Input imp. 2 meg Ω. 20 PF. Time base. 5 ranges 10 cps—300 KHz. Synchronization. Internal / external. Illuminated scale. 140 x 215 x 330 MM. Weight 15½lbs. 220/240V. A.C. Supplied brand new with handbook.

**TO3 Price £35 p.p. 10/-**

### TRANSISTORISED INTERCOMMS

P. & P. 3/6 any model)

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| Bellphone Street Door Intercomm. .. .. | £4.10.0 |
| 2 Station Intercomm. | £3.10.0 |
| 3 Station Intercomm. | £5.15.0 |
| 4 Station Intercomm. | £6.12.6 |
| Telephone Amplifier | £2.19.6 |
| 2 Station Mains Operated No Wires .. .. | £11.19.6 |

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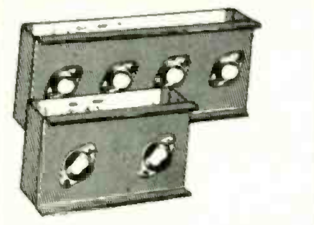

### *TRANSISTOR POWER AMPLIFIERS

12 watt 3 ohm 100mV Input 24 volt supply. Model MPA 12/3 £4.10 p.p. 3/-
12 watt 12–16 ohm 100mV Input 40 volts supply. Model MPA 12/15 £5.5 p.p. 13/-
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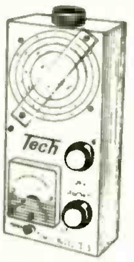
Power Supplies 24–40 volt 90/ p.p. 3/6
50—60 volt 97/6 p.p. 4/6
Model P.97 7 watt Amplifier 3 ohms C/P. 7mV Input, operates 12–18 volts D.C. Price 72/6 p.p. 2/6

### *GRID DIP METER



All transistor grid dip meter, absorption wavemeter and osc. detector. Frequency range 440kc/s to 280Mc/s in 6 coils. Uses 3 transistors plus diode with 500µA meter. Internal battery.
**TE15**
**Price .. £11.10.0**

### DC POWER SUPPLIES

220/250 volt A.C. Input
LAIDS 9 volt—500mA 45/-, p.p. 2/6
P112 o/P 6–9–12 volts lamp switched. Price £6.5.0
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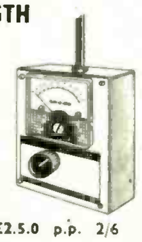
**BATTERY RECORD DECK**

British Made 3 speed 9 volt Deck. Takes all size of record. Fitted crystal cartridge. Brand New. P· · 60 4/-.

### *FIELD STRENGTH METER

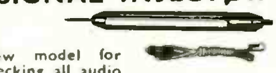


Covers 1–250Mc/s. Switches for model control and any application requiring peaking of transmitters and oscillators. 100µA meters. Complete with aerial.
**FS1 .. Price £2.5.0 p.p. 2/6**

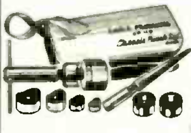
### *POCKET DOSIMETER

Small size Radiation Detector with bright easy to read scale. Fitted Pocket Clip. Range 0–50r. Brand new, quantity available. Price 12/- each

### *SIGNAL INJECTOR



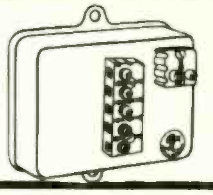
New model for checking all audio and RF up to VHF. Simple to use. Battery operated. Output approx. 1kc/s, 1·4V pp. Harmonics up to VHF.
**SE250B Price 35/- p.p. 1/6**



### *CHASSIS PUNCH KIT

Complete kit with punches ⅜in, ⅝in, ¾in, 1in, 1⅛in for metal, plastics, etc., up to 16 gauge.
**Price 55/-, p.p 4/6**

### *EXPERIMENTER'S MODULE



Terrific offer of brand new STC time delay electronic units. Adjustable 3–15 secs. 9–12V operated. Supplied complete with suggested used circuits.

**STC Module Price 35/- p.p. 2/6**

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Complete Range in stock of these Precision W/W Presets.

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### *MULTIMETER

Return of a popular model. 2000 ohms/V. 0/10/50/500/1000V a.c./d.c. 0/50µA. 0/10/250µA d.c. 0/10/100kΩ/1MΩ resistance. dB and capacitance scales. Size 5in. x 3½in x 1½in. Robust and easy to use. Complete with leads, batteries and instructions.
**THL 33A 82/6 p.p. 2/6**
**Leather case Price 22/6**

### *SWR ALIGNMENT METER

Ideal for all transmitter alignment. Built-in field strength meter 100µA. Complete. Ready to use. SWR 1:1 to 1:3.
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| ANTEX CN Iron .. .. | 29/6 |
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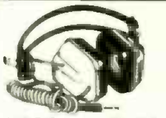
### *TRANSISTOR CHECKER

Complete capacity for checking all transistors npn and pnp for alpha, beta and leakage. Also diodes complete with leads and instructions.
**ZQM 2 .. Price £5.19.6 p.p. 3/6**

### STEREO HEADPHONES



Featuring soft Padded Headsets, wide frequency response. Adjustable Headbands. Fitted Jack plugs.

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| DHO 2/S Recommended 20C/S–15RC/S .. | £3. 9.6 |
| SE28 Built in Tweeters and Volume Controls | £9.19.6 |
| KOSS, KO727 £16.10.0. PRO-4A .. | £23. 0.0 |
| SP-3KC .. .. .. .. | £11.15.0 |

Above are mon/stereo suitable for 8-16 ohm systems.

Mono Switched 8/16 ohms and 4K ohms Price £4.4.0

**Stereo Headphone Amplifiers**
Inputs for PU/Tuner, Battery Model Mains Operated High Quality

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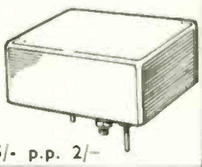
### *STC CRYSTAL FILTER



10·7Mc/s Crystal Filter Type 445 / LQU / 904A. Band Pass 10·7 6dB is ± 20 Kc/s. Insertion loss 5dB. Parallel terminations 2·7K, 25K. Normal Price £18.

**BRAND NEW SPECIAL OFFER 75/- p.p. 2/-**

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- 2½in units 6/8W, 5kc/s to 15kc/s. 8 ohms (suitable for 3–8 ohms). Price 12/6, p.p. 1/6.
- 3in units 10/12W, 3kc/s to 20kc/s. For 3 to 8 ohms—Price 15/-, p.p. 2/-. For 12 to 16 ohms—Price 20/-, p.p. 2/-.

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*For complete listening satisfaction choose either the—*

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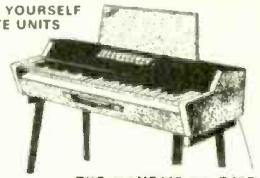

THE MAYFAIR 99 GNS
BROCHURE 9

### The MAYFAIR

A completely new development in portable electronic musical instruments and a new field for the home constructor. The 'MAYFAIR' produces a multitude of the most pleasing sounds with a wide range of tone colours suitable for classic or popular music. **The organ is fully polyphonic, that is full cords can be played over the entire keyboard.** Supplied as a kit of parts which includes 165 transistors, printed circuits panel, special fully sprung and depth of touch adjusted keyboard, attractive vynair covered cabinet with carry handle. A complete detailed and illustrated construction manual is provided with circuits and full parts list. All items may be purchased separately. All parts supplied are fully guaranteed. Full after sales service.

Deferred terms available
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Deposit £29.19.0
12 monthly payments of £7. Total £113.19.0
BUILT AND TESTED
Deposit £36.8.0 and
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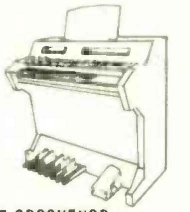
### The GROSVENOR

is designed for the more ambitious musician and has a much wider range than most commercial organs. **It comprises two four-octave (49 note) keyboards and a thirteen-note pedal board.** It has four pitches (i.e. 8ft. 4ft. 2ft. 1ft) on the upper or solo keyboard, three pitches (i.e. 16ft. 8ft. 4ft) on the lower or accompaniment keyboard, two pitches (i.e., 16ft. 8ft) on the pedal board. Variable sustain on the solo keyboard and variable vibrato on both keyboards. It has 15 voices in the solo tone-forming unit 10 voices in accompaniment tone-forming unit and 4 voices in the pedal tone-forming unit. **All components and kit sections are available separately including the Oak Console at £65 18 0.**

A complete detailed and illustrated construction manual is provided with circuits and full parts list. All items may be purchased separately. All parts supplied are fully guaranteed. Full after sales service and advice freely available.

**Once built the 'MAYFAIR' or 'GROSVENOR' will then provide years of enjoyable entertainment.**
**Call in—See them for yourself.**



THE GROSVENOR
KITS FROM £220 terms available
BROCHURE 9B

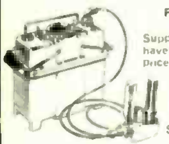
### PRACTICAL ELECTRONICS – ELECTRONIC ORGAN KIT

We are able to supply Parts as described in this series. Details on request

ORGAN COMPONENTS: COMPLETE RANGE IN STOCK · 49 AND 61 NOTE KEYBOARDS · 2 TO 5 AMP GOLD CONTACTS COILS AND CHOKES · REVERBERATION SPRINGS AND UNITS · STOP TABS AND ASSEMBLIES · PEDAL BOARDS · RHODIUM AND GOLD CLAD WIRE, ALSO PRINTED CIRCUITS ETC. COMPLETE RANGES FOR TRANSISTORISED ORGANS. ASK FOR NEW PRICE LISTS WITH DETAILS. LEAFLET 9B

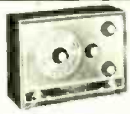
ALL ENQUIRIES TO: ORGAN DEPT. MR ELVINS

## PORTABLE GEIGER COUNTERS



FOR MEASUREMENT OF RADIO-ACTIVITY.
Supplied complete with instructions haversack, cables and probe. List price £70. OUR PRICE, NEW, TESTED COMPLETE WITH BATTERIES
£7.10.0
POST 10.
SPARE BATTERIES 15/- PAIR
POST 5/-

## NEW MODELS NOMBREX
### TRANSISTORISED Test Equipment



| MODEL | | £ | s. | d. | Leaflet No. |
|---|---|---|---|---|---|
| 29s | RF. Gen. | 21 | 0 | 0 | 35 |
| 29x | Xtal RF Gen. | 29 | 10 | 0 | 36 |
| 30 | Audio Generator | 19 | 10 | 0 | 24 |
| 31 | R.F. Generator | 12 | 10 | 0 | 25 |
| 32 | C.R. Bridge | 10 | 10 | 0 | 26 |
| 33 | Inductance Bridge | 20 | 0 | 0 | 29 |

## GRAVINER FIRE DETECTOR UNIT

The Detector Unit consists essentially of a highly sensitive 931A photo-electric cell combined with a firing circuit. Incorporates a single cold cathode electronic relay, capacitors and resistors designed to fail to safety if external wiring is open or short circuited. Encapsulated in a resin which fully insulates the unit electrically and provides a high degree of mechanical and thermal shockproofing. Original price £74. OUR PRICE, BRAND NEW £6 each, with data sheet

SIZE 4 x 3 x 2½ in.
Limited quantity available

## MULLARD 1 WATT AMPLIFIER

PORTABLE TRANSISTOR UNIT with volume control
Many uses: Intercoms, Baby Alarms, Guitar Practice, Telephone or Record Player Amplifier.
Optional Rexine covered Wood cabinet 12 x 9 x 4, 12/6.
7 x 4 in. speaker, 17/6.
Uses PP9 battery.
**45/-** pp. 3/6d.
Ask for Leaflet 2.

## BUILD A QUALITY TAPE RECORDER

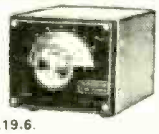
To get the best out of your MAGNAVOX DECK, you need a MARTIN RECORDAKIT. This comprises a special high quality 6 valve amplifier and pre-amplifier which comes to you assembled on its printed circuit board—in fact everything needed down to the last screw FOR MAKING A SUPERB TAPE RECORDER, which, when built, will compare favourably with instruments costing twice as much, yet you need no experience or technical skill to bring this about. THE INSTRUCTIONS MANUAL MAKES BUILDING EASY AND SUCCESS ASSURED

2 Track 36 gns. 4 Track 39 gns.
P.P. 22/6 either model
Kit comprises: Deck, Amplifier, Cabinet and speaker, with MICROPHONE 7 in 1,200 ft. tape, spare spool.
ALL UNITS AVAILABLE SEPARATELY. Today's Value £60.
ASK FOR BROCHURE 6.

## VHF FM SUPERHET TUNER MKII

'5 MULLARD TRANSISTORS & 4 DIODES ' 300 Kc/s BANDWIDTH ' PRINTED CIRCUIT CONSTRUCTION ' HIGH FIDELITY REPRODUCTION MONO AND STEREO

A popular VHF FM Tuner now used throughout the country for quality reception of monophonic and, with the decoder stereophonic broadcasts. There is no doubt about it—VHF FM gives the the *real sound*. Excellent stability economically priced.



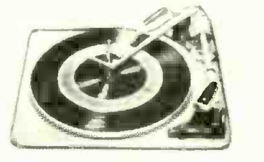
PARTS TOTAL COST £6.19.6.
*DECODER* £5.19.6.
(CABINET 20/- EXTRA) ASK FOR LEAFLET 3.

