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Guide to the Multi-range Testmeter

APRIL 1974

25p

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GOLDRING G800 cartridge

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- 3% distortion @1KHz
- 30-20,000Hz
- 25-40,000Hz
- 30-10,000Hz
- 0.5% for 100Hz
- 1% for 1KHz
- 2% for 10KHz

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250-0.55mm, 60mA x 6.5v. 2a. £0.95

250-0.65mm, 60mA x 6.5v. 2a. £1.05

250-0.75mm, 60mA x 6.5v. 2a. £1.15

250-0.85mm, 60mA x 6.5v. 2a. £1.25

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- 2.6mV Sensitivity @1KHz
- 3% distortion @1KHz
- 30-20,000Hz
- 25-40,000Hz
- 30-10,000Hz
- 0.5% for 100Hz
- 1% for 1KHz
- 2% for 10KHz

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SPEC.

<table>
<thead>
<tr>
<th>INPUTS</th>
<th>Output Power</th>
<th>Load Impedance: 4-16Ω into 8Ω</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magnetic Pick-up (within 1db RIAA)</td>
<td>12 biệt (0.775 volts)</td>
<td></td>
</tr>
<tr>
<td>Ceramic Pick-up to 3mV</td>
<td></td>
<td></td>
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<tr>
<td>Microphone 10mV</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tuner 250mV</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Auxiliary 3-100mV</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input impedance 4KΩ 1kHz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>OUTPUTS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tape 100mV</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Main output, Odb (0-775volts)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ACTIVE TONE CONTROLS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treble ± 10db at 10kHz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bass ± 12db at 10kHz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>OVERLOAD CAPABILITY (equalization taped) 40db on most sensitive input</td>
<td></td>
<td></td>
</tr>
<tr>
<td>OUTPUT NOISE LEVEL (below 10mV magnetic input) 60db</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DISTORTION 0-0.05% at 1kHz</td>
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</tr>
<tr>
<td>SUPPLY VOLTAGE ± 10-25 volts</td>
<td></td>
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<tr>
<td>SUPPLY CURRENT 15mA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Price £3-90 mono, £11-60 stereo</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Price inclusive of VAT &amp; P &amp; P</td>
<td></td>
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</tr>
</tbody>
</table>

POWER SUPPLY PSU50

The new PSU50 has a low profile look being only 21 inches high and can be used for either mono or stereo systems.

SPEC.

<table>
<thead>
<tr>
<th>OUTPUT VOLTAGE ± 25 volts</th>
</tr>
</thead>
<tbody>
<tr>
<td>INPUT VOLTAGE 250-260 volts</td>
</tr>
<tr>
<td>SIZE L: 70, D: 90, H: 50 mm</td>
</tr>
<tr>
<td>Price £3-23 Price inclusive of VAT &amp; P &amp; P</td>
</tr>
</tbody>
</table>

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130 Mono control unit
605 Power supply for 115
610 Power supply for 100
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250 Auto packer
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825 LF preamplifier
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1280 NI-CA VCD 1-12V
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<thead>
<tr>
<th>Model</th>
<th>Description</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>TP125</td>
<td>125 Watts RMS continuous sine wave output</td>
<td>£15-25</td>
</tr>
<tr>
<td>TL100</td>
<td>100 Watts RMS sine wave</td>
<td>£11-50</td>
</tr>
<tr>
<td>TL60</td>
<td>60 Watts RMS sine wave</td>
<td>£9-75</td>
</tr>
<tr>
<td>TL30</td>
<td>30 watts RMS sine wave</td>
<td>£7-50</td>
</tr>
</tbody>
</table>

Power supplies vacuum impregnated Transformers with supply board incorporating stabilised pre-amp supply:

<table>
<thead>
<tr>
<th>Type</th>
<th>Voltage</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>PS 125</td>
<td>125 volts for one TP125</td>
<td>£8.75</td>
</tr>
<tr>
<td>PS 100</td>
<td>100 volts for one TL100</td>
<td>£8.00</td>
</tr>
<tr>
<td>PS 60</td>
<td>60 + 40 volts for one TL60</td>
<td>£8.75</td>
</tr>
<tr>
<td>PS 30</td>
<td>30 + 30 volts for one TL30</td>
<td>£4.50</td>
</tr>
<tr>
<td>PSU 2</td>
<td>For supplying disco mixer</td>
<td>£3.50</td>
</tr>
</tbody>
</table>

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The AL10, AL20 and AL30 modules are similar in appearance and in their general specification. However, careful selection of the plastic power devices has resulted in a range of outputs from 3 to 10 watts R.M.S.

The versatility of their design makes them ideal for use in record players, tape recorders, stereo amplifiers and cassette and car audio systems in the car and at home.

### Parameter

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<th>Parameter</th>
<th>AL10</th>
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<th>AL30</th>
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<tr>
<td>Power output</td>
<td>3</td>
<td>8</td>
<td>10</td>
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<tr>
<td>Maximum Supply Voltage</td>
<td>25</td>
<td>60</td>
<td>80</td>
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### POWER SUPPLIES

12V. (Use with AL10 & AL20) 88p
24V. (Use with AL20 & AL30) 95p

### CURRENT SPECIFICATION

- 0.1% DISTORTION
- Hi-Fi Audio Amplifier

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- Signal to noise ratio: 50dB.
- Overall size: 63mm x 165mm x 30mm.

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SPM80 is especially designed to power the AL50 amplifier, up to 15 watts (R.M.S.) per channel simultaneously. This module embodies the latest components and circuit techniques incorporating complete short circuit protection. With the addition of the Mains Transformer MT80, the unit will provide outputs up to 15 watts (R.M.S.) into 8 ohms. Size: 82mm x 35mm x 20mm.

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SAFETY MAINS ISOLATING TRANSFORMERS
Prl. 120/240 V Sec. 120/240 V Centre Tapped and Screwed

Ref. Weight No. Size cm. P & P £

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115V 500W encased transformer, with main load and two 115V outlets sockets, 49-69, 69-70. 20 Watts version £5-02 P & P.

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Ref. Weight No. Size cm. P & P £

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Ref. Amps. Weight No. Size cm. Secondary Windings P & P £

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HIGH QUALITY - BRITISH MADE

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An inexpensive unit for the beginner in hi-fi fidelity and for general purposes. May be used with any hi-fi accessory. Amplifiers, Hi-Fi or Television receiver.

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Flux Density 12,000 gauzes
Useful response 45-17,000 Hertz 8 or 8 or 15 ohms models.

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12in. 15 watts
A high quality loudspeaker, its remarkable low cone resistance enables deep reproduction of the deepest bass. Fitted with a special copper drive and concentric HF cone resulting in full range reproduction with remarkable efficiency in the upper register.

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Flux Density 17,000 gauzes
Useful response 15,000-20,000 Hertz £3.95 Post Free £15.50

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A high quality loudspeaker, its remarkable low cone resistance enables deep reproduction of the deepest bass. Fitted with a special copper drive and concentric HF cone resulting in full range reproduction with remarkable efficiency in the upper register.

Bass Resonance 470 c/s
Flux Density 17,000 gauzes
Useful response 15,000-20,000 Hertz £3.95 Post Free £15.50

AUDITORIUM
12in. 25 watts
A full range reproduction for high power, Electric Guitars, etc. Ideal for Hi-Fi and Disco applications. Bass Resonance 500 c/s
Flux Density 15,000 gauzes
Useful response 20-35,000 Hertz 8 or 15 ohms models.

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A versatile digital multimeter for AC, DC, and resistance measurement.
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30,000 ohms, 1000V, 10A, 1.5/7.5/30/150/300/500/1k/10k/100k/1M/1G/10G DC
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### EDGWISE MODEL PE70

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### MODEL ED107 EDUCATIONAL METER

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### BAKELITE MODEL S80 Enlarged Window

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### POSTAGE & PACKING 15p

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### POWER RHEOSTATS

High quality ceramic. Made in various sizes and wattages. Insulated in various sizes, 16mm, 25mm, etc. Continuous reading. Single or multiple units available from stock. Single units in a range of sizes. Multiple units in large quantities. Price varies depending on quantity and size.

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### YAMABISHI VARIABLE VOLTAGE TRANSFORMERS

220V, 600V, 1200V, 2200V. Various sizes available. All transformers are fully tested and guaranteed. Price varies depending on voltage and size.

#### 5000 Watts

- 1 x 3.50
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### CP118 Chassis Punch Set

- Carefully machined to high standards.
- Contains 12 recess
- `Flat` punch 3/8" dia. x 11/16" long.
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- No soldering required. All components are sub-assy complete with printed circuit board. Availability depends on stock levels.
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- Walkie Talkies.
- Suitable for both indoor and outdoor use. Includes rechargeable batteries and chargers.

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- TRIO JR500 RECEIVER
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- TRIO 950U TRANSMITTER
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- Suitable for both FM and AM modes. Includes microphone, earphone, and internal speaker.

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### KEEBO 3 STATION INTERCOM

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### WALKIE TALKIES

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- Suitable for both indoor and outdoor use. Includes rechargeable batteries and chargers.

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### ALL PRICES EXCLUDE VAT

- Subject to change without notice.

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*Also see previous page.*
The Sinclair Cambridge... no other calculator is so powerful and so compact.

**Complete kit - £24.95!** *(PLUS VAT)*

**The Cambridge - new from Sinclair**
The Cambridge is a new electronic calculator from Sinclair, Europe's largest calculator manufacturer. It offers the power to handle the most complex calculations, in a compact, reliable package. No other calculator can approach the specification below at anything like the price — and by building it yourself you can save a further £5.50!

**Truly pocket-sized**
With all its calculating capability, the Cambridge still measures just $4\frac{1}{2}'' \times 2'' \times \frac{1}{2}''$. That means you can carry the Cambridge wherever you go without inconvenience — it fits in your pocket with barely a bulge. It runs on ordinary U16-type batteries which give weeks of life before replacement.

**Easy to assemble**
All parts are supplied — all you need provide is a soldering iron and a pair of cutters. Complete step-by-step instructions are provided, and our service department will back you throughout if you've any queries or problems.

**Total cost? Just £27.45!**
The Sinclair Cambridge kit is supplied to you direct from the manufacturer. Ready assembled, it costs £32.95 — so you're saving £5.50! Of course we'll be happy to supply you with one ready-assembled if you prefer — it's still far and away the best calculator value on the market.

**Features of the Sinclair Cambridge**
- *Uniquely handy package. $4\frac{1}{2}'' \times 2'' \times \frac{1}{2}''$, weight 3\text{\%} oz.*
- *Standard keyboard. All you need for complex calculations.*
- *Clear-last-entry feature.*
- *Fully-floating decimal point.*
- *Algebraic logic.*
- *Four operators (+, -, x, ÷), with constant on all four.*
- *Constant acts as last entry in a calculation.*
- *Constant and algebraic logic combine to act as a limited memory, allowing complex calculations on a calculator costing less than £30.*
- *Calculates to 8 significant digits, with exponent range from $10^{-8}$ to $10^{79}$.*
- *Clear, bright 8-digit display.*
- *Operates for weeks on four U16-type batteries.* *(MN 2400 recommended.)*
A complete kit!

The kit comes to you packaged in a heavy-duty polystyrene container. It contains all you need to assemble your Sinclair Cambridge. Assembly time is about 3 hours.

Contents:
1. Coil,
2. Large-scale integrated circuit,
3. Interface chip,
4. Thick-film resistor pack,
5. Case mouldings, with buttons, window and light-up display in position,
6. Printed circuit board,
7. Keyboard panel,
8. Electronic components pack (diodes, resistors, capacitors, transistor),
9. Battery clips and on/off switch,
10. Soft wallet.

This valuable book - free!
If you just use your Sinclair Cambridge for routine arithmetic - for shopping, conversions, percentages, accounting, tallying, and so on - then you'll get more than your money's worth.

But if you want to get even more out of it, you can go one step further and learn how to unlock the full potential of this piece of electronic technology.

How? It's all explained in this unique booklet, written by a leading calculator design consultant. In its fact-packed 32 pages it explains, step by step, how you can use the Sinclair Cambridge to carry out complex calculations.

Why only Sinclair can make you this offer
The reason's simple: only Sinclair - Europe's largest electronic calculator manufacturer - have the necessary combination of skills and scale.

Sinclair Radionics are the makers of the Executive - the smallest electronic calculator in the world. In spite of being one of the more expensive of the small calculators, it was a runaway best-seller. The experience gained on the Executive has enabled us to design and produce the Cambridge at this remarkably low price.

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And you benefit!

Take advantage of this money-back, no-risks offer today
The Sinclair Cambridge is fully guaranteed. Return your kit within 10 days, and we'll refund your money without question. All parts are tested and checked before despatch - and we guarantee a correctly-assembled calculator for one year.

Simply fill in the preferential order form below and slip it in the post today.

Price in kit form: £24.95 + £2.50 VAT. (Total: £27.45)
Price fully built: £29.95 + £3.00 VAT. (Total: £32.95)

To: Sinclair Radionics Ltd, London Road, St Ives, Huntingdonshire, PE17 4HJ

Please send me

[ ] a Sinclair Cambridge calculator kit at £24.95 + £2.50 VAT (Total: £27.45)
[ ] a Sinclair Cambridge calculator ready built at £29.95 + £3.00 VAT (Total: £32.95)

* I enclose cheque for £ , made out to Sinclair Radionics Ltd, and crossed.

* Please debit my *Barclaycard/Access account. Account number

* Delete as required.

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VAT Reg. No.: 213 877 98
SAFETY FIRST

TO encourage safety in the mere presence of electrical, electronic, radio or television apparatus, let alone during their operation, is not only laudable but vital. Hence the British Electrotechnical Approvals Board for Household Equipment (now affectionately BEAB) is extending the BEAB Approval Scheme to include audio and radio products including record players, radios, radiograms, mains/battery portable receivers with (curiously) "continuously rated audio outputs up to 6 ± 6 watts stereo or 10 watts mono". Manufactured equipment that is licensed to bear the BEAB approval marking has to be first subjected to some detailed and stringent tests at the BSI laboratory.

The specification for the tests, detailed in BS 415: 1972 (with amendments), highlights for the more casual of the manufacturers, and probably some of the amateur constructor fraternity, areas of potential risk in mains driven equipment that all too often are taken for granted. There are, of course, extreme cases like the ladies' dangling necklace test and the test which inserts artificial fingers into apertures almost in determination to find live contact. Generally the scheme is an excellent one. In most British equipment, that is designed and manufactured by responsible people, it is unlikely that no thought will be given to hazards such as shock, fire risk, ionised radiation, implosion and the like.

