THE "8-2 SPECIAL" 3-VALVE RECEIVER

1.67 to 32 Mc/s

a Short-Wave Design

2-Tone Alarm Generator • Transmitter V.F.O's • Semiconductor Device Coding Systems • Wide-Band Photophone
Television Sets, Receivers and Short Wave Transmitters are expensive to acquire and you no doubt highly prize your installation. Apart from the value of your Set, you might be held responsible should injury be caused by a fault in the Set, or injury or damage by your Aerial collapsing.

A "Scottish" special policy for Television Sets, Receivers and Short Wave Transmitters provides the following cover:

(a) Loss or damage to installation (including in the case of Television Sets the Cathode Ray Tube) by Fire, Explosion, Lightning, Theft or Accidental External Means at any private dwelling-house.

(b) (i) Legal Liability for bodily injury to Third Parties or damage to their property arising out of the breakage or collapse of the Aerial Fittings or Mast, or through any defect in the Set. Indemnity £10,000 any one accident.

(ii) Damage to your property or that of your landlord arising out of the breakage or collapse of the Aerial Fittings or Mast, but not exceeding £500.

The cost of Cover (a) is 5/- a year for Sets worth £50 or less, and for Sets valued at more than £50 the cost is in proportion. Cover (b) (i) and (ii) costs only 2/6 a year if taken with Cover (a), or 5/- if taken alone.

Why not BE PRUDENT AND INSURE your installation—it is well worth while AT THE VERY LOW COST INVOLVED. If you write to the Corporation's Office a proposal will be submitted for completion.

Write for full details, quoting reference 5304, to:

THE MANAGER
SCOTTISH INSURANCE CORPORATION LTD.,
66-67 CORNHILL, LONDON E.C.3
AERIAL EQUIPMENT

TWIN FEEDER. 300 ohm twin ribbon feeder similar K25, 8d. per yard. Post on above feeders and cable 2/- any length.

COPPER WIRE. 14G, H/D, 140 ft., 30/-; 70 ft., 16/-; Postage 4/-

FEEDER SPREADERS. 6/- each, Ceramic type F.S., 10d. each. Postage 2/-

2 METRE BEAM, 5 ELEMENT W.S. YAGI. Complete in box with 1" to 2" masthead bracket. Price 56/-

SUPER AERAXIAL. 70/80 ohm coax. 300 watt very low loss, 2/- per yard. 50 ohm 300 watt, 2/- per yard. P. & P. 2/-

TOUGH POLYTHENE LINE. Type ML1 (100lb.), 2d. per yd. or 12/- per 100 yds. Type ML2 (200lb.), 4d. per yd. or 2/- per 100 yds. ML4 (400lb.), 6d. per yd. ideal for guys, L.W. Supports, Halyards, etc. Postage 1/-

CERAMIC CENTRE PIECE for dipoles, Type AT, 1/- each. P. & P. 1/-

2 METRE BEAM, S ELEMENT W.S. YAGI. Complete in box with 1" to 2" masthead bracket. Price 56/-

SUPER AERAXIAL. 70/80 ohm coax. 300 watt very low loss, 2/- per yard. 50 ohm 300 watt, 2/- per yard. P. & P. 2/-

TOUGH POLYTHENE LINE. Type ML1 (100lb.), 2d. per yd. or 12/- per 100 yds. Type ML2 (200lb.), 4d. per yd. or 2/- per 100 yds. ML4 (400lb.), 6d. per yd. ideal for guys, L.W. Supports, Halyards, etc. Postage 1/-

NEW BOXED VALVES

3/4 each, 4 for 10/-

6N7GT 6S7GT 6AB7 6SH7 6AC7 6F7 6SK7 956

ABSORPTION WAVEMETERS. 3.00 to 35.00 Mc/s in 3 Switched Bands. 3, 7, 14, 21 and 28 Mc/s. Ham Bands marked on scale. Complete with indicator bulb, A MUST for any Ham Shack. ONLY 25/- EACH. Post free.

BANDCHECKER MONITOR. 3.00-35.00 Mc/s in 3 Switched Bands. 0-1 mA indicator. Monitor socket. Very sensitive, £3/13/6. P. & P. 3/-

VARIABLE CONDENSERS. All brass with ceramic end plates and ball race bearings. 50pF, 5/-; 100, 6/-; 160, 7/-; 240, 8/-; and 300pF, 10/-

SEALED RELAYS, 12v. 105Q Coil. Type A. 1 Pole, C.O. £5/- Type B. 2 Pole Norm, 2 Pole Norm. on, 12/6. P. & P. 1/-

AMATEUR RADIO

CHAS. H. YOUNG LTD.

170-172 Corporation Street, Birmingham 4

phone 021-236 1635

THE WIDEST RANGE IN THE MIDLANDS

HIRE PURCHASE PART EXCHANGE

Chas. H. YOUNG Ltd.

The Latest Edition of Engineering Opportunities

Have you sent for your copy?

ENGINEERING OPPORTUNITIES is a highly informative 132-page guide to the best paid engineering posts. It tells you how you can quickly prepare at home for a recognised engineering qualification and outlines a wonderful range of modern Home Study Courses in all branches of Engineering. This unique book also gives full details of the Practical Radio & Electronic Courses administered by our Specialist Electronics Training Division—explains the benefits of our Appointments Dept. and shows you how to qualify for five years promotion in one year.

SATISFACTION OR REFUND OF FEE

Whatever your age or experience you cannot afford to miss reading this famous book. If you are earning less than £30 a week send for your copy of "ENGINEERING OPPORTUNITIES" today—FREE.

British Institute of Engineering Technology

(Dept. 409B), Aldermaston Court, Aldermaston, Berkshire

The B.I.E.T. is the leading institute of its kind in the world

March 1967

449
**INSTRUMENTS**

**3" LOW-PRICED SERVICE OSCILLOSCOPE.** Model OS-2. Compact size 5" x 7" x 12" deep. Wt. only 2 lb. "Y" bandwidth 500 mc/s ± 3dB. Sensitivity 100mv/cm. TJR 20 c/s-200 kc/s in four ranges, fitted mu-metal CRT Shield. Modern functional styling.

Kit **£23.18.0** Assembled **£31.18.0**


Kit **£35.17.6** Assembled **£45.15.0**

**DE LUXE LARGE-SCALE VALVE VOLT-METER.** Model IM-15U. Circuit and specification based on the well-known model V-7A but with many worthwhile refinements. 6" Ernest Turner meter. Unique gimbal bracket allows operation of instrument in many positions. Modern functional styling.

Kit **£18.18.0** Assembled **£26.18.0**

**AUDIO SIGNAL GENERATOR.** Model AG-8U. 10 c/s to 100 kc/s, switch selected. Distortion less than 0.1%. 10V sine wave output metered in volts and db's.

Kit **£23.15.0** Assembled **£31.15.0**

**VALVE VOLT-METER.** Model V-7A. 7 voltage ranges d.c. volts to 1,500. A.c. to 1,500 r.m.s. and 4,000 peak. Resistance 0.1Ω to 1,000 MΩ with internal battery. Dc. input resistance 11 MΩ. db measurement has centre-zero scale. Complete with test prods, leads and standardising battery.

Kit **£13.18.6** Assembled **£19.18.6**

**MULTIMETER.** Model MM-1U. Ranges 0-1.5V to 1,500V a.c. and d.c.; 150µA to 15A d.c.; 0.21 to 20MΩ. 4½" 50µA meter.

Kit **£12.18.0** Assembled **£18.11.6**

**R.F. SIGNAL GENERATOR.** Model RF-1U. Up to 100 Mc/s fundamental and 200 Mç/s on harmonics. Up to 1000V output.

Kit **£13.18.0** Assembled **£20.8.0**

**SINE/SQUARE GENERATOR.** Model IG-82U. Freq. range 20 c/s-1 Mc/s in 5 bands less than 0.5% sine wave dist. less than 0.15% sec. sq. wave rise time.

Kit **£25.15.0** Assembled **£37.15.0**

**TRANSISTOR POWER SUPPLY.** Model IP-20U. Up to 50V, 1.5A output. Ideal for Laboratory use. Compact size.

Kit **£33.8.0** Assembled **£47.8.0**

**See Heathkit at the Grand Hotel, Southampton Row, London** (concurrent with the Audio Fair)

Complete your motoring pleasure with this outstanding CAR RADIO, Model CR-1

Will give you superb LW and MW entertainment wherever you drive. Tastefully styled to harmonise with any car colour scheme. Available for your convenience in two separate parts, RF Amp. Kit **£13.13.6** incl. P.T. IF/AF Amp. Kit **£11.3.6** excl. P.T.

**Total Price Kit (excl. Loudspeaker) £12.17.0 incl. P.T.**

**TRANSISTOR RADIOS**

**"OXFORD" LUXURY PORTABLE.** Model UXR-2. Specially designed for use as a domestic, car or personal portable receiver. Many features, including solid leather case. Kit **£14.18.0** incl. P.T.

**TRANSISTOR PORTABLE.** Model UXR-1. Pre-aligned I.F. transistors, printed circuit. Covers L.W. and M.W. Has 7" x 4" loudspeaker. Real hide case.

Kit **£12.11.0** incl. P.T.

**JUNIOR EXPERIMENTAL WORKSHOP Model EW-1.** More than a toy! Will make over 20 exciting electronic devices, incl. Radios, Burglar Alarms, etc. 72 page Manual. The ideal present! Kit **£7.13.6** incl. P.T.

**STEREO TRANSISTOR FM TUNER.** (Mono version also available)

Designed to match the AA-22U Amplifier. Available in separate units, can be built for a total price.

Kit (Mono) **£20.19.0** incl. P.T.

**FM Tuner**

**STEREO TRANSISTOR FM TUNER.** (Mono version also available)

Designed to match the AA-22U Amplifier. Available in separate units, can be built for a total price.

Kit (Mono) **£20.19.0** incl. P.T.

Cabinet extra **£2.5.0.**

**WELCOME TO OUR LONDON HEATHKIT CENTRE 233 Tottenham Court Road, W.1**

We open MONDAY-SATURDAY 9 a.m.-5.30 a.m.
THURSDAY ... 11 a.m.-2.30 p.m.

Telephone No: 01-636.7349

WHEN YOU ARE IN TOWN, WE HOPE YOU WILL VISIT US THERE
TAPE AMPLIFIERS —— TAPE DECKS —— CONTROL UNITS

HI-FI FM TUNER. Model FM-4U. Available in two units. R.F. tuning unit (£2.15.0 incl. P.T.) with I.F. output of 10.7 Mc/s, and I.F. amplifier unit, with power supply and valves (£13.13.0). May be used free standing or in a cabinet. Total Kit £16.8.0

HI-FI AM/FM TUNER. Model AFM-1. Available in two units which, for your convenience, are sold separately. Tuning heart (AFM-T1—£4.13.6 incl. P.T.) and I.F. amplifier (AFM-A1—£22.11.6). Printed circuit board, 8 valves. Covers L.W., M.W., S.W., and F.M. Built-in power supply. Total Kit £27.5.0

MAGNAVOX "363" TAPE DECK. The finest buy in its price range. Operating speeds: 1/2", 3/4" and 7/8". Two tracks, "wow" and "flutter" not greater than 0.15% at 7/8". £13.10.0

MAGNAVOX deck with TA-IM Kit £31.5.6

TRUVOX D-83 TAPE DECKS. High quality stereo/mono tape decks. D93/2, 4 track, £36.15.0 D93/4, 4 track, £36.15.0

TAPE RECORDING/PLAYBACK AMPLIFIER
Mono Model TA-1M kit £19.18.0 Assembled £28.18.0 Stereo Model TA-1M kit £25.10.0 Assembled £35.18.0

HI-FI CABINETS. A wide range available for example: Malvern Kit £18.1.0 incl. P.T.

MONO CONTROL UNIT. Model UMC-1. Designed to work with the MA-12 or similar amplifier requiring 0.25V or less for full output. 5 inputs. Baxandall type controls. Kit £9.2.6 Assembled £14.2.6

STEREO CONTROL UNIT. Model USC-1. Push-button selection, accurately matched ganged controls to ±1dB. Rumble and variable low-pass filters. Printed circuit boards. Kit £19.19.0 Assembled £27.5.0

EXHIBITION, Demonstrations of Hi-Fi (Admission free)
MARCH 30th—APRIL 2nd—11 a.m.—9 p.m. (8 p.m. Sunday).

SPEAKER SYSTEMS

HI-FI SPEAKER SYSTEMS. Model SSU-1. Ducted-port bass reflex cabinet "in the white". Two speakers. Vertical or horizontal models with legs, Kit £12.12.0, without legs, Kit £11.17.6 incl. P.T.

THE BERKELEY Slim-line SPEAKER SYSTEM, fully finished walnut veneered cabinet for faster construction. Special 12" bass unit and 4" mid/high frequency unit. Range 30-17,000 c/s. Size 50" x 17" x only 7½" deep. Modern attractive styling. Excellent value.

Kit £19.10.0 Assembled £24.0.0

COTSWOLD SPEAKER SYSTEMS. Outstanding performance for price. MFS: Size 35" x 16½" x 14½" deep.

Kit £25.12.0 Assembled £33.17.0

STANDARD: Size 26" x 23" x 14½" deep.

Kit £25.12.0 Assembled £33.17.0

MULTIPLEX DECODER, SD-1
for receiving Stereo FM.
Convert your existing FM Mono receiver to stereo with this low-cost, self-powered unit. Fully transistorised. Stylcd to match Heathkit models FM-4U and AFM-1 Tuners.

Kit £8.10.0 Assembled £12.5.0

Stylcd to match British Heathkit models.

NEW! Hi-Fi Models.

'AVON' The Mini Speaker System with Hi-Fi performance.

Only 7½" wide x 13½" high x 8¼" deep. Specially designed. Walnut veneered finished cabinet kit £38.16.0. Two speaker system and crossover network £48.16.0.

Low-cost 3 + 3W Transistor Stereo Amplifier, TS-23
Has all the essential features for good quality reproduction from gram, radio and other sources.

Kit (less cabinet) £17.15.0.
Kit (with handsome finished cabinet) £18.19.0.

SEND FOR THE LATEST FREE CATALOGUE
FULL SPECIFICATION OF ANY HEATHKIT MODEL ALWAYS AVAILABLE ON REQUEST

Mail Order prices quoted. Tel: 20217.
DAYSTROM LTD.
DEPT. RC.3
GLOUCESTER
THE WORLD'S SMALLEST RADIO COMES TO YOU IN THE NEW "SEE FOR YOURSELF" SEALED KIT PACK

SINCLAIR MICROMATIC

SIX STAGE TRANSISTOR RECEIVER

Now when you buy your Sinclair Micromatic Kit, you see every component instantly in the new sealed polystyrene Kit pack. Never before in the history of Radio has any Kit been so elegantly presented. Your Micromatic reaches your factory fresh and guaranteed. Check for yourself at once that every component is in its proper place in the new case made and shaped specially to take the Micromatic Kit. Your Micromatic Kit measures only 14/5" x 13/10" x 1/2".

BEAUTIFULLY STYLED CASE
POLISHED ALUMINIUM FRONT PANEL
CALIBRATED SPUN ALUMINIUM TUNING DIAL
AMAZING POWER, RANGE AND SENSITIVITY
NEW CIRCUITRY
BANDSPREAD TUNING PLUS A.G.C.
5 YEAR GUARANTEE

TECHNICAL DESCRIPTION
The Sinclair Micromatic is housed in a neat plastic case with attractive aluminium front panel and aluminium tuning dial to match, calibrated in metres and kc/s. Special Sinclair transistors are employed in a six-stage circuit of exceptional power and sensitivity. Two stages of powerful R.F. amplification are followed by a double diode detector from which the signal tuned in is passed to a high gain three stage audio amplifier. Automatic Gain control counteracts fading from distant stations. The set is powered by two Mallory ZM.312 Cells obtainable from radio shops, Boots Chemists, etc., for 1/7 each. They give approximately 70 hrs. working life. Inserting the earpiece plug switches the set on, withdrawing it switches it off. Complete kit of parts including lightweight earpiece, instructions and solder.

SINCLAIR MICROMATIC, ready built, tested and guaranteed, with earpiece, complete in presentation case.

SINCLAIR RADIONICS LIMITED
22 NEWMARKET ROAD, CAMBRIDGE.
Telephone OAC3-52731

452
THE RADIO CONSTRUCTOR
SINCLAIR Z12
INTEGRATED 12 WATT AMPLIFIER AND PRE-AMP
A MASTER OF POWER, COMPACTNESS AND VERSATILITY

For size alone, the Z.12 marks an important advance in quality design, for its amazing compactness opens up exciting new vistas in amplifier housing and application. Combined with this are fantastic power and superb quality which can provide an effortless output of 12 watts RMS continuous sine wave from the unique eight transistor circuit used. Basically intended as the heart of any good mono or stereo hi-fi system, the size and efficiency of this Sinclair unit make it equally useful for a car radio (with the Micro-6 for example), a high quality radio with the Micro FM, in a guitar, P.A. or intercom system, etc. Other applications are certain to suggest themselves to constructors. The manual included with the Z.12 details mono and stereo tone and volume control circuits by which inputs can be matched (and switched in) to the pre-amp. The size, performance and price of the Z.12 all favour the constructor seeking the finest in transistorised audio reproduction—it is in fact today's finest buy in top grade high fidelity.

12 WATTS R.M.S. OUTPUT
CONTINUOUS SINE WAVE
(24 W. PEAK)
15 WATTS R.M.S. MUSIC POWER (30 WATTS PEAK)

Ultra-linear class B output and generous neg. feed back.
Response—15 to 50,000 c/s ±1dB.
Output suitable for 3, 7.5 and 15 ohms loads. Two 3 ohm speakers may be used in parallel.

SINCLAIR MICRO FM
Combined FM Tuner Receiver

Use it as a Tuner
Use it as a Pocket F.M. Receiver
Outstanding Quality
Remarkable Circuitry using low I.F., Pulse-counting Discriminator & A.F.C.

Less than 3" x 1 ½" x 1½" and professional in every way, 7 transistor FM using pulse count discriminator for superb audio quality. Low I.F. makes alignment unnecessary. Tunes 88-108 Mc/s. The telescopic aerial suffices for good reception in all but poorest areas. Signal to noise ratio—30dB at 30 microvolts. Takes standard 9V battery. One outlet feeds to amplifier or recorder, the other allows set to be used as a pocket portable. Brushed and polished aluminium front, spun aluminium dial. A fascinating set to build.

GUARANTEE
If you are not completely satisfied when you receive your purchase from us, your money will be refunded at once in full and without question.

SINCLAIR STEREO 25
De-Luxe Pre-amp & Control Unit for Z.12 or other good stereo system

Designed specially to obtain the very finest results used with two Sinclair Z.12's for stereo. The best quality components, individually tested before acceptance, are used in its construction, whilst the overall appearance of this compact de-luxe pre-amp and control unit reflects the professional elegance which characterises all Sinclair designs. The front panel is in solid brushed and polished aluminium with beautifully styled solid aluminium knobs. Mounting is simple, and the PZ.3 will comfortably power the Stereo 25 together with two Z.12's. When fitted, the Sinclair 25 will grace any type of hi-fi furniture. Frequency response 25 c/s to 30 kc/s ±1dB connected to two Z.12's. Sensitivity Mic. 2mV into 50KΩ; Radio —3mV into 50KΩ; Radio —20mV into 4.7kΩ. Equalisation correct to within ±1dB on RIAA curve from 50 to 20,000 c/s. Size 6" x 2" x 2½" plus knobs.

BUILT, TESTED AND GUARANTEED

89/6

SINCLAIR RADIONICS LIMITED
22 NEWMARKET ROAD, CAMBRIDGE

Please send
NAME
ADDRESS

for which I enclose cash/cheque/money order value £ s d.

RC367
**BI-PAK SEMICONDUCTORS**

**LOW COST SILICON CONTROLLED RECTIFIERS (THYRISTORS)**

<table>
<thead>
<tr>
<th>Type</th>
<th>Voltage</th>
<th>Current</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 AMP</td>
<td>400 V</td>
<td>15 A</td>
<td>1.50</td>
</tr>
<tr>
<td>5 AMP</td>
<td>400 V</td>
<td>30 A</td>
<td>3.00</td>
</tr>
<tr>
<td>10 AMP</td>
<td>400 V</td>
<td>50 A</td>
<td>5.00</td>
</tr>
</tbody>
</table>

All prices are per piece. Free delivery with orders over £10.00. Free catalogues and/or, Gates, Memory Units, Timer Units, etc., details free.