## NEW—MALLORY LONG LIFE MERCURY BATTERIES 50% OFF LIST PRICES

*RM12 1.35 volts 3600 m/aH size 2" x ⅝ dia. OUR PRICE 5/- each

* RM625 10.35 volts 350 m/aH Pack of 8. Size 2⅛ x ⅝ dia.
OUR PRICE 10/- each
Easily split into eight 1.35v cells. These cells are ideal for any application where SMALL SIZE HIGH CAPACITY and LONG LIFE are required.
QUANTITIES AVAILABLE.

## GARRARD RECORD DECKS



BRAND NEW All below list price

| | £ | s | d |
|---|---|---|---|
| 2025 Mono/Stereo GKS 25 | 8 | 8 | 0 |
| 3000 LM Mono/Stereo 9TAHC | 9 | 18 | 6 |
| SP25 Mk II | 11 | 19 | 6 |
| AT60 Mk II | 13 | 0 | 0 |
| AP75 | 19 | 0 | 0 |
| SL55 | 11 | 19 | 6 |
| SL65 | 14 | 14 | 0 |
| SL75 | 29 | 0 | 0 |
| SL95 | 35 | 0 | 0 |
| A70 Mk II | 12 | 12 | 0 |
| B S R UA25 Mono | 5 | 19 | 6 |
| MA65 | 9 | 19 | 6 |
| MA70 | 12 | 12 | 0 |
| MA75 | 15 | 5 | 0 |
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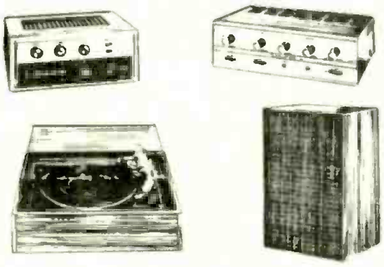

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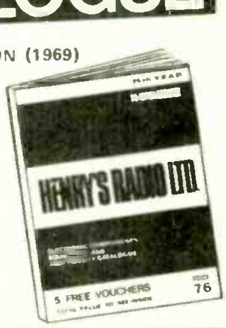


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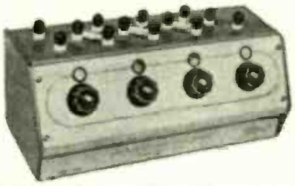
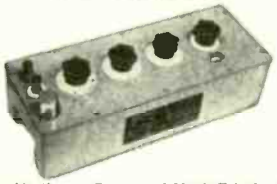
## ★ BRAND NEW LABORATORY TEST EQUIPMENT AT LESS THAN HALF PRICE!

### HIGH VALUE RESISTANCE BOX TYPE R.7003



Specification. Range: 0.01-11.10 Megohm in 111.0 Megohm divisions. Accuracy: 0.05%. Maximum power rating: 0.1W per step. Case: Hammer finished stove enamel.
List price £60. Our price **£22/10/-.**

### DECADE CAPACITANCE BOX TYPE R.7004



Specification. Range: 0.00002uF-1uF in 0.00002uF steps. Accuracy: 0.5%. Frequency Range: 40 c/s-10 Kc/s for all decades except X1=40 c/s-5 Kc/s. Case: Hammer finished stove enamel.
List price £60. Our price **£22/10/-.**

### MUTUAL INDUCTANCE BOX TYPE R.7005

Specification. Range: 0-11.110mH in 0.002 mH divisions. Accuracy: $\pm(0.3 \times \frac{0.012}{M})\%$ where M = value of mutual inductance in mH set on the box. Frequency range: 0-2.5 Kc/s for all decades except X1 = 0-15 Kc/s. Maximum current: 0.5A for decades 1A for variometer (both primary and secondary windings). Case: Polished teak.
List price £65.
Our price **£26/10/-**

### MUTUAL INDUCTANCE COIL TYPE R.7006

Specification. Value: 0.001 H. Accuracy: ± 0.3%. Operating Frequency: 5 Kc/s, 10 Kc/s. Maximum current: 1A, 3A. Resistance of coils: 4 ohm, 1 ohm. Case: Moulded plastic.
List price 8 gns.
Our price **50/-.**

★ A Special price of £65 is offered if the following equipment is ordered together: High Value Resistance Box, Decade Capacitance Box, Mutual Inductance Box, Mutual Inductance Coil.

### PORTABLE WHEATSTONE BRIDGE

Specification. Type: Moving Coil Galvanometer. Ranges: 1. 0.05 to 5 ohms. 2. 0.5 to 50 ohms. 3. 5 to 500 ohms. 4. 50 to 5,000 ohms. 5. 500 to 50,000 ohms. Scales: Switched. Slidewire: 0.5 to 50. Galvanometer Scale: 10-0-10. Case: Moulded plastic. Internal Source: 4V. Dry battery. Operating Temperature: +10 to +35 deg. C. Operating Humidity: Up to 80% R.H. Dimensions: 200 × 110 × 65mm. Weight: 0.9 kg.
List price £25. Our price **£9/19/6.**

### PORTABLE MULTIRANGE METER

Specification.
Ranges: 0-60 & 0-300uA. D.C. 0-3. 0-30 & 0-120mA. D.C. 1.2 & 12 amps D.C. 0.6-3 & 6-30 mA. A.C. 24-120 mA, A.C. 0.24-12A. A.C. 3-12-30-300-600-1,200 & 6,000 V, D.C. 0.6-3. 2.4-12. 6-30, 60-300, 120-600. 240-1,200 & 1,200- 6,000 V. A.C. 3-333 ohms. 0.3-30 Kohms. 0.03-3 megohms D.C. Resistance —12 to +78 Decibels. Frequency: 50 cps. Input Resistance D.C.: 20,000 ohms/volt. Input Resistance A.C.: 2,000 ohms/volt. Temperature Range: —10 to +50 deg. C. Dimensions: 255 × 215 × 170mm. Weight: 8 kg. Supplied with 2 voltage dividers. H.V. leads. spare rectifiers. 1.5 & 22.5 V. battery.
List price £25. Our price **£12/19/6.**

### SET OF MEASURING INSTRUMENTS

Specification Type: Moving Coil D.C. Ranges: 0-75mV, 0-3V, 3-15-150V, 3-150-450V, 0.3-0.75A. 1.5-7.5A. 15-30A. Scale Length: 82mm. Accuracy: 1.0%. Shunts: 1. 0.3-0.75 amps. 2. 1.5-7.5 amps. 3. 15-30 amps. Case: Moulded plastic. Carrying Case: Stove enamelled metal.
List price £30. Our price **£12/19/6.**

★ ILLUSTRATED LEAFLETS AVAILABLE ★

### PORTABLE RECORDING MILLIAMMETER

Specification. Type: Moving Coil, D.C. Range: 0-500 milliamps. Chart Width: 100mm. Scale Length: 127mm. Chart Speeds: 20, 60, 180, 600, 1800 and 5400 mm/hr. Precision: 1.5%. Shunts: 75mV (Internal). Operating Temperature: + 5 to + 50°C. Dimensions: 180h × 163 w × 245mm. Weight: 5.5kg. Complete with: 10 chart rolls, gears, inks, pipette, scale template and component case. List price £65. Our price **£35.**

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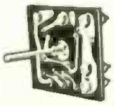

600w. module. Ideally suitable for photoflood or speed controller, etc. Will mount into standard socket boxes. Our price **49/6** + p. & p. 3/-.

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F.S.D. ± 10V, with sensitivity control set to maximum. F.S.D. ± 51V. Accuracy: Response such as to provide a record of a 3-5 c/s signal with not more than 30% less of amplitude as compared with a d.c. signal of valve equal to the peak a.c. amplitude. Power required: 230-50-60 and any of the following polarised voltages:
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58V—60 c/s 200V—60 c/s 20V—1,100 c/s
50V/1,100 c/s
Performance: Using Teledeltos paper enabling three separate channels to be recorded simultaneously. Chart speed 12in./min., chart width 12in. 3½in. per channel. Wt. 67½ lb. Size: 22 × 21 × 11 in. **£89/10/0.**

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- CHOKE OF CAPACITOR transistorised 120/130 volt A.C. INPUT.

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### TEN TURN 3600° ROTATION BRAND NEW

| Res. Ohms | Linearity Per cent | Manufacturer | Model | Price |
|---|---|---|---|---|
| 100/100/100 | | Beckman | A | 160/- |
| 100 | 0.5 | Beckman | A.8 | 60/- |
| 200 | 0.5 | Beckman | A | 60/- |
| 500 | 0.1 | Beckman | 8 | 70/- |
| 500 | | Colvern | 2501 | 45/- |
| 500 | | Foxes | PX4 | 40/- |
| 500 | | Colvern | 2610 | 50/- |
| 2K | 0.5 | Beckman | 8A1101 | 60/- |
| 2K | | Beckman | 7216 | 60/- |
| 2K | | Reliance | GPM15 | 40/- |
| 10K | 0.5 | Beckman | A | 60/- |
| 10K | 0.1 | Beckman X | A | 70/- |
| 10K | 0.05 | Beckman | A | 95/- |
| 15K | | Foxes | GPM15 | 50/- |
| 18K | | Beckman | A | 60/- |
| 20K | 0.5 | Beckman | A | 60/- |
| 20K | 0.05 | Beckman | 8A1244 | 95/- |
| 30K | | Colvern | 2402 | 30/- |
| 30K | | Beckman | 8A 95C | 60/- |
| 30K | 0.1 | Beckman | A.88 | 70/- |
| 30K | 0.5 | Beckman | 8A 1692 | 60/- |
| 30K | 0.25 | Beckman | 8A 1692 | 65/- |
| 50K | | Reliance | 07.10 | 45/- |
| 50K | | | 07.5 | 45/- |
| 50K | | Colvern | 2503 | 45/- |
| 50K | X | Foxes | PX 4 | 45/- |
| 50K | 0.5 | Beckman | A | 60/- |
| 50K | 0.1 | Beckman | A | 70/- |
| 100K/100K | | Ford | A | 100/- |
| 100K | 0.1 | Beckman | A | 70/- |
| 100K | 0.5 | Beckman | A | 60/- |
| 100K | | Colvern | 2501 | 45/- |
| 100K | | Colvern | 2610 | 50/- |
| 298K | 0.1 | Beckman | 8A 3902 | 70/- |
| 300K | 0.1 | Beckman | A | 70/- |

### THREE TURN 780° ROTATION

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|---|---|---|---|---|
| 100/100 | 0.5 | Beckman | A | 60/- |
| 300 | | Beckman | 9303 | 45/- |
| 10K | 0.5 | Beckman | A | 35/- |
| 10K | 0.5 | Beckman | C.ss | 45/- |
| 10K | 0.1 | Beckman | C | 55/- |
| 20K/20K | 0.1 | Beckman | C.8 | 60/- |
| 10K/10K | 0.1 | Beckman | C | 60/- |
| 50K | 0.5 | Beckman | C.8 | 35/- |

### FIFTEEN TURN 5400° ROTATION

| | | | |
|---|---|---|---|
| 25K/25K | Beckman B | 10 watts | £6.10s. |
| 46/K/46K | Beckman B | 10 watts | £6.10s. |

### TWENTY TURN 7200° ROTATION

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| 250 ohms | General Controls | PXM130 | 80/- |
| 1 Meg | General Controls | PXM130 | 80/- |
| 50K | Reliance | | 40/- |

### 156 TURN 56,160° ROTATION

460 ohms . . Kelvin Hughes . . . . KTP0701 **£9.10s.**

### FIVE TURN 1800° ROTATION

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| 500 ohms | Colvern | CLR 2505 | 40/- |
| 1.5K | Colvern | CLR 2605 | 40/- |

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| Colvern 8601 | 10K | £12.10s. |
| Colvern 9501 | 11K C.T. | £16.10s. |
| CLR 9604—Cam Corrected 25K | | £20. |
| 9101A/A 20K | | £16.10s. |

### PRECISION BECKMAN 40 TURN 14,400° ROTATION

Wirewound Precision Potentiometer. SE 107A 20 watts at 40°C. 3 $\frac{1}{16}$" Diameter. Servo Mounting. 200K. Brand New **£12.10s.** List Price £30.

### TRIMPOTS
990 GB — Wirewound Micropot Potentiometer. Low noise. Brand new, by well known manufacturer. 1 watt @ 70°C. 100 ohms and above ±5%. Available in the following values: Ohms: 5, 15, 25, 50, 100, 250, 400; 1K, 2K, 2.5K, 10K, 25K. **10/-** each.

### FERRANTI PRECISION CONTINUOUS WIREWOUND POTENTIOMETER, TYPE P4A

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Ideal for instrument chart drives, extremely quiet; useful in areas where ambient noise levels are low. Having a high starting torque a relatively high inertia load can be driven. 6 oz./in. at 1 r.p.m. 240 volts 50 cycles. 10 r.p.m. R, 1 r.p.m. R & L, ¼ r.p.m. L, ½ r.p.m. R, 1/5 r.p.m. R, 1/10 r.p.m. R, 1/12 r.p.m., 1/20 r.p.m., 1/40 r.p.m., 1/60 r.p.m., 1/180 r.p.m., 1/360 r.p.m.; 1/6 r.p. hour, 1/12 r.p.h.; 1 r.p.m., 1½ r.p.m. 25/-.

**HYSTERESIS CLUTCH MOTOR** with integral clutch allowing the motor to drop out of engagement with the gear train, thereby facilitating easy resetting when used in timers or in conjunction with a light spring. 6 oz. torque at 1 r.p.m. 240 v., 50 c/s. L=left, R=right. 15 r.p.m. L, 8 r.p.m. R & L, 6 r.p.m. L. 4 r.p.m. ¼, ½, ⅓ r.p.m. L. 1/5 r.p.m., 1/6 r.p.m., R & L, 1/10 r.p.m., 1/12, 1/15 r.p.m. L. Also 120 v. 50 c/s 2, 1/6, 1/12, 5/12, 4/11, 1/10 r.p.m. 25/-.