What has been needed is some form of yardstick by which a known hazard can be measured. Let us not be carried away by any thought that this standard is for manufacturers only. There are frequent cases where more strict attention to detail is needed by everyone who has mains driven appliances or electronic equipment.

We have only one serious complaint: that is the use of graphical symbols to indicate the nature of the supply (a.c. or d.c.) and to indicate live terminals. To the uninitiated layman, technical symbols mean nothing and he will not be inclined to buy BS3939 to find out before operating his new purchase.

Elsewhere in this issue we have highlighted only a few of the points in BS415 that we feel the general public need to know about. It is stressed that the detailed specification is designed to cover most contingencies of normal operation; we recommend manufacturers, suppliers and users to refer to this for more information.

M. A. COLWELL—Editor.

The May issue of Practical Wireless will include a special pull-out feature to make a handy booklet "Guide to Long Distance Reception of Radio and TV", (useful for locals, too!). Also appearing will be constructional projects: the medium wave "Mini-POP" (goes in a jacket pocket); an audio booster and power supply to enable you to hear cassette recordings in the car; a trace doubler to enable you to convert a single-beam oscilloscope for four displays. We shall also be giving first details of a super new project that we know will appeal to sports fans all over the world. Don't miss out—order your copy regularly NOW. (All advanced details are subject to the current national industrial situation).

Further details on page 1167

Export sales of British made Dolby

I
In a recent statement Phoenix Video sonic Ltd., of Braintree, Essex, Europe's only manufacturer of Dolby Noise Reduction Units announced significant export sales to Europe, North America and Japan.

A Videosonic spokesman stated: "Videosonic leads the world in the technical specification of its equipment: in the PD4 we have introduced a new high level Dolby 'B' circuit providing a unique range of over 95dB between noise and 0.1% distortion. At this time the PD4 represents the ultimate way to take the PSSST! out of tape."

To further extend our lead in the World Hi-Fi market, the PD2b has been introduced as the world's first battery operated Dolby Unit, allowing 'field' use in the most rigorous conditions. The integral microphone pre-amplifier makes this an ideal unit for reporter or similar usage.

World recognition of Video sonic technical manufacturing competence has been most encouraging, and we can only take pride in our immediate penetration of the Japanese market in the face of very strong local competition. We are advised that our range of Dolby products will be displayed and demonstrated in the top 850 Hi-Fi Retail Shops in Japan, and that local response to date has been very positive. Our first shipment to Japan leaves this week.

Portable Fluorescent Lamp (March P.W.)

WILL readers please note, that the transformer specified is now no longer available. An improved transformer is available from Messrs G. F. Milward at 77p plus 20p p & p. This includes full modification details and uses fewer components. A 21 in. 15W tube is available at 50p + 20p p & p, and it is claimed that this tube gives a greater light output than the 15W tube. S.A.E. to G. F. Milward for further details.
Bargains galore

If you are in the "Ally Pally" area on March 24th, pay a visit to the Collector's Bazaar which is being held in the Palm Court. This is a five-bazaar event which includes militaria, vintage post cards, vintage toys, transport relics and, of most interest to our readers, vintage records, horn gramophones, phonographs and probably some items of vintage radio equipment.

Practical Wireless visited one of these bazaars held at St. Johns Wood a few months ago, and it was there that Colin Riches purchased an Edison "Gem" phonograph to be featured in a future "Going Back."

If any readers want to find out the details of hiring a stall at the bazaar (£3-50 for the day) contact the organiser John Carter, Smewins, Shottesbrooke, nr. Maidenhead, Berks, SL6 3SR (Tel. Shurlock Row 539).

Otherwise, put on your cycle clips and pedal along to Alexandra Palace, Wood Green, London N.22, on March 24th. They'll let you in at 1 p.m. but be sure to have your entrance fee of 30p at the ready.

Hi-Fidelity 74

Hi-FIDELITY 74 is a rival exhibition to the Sonex show. It will be run at the same time and held at the Heathrow Hotel, Bath Road. It's the idea of Malcolm Blockley who is the Hi-Fi Division Sales Manager of Pyser-Britex Ltd.—the sole UK distributor of Marantz, Teledyne and Kenisonic equipment.

The organiser states that this show has been arranged because many manufacturers are fed-up with trying to demonstrate their products in small, cramped hotel bedrooms.

Hi-Fidelity 74 will run from March 27th to 31st inclusive but the first two days will be for the trade and press only.

Blast them out!

In order to reduce the effects of interference from an East German station at night, the BBC has increased the transmitting power of the Radio 4 Moorside Edge transmitter to 300kW.

Public Address Exhibition

Readers who have an interest in outdoor activities, such as rallies, will be planning events for the coming season. To get up to date on public address installations, it would be worthwhile to visit Sound '74, the international exhibition of the Association of Public Address Engineers. A lecture programme will be held concurrently on p.a. design, building acoustics, microphones, and the financial side of public address work from the practical point of view.

The A.P.A.E. has received more stand space bookings than previously, but there are still a few left for those who wish to come in at a late stage, including suppliers of disco equipment.

Admission is free to all interested persons: tradesmen, manufacturers, buyers, and users of public address and allied equipment in the entertainments business. Tickets can be obtained from exhibitors or from the A.P.A.E. Secretariat, 6 Conduit Street, London W1R 9TG.

The scope of activities covered is extended to include audio-visual effects.

Overseas readers will be interested to learn that the A.P.A.E. are exhibiting in Hall 9A at the Hanover Fair from 25th April to 3rd May 1974 and at the I.C.E.T.I.A. exhibition at Melbourne, Australia from 7th to 11th October.

Practical Wireless will be on show at the Hanover Fair.

UK wavebands and frequencies

THE BBC Engineering Department have issued a useful data sheet which shows the frequencies and wavebands allocated to broadcasting in the United Kingdom. Below we give the details from that sheet:

<table>
<thead>
<tr>
<th>Band</th>
<th>Frequencies</th>
<th>Service</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low frequency</td>
<td>160-255kHz (1875-1176m)</td>
<td>a.m. radio</td>
</tr>
<tr>
<td>(long waves)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medium frequency</td>
<td>525-1605kHz (571-187m)</td>
<td></td>
</tr>
<tr>
<td>(medium waves)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High frequency</td>
<td>3950-4000kHz (75-m band)</td>
<td>405-line television</td>
</tr>
<tr>
<td>(short waves)</td>
<td>5950-6200kHz (49-m band)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>7100-7300kHz (41-m band)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>9500-9775kHz (31-m band)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>11700-11975kHz (25-m band)</td>
<td></td>
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<tr>
<td></td>
<td>15100-15450kHz (19-m band)</td>
<td></td>
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<tr>
<td></td>
<td>17700-17900kHz (16-m band)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>21450-21750kHz (13-m band)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>25600-26100kHz (11-m band)</td>
<td></td>
</tr>
<tr>
<td>Band I</td>
<td>(v.h.f.) 41-68MHz (channels 1 to 5)</td>
<td>405-line television</td>
</tr>
<tr>
<td>Band II</td>
<td>(v.h.f.) 88-97-6MHz</td>
<td>f.m. radio</td>
</tr>
<tr>
<td>Band III</td>
<td>(v.h.f.) 174-216MHz (channels 6 to 13)</td>
<td>625-line television</td>
</tr>
<tr>
<td>Band IV</td>
<td>(u.h.f.) 470-582MHz (channels 21 to 34)</td>
<td></td>
</tr>
<tr>
<td>Band V</td>
<td>(u.h.f.) 614-854MHz (channels 39 to 68)</td>
<td>625-line television</td>
</tr>
<tr>
<td>Band VI</td>
<td>(s.h.f.) 11700-12500MHz</td>
<td>Not yet in use for</td>
</tr>
<tr>
<td></td>
<td>(11-7-12.5GHz)</td>
<td>broadcasting</td>
</tr>
</tbody>
</table>
Imagine the situation: you are driving your car in drizzly rain, you put on the windscreen wiper. One sweep is sufficient, so you switch it off. Five, ten or fifteen seconds later the windscreen needs another wipe, so you switch on the wiper again for another single stroke. This could go on for some time and tends to be tiresome.

The circuit here described saves this tiresome routine and allows you to relax in the automation of a variable time-sweep wiper. Although the circuit is designed for wiper motors with automatic parking facility, there is some information at the end of the article which will be helpful to those who have wiper motors without this facility.

**A VARIABLE TIME SWEEP WINDSCREEN WIPER**

P. S. Collins

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**Fig. 1.** Circuit of the Quickwipe for a vehicle with a POSITIVE earth system. It is essential to be quite sure which side of the battery is connected to chassis.

**Fig. 2.** In this circuit for a NEGATIVE earth system, different transistors are used and capacitors and diodes are reversed compared to those in Fig. 1.
Figures 1 and 2 are the circuits for positive and negative earthed vehicles; the difference lies only with the active components and reverse connection of the polarised ones. The circuit action remains the same. Tr1 and Tr2 form a multivibrator generating a pulse of fixed length with a variable repetition rate. VR1 allows this rate to be varied between approximately 3 and 30 seconds. Tr3, 4 and 5 form a pulse amplifier to drive the wiper motor.

The fixed pulse length is 3/4 second which is sufficient time to drive the motor long enough for its internal switches to take over the drive and thus return it to the park position. Switch S1 is centre off. One switch, S1b, switches for continuous operation, earth being directly applied to the motor.

In the other position, S1a, applies 12 volts to the circuit and S1b connects the motor as the load for the pulse amplifier. The vehicle wiper switch may now be regarded as redundant, or left in the circuit, as desired.

CONSTRUCTION

The whole unit can be comfortably housed in a die-cast box measuring 3 1/8 x 1 3/8 x 1 3/8 in. Figure 3 shows the printed circuit board. Tr5 is mounted on the lid with insulating washer and bushes. All leads from the circuit board and Tr5 are connected to a five-way terminal strip fixed to the side of the box. This enables easy connection to the vehicle’s wiring, as shown in Fig. 4.

Confirm the chassis polarity of the vehicle before constructing the unit. then use Fig. 1 OR Fig. 2 as appropriate.
NOTE: It may be possible to arrange the fixed pulse length to correspond with the time taken for the wipers to travel one complete sweep, in the case of wipers without the self-park facility. This could be achieved by altering the values of R5 and C5. These points are offered only as helpful guides. The author has conducted no tests in this regard and cannot therefore give any facts regarding accuracy or success.
IT does not seem many years since test meters were so expensive that, in the radio and TV trade, at least, one was shared between several engineers, the losers having to make do with wet fingers and neon screwdrivers! Test meters are now relatively cheap so that no enthusiast or handyman can really afford to be without one; whether it be for attending to the Hi-Fi system, fixing the car, or even sorting out a fault on the front door bell. Despite their simplicity in operation these meters can deceive the unwary and so it is hoped that a little basic theory will be of practical assistance.

The multi-range test meter commonly contains ranges such as AC and DC voltage, DC current and at least one resistance range. Other functions may be included on the more elaborate instruments but all use the basic meter movement plus the switching of various internal components in or out of circuit.

The DC Voltmeter

The meter movement fitted to most modern test instruments needs a current of something in the range of 1 to 1/100 of a milliamp to move a pointer across the full extent of the scale. The theoretical circuit of the basic meter movement is shown in Fig. 1. The “internal resistance” is not an actual resistor, but is the resistance of the coil of wire in the meter movement. From Ohm’s Law, (voltage = current x resistance) this 1mA meter movement shown will require a voltage of 0.1 volt for full scale deflection, (1/1,000 x 100/1 = 0.1 volt). This basic meter could therefore be used to measure voltages of up to 0.1 volt or currents of up to 1 milliamp—not very useful!

Fig. 1: Representation of meter movement must include resistance of moving coil.

The meter movement is basically a current operated device, but it can be made to read various quantities. A little thought will show that a 1mA meter movement will read full scale if 1 volt is applied to it through a series resistance which, including internal resistance, totals 1,000 ohms. From Ohm’s Law, 1 volt across 1,000 ohms causes a current of 1mA to pass. A voltmeter using a 1mA meter movement is said to have a sensitivity of 1000 ohms per volt.

Fig. 2: Series resistors for voltmeter allow for coil resistance. Only of importance on lower ranges.

Fig. 2 shows the meter wired to read four ranges of voltage and it will be seen that the total resistance of the meter is 1,000 ohms for every volt of the range in question. For this reason it is referred to as 1,000 OPV and this would usually be marked on the meter scale.

Such a meter does have its disadvantages and its relatively low resistance can greatly affect circuit voltages as will be shown. In Fig. 3a two 1 ohm resistors are connected across the supply and the voltage between X and Y is measured. If the meter is switched to the 1 volt range it has a total resistance of 1,000 ohms (remember 1,000 OPV) this resistance being shunted across R2. As the meter resistance is very high, compared to R1 and R2, its effect is negligible and the reading is given accurately as 0-5 volts. If, however, the meter is transferred to the circuit in Fig. 3b and another reading is taken the resulting accuracy is quite different. Once again, the reading should be 0-5 volts, but note what happens when the meter is
connected across R2. R2 is shunted by the meter’s resistance of 1,000 ohms and the resistance of the bottom half of the circuit drops to around 900 ohms. The voltage divides itself according to the ratio of the resistors and the meter reads just below 0.1 volts.

![Diagram](image)

The meter is not really wrong, it simply reads the voltage that is present when it is connected. Using the same meter a more accurate reading could be taken by switching to the 10 volt range when the test meter’s resistance would rise to 10,000 ohms; the meter’s resistance in parallel with R2 would then total 5,000 ohms and whilst the voltage reading would still be low at 0.35 instead of 0.5, it would be a little more realistic. Could we take the same argument further and switch to the 100 volt range with a meter resistance totalling 100,000 ohms, and obtain an accurate result? Unfortunately, no, since when the meter was switched to this range the pointer would move so little that we would not be able to take an accurate reading from it.