**T.R.S. BARGAINS IN KITS, COMPONENTS AND EQUIPMENT**

**TRANISTORS MIXED UNTESTED**

<table>
<thead>
<tr>
<th>Type</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 NPN Transistors</td>
<td>10/-</td>
</tr>
<tr>
<td>5 PNP Transistors</td>
<td>10/-</td>
</tr>
</tbody>
</table>

**SILICON DIODES**

- 1N4004, 1N4007, 1N4148: 10/-
- 1N4148, 1N4149: 15/-

**SILICON RECTIFIERS**

- 1N4001, 1N4007, 1N4004: 10/-
- 1N4148, 1N4149: 15/-

**MISCELLANEOUS**

- 15 VDC Power Supply (100 mA): 10/-
- 220 VAC Transformer (100 mA): 20/-

**NEW**

- Silicon 750mA Top-Hat: 20/-

**RANCH HOUSE 93/97 REGENCY STREET LONDON, W.1**

**VALUE PAKS FOR '67**

<table>
<thead>
<tr>
<th>Type</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>120 Germ. Diodes</td>
<td>10/-</td>
</tr>
<tr>
<td>20 All types Zeners</td>
<td>10/-</td>
</tr>
<tr>
<td>25 Transistors</td>
<td>10/-</td>
</tr>
<tr>
<td>10 Rectifiers</td>
<td>10/-</td>
</tr>
<tr>
<td>60 Silicon Diodes</td>
<td>200 mA</td>
</tr>
<tr>
<td>16 Rectifiers</td>
<td>10/-</td>
</tr>
</tbody>
</table>

**NEW SILICON BRIDGE RECTIFIERS TESTED**

- 600 V 2 Amp at 55°C: 25s. each.
- 800 V 2 Amp at 55°C: 30s. each.

**WE ARE SINCLAIR SPECIALISTS**

- We carry full stocks of these valuable filaments all-British designs as advertised and give prompt delivery.

**TO-5 SEMICONDUCTORS**

- 400 PIV: 22/6
- 600 PIV: 45/-

**TRANSFORMER MANUFACTURING SERVICE**

- We manufacture all types Radio Mains, Transf. Circuits, Quality QIP Transf., etc. Enquiries invited for special, prototypes for small production runs. Quotations by return.
BOUND VOLUME No. 19
of “The Radio Constructor”
FOR YOUR LIBRARY

Comprising 780 pages plus index

Volume 19 August 1965 to July 1966

PRICE 30/- Postage 4/6

Special discount of 10/- for regular readers
Where the 12 monthly issues making up the volume are returned, the price is only 20/- plus 4/6 postage

Available only from:
Data Publications Ltd.
57 Maida Vale London W9

MARCH 1967

TRANSISTORISED SIGNAL GENERATOR
Size 5½” x 3½” x 1⅞”. For IF and RF alignment and AF output, 700 c/s frequency coverage 460 Kc/s to 2 Mc/s in switched frequencies. Ideal for alignment to our Elegant Seven and Musette. Built and tested. 3½/. P. & P. 3/6.

TRANSISTORISED 1½ WATT AMPLIFIER
comprising 2AC 128, 20C 75 and 2 AA129 separate bass and treble volume controls. Complete with Power Supply AC mains 240V size 7⅞” x 3⅞” x 2”. Price 50/- plus 2/6 P. & P.

TRANSISTORISED 3 to 4 WATT AMPLIFIER KIT

8-watt 4-valve PUSH-PULL AMPLIFIER & METAL RECTIFIER
Size: 9” x 6” x 1⅛”. A.C. Mains, 200-250V 4 valves, for use with SId. or L.P. records, musical instruments, all makes of pick-ups and mikes. Output 8 watts at 5 per cent of total distortion. Separate bass and treble lift control. Two inputs, with controls for gram and mike. Output transformer tapped for 3 and 15 ohm speaker. Built and tested, £4.4.0. P. & P. 11/-. 8” x 5” speaker to suit price 14/6 plus £1/6 P. & P. Crystal mike to suit 12/6 plus £1/6 P. & P.

“MUSETTE” 6-Transistor Superhet Portable Radio
★ 2½” Speaker. ★ 6 Transistors Superhet Output 200mW. ★ Plastic Cabinet in red, size 4⅜” x 3” x 1⅞”, and gold speaker louvre. ★ Horizontal Tuning Scale. ★ Ferrite Rod Internal Aerial. ★ IF 460 kc/s. ★ All components Ferrite Rod and Tuning Assembly mount on printed board. ★ Operated from PP3 Battery. ★ Fully comprehensive instructions and point-to-point wiring diagram. ★ Printed Circuit Board. ★ Tunable over medium and long waveband. ★ Car aerial and earpiece socket.

ELEGANT SEVEN Mk. IIA
SPECIAL OFFER. 7” x 4” P.M. Speaker at no extra charge. Power supply kit to purchasers of “Elegant Seven” parts, incorporating mains transformer, rectifier and smoothing condenser, A.C. mains 200/250 volts. Output 9V 100mA. 7/6 extra.
Buy yourself an easy to build 7 transistor superhet radio for under £4.10.0. No one else can offer such a fantastic radio with so many de luxe features.
★ De luxe grey wooden cabinet size 12¼” x 8⅜” x 3¼”. ★ Horizontal easy to read tuning scale printed grey with black letters, size 11½” x 2”. ★ High “Q” ferrite rod aerial. ★ High gain stage. ★ B.C. coupled push pull output stage with separate A.C. negative feedback. ★ Room filling output 350mW. ★ Fully comprehensive instructions and point to point wiring diagrams. ★ Car aerial socket. ★ Fully tunable over medium and long wave, 168-535 metres and 1250-2000 metres. ★ All components, ferrite rod and tuning assembly mount on printed board. ★ Full after sales service. ★ Parts list and circuit diagram 2/6, free with parts.

Our new branch at 323 EDGWARE ROAD, LONDON, W.2 is now open
Personal shoppers only. “Early closing Thursday”
All orders by post to our Acton address

RADIO & TV COMPONENTS (ACTON) LTD.
21G High St., Acton, London, W.3
Shop Hours 9 a.m. to 6 p.m. Early Closing Wednesday
Goods not dispatched outside U.K. Terms C.W.O.
All enquiries Stamped Addressed Envelope.

ONLY £4.4.0
Plus 7/6 P. & P. & Fitting Kit

455
DABBING IN RADIO can be one of the most satisfying hobbies

It can also be one of the most frustrating — you might find that the very component you require for achieving a technological breakthrough is missing.
Don’t start ill-equipped. Send for the Home Radio Catalogue, which lists over 6,000 components with over 1,000 of them illustrated.
We cannot guarantee a technological break-through every time; although we will supply whatever you require in the electronics field. Spare yourself frustration and disappointment — send for this famous catalogue today! Please enclose 9/- P.O. or cheque with the coupon below.

The price of the catalogue is 7/6 (plus 1/6 p & p) but every catalogue contains 5 vouchers each worth one shilling if used as directed! You can’t lose!!
Transistorised 2-Tone Alarm Generator,  
by F. L. Thurston 458

Tetrode F.E.T. Improves A.G.C. Circuits,  
by M. J. Darby 461

One Minute Flasher for Transistor Equipment  
(Suggested Circuit No. 196),  
by G. A. French 462

Wide-Band Photophone,  
Part 2,  
by D. Bollen 465

Semiconductor Device Coding Systems,  
by A. Thomas 469

Transistor Direct-Reading Frequency Meter,  
by C. Crosbie 472

News and Comment 474

Building Transmitter V.F.O's,  
by F. G. Rayer, G30GR 477

The “8-2 Special” Receiver 480

Understanding Radio  
(The R.F. Pentode),  
by W. G. Morley 490

In Your Workshop 495

Corona Voltage Stabiliser Tubes,  
by J. B. Dance, M.Sc. 501

Can Anyone Help? 503

Radio Topics,  
by Recorder 504
Attention is immediately caught by the distinctive signal that this neat little assembly generates. It may be coupled to any a.f. amplifier.

The conventional alarm call generator, in the form of a continually sounding bell, suffers from a number of distinct disadvantages. These disadvantages do not result from any technical inadequacy in the alarm bell itself, but from the psychological characteristics of the human target at whom the alarm is aimed. To be effective in attracting attention a constant tone or signal must be produced at considerable volume, as it is a natural characteristic of the brain to suppress all constant level signals; our hearing has, in effect, a built-in a.g.c. system. Since these alarm calls are transmitted at considerable volume they tend, if the listener is within close proximity, to attract attention in a very jarring and upsetting way. Most readers will, no doubt, have had that feeling of distinct shock as a bell goes off within a few feet of the ear when they have walked past in a mood of deep concentration!

Changing Tones
Scientific tests have shown that the brain responds
most readily to audio tones that are continually changing either in frequency or in volume, and that, with such signals, the attention can be attracted quite easily even at very low volume levels. Such signals are thus of considerable advantage in applications where they may be used to attract attention without creating undue disturbance, i.e., in “doctor calling” services in hospitals, in the homes of old folk, etc. This high response of the brain to changing, rather than constant level signals, applies to all of the senses. It is most striking in sight where, for example, the movement of a single rabbit in a large field, or the flicker of a single bulb amongst thousands of lights, immediately attracts the attention.

The unit that forms the basis of this article is a fully transistorised 2-tone alarm call generator, and may be used to feed the call signal to either a power amplifier or radio transmitter, or some other distribution system. Amongst the applications which are of interest to the amateur, it may be used as a front door “visitor announcer”, as an extension “phone call indicator”, as an intercom “call” generator, or as an alarm generator for use with a rain sensor, heat or smoke indicator or burglar detector.

Circuit Operation

The full circuit diagram of the 2-tone generator is shown in Fig. 1. It is possible to build a 2-tone generator using fewer transistors than shown here, but this will usually involve the use of a transformer which, in many cases, may be difficult to obtain. The circuit of Fig. 1 calls for no specialised components, is tolerant of quite wide variations in component values, and presents no constructional problems.

The circuit can be divided into two distinct sections, TR1-TR2 being a low frequency pulsing or switching generator, whilst TR3-TR4 is the audio frequency generator.

TR1 and TR2 are wired as a conventional stable multivibrator. Here, one or other of the two transistors is biased hard on while the other is biased off, this condition being held for a pre-determined length of time until, suddenly, the states of the two transistors change over. This second condition is also held for a pre-determined length of time, after which the circuit states suddenly change back again, and another cycle commences.

The output of the TR1-TR2 circuit, taken from TR2 collector, has the form of a rectangular waveform, the mark-space, or on-off ratio of the waveform depending on the individual time constants in the circuit. In Fig. 1, this mark-space ratio can be altered by varying the setting of RV1. With the circuit values shown, the circuit operated in the prototype at a frequency of slightly greater than 1 c/s, but this can be increased or decreased as required, by either decreasing or increasing the values of C1 and C2.*

The second part of the circuit, TR3-TR4, is the audio oscillator section. Here, TR3 is wired as a grounded base amplifier, with collector load R7 and emitter bias resistor R8, whilst TR4 is wired as an emitter follower, with emitter load R9. The base bias of the grounded base amplifier is determined by R5 and R6, the input to the transistor being applied to the emitter. Thus, if a negative-going signal is applied to the emitter the effective base-bias is reduced and the emitter (and collector) current is decreased; the voltage drop across R7, therefore decreases also, and the collector voltage of TR3 goes negative. The input and output signals of TR3 are thus in phase. The signal at TR3 collector is fed to TR4 base, and this transistor, being an

---

* Due to the relatively wide tolerance on electrolytic capacitor values, it may be found that some components with the nominal values specified for C1 and C2 offer a slightly different switching frequency to that mentioned here.—Editor.

**COMPONENTS**

<table>
<thead>
<tr>
<th>Resistors</th>
<th>(All fixed values ¼ watt 10%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1</td>
<td>5.6kΩ</td>
</tr>
<tr>
<td>R2</td>
<td>5.6kΩ</td>
</tr>
<tr>
<td>R3</td>
<td>8.2kΩ</td>
</tr>
<tr>
<td>R4</td>
<td>8.2kΩ</td>
</tr>
<tr>
<td>R5</td>
<td>33kΩ</td>
</tr>
<tr>
<td>R6</td>
<td>5.6kΩ</td>
</tr>
<tr>
<td>R7</td>
<td>4.7kΩ</td>
</tr>
<tr>
<td>R8</td>
<td>1.7kΩ</td>
</tr>
<tr>
<td>R9</td>
<td>4.7kΩ</td>
</tr>
<tr>
<td>RV1</td>
<td>250kΩ, preset, skeleton potentiometer</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Capacitors</th>
<th>(All capacitors miniature types. C1, C2 and C4 may require adjustment—see text)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>2µF electrolytic, 12V wkg.</td>
</tr>
<tr>
<td>C2</td>
<td>2µF electrolytic, 12V wkg.</td>
</tr>
<tr>
<td>C3</td>
<td>0.01µF</td>
</tr>
<tr>
<td>C4</td>
<td>0.1µF</td>
</tr>
<tr>
<td>C5</td>
<td>4µF electrolytic, 12V wkg.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Transistors</th>
<th>TR1 OC75</th>
<th>TR2 OC75</th>
<th>TR3 OC71</th>
<th>TR4 OC71</th>
</tr>
</thead>
<tbody>
<tr>
<td>Switch</td>
<td>S1</td>
<td>s.p.s.t. switch (see text)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Battery</td>
<td>4.5 to 9 volts</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>Veroboard, 0.15in matrix, 2¼ x 1¼in (7 strips x 18 holes)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Wire, etc.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

MARCH 1967

459
emitter follower, gives an output at its emitter which is also in phase with its input, but at a low impedance level. The signal at TR4 emitter is thus in phase with, but of greater amplitude than, the signal at TR3 emitter input. In consequence, we have the required conditions for oscillation and, when the operating frequency of the two transistors, and this bias is derived from TR2 collector. The frequency of the TR3-TR4 oscillator is thus varied automatically by the switching oscillator given by TR1 and TR2.

The output of the unit is taken, via C5, from the

the coupling capacitor C4 is inserted, the circuit does in fact oscillate. The operating frequency is determined mainly by the values of R7 and C4. In practice, this frequency is adjusted by altering the value of C4.

The base-bias to TR3 also has some effect on the emitter of TR4. Any supply between approximately 4.5 and 9 volts may be used.

Construction
The circuit is wired up on a small piece of Veroboard

(Continued on page 489)
Tetrode F.E.T. Improves A.G.C. Circuits

by

M. J. DARBY

If one applies an A.G.C. control voltage to a valve or transistor i.f. amplifier stage, there is a change in the effective input capacitance owing to Miller effect considerations. This inevitably leads to some detuning.

This difficulty may be avoided by the use of one of the 3N89 field effect transistors manufactured by the Siliconix Company. These components have two completely separate gate electrodes. (For a discussion of field effect transistors, see the article “Field Effect Transistors” in The Radio Constructor, February 1966.) In the 3N89 the two gates are physically in parallel rather than in tandem as in a multi-grid valve. As shown in Fig.1, the second gate does not screen the first gate from the drain and application of a.g.c. to the second gate does not therefore affect the input capacitance associated with the first gate.

An i.f. amplifier circuit for 45 Mc/s using the Siliconix 3N89 is shown in Fig. 2. The gain of this amplifier may be altered over a range of 40dB in a typical case by an a.g.c. control voltage of 0 to +6 volts. The variation in the resonant frequency of the input and output tuned circuits was undetectable when measured with equipment of resolution 0.1%. If, however, the a.g.c. was applied to the first gate, the resonant frequency altered by about 300 kc/s per volt of a.g.c. bias.

Another circuit designed by the Siliconix Company employs four 3N89’s in a high input impedance amplifier which provides a gain of about 60dB for a power consumption of less than one hundred microwatts (actually −3 volts at 28 microamp and +8.5 volts at one microamp). The first three tetrode f.e.t.’s of this amplifier are used as voltage amplifiers, each having a gain exceeding 10, whilst the final stage is a source follower.

Further information on the applications of the 3N89 is available from the manufacturers, Messrs. Siliconix Inc., 1140, West Evelyn Avenue, Sunnyvale 14, California, U.S.A.
ONE-MINUTE FLASHER
FOR TRANSISTOR EQUIPMENT

SUGGESTED CIRCUIT No. 196

By G. A. FRENCH

In the "Suggested Circuit" article published last month the writer pointed out that a shortcoming with battery operated transistor equipment is that it is impractical to fit a pilot lamp to give continuous warning that the equipment is switched on. This is due to the relatively heavy current which such a lamp would draw from the battery. At the same time, it is quite easy to forget to switch off transistor equipment, whereupon current is, once again, unnecessarily drawn from the battery.

Last month's article then went on to discuss a simple circuit which caused a pilot lamp to flash immediately after an item of transistor equipment was switched on and to flash again immediately after it was switched off. The necessity for causing the lamp to flash when switching off would then act as a reminder to the user of the equipment. A disadvantage with the circuit was that it could not be employed with transistor equipment having high-value bypass capacitors across the supply lines.

The writer has returned to the same subject this month, but the circuit to be described offers a completely different type of visual indication to show that the equipment is switched on. In this case a pilot lamp is caused to flash approximately once per minute whenever the associated equipment is switched on. Due to the use of a high-value capacitor which discharges into the pilot lamp to cause the flash, the overall battery consumption averages at slightly less than 2.5mA only. The flashing of the lamp gives a positive indication that the equipment is switched on and, despite the fact that the flash occurs only once per minute, this should still catch the attention of the user of the equipment. The flashing circuit is connected across the battery supply lines of the equipment, immediately after the on-off switch.

Some considerable thought was given to evolving a design which would employ the minimum number of components in the flashing circuit, and the writer was eventually able to pare these down to 2 transistors, a diode, 4 resistors and 2 capacitors. Of these, the most bulky component is the high-value capacitor (which would be necessary with any design following the flashing principle employed here), whilst the remaining components are all small and take up little space. Thus, the flasher circuit could be installed in many transistor radios of the larger type.

Basic Multivibrator Circuit

To enable a lamp to flash at regular intervals some form of periodic switching is required, whereupon it becomes difficult to devise a circuit which does not employ an electro-mechanical component such as a relay or thermal switch, etc., or a relaxation oscillator. Circuits incorporating electro-mechanical devices are obviously unattractive here, if only because of the operating current entailed. So far as relaxation oscillators are concerned, the simplest circuits are provided by the blocking oscillator and the multivibrator. A blocking oscillator requires fewer components than a multivibrator, but one of these components is a transformer, which will take up more space than several resistors or capacitors. So it was finally decided to produce a design based on the multivibrator.

The most important requirement of the flashing circuit is that it should draw a low average current from the battery supplying the equipment in which the circuit is to be fitted. It would be a fairly acceptable approach to have the battery supply the flashing light directly,
even though a sudden high current would be drawn from the battery during the period of the flash. This method of operation would cause a low average current to be drawn from the battery, even though the peak current was relatively high.

It might in consequence be thought that the multivibrator circuit of Fig. 1 would give the required performance. The operation of the circuit is, at first sight, very simple: the values of the resistors and capacitors can be chosen so that TR2 is on (i.e. conductive) for a short time and is off (i.e. non-conductive) for a long time. The lamp will then only be illuminated when TR2 is on, whereupon it would seem that the low average current requirement for a flashing indicator has been met.

Unfortunately, the simple circuit of Fig. 1 presents several design difficulties which have a serious effect on its performance. Since these difficulties have a bearing on the flashing circuit which was finally evolved, they will now be briefly considered.

If, in Fig. 1, TR3 is to remain off for a long period, C1 requires a relatively large value. When TR2 comes on, to cause the bulb to be illuminated, TR1 becomes non-conductive and C1 commences to charge by way of R1 and the base-emitter junction of TR2. However, one of the requirements of the circuit is that TR2 be conductive for a short period only. If C1 is to acquire a reasonable charge during this short period it is therefore necessary to give R1 a low value. But the consequence of a low value in R1 is that, when TR1 becomes conductive after the lamp has extinguished, a relatively high current is drawn through this resistor.

Thus, the circuit of Fig. 1 has the disadvantages, for the present application, that the full lamp current is drawn from the supply when the lamp is illuminated, and that a relatively high current is drawn from the supply when the lamp is extinguished. Although Fig. 1 is practicable, it is not because of these two shortcomings, particularly attractive.

A Practical Circuit

By the addition of another resistor and a small silicon diode, it is possible to overcome these problems to a very great extent. A practical circuit devised by the writer is shown in Fig. 2, and it represents this month’s "Suggested Circuit".