**TORQUEMOTOR 225 BY ELLIOTT** Originally designed to operate hydraulic valves or hydraulic motor under extreme conditions of temperature, altitude and vibration. The torquemotor is practically unaffected by vibration or sudden shock, i.e. consists of a moving iron rotor with a travel of 7 degrees either side of centre. MIN TORQUE (gm-cm) 500 at zero at 6 degree. 70 gm cm. Total hysteresis at 0°C. 0-58 degree current 45 M/A. £9.10.0.

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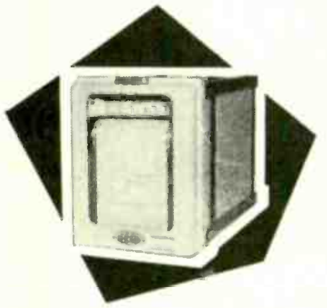
**SINGLE PEN RECORDER BY RECORD ELECTRICAL**



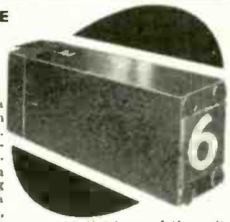
(Illus.). 3 in. chart, sensitivity 500 micro amps. Coil res. 1.53k. Fully interchangeable gears available to make a wide range of chart speeds. 200/250v. Size: 8 × 11 × 6 in. Brand new—complete with chart and ink. List over £100. Our price £49.10.0.

**TRANSITROL 2 POSITION INDICATING TEMPERATURE CONTROLLER BY ETHER**

**TYPE 990**

Completely transistorised self-contained direct deflecting units for indicating and controlling temperature accurately over a wide range. Suitable where a signal can be converted into D.C. Sensitivity 10 ohms per M.V. Minimum F.S.D. 8 M.V. Cold junction compensation, thermocouple break protection. Coppe compensation. Calibrated scale length, 6.5 in., 0-800 degrees centigrade accuracy ±1%. Front panel size 10 × 5½ in., weight 11 lb. Mains supply 100-260 v. Control switching and Thermocouple connections all at back of case. Our price £22.10.0. List price £49. New condition.

**MINIATURE DIGITAL DISPLAY**

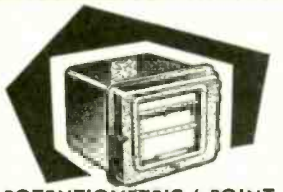


Operates on a rear projection 6.3 pilot lamp. The lamp projects the corresponding digit on the condensing lens through a projector lens, on to the viewing screen at the front of the unit. 1 in. width, 3 1/16 in. deep. 1 7/16 in. high. Weight 3½ oz. Character size ¾ in. high, 0.9 with 8 right hand decimal point and degree. Available to special order, words and other characters or colour, at cost of artwork or plates. List price 6 gns. Our price 49/6.

**EAC DIGIVISOR Mk. II DIGITAL READ-OUT DISPLAY**

Ideally suitable for use in conjunction with transistorised decade counting devices. No need for amplifiers or relays as only a few milliwatts of power are required to charge the digits. The DIGIVISOR incorporates a moving coil movement which moves a translucent scale through an optical system and the resultant single plane image is projected on a screen. The translucent scale is made to represent digits 0-9. Specifications: 6.3 volt, 250 microamp. Image height ⅝ in. Size 4 9/16 × 2 39/64 × 1½ in. Our price 3½ Gns. List price 8½ gns.

**FOUR CHANNEL HIGH SPEED PEN RECORDER** by Kelvin Hughes, with four channel amplifier, giving a frequency range of 0-100c/s.
The Recorder consists basically of a magnet carrying in its poles four stiffly suspended moving coil units, each with a stylus arm attached. The stiffness of the coil unit suspension enables the instrument to withstand the effects of vibration and acceleration.
Mains operated. Pen deflection ± 7.5 m.m.
6 chart speeds—0, 5; 1; 2; 4; 8; and 16 cm/sec.
Excellent condition. £195
N.B. Two channel version available, giving ± 16.5 m.m. deflection.

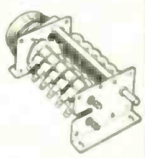


**POTENTIOMETRIC 6 POINT STRIP CHART RECORDER BRAND NEW**

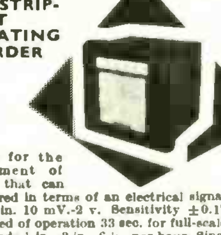
For use with thermocouplers, pyrometers and other e.m.f. sources. 6 point. Range (—100) —0—(+100) mV; 0—1.600 deg. C. 6¼ in. chart width; pen speed 8 secs. Accuracy ±0.5%; 10 chart speeds 20-720mm/hr. Tropicalised. Including tools and spares. Listed at over £200. Our price £79.10.0. 12 point version available £99.10.0.

**REPEAT CYCLE TIMERS**

These timers repeat a set cycle of switching operations via a cam and micro switch, for as long as the motor is energised. Single Cam RB 21 in 2 min., 3 min., 4 min., 5 min., 6 min. cycles @ 45/-. Twin Cam RD 22 in 1 min., 2 min., 3 min. 4 min., 5 min. cycles @ 55/-. 4 Cam RD 24 in 4 min., and 5 min. cycles @ 75/-. 6 Cam RD 26 in 1 min., 2 min., 3 min., 4 min., 5 min. cycles @ 95/-. 8 Cam RD 28 in 1 min., 2 min., 3 min., 4 min., 5 min. cycles @ 115/-. All + p. & p. 5/-.



**KENT STRIP-CHART INDICATING RECORDER**



Suitable for the measurement of anything that can be measured in terms of an electrical signal Chart width 9¾ in. 10 mV.-2 v. Sensitivity ±0.17 of full scale. Speed of operation 33 sec. for full-scale travel. Chart speeds ¾ in., 3 in., 6 in. per hour. Single point £49.10.0.

**DIGITAL MAGNETIC DATA STORAGE DECK**

**Seven track record replay heads**

These machines originally ex-computers, but lend ideally for use as audio stereo multi-track recording units or data storage. Record and Playback Heads encased in one common unit. This unique close spacing of Record and Playback Head will enable the operator to monitor instantly while recording, crosstalk between tracks absolute minimum. Head Resistance 40 ohms and 7 ohms. Freq. Response approx. 30 c.p.s.—30 Kc/s with a good response to 50 Kc/s. Deck driven by one synchronous capstan motor and two variable-speed rewind motors. Electro-pneumatic capstan take-up mechanism. Speed 37½ i.p.sec. (Note: Capstan Head can be easily removed and any diameter Capstan Head corresponding to any speed can be fitted.) All deck function push buttons are illuminated and are brought out to separate multi-core leads which can be wired to any deck function or auxiliary equipment. Finished in brush-aluminium and matt-black. Size: 27 × 26 × 8 in. Weight 90 lb. 230v-380v. A.C. Capstan motor speed 1,500 r.p.m. Must have cost £1,000. Our price £65. New condition but ex-equipment. VACUUM ASSEMBLY required for computer and data use. £7.10 extra. Seven Track record replay head, ex-computer, complete with guides, little used. £12.10.0.
½ in. Tape, 2,400 ft. £8.10. new. Empty reels 25/-, in cassettes 45/-.
AMPEX FR300 Tape Deck in free standing 6ft. cabinet less heads. £99.10.0.

**MINIATURE MOVING COIL RELAY S115**

By Sangama Weston, suitable for D.C. circuit. A high sensitivity relay more sensitive than the electromagnetic type. Single Coil Resistance 2K. 50 - 0 - 50 Micro-Amp. List price £4.10. Our price 20/-

**BRAND NEW S.E. LABORATORIES TRANSDUCER** complete with encapsulated Amplifier/demodulator S.E. 441/2
Frequency D.C.—60 c.p.s.
Available in the following ranges:
SE150, SE50 or SE165A.

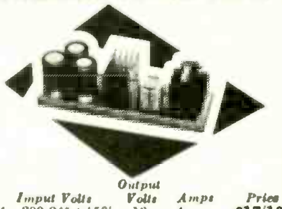
| | | |
|---|---|---|
| 0 - 25 p.s.i. | 0 - 350 p.s.i. | 0 - 2000 p.s.i. |
| 0 - 50 p.s.i. | 0 - 500 p.s.i. | 0 - 3000 p.s.i. |
| 0 - 200 p.s.i. | 0 - 750 p.s.i. | 0 - 4000 p.s.i. |

Also available differential types ± 5 p.s.i., ± 10 p.s.i.
List price £70 + Our price £15

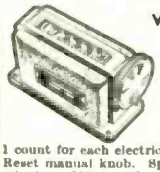
**PHOTOMULTIPLIER VMP11/44 (CV 2317) by 20th Century Electronics** Cathode sensitivity 40μ A/L. Operating volts for 10 A/L 1100 volts. DARK current 0.004μA. £8.10.0.

**PROGRAMME BOARDS BY SEALECTRO.** These boards are basically a multi pole multi throw switch device consisting of a X-Y Matrix with two contact decks in the Z Plane running at 90 degrees to each other. Contact is made by either, shorting or plugging in pins. Ideal for prototype work, etc. Boards available in 16 × 16 2 plane £4.5.0.
24 × 60 2 plane £12.10.0. Pins available 1/3 each.

**ADVANCE TRANSISTORISED DC STABILISED POWER UNITS**

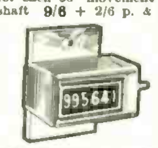


| | Imput Volts | Output Volts | Amps | Price |
|---|---|---|---|---|
| DC 4 | 200-245 ± 15% | 12 | 4 | £17/10/- |
| DC 3 | 200-245 ± 15% | 12 | 1.25 | £10/10/- |

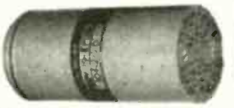


**VEEDER ROOT SIX DIGIT COUNTER** Suitable for counting all kinds of production runs, business machine operation. Electro mechanically driven 1 count for each electrical impulse received. Reset manual knob. Speed 800 counts per minute. 230 v., 50 cycle. Size 3.25 × 2.5 × 1.62 in. Ex-equipment but new condition. Special price 55/- + 5/- p. & p.

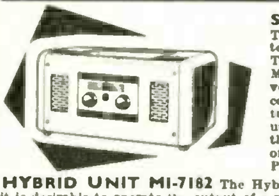
**MINIATURE SQUARE COUNTER 6 DIGIT** by Veeder Root. Rotary ratchet type, adds 1 count for each 36° movement of shaft 9/6 + 2/6 p. & p.



**HI-SPEED QUICK RESET ELECTRO MAGNETIC COUNTERS** Push button reset 6 digits. 48v. DC 3.5 watts. 20 counts per second. Size 3.875 × 2.625in. Panel mounting. List £8. Our price 79/6.



**"V" SCAN DIGITAL SHAFT ENCODER BY MOORE REED** TYPE 18 DV-19-EP 116 3 discs. Size 18. Counts 524288 in 1024 revolutions of shaft in V Scan. Brand new in maker's original sealed tins. List price £75 approx. Our price £22.10.



**SPEECH INVERTER MI-7181-A**
The R.C.A. Speech Inverter is a device intended for use in radio-telephone installations where privacy is a prime consideration. The equipment when used in conjunction with the R.C.A. MI-7182 Hybrid Transformers enables parallel two-way conversations on a single telephone pair line at each terminal of the communications system. With inversion, speech fed into the transmitting inverter circuit will feed the radio transmitter with unintelligible signals. These signals will remain unintelligible until they pass through a receiving inverter circuit at the other end of the communication channel. (Used only under Licence in U.K. P.O.A.) £12.10.0.

**HYBRID UNIT MI-7182** The Hybrid Unit is designed for use with the Speech Inverter where it is desirable to operate the output of a receiving circuit and the input of a transmitting circuit from a single pair of telephone wires whose electrical characteristics are essentially constant. When the Hybrid Unit is properly connected and balanced to the line, high attenuation will be provided between the receiver output circuit and the transmitter input circuit. £10.10.0.

**EVERSHED BRIDGE MEGGER**

250 volt, 50 meg. Insulation tester with built-in four decade bridges with ratio arms giving ratios of 100-10 — 1 — 0.1 + 0.01 and Selector switch for insulation, resistance and variety measurements. £29.10.0.
500 volt 0-100 meg. with Varley Loop. £69.10.0.

**VACTRIC 144-WAY HIGH SPEED MINIATURE SAMPLING SWITCHES,** consisting of 24 segments in six bank. 8000 samples per second can be obtained from these switches. Ideally suitable for data logging application. Low inherent noise and contact resistance permitting high speed sampling of the most difficult transducers. Pulse generator for digital counting. Brand new. £25.