If we want a more accurate reading in a high resistance circuit the answer is a more sensitive meter movement that will allow us to insert larger values of voltage multiplier resistors. If for instance, we substitute a meter with a 50 micro-amp movement (0-0.5mA), we will obtain a sensitivity of 20,000 OPV. Using circuit Fig. 3b we would then obtain, on the 1 volt range, a reading that was almost correct, (20,000 ohms being shunted across R2), or by switching to the 10 volt range using this higher sensitivity meter we would obtain a reading that was accurate to within all normal requirements.

As has been illustrated, the DC voltmeter can only read the voltage which is present when it is connected. It cannot guess at the voltage which appears when it is disconnected. When using a voltmeter one should get into the habit of comparing the resistance of the range being used with the resistance of the circuit being measured.

In many cases when operating in a high resistance circuit a more accurate reading will be obtained if a higher voltage range is used. If in doubt a reading should be taken on two adjacent ranges of the test meter. With any good quality instrument these readings should be about the same, but if they are not it implies that the meter is loading the circuit on the lower voltage range.

**Valved or Transistorised Voltmeters**

To obtain higher sensitivities using normal techniques requires very expensive and delicate meter movements. It is not common practice, therefore, to make multi-range test meters with a sensitivity of much over 50,000 OPV. In some circumstances an even higher sensitivity is required, so that test meters of as high a sensitivity as this would be of little use at measuring, say, 0.1 volts in a circuit with resistance of several megohms. To enable higher sensitivities to be obtained, the valve and then the transistorised voltmeter were introduced. In these devices amplification is used so that an input resistance of 10 megohms or more is presented, even on the lowest voltage ranges. Such instruments are essential if tests are to be made in some high impedance transistorised circuits where very small voltages are present.

**Frequency Response**

Most test meters are basically intended for making tests at the mains frequency and their accuracy often falls off at frequencies in the audio range. One should check the frequency response of a test meter before relying upon it to check audio or bias frequency voltages. In the latter case it should be remembered that high frequency bias voltages can damage the rectifier in some test meters, and also that even if the meter’s frequency response is adequate that its loading (possibly only a few hundred OPV) can, in many circuits, much reduce any voltage present. If it is desired to accurately measure voltages at high audio or radio frequencies the valve or transistorised voltmeter is again essential.

**The AC Voltmeter**

The AC ranges of multi-range test meter function in very much the same way as the DC ranges except that a rectifier is incorporated to enable the basic DC meter movement to function, see Fig. 4. As with the DC voltage section of the meter, the amount of loading on the circuit being tested is indicated by the sensitivity in ohms-per-volt. Rectifiers have a tendency to be non-linear at low current.
levels and so, in the interest of accuracy, it is common to reduce the sensitivity of the test meter when switched to the AC ranges. The popular Avo Model 8, for instance, has a sensitivity of 20,000 OPV on the DC ranges but only 1,000 OPV on the AC ranges.

The Direct Current Ranges

The basic DC meter movement, as we have seen, will reach full scale when a small current is passed through it. The example shown in Fig. 1 needed 1mA for full scale deflection. If it is desired to measure a larger current, some of the current must be by-passed. The circuit with various resistors which are known as “shunts” is shown in Fig. 5. The value of shunt resistor R3, for instance, is calculated so that when the test meter is measuring 1A, 999 milliamps go via R3 and 1mA passes through the meter.

This is not the case. Here the effect of adding the meter in series with the circuit is to considerably increase the value of the emitter resistor. Increasing this effective value would mean that the current which flowed with the test meter connected would be much less than the current which normally flowed in the circuit.

When checking current flow in low impedance circuits, it is better to measure the voltage across a known resistor and then to calculate the current.

The Resistance Ranges

Figure 7 shows a basic method of resistance measurement. If the test prods are touched together R2 can be adjusted until the meter reads full scale, the current being provided by the battery. As we have seen a 1mA meter when used as a voltmeter

An excellent view of the latest AVO Model 8. It uses printed circuit techniques for shunts and switchboards. (Courtesy AVO Ltd. Dover)
has a sensitivity of 1,000 OPV and here, if the battery is exactly 1.5V, R1 plus R2, plus internal resistance must equal 1,500 ohms, when R2 is set to provide full scale deflection with the test prods touching. If now, instead of touching the test prods together, we connect them to a resistor being tested, of 1,500 ohms, the meter will then read half-scale as an external resistor of the same value as the built-in resistance has been added to the circuit. The centre of the scale would be marked 1,500 ohms and with suitable calibration resistors of between, say, 50 and 50,000 ohms, resistors could be checked using this set-up, with reasonable accuracy.

![Fig. 7: Basic circuit for measuring resistance.](image)

To divide the range by 10 we can shunt the meter as was done on the current ranges so that the sensitivity of the circuit becomes 100 OPV, enabling R1 and R2 to be reduced to 1/10 of their previous value. Alternatively, we can multiply the range by 10 by fitting a 15V battery and increasing R1 and R2 tenfold. In this way we obtain a meter with a centre scale range of 150, 1,500 and 15,000 ohms on three ranges enabling resistors from below 10 to above 500,000 ohms to be checked with good accuracy.

Use of Ohms Range

From the above discussion it will be seen that a current is passed through the component to be tested and that a voltage is also applied across it. In most cases this will do no harm, but it is wise to be aware that voltages of up to 25 or so are possible on the high resistance ranges and that currents in the order of 100mA or more may be found on the low ohms ranges of some test meters. When checking circuits where there is the slightest risk of damage being caused, it is wise to avoid using the highest or lowest ohms range on the test meter and to concentrate tests on the range which applies low voltage and low current. If magnetic devices, such as tap heads, are tested, note that they will be magnetised by the meter current. These tests should not be made, therefore, unless a defluxer is available to remove the residual magnetism.

It should be noted that no checks of resistance can be made unless the circuit which is being tested, is completely dead. All voltage sources should therefore be disconnected before tests take place, as, quite apart from giving the wrong results, severe damage can be caused to the test meter and equipment if resistance tests are attempted on live circuits. Devices such as transistors, diodes and electrolytic capacitors are inherently polarity sensitive so the polarity of the voltage output of the test meter should be noted whilst making tests on these devices. As will be seen from Fig. 8 using normal circuit arrangements the polarity of the test prods is normally opposite on the ohms range to that marked on the meter for the voltage and current ranges.

Decibels

Many test meters have a scale marked in decibels marked in + and – values over a total of 15dB’s or so. It must be clearly understood that the decibel is not an absolute value, such as the ohm or volt, but, as will be seen from the shape of the dB scale, is a logarithmically based system of comparison. Whilst many test meters are calibrated so that 0dB = 0.775V this is just an arbitrary figure. In practical use, such as measuring the frequency response of an amplifier, the signal level is adjusted so that the output when measured with the test meter set to a suitable range, reads 0dB. If the input frequency is then varied the output variation, and hence the frequency response of the equipment being tested, can be read off directly in decibels.

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To be really useful in making this kind of test the response of the test meter and the output of the audio generator must be flat with frequency, otherwise one is liable to end up in the position of the wheel-tapper who condemned 100 wheels only to find he had a cracked hammer! Remember, it costs next to nothing to print a decibel scale on a meter but it costs pounds to incorporate the response and accuracy needed to make it really meaningful for even simple audio frequency response measurements.

**Precautions in use**

Multirange test meters are precision instruments which can easily be damaged by over-loading. Whilst many meters have built-in automatic protection, these circuits only give a **limited** protection; they do not cater for gross overloads. A moments carelessness can leave an instrument which is beyond economical repair. To avoid disasters follow the makers' instructions, together with the following suggestions:

1. Always leave the instrument switched to a high voltage range when not in use. **Never** on a current or ohms range.
2. Never connect meter to any live circuit when switched to ohms.
3. Be extra careful to avoid short circuits when using the current ranges.
4. When measuring unknown voltages or currents switch to the highest range **first**, and only change over to a lower range if less than, say, one third of full scale deflection is registered.

**Buying a meter**

There is a host of small test meters available, many of which should be more than adequate for the average hobbyist. Aim to get a meter which has a sensitivity of 10,000 OPV or more on the DC ranges and which has a scale which is clear to read. A resistance range coverage of from, say, 1 ohm to 2 megohms, will fill most needs. AC current ranges are not really of any great importance, as current can always be calculated from resistance and voltage measurements, but a few DC current ranges will be found useful.

When comparing meters it can be advantageous to take along a battery and a few known values of resistors. There is nothing like a practical test to prove whether readings are plain and straightforward or confused and ambiguous. The cost?—£15 will buy a meter which is likely to be more than good enough but look around and testers costing well under £10, which are by no means cheap and nasty, can be found.
LAST month's emitter followers were all types of current amplifiers. In every case the output voltage was the same, or slightly less than the input voltage. Many applications require voltage amplification—e.g. raising the output level of a microphone to an extent that when current amplification is applied the resultant signal could drive a loudspeaker. The grounded emitter amplifier will provide a reasonable degree of voltage and current amplification and, perhaps, the most used type of amplifier stage in the whole of electronics. Because both voltage and current is amplified we call the grounded emitter stage a power amplifier but not necessarily in the sense that you can expect several watts of useful output; specialised power stages are better equipped for the latter purpose and these will be covered later in the series.

![Diagram of grounded emitter amplifier](image)

Referring to Fig. 42, we know that we can make the voltage at point A go to +9V by ensuring that the transistor is cut off (i.e. by passing zero base current) and conversely we can make it fall to zero volts by passing a certain amount of base current through R2. By knowing an accurate value of $h_{FE}$ for the transistor we could calculate a value for R2 that will cause just sufficient collector current to flow that the voltage drop across R1 will be 4.5V. Theoretically we could hold the voltage at A exactly mid-way between the two supply rails. At the same time we could connect a source of voltage through a capacitor to the base of the same transistor and (assuming the source voltage was zero at the time) this would not affect our bias condition. However, as soon as we begin to generate a voltage from the source this would cause current to be added or subtracted from the bias current (depending on the polarity of the a.c. signal) and would cause the voltage at A to rise and fall in exact relation—except for the 180° change of phase. Having point A biased “mid rail” allows maximum peak swings of voltage without the transistor clipping (going totally out of conduction) or bottoming (going into saturated conduction) unsymmetrically. In the ideal amplifier the voltage seen at A should faithfully represent that from the source.

In practice the method of obtaining this mid-rail bias shown in Fig. 42 is not very satisfactory because the $h_{FE}$ for the transistor must be accurately known and this can vary widely from one device to another (even though they may be of the same type number).

**Base current**

A simple way of compensating for this device variation is to use the potential at A as the voltage source for providing the base current—shown in Fig. 43. If the potential at A is too high the base current will be increased, hence the collector potential falls; conversely if A tends to be too low the base current decreases and the potential at A is forced to rise. By careful selection of component values this feedback bias circuit caters well for quite wide variations in the gains of transistors. It is not perfect by any means but is an improved way of getting a mid rail voltage reliably. You can make up the circuit of Fig. 43 on T Dec and try different BC108 devices. The voltage you measure should not fall outside the range of +5.5 to +5.5V. For those interested it is quite easy to arrive at the component values. First of all assume that the collector load is to be 1kΩ. For the potential at A to be +4.5V (assuming a 9V supply) the drop of 4.5V across R1 will be caused by a collector current of...
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4.5mA. If we expect an $h_{FE}$ of around 200 for the BC108 this means that the base current needed to cause 4.5mA collector current is $4.5/200 = 0.0225$mA. The value of R2, to give this current is calculated from the potential difference across it (potential at A minus the 0.6V base emitter drop) divided by the base current $3.9/0.0225k\Omega = 170k\Omega$. The small base current drawn will theoretically modify our original assumption of the potential at A but is so small that it can be ignored. Strictly speaking we should have shown R2 as having a value of 170k$\Omega$ but because of other experiments to follow we have made it 150k$\Omega$. The effect of this is to cause the quiescent voltage to be slightly less than mid-rail—but near enough for the experiment.

A crystal microphone is a very easily obtainable source of a.c. voltage that is of a capacitive nature and this can be connected straight across the base of Tr1 and ground of our circuit without affecting the bias conditions (see Fig. 45). Note that we have split the value of our original R2 between two resistors (R2 and R3) in series. Initially leave out the capacitor C1 and connect a meter set to a low a.c. range through a capacitor to point A. Most modern test meters have this capacitor built into them if you use the input socket marked “Output”. The capacitor is there so that the meter only responds to a.c. components on top of the d.c. quiescent voltage at A. Whistle loudly into the microphone and you should see a slight movement of the meter (probably 4V maximum).

Remember, though, that the output from the microphone is unlikely to be greater than a few tens of millivolts. Clearly there is some form of voltage amplification. If you think about it, though, the a.c. fluctuations at A are being fed back, out of phase, to the base through resistors R2 and R3. This will negate the input signal and the overall gain of the amplifier is going to be considerably impaired. We can, however, prevent the a.c. component of the feedback signal reaching the base by connecting a capacitor from the junction of R2 and R3 to ground. Do this while whistling into the microphone and you should see at least a two to one improvement in amplification. We call C1 a decoupling capacitor and it should be of a high enough capacitance to shunt even the lowest frequencies to ground.
The output current from a crystal microphone is very small—because of its high impedance—particularly at low frequencies but there must be quite a reasonable current generated between collector and emitter of the transistor to give rise to the voltage swings we can see at point A. Thus the transistor can be seen to give both current and voltage amplification. The component values in Fig. 45 are not really ideal for coupling from a crystal microphone because we require a fair amount of a.c. base current from the source, and as mentioned earlier, there is not much of this available at low frequencies. The low frequency response of this amplifier would therefore be pretty poor. We can, however, use exactly the same approach to make a stage that needs only one tenth of the input current by increasing all our resistance values by factors of ten (the first stage of Fig. 47). The output from the collector of Tr1 is now coupled as an a.c. signal source to the base of Tr2 which, excluding C4, is identical to the stage we have just described. Before connecting C4 or Tr3 measure the a.c. signal at point A exactly as before; you should see a really high voltage swing (getting on for three or four volts) and more than that, you can get a useful reading for ordinary speech a few inches away from the microphone.

The circuit is clearly providing more voltage gain and has a more useful response at the lower frequency of the human voice. Obviously by increasing the gain at low frequencies we must be overdoing it at high frequencies therefore we insert capacitor C4 which is used, deliberately, to feedback signal from the collector of Tr2 to its base. Because it has a low value it will provide more negative feedback at high frequencies than at low frequencies and hence helps to linearise the frequency response of the two stage amplifier. Use the "whistle and speech" test to see that the amplitude for the whistle is reduced but the level for normal speech has not been appreciably affected. Because we now have a useful voltage swing at A for speech we can use a current amplifier (an emitter follower) to give sufficient current at that voltage to drive a loudspeaker. This is provided by Tr3.