As will now be explained, the circuit of Fig. 2 allows the lamp to flash at intervals of about one minute, whilst the average current drawn from the supply is slightly less than 2.5mA, with peaks of the order of 3.7mA.

Let us commence an examination of Fig. 2 at a moment in the multivibrator cycle when TR2 is on and TR1 is off. In this condition, C1 is charging via R1 and the base-emitter junction of TR2. However, one of the requirements of the circuit is that TR2 be conductive for a short period only. If C1 is to acquire a reasonable charge during this short period it is therefore necessary to give R1 a low value. But the consequence of a low value in R1 is that, when TR1 becomes conductive after the lamp has extinguished, a relatively high current is drawn through this resistor.

Thus, the circuit of Fig. 1 has the disadvantages, for the present application, that the full lamp current is drawn from the supply when the lamp is illuminated, and that a relatively high current is drawn from the supply when the lamp is extinguished. Although Fig. 1 is practicable, it is not because of these two shortcomings, particularly attractive.

A Practical Circuit

By the addition of another resistor and a small silicon diode, it is possible to overcome these problems to a very great extent. A practical circuit devised by the writer is shown in Fig. 2, and it represents this month’s "Suggested Circuit".

As will now be explained, the circuit of Fig. 2 allows the lamp to flash at intervals of about one minute, whilst the average current drawn from the supply is slightly less than 2.5mA, with peaks of the order of 3.7mA.

Let us commence an examination of Fig. 2 at a moment in the multivibrator cycle when TR2 is on and TR1 is off. In this condition, C1 is charging via R1 and the base-emitter junction of TR2. However, one of the requirements of the circuit is that TR2 be conductive for a short period only. If C1 is to acquire a reasonable charge during this short period it is therefore necessary to give R1 a low value. But the consequence of a low value in R1 is that, when TR1 becomes conductive after the lamp has extinguished, a relatively high current is drawn through this resistor.

Thus, the circuit of Fig. 1 has the disadvantages, for the present application, that the full lamp current is drawn from the supply when the lamp is illuminated, and that a relatively high current is drawn from the supply when the lamp is extinguished. Although Fig. 1 is practicable, it is not because of these two shortcomings, particularly attractive.

A Practical Circuit

By the addition of another resistor and a small silicon diode, it is possible to overcome these problems to a very great extent. A practical circuit devised by the writer is shown in Fig. 2, and it represents this month’s "Suggested Circuit".

As will now be explained, the circuit of Fig. 2 allows the lamp to flash at intervals of about one minute, whilst the average current drawn from the supply is slightly less than 2.5mA, with peaks of the order of 3.7mA.
seconds along the time axis. At this changeover point, TR1 comes on and TR2 becomes non-conductive. As shown in the upper curve, there is about 8.5 volts across C1 and this rapidly drops to about 0.4 volts as the capacitor discharges into the lamp. The period of rapid discharge is indicated as “lamp flashes” in the diagram. Also at the 10 second point, the total current drawn from the supply rises suddenly from about 1.4mA to some 3.7mA. The reason for this increase will be discussed shortly.

At the end of the “lamp flashes” period in Fig. 3, C1 has a potential of about 0.5 volts. C1 continues to discharge (into R3) until, at about 25 seconds along the curve, the voltage across its plates is nearly zero. TR2 then comes on whilst TR1 becomes non-conductive, and the second changeover takes place. This fact is indicated in the lower curve by a sudden rise in current from 3 to 3.6mA. With TR2 on, capacitor C1 commences to charge, and the voltage across its plates slowly increases until, at about 75 seconds along the curve, it is around 8.5 volts. The increasing voltage across C1 is accompanied by a decreasing current drawn from the 9-volt supply, as shown in the lower curve. Around 75 seconds the second changeover takes place, and another cycle commences.

The lower curve may now be analysed in detail. There is, at the 10 second point, a rise in current to some 3.7mA. Ignoring leakage currents, this 3.7mA is due to the current drawn through R1 via TR1 (which has now come on), plus the charging current in C2 via R4 and the base-emitter junction of TR1, plus the smaller currents in R2 and R3. This total current falls fairly rapidly to about 3mA, the fall being due to the decreasing charging current in C2. When TR2 comes on, at about 25 seconds along the time scale, the current again rises to a peak, this time of about 3.6mA. Ignoring leakage currents, the 3.6mA is given by the current drawn through R4 by TR2 (which is now on), plus the charging current in C1 via R1 and the base-emitter junction of TR2, plus the smaller currents in R2 and R3. As C1 becomes more fully charged, the total current drawn from the supply drops to about 1.4mA, and consists almost entirely of the currents drawn via R3, R3 and R4.

It may now be appreciated that the values of the resistors are critical if a low average supply current is to be achieved. The most important value is that for R1, since it must have a value sufficiently low to allow C1 to become nearly fully charged when TR1 is off, yet not so low that an allow too great a current to be drawn when TR1 is on. The value quoted, 3.3kΩ, allows slightly less than 3mA to flow when TR1 is off, and provides the best practical compromise between the two conflicting requirements for a 1-minute cycle.

When TR1 comes on it must pass a 60mA pulse of current through the pilot lamp. Assuming a minimum gain of 80 in TR1 (the minimum figure specified by Mullard for an ACY19 at 1/50 of 60mA must, therefore, flow in TR1 base. R4 has a value of 10kΩ, which allows a pulse of slightly less than 1mA to flow through the initially discharged C2 into the base of TR1 immediately after the changeover, and this is sufficient to allow the lamp to flash. The value of 10kΩ is therefore about the highest which can be given to R4 if reliable flashing is to be achieved. Indeed, should a low-gain specimen be used in the TR1 position, it may be necessary to slightly reduce the value of R4 to obtain a good flash). This means that, during the period when TR2 is on, the standing current it draws cannot be reduced below a value which is slightly less than 1mA. An increase in R4 to reduce this current may prevent reliable flashing from occurring.

The period during the cycle after the termination of the flash, and until TR2 comes on, detracts from the overall efficiency of the circuit because no useful function is being carried out. All that happens here is that C1 is discharging slowly into R3 whilst TR1 is drawing nearly 3mA because of the necessarily low value in R1. This period could be decreased by reducing the value of R3. However, R3 is reduced below the 33kΩ specified, the advantage gained—a reduction of the length of the useless period—is offset by the additional current flowing throughout the cycle in R3 itself! The value specified for this resistor represents the best compromise between these two opposing effects.

The values of C2 and R3 control the time that TR2 is off and C1 is allowed to charge up, and it was found that 400μF and 150kΩ worked well in practice. Bearing in mind that leakage currents may be present in both C2 and TR1, the value chosen for R3 is somewhat high. At the same time, if this value is reduced the capacitance in C2 has to be increased and the latter component becomes more expensive. In practice, the prototype circuit functioned perfectly with a 150kΩ resistor in the R2 position. To check that a measure of reliability was still “in hand”, a 470kΩ resistor was temporarily connected in the R2 position. The circuit still functioned satisfactorily, although the length of the multivibrator cycle was, of course, extended.

Practical Points
The components employed in the circuit require a little comment. The pilot lamp is a Radiospares...
It should be noted that some of the equipment described in these articles is the subject of a provisional patent application.

Installation of the Transmitter

Careful screening is necessary at the transmitter end if a.c. bias is to be employed, otherwise interference will be caused to nearby long and medium wave receivers. The reflector and tube can be mounted on a pole, or placed in a window, where line of sight transmission of several hundred yards can be arranged.

Switch on the power amplifier and tube power supply, and either dab a finger on the open circuit power amplifier input or feed a high level signal to the tube. This should cause the tube to fire and the 100mA meter to read. If all is well, a loud hiss should be audible from the receiver, with possibly a low note of around 700 c/s generated by the tube. With gain set at zero, switch on the pre-amplifier and bias, and adjust VC1 of Fig. 6 (published last month) until the noise at the receiver diminishes. If there is any instability in the system, the background mush will continue or get louder.

The prototype circuit was checked with a brand-new PP9 battery having a terminal e.m.f. of 9.5 volts (which, assuming negligible leakage currents, is reflected in the fact that the currents shown in the lower curve of Fig. 3 tend to be marginally above their calculated values). To stimulate the effect of a run-down battery, the circuit was then checked with a 6-volt battery. Although the flash given at this lower voltage was less brilliant than with the 9-volt battery it was still noticeable and capable of attracting attention.
When these arrangements are complete a signal can be transmitted and range tests begun. At full modulation the needle of the 100mA meter will begin to flicker and, at the point where excessive modulation is applied, the reading will rise appreciably. At distances up to 100 yards very simple receivers will serve for tests. A selenium cell coupled to a three-transistor a.f. amplifier allows intelligible short range working, but the frequency response will be poor. Such an arrangement, however, may be used as a "field strength" meter, prior to more sophisticated reception arrangements. A phototransistor type of receiver will give full frequency response, but tends to be noisy in operation.

For comparison, a 15 watt 240 volt bulb was connected in place of the fluorescent tube, under similar conditions with the exception that the dropper resistor $R_1$ of Fig. 2 (published last month) was short-circuited so that the lamp glowed brightly. With a wide-band phototransistor receiver, full treble boost and maximum bass cut from a QUAD pre-amplifier (added to the large degree of treble boost given in the Photophone's compensation network), and taking 200 c/s as the 0db reference point, the signal was down to $-10$ db at 5 kc/s, and $-15$ db at 15 kc/s. At 15 kc/s the bulb was grossly overloaded and threatened to burn out, and this was the highest level of treble pre-emphasis that could be reasonably applied. Under the same circumstances, the fluorescent tube will peak above 30 kc/s and maintain its output to well beyond 60 kc/s. Without a lens to focus its light to a beam, range from the 15 watt bulb was inferior, being scarcely 100 yards.

**Overall Efficiency**

The limit to range with any system employing modulated light is set by receiver noise, light excursion or degree of modulation of the transmitter lamp, and the matching of the lamp's peak spectral response to the optimum spectral response of the receiving photocell, photodiode, or phototransistor. With a good design of receiver, the presence of strong ambient light, during the hours of bright sunlight, should have no effect on receiver sensitivity or noise. The resultant effect may be likened to a large d.c. component upon which a small a.c. signal is imposed, daylight being the d.c. component. If a vacuum photocell operated at a low voltage is used, this should contribute virtually nothing to the noise generated by its following amplifier. Unfortunately, phototransistors are not quite so good in this respect, and their noise tends to be significantly high. Light excursion is mainly dependant on the type and power of lamp used. Due to its thermal inertia, a filament bulb is very inefficient at anything approaching high frequencies and the...
Fig. 11. The circuit of the photocell and pre-amplifier unit. It is recommended by the manufacturers of the photocell that the cathode connection should be made to pins 1, 2, 6 and 7 connected together, and the anode connection to pins 3, 4, and 5 connected together. The output connects to the subsequent amplifier via screened cable with the braiding connected to chassis.

Resistors

(All resistors ½ watt 10%)

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>R₁</td>
<td>300kΩ</td>
</tr>
<tr>
<td>R₂</td>
<td>47kΩ</td>
</tr>
<tr>
<td>R₃</td>
<td>300kΩ</td>
</tr>
<tr>
<td>R₄</td>
<td>47kΩ</td>
</tr>
<tr>
<td>R₅</td>
<td>12kΩ</td>
</tr>
<tr>
<td>R₆</td>
<td>4.7kΩ</td>
</tr>
<tr>
<td>R₇</td>
<td>27kΩ</td>
</tr>
<tr>
<td>R₈</td>
<td>4.7kΩ</td>
</tr>
<tr>
<td>R₉</td>
<td>4.7kΩ</td>
</tr>
<tr>
<td>R₁₀</td>
<td>1kΩ</td>
</tr>
</tbody>
</table>

Capacitors

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>C₁</td>
<td>0.1µF paper</td>
</tr>
<tr>
<td>C₂</td>
<td>100µF electrolytic, 12V wkg.</td>
</tr>
<tr>
<td>C₃</td>
<td>15µF electrolytic, 12V wkg.</td>
</tr>
<tr>
<td>C₄</td>
<td>15µF electrolytic, 12V wkg.</td>
</tr>
<tr>
<td>C₅</td>
<td>100µF electrolytic, 12V wkg.</td>
</tr>
<tr>
<td>C₆</td>
<td>15µF electrolytic, 12V wkg.</td>
</tr>
</tbody>
</table>

Transistors

TR₁,₂,₃  ACY28 (or equivalent)

Photocell

V₁  90AV (Mullard)

Switch

S₁  s.p.s.t., toggle

Valveholder

B7G valveholder with centre spigot

more powerful the bulb the worse does this become, thus setting a natural limit to transmitter power. Discharge tubes will permit large modulation powers without loss of treble response but these, too, do not normally respond to very high frequencies because of the ionisation effects of their gas filling. The efficiency of a fluorescent tube in this context is something of a mystery, but the writer attributes it to the ability of its phosphor coating to respond rapidly to changes in the ultraviolet content of the internal discharge. It is this ultra-violet which activates the phosphor and causes it to throw off visible light. The performance of different types of tube has already been discussed in Part 1 of this series.

The light output from filament bulbs peaks
The inside of the receiver collimator box. The photocell is at the rear with the pre-amplifier before it. The battery is fitted to the right-hand wall of the housing, and the on-off switch to the rear wall at top left.

towards the infra-red end of the spectrum, and phototransistors and caesium oxidised silver photocells are sensitive to this. The fluorescent tube's maximum output lies towards the blue and ultra violet and, depending on the phosphor employed, a caesium antimony cell will provide a good spectral "match". The light output from a fluorescent tube is rather peculiar, consisting of sharp peaks of varying heights and widths distributed along the spectrum. With a caesium antimony photocell, the most efficient tubes to use for an optimum match are Ultra Violet, Blue, and Daylight coatings, in that order. The Ultra Violet tube will be approximately four times as efficient as the Daylight tube. In fact, performance figures given here for the Photophone were based upon Warm White tubes, which are even a less efficient match than the Daylight, so there is considerable scope for improvement. Fig. 9 shows the spectral responses of a Blue tube and a caesium antimony photocell.

With the prototype Photophone transmitter at full drive, distortion on peaks was objectionable, particularly when a music signal was being transmitted, and it was difficult to strike a suitable balance between distortion and long range with a good signal-to-noise ratio. Eventually, the simple volume compressor of Fig. 10 was added to the Photophone power amplifier, and this proved to be most effective. A 6V 0.06A bulb is encased in a small light-tight container, in close contact with a light dependent resistor type ORP60. As the amplifier output approaches the point where the fluorescent tube overloads and clips the peaks the bulb tends to glow brightly, and its light causes the resistance of the l.d.r. to drop and shunt the p.a. input, which in turn reduces p.a. output. VR1 controls the extent to which which compression is applied and S1 allows compression to be completely removed when desired. With compression, a very high modulation level can be maintained, to enhance signal noise ratio and increase "talk power" without distortion.

Range Tests

For range tests with the original, distances were determined by taking a 6 inch to 1 mile map of the area, marking it with 100 yard circles centred on the transmitter location, and identifying the position of the receiver by means of landmarks. The quality of music signals up to 200 yards was excellent, but beyond that the noise level of the receiver tended to drown the quiet passages unless treble cut was used to diminish receiver hiss. At 400 yards speech signals were completely intelligible and the vocal "character" of the talker came over well. 500 yards seems to represent a "light barrier" to all moderate power light signals. A tone could just be heard at that distance, using a single 20 watt fluorescent tube at the transmitter, but speech was indistinct.

The Receiver Equipment

We next turn to the equipment fitted at the receiver end. As has already been mentioned, the performance of a modulated light receiver will be dependent on self-generated noise, ambient light, and correct matching of the transmitter spectral output to the receiver's photosensitive device. There is also a further factor, this being the optical coupling between transmitter and receiver. Phototransistors were ruled out for the author's receiver because they are noisy and do not provide a good spectral match to a fluorescent tube. On the other hand, a caesium antimony photocell can be operated at a low voltage to give a good match and adequate gain, with suitable transistor circuitry, as well as a very low noise performance.

The author's receiver was constructed in two units, these consisting of a photocell pre-amplifier, and a portable a.f. amplifier with tone controls. The former unit is suitable for feeding directly into a fixed-location valve or transistor amplifier. The portable amplifier was designed to give a good quality output to a pair of Hi-Fi headphones. Alternatively, it can feed into a small 25 to 30Ω speaker at around 400 milliwatts.

Photocell Pre-amplifier

The circuit of Fig. 11 shows how a 90AV caesium...
antimony photocell is coupled to a bootstrapped Darlington Pair. This particular circuit offers a very high input impedance and has the advantage that, with TR1 passing a very small collector current, low noise amplification is possible. Capacitor C3 feeds the bootstrap in-phase signal to the bias network end of R3, and the a.c. signal from the photocell passes, via C1, to the base of TR1. With this arrangement, tests were conducted using higher photocell voltages, up to 48 volts, but there was no measurable increase in sensitivity and photocell noise became apparent as voltage increased. C1 effectively blocks the large standing current when the photocell is functioning in bright sunlight, but allows the minute a.c. signal superimposed on the d.c. to pass freely to the amplifier. R1 was selected to give the best overall performance. TR3 is a straightforward common-emitter amplifier, coupled to the emitter of TR2. At short ranges, the circuit of Fig. 1 gives headphone strength signals, and the overall response of the pre-amplifier is substantially flat to more than 60 kc/s. The photocell itself has an inter-electrode capacitance of only 0.7pF and appears to be able to respond to frequencies well beyond the capabilities of the pre-amplifier. The output from the pre-amplifier is coupled to the following amplifier by means of a length of coaxial cable.

(to be concluded)

Semiconductor Device Coding Systems

by A. Thomas

Notes on some of the semiconductor coding systems currently encountered in the U.K.

Now that there are such a vast number of semiconductor devices obtainable, it is thought that a review of some of the coding systems in use in the U.K. would be helpful for the amateur enthusiast.

Semiconductor manufacturers have slipped up in not realising the vast potential of their devices and the need for a significant coding system right from the start. This has been corrected somewhat in Europe and Great Britain by the Pro-Electron system but, even now, some manufacturers stick to their own individual systems.

In America, right from the early days, a serial coding has been in use. The system is purely a serial number which has no device significance. This system is known as the JEDEC code, and any manufacturer may submit a complete set of device specifications to a registering body, and a code is issued; any other manufacturer may then use the code if their device follows the specification entirely. The writer has seen many alternative significant systems proposed in the American technical press, but none have been universally adopted.

Pro-Electron Code as Applied to Semiconductors

This system is controlled by the organisation Pro-Electron in Luxembourg, and enjoys a wide use on the Continent and in this country.

For industrial devices the code consists of three letters and two digits. The first letter specifies the device material, whilst the second letter specifies the device function as shown in Table I. The remaining letter and two digits constitute a serial number.

For entertainment devices the code is modified to give immediate indication that it is an entertainment device. The first two letters carry the same significance as above and this is followed by three figures which constitute the serial number.

JEDEC Code

Under this coding system, the devices are registered with the Joint Electron Device Engineering Council, and as previously stated, there is no device significance. Transistors to this code are obtainable from a great many manufacturers in this country, whether the company is of American parentage or not. The code starts with IN, 2N, or 3N, and may have a prefix, USA (army), USN (navy), JAN (Joint army navy), if for military (MIL) use.

Newmarket House Code

Newmarket Transistors Ltd. have a significant coding system, and this is set out in Tables II and III.

CV Specifications

CV specifications apply to transistors, diodes and
valves, and to other electronic devices manufactured for use by Military, Post Office and other Government departments. The code consists of CV followed by a four figure serial number which has no device significance. There are several books of equivalents available, but these are not entirely up to date.

**Mullard Coding**

This company codes the majority of its devices to the Pro-Electron system, some being available to JEDEC codes.

Some exceptions are:
- Germanium diodes and rectifiers, GEX, GEM, OA (2 figures)
- Silicon diodes and rectifiers, OA (3 figures)
- Germanium transistors, GET, OC (up to 199)
- Silicon transistors, OC (200 up)
- Phototransistors, OCP
- Photodiodes, OAP
- Photo cells, ORP.