**DIFFERENTIAL PRESSURE TRANSDUCERS** by Sifam Ltd. G.B. Type H33
Range ± 900MB Resistance 942 ohms.
Our Price £19.10.0

**HOLLERITH 80 COLUMN CARD VERIFIER.** Complete with Verifier By ICT, Type No. H 129/2489. Good condition £95.

**ELECTRONIC BROKERS LTD., 49-53 PANCRAS ROAD, LONDON, N.W.1. Tel: 01-837 7781/2 Cables: SELELECTRO**


www.americanradiohistory.com

# SEMICONDUCTORS

## BRAND NEW FULLY GUARANTEED

### A SELECTION FROM OUR MAY CATALOGUE LISTED BELOW

**DIODES & RECTIFIERS**

| | |
|---|---|
| IN461 | 1/6 |
| IN914 | 1/6 |
| IN916 | 1/6 |
| IN4007 | 4/6 |
| IS010 | 3/- |
| IS021 | 4/- |
| IS025 | 5/- |
| IS113 | 3/- |
| IS120 | 2/6 |
| IS121 | 2/6 |
| IS130 | 2/6 |
| IS132 | 2/6 |
| IS131 | 3/- |
| AA119 | 2/- |
| AAZ13 | 2/- |
| AAZ15 | 2/6 |
| AAZ17 | 2/6 |
| BA100 | 2/- |
| BA115 | 1/6 |
| BAX13 | 2/6 |
| BAX16 | 2/6 |
| BAY18 | 3/6 |
| BAY31 | 2/6 |
| BAY38 | 2/6 |
| BY100 | 4/6 |
| BY122 | 3/- |
| BY124 | 3/- |
| BYX10 | 5/6 |
| BYZ10 | 9/- |
| BYZ11 | 7/6 |
| BYZ12 | 6/6 |
| BYZ13 | 5/- |
| FST3/4 | 4/6 |
| FST3/8 | 6/- |
| OA5 | 2/6 |
| OA9 | 2/- |
| OA47 | 2/- |
| OA70 | 1/6 |
| OA73 | 2/- |
| OA79 | 1/9 |
| OA81 | 1/6 |
| OA85 | 1/6 |
| OA90 | 1/6 |
| OA91 | 1/6 |
| OA95 | 1/6 |
| OA182 | 2/- |
| OA200 | 2/- |
| OA202 | 2/- |

**BRAND NEW 1½ AMP PLASTIC RECTIFIERS**

| PIV | Price |
|---|---|
| 50 | 2/9 |
| 100 | 3/- |
| 200 | 3/3 |
| 400 | 3/6 |
| 600 | 3/9 |
| 800 | 4/- |
| 1000 | 4/6 |

**3 AMP STUD TYPE**

| PIV | Price |
|---|---|
| 50 | 3/- |
| 400 | 4/6 |
| 800 | 6/- |

**TRANSISTORS**

| | |
|---|---|
| 2G371 | 3/- |
| 2G374 | 5/6 |
| 2G381 | 4/6 |
| 2N696 | 5/- |
| 2N697 | 5/- |
| 2N706 | 2/6 |
| 2N706A | 2/6 |
| 2N708 | 4/- |
| 2N753 | 5/6 |
| 2N914 | 3/6 |
| 2N916 | 3/6 |
| 2N929 | 5/6 |
| 2N930 | 6/6 |
| 2N987 | 10/6 |
| 2N1131 | 8/6 |
| 2N1132 | 8/6 |
| 2N1302 | 4/6 |
| 2N1303 | 4/6 |
| 2N1304 | 5/6 |
| 2N1305 | 5/6 |
| 2N1306 | 6/6 |
| 2N1307 | 6/6 |
| 2N1308 | 8/- |
| 2N1309 | 8/- |
| 2N1420 | 7/6 |
| 2N1507 | 7/6 |
| 2N1527 | 7/6 |
| 2N1605 | 9/6 |
| 2N1613 | 6/6 |
| 2N1711 | 6/6 |
| 2N1889 | 8/- |
| 2N1893 | 8/- |
| 2N2147 | 17/6 |
| 2N2148 | 12/6 |
| 2N2160 | 14/6 |
| 2N2193 | 5/6 |
| 2N2193A | 5/6 |
| 2N2194A | 4/6 |
| 2N2217 | 6/- |
| 2N2218 | 6/- |
| 2N2219 | 6/- |
| 2N2220 | 5/- |
| 2N2222 | 5/- |
| 2N2287 | 21/6 |
| 2N2297 | 6/- |
| 2N2302 | 12/6 |
| 2N2303 | 13/6 |
| 2N2368 | 8/6 |
| 2N2369 | 7/6 |
| 2N2369A | 5/- |
| 2N2411 | 6/6 |
| 2N2412 | 6/6 |
| 2N2483 | 5/6 |
| 2N2484 | 5/6 |
| 2N2539 | 4/6 |
| 2N2540 | 4/6 |
| 2N2613 | 7/9 |
| 2N2614 | 7/6 |
| 2N2645 | 6/- |
| 2N2646 | 11/6 |
| 2N2696 | 6/6 |
| 2N2711 | 8/6 |
| 2N2712 | 8/6 |
| 2N2713 | 9/- |
| 2N2714 | 9/- |
| 2N2904 | 8/- |
| 2N2904A | 8/- |
| 2N2905 | 8/- |
| 2N2905A | 8/- |
| 2N2906 | 8/- |
| 2N2906A | 8/- |
| 2N2907 | 8/- |
| 2N2923 | 4/- |
| 2N2924 | 4/6 |
| 2N2925 | 5/- |
| 2N2926: | |
| .. Green | 3/- |
| .. Yellow | 2/9 |
| .. Orange | 2/6 |
| .. Red | 2/9 |
| .. Brown | 2/6 |
| 2N3011 | 5/- |
| 2N3053 | 6/6 |
| 2N3054 | 12/6 |
| 2N3055 | 15/- |
| 2N3133 | 6/- |
| 2N3134 | 10/6 |
| 2N3135 | 6/- |
| 2N3136 | 6/- |
| 2N3390 | 10/6 |
| 2N3391 | 7/6 |
| 2N3391A | 6/- |
| 2N3392 | 6/6 |
| 2N3393 | 6/6 |
| 2N3394 | 5/6 |
| 2N3402 | 8/6 |
| 2N3403 | 9/- |
| 2N3404 | 12/6 |
| 2N3405 | 12/6 |
| 2N3414 | 6/6 |
| 2N3415 | 7/6 |
| 2N3416 | 7/6 |
| 2N3417 | 9/6 |
| 2N3570 | 12/6 |
| 2N3572 | 12/6 |
| 2N3605 | 5/6 |
| 2N3606 | 5/6 |
| 2N3607 | 4/6 |
| 2N3662 | 11/6 |
| 2N3663 | 12/6 |
| 2N3702 | 4/- |
| 2N3703 | 4/6 |
| 2N3704 | 5/6 |
| 2N3705 | 4/6 |
| 2N3706 | 4/- |
| 2N3707 | 4/- |
| 2N3708 | 4/- |
| 2N3709 | 4/- |
| 2N3710 | 4/- |
| 2N3711 | 4/- |
| 2N3721 | 7/6 |
| 2N3819 | 9/- |
| 2N3820 | 20/- |
| 2N3823 | 21/6 |
| 2N3900 | 10/6 |
| 2N3900A | 11/6 |
| 2N3901 | 19/6 |
| 2N3903 | 8/- |
| 2N3904 | 8/6 |
| 2N3905 | 8/6 |
| 2N3906 | 8/6 |
| 2N4056 | 12/6 |
| 2N4057 | 17/6 |
| 2N4058 | 6/6 |
| 2N4059 | 5/- |
| 2N4060 | 5/- |
| 2N4061 | 5/- |
| 2N4062 | 5/6 |
| 2N4244 | 8/6 |
| 2N4284 | 3/6 |
| 2N4285 | 3/6 |
| 2N4286 | 3/6 |
| 2N4287 | 3/6 |
| 2N4291 | 3/6 |
| 2N4292 | 3/6 |
| 2N4433 | 6/- |
| 2N4434 | 6/- |
| 2N3506 | 11/6 |
| 2S102 | 6/6 |
| 2S103 | 6/6 |
| 2S104 | 6/6 |
| 3N128 | 18/6 |
| 3N140 | 15/6 |
| 3N141 | 19/6 |
| 3N142 | 16/6 |
| 3N143 | 19/6 |
| 40152 | 24/- |
| 40250 | 16/6 |
| 40251 | 17/6 |
| 40253 | 8/6 |
| 40254 | 10/6 |
| 40360 | 12/6 |
| 40361 | 12/6 |
| 40362 | 14/6 |
| 40370 | 8/6 |
| 40467 | 16/6 |
| 40468 | 16/6 |
| AC107 | 6/- |
| AC126 | 4/- |
| AC127 | 3/- |
| AC176 | 5/6 |
| AC187 | 12/- |
| AC188 | 12/- |
| ACY17 | 5/- |
| ACY18 | 5/- |
| ACY19 | 5/- |
| ACY20 | 5/- |
| ACY21 | 5/- |
| ACY222 | 4/- |
| ACY28 | 4/- |
| ACY40 | 4/- |
| AD140 | 8/- |
| AD149 | 8/- |
| AD161 | 7/6 |
| AD162 | 7/6 |
| AF114 | 5/- |
| AF116 | 5/- |
| AF117 | 5/- |
| AF118 | 12/6 |
| AF124 | 5/- |
| AF125 | 5/- |
| AF126 | 5/- |
| AF127 | 5/- |
| AF181 | 8/6 |
| AF186 | 11/- |
| AF239 | 7/6 |
| AFZ11 | 5/6 |
| AFZ12 | 6/6 |
| ASY26 | 5/6 |
| ASY27 | 8/6 |
| ASY28 | 5/6 |
| ASY29 | 4/6 |
| ASZ20 | 7/6 |
| ASZ21 | 4/6 |
| AUY10 | 20/- |
| BC107 | 3/6 |
| BC108 | 3/6 |
| BC109 | 3/6 |
| BC113 | 6/6 |
| BC118 | 6/6 |
| BC125 | 13/6 |
| BC126 | 13/6 |
| BC145 | 13/6 |
| BC147 | 5/- |
| BC148 | 4/6 |
| BC149 | 5/- |
| BCY30 | 7/6 |
| BCY32 | 4/6 |
| BCY32 | 7/6 |
| BCY33 | 5/6 |
| BCY34 | 4/6 |
| BCY38 | 5/6 |
| BCY39 | 6/6 |
| BCY40 | 7/6 |
| BCY42 | 5/- |
| BCY43 | 5/- |
| BCY54 | 7/6 |
| BCY70 | 5/6 |
| BCY71 | 9/6 |
| BCY72 | 5/- |
| BD121 | 19/6 |
| BD124 | 12/- |
| BF115 | 4/6 |
| BF117 | 10/6 |
| BF167 | 6/6 |
| BF173 | 7/6 |
| BF180 | 8/6 |
| BF181 | 8/6 |
| BF182 | 7/- |
| BF184 | 7/6 |
| BF194 | 6/6 |
| BFX12 | 5/6 |
| BFX13 | 5/6 |
| BFX29 | 12/6 |
| BFX30 | 15/- |
| BFX43 | 8/6 |
| BFX44 | 8/6 |
| BFX84 | 8/3 |
| BFX85 | 10/- |
| BFX86 | 8/6 |
| BFX87 | 10/- |
| BFX88 | 5/- |
| BFY17 | 4/6 |
| BFY18 | 4/6 |
| BFY19 | 4/6 |
| BFY20 | 12/6 |
| BFY21 | 8/6 |
| BFY23 | 7/6 |
| BFY24 | 9/- |
| BFY25 | 5/- |
| BFY26 | 4/- |
| BFY29 | 10/- |
| BFY30 | 10/- |
| BFY36 | 4/- |
| BFY37 | 5/- |
| BFY41 | 10/- |
| BFY43 | 13/6 |
| BFY50 | 4/6 |
| BFY51 | 4/6 |
| BFY52 | 4/6 |
| BFY53 | 5/6 |
| BFY56A | 11/- |
| BFY75 | 6/- |
| BFY76 | 6/- |
| BFY77 | 11/6 |
| BFY90 | 12/6 |
| BSX19 | 5/6 |
| BSX20 | 5/6 |
| BSX21 | 8/6 |
| BSX76 | 4/6 |
| BSX77 | 6/6 |
| BSX78 | 6/6 |
| BSY26 | 4/- |
| BSY27 | 4/- |
| BSY28 | 4/- |
| BSY29 | 4/- |
| BSY38 | 4/6 |
| BSY39 | 4/6 |
| BSY40 | 5/6 |
| BSY51 | 10/6 |
| BSY52 | 6/- |
| BSY95A | 3/6 |
| D16P1 | 12/- |
| D16P2 | 12/6 |
| D16P3 | 13/- |
| D16P4 | 13/6 |
| GET113 | 4/- |
| GET114 | 4/- |
| GET873 | 3/- |
| GET880 | 6/- |
| GET881 | 4/6 |
| MAT100 | 6/- |
| MAT101 | 6/- |
| MAT120 | 6/- |
| MAT121 | 6/- |
| MJ480 | 20/6 |
| MJ481 | 27/6 |
| MJ490 | 22/6 |
| MJ491 | 29/6 |
| MPF102 | 8/6 |
| MPF103 | 7/6 |
| MPF104 | 7/6 |
| MPF105 | 8/- |
| MPS3638 | 6/6 |
| NKT0013 | 8/6 |
| NKT212 | 5/6 |
| NKT216 | 7/6 |
| NKT217 | 6/6 |
| NKT261 | 4/6 |
| NKT262 | 4/6 |
| NKT264 | 4/6 |
| NKT272 | 4/6 |
| NKT274 | 4/6 |
| NKT281 | 5/6 |
| NKT403 | 15/- |
| NKT404 | 12/6 |
| NKT405 | 15/- |
| NKT603 | 6/6 |
| NKT613 | 6/6 |
| NKT674F | 5/- |
| NKT677F | 5/- |
| NKT713 | 5/6 |
| NKT736 | 6/6 |
| NKT781 | 6/- |
| NKT10419 | 6/- |
| NKT10439 | 6/- |
| NKT10519 | 6/- |
| NKT20329 | 8/6 |
| NKT20339 | 10/6 |
| NKT80111 | 15/6 |
| NKT80112 | 19/6 |
| NKT80113 | 22/6 |
| NKT80211 | 18/6 |
| NKT80212 | 18/6 |
| NKT80213 | 18/6 |
| NKT80214 | 18/6 |
| NKT80215 | 18/6 |
| NKT80216 | 18/6 |
| OC26 | 6/6 |
| OC28 | 6/6 |
| OC30 | 8/- |
| OC35 | 6/6 |
| OC36 | 6/6 |
| OC41 | 4/- |
| OC44 | 4/- |
| OC45 | 2/6 |
| OC71 | 2/6 |
| OC72 | 4/6 |
| OC75 | 4/6 |
| OC81 | 4/- |
| OC81D | 3/- |
| OC81DM | 3/- |
| OC83 | 4/6 |
| OC139 | 6/6 |
| OC140 | 6/6 |
| OC170 | 6/- |
| OC200 | 5/6 |
| OC201 | 5/6 |
| OC202 | 8/6 |
| OCP71 | 8/6 |
| ORP12 | 8/6 |
| ORP60 | 10/- |
| ORP61 | 10/- |
| P346A | 5/6 |
| TIS34A | 17/6 |
| TIS43 | 8/6 |
| TIS44 | 3/- |