Note that it is necessary to decouple the power rail between the output stage and the amplifiers by means of R7 and C6. Without these components the current drawn by the output transistor could cause voltage variations on the line which are then seen as a form of signal by the preceding stages and amplified. This leads to instability and the whole circuit would oscillate wildly.

The amplifier of Fig. 47 does not have a particularly good frequency response but is quite adequate for intercom or baby alarm applications. No volume control is provided and in some circumstances you might encounter acoustic feedback (howl-round). This can be prevented by keeping the microphone and the loudspeaker well apart.

A problem with the circuits we have covered, so far, is that the voltage gain is very much dependent on the $h_{FE}$ of the transistor in question. There are other circuits which—at the expense of a little gain—enable us to get what there is under reasonably accurate control.

To be continued
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The concepts of input impedance and output impedance are not really difficult to understand although there is no single rule to cover every situation. What is correct practice depends almost entirely on the individual design requirements. The most important rule of impedance matching is derived from the maximum power transfer theorem.

**The maximum power transfer theorem**

If a signal source with a purely resistive output source is required to drive a purely resistive load, maximum power will be transferred from source to load when the load resistance is equal to the output impedance of the source. It should be noted that the theorem assumes that the input and output impedances to be purely resistive, which will rarely be the case in practice, and that to deliver maximum power to the load is the sole requirement.

Assuming that our signal source may be represented by an a.c. voltage source in series with a resistance (Fig. 1) and that our load may be represented by a pure resistance (Fig. 2), we can combine the two (Fig. 3) and write some pertinent equations as follows.

Calling the power delivered to the load $P$

$$V_L = \frac{V_S R_L}{R_L + R_S} \text{ by potential divider action}$$

and $I = \frac{V_S}{R_L + R_S}$ where $I$ is the a.c. current flowing

$$P = IV_L$$

$$P = \frac{V_S^2 R_L}{(R_L + R_S)^2}$$

where $V_L =$ load voltage, $V_S =$ source voltage, $R_L =$ load resistance, and $R_S =$ source resistance.

Given the source voltage and the source and load resistances we can, with this formula, calculate the power delivered to the load. But we can do more than that. If we assume arbitrary values for $V_S$ and $R_L$ we can plot a graph of $R_L$ against $P$. The curve obtained will be similar to that in Fig. 4. From the graph it may be seen that the power transferred is at maximum at approximately the point where $R_L$ equals $R_S$. It may be shown that $P$ reaches a maximum when $R_L$ is exactly equal to $R_S$.

Maximum power transfer between source and load occurs when the source resistance is equal to the load resistance.

**Other considerations**

In practice, however, it is not as straightforward as this because maximum power transfer may not be our only concern. Consider the simple audio output stage shown in Fig. 5. The purpose if $T_1$ is to match the speaker impedance to the output impedance presented by the transistor.

From the maximum power transfer theorem, one could reasonably assume the the "correct" load resistance would be the output resistance of the transistor, but this is not so. In this case maximum
efficiency (i.e. power transfer from amplifier to load) is not our main concern.

Of greater importance is the maximum power that the stage will deliver without distortion due to bottoming (the transistor being turned off by the input signal) or saturation. In fact the load resistance into which the stage will deliver the maximum power without distortion, known as the optimum load, is equal to the supply voltage divided by the quiescent collector current and has nothing to do with the actual output resistance of the stage.

At r.f. however, the relative bandwidth will generally be much less and it is usually easy to make the reactive elements of source and load cancel out in the frequency band in use. As an example, one of the functions of the aerial tuning unit in a transmitting system is to cancel out the reactive elements of the aerial impedance.

Equal load and source resistance

Now let us consider another situation in which it would be better to deviate from the rule of making the load resistance equal to the source resistance because maximum power transfer is not our only concern. Fig. 6 shows the equivalent circuit diagram of a typical crystal microphone or ceramic pick-up. The output impedance of such a device consists of a fairly large resistance (typically a few megarhms) in series with a small capacitance of perhaps two or three hundred picofarads. If the capacitive element was absent, the transducer drives a pre-amp with an input resistance equal to \( R_s \) and all would be well.

However, at the lower audio frequencies, the reactance of \( C \), in a practical transducer becomes large enough to be significant in comparison to \( R \), and attenuation of the bass frequencies would result if the input impedance of the pre-amp were equal to \( R_s \).

Since an inductance in series with the transducer would only cancel the capacitance at a single frequency and would, in any case be ridiculously large, the simplest solution to the problem is to make the input impedance of the pre-amp very large compared to \( R_s \). The reactance of \( C \) at bass frequencies would then be insignificant compared to the total resistance in circuit and no significant attenuation of the bass frequencies would occur.

High impedance input

The circuit diagram of a crystal microphone driving a pre-amp with an ample input resistance of 10M\( \Omega \) is shown in Fig. 7. One could reasonably think, from the maximum power transfer theorem, that the large ratio between the resistive component of the source impedance and the load resistance would result in a large loss of available power.

This is the case, but it may be shown that the power gain of a common source f.e.t. stage (and that of a common cathode valve stage) is proportional to the value of the resistor (R1 in Fig. 7) shunting the input, which is roughly equal to the

---

Continued on page 1166
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This simple automatic battery charger was originally designed for use with the very popular battery operated fluorescent lamp described in the December issue of Practical Wireless. Its purpose was to keep the battery in a fully charged state, restoring energy used when mains power is available.

The circuit is of course suitable for charging any 12 volt car battery at a maximum rate of 2.25A. When the battery reaches full charge (13.5 volts) a "crowbar" circuit operates and shuts off the charge current. Interruption of the mains supply restores the crowbar to its off state.

Circuit description

The circuit diagram is shown in Fig. 1. A mains isolation transformer with a 30V centre-tapped secondary winding feeds a full-wave thyristor circuit to provide the charging current. The thyristors are triggered by the d.c. potential applied to the gate electrodes via diodes D1 and D2 and the associated smoothing capacitor C1.

Resistors R1, R2, and R3 limit the gate current together with the indicator lamp LP2. Resistor R1 and lamp LP2 also limit the current through the crowbar thyristor CSR3 when it is 'on'. Resistors R4 and R5 are connected in parallel. They limit the charge current to 2.25A to protect the transformer, CSR1 and CSR2. Diode D3 is included to stop current flowing back from the fully charged battery into the crowbar circuit once it has triggered.

The crowbar trigger potential is set by the 6.8V zener diode D4 in the gate circuit of CSR3. By using the potentiometer across the circuit output it is possible to adjust the voltage of the output to a predetermined level at which the crowbar circuit 'fires'. The crowbar thyristor 'shorts' the main gates to earth and stops them from receiving gate pulses, so stopping conduction.

🌟 Components list

<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1</td>
<td>6Ω 5W wirewound resistor</td>
</tr>
<tr>
<td>R2, R3</td>
<td>270Ω ½W</td>
</tr>
<tr>
<td>R4, R5</td>
<td>1Ω 10W wirewound</td>
</tr>
<tr>
<td>R6</td>
<td>1-2kΩ ½W</td>
</tr>
<tr>
<td>R7</td>
<td>330Ω ½W</td>
</tr>
<tr>
<td>VR1</td>
<td>2-2k potentiometer (miniature preset)</td>
</tr>
<tr>
<td>C1</td>
<td>640μF 25V</td>
</tr>
<tr>
<td>LP1</td>
<td>Mains neon indicator</td>
</tr>
<tr>
<td>LP2</td>
<td>6-3V 0-2A lamp</td>
</tr>
<tr>
<td>S1</td>
<td>Single pole, single throw toggle</td>
</tr>
<tr>
<td>FS1</td>
<td>3A fuse</td>
</tr>
<tr>
<td>T1</td>
<td>Mains transformer, secondary 30V centre tapped, 3A</td>
</tr>
<tr>
<td>CSR1</td>
<td>2N3228 TO-66 or any 50V 5A thyristor, and mounting hardware</td>
</tr>
<tr>
<td>CSR2</td>
<td>2N3228 TO-66 or any 50V 5A thyristor, and mounting hardware</td>
</tr>
<tr>
<td>CSR3</td>
<td>TIC44</td>
</tr>
<tr>
<td>D1</td>
<td>1N4001</td>
</tr>
<tr>
<td>D2</td>
<td>1N4001</td>
</tr>
<tr>
<td>D3</td>
<td>1N1612R or any 50V 5A stud type (stud is anode) and mounting hardware</td>
</tr>
<tr>
<td>D4</td>
<td>6-9V 1 watt zener diode</td>
</tr>
</tbody>
</table>

Lamp holder (m.e.s.), connecting wire, mains lead, fuseholder, nuts, bolts, etc. Heatsinks (see Fig. 3.)

**Fig. 1:** Schematic circuit of the automatic battery charger.
When the board is complete and all wires to the transformer are connected make a final wiring check. Then set VR1 fully anticlockwise, and switch on the mains. Measure the voltage across C1; it should be approximately 20V.

Then connect a fully charged 12V battery (about 13.4V off load) across the output terminals. Advance VR1 slowly until the crowbar circuit just operates (lamp LP2 comes 'on'). The voltage measured between earth and R4, R5 and D3 junction should then be about 14V. Do not move the setting of VR1 again—sealing with a dab of glue is a good safeguard. Switch off the unit and disconnect the battery.

Connect a discharged battery to the unit and switch on. If an ammeter is available check the charge rate—about 2.25A. Alternatively measure the voltage across R4, R5; this should be about 1.1V. The crowbar circuit should not operate until the battery is fully charged and reaches 13.4V. Once operated the crowbar cannot be reset unless the mains supply is interrupted.

During power cuts this will be "automatically" accomplished.

**IMPEDEANCE MATCHING—continued from page 1162**

input impedance of the stage. Thus, a high input impedance makes for higher power gain and, hence, greater output power from the stage as well as improving the bass response, as it does in this particular application.

**Power fall-off**

There are many such situations in which maximum transfer of power from source to load is not our only concern and load resistance should not be made equal to source output resistance. But the basic principles should be borne in mind. The maximum possible power will be delivered to the load when the input resistance of the load is equal to the output resistance of the source and any reactive components in the source impedance should be cancelled out by equal but opposite reactive elements in the load impedance.

In many practical cases exact equality of source and load resistances is not easy to achieve. It may be seen from Fig. 1 that the power transfer falls off more rapidly with decreasing load resistance than it does with increasing load resistance. Therefore, if it is necessary for a mismatch to occur, it is clearly much better to make the load resistance greater than the source resistance.
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PRACTICAL WIRELESS—THE MAGAZINE WITH THE BEST CONSTRUCTIONAL ARTICLES EACH MONTH
Fig. 1. First part of the circuit of the Slimline receiver. This contains the mixer stage Tr1 and the oscillator Tr2. Padders C5 and C6 are automatically connected into circuit when the appropriate coil L2 is inserted.

Fig. 2. The output from the mixer stage feeds into the first IF transformer IFT1 and amplified by Tr3 and Tr4. The capacitors across the windings are part of the IFT assemblies.

Fig. 3. The audio signal from the detector diode D1 in Fig. 2 is fed via the volume control to Tr5 and further amplified by Tr6, 7 and 8 and thence to the speaker.
This portable receiver is in a 7×5in. case only 1 in. deep, though to these dimensions must be added those of the Trimmer, Fine Tuning and Volume/On-Off controls at one end, and the Band-setting dial on the front. These do not however increase the size very much. The receiver may be operated with its own telescopic rod aerial, with an improved aerial such as a few yards of thin insulated flexible wire or with a conventional aerial.

The coverage of the five bands is approximately as follows:

<table>
<thead>
<tr>
<th>Band</th>
<th>Frequency Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>160—350kHz</td>
</tr>
<tr>
<td>2</td>
<td>580—1500kHz</td>
</tr>
<tr>
<td>3</td>
<td>1.75—4.0MHz</td>
</tr>
<tr>
<td>4</td>
<td>5.9—11.5MHz</td>
</tr>
<tr>
<td>5</td>
<td>13—27MHz</td>
</tr>
</tbody>
</table>

The receiver thus has a wide general utility, tuning medium and long waves, if required, in addition to the most popular short wave bands.

Eight transistors and one diode are employed and the receiver is wired and assembled in separate units. A dual-gate 3N141 mixer is used with an MPF102 FET oscillator, followed by two BFY195’s and AA119 diode for IF amplification, demodulation and AGC. The audio section has a BC109 pre-amplifier and BC107 driving an AC127 and AC128 complementary output stage, which provides adequate power for the internal speaker.

CIRCUIT DETAILS

The telescopic aerial, or a short wire aerial, is connected to socket A2 Fig. 1, but longer indoor or outdoor aerials are plugged into socket A1, using the primary coupling winding of the aerial coil L1. This circuit is tuned by VC1 and the panel trimmer VC3 is provided so that this can be peaked for maximum efficiency with any aerial. Signals are taken to gate 1 of Tr1 and gate 2 is coupled by C7 to the oscillator Tr2. The oscillator coil L2 is tuned by the second section of the ganged capacitor VC1/VC2. VC4 is a bandspread tuning control to allow easy tuning on the short wave bands.

L1 and L2 are plug-in coils so there is no need to obtain coils for those bands which are not required. Band 1 is for long wave coverage and may not be wanted in some areas. The extreme high frequency end of this band is not used (above about 350kHz) as instability arises when this stage is tuned near the intermediate frequency, as would be expected.

Band 2 is for medium wave coverage while Band 3 includes shipping and other transmissions, as well as the 160m and 80m amateur bands. Most general short wave broadcasts come in Band 4 and also Band 5.

Capacitors C5 and C6 in Fig. 1 are padders and the correct value is brought into circuit for each coil when it is inserted, by wiring to the appropriate socket pins. TC1 is an integral trimmer on VC2. If VC1/2 is a type without trimmers a separate 30pF or similar small pre-set must be connected here.

Fig. 2 is the circuit of the IF amplifier. IFT1 and IFT2 are double tuned and IFT3 single tuned and these, with the two BFY195’s, result in good selectivity and gain. The demodulator diode D1 provides audio signals for the volume control VR1, and automatic gain control bias for the first IF stage. Current for the IF stages is taken from the 9V supply, through R12, the mixer drain circuit being supplied through the primary of IFT1. The on-off switch S1 is incorporated with the volume control VR1.