**TABLE I**

Pro-Electron Code as Applied to Semiconductors

<table>
<thead>
<tr>
<th>First Letter</th>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>Germanium</td>
</tr>
<tr>
<td>B.</td>
<td>Silicon</td>
</tr>
<tr>
<td>C.</td>
<td>Intermetallic Compound</td>
</tr>
<tr>
<td>R.</td>
<td>Materials for radiation detectors, Hall Effect generators, etc.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Second Letter</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>Diodes, (apart from other diodes listed below), including voltage dependent capacitors.</td>
</tr>
<tr>
<td>C.</td>
<td>Transistors for a.f. applications, low power.</td>
</tr>
<tr>
<td>D.</td>
<td>Transistors for a.f. applications, high power.</td>
</tr>
<tr>
<td>E.</td>
<td>Tunnel diodes.</td>
</tr>
<tr>
<td>F.</td>
<td>Transistors for r.f. applications, low power.</td>
</tr>
<tr>
<td>G.</td>
<td>Miscellaneous.</td>
</tr>
<tr>
<td>H.</td>
<td>Field Probe.</td>
</tr>
<tr>
<td>K.</td>
<td>Hall Generator.</td>
</tr>
<tr>
<td>L.</td>
<td>Transistors for r.f. applications, high power.</td>
</tr>
<tr>
<td>M.</td>
<td>Hall Modulators and multipliers.</td>
</tr>
<tr>
<td>P.</td>
<td>Photo semiconductors, including radiation devices.</td>
</tr>
<tr>
<td>R.</td>
<td>Breakdown devices, low power, including controlled switches, etc.</td>
</tr>
<tr>
<td>S.</td>
<td>Transistors for switching applications, low power.</td>
</tr>
<tr>
<td>T.</td>
<td>Breakdown devices, high power, controlled rectifiers, p.n.p.n. diodes.</td>
</tr>
</tbody>
</table>

| U.            | Transistors for switching applications, high power. |
| Y.            | Diodes, high power. |
| Z.            | Zener diodes. |

**TABLE II**

Newmarket House Code—Silicon Transistors

<table>
<thead>
<tr>
<th>NKT</th>
<th>1st digit. 2nd digit. 3rd digit. 4th digit. 5th digit.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st Digit. Fabrication.</td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Epitaxial n.p.n.</td>
</tr>
<tr>
<td>2nd Digit. Frequency (fT).</td>
<td></td>
</tr>
<tr>
<td>0.</td>
<td>Less than 100 Mc/s.</td>
</tr>
<tr>
<td>1.</td>
<td>100 Mc/s min.</td>
</tr>
<tr>
<td>2.</td>
<td>200 Mc/s min.</td>
</tr>
<tr>
<td>3.</td>
<td>300 Mc/s min.</td>
</tr>
<tr>
<td>4.</td>
<td>400 Mc/s min.</td>
</tr>
<tr>
<td>5.</td>
<td>500 Mc/s min.</td>
</tr>
<tr>
<td>6.</td>
<td>600 Mc/s min.</td>
</tr>
<tr>
<td>7.</td>
<td>700 Mc/s min.</td>
</tr>
<tr>
<td>8.</td>
<td>800 Mc/s min.</td>
</tr>
<tr>
<td>9.</td>
<td>900 Mc/s min.</td>
</tr>
<tr>
<td>3rd Digit. Gain (hFE).</td>
<td></td>
</tr>
<tr>
<td>0.</td>
<td>Less than 10.</td>
</tr>
<tr>
<td>1.</td>
<td>10 min.</td>
</tr>
<tr>
<td>2.</td>
<td>20 min.</td>
</tr>
<tr>
<td>3.</td>
<td>30 min.</td>
</tr>
<tr>
<td>4.</td>
<td>40 min.</td>
</tr>
<tr>
<td>5.</td>
<td>50 min.</td>
</tr>
<tr>
<td>6.</td>
<td>60 min.</td>
</tr>
<tr>
<td>7.</td>
<td>70 min.</td>
</tr>
<tr>
<td>8.</td>
<td>80 min.</td>
</tr>
<tr>
<td>9.</td>
<td>90 min.</td>
</tr>
<tr>
<td>etc.</td>
<td></td>
</tr>
<tr>
<td>4th Digit. (Vcbo).</td>
<td></td>
</tr>
<tr>
<td>0.</td>
<td>Less than 15V.</td>
</tr>
<tr>
<td>1.</td>
<td>15V min.</td>
</tr>
<tr>
<td>2.</td>
<td>30V min.</td>
</tr>
<tr>
<td>3.</td>
<td>45V min.</td>
</tr>
<tr>
<td>4.</td>
<td>60V min.</td>
</tr>
<tr>
<td>5.</td>
<td>90V min.</td>
</tr>
<tr>
<td>6.</td>
<td>120V min.</td>
</tr>
<tr>
<td>5th Digit.</td>
<td></td>
</tr>
<tr>
<td>Device Registration Number.</td>
<td></td>
</tr>
</tbody>
</table>

**TABLE III**

Newmarket House Code—Germanium Transistors

<table>
<thead>
<tr>
<th>NKT</th>
<th>1st digit. 2nd digit. 3rd digit.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st Digit. Type.</td>
<td></td>
</tr>
<tr>
<td>2nd and 3rd Digits.</td>
<td></td>
</tr>
<tr>
<td>Device Registration Number.</td>
<td></td>
</tr>
</tbody>
</table>

**HAVING DIFFICULTY?**

Don't we all, from time to time. However, we hasten to add that we are referring here to the obtaining of your copy of The Radio Constructor. It is published on the 1st of every month and is available from Newsagents and Booksellers. Where, for one reason or another, this is not possible, copies can be obtained direct from us (Data Publications Ltd., 57 Maida Vale, London, W.9) single copies at 3s. post paid or, if preferred, on annual subscription at 36s. post paid to any part of the world.
I should like a copy of the Electroniques Hobbies Manual. Enclosed is a cheque P.O. for 1016.

NAME

ADDRESS

R.C.4

OBTAIN A PROFESSIONAL FINISH TO YOUR EQUIPMENT!

Choose housings and equipment practice from the Electroniques catalogue.

With the new Hobbies Manual, you can obtain these—and over 11,350 other items—direct from Electroniques or through your Local Electroniques dealer! The service is fast; the choice is the most comprehensive ever offered. And the components, which are supplied by 85 leading manufacturers, meet every kind of need—whether the project is advanced or elementary!

1 For Small Electronic Assemblies
These attractive DATUM Dinkicases are available in four sizes ranging from 4" x 6" x 4" to 7" x 12" x 7". Grey hammer finish front and rear; panels front and rear grey gloss enamel. A retractable leg can be supplied if required (as illustrated).

2 Sloping Panel Cases
These DATUM cases, by using the feet provided in alternative positions, can provide a narrow base (upright) case or a wide based case. Four sizes provide eight alternatives. Dark grey hammer finish cases; top panels grey gloss enamel. Dimensions from 12" to 24" inches width overall.

3 Modular Equipment Practice and Equipment Cases
Professional quality 19 inch equipment cases available for the amateur at competitive prices. Symmetrical design allows panels fitted front and rear. Ideally suited for MCS 19 inch modular dossier system. A complete range of panels, sub-racks and system accessories is available. Stocked in seven sizes. Finish matches Dinkicases.

4 Diecast Boxes with unique slot-guide system
These versatile diecast boxes are stocked in 5 sizes, to be used as screened sub-assemblies for complete equipments, test sets, and junction boxes, and they can be used as plug-in assemblies on the MCS board system. A special range of VEROBOARD is designed to fit the slot guides in the boxes, which will also fit DATUM Dinkicases. As used in our modular communication assemblies.

Send now for your Manual, on the coupon above, to this address:
Electroniques (Prop. STC Ltd.)
Edinburgh Way, Harlow, Essex.
Telephone: Harlow 26777.
Transistor Direct-Reading Frequency Meter
by
C. Crosbie

A reliable design which employs circuit principles that are simple to understand, and which offers a direct indication of frequency up to 100 kc/s.

Several models of the direct-reading frequency meter described in this article have been built by the author and have given reliable results without introducing any difficulties. The principle of operation is easy to follow, and the method employed for final setting up dispenses with close-tolerance component.

The specification is as follows:
- Frequency range—10 c/s to 100 kc/s
- Minimum operating signal—0.5 volt peak
- Input impedance—1kΩ approx.
- Power supply—10mA at 6V.

Circuit Operation
The circuit of the meter appears in Fig. 1. The frequency to be measured is applied to TR1 via capacitor C1, the input voltage being 0.5 volt or more. TR1 is a conventional amplifier and is overloaded by this input signal, producing a squared wave at its collector. The collector voltage can only swing by about ±1.5 volts from its no-signal condition. The waveform shown in Fig. 2 (a) represents an input sine wave at the base of TR1, whilst that at Fig. 2 (b) shows the squared wave at its collector.

It is desired to obtain one pulse per input cycle, and so the square wave is next applied to the differentiator given by C3 to C6 (as selected by S1(a)) and R5. S1(a), which is a section of the range switch, selects suitable capacitance values for the range required. The differentiated signal applied to diode D1 is illustrated in Fig. 2 (c), where it may be seen that positive and negative “spikes”, or pulses, are produced.

Diode D1 performs two functions. Firstly, it selects only positive pulses and, secondly, only the top parts of such pulses. This latter function is necessary due to the imperfect squaring given by TR1, which allows small spurious pulses to appear at the foot of the main pulse. Thus, one positive pulse for each input cycle is available at the cathode of D1, as shown in Fig. 2 (d).
Pulse-Shaper

The pulse-shaper consists of a conventional monostable multivibrator, of which a simplified diagram is shown in Fig. 3. Fig. 3 illustrates how, due to the constant voltage (of the order of 4.7 volts) appearing across zener diode $Z_{D1}$, the circuit may be looked upon as having a main supply of 4.7 volts negative together with a bias supply of 1.3 volts positive.

In the absence of signal, the positive bias voltage on $TR_3$ base holds this transistor off, transistor $TR_2$ being fully on. A positive pulse applied to the base of $TR_2$ causes this transistor to become non-conductive, whereupon multivibrator action brings $TR_3$ on. $TR_3$ remains on until the capacitor switched in by $S_{1(b)}$ has discharged sufficiently into $R_6$ for $TR_2$ to become conductive again. Thus, a positive-going pulse appears at the collector of $TR_3$ whose length depends upon the values of $C_7$ to $C_{10}$ and $R_6$. Switch $S_{1(b)}$ ensures that the capacitance value selected provides a pulse that (continued on page 476)
News . . . and .

Talking Tyre Reports on its Performance by Radio

American engineers can now fix a tiny radio transmitter to a tyre and pick up information about its performance.

The miniature radio transmits extremely accurate measurements of the temperature and inflation pressure of the tyre while it is being accelerated and decelerated on a wheel, and subjected to other realistic operating conditions.

Information on pressure comes from a tiny thermistor attached to the valve. Temperatures are measured by four thermistors, each about the size of a pinhead. Three are embedded in different parts of the tyre. The other is suspended in the air inside.

These devices convert their measurement to electrical signals which are then broadcast by the transmitter over five channels simultaneously and picked up by an FM receiver attached to machines which record the data as graphs.

The system, developed by Goodyear, is enabling engineers to test new materials and designs for both car and airplane tyres.

New Thames-Side Venue for VHF Convention

The Radio Society of Great Britain is taking its annual VHF Convention out of London this year for the first time, and is to hold it at the Winning Post Hotel at Whitton, near Twickenham. The date is 13th May.

The Convention—this year's will be the thirteenth in the series—always has an international flavour, and attracts many v.h.f. transmitting men from the nearer European countries.

As in past years, a lecture session will occupy the afternoon proceedings. It will be followed by a banquet in the evening at which several distinguished personalities from the electronics profession will be present.

A comprehensive trade show by v.h.f. equipment specialist suppliers and a home construction competition will once again play their part in making the Convention one of the RSGB's most successful technical and social events.
Precision Wire Strippers for Miniature Assemblies

Plansel automatic wire and cable-stripping pliers, a product of Creators Ltd., are now obtainable from Henri Picard & Frère, Ltd., as a new addition to their range of tools for miniature electrical assembly work. The Plansel is a precision tool, with interchangeable blades capable of accurately stripping conductors from \( \frac{1}{32} \) in to 0.005 in and from 4 mm to 0.4 mm. The action is synchronised with a single pressure on the handles, which causes one jaw to grip the cable, while the other strips the insulation gently sideways with an automatic release to avoid damage to fine stranded cables. One set of blades is supplied with each tool and others are available from stock.

Portable Electric Tools

Safe and Unsafe

With the increasing number of do-it-yourself enthusiasts there has been a startling rise in the number of accidents due to the improper use of portable electric tools.

Aware of this problem, Wolf Electric Tools Limited, who manufacture what are probably the safest “double insulated” portable electric tools on the market, together with the British Safety Council, have produced a useful “at-a-glance” ten point safety code in the form of a double-crown poster for use in factories, mines, building sites, garages, technical colleges and even in the home workshop.

Says Council Controller James Tye: “We are concerned in the British Safety Council at the number of accidents involving electric tools when the elementary rules are ignored. When observed, the ten points in this safety code would prevent 95% of the accidents involving portable electric tools.”

The contents of the code are set out in the adjoining paragraph.

The above remarks are concerned with safety in the use of tools, unfortunately from time to time one learns of tools and equipment which are themselves unsafe. One such case concerns some electrical soldering irons imported from Hong Kong, in respect of which the Home Office has issued a warning because the insulation is inadequate and there is no provision for earthing.

The irons have black plastic pistol-grip handles 4 or 5 in long. Sold in polythene bags, the tools bear one of two labels. One states: “Power Soldering Iron 40 watt 200–240 volt. Pistol Grip. Empire Made.” The other states: “Soldering Iron 40 watt 240 volt. Made in Hong Kong.”

The Hong Kong government reported that the soldering irons were produced in 1964 to the specifications of a British buyer who submitted a sample to the factory. A total of 3,500 of the tools were made. The factory closed down in 1965.

No further consignment of this particular type of tool was exported by the factory after this sole transaction. The Colony’s Commerce and Industry Department was seriously concerned about the matter, and carried out a full investigation.

This particular case does not mean that other electrical goods imported from Hong Kong are unsafe.

Safety Code:

1. Check that voltage on tool nameplate agrees with supply voltage.
2. Tools with 3 core cables must be efficiently earthed.
3. Double-insulated tools (2 core supply) must bear the B.S.I. “Kitemark”.
4. Connect leads firmly to the correct terminals.
5. Always treat cables with care.
6. Ensure that tools are properly plugged into supply sockets.
7. Remove plug from supply socket before making any adjustment to tool.
8. Never tamper with machines.
10. Wear goggles when grinding or sanding.

“Get with it Gladys, you are about as modern as a valve mains-portable”
is always shorter than a cycle of any frequency in the range selected.

It is necessary to include the pulse-shaper offered by TR2 and TR3 in the frequency meter circuit because the pulses obtained after D1 are not constant in amplitude. They depend on the rise time of the squared output from TR1 which, in turn, depends on both the amplitude and frequency of the input signal. The pulses at TR3 collector remain constant in shape and length irrespective of input amplitude (above the minimum specified) and frequency (within the range selected). The output pulses at TR3 collector are shown in Fig. 2 (e).

**Meter Circuit**

Since equal pulses are produced at the collector of TR3 at the rate of one per input cycle, it follows that the average voltage across VR1 becomes directly related to input frequency. As input frequency increases, so does pulse frequency and, hence, the average voltage across VR1. This average voltage is measured by the voltmeter circuit given by VR2 to VR5 and meter M1.

When function switch S2 is in position 3, the lower end of VR1 is applied to whichever variable resistor—VR2 to VR5—has been selected by S1(c), and hence to meter M1. The negative terminal of M1 connects to the top end of VR1 whereupon it becomes capable of reading the average voltage across VR1. VR2 to VR5 are preset variable resistors which are employed to take up variations, within tolerance, in capacitors C7 to C10. These resistors are adjusted so that, when S1 is set to position 1, 2, 3 and 4 respectively, full-scale readings are given in the meter at frequencies of 30 c/s, 300 c/s, 3 kc/s and 30 kc/s. In consequence, with S2 in position 3 (corresponding to “Frequency x 1”) range switch S1 selects 0–30 c/s, 0–300 c/s, 0–3 kc/s and 0–30 kc/s.

Setting S2 to position 4 (“Frequency x \( \frac{10}{3} \)”) causes the positive input of the voltmeter section to be applied to the slider of VR1. This potentiometer is adjusted to tap off \( \frac{3}{10} \) of the average voltage across VR1. If, to take an example, S1 is in position 1 an input frequency of 100 c/s will then cause the meter to give full-scale deflection. The consequence is that, with S2 in position 4, the range selected by S1 becomes 0–100 c/s, 0–1 kc/s, 0–10 kc/s and 0–100 kc/s. The advantage of the multiplying facility offered by VR1 is that a total of 8 ranges become available with only four preset resistors in the voltmeter circuit and four capacitors in the multivibrator. Many commercial measuring instruments use the sequence 1, 3, 10, 30, etc., in their ranges, since this conveniently obviates the difficulty of resolving readings over the first 30% of the scale, and it is possible for the home-constructor to obtain meter movements scaled for both 3 and 10. For instance, the Radiospares Panel Meters type MR26 and MR31 are both scaled 0–3 and 0–10 in volts. These consist of basic movements having an f.s.d. of 100μA.

When function switch S2 is set to position 2, the positive terminal of the meter connects to the positive supply line via R11. This resistor has a value which enables the meter to read 10 volts f.s.d., whereupon it provides an indication of battery voltage.

Any meter with an f.s.d. of 250μA or less may be used in the M1 position. The highest average voltage likely to appear across VR1 is of the order of 3 volts, and this will correspond to 100 c/s on Range 1, and so on. The preset resistors VR2 to VR5 should therefore have values which cause an f.s.d. reading in the meter when about 1 volt is applied from S2(b) (either from the lower end of VR1 for a frequency of, say, 30 c/s at range 1 with S2 in position 3, or from the tap in VR1 for a frequency of 100 c/s with S2 in position 4). For a 250μA meter the final adjusted value in VR2 to VR5 will be of the order of 4kΩ; for a 200μA meter, 5kΩ; for a 100μA meter, 10kΩ; and for a 50μA
meter, 20kΩ. The actual values chosen for these components should be about twice those just mentioned. The corresponding values in $R_{11}$ are 40kΩ, 50kΩ, 100kΩ and 200kΩ respectively.

Calibration
The 30 c/s, 300 c/s, 3 kc/s and 30 kc/s ranges are calibrated first, with $S_2$ in position 3. $S_2$ is then set to position 4 with, say, a 300 c/s input on range 2. $VR_1$ is next adjusted for 30% deflection of the meter. This setting will then hold for all the other ranges.

The preset resistors $VR_2$ to $VR_5$ are set up with known input frequencies obtained, preferably, from a calibrated signal generator. If this is not available, a non-smoothed full-wave rectified mains signal makes a fair 100 c/s reference. This, in combination with an uncalibrated variable frequency oscillator, could be used for calibration, carrying on calibration points from one range to the next. However, greatest accuracy will be given with the calibrated generator.

Construction
The frequency meter may be built up in any convenient form, the major layout requirement being that short connecting leads are used in the signal and multivibrator circuits and that the stages proceed logically in the same order as in the circuit diagram.

Switches $S_1$ and $S_2$ may be 3-pole 4-way Yaxley switches of the “wave-change” type. The other parts are specified in the Components List.

---

**Building Transmitter V.F.O’s**

*by*

**F. G. RAYER G3OGR**

Drawing from a wealth of experience in the design and construction of transmitters, our contributor describes a number of v.f.o. circuits which offer excellent practical results. The amateur bands covered are 160 metres (1.8-2.0 Mc/s), 80 metres (3.5-3.8 Mc/s), 40 metres (7.0-7.1 Mc/s), 20 metres (14.0-14.35 Mc/s) and 15 metres (21.0-21.45 Mc/s).

A VARIABLE FREQUENCY OSCILLATOR is often used with a transmitter so that operating is not limited to those frequencies for which crystals are to hand. The v.f.o. circuits described in this article can be built into a home-constructed transmitter, or may be used as separate units with home- or commercially-made transmitters.

If the coil and other information is followed, there should be no difficulty in securing suitable band coverage. Some of the circuits can employ easily obtained ready-made coils, and suitable tuning ranges can then be expected without the nuisance of winding or modifying home produced coils.

**Hartley Oscillator**
The Hartley oscillator is much less used than in earlier years, but is still worth considering. Fig. 1 gives a suitable circuit for 3.5-3.8 Mc/s. Coupling from the oscillator tuned coil $L_1$ is by way of the electron stream in the valve, with further isolation given by the screen grid. A large output is available. With a single buffer/multiplier stage before the p.a., sufficient drive is available on the 3.5, 7, 14 and 21 Mc/s bands.