**INTEGRATED CIRCUITS**

**RCA**

| | | | |
|---|---|---|---|
| CA3005 | 30/- | CA3020 | 27/6 |
| CA3011 | 20/- | CA3021 | 42/6 |
| CA3012 | 25/- | CA3022 | 35/- |
| CA3013 | 30/- | CA3023 | 32/6 |
| CA3014 | 30/- | CA3028A | 25/- |
| CA3018 | 30/- | CA3036 | 20/- |
| CA3019 | 27/6 | | |

DATA AND APPLICATION SHEETS FOR RCA DEVICES 2/- PER TYPE

**FAIRCHILD**

| | | |
|---|---|---|
| L900 | 11/- | Buffer |
| L914 | 11/- | Dual Gate |
| L923 | 14/- | JK Flip Flop |

**MULLARD**

| | | |
|---|---|---|
| TAA263 | 18/6 | Linear AF Amplifier |
| TAA293 | 25/6 | General purpose Amplifier |
| TAA241 | 72/6 | |
| TAA320 | 15/6 | M.O.S. Pre Amplifier |

**MOTOROLA**

| | | |
|---|---|---|
| MC724P | Quad 2 Input Gates .. .. | 19/6 |
| MC789P | Hex Inverter .. .. | 19/6 |
| MC790P | Dual JK Flip Flops .. | 32/6 |
| MC799G | Dual Buffer .. .. | 29/6 |

**GENERAL ELECTRIC**

| | | |
|---|---|---|
| PA230 | Low Level Amplifier .. | 27/6 |
| PA234 | Audio Amplifier .. | 26/6 |
| PA237 | 2 Watt Audio Amplifier | 45/- |

DATA SHEETS 6d. EACH TYPE

**ZENER DIODES**

| | | | |
|---|---|---|---|
| 1½ Watt | ±10% | 2·7V–33V | 4/6 |
| 1 Watt | ± 5% | I.R. or Texas 3·3V–200V | 7/6 |
| 400 m/w | ± 5% | S.T.C. 3·3V–30V | 5/- |
| 250 m/w | ±10% | Mullard 3V–16V | 4/- |

**THYRISTORS**

1 AMP; 50V 5/-, 100V 5/6, 200V 7/6, 400V 9/6
3 AMP; 50V 6/-, 100V 7/6, 200V 8/-, 300V 9/-, 400V 10/6
5 AMP; 400V 12/6
Equivalent BTY91/100R which is 12 AMP; 100V 15/-

**COMPONENTS**

**SPEAKERS (3 OHM)**

| | | | |
|---|---|---|---|
| 8" × 5" | 19/6 | 7" × 4" | 15/6 |
| 3" | 9/6 | 5" | 14/6 |
| 8" | 27/6 | 12" | 39/6 |
| 10" × 6" | 37/6 | 9" × 4" | 23/6 |
| 5" × 3" | 12/6 | 6½" | 23/6 |

Postage and Packing 2/9

**VEROBOARD CUTTERS** 9/-

| | |
|---|---|
| 3¾" × 2½" | 3/6 |
| 3¾" × 3¾" | 4/3 |
| 17" × 3¾" | 16/- |
| 3¾" × 5" | 5/6 |
| 5" × 2½" | 4/3 |

Available 0·1 or 0·15 Matrix

**RESISTORS**

| | |
|---|---|
| ½ Watt 10% | 4d. |
| ¼ Watt 5% | 5d. |
| 1/8 and 1 Watt | 6d. |
| 3 Watt | 1/6 |
| 5 Watt | 2/- |

**MINIATURE ELECTROLYTICS**

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| | | | | |
|---|---|---|---|---|
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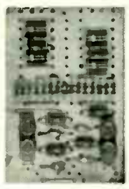

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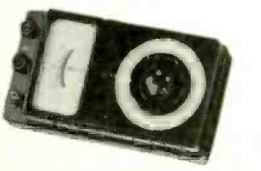

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| 6SN7GT | 5/6 |
| 6SQ7 | 7/- |
| 6SR7 | 7/- |
| 6T8 | 6/- |
| 6U4GT | 12/- |
| 6U8 | 6/6 |
| 6V6GT | 6/- |
| 6X4 | 4/6 |
| 6X5GT | 5/- |
| 6X8 | 11/- |
| 6Y6G | 11/6 |
| 7B5 | 10/- |
| 7B6 | 11/- |
| 7B7 | 7/- |
| 7C5 | 14/6 |
| 7K7 | 10/- |
| 7N7 | 17/6 |
| 7Q7 | 9/- |
| 7R7 | 12/- |
| 7S7 | 22/6 |
| 7Y4 | 11/- |
| 7Z4 | 7/6 |
| 9BW6 | 7/- |
| 10C2 | 10/- |
| 10D1 | 8/- |
| 10D2 | 8/- |
| 10F1 | 18/- |
| 10F9 | 10/- |
| 10F18 | 7/6 |
| 10L1 | 7/6 |
| 10LD11 | 10/- |
| 10P13 | 10/- |
| 10P14 | 16/- |
| 10Y | 17/6 |
| 11D3 | 7/- |
| 11D5 | 7/- |
| 11E3 | 65/- |
| 12AB5 | 9/- |
| 12AB7 | 6/- |
| 12AC6 | 7/- |
| 12AD6 | 6/- |
| 12AE6 | 7/6 |
| 12AL5 | 7/6 |
| 12AQ5 | 7/- |
| 12AT6 | 4/6 |
| 12AT7 | 6/- |
| 12AU7 | 5/9 |
| 12AV6 | 5/6 |
| 12AV7 | 8/- |
| 12AW6 | 20/- |
| 12AX7 | 5/6 |
| 12AY7 | 13/6 |
| 12B4A | 9/6 |
| 12BA6 | 6/- |
| 12BA7 | 6/- |
| 12BE6 | 6/- |
| 12BH7 | 6/- |
| 12BY7 | 10/- |
| 12CU6 | 15/- |
| 12E1 | 20/- |
| 12K5 | 10/- |
| 12K7GT | 7/- |
| 12K8GT | 8/- |
| 12Q7GT | 6/- |
| 12SC7 | 4/6 |
| 12SF5 | 9/- |
| 12SF7 | 9/- |
| 12SG7 | 6/- |
| 12SH7 | 4/6 |
| 12SJ7 | 4/6 |
| 12SL7GT | 7/6 |
| 12SN7GT | 7/6 |
| 12SQ7 | 7/6 |
| 12SR7 | 5/6 |
| 12SY7 | 6/- |
| 12X4 | 7/6 |
| 14S7 | 15/- |
| 19AQ5 | 7/6 |
| 19E2 | 12/6 |
| 19G3 | 65/- |
| 19G6 | 25/- |
| 20CV | 62/6 |
| 20D1 | 9/- |
| 20P1 | 10/- |
| 20P3 | 12/- |
| 20P4 | 19/- |
| 20P5 | 19/- |
| 25BQ6 | 12/- |
| 25C5 | 9/- |
| 25CU6 | 12/- |
| 25L6GT | 6/6 |
| 25Z4G | 6/- |
| 25Z5 | 8/- |
| 25Z6GT | 11/- |
| 27M1 | 65/- |
| 28D7 | 9/- |
| 30A5 | 7/- |
| 30C1 | 6/6 |
| 30C15 | 14/- |
| 30C17 | 15/- |
| 30C18 | 14/- |
| 30F5 | 16/- |
| 30FL1 | 15/- |
| 30FL12 | 17/6 |
| 30FL13 | 8/- |
| 30FL14 | 14/6 |
| 30L1 | 6/- |
| 30L15 | 16/- |
| 30L17 | 16/- |
| 30P12 | 15/- |
| 30P19 | 14/- |
| 30PL1 | 15/- |
| 30PL13 | 17/6 |
| 30PL14 | 14/- |
| 35A3 | 9/- |
| 35B5 | 12/- |
| 35C5 | 6/6 |
| 35D5 | 12/- |
| 35L6GT | 8/- |
| 35W4 | 4/6 |
| 35Z3 | 10/- |
| 35Z4G | 4/- |
| 35Z4GT | 8/6 |
| 35Z5GT | 6/- |
| 50A5 | 12/- |
| 50B5 | 12/- |
| 50L6GT | 8/6 |
| 53KU | 13/6 |
| 58CG | 45/- |
| 75 | 9/- |
| 75B1 | 8/6 |
| 75C1 | 8/- |
| 80 | 7/- |
| 83A1 | 12/6 |
| 83V | 10/- |
| 85A1 | 7/6 |
| 85A3 | 7/6 |
| 90AG | 46/- |
| 90AV | 46/- |
| 90C1 | 12/- |
| 90CG | 25/- |
| 90CV | 25/- |
| 95A1 | 8/6 |
| 150B2 | 11/- |
| 150B3 | 10/- |
| 150C4 | 10/- |
| 262B | 35/- |
| 267B | 60/- |
| 304TH | 280/- |
| 307A | 10/- |
| 310A | 25/- |
| 311A | 35/- |
| 313C | 25/- |
| 328A | 35/- |
| 329A | 30/- |
| 715A | 40/- |
| 715B | 70/- |
| 715C | 80/- |
| 804 | 90/- |
| 807 | 9/- |
| 811A | 30/- |
| 812A | 60/- |
| 813 | 75/- |
| 816 | 25/- |
| 829B | 60/- |
| 832A | 55/- |
| 837 | 15/- |
| 845 | 200/- |
| 866A | 14/- |
| 872A | 55/- |
| 884 | 10/- |
| 927 | 50/- |
| 931A | 65/- |
| 1805 | 7/6 |
| 2050 | 15/- |
| 5544 | 120/- |
| 5545 | 150/- |
| 5551A | 300/- |
| 5557 | 80/- |
| 5642 | 11/- |
| 5651 | 7/- |
| 5654 | 7/- |
| 5670 | 10/- |
| 5672 | 6/- |
| 5684 | 115/- |
| 5718 | 24/- |
| 5751 | 11/- |
| 5763 | 12/- |
| 5796 | 280/- |
| 5814A | 12/- |
| 5840 | 20/- |
| 5842 | 60/- |
| 5847 | 60/- |
| 5879 | 17/6 |
| 5881 | 17/6 |
| 5886 | 40/- |
| 6060 | 7/6 |
| 6064 | 8/- |
| 6073 | 9/- |
| 6074 | 9/6 |
| 6080 | 27/6 |
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| 6146B | 47/6 |
| 6350 | 4/- |
| 6360 | 25/- |
| 6386 | 75/- |
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| DF96 | 7/- |
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| DK40 | 10/- |
| DK91 | 6/- |
| DK92 | 8/3 |
| DK96 | 7/6 |
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| EF97 | 10/- |
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| EL42 | 10/- |
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| EL90 | 6/- |
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| EL360 | 22/- |
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| EM34 | 16/- |
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| EM87 | 10/- |
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| EY51 | 7/6 |
| EY80 | 8/6 |
| EY81 | 7/- |
| EY83 | 10/- |
| EY84 | 9/6 |
| EY86 | 7/6 |
| EY87 | 8/- |
| EY88 | 8/- |
| EY91 | 4/- |
| EZ40 | 8/- |
| EZ41 | 8/6 |
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| UU8 | 7/- |
| UU10 | 10/- |
| UY1N | 9/- |
| UY11 | 20/- |
| UY21 | 9/6 |
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| UY85 | 6/- |
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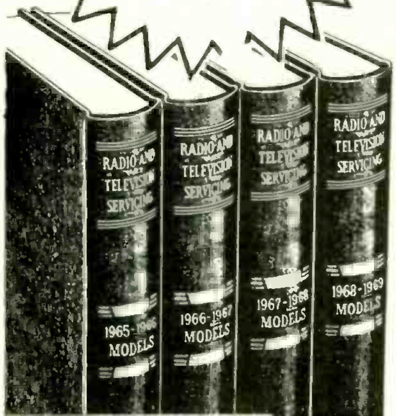


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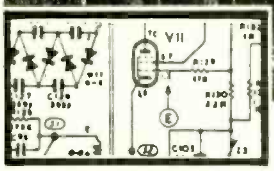

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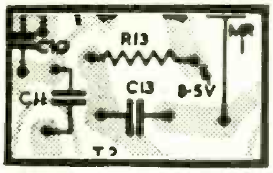


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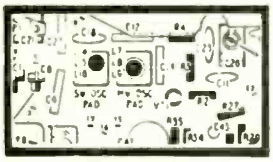

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*Address* ..............................

.............................. *County* ..............................

*Occupation* ..............................

*Signature* .............................. Mr. / Mrs. / Miss
RTV4/EERB/4003

*Please tick (✓) here*
The address on left is
My/our property ☐
Rented unfurnished ☐
Furnished accom. ☐
Temporary address ☐
*If none of the above please answer here*
..............................