The circuit of the audio stages is shown in Fig. 3. Tr5 is a low level high gain amplifier with output to the driver Tr6 which drives the NPN/PNP pair Tr7 and Tr8, R17 providing stabilisation of the DC operating conditions. The circuit is intended for an 18 ohm speaker but it will be found that good results are obtained with a 25 ohm or 35 ohm unit.

CONSTRUCTION

Both sides of the mixer/oscillator board are shown in Fig. 4. Plain perforated Veroboard is most suitable, with 0.15in matrix. The resistors and capacitors are inserted as shown and the board turned over and leads soldered underneath. In most places the wire ends of the components are long enough to reach other points. Soldered joints should be small and leads kept near the board, with sleeving on leads which may touch each other. The tag MC is later secured with a 6BA or 8BA bolt, to hold the board clear of the panel and to form a negative or earth return.
Important. An insulated gate transistor of the 3N141 type has an extremely high gate internal resistance and it can be destroyed by the static charge of metal or plastic tools, or by touching its leads with the fingers. Despite this, there is virtually no danger to the transistor if it is installed correctly and once R1, R2 and R3 are connected to it, these protect the gate circuits from static charges.

Leave Tr1 until other wiring on this board is finished. Tr1, as supplied, should have a thin spring or loop which short circuits its four leads, to protect it. This is not removed until the transistor is soldered in place. If it has to be unsoldered for any reason, a length of thin, clean wire should be wound round the four leads, under the transistor, before this is done. Spread the leads with a matchstick so that they come through the holes shown in Fig. 4, bend over the wires from R1, R2 and R3, and solder them to the transistor leads.

It is convenient to use colour coded leads for the external connections. These may be green from C2 for VC1 and pin 6 of L1, yellow for the drain circuit, white from Tr2 drain to pin 8 of L2 and black for VC2 and pins 1 and 7 of the holder for L2.

The IF board is shown in Fig. 5. Holes for the IFT pins and screening can tags should be drilled first. The pins are identified by their spacing, and should be arranged as in Fig. 5. A very small round file may be useful in adjusting the positions of holes, if drilling is not quite correct, so that the IFT's fit without strain on their pins. Holes should also be drilled so that the cores can be reached. Two small tags are secured with the bolts MC, which also fix two angle brackets in place. These brackets allow the board to be fixed to the receiver panel.

Note the polarity of C10, C12 and D1. Proceed with the wiring as for the mixer-oscillator board, with insulated sleeving where required. The wire ends of R12 and C14 can be left projecting, so that other connections can be soldered on later.

The AF amplifier board is built in a similar manner, components being positioned as in Fig. 6. As it is rather difficult to see the transistor lead positions when these are in place, short pieces of coloured sleeving may be put on these wires first, to identify them—green for emitter, blue for base and orange for collector.

Capacitors C16 and C20 are arranged vertically. Bolts secure the tags MC and small brackets, as with the IF board. If necessary, these brackets can be cut from a small spare section of flanged universal

<table>
<thead>
<tr>
<th>★ components list</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Resistors</strong></td>
</tr>
<tr>
<td>R1 100kΩ</td>
</tr>
<tr>
<td>R2 2.2kΩ</td>
</tr>
<tr>
<td>R3 100kΩ</td>
</tr>
<tr>
<td>R4 5.6kΩ</td>
</tr>
<tr>
<td>R5 1MΩ</td>
</tr>
<tr>
<td>R6 2.7kΩ</td>
</tr>
<tr>
<td>R7 120kΩ</td>
</tr>
<tr>
<td>R8 47kΩ</td>
</tr>
<tr>
<td>R9 330kΩ</td>
</tr>
<tr>
<td>R10 390kΩ</td>
</tr>
<tr>
<td>R11 27kΩ</td>
</tr>
<tr>
<td>R12 1.5kΩ</td>
</tr>
<tr>
<td>R13 220kΩ</td>
</tr>
<tr>
<td>R14 1.5kΩ</td>
</tr>
<tr>
<td>R15 10kΩ</td>
</tr>
<tr>
<td>R16 220kΩ</td>
</tr>
<tr>
<td>R17 270kΩ</td>
</tr>
<tr>
<td>R18 680kΩ</td>
</tr>
<tr>
<td>R19 47kΩ</td>
</tr>
<tr>
<td>R20 2.2kΩ</td>
</tr>
<tr>
<td>R21 2.2kΩ</td>
</tr>
<tr>
<td>VR1 10kΩ log. pot. with switch S1</td>
</tr>
</tbody>
</table>

| **Capacitors**    |
| C1 100pF          |
| C2 100pF          |
| C3 0.01µF         |
| C4 0.047µF        |
| C5 470pF          |
| C6 150µF          |
| C7 5pF            |
| VR1 1000µF        |
| VC1 206-176pF gang (Jackson 00) |
| VC2 50pF (Jackson C804) |
| VC3 4.5pF (Jackson C804) |
| TC1 30pF trimmer, see text |

| **Semiconductors**|
| Tr1 3N141         |
| Tr2 MPF102        |
| Tr3 BFY195        |
| Tr7 AC127         |
| Tr8 AC128         |
| Tr6 BC109         |
| Tr5 AC128         |
| Tr4 BFY195        |
| Tr10 BC107        |
| D1 AA119          |

| **Inductors**     |
| IFT1/2 IF Transformer (Denco IFT18/465) |
| IFT3 IF Transformer (Denco IFT14) |
| L1/2 Plug-in coils, 9 pin miniature valve type for ranges required (Denco—'Blue' for aerial coils and 'Red' for oscillator coils) |

| **Miscellaneous** |
| Speaker, about 3½ in. dia., 18 to 35 ohms. Telescopic aerial, Small sockets, 0.5 x 0.8A valveholders, plain (2). Perforated veroboard 0.15m matrix, 15 x 1 in, 31 x 3 in and 2½ x 5 in. Knobs 4. Perspex for dial. |

| **Casework** |
| Plates 7 x 5 in (2) (CU168) |
| Flanged members 7 x 1 in (2) (CU54A) |
| Flanged members 5 x 1 in (2) (CU52A) |
| All from Home Radio. |
chassis, as used later for the coil holders. Both brackets and insulated board are drilled for 8BA bolts.

A piece of metal with a flange, for mounting the coil holders, is cut $2\frac{3}{4} \times 1\text{in}$ so that the holders can be fitted as in Fig. 7. A small section is cut away near L2 as shown, to allow the speaker to fit.

The flange is bolted 1in. from the edge of the panel, as in Fig. 8. There is little free space so items should be positioned carefully. The flange is held with 6BA countersunk bolts and nuts. The ganged capacitor is held with three 4BA bolts, which must be cut or filed short so that they do not project beyond the thickness of the capacitor's front plate.

Wiring can then be completed as in the diagrams. The IF, AF and mixer-oscillator boards are held with 8BA countersunk bolts. The one $5 \times 1\text{in}$ flanged runner is fixed with bolts or self-tapping screws so that VC3, VC4 and VR1 can be mounted, but the other flanged members are left off until later. Leads between units are run against the metal. The speaker is cemented over a $1\frac{3}{4}\text{in}$ diameter hole and the leads soldered to it. Other connections will be seen in Figs. 7 and 8.

The battery is mounted by a bracket, to which a negative snap connector is bolted. This both holds the battery and provides the negative connection. Two small sockets provide A1 and Earth connections. When all wiring is finished, except for the telescopic aerial, the receiver can be aligned. Do not forget to remove the shorting collar or wire from the mixer transistor.
IF ALIGNMENT

As the IFT's are supplied pre-aligned, the cores should not be touched until reasonable results are being obtained. A properly fitting tool must be used, such as that available from the IFT maker, as a wedge-shaped blade may easily break the cores so that they cannot be rotated. Where a signal generator is available, place the output lead of this near the yellow lead (mixer drain) and adjust the cores for best output.

If no generator is available turn the audio gain control to near maximum and tune in a weak but stable signal, such as that obtained from a local BBC transmitter, with no aerial at all in use. With this tuned in correctly, adjust the five cores slightly, as may prove to be necessary, for best volume. An alternative is to connect a high resistance test meter across VR1 (positive to chassis) and use a somewhat stronger signal, so that cores can be peaked for the best reading. When these cores have been adjusted, they should be left alone since their settings are not changed when dealing with the mixer and oscillator circuits.

MIXER/OSCILLATOR ALIGNMENT

If VC1/2 has trimmers, open fully the trimmer on VC1 and screw down the trimmer on VC2 and set VC3 and VC4 about half open. Each range is dealt with separately. Suppose that Range 3 is aligned first. Adjust the core of L2 (Red coil) so that band coverage is approximately correct. Then tune in a signal around 3.5 to 4.0MHz and adjust VC3 for best volume. Leave VC3 at this setting and tune to a signal around 1.9MHz. The core of L1 is then adjusted for best results, after which there is little need for much adjustment of VC3, throughout the band. When VC3 is peaked for best results, it should be neither fully closed nor fully open.

The other ranges are dealt with in the same manner. The cores of L2 are adjusted in that
direction which takes them away from the smaller winding for Ranges 1 and 3, otherwise continuous oscillation may prove troublesome at the high frequency end of these bands. This arises from the degree of coupling between L2 and its feedback winding. Should excess oscillation or “squeegging” of the oscillator be troublesome, R4 could be increased in value. On the other hand, if Tr2 has somewhat reduced gain the value of R4 could be reduced. However, with the value shown, several MPF102 transistors proved satisfactory, so this should not be necessary.

**FINISHING OFF**

The aerial is fixed to a small right angle bracket which is pivoted on a 6BA bolt passing through the side of the case. The hole is drilled to take an insulated bush and an insulated washer rests between the bracket and case. A spring washer is placed under the screw head and the nuts locked together so that the aerial can be extended vertically with the case flat or standing upright. A flexible lead runs from the aerial to C1.

The dial is marked on card and is about 2½ in. in diameter. The control knob is a shallow type to which is attached a 2½ in. diameter disc of 1/16 in. thick Perspex. This can be fixed with adhesive or self-tapping screws. A line is marked across the Perspex. A disc can be easily cut with an adjustable tank or washer cutter, but if this is not available a pointer knob could be substituted for the disc.

The case is completed by screwing on one 7 × 1 in member and the remaining 5 × 1 in member. The 5 × 1 in members fit inside the 7 × 1 in members so that the top 7 × 1 in flanged member can be taken off to change the battery or coils. The back, a 7 × 5 in flat plate, is permanently attached with self-tapping screws, but only one screw is run into the top member flanges.

There is some opportunity for individual choice in the way in which the case is finished. If left bare or painted, gauze or perforated metal should be fitted over the speaker aperture inside. The case shown was covered at the front with fabric and self-adhesive material as used for shelves, boxes, etc.
POWER AMPLIFIER ASSEMBLY

The first stage in assembly is to mount all components except the plastic power transistors onto the board, ensuring correct polarity of electrolytic capacitors. Solder each joint carefully—do not overheat the components, but make sure joints are properly made. Check that all parts are in the correct position and then cut off all excess lead wires. Note that R13 and C9 are mounted on the speaker sockets, not on the printed board.

Next fit the output and driver transistors onto their respective heat sinks ensuring that the mica washers and nylon bushes are correctly located. Check that each device is isolated from the heatsink after assembly. Then form the leads for insertion into the printed board. Do not bend the leads less than 45° from the transistor body. Do support the leads near the body with long-nose pliers whilst forming. Do not radius the bends tighter than 45°.

Mount the strip of four output devices onto the circuit board and solder up the connections. Then mount the two driver transistors in a similar fashion. Once soldered ensure that the power transistors are not bent back and forth on their leads—plastic packaged devices can be easily damaged by stressing the lead outs. Once complete the power board should be put away safely until needed later on.

TUNER AND IF CIRCUIT (UNIT 3)

The AM section utilises the Ferranti ZN414 integrated circuit IC1 and a single transistor amplifier Tr1. A small ferrite rod aerial forms part of a double-tuned aerial circuit which is used to eliminate swamping effects of strong local transmissions by improving the selectivity. The circuit and printed board illustrated are for the single-station version. Further channels may be added by inserting a suitable two-pole rotary switch at the points marked "X" and "Y" in Fig. 10 to select additional pairs of trimmer capacitors for each station required.

The ferrite aerial may be insufficient in some areas of poor signal strength. The AM aerial socket, which is loosely coupled to the ferrite rod by two turns of insulated wire, allows adequate reception under such conditions by connection of an external aerial.

In the FM section, a Mullard varicap tuned module type LP1186 feeds an RCA IF amplifier integrated circuit IC2 through a ceramic filter tuned to 10.7 MHz. This integrated circuit requires only one IF coil to provide the audio output for the decoder and also an AFC control voltage.

The prototype Tuner and IF board shown here has some variations in layout from the final version given in Fig. 12.
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C296 SERIES

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Fig. 10: Circuit of the Tuner and IF section, including the separate AM Tuner Board.

Fig. 11: Circuits of the alternative VHF tuning control arrangements described in the text—
(a) Full Band II coverage
(b) Four-station preselected tuning.
Fig. 12: Component location and printed circuit layout for the main Tuner and IF board. Both drawings are actual size.
The values given for the tuning control circuit allow coverage of 88-100 MHz. A restricted coverage has the advantage of making the tuning finer and spaces the stations farther apart. The alternative circuit of Fig. 11a provides coverage of the full band 88-104 MHz whilst a four-station preselected tuning arrangement is given in Fig. 11b.