$L_1$ is a Wearite PHF5 coil, which is air-cored and of fixed inductance. The unwanted primary is removed. A lead for the cathode tap is soldered to the tuned winding 3½ turns from the earthy end, the enamel on the winding wire being scraped away at the appropriate point to

MARCH 1967
enable the solder joint to be made. Set the 75pF capacitor with its vanes nearly closed, then adjust the 60pF trimmer until the v.f.o. is heard at 3.5 Mc/s on a receiver. Coverage is then 3.5-3.8 Mc/s with a little to spare.

$L_2$ depends on the purpose in view. For 3.5-21 Mc/s working, a small core-tuned coil broadly resonant at about 7.1 Mc/s is suitable. This functions as a choke for 3.5 Mc/s and, for higher bands, allows an output to be taken at about 7.1 Mc/s. The core is adjusted for maximum p.a. grid current near the middle of the 14 Mc/s or 21 Mc/s band. (Details of a suitable coil for 7.1 Mc/s operation are given when the circuit of Fig. 3 is discussed.)

A similar circuit can be used for 160 metres. $L_1$ can then be 26 turns of 32 s.w.g. enamelled wire, the turns being wound side by side on a 1in diameter former, with the cathode tap 8 turns from the earthy end. The fixed capacitor changes to 250pF and the tuning capacitor to 100pF. $L_2$ can be broadly resonant at about 1.9 Mc/s.

V.F.O. and Operating Frequency

Pulling or frequency modulation effects are less likely when the transmitter output is a multiple of the v.f.o. frequency. For 3.5-3.8 Mc/s, the v.f.o. can tune 1.75-1.9 Mc/s. A 7 Mc/s v.f.o. is often used for the 14, 21 and 28 Mc/s bands, to avoid the need for much frequency multiplication.

Results can still, nevertheless, be satisfactory with the transmitter output on the v.f.o. frequency, whereupon a 1.75-2.0 Mc/s v.f.o. allows coverage of the 1.8-2.0 Mc/s and 3.5-3.8 Mc/s bands. Should 1.8-2.0 Mc/s be unwanted, a 3.5 Mc/s v.f.o. can be used for operating straight through on the 80 metre band, as well as higher frequency bands. When no frequency multiplication is wanted, the anode circuit, such as $L_2$ in Fig. 1, should be untuned, or at least not resonant at the working frequency.

If a v.f.o. is added to a crystal controlled transmitter, it is convenient to use the original crystal oscillator stage as a doubler. Instability is then very unlikely. Input to the crystal oscillator grid circuit is thus at half the frequency required at the anode.

Clapp Oscillator

The Clapp oscillator is popular and is capable of high frequency stability. Fig. 2 shows a suitable triode circuit. The large capacitors from grid, cathode and anode circuits swamp changes in capacitance in the valve and valveholder.

For 3.5-3.8 Mc/s, $L_1$ can be 22 turns of 32 s.w.g. enamelled wire wound side by side on a 1in diameter cored former. Nearly close the variable capacitor vanes, and adjust the core until the v.f.o. is heard on 3.5 Mc/s. The 3.5-3.8 Mc/s band will then be covered.

For 1.8-2.0 Mc/s, $L_1$ can be 55 turns of 32 s.w.g. enamelled wire, wound side by side on a 1in cored former. The fixed capacitor from coil to chassis is changed to 250pF. If there is no objection to further adjustments, the total capacitance of 270pF (or 250pF for 1.8-2.0 Mc/s) can be made up from a 200pF fixed component with 100pF trimmer in parallel. It will then be found that adjustments to $L_1$ core and this trimmer allow some variation in the total band coverage secured by full rotation of the tuning capacitor.

Output from the cathode is generally sufficient to drive an

Fig. 2. A triode Clapp oscillator. Satisfactory results have been obtained using either a 2.6mH short-wave choke or a 23mH all-wave choke in the r.f.c. position.
original crystal oscillator stage at fundamental frequency or double fundamental frequency. For higher frequency multiplication, an extra buffer/multiplier will generally be needed.

Fig. 3 shows a buffer/multiplier circuit suitable for use with Fig. 2 and other v.f.o. circuits. L₁ is an r.f. choke, and is selected when the amplifier is working straight through at the same frequency. L₂ is tuned to about 7.1 Mc/s, and is in circuit when the 3.5 Mc/s v.f.o. is driving the p.a. for 14 Mc/s and higher frequency bands. L₂ can have 34 turns of 32 s.w.g. enamelled wire, wound side by side on a ½ in diameter cored former. The core is adjusted for maximum p.a. grid current at about the centre of one of the h.f. bands (say 14.2 Mc/s).

Double-Triode V.F.O.

The circuit in Fig. 4 uses a 12AT7 as Clapp v.f.o., cathode coupled to a buffer-amplifier-doubler. This gives excellent isolation of the v.f.o. from following stages, and a relatively large output.

For 1.8–2.0 Mc/s, L₁ can be 95 turns of 34 s.w.g. enamelled wire wound side by side on a ½ in diameter cored former. Set the 75pF tuning capacitor vanes half closed, and adjust L₁ core until the v.f.o. is heard on 1.9 Mc/s.

For working straight through without multiplication, the r.f. choke shown is satisfactory. But if a higher frequency band is to be worked (e.g. 3.5 Mc/s) a broadly tuned coil, resonant at twice the frequency of L₁, may be substituted. This will increase output while multiplying. The cathode bias of the second section is essential for full output.

As with the other circuits, the h.t. voltage can be varied to some extent, according to the supply available, or output wanted. The v.f.o. should generally be operated at a fairly low voltage. If maximum output is wanted, the second triode section can receive 250V.

Band Coverage

Exact capacitor values are quoted in the circuits given here so that the wanted band can be found and covered immediately. In all cases there is a little unused rotation of the tuning capacitor towards the maximum and minimum settings. This allows calibration at 100 kc/s points—for example, at 3.5, 3.6, 3.7 and 3.8 Mc/s—and filling in between these marks with equal divisions when using a capacitor with semi-circular vanes. It is preferred that a band completely fill the 180-degrees rotation of the variable capacitor, then a vane or so should be taken off at the rear. Check coverage at both ends of the band before removing a further vane.

Probably the simplest, and most accurate method of checking coverage and calibrating the v.f.o. dial is to use a 100 kc/s crystal marker in conjunction with a receiver. This will supply 0.1 Mc/s calibration points. Should 50 kc/s (0.05 Mc/s) calibration points be wanted, calibrate the 100 kc/s points first, then tune the receiver to the second harmonic of the v.f.o. The 50 kc/s points can then be found against the 100 kc/s pips of the crystal marker.

Coils

Buffer and multiplier anode coils can be of normal type, as no particular frequency stability is required here. The actual v.f.o. tuning coil should not, however, be subject to random changes in inductance. Some commercially made variable frequency oscillators use small coils resembling those found in receivers; others have baked and impregnated coils.

(continued on page 487)
The “8-2 Special” short-wave receiver has been designed specifically for the beginner who wishes to start on the right track—with t.r.f. construction—before crossing the line to superhet building with its inherent tracking problems. As a comparatively simple design, it signals a clear way ahead for ease of construction and the author expresses the view that the receiver brings home the goods with regard to first class results, particularly in respect of Top Band Dx operation.

The “8-2 Special” short-wave receiver has been specifically designed with the beginner in mind and it may be constructed in the first instance as a 2-valve design by omitting the r.f. stage given by $V_1$, adding this valve later as time and available cash permit. The design itself is simple with no frills or “gimmick” circuits and is very easy to get working. The completed 3-valve receiver performs very well for it is, as may be seen from the circuit diagram of Fig. 1, really a 6-valve design, each glass envelope consisting of (in effect) two valves. On Top Band (1.8 to 2.0 Mc/s) c.w. or Morse transmissions have been logged from all over the British Isles—GM, GW—and several from the Continent. On all the other bands, both amateur and broadcast, the results have been equally successful. With the coils specified, the overall coverage is 1.67 Mc/s to slightly higher than 31.5 Mc/s (180 to 9.5 metres).

The foregoing results were obtained with an outside inverted “L” long wire aerial, about 30 feet high, oriented roughly 12 degrees North (North at the end remote from the receiver) of a line running directly from East to West. If possible, the constructor should use a similar outside aerial. An important factor for the beginner to bear in mind is the receiver earth connection. This should preferably be taken to earth itself. Connection to a water pipe often gives inferior results, and it has also to be remembered that in modern houses the piping may be of the plastic type. The earth wire should be of a thicker gauge than the aerial wire and should be as short and direct as possible, terminating in a metal rod (copper is preferable) driven as far into the earth as possible. A good earth connection is all-important with a receiver of this type.

Circuit

From Fig. 1 it will be seen that, as was just mentioned above, each of the three valves performs a double function. Also each has a type coding with the suffix 82; hence the title of this article—the “8-2 Special”. The majority of t.r.f. designs tend to be of the three valve type but in this case it was decided to make each of the valves a “double type”. The result is a six stage design, bringing the final performance close to that of a communications class receiver.
With the three valve circuit shown in Fig. 1, the main troubles associated with t.r.f. designs—radiation interference by an oscillating detector stage, difficult reaction or "dead spots", and lack of selectivity have been very largely overcome. Provided the r.f. valve V1, is included, radiation interference by an oscillating detector stage is eliminated. In addition, reaction is nearly constant (i.e. the oscillation point remains almost always at the same setting of the reaction control C7) and dead spots are completely absent, whilst selectivity is adequate bearing in mind the fact that this is a t.r.f. design.

The r.f. stage employs an ECF82 triode-pentode frequency changer, this being a type for use in television receivers. It performs here as firstly (V1a) a grounded grid triode presenting a low impedance input to the aerial. This circuit isolates the tuned r.f. pentode, V1(b), from the aerial, thereby removing all damping effects from the tuned grid circuit of the pentode and providing a high degree of selectivity with respect to the r.f. stage as a whole.

The aerial input is, via the capacitor C1 to the cathode (pin 8) of V1(a), the resistor R1 providing a small amount of bias for this stage. The grid is grounded direct to chassis and the output from this isolating stage is taken to the top of the coil L1 via the capacitor C2. The winding L1 is, of course, that which would normally be used in conventional r.f. stages for aerial coupling.

The winding L2 is tuned by C4(a) this being one half of a two-gang variable capacitor, the other half of which (C4(b)) tunes the grid of the detector stage. The cathode of the pentode section obtains a bias voltage via the components R2, R3 and C3, it being made variable by means of the potentiometer R3. This is the r.f. gain control, and it will be found capable of taking the stage from minimum to near maximum gain without unwanted oscillation taking place. Screen-grid voltage (pin 3) is supplied via the resistor R6, the screen-grid being bypassed to chassis by C5. The anode h.t. supply is via R5 and RFC2. The r.f. signal tuned by the combination C4(a), L2, is presented to the pentode grid (pin 2), amplified and passed via the coupling capacitor C6 to the top of winding L3.

Winding L3 is that normally associated with the aerial input of a two-valve design and it is to this
point, should V1 be initially omitted from the design, that the aerial should be connected if a two-valve design is preferred in the first instance. Alternatively, the beginner could leave the connection from C8 to tag 8 of L3 unsoldered in the first instance so that, when testing the receiver, the aerial could be connected to this point. This would ensure that the circuit around V2 and V3 is working correctly before inserting V1 into its valveholder.

It will be noted that, in this design, the pentode couples to the detector tuned circuit by way of winding L3, and that this ensures that maximum selectivity is obtained. In some designs, connection from the r.f. stage is made via a small-value capacitor direct to the grid circuit of the detector stage. Similarly, in some designs, a capacitive coupling might be used to the grid tuned circuit of V1(b). These methods were not considered advisable for the present receiver, where one of the main aims is to obtain better selectivity than is given by the more usual class of t.r.f. receiver.

The amplified r.f. signal applied to L3 is coupled into winding L5, this being tuned by C4(b). The signal is then applied to the grid of the detector, V2(a).

The detector and first audio amplifying stages are constructed around an ECC82 double-triode, V2(a) being the detector and V2(b) the audio stage. The components C9 and R7 are the grid capacitor and grid leak respectively and these, together with the other components in the detector stage, ensure that reaction is smooth and positive with no "backlash" or overlap. It is necessary for this stage to oscillate when receiving c.w. signals. When reaction is just short of the oscillation point, sensitivity and selectivity are at a maximum. The feedback winding necessary to obtain reaction is given by L4, the variable capacitor C7 being the reaction control. The capacitor C8, connected from the anode of V2(a) to chassis, ensures that reaction is "silky smooth" with no trace of "ploppy" results or howl. The anode decoupling components are R8 and C10, the h.t. being applied via R9 and RFC3. The detected signal is fed to the first audio stage via the coupling capacitor C11. The components R11 and C14 supply cathode bias to this stage.

The audio signal from V2(b) is tapped off by the slider of the a.f. gain control, R13, and is applied to the grid of the following stage V3(a), this being the second audio amplifier.

The second audio stage and the power amplifier stage use an ECL82, V3(a) being the triode amplifier and V3(b) the pentode power output stage.

The amplified audio signal from the anode of V3(a) is passed via the coupling capacitor C17 to the grid of V3(b), R14 and C15 providing cathode bias for the triode and R16, C16 for the pentode section. The whole of this stage is decoupled from the h.t. line via the 5 watt resistor R18, R15 supplying h.t. voltage to the anode of the triode, and the speaker transformer primary winding supplying h.t. voltage to the anode of the pentode section. The electrolytic capacitor C18 is the h.t. bypass component to chassis.

It will be seen that the receiver has a considerable amount of a.f. gain. In most instances it may be
operated with the a.f. gain control slider set fairly well back at the minimum volume end of its track. The high a.f. gain ensures that there is plenty of amplification in reserve for the reception of very weak signals. Due to the amplification provided it is possible that some ECC82's may exhibit a small level of microphonicity, this giving rise to a "ping" in the speaker when the valve, or the chassis adjacent to the valve, is tapped. This does not represent a fault symptom and will not prevent operation of the receiver in the normal manner. It would be preferable not to attempt to mount the speaker in the same cabinet as the receiver chassis, since acoustic feedback may be troublesome if a particularly microphonic ECC82 were used in the V2 position.

In the circuit as shown, no provision has been made for headphone operation by the inclusion of a headphone jack. If the constructor particularly desires to use headphones, a jack socket may be fitted to the receiver at any convenient point away from the V1 and V2 stages, this coupling to the anode of V3(a) (pin 9) by way of an 0.05μF capacitor and screened cable, as illustrated in Fig. 2. The audio gain control should normally be kept at a low setting when using headphones because of the high a.f. amplification in the receiver, and because an uncomfortably high output may otherwise be passed to the phones when tuning through a powerful

| COMPONENTS |

**Resistors**  
(All stated values ½ watt 10% unless otherwise stated)

| R₁ | 330Ω |
| R₂ | 100Ω |
| R₃ | 5kΩ pot. 1in. |
| R₄ | 33kΩ |
| R₅ | 5.6kΩ |
| R₆ | 100kΩ |
| R₇ | 1.5MΩ |
| R₈ | 100kΩ |
| R₉ | 10kΩ |
| R₁₀ | 33kΩ |
| R₁₁ | 1kΩ |
| R₁₂ | 470kΩ |
| R₁₃ | 500kΩ pot. log |
| R₁₄ | 2.2kΩ |
| R₁₅ | 220kΩ |
| R₁₆ | 470Ω |
| R₁₇ | 680kΩ |
| R₁₈ | 1.5kΩ 5 watt |

**Capacitors**

| C₁ | 0.001μF silver mica or ceramic |
| C₂ | 100pF silver mica |
| C₃ | 0.01μF tubular, (Mullard) |
| C₄/a/b | 310±310pF, variable, 2-gang, type E (Jackson Bros Ltd) |
| C₅ | 0.01μF tubular, (Mullard) |
| C₆ | 100pF silver mica |
| C₇ | 100pF variable, type C804 (Jackson Bros Ltd) |
| C₈ | 200pF silver mica |
| C₉ | 100pF silver mica |
| C₁₀ | 0.1μF tubular, (Mullard) |
| C₁₁ | 0.01μF tubular, (Mullard) |
| C₁₂ | 0.01μF tubular, (Mullard) |
| C₁₃ | 0.1μF tubular, (Mullard) |
| C₁₄ | 12μF electrolytic, 6V wkg. |
| C₁₅ | 12μF electrolytic, 6V wkg. |
| C₁₆ | 25μF electrolytic, 25V wkg. |
| C₁₇ | 0.01μF tubular, (Mullard) |
| C₁₈ | 8μF, electrolytic, 350V wkg. |

**Output Transformer**  
T₁ Type 117E (H. L. Smith & Co Ltd)

**Speaker**  
7 × 4in elliptical, 3Ω

**R.F. Chokes**  
RFC₁/₂/₃ 2.5mH, type CH1  
(H. L. Smith & Co, Ltd)

**Dial & Drive**  
Electroniques (STC Ltd), type SMD2.  
(Home Radio Cat. No: DL6)

**Valves**

| V₁ | ECF82 (Mullard) |
| V₂ | ECC82 (Mullard) |
| V₃ | ECL82 (Mullard) |

**Valveholders**

5 off B9A with centre spigots (2 with skirt & can for V₁ and V₂)

**Tagstrips**

7-way (3 tags earthed)  
5-way (2 tags earthed)

**Knobs**

3 off (H. L. Smith & Co. Ltd)

**Coils**

Miniature Dual-Purpose,  
Blue (L₁, L₂) and  
Green (L₃, L₄, L₅).  
Ranges 3, 4 and 5. (Denco Ltd.)

**Chassis**

9 × 7 × 2in (H. L. Smith & Co. Ltd)

**Panel**

10 × 8in (H. L. Smith & Co, Ltd)

**Miscellaneous**

2BA and 4BA nuts and bolts; aerial/earth and speaker output socket strips each fitted with plugs; p.v.c. wire; rubber grommets (1 off 3in, 4 off 4in) coaxial cable, solder, etc.
signal. An important point to note is that the receiver should not be switched on without a suitable load (such as the speaker) connected across the output sockets. Without such a load, high a.f. voltages may be developed across the primary of the output transformer with a possible risk of damage. If it is intended to disconnect the speaker when the receiver is switched on (so that, for instance, headphones may be used on their own) a 10Ω 1 watt resistor should be permanently connected across the output sockets inside the chassis. This will provide a permanent load of sufficiently low value, and will not noticeably affect speaker matching.

Power Supply

The power supply for this receiver is given by the power pack described in the December 1966 issue of this magazine and the writer has been informed that back numbers of that issue are still available for those who have not seen a copy. However, for those who wish to incorporate a power supply on the same chassis as the receiver, a suitable circuit is shown in Fig. 5. With the prototype the power supply is, of course, a separate unit, the writer favouring this method for the reasons that it considerably assists with the reduction of mains hum and that the separate power supply may be used for other items of equipment if so desired. The power supply featured in the December 1966 issue is fitted with a volt-meter and a milliammeter and this may not be required by all beginners—hence the circuit shown here. Any power supply, provided it is fully isolated from the mains by a mains transformer, and incorporates a full-wave rectifier and adequate smoothing components, may be used. The ratings should be 250 volts at 50mA and 6.3 volts at 2A. When the power supply described in the previous issue is employed, ensure that the 6.3 volt wiring is such that both receiver and power unit chassis are at the same potential.

Construction

Fig. 3 (a) shows the plan view of the chassis deck, the drilling positions for V1, V2, V3, L1, L2 and L3, L4 L5 being clearly set out alongside the respective dimensions. Measurements should be made on the chassis deck and the drilling points marked with a pencilled cross such that, if a mistake has been made, it may be removed by rubbing lightly with a finger. Having ensured that the correct markings have been made, drill the holes firstly with a 1/16 in. drill, enlarge with a 1/8 in. drill inserted into a handbrace and then cut the valveholders for the valves and coils with a 9A chassis cutter. It is an advantage in this type of work—"chassis bashing" as it is termed—to have at hand a self-tapping centre punch with which to mark the drilling points prior to the actual drilling operation. In this manner the drill will not "wander" when applied to the chassis deck.

Having cut the five holes, position V1 valveholder such that pins 1 and 9 are nearest the centre of the chassis; V2, pins 1 and 9 nearest the front chassis apron; V3, pins 1 and 9 nearest the centre of the chassis; the valveholder for L1,2, pins 1 and 9 nearest the rear chassis apron; and the valveholder for L3,4,5, pins 1 and 9 nearest the centre of the chassis. Mark and drill the mounting holes with a 1/16 drill. Fit all five valveholders with an earth tag each, under one of the securing nuts.

Two tagstrips are used with this receiver and they should be positioned as shown in the below-chassis illustration. The 7-way tagstrip lies midway between V3 and L3,4,5. This tagstrip has 3 tags earthed to chassis, and the nut and bolt securing the rear fixture lug of the two-gang tuning capacitor. After the tuning capacitor has been fitted (as will be described shortly) the 7-way tagstrip is mounted in position, using 4BA nuts and bolts at each of the remaining earth tags.