**WW—139 FOR FURTHER DETAILS**

**CONDENSERS.** 8 mfd. 600 v. Brand New. Cornell Dubilier Paper Condensers, 4in × 3½in. × 1½in. with fixing clips. **7/6** ea. P. & P. 2/-.

**SLYDLOK FUSES** 15 amp., **1/6** ea., **15/-** per doz.

**HEADPHONES.** 5 amp. **1/3** ea. **13/-** Doz. P. & P. ea. 12 2/-. DLR5 Bal. Armature, **9/6**. P. & P. 3/-. M/Coil with ear muffs and wired M/C mic., **12/6**. P. & P. 3/-. No. 10 Assembly M/Coil with M/Coil Mic., **12/6**. P. & P. 3/-.

**SMALL MOTORS.** 12-24 v. D.C., reversible, with gears attached, **10/-** ea.; with blower attachment, **10/-** ea.; each item post 2/6.

**TRANSMITTER.** BC 625, part of T/R. SCR522. For spares only. Chassis only. Complete with valves *except* 832s and Relay. **21/-** ea. Carr. 4/-. 832 valves **7/6** ea. P. & P. 2/- ea. valve, used.

**SIEMENS HIGH SPEED RELAYS.** Type H69D, 500 + 500 ohms, **5/-** ea.; Type H96E, 1,700 + 1,700 ohms, **7/6** ea. Carr. 1/-.

**"TELE L" TYPE FIELD TELEPHONES.** These telephones are fitted in strong steel case complete with Hand Gen. for calling each station. Supplied in new condition and tested. **50/-** per pr. Carr. 7/6.

**MORSE KEYS.** No. 8 assembly complete with leads, terminals and cover, **6/6** ea. Carr. 2/6.

**VIBRATORS.** 12 v. 4 pin MALLORY TYPE 6634C. **6/-** ea. 12 v. 7 pin Plessey Type 12SR7. **7/6** ea. Carr. 1/6.

**ELECTRO MAGNETIC COUNTERS.** Register up to 9999, coil res. 300Ω. 5/- ea. Carr. 1/-. not re-setable. Ex-equipment. Open type.

**LIGHTWEIGHT HEADSET** (part of "88" W. Set Equipt.) complete with Boom mic., carbon made to highest Ministry Spec. Moving coil earpieces. Our price **20/-** ea. Carr. 3/-. Also Super Lightweight hand set, **10/-** ea. Carr. 2/-.

**200 AMP. 24 v. D.C. GENERATORS.** Type P3 ex-Air Ministry, **£9** ea. Carr. £1.

**Generators.** Type 02. 3,000 watts, 30 v. D.C. **£6** ea. Carr. 15/-.

**Rotary Convertors.** Type 8. D.C. Input 24 v., A.C. Output 115 v. 400 c/s, 3 phase, 1.8 amps. **£5** ea. Carr. £1.

**Invertors.** Type 201A (5UB6300). D.C. 25/28 v. r.p.m. 8,000, A.C. 115 v. 1600 c/s, single phase. **£10** ea. Carr. incl.
All above items ex-gov. stock, in used condition.

**CONDENSERS.** .1 mfd. 1,500 v. Sprague, paper. **9d.** ea., **7/6** doz. .1 500 v. **5/6** doz. postage on 12 of ea. item 2/-.

**HEAVY DUTY TERMINALS.** Ex-equipt. Black only, will take spade terminals and wander plug. **1/6** pr., **15/-** doz. pairs. P. & P. 1/6 ea. doz.

**FATIGUE METERS.** 24 v. D.C. Consisting of 6 × H96D Relays. 500 × 500 Ω. 6 × 300 Ω Electro Mag. counters, etc. **£2/10/-** ea. Carr. 6/-.

**AMERICAN AUTOPULSE 24 v. PUMPS** for mounting between carb. and main fuel tanks as auxiliary pump. New—**30/-** ea. P. & P. 5/-. 7 g.p.h. Size 7in × 2½in. × 2½in.

**Telephone Hand Generators.** No. 26 A.N. In wooden case. **7/6** ea. P. & P. 4/6.

**S.T.C. MINIATURE SEALED RELAYS, TYPE 4184 G D,** 700Ω 24 v. (will work efficiently on 12 v. D.C.) (ex-equipment). 2 C/overs. **7/6.** P. & P. 1/-. 6 or more post paid.

**SMALL D.C. MOTORS.** 2in × 1½in. × 1½in. Rated 24 v., will work on 12 v. ½in. length drive shaft. Ideal for model makers, etc. **10/6** ea.

B. S. Radio and Electrical Stores
108 CHESTER ST., BIRKENHEAD, CHESHIRE

**Tel. BIRKENHEAD 6067**
Terms Cash with Order.

www.americanradiohistory.com

# CLASSIFIED ADVERTISEMENTS

**DISPLAYED SITUATIONS VACANT AND WANTED:** £6 per single col. inch.
**LINE** advertisements (run-on): 7/- per line (approx 7 words), minimum two lines.
Where an advertisement includes a box number (count as 2 words) there is an additional charge of 1/-.
**SERIES DISCOUNT:** 15% is allowed on orders for twelve monthly insertions provided a contract is placed in advance.
**BOX NUMBERS:** Replies should be addressed to the Box number in the advertisement, c/o Wireless World, Dorset House, Stamford Street, London, S.E.1.
No responsibility accepted for errors.

Advertisements accepted up to JUNE 6 for the JULY issue, subject to space being available.


BBC ENGINEERING DIVISION
(CODING OFFICE, COMPUTER PROJECTS)
requires an

**ASSISTANT (Technical)**

for work on the classification and standardisation of components and the preparation and maintenance of stores inventories involving the use of computer based procedures. A good knowledge of the principal forms and characteristics of electronic components and materials is essential, together with the ability to correlate data and to work logically and accurately. An interest in computer applications is necessary and a suitable qualification in electrical engineering is desirable. The post is based in London.

Commencing salary £1,400 p.a. to £1,550 p.a. in a scale having a maximum of £1,775 p.a. (includes London Weighting). Write for application form to Engineering Recruitment Officer, BBC, Broadcasting House, London W1A 1AA, quoting reference No. 69.E.2097 W.W.

2165

**Your Chance to Run a New Field Workshop**

Honeywell's new computer field workshop is a beckoning new venture. Full of expansion potential and unlimited opportunities for someone to apply and develop new ideas. It could be you . . . if you can meet these needs:—
**WE NEED** an Engineer to organise and run this new field workshop which will be concerned with the repair of Computer Sub Assemblies, both Electronic and Mechanical. He will be based at our Greenford, Middlesex office.
**YOU NEED** to be in the 20 to 35 age bracket, have previous experience in electronic repair work, a good knowledge of transistor circuits, particularly flip flops and stabilised power supplies, plus the ability to construct any special equipment necessary under the guidance of a Senior Engineer. Some experience of typewriter or teleprinter type mechanics would be an advantage.
This out of the ordinary job will interest applicants from the Radio and TV industry or ambitious engineers who have Laboratory Technician experience.
**For further information please phone John Chatterton at 01-568 9191 ext. 738 or Brian Burge on ext. 635. Or you can write to Honeywell Ltd., EDP Field Service, Great West Road, Brentford, Middlesex.**

**Honeywell**

**TELECOMMUNICATIONS TECHNICAL OFFICERS**

METROPOLITAN POLICE OFFICE

THREE POSTS for men or women, normally aged at least 23, in the Lines Section of the Telecommunications Branch at New Scotland Yard.

DUTIES include provision, development and maintenance of line communications and associated equipment, and are essentially of a co-ordinating and planning nature.

QUALIFICATIONS: O.N.C. in Engineering (including a pass in Electrical Engineering A), or City and Guilds Intermediate Certificate in Telecommunications Engineering (old syllabus, i.e. subject No. 50) plus Radio II, *or* Intermediate Telecommunications Technicians' Certificate (new syllabus, i.e. subject No. 49) plus Certificates in Mathematics B, Telecommunications Principles B, and Radio and Line Transmission B, *or* equivalent standard of technical education. At least 5 years' appropriate experience essential.

SALARY (Inner London): £1,244 (at age 23)—£1,472 (at 28 or over on entry); scale maximum £1,646. Promotion prospects. Non-contributory pension.

WRITE to Civil Service Commission, Savile Row, London, W1X 2AA, or telephone 01-734 6010, Ext. 229 (after 5.30 p.m. 01-734 6464 "Ansafone" service), for application form, quoting S/7169/69. Closing date 28th May 1969.

2167

**V.H.F. TELEVISION RELAY & COMMUNAL AERIAL SYSTEMS**

We are planning a considerable expansion of our activities and have the following vacancies:

**I. A SENIOR ENGINEER**

to have control of all aspects of systems design, planning, estimating, installation and commissioning.

**II. ENGINEERS**

capable of undertaking either:
(*a*) System planning and estimating.
(*b*) control of installation work.
or (*c*) test and commissioning duties.

Candidates for these appointments must have a good background of practical experience in this field of work, and an up-to-date knowledge of techniques and equipment.

Applications, which will be treated in strict confidence, should be sent to:

**BRITISH RELAY**

**The General Manager,
Special Services Division,
British Relay House,
41, Streatham High Road, S.W.16**

2170


www.americanradiohistory.com

## GEC-Marconi Electronics

# ELECTRONIC TECHNICIANS

are required to work on calibration, fault-finding and testing of telecommunications measuring instruments. The work is varied and will enable technicians with experience of r.f. circuits to broaden their knowledge of the latest techniques employed in the electronics and telecommunications industries by bringing them into contact with a wide range of the most advanced measuring instruments embracing all frequencies up to u.h.f.

Entrants may be graded as Testers, Test Technicians or Senior Test Technicians according to experience and qualifications. Our expanding production programme geared to our recognised export achievement provides security of employment combined with good prospects of advancement, not only within these grades, but into other technical and supervisory posts within the Company.

Salaries are attractive and conditions excellent. A Pension Scheme includes substantial life assurance cover provided by the Company. Assistance with removal may also be given in appropriate cases. Please apply in writing, giving brief details including age, experience and salary to:

The Recruitment Manager,
Marconi Instruments Ltd.
Longacres, St. Albans, Herts.

mi

Member of GEC-Marconi Electronics Limited

**THE GENERAL POST OFFICE**
has vacancies for

## RADIO OPERATORS II

at its

**COAST RADIO STATIONS**

Applications are invited from men between 21 and 35 years of age who must hold either the Postmaster General's First or Second Class Certificate of Competence in Radiotelegraphy or an equivalent certificate issued by a Commonwealth Administration or the Irish Republic.

The posts which will be temporary in the first instance, carry a salary scale of £765-£1,129, depending on age at entry, but successful applicants will be eligible to enter the open competitive selection for permanent appointment to be held in the late summer of 1969.

Applicants should write to: The Inspector of Wireless Telegraphy, Union House, St. Martin's-le-Grand, London, E.C.1, or telephone 01-432 5628 for further information. 2163

**COUNTY BOROUGH OF LUTON**

## Telecommunications Technician

Applications are invited for the post of TELECOMMUNICATIONS TECHNICIAN in the Borough Architect's Department for servicing ground-to-air equipment at Luton Airport. Applicants experienced in the servicing of Decca 424 Radar, Marconi AD 210C Direction Finder, Mufax facsimile reproduction equipment and I.L.S. equipment and holders of the appropriate H.N.C. certificates preferred.

Duties will involve shift working. Commencing salary within Technician Grades 4/5/6 (£1,055-£1,715 per annum) according to qualifications and experience. Housing accommodation considered. Reasonable removal expenses paid.

Forms of application may be obtained from the Chief Executive Officer and Town Clerk, Town Hall, Luton, Beds., to whom completed applications should be returned as soon as possible.

2168

The 5 GeV Electron Synchrotron NINA situated at Daresbury Laboratory in north-west Cheshire, is being used for research into high energy physics by university and resident groups.

This is a complex facility and work here offers a challenging opportunity for men interested in devising and developing new devices and techniques in many cases in completely new fields. A

# TECHNICAL OFFICER

is required to join the Group responsible for the development and operation of the Synchrotron. He should be prepared to undertake development work on various projects and carry out this work with a high degree of personal responsibility. He should also be prepared to spend some of his time (at present 50%) as a member of the operating crew on a three shift basis.

Applicants should be at least 26 years of age and must have served a recognised engineering apprenticeship or have had comparable training. They must also possess an O.N.C. or equivalent in Electrical Engineering or Applied Physics and have experience in electro-mechanical and electrical work. Some electronic and high vacuum work would be an advantage.

Starting salary will be assessed according to age, qualifications and experience on the scale **£1,347-£1,565** (this scale is under review). A shift allowance (at present 14½% of salary) is paid in addition to salary.

Write for application form quoting reference DL/298/M to:

*Science Research Council*

**DARESBURY NUCLEAR PHYSICS LABORATORY**

**Personnel Officer,
Science Research Council,
Daresbury Nuclear Physics Laboratory,
Daresbury,
Nr. Warrington.**

2182

www.americanradiohistory.com

# STAR

## Mobile Radiotelephone expansion

Only four months after its introduction to world markets the new Star mobile radiotelephone equipment has received orders in 25 important export countries.

The outstanding success of this advanced radiotelephone equipment is creating new career opportunities in home and export marketing for Area Sales Managers.

Experience in sales or service of mobile radiotelephones or communications equipment is desirable.

These positions are a first-class opportunity for marketing men with drive and imagination and offer excellent possibilities for high earnings and advancement.