---

### Components List

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<th>TUNER &amp; IF BOARDS</th>
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<td>Resistors</td>
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<td>R7 120Ω</td>
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<td>R10 22kΩ</td>
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<tr>
<td>VR1 50kΩ</td>
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</table>

#### Capacitors
- C1 3pF ceramic
- C2 0.22μF ceramic
- C3 0.47μF polyester
- C4 250pF ceramic
- C5 10μF 16V
- C6 0.047μF polyester
- C7 10μF 16V
- C8 0.1μF polyester
- C9 0.02μF polyester
- C10 0.08μF polyester
- C11 220pF ceramic
- C12 0.22μF ceramic
- C13 0.47μF polyester
- C14 250pF ceramic
- C15 10μF 16V
- C16 0.02μF polyester
- C17 10μF 16V
- C18 0.1μF polyester
- C19 47μF 16V
- C20 220pF ceramic

#### Semiconductors
- Tr1 BC113
- IC1 ZN414 (Ferranti)
- Tr2 2N6288 (RCA)
- IC2 CA3089 E (RCA)
- D1 BZY88 C5V1
- D2 BZY88 C5V3
- D3 BZY88 C15

#### Miscellaneous
- L1 55 turns of 30swg enamelled copper wire on 24" x 1/8" dia. ferrite rod
- L2 Single-tuned Medium Wave coil
- L3 RF Choke 15μH Toko TBA 150J
- L4 Toco KACS-K88-HM
- CF1 Crystal filter Verniton FM4 or Toko CFS10-7
- S1 SPST mini. toggle switch
- FM tuning head Mullard LP1186
- Tuning drive drum 1/2" dia.
- Slow-motion cord drive spindle
- Cord tension spring 3/4" 3 small nylon pulleys
- Printed circuit boards

#### Notes
1. RCA semiconductors are available from E.C.S. (Windsor) Ltd. (see Part 1 of this project).
2. Toko components are available from Ambit International.

---

Four power supplies are derived from the main 34V rail through a series stabiliser transistor Tr2 and various filter networks.

1. The decoder 15V supply is taken direct from the stabiliser and decoupled via C18.
2. The AM tuner 1.5V supply is provided by a resistive potential divider across the 15V supply R5/R6. Decoupling is provided by capacitor C5.
3. The FM IF and tuner varicap supply is taken from the 15V supply via R14 ar-1 decoupled by C14/C17. This supply is 12V.
4. The FM tuner 8V supply is provided from the 12V supply by R9, D1/D2 and R7. Decoupling is provided by C7, C8 and C9.

When assembling the printed board care must be taken not to overheat the integrated circuit pins and also not to short-circuit the adjacent connections as they are fairly close together. Ensure that all electrolytics and diodes are polarised correctly and that the ZN414 leads are correctly positioned. The ceramic filter CF1 may be mounted any way round—the centre pin is earthed and either of the other two pins may be input or output. The series stabiliser transistor Tr2 does not require isolation from either its heatsink or the copper print on the board.
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CRATA—continued

The AFC switch is mounted on the tuner back panel near the aerial sockets—it may be sited on the front panel if required, but do not locate it near to the mains neon and switch.

The AM aerial board, Fig. 13, on which the ferrite rod is mounted should ideally be mounted such that it can be rotated through 90° for maximum signal pickup. Alternatively it may be rigidly mounted in the correct position if the tuner will always be sited in one particular place. The leads between the printed board and the rotary switch in the multi-station version should be kept very short. A suitable position for the switch is immediately above the Input Selector.

Due to pressure on editorial space, details of the Stereo Decoder have been held over until our May issue which will also describe the Power Unit and Chassis.
OScilloscope Displays

The very heart of any oscilloscope is the cathode ray display tube. After all the electronic functions have been executed the ultimate result is displayed, visibly, on the face of the tube. We shall take a look at a few types of CRT and their associated circuits, as applied to oscilloscopes.

The electron beam, produced by an electron gun, passes through a deflecting mechanism and arrives at the screen where it causes the screen material to fluoresce. The whole mechanism is housed in an evacuated glass container and, in an oscilloscope, only the front face is visible. Fig. 1 shows the general arrangement. For oscillographic use we require a bright spot of light, intense but very small.

Electron gun
Envelop Deflection system
Fluorescent screen

Fig. 1: Main elements in a CRT intended for use in an oscilloscope.

It is the purpose of the electron gun to produce the narrow stream of electrons of high energy to cause local luminescence of the screen. When the beam hits the phosphor screen it causes fluorescence. However, if the beam is cut off suddenly the screen continues to glow with phosphorescent light. It is this phosphorescent light that determines the afterglow of the tube.

Electron Gun

A hot cathode on the axis of the tube produces electrons by thermionic emission, as in a conventional electronic valve. By a suitable arrangement of anodes an electric field distribution inside the tube is created focusing the electrons into a high velocity pencil, arranged to converge on to the screen. A simple gun arrangement is shown in Fig. 2

This type of arrangement is often used and is known as a pentode or five electrode gun.

The cathode is heated to emissive temperature and is surrounded by the grid, in this case shaped like a top hat with a hole in it, known as a Wehnelt cylinder. The grid is maintained slightly negative with respect to the cathode and focuses the space charge around the cathode along the axis of the gun.

The first anode (A1) is positive with respect to the cathode by perhaps a couple of hundred volts. Fig. 3 shows how the electrons are accelerated out of the grid area towards the first anode, and in so doing are focused at Z by the equipotential lines, shown dotted. The diameter at Z is used as an "image" and consequently should be as small as possible for a small spot on the screen. The electron beam enters the first anode diverging and a number of stops are added to keep the beam width small and keep out fringe electrons which impair definition. The diverging electron beam emerging from the first anode now needs to be focused on to the screen, or put another way, an image of Z is projected on to the screen.

Fig. 2: top, arrangement of electrodes used in a pentode gun. Fig. 3, centre, shows the beam focusing action of the grid and A1. Fig. 4, bottom, the effect of the remaining anodes A2 and A3 in focusing the beam on to the screen.

Fig. 4 shows how the second (A2) and third (A3) anodes accomplish this focusing. The second anode is at a higher potential than A1, and A3, the final anode, is at a still higher potential. Thus the equipotential lines are as shown dotted. The beam of electrons now converges as it crosses the A2-A3 fields and by adjustment of the voltage between A2 and A3 the beam can be focused on the screen of the CRT.
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Output Net No. Price

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**AUDIO- WOUND RANGE**

Power

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<td>983</td>
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In simpler types of CRT A2 is omitted giving a tetrode electron gun. The final focusing takes place between A1 and the final anode and geometrically is suitable for a fine spot. However, if focusing is achieved by varying A1 (the final anode potential is fixed as we shall see later) this affects the velocity of the beam because A1 is the primary accelerating anode. The change in velocity changes the position of the point Z and the range of focus is restricted for a good spot size. This situation in practice means that when the grid potential (brightness) or the A1 potential (focus) is altered the other potential must be changed as well, giving restricted focus and brightness range. It is for this reason that the pentode type of tube is almost universally used.

**BEAM DEFLECTION**

An electron has a negative charge of $1.6 \times 10^{-19}$ coulombs. This is a very small charge, and conversely any electric field acting on the electron will produce only a very small force. However the mass of the electron is very small and so large accelerations can be produced with only moderate potentials.

![Electron beam](image)

**Fig. 5:** Effect of the deflecting plates on the electron beam.

If a beam of electrons, focused into a fine pencil, is allowed to pass between two parallel plates as in Fig. 5, the electrons will experience a force towards the positive plate and it can be shown that the deflection is proportional to the deflecting voltage ($V_d$) and inversely proportional to the accelerating voltage ($V_a$). A purely mathematical outlook shows that electrostatic deflection produces a (theoretically) linear deflection mechanism.

**DEFLECTION PLATES**

In order to keep the sensitivity as high as possible the tube is physically large and the deflector plates are placed as close together as possible, usually of the form shown in Fig. 6 to permit high deflection sensitivity to be achieved without the beam catching the actual deflector plates. If this occurs (for example if the timebase is over-driven to give X expansion) secondary emission occurs at the surface of the plates, and the low energy secondary electrons can be accelerated towards the screen causing flare and high background illumination. This undesirable effect can be avoided by coating the plates with a material of low secondary emission, or providing “beam catchers,” small cups that accept the beam when driven off the screen. The X plates are usually mounted nearer to the tube face so that the Y plates have the maximum sensitivity.

To ensure that the electron beam does not become distorted in any way by extra acceleration due to the deflector plates they are arranged to be at the same potential as the final anode. Of course this is only true when the beam is travelling along the axis, but to prevent any gross errors on deflection it is common to provide symmetrical or push-pull deflection. This ensures that the mean electric field is not altered by deflection.

![Deflection plates](image)

**Fig. 6:** Arrangement of the X and Y plates, the Y plates being nearer to the gun system.

If the plates and final anode were at differing potentials then there would be a deformation of the circular cross-section of the beam (remember it is NOT in focus at this point, only at the screen where the cross-section area should be almost zero) by the plates attracting, or repelling, the outer electrons at opposite sides of the beam. This gives a sausage-shaped spot and the remedy is to make the final anode potential variable so that it may be matched to the Y plates. The X plates are then adjusted to be equal to the Y plate potential (as we shall see in a later section, it would be difficult to alter the Y plate potential). The control for setting the final anode volts is known as the “Astigmatism” potentiometer and is usually a front panel control.

![Astigmatism display](image)

The same CRT displaying a $1kHz$ square wave. Astigmatism is most noticeable as is the lack of HF response due to the simple deflection amplifier.
Another cause of incorrect spot size and shape is due to the pencil of electrons tending to spread, all being negatively charged. However, in high voltage tubes the velocity of the beam is high enough to keep the electrons in line by the magnetic field that they produce. The mechanism of electrostatic deflection relies on the electron beam being in the field of the deflector plates for a finite time. This means that when a very high frequency, say above 100MHz, signal is applied to the plates the signal may have changed before the electrons have emerged.

If, for example, a beam of electrons takes 10ns to travel through the plates a 100MHz signal will have completed one cycle and the deflection will be zero. In modern high velocity tubes the effect only occurs over 150 or 200MHz and the remedy is to arrange a series of deflectors, linked so that the velocity of the signal down the plates is the same as the velocity of the electron beam. However there are few uses for deflection amplifiers that can produce 200MHz output so this is of academic interest only.

**THE FINAL ANODE**

In order to produce the high velocity beams that are required to display fast transients, a high accelerating voltage is required. As we have seen, if this is applied to the final anode deflection sensitivity will be reduced so we apply the accelerating potential after deflection, called post deflection acceleration or PDA. Several methods of applying the PDA potential are used but they all aim at not reducing the deflection sensitivity, most important when the deflection amplifiers use transistors having only a limited output voltage swing.

The field of the PDA is such as to produce a slightly convergent lens giving a smaller image and also, if it penetrates into the deflector plate region, causes acceleration before and during deflection, decreasing the scan even further. But in spite of this the PDA system offers a distinct advantage of increased trace brightness.

A fine wire mesh can be placed in the path of the beam just after deflection and if connected to the final anode acts as a screen to keep any PDA fields out of the deflection system. This arrangement gives rise to a PDA field that acts as a diverging lens, magnifying the deflection considerably, but also the spot size. Alternatively this mesh can be placed near the screen and PDA applied between the mesh and the screen. This gives very good results without affecting geometry but such tubes are prone to internal flashover.

**SCREEN PHOSPHORS**

The screen material or phosphor is arranged to give the highest possible light output of the correct colour and persistence. The table shows the range of phosphors used in cathode ray tubes, the most usual being P1 or P5, whilst P7 is sometimes used for medical applications.

![Phosphor Types and Principal Applications](image)

Table of phosphor types and principal applications.

Although the trace produced on a tube can be intensely bright, even with only a couple of kV, the contrast between the trace and the background (grey/white) is usually quite small. A filter of about 65% transmission, of the colour of the trace, placed in front of the tube can increase the contrast by a large amount despite a decrease in light output.

**GRATICULES**

The graticule or measuring scale can be engraved on the filter or a better idea is to cut the graticule into a piece of perspex. If the markings are on the front, the observer can move so that the reflection of the line from the back surface of the graticule are in line with the actual lines. This ensures zero parallax when making measurements. The perspex can be lit from the side by a red bulb causing the cuts in the perspex to light up red, although white light is better for photography due to the uneven spectral response of films. Constructors making their own graticules out of perspex must bear in mind that the clearest line, especially with side illumination, is produced by carving the perspex with a sharp knife and not by scratching.
An A to Z guide to component buying

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PHOTOGRAPHY

Photographic film (even so called panchromatic) is most sensitive in the blue region and for this reason blue tubes are best suited to making photographic records. However, fast film (400ASA) together with a wide aperture, f2-8 or better, can give reasonably short exposures from a green tube. When using single lens reflex cameras, best suited to this type of work, it is important to remember that the image on the film is scanned from right to left (lens inversion) and the direction of motion of the blind could well be from left to right, giving a small vertical exposure if the scope sweep speed is slow. The average shutter takes 1/50 or 1/60 of a second to scan the film and so one must be aware of these difficulties when dealing with fairly slow sweep speeds at fast shutter speeds. For single shot photography it is best to have the shutter completely open before the appearance of the trace.

ABERRATIONS

The ideal characteristics of a cathode ray tube are not always realised in practice due to assumptions in the theory, or plain constructional error (anodes off axis, etc.). One of the most important flaws or "aberrations" is that known as "Astigmatism" and this has already been dealt with, together with its cure.

Most of the other aberrations are most apparent when the tube is displaying a raster. Ideally such a raster should be capable of being focused into a perfect square of scan lines, all in focus. Some defocusing occurs in deflections due to lens action between the final anode and plates, and between the plates. The effect between the plates is reduced by placing an "interplate shield" between the two sets of plates with a hole for the beam to pass through. This shield is at final anode potential and reduces the defocusing effects.

If the raster takes on the shape of Fig. 8a the distortion is known as pin-cushion distortion and is caused by the deflected beam traversing through a greater distance between the second set of plates thus arriving at an oblique angle. This can be reduced by making the second pair of plates as in Fig. 8b. Fig. 8c shows barrel distortion caused by loss of extreme scanning sensitivity due to the PDA fields. This can only be reduced by careful design of the PDA spiral. Fig. 8d shows trapezium distortion. This is caused by asymmetrical Y deflection accelerating the beam as the driven Y plate goes positive and decreasing the X sensitivity accordingly. Specially designed plates are available for asymmetrical deflection only.

CRT DEFECTS

Other defects occur in specific tubes and it must be realised that any CRT is a compromise between conflicting factors. Consequently the best instrument tubes as fitted in laboratory scopes can cost several hundreds of pounds, but the home constructor can purchase surplus tubes for just a few pounds and many quite good home-made scopes have been built using these tubes.

With age or abuse cathode ray tubes tend to develop faults the most serious of which is likely to occur at virtually any time, is when the mechanical structure of the electron gun fails. The gun is constructed with tiny spot welds and severe shock or vibration can cause an element to be dislodged. If this happens the tube is almost surely destined for scrap.