The 5-way tagstrip is secured to the chassis by means of 4BA nuts and bolts, both earth tags being bolted into position. This tagstrip is shown alongside V1 valveholder.

For ease of construction, the rear chassis apron should next be dealt with, and this is shown in Fig. 3 (c). A 3/8 in. rubber grommet is fitted to this apron for the power input leads. Drill and fit the grommet. To the left of the grommet fit the speaker output Paxolin socket strip—no dimensions are given here because these components are often of differing sizes. Fit also the socket strip for the aerial and earth connections, as shown in the photograph. These strips are secured to the chassis rear apron by means of two 6BA nuts and bolts, an earth tag being fitted under the nut of each strip nearest the centre of the apron. The sockets proper of each tagstrip
Fig. 3. Drilling measurements for (a) the chassis deck, (b) chassis front apron, (c) chassis rear apron (see text), and (d) the front panel. The hole for $C_4(a)(b)$ in (d) is marked out with the aid of the tuning capacitor itself.
Nearest rear of chassis

Tag 3 R3

Coaxial braiding

Coaxial conductor to pin 8 L3

Tag 1 R13

HT+ RFC1

(a)

Nearest rear of chassis

Soldered to metal case

Tag 5 5-way tagstrip

R3

(c)

HT+ input

Coil

R9

R18

Tag 2 of 5-way tagstrip

(b)

Also secures rear flange of C4a-b

Coaxial conductor to pin 1 of V3

R13

(d)

Coaxial braiding

Tag 5 5-way tagstrip

Soldered to metal case

Fig. 4. Wiring-up details of (a) the 5-way tagstrip, (b) the 7-way tagstrip, (c) the r.f. gain control R3, and (d) the a.f. control R13. Both (c) and (d) are rear views.

Drilling work, obtain the front panel and mark and drill the three lower holes as shown in Fig. 3 (d). Drill the holes firstly with a \( \frac{1}{8} \) in. drill and enlarge with a \( \frac{2}{3} \) in. drill as previously described.

The next task is to hold or clamp the panel to the front apron of the chassis in the position that it will finally occupy, in which \( \frac{1}{8} \) in. of panel extends on each side of the chassis. Carefully mark the centres of the three holes in the front apron and drill to \( \frac{1}{8} \) in. diameter. The panel and chassis holes should now coincide when R3, R13 and C7 are fitted and secured to the assembly. Note that, with C7, both nuts should be removed, only one being replaced to secure this component to the panel and chassis.

Before finally fitting these three components, however, the tuning capacitor, \( C4a-b \), should be placed on the chassis deck such that the spindle end is against the rear of the front panel when the latter is temporarily in place. Mark the spindle position on the rear of the panel and drill to \( \frac{1}{8} \) in. diameter, following this by cutting a hole with the B9A chassis cutter. Fit the panel with the dial drive mechanism as shown in the manufacturer's literature. Secure the panel to the chassis by fitting the three lower control R3, R13 and C7 into position. Next, place the tuning capacitor on the chassis deck and mark and drill (\( \frac{1}{4} \) in.) its three fixing holes after the capacitor spindle has been inserted into the drive mechanism and temporarily secured. Using the rear bolt also for securing the appropriate earth tag (tag 7—see Fig. 4 (b)) of the 7-way tagstrip, drill the other two holes for this tagstrip and secure both this and the capacitor into position. Referring to the literature supplied with the dial, use the template provided and drill the holes required for fitting the actual dial and cover to the front panel.

Alongside each tag, of the tuning capacitor nearest the chassis, drill a \( \frac{1}{8} \) in. hole and fit rubber grommets to these holes. These will carry the fixed vane connections from the tuning capacitor through the chassis deck.

Place the output transformer Ti on the chassis deck in the position shown in the above-chassis illustration and drill the four holes required to secure this component into position (\( \frac{1}{8} \) in.) by using the transformer lugs as a template. Mark and drill a further two holes (\( \frac{1}{4} \) in.), and fit each with a rubber grommet. Position Ti such that the white and orange wires protrude through the chassis nearest V3. Secure Ti into position by means of 2BA nuts and bolts.

The mechanical assembly is now complete and wiring-up may commence.

(to be concluded)

NEW CATALOGUE

Arthur Sallis Radio Control Ltd., of 93 North Road, Brighton, Sussex, have just issued their new illustrated Catalogue No. 17. A large selection of new miniature components, semiconductors, Government and manufacturers surplus electronic equipment are listed and the price of this informative publication is 3s. post free from the above address.
Building Transmitter V.F.O's
(continued from page 479)

The coil should be wound tightly, with turns cemented in place. It is best not to fit it in a closely fitting screen, nor unnecessarily near a valve or other source of heat.

If the coil core is adjustable, this should be sealed afterwards. Should an adjustable inductance be felt troublesome, a coil of fixed inductance can usually be substituted. A pre-set capacitor is then required. For example, L1 in Fig. 2 may be a Wearite PHF6 coil with the primary removed, and 31 turns unwound from the grid end of the secondary. In this case the variable capacitor is 80pF, and the parallel capacitance made up from a 200pF 1% fixed capacitor and a 30pF trimmer in parallel. Coverage is then 3.5-3.8 Mc/s, with a little to spare at band-edges.

For an air cored coil, a ceramic former, wound with wire under tension, is considered helpful. But with ordinary coils of the type described, frequency drift is likely to be less than can be observed by visual dial readings.

RF Chokes
Suitable choke inductances are indicated in the circuits, but others are often satisfactory in practice. Current in v.f.o. and buffer stages is small, so that receiver type chokes are suitable. The choke should be efficient at the required frequency. In the circuits described, sectionalised short wave 2.6mH chokes, and even 2.3mH all-wave chokes, have been used. In some equipment where space was limited, miniature 5mH and similar chokes (as often fitted in transistor receivers) have been employed with no apparent change in results. A 2.5mH choke can of course be used where a 2.6mH component is referred to, and typical of the components which may be employed are the Electro-niques CCC7 (2.5mH) the Denco RFC.5 (2.6mH) and the Osmor QC1 (23mH).

Temperature Compensation
Temperature compensation may be attempted by a selection of positive and negative temperature coefficient capacitors. The temperatures found in different parts of the v.f.o. are however, likely to vary in a dissimilar manner after switching on, with the result that anything approaching complete temperature compensation is very difficult to achieve.

Drift can be heard by beating the v.f.o. with a crystal oscillator or marker output on a receiver. It is likely to be relatively fast when the v.f.o. is switched on, settling down after fifteen or twenty minutes. Commercially manufactured equipment usually shows a similar drift.

If the v.f.o. is soundly built, with the valve and other sources of heat clear of coil and capacitors, a circuit having no temperature compensation can be satisfactory for the bands from 1.8 Mc/s to 28 Mc/s.

Stability
A common fault with a v.f.o. is lack of stability, this showing up as frequency modulation. Several causes may be responsible. The trouble is probable if the v.f.o. is operating on the transmitter output frequency, and has insufficient screening and isolation. To avoid this, screen the v.f.o. completely. A good method of construction is to use a small box or four-sided chassis to contain all the v.f.o. components except the valve, whose holder is mounted on the box top. A screening is fitted to the valve-holder. Simply improving v.f.o. screening, with no other change whatever, may remove frequency modulation troubles.

At least one buffer or buffer-amplifier-multiplier should be present between the v.f.o. and p.a. The h.t. supply to the v.f.o. should also be regulated, or obtained from a separate supply, so that the voltage does not fluctuate with modulation.

Fig. 5. V.F.O. tuned circuits with switched coverage

Frequency modulation can usually be traced to one of the following causes: inadequate v.f.o. screening, poor regulation of the v.f.o. h.t. supply, having the v.f.o. on the same frequency as the p.a. stage, or not employing at least one buffer between the v.f.o. and the p.a.

Multi-Band Coverage
When the v.f.o. has a single range, coverage of the h.f. bands grows cramped. This fact does not reduce efficiency, but it is worthwhile opening out the scale if the h.f. bands are used frequently.

If the v.f.o. tunes 3.5-3.8 Mc/s, the 3.5-3.6 Mc/s sector will cover 7-7.2 Mc/s, 14-14.4 Mc/s, and 21-21.6 Mc/s when followed by buffer-multipliers. So if the v.f.o. can tune 3.5-3.8 Mc/s for 80 metres, and 3.5-3.6 Mc/s for the 40, 20 and 15 metre bands, this gives a more convenient coverage.

Fig. 5 shows two ways of altering v.f.o. range. Each employs a 2-way switch. In Fig. 5 (a), with the switch...
Two-Band V.F.O.

Constructing the v.f.o. to give an output on two bands, offers several advantages. A useful circuit of this kind is shown in Fig. 6. A 2-pole 2-way switch selects L1 or L2, with trimmers TC1 or TC2. L1 tunes 1.75–1.9 Mc/s, and the output may be doubled for operating in the 3.5–3.8 Mc/s band.

When L2 is in use, coverage is from 7–7.2 Mc/s. This allows ample drive without much frequency multiplication for 14 and 21 Mc/s bands, and straight through working for the 7 Mc/s band.

By adjusting L1 inductance with TC1, and L2 with TC2, band coverage can be modified to achieve a

---

*In Fig. 5 (a) the values of TC2 and TC3 depend upon the values of TC1, VC1, and C1, and may be found experimentally. In Fig. 5 (b), TC2 should have a maximum value equal to or greater than TC1 plus two-thirds of VC1. Initially adjust TC2 so that VC2, without vanes removed, tunes to 3.6 Mc/s near the minimum capacitance end of its range. Then remove vanes to achieve the 3.5–3.6 Mc/s range required. This approach obviates the risk of removing too many vanes from VC2.—Editor.

---

**Fig. 6. A 2-band v.f.o. intended for a transmitter operating on the 3.5, 7, 14 and 21 Mc/s bands. The two switches shown form a single d.p.d.t. switch**

at X, C1 in conjunction with VC1 tunes 3.5–3.8 Mc/s, TC1 being the trimmer. Capacitor values can be as mentioned earlier. When the switch is at Y, the series capacitor TC2 reduces the effective value of VC1, while TC2 compensates for the reduction in effective capacitance of TC1 and VC1. Adjust TC2 and TC3 for 3.5–3.6 Mc/s coverage.

The circuit in Fig. 5 (b) employs a 2-gang capacitor, and gives very satisfactory results. C1 is present on both switch positions. With the switch at X, VC1 with TC1 covers 3.5–3.8 Mc/s. Values can be as for a single range v.f.o. When the switch is at Y, VC2 and TC2 are in use. VC2 has nearly two-thirds of its vanes removed, and TC2 is larger so that 3.5 Mc/s is reached with VC2 vanes closed, and 3.6 Mc/s with VC2 vanes open.*

With these circuits, each band is marked on the v.f.o. scale. The 3.5–3.8 Mc/s band is individually calibrated. Frequencies on the 7, 14 and 21 Mc/s bands are multiples of those on the 3.5–3.6 Mc/s band. There is good bandspread, with easy calibration and very few additional components in the v.f.o. circuit.

---

**Fig. 7. A v.f.o. with regulator and buffer-amplifier**
good spread of frequencies on both scales. Each band is individually calibrated, after both have been set up. The 7 Mc/s and higher frequency bands are on the same scale.

In Fig. 6, L1 consists of 55 turns of 32 s.w.g. enamelled wire occupying a 3/4 in on a 3/4 in cored former. L2 consists of 12 turns of 24 s.w.g. enamelled wire wound side by side on a 3/4 in cored former.

2-Stage V.F.O.

Fig. 7 shows a circuit with voltage regulator, and buffer-multiplier-amplifier stage. L1 consists of 22 turns of 32 s.w.g. enamelled wire wound side by side on a 3/4 in diameter cored former, or of any other coil giving 3.5-3.8 Mc/s coverage. For this band the r.f. choke forms the anode circuit of the EF91. With some equipment, this untuned choke may also prove to be more suitable for the 7 Mc/s band. For increased output on the higher frequencies L2 is switched in. It can have about 34 turns, wound with same wire as L1. Its core is adjusted by observing p.a. grid current. The h.t. line resistors are for a 275-300V supply. Resistor Rx may be reduced in value or omitted for a 250V or similar supply.

Drive Obtained

A guide to the results obtained with the circuits described may be useful. If the circuit of Fig. 1 is followed by a 5763 buffer-multiplier, sufficient drive for an 807 or 6146 can be obtained on 3.5-21 Mc/s bands. In these circumstances, Fig. 2 provides enough drive on the fundamental and second harmonic and, with the additional buffer-amplifier in Fig. 7, sufficient drive for 3.5-14 Mc/s bands.

Fig. 4, followed by a buffer-multiplier, will allow three bands to be worked. For a simple type top band transmitter, Fig. 4 can drive the p.a. directly. Fig. 6 gives increased 7 Mc/s output, and may be used for all bands when followed by two buffer-amplifiers.

Maximum drive is obtained when the v.f.o. is built into the transmitter. If it is separate, a screened co-axial cable can take the v.f.o. output to the original crystal controlled stage, but this cable reduces the drive obtained.

Editor’s Note

The Wearite PHF5 and PHF6 coils referred to in this article are r.f. coupling coils having tuned winding inductances of 5.5 and 37.5uH respectively. They are available from Home Radio (Mitcham) Ltd. under Cat No. CO84/5 for the PHF5 coil and CO84/6 for the PHF6 coil.

If satisfactory, disconnect the supply and wire up the rest of the circuit as indicated. The unit is now complete and ready for use. If required, the keying frequency of the generator can be increased by reducing the values of C1 and C2, or it can be decreased by increasing the values of these two capacitors. The tone frequency can be altered by changing the value of C4.

In use, the output of the generator should be fed into an amplifier having an input impedance of greater than 1kΩ. If the output is to be fed into a lower impedance than this, wire a 1kΩ resistor in series with the output lead.

The generator is turned on and off by a switch wired in series with the negative supply lead, this being shown as S1 in the circuit diagram. If required, the unit can be switched from several alternative points by simply wiring suitable switches in parallel. These switches can also connect the supply to the power amplifier or alternative equipment with which the generator is to be used.

HIGH SENSITIVITY TRANSISTOR VHF PORTABLE

Part 2 of this article, a double superhet receiver for reception of the B.B.C. f.m. broadcasts, will be published next month and this concluding instalment will be devoted to constructional points together with details of optional a.f.c. and tuning indicator circuits.

AVAILABILITY . . .

When items are specified in our various Components Lists, we take the utmost care to ensure that such components are readily available to readers. This entails not only the careful editing of original copy but also, in many cases, correspondence with the author concerned (“where did you obtain this component—junk box or the Ark?”) and telephone calls to both manufacturers and retailers to ascertain current availability and/or the supply of suitable alternatives.
In last month's article in this series we gave some final notes on the three-stage long, medium and short wave receiver which forms the second constructional project in the "Understanding Radio" series, after which we discussed r.f. amplification and showed how the added screen-grid in a tetrode valve enabled r.f. amplification to be obtained without instability. The tetrode valve is the forerunner of the pentode valve, which will be described in this month's contribution.

In the next issue we return to constructional matters, and details will be given for the addition of an r.f. amplifier to the three-stage long, medium and short wave receiver.

Negative Resistance
When we discussed the tetrode valve last month we saw that, when electrons from the cathode strike the anode, further electrons (known as secondary electrons) are emitted from that anode. These secondary electrons are attracted to the screen-grid if the anode voltage is more negative than the screen-grid voltage. This secondary emission effect results in the tetrode having $I_aV_a$ curves of the type shown in Fig. 1. (Fig. 1 is Fig. 8 (b) from last month, reproduced again for reference.)

We also saw, in the last article, that the curves between points A and B in Fig. 1 exhibit negative resistance because, when anode voltage increases, anode current decreases. Such an effect is, of course, completely opposite to the positive resistance offered by a normal resistor with which, when voltage increases, so also does current.

It is possible to make use of the negative resistance exhibited at the anode of a tetrode by assembling the oscillator circuit shown in Fig. 2. This oscillator has the interesting feature that only two connections are made to the parallel tuned circuit, there being no coupling windings or other means of obtaining positive feedback as has occurred in the single-valve oscillators we have previously examined. The supply voltages applied to the anode and screen-grid are such that the anode voltage is more negative than the screen-grid voltage. This secondary emission effect results in the tetrode having $I_aV_a$ curves of the type shown in Fig. 1. The grid is given a fixed bias, which may, conveniently, be 1 or 2 volts negative of the cathode. The screen-grid is bypassed to the cathode by a capacitor having a low reactance at the frequencies it is intended to deal with. For simplicity, batteries are shown in Fig. 2, but any other means of supplying h.t. and grid bias voltages can, of course, be employed.

Oscillation is obtained in Fig. 2 because the negative resistance offered by the tetrode anode cancels out the positive resistance given by the losses in the tuned circuit. To maintain oscillation the negative resistance must be greater than the positive resistance due to tuned circuit losses, and the amplitude of the oscillation is limited between the points where the anode voltage changes from the negative to the positive resistance condition. In Fig. 1, this corresponds to the points where the downward-sloping section of the curve meets the upward-sloping sections.

The circuit of Fig. 2 is known as a Dynatron oscillator. It is not normally encountered in receiver circuits, but it has applications in experimental or test equipment work. The resonant frequency of an unknown tuned circuit can, for instance, be found by simply connecting it into a Dynatron oscillator circuit. Provided its losses are not too high the tuned circuit will then oscillate at its resonant frequency, which can be measured on other equipment. The measuring equipment could be a receiver with a calibrated tuning scale which is adjusted to receive the oscillatory frequency.

RF Amplification
In receiver work we are more concerned with using a tetrode valve as an r.f. amplifier than with its performance in the Dynatron oscillator circuit. When it is used as an r.f. amplifier, the tetrode valve will appear in a circuit of the type shown in Fig. 3, in which tuned circuits appear in both grid and anode circuits. In a circuit of this nature we set up the anode and screen-grid supply voltages so that the anode voltage is always on the more linear section (i.e. the section more closely resembling a straight line) of the $I_aV_a$ characteristic, as shown by the curves to the right of point C in Fig. 1. This requirement may be assured in
Fig. 1. Representative IdVg curves for a tetrode valve

Fig. 3 by giving the screen-grid dropping resistor a value which allows the screen-grid to be well negative of the anode. We obviously do not want the anode voltage to approach the negative resistance section between points A and B of Fig. 1, because the anode tuned circuit may then tend towards oscillation due to Dynatron effect. Even with an anode supply voltage considerably higher than the screen-grid voltage, we may still encounter difficulties if the amplified r.f. signal at the anode has a very high amplitude, since negative half-cycles may cause the anode voltage to swing into the negative resistance section.

Anode A.C. Resistance

Let us now turn to another aspect of the curves shown in Fig. 1. In this instance we shall assume that the tetrode has supply voltages, and handles signal amplitudes, which are such that the anode is always on the more linear section of the characteristic to the right of point C in Fig. 1. Let us next examine what occurs under these conditions.

The most evident feature of the more linear section is that the IdVg curves are very nearly horizontal. We have already seen\(^1\) that the anode a.c. resistance (ra) of a valve may be represented by the slope of its IdVa curve. Fig. 4 shows two imaginary IdVg curves, the curve at Fig. 4 (a) having a greater slope than that at Fig. 4 (b). The lower slope at Fig. 4 (b) infers that unit change in anode voltage results in a smaller change in anode current than in Fig. 4 (a), and that the curve of Fig. 4 (b) represents a higher anode a.c. resistance in consequence. Inspection of the tetrode IdVa curves to the right of point C in Fig. 1 shows that these have very little slope and are, indeed, nearly horizontal. In consequence, a change in anode voltage results in an extremely small change in anode current, and it follows from this that the anode a.c. resistance must be very high.\(^2\) This is in fact true and, in practice, tetrodes can exhibit anode a.c. resistances of 1MΩ or even more.

Another valve characteristic previously dealt with is mutual conductance (gm), which defines the change in anode current for a unit change in...
grid voltage, and which is expressed in terms of "mA per volt". Examination of the curves to the right of point C in Fig. 1 shows that we get a very noticeable change in anode current when we change the grid voltage from -1V to -3V and, again, when we change it from -3V to -5V. These changes in anode current for change in grid voltage are of the same order as are given by the voltage amplifier triodes we have examined previously. In consequence, we can look upon a tetrode as having about the same value of mutual conductance as we find in a voltage amplifier triode.