Please write giving details of your experience to:

STC Personnel Manager—42200, STC Mobile Radiotelephones Ltd., Oakleigh Road, New Southgate, London, N11 ITT

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BROADCASTING ENGINEERS

*required by*

# INTERTEL

in Vision Control and Video Tape. Colour experience desirable. Applicants should be prepared to travel extensively throughout Europe if required. Applications, giving details of qualifications, age and experience should be addressed to:

*Head of Technical Operations*
INTERTEL (VTR STUDIOS) LTD.
WYCOMBE ROAD, WEMBLEY,
MIDDLESEX

2164

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The current expansion programme of our Flight Simulator Division entails the consolidation of a newly-formed Standards policy. We need a

# STANDARDS ENGINEER

Applicants should be qualified Engineers with a minimum qualification of H.N.C. a degree is preferred. They should have had a minimum of twelve months experience in an established Standards Organisation. The primary task will be to co-ordinate a Standards Policy within the Division and to liaise with other Standards Engineers within the Redifon group of Companies. He will also act as Secretary to the Standards Committee.

Also a:

# COMPONENTS ENGINEER

Qualifications to H.N.C. standard are preferred. A good knowledge of Component Technology and the market is essential. He will liaise with the Standards Engineer and with Design Engineers to provide an advisory service in the selection of electronic components in use throughout the Division. He will also advise and co-ordinate in the testing and evaluation of components when this is necessary.

These positions will carry excellent salaries, high job interest, good working conditions.

A contributory pension scheme coupled with free life assurance is in operation also a sick pay scheme.

Applications should be made, quoting reference DEV2, to:

H. C. Hall, Personnel Manager,
REDIFON LIMITED
FLIGHT SIMULATOR DIVISION
Gatwick Road, Crawley, Sussex
Tel: Crawley 28811

THE QUEEN'S AWARD TO INDUSTRY

REDIFON

A Member Company of the Rediffusion Organisation

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# HACKER RADIO DEVELOPMENT GROUP

designing Radio Receivers, Record Players, Radiogramophones and High Fidelity Equipment of the highest quality, invites applications for additional staff.

**ASSISTANT RADIO ENGINEER** Circuit Design
**ASSISTANT AUDIO ENGINEER** Circuit Design
**DESIGNER DRAUGHTSMAN**

Good salary, prospects and working conditions. Pension Scheme. Apply, stating qualifications to:

Technical Director,
Hacker Radio Limited,
Norreys Drive, Cox Green, Maidenhead, Berkshire.

2203

## NORTH THAMES GAS

# TECHNICAL ASSISTANTS

to the

## COMMUNICATIONS OFFICER

at Fulham SW6

**In the general field on line telecommunications.**

The ability to plan and negotiate high grade networks for speech, telemetry and data transmission is required together with a thorough knowledge of the associated G.P.O. terminal equipment.

A general knowledge of P.A.B.X., P.M.B.X. and subscribers' apparatus is desirable.

The salary will be in the range of £1,375 to £1,725 per annum.

**Radio.** To assist in the planning of systems which will include fixed to mobile, short range hand held and fixed to fixed working. The ability to prepare specifications for complete schemes and supervise contracts is required.

A minimum of five years experience is visualised.

The salary will be in the range of £1,375 to £1,835 per annum.

Both vacancies are based on Fulham, but applicants should be prepared to travel throughout the Board's area and a car allowance will be paid in appropriate cases.

Applications, giving fullest details, should be sent to:

The Appointments Officer
North Thames Gas
30 Kensington Church Street, London W.8
quoting reference **WW/4419**

**COMMUNICATIONS**

## SALES MANAGER

required by High Fidelity equipment manufacturer. Commercial experience and ability to work on own initiative essential. Knowledge of Hi-Fi and experience of customer liaison desirable. Apply, stating age, experience and salary required to:

ROGERS DEVELOPMENTS (Electronics) Limited, 4/14 Barmeston Road, Catford, S.E.6. Telephone: 01-698 7424/4340. 2162

## T.V. ENGINEERS

RADIO RENTALS have a vacancy for a top grade Engineer in the TWICKENHAM area. 5-day week, good salary, commission and car allowance or vehicle supplied. Colour training will be arranged.

Apply to:

**Branch Manager, Radio Rentals,**
21 King Street, TWICKENHAM.

2172

BATH EDUCATIONAL TELEVISION SERVICE

## OPERATIONAL AND MAINTENANCE ENGINEER

Applications are invited from suitably qualified and experienced candidates for a post as Operational and Maintenance Engineer with the B.E.T.S. Duties will include the operation, testing and maintenance of a comprehensive range of video and audio equipment at the Studio centre in Bath.

Further information and forms of application can be obtained from: The Secretary, Bath Educational Television Service, Northgate House, Bath, BA1 5AL.

2171

## RADIO TECHNICIANS

**Vacancies to be filled by October, 1969**

A number of suitably qualified candidates are required for unestablished posts, leading to permanent and pensionable employment (in Cheltenham and other parts of the UK, including London). There are also opportunities for service abroad.

Applicants must be 19 or over and be familiar with the use of Test Gear, and have had practical Radio/Electronic workshop experience. Preference will be given to such candidates who can also offer "O" Level GCE passes in English Language, Maths and/or Physics, or hold the City and Guilds Telecommunications Technician Intermediate Certificate or equivalent technical qualifications. A knowledge of electro-mechanical equipment will be an advantage.

Pay according to age, e.g. at 19—£869; at 25—£1,130 (highest age pay on entry) rising by four annual increments to £1,304.

Prospects of promotion to grades in salary range £1,217-£2,038. There are a few posts carrying higher salaries.

Annual Leave allowance of 3 weeks 3 days rising to 4 weeks 2 days. Normal Civil Service sick leave regulations apply.

Application forms available from:
**Recruitment Officer (RT 3),**
**Government Communications Headquarters,**
**Oakley, Priors Road,**
**CHELTENHAM, Glos, GL52 5AJ.**

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# TEST ENGINEERS

Engineers are required for final test of solid state R/F prototype and pre-production equipment operating at U.H.F. and microwave frequencies.

These positions would be ideally suitable to ex-service radio/radar personnel, television service engineers, etc., with experience of transistorised circuitry.

The Company offers first-class holiday, sick payment and welfare facilities, including an excellent group pension and insurance scheme. The two modern establishments are located at Bushey and Hemel Hempstead, Herts., within easy access of the M.1.

**Apply in writing,
quoting reference WWRM2 to:
Personnel Officer,
Ether Engineering Ltd.,
Park Avenue, Bushey, Herts.**

Ether Engineering Ltd

# PRODUCTION TEST ENGINEERING

Due to our successful Research and Design work many exciting new projects are entering a production phase and we require Engineers and Technicians to participate in this work.

Minimum qualifications required are a basic understanding of Transistor circuitry enabling testing to specification to be carried out on our Data Processing and Servo Control Systems, etc.

Electrical Engineering Certificates an advantage, but not essential if experience in a similar activity can be offered.

Apply:
Personnel Officer
RECORDING DESIGNS LTD.
Blackwater Station Estate
Blackwater, Camberley, Surrey
Telephone Camberley 24622

rdl

2176

# SENIOR FIELD ENGINEER

Required for Computer and Data Processing Peripheral units, to operate from London, there are excellent prospects for a man with good electro-mechanical practice who can show initiative and can write clear factual reports. A car and operating expenses and good salary are offered to the right man.

# DRAUGHTSMAN—CHECKER

Required for electro-mechanical work. Promotion prospects are good for a man with proved ability and initiative.

# AUDIO EQUIPMENT DEVELOPMENT ENGINEER

Required for work connected with Public Address, sound recording and reproducing and Cinema Projection Equipment. Applicants must have a good experience of Technical Audio work.

**Apply in writing to
The Chief Engineer,
Westrex Co. Ltd.,
152, Coles Green Road,
London, N.W.2.
or telephone
01-452 5401 Extension 12.**

Westrex
A DIVISION OF LITTON INDUSTRIES

www.americanradiohistory.com

# POST DESIGN SERVICES

Our POST DESIGN SERVICES SECTION at Wandsworth has a vacancy for a man with a basic theoretical and practical knowledge of radio. He would also need the ability to prepare written technical leaflets from laboratory information and a knowledge of M.O.T. Post Design procedure would be an advantage.

Applications in writing please to:–
**The Personnel Officer,**
REDIFON LIMITED,
**Broomhill Road, Wandsworth, London, S.W.18.**

**REDIFON**

A Member Company of the Rediffusion Organisation

# Radiomobile CAR RADIO DESIGNERS

**Do you:—**

- Have a Degree or HND/HNC in electronics?
- Have experience in radio receiver design, not necessarily car radio?
- Like the idea of working with a dynamic design team and seeing your project through to production?
- Have ideas for using microcircuits?

**IF YOUR ANSWER TO MOST OF THESE QUESTIONS IS YES**

WHY NOT TELEPHONE ME, Peter Wilding (Engineering Manager) on 01-452 0171— (Reverse charges of course).
On any weekday
or send me your career details—

**We need people like you—and will pay well for the right men—or women**

# 4

## COMMISSIONING ENGINEERS OR TECHNICIANS

Experienced in servicing or testing digital equipment. Training on Equipments given where necessary.

## PROTOTYPE WIREMEN

Experienced on electronic rack wiring, but desiring more varied work.

These vacancies are in a team commissioning an advanced system of machine tools on line to a computer. They involve installation, test, evaluation and maintainance of machine tools and automatic conveyors.

Please write for Company brochure and application form to
Mr. K. Oxenham, Head Office Personnel Officer,

**MOLINS MACHINE COMPANY LIMITED**
**2 Evelyn Street, London SE8**

www.americanradiohistory.com

## TECHNICAL AUTHORS

A Technical Publications Contractor has vacancies in their Home Counties offices and on site for personnel to be engaged in the preparation of manuals for a wide range of electronic and allied equipment to Ministry and Commercial requirements. Applications are invited from practising or aspiring authors with relevant experience. Box No. 5052.

## ELECTRONIC SERVICE ENGINEERS

required by OLYMPIA BUSINESS MACHINES for their London workshops to work on a range of electronic calculators. A good salary and working conditions are offered.

*Also required:* **Young Men** with strong interest in electronics but without complete experience will be trained. Courses are available through this company. Day release for selected trainees. Please apply in writing to:

**D. H. Smith,**
**Olympia Business Machines**
**Company Ltd.,**
**299a Edgware Road, London, W.2.**

2198

## TECHNICIAN

Applications are invited for the post of technician to maintain computer systems, to construct computer hardware, and to assist in the general running of a small electronics laboratory.

Suitable qualifications are experience in electronic equipment, construction and maintenance of electro-mechanical devices and an interest in the subject generally.

Salary range £847-£1,400. Superannuation scheme.

Apply in first instance by letter, stating briefly personal details and relevant experience, to Mr. J. A. Payton, Centre for Computing and Automation, Imperial College, London, S.W.7. 2201

## CHIEF SOUND RECORDIST

required by the CENTRAL OFFICE OF INFORMATION for its Radio Division which is responsible for the production and fast transmission of radio programmes on magnetic tape and disc or by circuit for use by broadcasting stations overseas. Programmes vary from brief interviews to half an hour in length and total output is about 50 hours per week, in some 30 languages.

The Chief Sound Recordist will have control of a staff of maintenance engineers and sound recordists and will be responsible for all sound recording operations. His duties will include the management of recording studios and copying channels, and the servicing of static and portable equipment. He will supervise recording by outside contractors and liaise closely with the GPO about the control of private wire circuits within the U.K. and line facilities to overseas territories. He will be responsible for the planning, design and installation of such new facilities as may be required by the development of the service and by technical advances in the medium. Salary £1,850-£2,355 per annum.

Please send postcard for application form to Manager (PE/A/185/EW). Department of Employment and Productivity, Professional and Executive Register, Atlantic House, Farringdon Street, London, E.C.4. Closing date for completed application forms 4 June 1969. 2207

# Tradesmen and Technicians

Applications are invited from competent men who are attracted by the opportunity to work overseas for a year or two (with generous leave and free air passages), earn an attractive salary and qualify for tax concessions.

Our immediate vacancies are as follows :–

| | |
|---|---|
| **FITTERS INSTRUMENT** (Ref. FT1) | Suitable applicants would be ex-RAF or civilian trained fitters with Flight Instrumentation experience in 1st and 2nd line servicing associated with Lightning and Jet Provost aircraft. |
| **FITTERS WIRELESS (AIR)** (Ref. FTW/A) | Suitable applicants would be ex-RAF or RN trained fitters with 1st and 2nd line servicing experience of Airborne communication equipment, P7R 175, ARC 52, TACAN and IFF.MK 10. |
| **FITTERS RADAR (AIR)** (Ref. FTR/A) | Suitable applicants would be ex-RAF or RN trained fitters with 1st and 2nd line servicing experience of Airborne Radar equipment, AI 23B, TACAN and IFF.MK 10. |
| **FITTERS RADIO/RADAR** (Ref. FTR/R) | Suitable applicants would be ex-RAF or RN trained fitters who have received a formal course on TACAN, IFF, VHF/UHF and PTR 175 and are experienced at 1st and 2nd line servicing level. |
| **FITTERS ELECTRICAL (GROUND)** (Ref. FTE/G) | Suitable applicants would be ex-RAF or RN trained fitters with experience of servicing and maintaining Airfield ground servicing vehicles and equipment. |
| **LABORATORY TECHNICIAN** (Ref. LTN) | Suitable applicants would be ex-Service or civilian trained technicians who are familiar with the use of electronic, radio and radar test equipment. They would be required to assist Electronic Instructors in the laboratory. |

*Please apply, quoting the appropriate reference, to :*

**THE PERSONNEL MANAGER**
**AIRWORK (OVERSEAS) LIMITED**
**BURLINGTON ARCADE**
**BOURNEMOUTH . HANTS**

www.americanradiohistory.com

# ELECTRONIC ENGINEERS

Service Engineers required for Offices, throughout the United Kingdom, of well-known Company manufacturing Electronic Desk Calculating Machines. Applicants should possess a sound knowledge of basic Electronics with experience in Electronics, Radar, Radio and T.V. or similar field. Position is permanent and pensionable. Comprehensive training on full pay will be given to successful applicants. Please send full details of experience to the Service Manager, Sumlock Comptometer Ltd., 102/108 Clerkenwell Road, London, E.C.1.