Also linked to the mechanical structure of the tube is a fault producing what is known as a "soft" tube. This occurs when a small amount of air leaks into the bulb through an imperfect glass-to-metal seal. This may become evident only after many hours of operation and the symptoms are a diffuse display and a blue glow in the gun assembly. As the pressure inside the tube rises further, tracking occurs in the gun and external circuits can be damaged. In order to avoid this fault occurring it is necessary to take great care when handling the tube and making connections to it. Connections should never be soldered directly on to the tube pins as this is almost certain to break a seal or even crack the envelope, with glass flying everywhere at high velocity.

Perhaps the most common fault, linked directly to old age, is low cathode emission. The cathode surface looses emissivity either by the emissive layer evaporating or becoming poisoned by the remaining gas in the tube. The effect is that in order to see a trace at all the brightness control has to be advanced so far that the beam spot goes out of focus and silvery. The silvery effect is due to the cathode emitting in patches and on some scopes, if the focus control has sufficient range (making focus anode nearly the same potential as final anode), it is possible to produce an image of the cathode on the screen. The image looks a little like the full moon, the dark patches representing areas of low emission.

Sometimes a low emission tube can be improved by deflecting the spot off screen and turning brightness full up for a couple of hours. If this does not work a small transformer supplying 6-3V+10% can be used to supply the heater (common practice in TV's). However the insulation of such transformers is doubtful over 1kV and a breakdown would make the tube heater/cathode short or damage it in an even worse manner. A small auto transformer is

Fig. 8: Pin cushion distortion (a) can be corrected by shaping the plates as in (b). (c) illustrates barrel distortion and (d) trapezium distortion.
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PLUS BUYERS’ GUIDE to Radio and Electronic Components—PART 2

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Lionel Howes has been appointed Editor of Practical Wireless and of our associate magazine Television. Eric Dowdeswell has been appointed Assistant Editor of Practical Wireless.

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581
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IF rejection 65dB

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List of Prices

<table>
<thead>
<tr>
<th>Description</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complete system including post and VAT</td>
<td>£2.00</td>
</tr>
<tr>
<td>Individual sheets</td>
<td>22p</td>
</tr>
<tr>
<td>Sample sheet</td>
<td>22p</td>
</tr>
<tr>
<td>Copper laminate (boards) size 6” x 4½” 6 sheets</td>
<td>50p</td>
</tr>
<tr>
<td>(with six months guarantee)</td>
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Printed circuit board PCB transfer systems patent applied for.

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3) Recessed handles with fixing screws, jack socket, all fixing screws, corner plates, glue, and full instructions

**PRICE & TYPE LIST**

<table>
<thead>
<tr>
<th>Type</th>
<th>Size</th>
<th>Price manufactured</th>
<th>Kit price</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 x 12” (illustrated above)</td>
<td>'36&quot; x 18&quot; x 13&quot; x 3&quot;</td>
<td>£19.50</td>
<td>£12.50</td>
</tr>
<tr>
<td>4 x 12” (illustrated above)</td>
<td>31&quot; x 31&quot; x 13&quot; x 3&quot;</td>
<td>£24.50</td>
<td>£17.50</td>
</tr>
<tr>
<td>1 x 18”</td>
<td>48&quot; x 27&quot; x 13&quot; x 3&quot;</td>
<td>£30.00</td>
<td>£21.50</td>
</tr>
<tr>
<td>1 x 15” with two top horn cutouts</td>
<td>31&quot; x 31&quot; x 13&quot; x 3&quot;</td>
<td>£24.50</td>
<td>£17.50</td>
</tr>
<tr>
<td>Mini Disco (state deck cutout BSR, GARRARD etc.)</td>
<td>36&quot; x 20&quot; x 13&quot; x 3&quot;</td>
<td>£21.00</td>
<td>£13.50</td>
</tr>
<tr>
<td>Maxi Disco (illustrated) (state deck cutout BSR, GARRARD etc.)</td>
<td>42&quot; x 20&quot; x 10&quot; x 4&quot;</td>
<td>£20.00</td>
<td>£13.00</td>
</tr>
</tbody>
</table>

Please ask for quotation on any other type or size of cabinet you may require.

ALL OUR PRICES INCLUDE VAT AND UK DELIVERY

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**PRICE:** £9-50  U.K. ORDERS PLEASE ADD VAT

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All parts and instructions with Zenister Diode, Printed Circuit, Bridge Rectifiers and Double Wound Mains Transformer. For use with 240, 230 or 125 volts. 95p each. 2 x 45p. 200 watts. With tuning gang. £4.20 Post £2.40

R.C.S. GENERAL PURPOSE TRANSISTOR PRE-AMPLIFIER BRITISH MADE

Ideal for Mats, Tape, P.F., Galler, etc. Can be used with factory built P.A., or as a complete unit. £2.95 £4.20 Post £2.40

RADIO COMPONENT SPECIALISTS


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ELAC 9 x 4in. Hi-Fi SPEAKER. TYPE STRM. THIS FAMOUS AND WIDELY USED UNIT NOW AVAILABLE AT BRAND NEW PRICE. 10 WATT. 5 OGM. CERAMIC MAGNET. £2.95

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R.C.S. GENERAL PURPOSE TRANSISTOR PRE-AMPLIFIER BRITISH MADE

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**MAPLIN ELECTRONIC SUPPLIES**

**ORGAN BUILDERS**

- THE DM02
  - 13 Master Frequencies on ONK tiny circuit board.
  - 13 frequencies digitally derived from a SINGLE h.f. master oscillator.
  - Initial tuning and final adjustment in a SPECIAL STANDARDIZED & HANDMADE case.
  - Easy to handle and move.
  - Ideal for use with other MOCOM ripplers.

- REVERBERATION UNIT
  - Enhances the sound of any electronic musical instrument.
  - Ready built, tested, and approved.

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- Sub-miniatute Axial lead electrolytic
  - MVD Price
  - 1µF 20v 0.5µ £0.20
  - 2µF 20v 0.5µ £0.20
  - 3µF 20v 0.5µ £0.25
  - 6µF 20v 0.5µ £0.30
  - 10µF 20v 0.5µ £0.35
  - 15µF 20v 0.5µ £0.40
  - 22µF 20v 0.5µ £0.45
  - 33µF 20v 0.5µ £0.50
  - 47µF 20v 0.5µ £0.55
  - 56µF 20v 0.5µ £0.60
  - 100µF 20v 0.5µ £0.65
  - 220µF 20v 0.5µ £0.70
  - 470µF 20v 0.5µ £0.75
  - 1µF 20v 1µ £0.80
  - 2µF 20v 1µ £0.85
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  - 6µF 20v 1µ £0.95
  - 10µF 20v 1µ £1.00

- LANDMARK (without tremulant) £12.25

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- Pat terminal clips 1 red, 1 black insulated £0.50
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- Silicon grease in special dispensers 20ml. £2.50
- Red neon 34V panel mounting £1.50
- Lacing Cord Strong rayon cored P.V.C. £2.50
- Panel fuse holders 20mm £0.50
- 11mm £0.25

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  - RT7090 min. output transformer Prl. 1.75p
  - RT7090 max. output transformer Prl. 2.25p
  - Sub-mins Transformer 6-5V 100mA
  - 3.60-12.0v 20mA
  - Size: Both approx. 38 or 50 or 75mm.
  - Min. MAINS Transformer (60: 30 35 1) 0-15 0-250V, 0-15 0-250mA £1.50
  - Mains transformer MT0AT
  - Pnl. 200-220-240V, Sec. 15-16-09-24-36V £4.91
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**Post & packing FREE in U.K.**

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250 VA Isolation Unit (Interlocking Screen) housed in a tough Fibreglass case with carrying handle. Complete with Heavy Duty 8 core power cable, splash proof outlet plug and waterproof internal fuse. 110 Volt and 240 Volt versions available. Price £5.50. 

Carriage £1.20

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8610; 60mm Wide; 8611: 110mm Wide x 48mm. High x 46mm Deep. Movement. I.R. Movement. I.R.— glass. 0-50 micro A. 1250 0-50 micro A. 1400 0-100 micro A. 2200 0-500 micro A. 2700 0-1 mA. 2100 0-5 mA. 2170 0-10 mA. 2260 0-25 mA. 2260 0-50 mA. 2300 0-1 A. 2350 0-2.5 AMP. 250 0-5 AMP. 250 0-10 AMP. 500 0-25 Volt. 15K 0-25 Volt 15K 0-100 Volt 250K 0-100 Volt 250K 10-100 Volt 100K 10-100 Volt 100K 40-150 Volt 500K 40-150 Volt 500K Vit 5200 VU Meter 5200


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1 watt at 100°C. From £0.035. Post 2lp. Sale above 500 pairs 10% off at 50p per 100.

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A reliable unit ideal for timing delay, delay timers, or any other time delay. It can be used to time anything from 0.1 second to 24 hours. It is easy to set and adjust. The timer is adjustable. A good value product, White Case 33 x 21.17". Setting instructions included. Price £5.50. Post 2lp.

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CONFIDENTIAL

Quantities for large quantities, prices on application. Total Remittance. PLEASE ADD 8% FOR V.A.T.

SAFETY ISOLATING

Prim. 110V/240V, Sec. 240V. Centre Tap with Respect of VA. Ref. Price Price Price

<table>
<thead>
<tr>
<th>Watts</th>
<th>Closed Plugs</th>
<th>Open Post</th>
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12 & 24 Volts

Price 200-240V. Amp. Price Post

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30 Volts

Price 500-240V. Sec. 12, 15, 20, 30, 40, 80. Amp. Ref. Price Price Post

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50 Volts

Price 200-240V. Sec. 19, 23, 30, 40, 80. Amp. Ref. Price Price Post

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60 Volts

Price 200-240V. Sec. 24, 30, 40, 60, 80. Amp. Ref. Price Price Post

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MINIATURE EQUIPMENT

Price 200V with screen. Volts

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PLASTIC CASED SILICON BRIDGE RECTIFIERS

One Amp Two Amp Four Amp Six Amp

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AUTO TRANSFORMERS

Case versions are 240 Volt Mains to 110 Volts, smart steel case units marked in tough plastic with power lead and fuse 115 Volt American type socketed up to 500VA. Above 600VA a cable entry.

VA. Ref. Price Price Price

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POWER UNIT Type CC 12-05

Output switch 3, 4, 5, 6, 7, 8 and 12 volts at 20mA D.C. Operates from 240 V mains suitable for Radios, Tape Recorders, Record Players, etc. Suitable 110-240 V 50-60 Hz. £8.50. Post 1lp.

A.S.P. LTD.

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Regd. No. 912966 London
TUAC DISCOTHEQUE MIXER WITH AUTO FADE

Designed for the discerning D.J. of professional standard. Offering a vast variety of functions. Controls: Mic Vol; Tone; over-ride depth; auto/Manual Sw; Tape Vol; L & R Deck Faders; Deck Volume; Treble and Bass; H. Phon Vol Selector; Master Vol On/Off Sw. Max output 1V RMS.

Specification: Deck Inputs—50mV into 1m(Ω); Deck Tone Controls—Treble +28 - 15dB at 12kHz. Bass +22 - 15dB at 40Hz; Mic input—200 ohms upwards. 2mV into 10k(Ω); Mic Tone Control—Total Variation Treble 15dB. Total Variation Bass 10dB; Tape input —30mV into 47k(Ω); Power Requirements—30-45 volts at 100mA.

£26.50

PANEL SIZE
18 x 4½ in.
DEPTH 3in.

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SOCODI, 9 The Friars, Canterbury, Kent. Tel. Canterbury 60948.
WEC LIGHTING, 35 Northam Road, Southampton, Hants. Tel. Southampton 28102.
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- R.C.A. 8 Amp Triacs
- 1000W per channel
- Each channel fully suppressed and fused
- Master control to operate from 1W to 100W
- Full wave control—12 easy connections

£14.90

Single Channel Version £6.60

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SPECIALISTS IN QUALITY TRANSISTOR EQUIPMENT - OPEN 6 DAYS A WEEK 9:30am - 6:00pm
NEW TUAC POWER MODULES offering more power and quality than ever before.

**Specification on all power modules:**
- All output power ratings ± 0.5dB;
- Output impedance 8-15 ohms; THD at full power 2%; typically 1%;
- Input sensitivity 60mV into 10kΩ;
- Frequency response 20Hz-20kHz ±2dB; Hum and noise better than -70dB.

**TP125**
7 x 6½ x 3in
£17.00
- 125 watts RMS continuous sine wave output
- 4 R.C.A. 150 watt 15 amp output transistors

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- 2 R.C.A. 40 watt output transistor

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5 x 5 x 3 in
£11.50
- 60 watts RMS continuous sine wave output
- 2 R.C.A. 110 watt 15 amp transistors

**TL100**
5 x 5 x 3 in
£13.20
- 100 watts R.M.S. continuous sine wave output
- 2 R.C.A. 150 watt 15 amp transistors

Power supplies vacuum impregnated Transformers with supply board incorporating pre-amp supply:
- PS 125 ± 50 volts for one TP125 ........................................ £11.50
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- PS 60 ± 40 volts for one TL60 ............................................ £9.30
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- PSU 2 for supplying disco mixer ........................................ £4.65

**PREAMPLIFIERS**

All TUAC audio modules are constructed on glass fibre P.C. board, are ready assembled and fully tested. Low noise silicon and FET transistors together with H.S. carbon film resistors are used throughout. Extensive research has gone into various wide range tone control circuits producing superb sound quality from any signal.

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**VAO6** Vol. Treble and Bass controls. Sensitivity 8mV, Treble +28—15dB at 12kHz. Bass ±18dB at 40Hz. £4.15

**AMFO1** TUAC Auto Fade Unit fades music when you speak. Auto Mic Over-ride for Disco use. Feed Deck and Mic Pre-amps in. Auto fade O/P to main Amp. 38mV operating level. Depth and Vol. Controls. £4.90

**ALL PRICES INCLUDE V.A.T. (8%) AND POSTAGE AND PACKING**

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Tel. 021-327 2339

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(CIRCUIT INCLUDED).
"CURRENT ECONOMY" TRANSISTOR (600 ma.).
"MAXIMUM LIGHT" TRANSISTOR (1-3A)
RESISTORS/CAPACITORS TO SUIT
LAMPHOLDERS (LONG LEAD)
(SHORT LEAD)
WHITE ENAMEL CASE, 18" or 21" (Postage 30p)
TUBE, 18"-15 WATT or 21-13 WATT
(NOTE:- TUBE ONLY SUPPLIED IF CASE ORDERED,
TO PREVENT POSTAL DAMAGE)
13 WATT FITTING READY BUILT AND TESTED—
INCLUDING TUBE (Postage 30p)
£3.75
Post/Packing 25p per order except where shown

£1 100 1 WATT RESISTORS
100 DIODES
POSTAGE 25p
PACK No. 1
POSTAGE 25p
PACK No. 2

£1 1 VERO-BOARD CUTTER 50 SQ. IN.
"OOG PIECES"
VERO

£1 22 ASSORTED UNUSED
MARKED, TESTED
TRANSISTORS
BC547 ETC.