A final point arising from the earlier articles is that the amplification factor ($\mu$) of a valve is equal to the product of the anode a.c. resistance and the mutual conductance. That is:

$$\mu = g_m r_a$$

Since we have a mutual conductance in the tetrode which is of the same order of magnitude as that in a voltage amplifier triode, and at the same time have an anode a.c. resistance which is considerably higher, this equation tells us that the amplification factor must be similarly much higher. Such an assumption is correct, and the amplification factor of a tetrode can, in practice, be of the order of 1,000 or even more.

The fact that a tetrode offers a high amplification factor makes it possible to use the valve as a high-gain a.f. voltage amplifier in a circuit of the type shown in Fig. 5. With the requisite component values, the tetrode valve will offer a greater amplification than a triode. In Fig. 5 the screen-grid bypass capacitor should have a low reactance at audio frequencies and could, typically, have a value of 0.1µF. The anode voltage must not be allowed to fall below the more linear section of the $I_a V_a$ characteristic. A signal at the anode with sufficiently large amplitude could cause the anode to enter the non-linear section of the $I_a V_a$ characteristic on the peaks of negative half-cycles, with the result that the anode signal would become seriously distorted. This factor limits the amplitude of the amplified signal which may appear at the anode of the amplifier in Fig. 5.

The Pentode

The original intention behind adding the screen-grid in the pentode valve is to improve the linearity of the device. This is achieved by connecting an additional grid between the screen-grid and the anode. The additional grid is connected to the cathode.
grid to the triode (and thereby forming the tetrode) was merely to reduce the internal capacitance between anode and grid to a negligible value, thereby enabling the valve to function as an r.f. amplifier without instability. However, the presence of the screen-grid causes considerable changes to the operation of the valve. First, if the anode voltage is below screen-grid voltage the $I_aV_a$ characteristic can exhibit negative resistance. Second, if the anode voltage is higher than screen-grid voltage the valve exhibits a much higher amplification factor than does a triode. It would be desirable to eradicate the negative resistance effect in the tetrode whilst retaining the high amplification factor. This requirement is achieved with the pentode valve, which has superseded the tetrode valve in receiver applications. It should be added that, although the tetrode valve is now outmoded, it is necessary to understand how it functions if pentode operation is to be fully appreciated.

In the pentode a third grid is interposed between the screen-grid and the anode, and it is connected to the cathode as shown in Fig. 6. Since this third grid is negative of the anode it repels the secondary electrons which the anode emits, and these are forced to return to that electrode. The third grid consists of wires having the same basic construction as the control grid, but with wider spacing between wires. Because of the wide spacing, this additional grid does not prevent electrons from the cathode travelling to the anode in the same way as occurred in the tetrode valve.

The fact that the third grid prevents secondary electrons from the anode reaching the screen-grid causes the non-linearity and negative resistance exhibited by the tetrode to be completely eliminated. A set of typical $I_aV_a$ curves for a pentode appears in Fig. 7, and it will be seen that these are similar to those for the tetrode in Fig. 1, with the exception that the non-linear section has now disappeared entirely. The pentode $I_aV_a$ curves remain very nearly straight down to a value of anode voltage which is much lower than screen-grid voltage, and it follows from this that the signal at the anode can have a large amplitude without introducing serious distortion. In other respects, the pentode resembles the tetrode when the latter operates over the more linear section of its $I_aV_a$ curve. The pentode can operate as a stable r.f. amplifier, and it has a high anode a.c. resistance and a high amplification factor.

The additional grid introduced into the pentode is known as the suppressor grid, because it suppresses the effect of secondary emission from the anode. When the grids in the valve are referred to by the letter $g$ and subscript numbers, the suppressor grid is designated as $g_s$ (the control grid being $g_1$ and the screen-grid $g_2$). In some valves the suppressor grid connection is brought out to a separate pin, whereas in others it is internally connected to the cathode. When the suppressor grid connection is brought out separately it may be connected externally to the cathode at the valveholder (or to chassis, which will usually be close to cathode potential). The circuit symbol for the pentode is shown in Fig. 8. The term "pentode" derives from the fact...
that the valve has five electrodes (the cathode, the three grids and the anode).

The type numbers for pentodes follow the usual coding practices. For instance, the 6BW7, an r.f. pentode on the B9A base, follows the American coding in which the figure 6 signifies a 6.3 volt heater and the final 7 signifies the number of “useful elements”, which in this case consist of the heater, the cathode, the three grids, the anode and an internal screen around the electrode assembly. The letters BW have no significance to the user apart from identification of the valve.

A typical pentode coded with the European system is the EF91. In this code the letter E signifies a 6.3 volt heater and the letter F a voltage amplifier pentode. The first figure, 9, indicates a B7G base, whilst the second figure, 1, is merely a number indicating the design or development.

Because of the high amplification offered by the pentode, it is often used as an a.f. amplifier. A representative circuit is shown in Fig. 9 in which an EF86 pentode is employed. The EF86 is specifically designed for this class of work and, with the component values shown in the diagram, the stage gain (anode signal voltage divided by grid signal voltage) is very nearly 200. The letters EF in the coding for the EF86 signify a 6.3 volt heater and a voltage amplifier pentode respectively, whilst the first figure, 8, indicates a B9A base. The second figure, 6, is the design or development number.

**Variable-Mu Pentodes**

For a number of r.f. amplifier functions in receivers it is desirable to be able to control the gain of a pentode stage by varying its grid voltage. The required effect is that the stage gain should reduce as the control grid goes negative.

Fig. 10 (a) shows an $I_aV_g$ curve for a pentode which is not specifically intended for this class of operation. As may be seen, the anode current falls to zero at a grid voltage of $-6V$, this being the cut-off voltage for the valve at the anode and screen-grid voltages indicated. By suitably spacing the wires in the control grid it is possible to obtain the $I_aV_g$ characteristic illustrated in Fig. 10 (b). This characteristic shows a continual curvature throughout its length and the cut-off voltage is reached at $-33V$. The curve of Fig. 10 (b) is representative of a variable-mu (or variable-$\mu$) r.f. pentode, and it demonstrates the fact that the mutual conductance of the associated pentode may be adjusted “smoothly” by varying the control grid voltage. With the curve of Fig. 10 (a), change in mutual conductance are liable to be more abrupt as cut-off point is approached.

The variable-mu effect is obtained by variations in the spacing between the control grid wires along the length of the control grid assembly. In a typical assembly the wires at each end may be closely spaced, the spacing increasing towards the centre so that the centre wires are proportionately widely spaced apart. When an alternating signal voltage is applied to the grid, the consequent control over electrons reaching the anode decreases as the grid wire spacing increases. Thus, with the grid assembly just mentioned, greatest control at low negative grid voltages is exerted by the closely spaced wires at the end. At high negative grid voltages the electrons from the cathode will not pass through the closely spaced wires at the end of the grid structure, and will only pass through the widely spaced wires at the centre, where less control is exerted.

Although the type of valve under discussion is known as a variable-$\mu$ valve, it is more helpful to think in terms of the changes in mutual conductance which occur when the control grid voltage is varied.

3 As we shall see later, some pentodes are designed to drive loudspeakers or carry out similar functions involving a relatively high power in the anode circuit. These are known as “output pentodes” and are designated by the letter L.
"**D**O YOU REMEMBER," ASKED DICK, 
"what we were doing this time last year?"

Smithy took a prodigious draught from his battered tin mug, then placed it reflectively down on his bench alongside the debris remaining from his recently consumed lunch. A bleak February wind howled outside the window behind him, but inside the Workshop all was warm and snug.

"I can't," replied Smithy eventually, "say that I do remember."

"Cast your mind back."

Obligingly, Smithy allowed his thoughts to wander once more to the February of 1966.

"All that I can recall," he remarked eventually, "is that life twelve months ago followed exactly the same pattern as it's following today. In other words, I was repairing sets whilst you were wrecking them!"

"That February," said Dick impatiently, "we were talking about computers."

A sudden glimmer in Smithy's eye betokened recollection.

"Why, that's right," he exclaimed. "I remember now! I gave you some gen on simple AND and OR gates, together with the Boolean algebra that goes with them. If I'm not mistaken, I also mentioned NAND and NOR gates, too."

Binary Numbers

"You did," agreed Dick. "You explained what truth tables were, too. Dead fascinating it was!"

"As I remarked at the time," said Smithy, "you must bear in mind that I was only just brushing over the surface of the subject."

"Perhaps so," conceded Dick, "but you did give me an insight into principles which, until then, were completely unknown to me. Also, with computers being used as much as they are these days, a keen young working lad such as myself has to pick up at least a smattering of knowledge on the subject. And it happens, there's something else to do with computers I don't know anything about."

"What's that?"

"This binary number business. Computers work with binary numbers, don't they?"

"Digital computers do," said Smithy. "But don't forget that there are analogue computers as well. Analogue computers are used to solve problems by replacing each item in an equation representing the problem with an analogous electrical quantity such as capacitance, inductance, voltage, current or amplification. A circuit is set up in which the terms of the equation are replaced by electrical quantities, with the result that the overall effect on a system of varying one or more quantities can be found very quickly. Analogue computers are very useful for working out complicated problems concerning aircraft performance and things like that. However, the answer they give to any problem is an approximate one, because it depends on the tolerances in the physical components which represent the terms in the problem. Digital computers, on the other hand, deal directly with figures and can give answers which are completely accurate. Most of the large computers you read about these days are digital computers, and these are the ones which work with binary numbers."

"Ah," said Dick, gratified. "I knew I was on the right track. How does this binary number business work, then?"

"It's dead simple," replied Smithy carelessly. "You just have two numbers. One of these is zero and the other is one."

With the manner of one who has answered a complicated question to the complete satisfaction of the enquirer, Smithy sipped at his tea and lapsed into silence. Dick glared at him irritably.

"Thank you very much," he remarked sarcastically. "After having picked up that priceless piece of information, I am now fully qualified to go out and service my first computer!"

Resignedly, Smithy drained his mug. It was obvious that yet another lunch-break was going to be sacrificed to Dick's relentless pursuit of knowledge.

"Fill that up," he ordered, holding out the mug, "then come back over here, and I'll see if I can introduce you to the subject of binary numbers."

---

This month Smithy the Serviceman, at the instigation of his able assistant, Dick, once more enters the fascinating world of the digital computer. On this occasion he embarks on an explanation of the simpler facets of binary notation.
Delighted, Dick rushed to the Workshop teapot with Smithy’s mug, returning almost immediately with this disgraceful utensil fully charged with the life-saving fluid.

“Right,” said Smithy, briskly. “Let’s get down to business! Now the first thing you have to bear in mind is that the calculations in a digital computer are carried out with the aid of circuits which can exist in one of two conditions. Transistors represent a typical example of the components employed, and they appear in circuits where their state represents one of the numbers handled by the computer in its calculations. Now, the only reliable way of using a transistor in this manner is to allow it to have two states only, these being either fully conductive or fully cut-off. Other circuits in the computer, including those used for storing numbers for later use in a calculation, are similarly restricted to two-state working if they are to operate reliably. Since the individual computer circuits can only work in one of two states, this fact has to be catered for in the arithmetic system that they use. That’s where the binary notation comes in, because in the binary system there are only two digits, those being zero and one.

A transistor can then represent zero by being in the fully conductive state, and one by being in the fully cut-off state. Or vice-versa, according to the requirements of the particular circuit into which the transistor is connected.”

“In other words,” said Dick, “the whole reason for using binary numbers with computers is that these are the only numbers which the computer circuits can reliably handle.”

“Exactly,” confirmed Smithy. “The problem can be presented to the computer in terms of ordinary decimal numbers, and the answer can similarly be printed out by the computer in decimal numbers. But the actual calculations carried out in the works of the computer will be done in binary.”

Number Systems

“I see what you mean,” said Dick. “Is it possible, then, to represent a decimal figure in binary numbers?”

“Of course it is,” replied Smithy. “All numbering systems correspond to accepted conventions. If, for instance, we count nine apples we can use the decimal digit, 9, to denote the quantity. The old Romans would have used the symbol IX.

Fig. 1. A quantity may be expressed accurately in any numerical system. Here we see the figure 9 in its decimal form, with its equivalent in Roman presentation and in binary notation

<table>
<thead>
<tr>
<th>DECIMAL</th>
<th>OCTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>IX</td>
</tr>
<tr>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>13</td>
<td>13</td>
</tr>
<tr>
<td>14</td>
<td>14</td>
</tr>
</tbody>
</table>
is to select the number which represents the highest single digit in the system and then work on from there. The highest single digit could be any number within reason, although some numbers would make arithmetical processes very difficult. Quite a convenient system, from the calculation point of view, would be a duodecimal system in which the changeover to two digits occurs at 12. For this you'd have to invent two symbols to act as single digits for 10 and 11, after which 12 would be represented as one, zero."

"I see," said Dick. "I hadn't realised that you could play around with numbers quite as easily as all that."

"You can do all sorts of things with them," replied Smithy cheerfully, "provided you use a bit of common-sense when you do calculations with them. However, the main point I wanted to make is that a quantity doesn't have to be expressed in terms of the decimal system. It can be expressed just as accurately in any other numerical system. I mentioned the octal system because you will encounter references to it in text-books or articles dealing with computers. The duodecimal system doesn't appear to have many applications in computer work, although it is sometimes referred to in general mathematics. With computers, you will also find references to the hexadecimal system, in which the changeover to two digits is made at decimal 16. Six new single-digit symbols have to be introduced to replace the decimal numbers 10 to 15 inclusive, and that's all I need to say about it at the moment."

"Good show," said Dick. "Let's get back to the binary system!"

"Fair enough," grinned Smithy, scribbling out a further series of figures on a new page of his pad (Fig. 3). "I wondered how long you'd be able to restrain your impatience! Now, with the binary system the arbitrary rule is that there shall be no single digit higher than 1. Whereupon the binary numbers increase in the manner shown in this table I'm making out. The binary equivalent of decimal 0 is zero, and the binary equivalent of decimal 1 is one. So there's no change there. When we reach decimal 2, however, we bump into the arbitrary rule in binary which says that there shall be no single digit higher than 1. So we put a zero and add a one to the left of it, giving us binary one, zero. Decimal 3 is easy, and the right hand digit goes up to one, giving us binary one, one. At decimal 4 the arbitrary rule comes into action again and so we put two zeros and add a one to the left, giving us one, zero, zero. And so the numbers continue. Decimal 5 is binary one, zero, one; decimal 6 is binary one, one, zero; decimal 7 is binary one, one, one; and decimal 8 is binary one, zero, zero, zero."

"The next one," remarked Dick, "is decimal 9. Which gives us the binary one, zero, zero, one number you put down initially when you were talking about those 9 apples. You know, Smithy, you must be pretty smart to remember binary equivalents just like that!"

"I don't bother to remember them," remarked Smithy. "With small numbers it's quite easy to convert decimal to binary, or binary to decimal, by simple mental arithmetic."

**Binary To Decimal**

"I know," complained Dick, "there'd be a snag somewhere!"

Surprised, the Serviceman looked up at his assistant.

"What's biting you?" he asked.

"I thought you'd been following me without any trouble at all up to now."

"So I have been," said Dick unhappily. "But we've now come to the point where I'm stymied. It's all right for you to talk lightly about..."
mental arithmetic, but I have got
to rely on the old paper and pencil,
mate!"

"If that's all you're worried
about," commented Smithy, "you
can forget it. There's no necessity
to use mental arithmetic in converting
from one system to another, and
you can do it all on paper if you
like."

"Well," that's a relief," said
Dick thankfully. "My mind always
goes blank when anyone mentions
'mental arithmetic'. Like the fly,
I stick to paper!"

"As you like," commented Smithy.
"You'll probably find, though, that
you'll tend to convert the smaller
numbers mentally after you've had a
bit of experience with them. Inci-
cidentally, I'm glad to see you've
picked up the 'one, zero, zero,
one' patter when referring in speech
to binary numbers. It makes things
easier when you're tackling them
for the first time."

Smithy returned to his pad.
"Let's press on to the next step,"
he went on. "Which consists of
making a comparison between deci-
mal and binary numbers. I'll start
off by writing down a series of
decimal figures to form the left
hand column of a table, these
could, for instance, be 10101.
Dick, enter the numbers. "Let's
start at an easy one, which is 1
times 2 squared in the middle.
That's obviously 1 times 4. The
next one is zero times 2 cubed or
zero times 8, so the answer here is
zero. The end one at the left is
one times 2 to the power of 4,
so that will be one times 16. Now
I'm getting to what, with me, is
the dicey bit. If 10 to the power of
one is 10, is 2 to the power of one
2?"

"It is."

"Not that it matters," said Dick,
because the zero makes the product
nothing anyway! Also, would 2
to the power of nought be 1?"

Smithy nodded gravely.
"Then that's it," announced Dick
triumphantly. "Binary 10101 is equal
to 1 plus 4 plus 16. And that's 21."

"Which is," confirmed Smithy,
"exactly correct. You've now carried
out your very first conversion of a
binary number to the decimal
system. You use the same process
for converting any other binary
number to decimal, and all you
have to remember is that the series
of 2 with increasing powers is the
same as the series 1, 2, 4, 8, 16,
32, 64, and so on. You then use
this progression to find the decimal
equivalent."

"This is a lot simpler than I
thought it would be," said Dick
excitedly. "Try me out with another
one!"

"O.K.," said Smithy obligingly.
"Let's think up one that's a bit
longer. Write down the decimal
equivalent of the binary 110011."

Fig. 6. The digits of a binary number qualify 2 to a power which depends
upon the position of the digit, in a similar manner to Fig. 6. In this diagram
we see that binary 10101 is equal to decimal 21
"Right," said Dick confidently. "Well, working from the right, we get 1 times 1, which is 1. We then have 1 times 2, which is 2; 1 times 4, which is 4; zero times 8, which is zero; zero times 16, which is zero; 1 times 32, which is 32; and 1 times 64, which is 64. So the whole number is equal to 1 plus 2 plus 4 plus 32 plus 64. Half a mo!"

There were several moments of anguished calculation.

"That's it," exulted Dick. "The answer is 103!"

"Excellent," commended Smithy warmly. "You've got the whole binary to decimal business completely buttoned up, Dick. We're now going on to a further step which involves the demonstration of an extremely intriguing little effect. I'm going to add a zero to the right hand end of that binary number you've just tackled and then see what the decimal result is.

Smithy retrieved his pad and wrote down the new number. (Fig. 8)

"I'll start from the right," he remarked. "Whereupon I get no 1, one 2, one 4, one 8, no 16, no 32, one 64 and one 128. And that little lot adds up to 206."

"Clarified," said Dick, impressed.

"It's exactly twice the previous number."

"I know," replied Smithy, "and this little exercise confirms the fact that, if you want to multiply a binary number by 2, you add a zero at the right hand end. Similarly, if you want to divide a binary number by 2 you just chop off the digit at the right hand end. If this is a zero then you've achieved an exact division by 2. If the right hand digit is a one, you've achieved a division by 2 with a remainder of one. Which also goes to show that all even numbers in binary end in zero and all odd numbers end in one.

Decimal To Binary

"Blow me," ejaculated Dick, "you don't half bump into some crafty effects with this binary bit."

"It's funny you should say that."

"Why?"

"Because the word 'bit' is, actually, short for 'binary digit'," replied Smithy, draining his mug for the second time that afternoon. "A 'bit', or 'binary digit', may have a value of one or zero only. You'll also encounter the term 'bit' in information theory, in which it defines the smallest possible piece of information which can be transmitted or stored. Now, how about filling up my mug for me?"

But there was no reply from Smithy's assistant and, glancing round, the Serviceman saw that Dick's face wore the withdrawn expression which indicated one of his periodic visitations from the Muse. Dick had the disconcerting habit of being able to compose instant doggerel to suit almost any occasion. Smithy sighed, and hoped it wouldn't be too bad this time.

Suddenly, Dick's face cleared.

"Here we are, Smithy," he said proudly. "Just listen to this little effort I've made up.

'Said the One to the Nought, 'Please admit it. I'm your better in learning—I'm with it.'

'Said the Nought, 'What bombast! My exams are all passed.'

'I'm an O-level binary digit!'

'I suppose," commented Smithy, "that I've heard worse."

"I'm glad you liked it," said Dick, pleased, as he picked up Smithy's proffered mug and took it over to the Workshop sink for replenishment. "Dead swinging I am on the ode scene, these days!"

"I wouldn't argue," replied Smithy carefully. "Anyway, I haven't yet told you how to convert decimal into binary."

"Ah, that sounds interesting," said Dick, returning with Smithy's mug. "Is it as easy as converting the other way?"