82

ITT Marine

# MARINE RADIO ENGINEER

Due to our expanding business in the South Wales area, we urgently require an additional engineer to work from our Cardiff Depot on service and installation of marine radio and associated equipment.

Candidates must be ex-Merchant Navy Radio Officers with a minimum of three years' sea-service and preferably previous experience of installation and maintenance of equipment.

Apply to Head Office Personnel Manager, giving brief details of qualifications and experience.

**International Marine Radio Co. Ltd., 1 Peall Road, Croydon, Surrey, CR9 3AX.**

# NORWICH CITY COLLEGE

## DEPARTMENT OF ELECTRICAL ENGINEERING

The Department of Electrical Engineering of the Norwich City College offers students who have studied Physics and Mathematics at Advanced level in the G.C.E. and passed in one subject, a modern sandwich course for the Higher National Diploma in Electrical and Electronic Engineering. Subjects studied include Computation, Statistics, Economics and Law, Electronics, Control, Telecommunications, Power and Machines. Well balanced and interesting industrial training with pay will be arranged as required. The course is approved for major grant awards by Local Authorities.

Accommodation will be arranged by the College if desired.

Enquiries about the course starting in September 1969 should be made to:

**E. Jones, B.Sc., Ph.D., C.Eng., M.I.E.E., Head of Department of Electrical Engineering, Norwich City College, Ipswich Road, Norwich, Norfolk. NOR 67D.**

2184

# Computer Engineering

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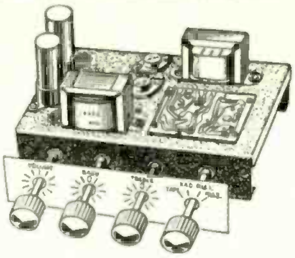
## NEW ! HSL.700 Mono Transistor Amplifier



A really high fidelity monaural amplifier with performance characteristics to suit the most discriminating listener. 6 transistor circuit with integrated preamplifier assembled on special printed sub panel. AD-161-AD162 operating in symetrical complementary pair. Output transformer coupled to 3 ohm and 15 ohm speaker sockets. Standard phono input sockets. Full wave bridge rectifier power supply for A.C. mains 200-240 v. Controls: Bass, Treble, Volume/on/off. Function selector for PU1, PU2, Tape, Radio. The HSL.700 is strongly constructed on rigid steel chassis, bronze hammer enamel finish, size 9½ in. x 5 in. × 4½ in. high. Performance figures:

Sensitivity—PU1-50 m/v., 56K input impedance.
PU2-110 m/v. 1 meg. input inpedance.
Tape—110 m/v, 1 meg. input impedance.
Radio—110 m/v, 1 meg. input impedance.

Output power measured at 1 Kc-6.2 watts RMS into 3 ohms, 5.8 watts RMS into 15 ohm. Overall frequency response 30 c/s-18 Kc/s: Continuously variable tone controls; Bass, + 8db to 12 db at 100 c/s. Treble, + 10 db to − 10 db at 10 Kc/s.

The HSL.700 has been designed for true high fidelity reproduction from Radio Tuner, Gramophone deck and Tape Recorder pre amp but is also capable of being used in conjunction with a guitar by connecting to PU1 socket and the peak output power will then be in the region of 15 watts.

Supplied complete with knobs, attractive anodised aluminium front escutcheon panel, long spindles (can be cut to suit your housing requirements), full circuit diagram and operating instructions. LIMITED NUMBER. OUR SPECIAL PRICE £7.19.6. P. & P. 7/6.

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**PRICES:** Amplifier Kit £10/10/0; Power Pack Kit £3/0/0; Cabinet £3/0/0. ALL POST FREE.

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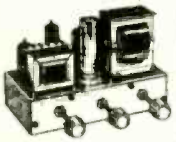

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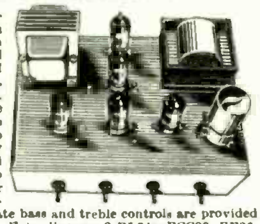

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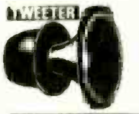


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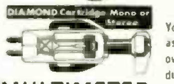


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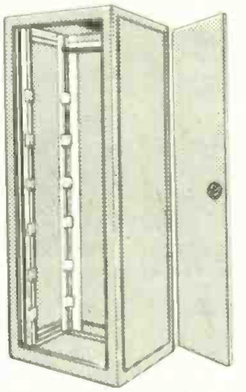

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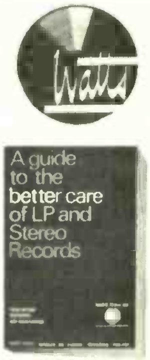


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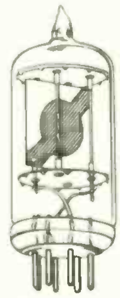

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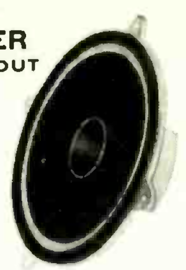

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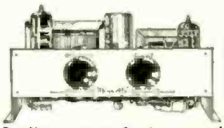

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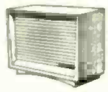

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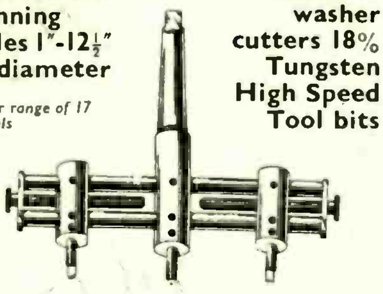

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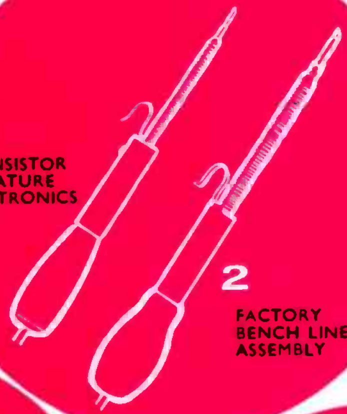
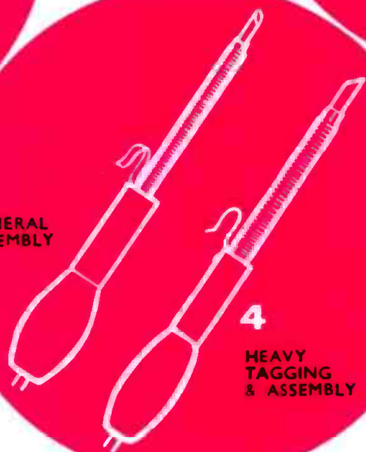
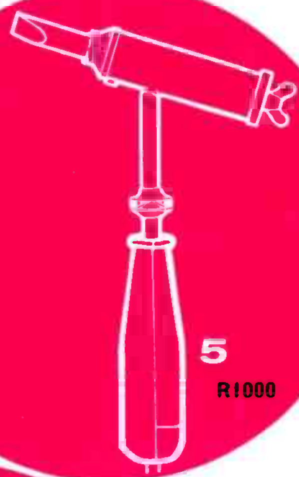
# SOLDERING INSTRUMENTATION

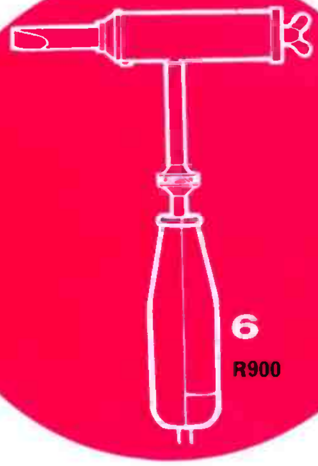
ADCOLA PRODUCTS LIMITED (Regd Trade Mark)

**HIGH EFFICIENCY INSTRUMENTS**




1. DIA.—3.2 mm dia detachable bit Standard temp 340 c at 19 watts. Special temps from 250 c 400 c Weight 4.5 ozs. 127 grms.
2. —4.75 mm dia. detachable bit Standard temp. 360 c at 23 watts. Special temps. from 250 c 410 c Weight 6 ozs 170 grms.
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4. —7.9 mm dia detachable bit Standard temp 360 c at 30 watts. Special temps. from 250 c 410 c. Weight 7 ozs. 198 grms.
5. OFFSET BIT SIZE ½" 12.7 mm diameter
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BOTH AVAILABLE IN THE FOLLOWING TEMPERATURES 250 c—27 watts, 360 c—50 watts, 410 c—60 watts, 500 c—90 watts. Supplied in all voltages from 6 volts to 250 volts

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# TO MANUFACTURERS OF SOLDERED JOINTS

THE QUEEN'S AWARD TO INDUSTRY 1966

ERSIN Multicore 5 CORE SOLDER

- Contains 5 cores of non-corrosive high speed Ersin flux. Removes surface oxides and prevents their formation during soldering. Complies with B.S. 219, 441, DTD 599A, B.S.3252, U.S. Spec. QQ-S-571d.
- Savbit alloy contains a small percentage of copper and thus prolongs the life of copper soldering iron bits 10 times. Liquidus melting temperature is 215°C – 419°F. Ministry approved under ref. DTD/900/4535
- Solder Tape, Rings, Preforms and Washers, Cored or Solid, are available in a wide range of specifications.

**STANDARD GAUGES IN WHICH MOST ALLOYS ARE MADE AND LENGTHS PER LB. IN FEET.**

| S.W.G. | INS. | M.M. | FT. PER LB. 60/40 | SAVBIT |
|---|---|---|---|---|
| 10 | .128 | 3.251 | 25.6 | 24 |
| 12 | .104 | 2.642 | 38.8 | 36 |
| 14 | .080 | 2.032 | 65.7 | 60.8 |
| 16 | .064 | 1.626 | 102 | 96.2 |
| 18 | .048 | 1.219 | 182 | 170 |
| 19 | .040 | 1.016 | 262 | 244 |
| 20 | .036 | .914 | 324 | 307 |
| 22 | .028 | .711 | 536 | 508 |
| 24 | .022 | .558 | 865 | 856 |
| 26 | .018 | .46 | 1292 | 1279 |
| 28 | .014 | .375 | 1911 | 1892 |
| 30 | .012 | .314 | 2730 | 2695 |
| 32 | .010 | .274 | 3585 | 3552 |
| 34 | .009 | .233 | 4950 | 4895 |

**STANDARD ALLOYS INCLUDE**

| TIN/LEAD | B.S. GRADE | LIQUIDUS MELTING TEMP °C. | °F. |
|---|---|---|---|
| 60/40 | K | 188 | 370 |
| Savbit No 1 | — | 215 | 419 |
| 50/50 | F | 212 | 414 |
| 45/55 | R | 224 | 435 |
| 40/60 | G | 234 | 453 |
| 30/70 | J | 255 | 491 |
| 20/80 | V | 275 | 527 |

**HIGH AND LOW MELTING POINT ALLOYS**

| ALLOY | DESCRIPTION | MELTING TEMP. °C. | °F. |
|---|---|---|---|
| T.L.C. | Tin/Lead/Cadmium with very low melting point | 145 | 293 |
| L.M.P. | Contains 2% Silver for soldering silver coated surfaces | 179 | 354 |
| P.T. | Made from Pure Tin for use when a lead free solder is essential | 232 | 450 |
| H.M.P | High melting point solder to B.S. Grade 5S | 296-301 | 565-574 |

## EXTRUSOL®

**EXTRUSOL** is a new concept in solder for solder machines, baths and pots used in the electronics industry.

**EXTRUSOL** is a very high purity solder which is also substantially free of oxides, sulphides and other undesirable elements.

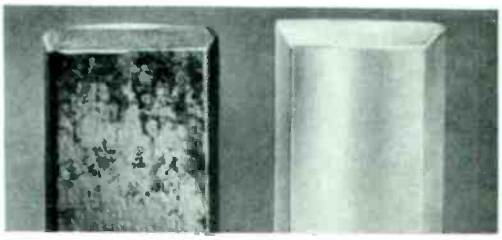
The percentages of impurities in **EXTRUSOL** are considerably lower than those quoted in national or company specifications, thus providing a solder more suitable for use in the electronics industry.

**EXTRUSOL** can be released under AID authority and conforms with USA QQ-S-571d

### ADVANTAGES OF EXTRUSOL

1. Less dross on initial melting
2. More soldered joints per pound of solder purchased
3. Less reject joints
4. Improved wetting of electronic components and printed circuit boards
5. More uniform results

ALL EXTRUSOL IS COMPLETELY PROTECTED BY PLASTIC FILM FROM THE MOMENT OF MANUFACTURE UNTIL IT IS USED



A section of a typical cast solder bar. Note the surface dross and general contamination.

A section of an **EXTRUSOL** bar with the plastic coating removed showing no dross or contamination.

**EXTRUSOL** is supplied in 1-lb. and 2-lb. Trapezium Bars and Pellets in different alloys with strictly controlled tin contents to suit the appropriate soldering machines, baths and pots. Bars are available for automatic solder feed.

**Ask for full details on solders, fluxes, soldering chemicals, on your company's notepaper.**

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