£1 5 COMPUTER PANELS
CONTAINING MARKERS OF
DIODES, TRANSISTORS,
ACROSS, RESISTORS &
CAPACITORS

NOTE:- ALL GOODS PLUS 8% VAT (EXCEPT OVERSEAS)

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BRISTOL BS1 3NG

THE RADIO SHOP
TELEPHONE 0272-211196

1-6AMP PLASTIC
TOS
NAS0161W 100V .27
NAS0161X 100V .26
NAS0162X 200V .58
NAS0163X 2000V .18
NAS0164X 600V .44
NAS0166X 600V .56
NAS0168X 600V .56
NAS0170X 600V .56

SAMP "CLIPPED"
TAB
NAS3001W 100V .20
NAS3001X 100V .20
NAS3002W 200V .30
NAS3002X 200V .30
NAS3004X 400V .44
NAS3005X 400V .52
NAS3006X 600V .52
NAS3006X 600V .52

1-8 AMP MIN. TOS
4 AMP ISOLATED
5 AMP ISOLATED
NAS08P 500V 25
NAS08P 500V 25
NAS08P 500V 25
NAS08P 500V 25
NAS08P 500V 25
NAS08P 500V 25
NAS08P 500V 25
NAS08P 500V 25

8 AMP ISOLATED
15 AMP ISOLATED
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NAS08P 500V 25
NAS08P 500V 25
NAS08P 500V 25
NAS08P 500V 25
NAS08P 500V 25
NAS08P 500V 25
NAS08P 500V 25

CLOCK CHIP 7551

THE DEVICE 7551 represents a major breakthrough in Clock Chip design. Incorporating many features available for the first time:
395 DAY CALENDAR - 12HR HR. OPERATION - ALARM - SNOOZE ALARM - SIX DIGIT CAPABILITY - DIRECT DRIVE TO LED DISPLAY - CONTINUOUS OPERATION DURING MAINS FAILURES.
Copy of data available—please send 1sp stamp.
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104 LED-7 sec. display 2p
1-5 each

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596
The SPARKRITE Mk.II is a full capacitive discharge electronic system. Specifically designed to retain the points assembly with all the advantages and none of the disadvantages. No tolerate because contact breaker bounce is eliminated electronically by a pulse suppression circuit which prevents the unit becoming noisy. The points bounce open at high rpm. Contact breaker burn is eliminated by reducing the current to about 1/50th of normal, thus avoiding arcing. But you can still revert to normal ignition if need be. In seconds, if points go (very unlikely) you can get replacements anywhere. All these advantages:

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- Efficient burning with less air pollution.

The kit comprises everything needed

Ready drilled scratch and rust resistant case, metalwork, cables, coil connectors, printed circuit board, top quality 5 year guaranteed transformer and components, full instructions to make complete new system, and 8 page installation instruction leaflet.

WE SAY IT IS THE BEST SYSTEM AT ANY PRICE!
### Resistors

<table>
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<th>Value</th>
<th>Ohms</th>
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<th>10 to 99</th>
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### Electrolytic Capacitors

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<tr>
<td>0.000000001</td>
<td>0.00007</td>
</tr>
</tbody>
</table>

### Potentiometers

- **Rotary, Carbon Track**: Double wipers for good contact and long working life.
- **Linear, Carbon Track**: Suitable for low noise applications.

### Capacitors

- **Diatonic**: In carbon film, metal, and plastic types.
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For more information, write to: ETE Maritime Radio Services Division (RC10), ET 17.1.1.2., Room 643, Union House, St. Martins-le-Grand, London, EC1A 1AS.

WIRE RECORDERS record only 24v DC I/P complete with spool of wire I/P level 15 Mill/V, running time 75 min spools 3½ dia by 1" would take 1" tape, wire speed 30" per sec in case size 5⅜ x 11 x 6" in good cond with instructions £5-25. POWER UNITS stabilised for use with BC221 freg meter mains I/P fits in battery box gives 135v & 6-3 with circ tested £7-16 CONTAMINATION METERS No. 1 -1 to 10 Mill/Rongt per Hr meter indicator also sk for phones complete with mains P.U. & carrying case with instructions new boxed & tested £8-10 CT38 ELECTRONIC MULTIMETERS bench type for 24ov mains these have 97 ranges of V, A, W, R, etc. with H/Bk tested £23. BATTERIES Lead Acid type 24v 25 amp/hr topped at 2v steps in lightweight carrying container new with instructions £10-40. AERIAL TUNING UNITS ex A/C 2 to 18 Mc/s Tx type remote controlled contains 1000pf tun cond, large coll, meter, Ae c/jo relay etc in case 8 x 7 x 14" £5-15. ELEC CONDS all heavy duty types with screw term new ex USAF 82,000uf 17-5v £3, 44,000uf 27-5v £3, 8,400uf 40v 65p, 4,600uf 20v 65p, 1200uf 75v 80p, METER UNIT X pointer type dual £115 Ua for use with 1155Rx approx 3" dia okay for Stereo Balance Ind new £1-79. DIODES 200 PIV 8 amps 4 for 70p, also 800 PIV 750 Ma 15 for £1-10 new. CRYSTAL OVEN with 12 type Hc68u holder can be removed 76p.

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EXHIBITIONS ?!

WHAT is happening to the R.S.G.B. National Mobile Rally? This annual event, as many readers will be aware, took place in the grounds of Woburn Abbey during the month of August.

It was not the day of continuous rain that made the exhibition part of the rally a wash-out—attendance was good despite the climatic conditions. Apathy on the part of the organisers and many exhibitors resulted in dismal displays on nameless stalls.

Who were these nameless exhibitors? These people were, in effect, representatives of one of our greatest national activities—Amateur radio and the amateur electronics constructor. The question being asked was, "surely this is not the R.S.G.B. National Mobile Rally? I must have taken the wrong turning!"

Exhibitors displaying new equipment and those displaying 'surplus' gear were intermixed. Yours truly spent a considerable amount of time trying to find the whereabouts of various exhibitors, without avail. Little information was forthcoming—even from the R.S.G.B. stand itself! Well-established and respected manufacturers and distributors were conspicuous—by their absence. Who can blame them?

Someone had better pull up their socks or we may see the rapid demise of what should be, as the title implies, our National Mobile Rally.

Do you remember the Radio Communications or Hobbies Exhibitions sponsored by the Radio Society of Great Britain? They were held annually in the London area and were extremely popular. What happened to them.

Practical Wireless and other major organisations, gave their support on numerous occasions and we are justly proud of the part that we contributed by showing our flag, on behalf of the radio and electronic constructor.

This hobby of ours encompasses an exceedingly wide sphere in the field of electronics and it is the responsibility of the Editor and his staff—as a team—to balance the editorial contents of each issue—to cater for many tastes. The satisfaction that the constructor derives from 'switching it on' is extremely gratifying and indeed therapeutic. We are indeed fortunate in that we live in an era of component plethora. Of course, there are shortages in many areas, but we suggest that the pessimists cast a careful eye over the pages of our 1974/5 PW Buyers' Guide to Radio and Electronic Components.

Many new items are included, each month by advertisers in their respective columns. Take a good look at the small print, you could be pleasantly surprised!

We shall be exhibiting at the 1974 International Audio Festival and Fair, Olympia, London. Many PW constructional projects will be on show, including unique constructional designs not yet published in this country. A further exciting development in the PW Tele-Tennis constructional project will also be unveiled.

Members of the editorial and advertising departments will be in attendance to deal with enquiries. We shall also have a limited number of free 'give-aways' to visitors.

Don't forget the PW slogan—Stay tuned to PW for full coverage of the finest and up-to-the-minute constructional projects.

A date for your diary—Practical Wireless, Stand B12, International Audio Festival & Fair, Olympia, 28th October—3rd November Inclusive.

LIONEL E. HOWES—Editor.

NEWS...

Crofton move

CROFTON ELECTRONICS have moved. Their new address is: 124 Colne Road, Twickenham, Middlesex. (Tel: 898 1569).

A foolproof Electric Lock

SOME quite clever ideas have appeared in journals for electronic locks. But our vote goes to a professional approach recently announced which, as far as we can see, is almost fool-proof. The code for this lock is carefully stored in a CMOS shift register memory. When the "electronic" key is inserted, the code in the key is interrogated by the lock which compares it with the code in its memory. If the two codes are identical the lock will open. The key itself contains another shift register with the identical code in its memory banks. Even a small 32-bit memory would provide a possible four million combinations.

When the key is inserted into the lock it activates a micro-switch. This causes the lock to transmit a series of pulses which in turn make the "key" enter its code into the lock for comparison. Because the key does not emit signals (i.e. magnetic or sonic or anything else) it is impossible to "read" the code from the key. Again, any exploratory signals sent into the lock would immediately alter or destroy its memory (fail safe).

One last cunning asset. The speed of operation of the memory circuits in the lock is fast when opening the door with the correct key. But slow by "logic" standards. If you were to permute all combinations possible by plugging in some sort of pulsing device into the lock instead of the key—it would take well over a year to run through all the possible combinations. Sorry—not available on the market yet and that's all the information we can get at present.
Not to be missed –

THE LATEST Heathkit Catalogue is now available free from: Heath (Gloucester) Limited, Bristol Road, Gloucester, GL2 6EE. Write, or phone Gloucester 29451, for a copy. Or if you happen to be in London or Gloucester, call in and collect one.
The London Heathkit Centre is at 253 Tottenham Court Road, and the Gloucester showroom is next to the factory in Bristol Road.
The catalogue contains details of the very large range of electronic kits, many available for the first time in this country.
It talks in detail about kit building “The Heathkit Way” and shows how easy it is to build a Heathkit. Even a complete novice need have no worries as the instruction manual, with the aid of large pictorials and step-by-step instructions, leads you every step of the way.
Its 64 pages give details of many exciting models for home construction, ranging from a large selection of audio and Hi-Fi equipment through electronic calculators, digital electronic clocks, electronic thermometers, an ultrasonic burglar alarm, to test instruments for the electronic hobbyist and home car service. Even a 12 inch black and white portable television kit is available.

Heathkit’s Catalogue

New kit models include an l.m. tuner with digital readout and computer tuner, a 4 channel SQ amplifier, a battery powered electronic thermometer and a de-luxe digital electronic clock with alarm. All models are available for cash or on extended credit terms through the very popular Heath Money Budget Plan. A free technical consultation service is in operation both before and after purchase.

Hi-Fi Accessories by Bib

BIB HI-FI Accessories Limited announce the publication of a comprehensive 16-page full colour catalogue, which illustrates and describes their very large range of hi-fi accessories which now comprises more than 70 products.
The catalogue has been designed so that it can be easily reprinted in foreign languages and arrangements are already in hand to print it in French, German and Italian.
For the UK market a single sheet retail price list is inserted in the catalogue.
Bib Hi-Fi Accessories Ltd., PO Box 78, Hemel Hempstead, Herts, HP2 7EP.

Wolsey’s Colour King at sea

WOLSEY ELECTRONICS equipment is now being increasingly used on marine installations and the most recent of these, through Aerialwork Limited of Southampton, their agents for Southern England, has been the installation of a communal TV and radio system to the officers and crew’s quarters on the ferry “Eagle”. In order to receive various transmitters whilst at sea, a Wolsey Broad Band “Colour King” u.h.f. aerial and FM411 array were erected with a rotator motor and remote control unit. The aerials and mast were specially treated to withstand exposed sea conditions. The well-proved Wolsey “Mercury” amplifier was fitted and provision was made for a monochrome video cassette recorder and additional outlet points to public rooms should this be required at some future date.
The 11,500 ton “Eagle” which is controlled by one of the P & O Group of Companies—Southern Ferries—is the largest on/off car ferry to use the port of Southampton and operates a regular service to Lisbon, Algeciras and Tangier.
LONG-DISTANCE reception of weak FM signals is possible provided that a high gain aerial is used and that the receiver has high sensitivity. Some older types of receiver lack the sensitivity of their modern counterparts and the use of an aerial amplifier can improve reception considerably.

We have to be careful in the use of such an amplifier however, since high gain is not the only pre-requisite. If the amplifier adds as much noise as it increases the signal, then we are no better off. The amplifier must have a good noise factor, that is, it increases the signal by a much greater amount than it increases the noise.

Another aspect we have to consider is the type of reception we expect, having provided the amplifier. If the incoming signal is very weak indeed than we may be able to improve it, but if it fades away to nothing, no amount of amplification will bring it back again. This situation can exist during fading conditions, when total cancellation of the signal at the aerial occurs because of multipath reception. An amplifier can be useful, however, since it shortens the time during which the signal is unusable. Imagine a threshold level below which the signal must not fall if a satisfactory signal-to-noise ratio is to be maintained; if the amplifier lifts the entire incoming signal, this can fall to a lower level before becoming unsatisfactory.

CROSS MODULATION

The VHF FM band is becoming quite crowded and the weak signals we wish to amplify may be situated very close to a strong local transmission. Unless our amplifier is correctly designed, a strong possibility exists that cross-modulation will occur between the various signals present, due to the high amplitude of the local signals. The signals we wish to receive may then become completely lost in the mess which results. Once this has happened, it is impossible to separate the signals again, so we must prevent such a thing happening in the first place.

Cross-modulation can not only occur in the amplifier but also in the input stages of the receiver. A valve receiver is far more tolerant of high input levels than its transistor counterpart. Too much amplification before the receiver's RF stage can therefore cause intermodulation and it will be seen that excessive gain can be a real disadvantage. Any aerial amplifier used for FM work should therefore not have so much gain that the local signals will cause cross modulation, have enough gain to substantially improve weak signals, and, itself, have