"Pretty well," replied Smithy laconically. "I'll demonstrate the idea by choosing a decimal number at random. I'll take a fairly high number, say 181. What I next do is to write out the series 1, 2, 4, 8, and so on, until I get to the highest number which is below the decimal number I want to convert. I write the series down from right to left." (Fig. 9)

Once more Smithy's pen clattered over his pad.

"In this case," he continued, "I'll stop the progression at 128 because the next number in the series is 256 and this is higher than 181. I put a one under 128 and subtract it from 181 whereupon I've got 53 left. 64 is higher than 53 and I put a zero under 64. At the same time, 32 is lower than 53 and so I put a one under it and subtract, giving me 21. 16 is lower than 21 and I put a one under this, too, and subtract again, whereupon I have 5 left. 8 is higher than 5 and a nought goes under it. 4 is lower than 5, so a one goes under it and, after subtraction, I've got 1 left. So a nought goes under the 2 and a one goes under the 1, and there's no further remainder. And there you are! The binary number is read from the bottom line and, in this case, it's 10101011."

"Stop me," breathed Dick. "Now that is something. Can you do this with any decimal number?"

"Any number you like," replied Smithy. "If you look at the numbers in that table I made up, you'll see that all the binary equivalents can be produced by following the procedure I've just described. You just keep working along the progression until there's no remainder left. If the remainder becomes zero before the end you just continue with noughts along the bottom line as appropriate. For instance, with decimal 8 the remainder goes to zero after 8 in the progression, whereupon the binary equivalent is 1000."

Addition And Subtraction

"What," asked Dick, "about addition of binary numbers?"

"That's pretty simple too," said Smithy. (Fig. 10)

<table>
<thead>
<tr>
<th>1</th>
<th>1</th>
<th>1</th>
<th>0</th>
<th>0</th>
<th>1</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1x64)+ (1x32)+ (0x16)+ (0x8)+ (1x4)+ (1x2)+ (1x1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(64)+ (32)+ (0)+ (0)+ (4)+ (2)+ (1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>=103</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Fig. 7. Another exercise in converting a binary number to its decimal equivalent

| Fig. 8. Demonstrating that the addition of a zero at the right hand end of the binary number of Fig. 7 causes its value to be doubled. (Inspection shows that each of the useful products in the second line is moved up by a factor of 2) |
|---|---|---|---|---|---|---|
| 0 | 0 | 1 | 1 |
| (1x128)+ (1x64)+ (0x32)+ (0x16)+ (1x8)+ (1x4)+ (1x2)+ (0x1) |
| (128)+ (64)+ (0)+ (0)+ (8)+ (4)+ (2)+ (0) |
| =206 |
Smithy. “All you have to remember is that there’s no 2 in binary, with the result that 1 plus 1 comes to 10. After that, it’s just the same as a decimal addition. Let’s work out a little addition problem using binary numbers chosen at random.”

Smithy jotted down the figures on his pad. (Fig. 10).

“Here we are,” he said briskly. “Let’s work this one out, starting at the right-hand column of digits. Here we have 1 plus 1, giving us 0 for the bottom line with 1 to carry to the left. The second column from the right is 0 plus 0 so, with the 1 we’ve carried over, we put down 1 in the bottom line. The third column from the right is 0 plus 0. There are no numbers carried from the previous column so we just put 0 here. The fourth column from the right is 0 plus 1 with no numbers carried, so we put down 1. The fifth column is 1 plus 1, giving us 0 to put down and to carry. The sixth column is 1 plus 1 plus the 1 carried over, and the answer here is 11. We put down 1, and carry 1 to the seventh column from the right where the result comes to 10.”

Smithy scribbled on his pad for a few moments. “So far, so easy,” he explained. “Here we are! The top line comes to 113 in decimal, the middle line to 57 in decimal and the bottom line to 170 in decimal. So the answer we got in binary is proved correct in decimal.”

“That seems easy enough,” commented Dick. “What about subtraction?”

“That’s fairly easy in principle,” replied Smithy, “but it tends to get a little involved in practice, as I’ll show you in a moment. You first of all have to remember three obvious facts. These are that 1 minus 0 is 1, 1 minus 1 is 0, and that 10 minus 1 is 1. You then carry out the subtraction using the same basic principles as in decimal. Let’s try out an example.” (Fig. 11).

“Off you go, then,” said Dick. “I’m right behind you!”

“Good,” said Smithy. “Well, we’ll start at the right hand column again. This is 1 minus 1, giving us 0. No difficulty there! The next column is 0 minus 1, so we say we’re subtracting 1 from 10, whereupon we put the answer 1 in the bottom line and we have to borrow 1 from the next left-hand column. We carry out the same borrowing process, of course, when we subtract in decimal. The third column from the left is 1 minus 0, but we’ve already borrowed a 1, so it becomes 0 minus 0, which equals 0. The fourth column from the right is 0 minus 1, so we once again borrow a 1 from the next left top digit and put down 1 on the bottom line. But the next left digit in the top line is also a 0, and so the borrowing action causes this to change to 1 and a 1 to be borrowed from the next digit along. The fifth column from the right is equivalent therefore to 1 minus 1, giving us zero. When we look at the sixth column, from the top digit of which we’ve already borrowed a 1, we’re faced with yet another 0! So this reverts to 1 also and we borrow again from the seventh left column which, at long last, is a 1. The sixth column from the right is therefore 1 minus nothing, which gives 1. The 1 in the seventh column has already been borrowed by the sixth column do more than just mention the fact that this alternative approach exists.”

Smithy glanced at the Workshop clock and started.

“Come on Dick,” he said, getting up hurriedly. “We should have got back to work all of twenty minutes ago! You’ll get me the sack one of these days, keeping me nattering on like this after lunch-break.”

“Sorry, Smithy,” said Dick contritely. “I just hadn’t noticed the way the time was going.”

A thought occurred to him and he dug into his trouser pocket and handed a coin to Smithy.

“Whilst I remember it,” he remarked. “Here’s that 10 shillings I borrowed from you last week.”

“This isn’t 10 bob,” replied Smithy, suspiciously. “It’s a florin.”

“I know,” said Dick. “But I’ve suddenly discovered an easy way of clearing up all my outstanding debts. From now on I’m going to assume that they’re all in binary notation!”

---

**Fig. 9. Showing the steps involved in converting a decimal number to the binary system**

---

**Fig. 10. An addition with binary numbers. The numbers in brackets at the right are the decimal equivalents**

---

**Fig. 11. Subtracting one binary number from another. Again, decimal equivalents are given, in brackets, at the right**
Most readers will be familiar with cold cathode gas filled stabiliser tubes; they enable a stabilised potential in the range of about 75 to 150 volts to be obtained at currents of the order of 10mA. Various types of electronic equipment such as Geiger tubes, photomultiplier tubes and cathode ray tubes require a supply potential in the range 400 to 2,000 volts or more, but the current taken is usually less than 1mA. Although the normal type of gas filled glow discharge stabiliser tube is unsuitable for this application (unless used as a part of a complex stabiliser), a type of tube known as a corona voltage stabiliser has been developed during the last decade specifically for this type of application.

The Corona Discharge
A corona discharge can take place from an electrode which is shaped so that a high electric field strength is present at some parts of its surface. All television servicemen are familiar with the corona discharge which sometimes occurs from any point in the e.h.t. circuit of a television receiver and which is sometimes suppressed by means of a small piece of wax. Such corona discharges do not normally occur on smooth surfaces, but readily occur from a pointed part of the surface. The end of a stray wire is a common source of such an unwanted corona discharge.

Any stray electrons (formed by cosmic rays, stray radioactive atoms, etc.) will be accelerated by the electric field until they have enough energy to form ions in the air. The electrons thus formed are in turn accelerated until they have sufficient energy to form more ions. Thus enough ions are formed to carry a small current. Some of the air molecules gain energy from the electrons in the discharge and give out light as they return to the normal state. In a darkened room one can therefore see the well-known weak glow in the region of a corona discharge; it surrounds the area of high electric field strength.

Structure
A corona stabiliser tube consists of a central wire surrounded by a cylindrical cathode, the central wire being made positive in order to render the discharge as stable as possible. Some types of corona tube have a B7G or B9A base with a top cap anode, whilst other types have a cap at each end or flying leads. Owing to the high potentials used few (if any) single-ended corona tubes have been manufactured.

Almost the whole of the potential applied to the tube appears in the region of the central anode wire where the ionisation occurs. The fact that this potential is virtually independent of the current passing through the discharge enables the corona tube to be employed for stabilisation purposes. A relatively small voltage is present between the outside of the ionisation region and the cathode. This voltage is, however, approximately proportional to the current flowing through the tube and therefore limits the voltage stability of the tube.

Circuit
The basic circuit in which a corona stabiliser circuit is used is shown in Fig. 1. This type of circuit is the same as that for the common glow discharge stabiliser tube. In the case of corona stabiliser tubes, however, the applied potential, $V_1$, is much greater than in the case of glow discharge tubes, and the currents $I_1$ and $I_2$ are much smaller than with the glow discharge tube circuits.

Operating Conditions
As in the case of the glow discharge stabiliser tubes, there is a minimum current which must be passed through the tube to ensure satisfactory operation. This minimum current is usually in the range of 1 to 20μA. At smaller currents the discharge may be intermittent. The maximum current which should be passed through a corona stabiliser is usually in the range of 300μA to 1mA. Higher currents may cause the voltage across the tube to...
Corona stabiliser tubes fall as the discharge takes the form of a "streamer". The operating voltage of a corona tube is usually in the range of 350 to 7,000 volts, although tubes with higher operating voltages can be manufactured. Two or more tubes can be connected in series if a very high voltage is to be stabilised. This will also enable stabilised voltages of less than the full voltage present across the series connected tubes to be obtained.

Corona stabiliser tubes are normally filled with pure hydrogen, since the highly mobile positive ions formed in this gas enable the rate of change of operating voltage with change of current to be kept to a minimum. In addition the use of hydrogen results in a higher maximum operating current than would be possible with other gas fillings. The operating voltage of a tube is approximately proportional to the gas pressure; it may also be raised by increasing the diameter of the electrodes, but this will result in an increased change of operating voltage for a given change of the tube anode current.

A small amount of thorium oxide is included in some of the lower voltage corona tubes. The thorium is very weakly radioactive and provides ions which initiate the discharge. This ensures that the tubes strike promptly when a suitable potential is applied. The higher voltage tubes will strike promptly without this material.

Circuit Design

In the circuit of Fig. 1 the resistor R is usually more than 1MΩ. Its value can be found by applying Ohm's Law to the circuit. The current I₂ is usually fixed at a value about half-way between the maximum and minimum tube operating currents. The current flowing through R is equal to the sum of I₂ and the load current I₃. The unstabilised input voltage, V₁, is generally about 1.2 to 1.5 times the operating potential of the tube, V₂. The potential across the resistor R is equal to (V₁ − V₂). The value of R is calculated from the voltage across it and the current passing through it.

When the circuit has been designed using these principles, it should be checked to ensure that any variations in the input voltage and in the load can be accommodated without the operating conditions of the tube passing outside the recommended limits. For example, if the input voltage is liable to increase by up to 10%, a check should be made to ensure that this increase will not result in the current through the tube exceeding the maximum permissible value. Similarly if V₁ is liable to fall by 10%, a check should be made to ensure that a current at least equal to the minimum recommended tube current will continue to pass through the stabiliser tube. In addition, the unstabilised input voltage should always be kept at least 1.1 times the operating voltage of the tube or there may be a delay in striking.

Equivalent Circuit

The equivalent circuit of Fig. 1 is shown in Fig. 2. The components inside the dotted lines represent the tube itself. It can be seen that the tube behaves as a steady source of potential, v, in series with the resistor r. This resistor r represents the impedance of the tube. It is typically of the order of 100kΩ; the lower the value of this imaginary resistance, the better the stabilisation. The value of r varies somewhat with the current passing through the tube owing to gas heating effects.

Corona stabiliser tubes (like glow discharge tubes) cannot be connected in parallel for higher current operation. This is because one of the tubes will have a slightly higher operating potential than the other and will probably pass a negligible current.

Further Circuits

When corona stabilisers are used in series, capacitors should be connected in parallel with each tube as shown in Fig. 3. The values of these capac-
tors may be a few thousand picofarads. If they are omitted, relaxation oscillations may occur.

In the circuit of Fig. 4 two corona stabilisers are employed in cascade. The variation of the stabilised output will be much less than in the simple circuit of Fig. 1 for changes in the supply voltage. However, the output impedance of the circuit is similar to that of the circuit of Fig. 1 and therefore the change in the output voltage with change in the load will also be similar. The operating potential of the first tube should be at least about 15% above that of the second tube.

Occasionally a corona stabiliser may be used to control the grid potential of a valve. In the circuit of Fig. 5, $V_1$ is a corona tube. As the input voltage varies between 3,720 and 4,280, the anode current of the triode varies from 0.29 to 1.05mA at full load and 1.09 to 1.85mA at no load, but the variation in the output voltage is too small to measure.

The use of the corona stabiliser in Fig. 5 enables almost 100% of negative feedback to be available (even at zero frequency) so that the output impedance is about $1/g_m$ (where $g_m$ is the mutual conductance of the triode). The output impedance is typically about 500Ω—which is extremely low for an e.h.t. supply unit providing some 2,750 volts. The current passing through the stabiliser tube is about 90µA.

References
1. R. O. Jenkins, "Corona Discharge finds a useful application in Voltage Stabilisers", Electrical Review, 14th June 1963

LOW-COST TELEMETRY FOR UPPER ATMOSPHERE RESEARCH

EMI Electronics has developed a budget-priced solid-state telemetry system to enable scientific data for upper atmosphere research to be obtained at a fraction of the cost normally associated with rocket vehicle instrumentation. It has been evolved from a system designed initially by the Royal Aircraft Establishment and then refined and developed over the course of ten years by EMI Electronics in its capacity as design authority for missile telemetry to the Ministry of Aviation. Its format has been proved by thousands of successful firings and its small physical dimensions are likely to be even further reduced by the adoption of new techniques under development. Standard senders are available for SKUA and PETREL rockets; close technical liaison with the rocket manufacturer, Bristol Aerojet Limited, has resulted in designs of aerial systems and mountings being readily available. Senders and sub-units can also be made-to-measure for other rockets; the telemetry units can be fitted in diameters as small as 2.9in (7¾cm).

CAN ANYONE HELP?

Requests for information are inserted in this feature free of charge, subject to space being available. Users of this service undertake to acknowledge all letters, etc., received and to reimburse all reasonable expenses incurred by correspondents. Circuits, manuals, service sheets, etc., lent by readers must be returned in good condition within a reasonable period of time.

Baird Tape Recorder Type TR1.—R. G. Coombe, 45 Saxon Road, Heavitree, Exeter, Devon—borrow or purchase service sheet or circuit diagram.

* * *


Hallicrafters Sky Champion.—J. R. Ault, 17 Hollyhedge Road, West Bromwich, Staffs.—circuit diagram and alignment details.

* * *

Hartley Type 13A Oscilloscope, Ref: 10S/831.—E. W. Tootell, 14 Tennyson Avenue, Chorley, Lancs.—loan or purchase of manual.

MARCH 1967
In technical circles these days the with-it word seems to be "fluidics". Cambridge saw the second Cranfield Fluidics Conference during 3rd to 5th January, and I note that the Ministry of Technology is currently encouraging development and experimental work in fluidics at the British Hydro-mechanics Research Laboratory and the National Engineering Laboratory.

The term fluidics describes a new method of obtaining automatic logic functions, and it is based on a very old observation. If you apply your thumb to the bathroom tap you can change the direction of the stream of water which emerges over a considerable angle, and with negligible physical effort. In fluidics, the direction of a stream of fluid, which can be gas or liquid, is altered under the influence of another stream having a much lower pressure. Thus, a jet of fluid can be transposed from one output tube to another. As can be imagined, this gives the first step towards switching and amplification, as we know these factors in electronics. In fluidics, however, the flow of current is replaced by a flow of fluid.

**Fluidic Devices**

At the moment, fluidic devices are being used as though they were analogues of electronic devices. Fluidic devices are referred to as flip-flops, AND gates, OR gates, NOR gates, Schmitt triggers and amplifiers, and they are coupled together by tubing to form basic operating circuits in just the same way as the corresponding electronic devices are coupled together by copper conductors. The fluidic operation in each device is obtained by carefully designing the shape of the channels, jets and chambers through which the fluids pass. There are even fluidic resistors, whose function is to provide a linear pressure-flow restriction. All these devices have nozzles for the application of interconnecting tubing, in the same way as electronic devices have terminals or lead-outs for interconnecting wiring.

The speed of operation of fluidic devices is in the order of milliseconds. This is a very much slower speed than is given by electronic components, and so it is unlikely that fluidics will ever offer any significant competition in the computer field. But fluidics have an important advantage in the sphere of machine control and automated production line processes where a cycle of relatively simple operations has to be controlled. Pneumatic and hydraulic machine control equipment has been in use for a long time, and the addition of fluidic logic devices enables such equipment to offer more sophisticated control sequences. However, the main attraction of fluidic systems in the production field is that the components are extremely robust and are not affected by high temperatures or vibration levels. Because of this, some production engineers tend to look upon them with greater favour than on electronic systems, which seem to have gained an undeserved reputation for esoteric unreliability. It is a little ironic to think that the logic philosophy engendered by electronics has been the starting point from which the new fluidic systems—which will replace some electronic systems—have been able to develop.

Much of the commercial development work in current fluidic devices has been carried out by Corning Glass Works in America, whose English representatives are Electrosil Ltd., Sunderland, Co. Durham. There are a number of wholly British concerns engaged in commercial applications, notable amongst these being Techne (Cambridge) Ltd., who specialise in machine control.

Whatever other problems they encounter, students of fluidics will not, at any event, have any difficulties with regard to the direction in which the actuating fluid runs, as opposed to students of electronics who have to deal with a "conventional" flow of electric current which is dead opposite to the flow of the electrons which constitute the current!

**I'm All Right, Jack**

Turning to matters closer to the home-constructor, I note that a little matter of terminology seems to confuse some newcomers to our hobby. This matter has to do with jacks and jack-plugs. The jack-plug is, of course, the part of a jack that is pushed into a plug (or socket). The plug is the part that is pushed into a jack. The plug has a male connector, and the jack has a female connector. The jack-plug is usually cylindrical, and the plug is usually rectangular. The plug has a hole in the middle, and the jack has an opening in the middle. The plug goes into the jack, and the jack-plug goes into the plug. This is the standard way of connecting two devices together.

**Cartoon**

"... I'm trying to break away from the usual box shape..."
course, the plug having a sleeve and tip to which earphones are normally connected. The jack is the socket into which the jack-plug is inserted.

For some reason there is a fairly widespread belief that the word "jack" applies to the plug, but this is quite incorrect and the term actually applies to the socket.

In most of the articles appearing in The Radio Constructor we skate over the problem by referring to the "jack plug" and the "jack socket". The component is thereby identified without any risk of ambiguity, even though the addition of "socket" is superfluous.

Some newcomers are also a little bewildered by "hfe", with respect to transistors. This defines the small signal gain (actually "the small signal forward current transfer ratio with the output short-circuited to alternating current") of a transistor when it is connected in the common collector mode, and is equivalent to the earlier terms α (alpha "dash") or β (beta). All three mean the same thing and may be encountered in general electronic literature. The term hfe is that which is most commonly used these days.

Arousing from a conversation with a friend, there is a little further confusion over the American word "transconductance", as applied to valv.e.s. To make things a wee bit more unfamiliar, this transconductance is quoted in microhars. In this particular context, transconductance (it should really be "grid-anode transconductance") is the transconductance of our own mutual conductance (gm) which you will remember, defines the change in anode current for change in grid voltage, the anode voltage being held constant. We express this as "mA per volt" and use the equation:

\[
\text{gm} = \frac{dB}{dV} \quad \text{(V_a constant)}
\]

Now, from Ohm's Law we say that resistance is voltage divided by current whereas mutual conductance, from the equation, is current divided by voltage. A mho, which is the unit of conductance, is the reciprocal of an ohm (i.e. it is current divided by voltage) and so we could if we wished refer to mutual conductance in mhos. However, the figures turn out easier if we use microhars, as the Americans do, whereupon a transconductance of 1,000 microhars is the same as a mutual conductance of 1mA per volt. Just divide the transconductance microhars figure by 1,000 and you have the mutual conductance in mA per volt.

Wide-Band Photophone

The "Wide-Band Photophone" articles by D. Bollen have represented an important step forward in the highly interesting field of communication by light. I now pass on a little further information from the author which arrived too late for publication in the articles.

Imported versions of the 90AV photocell specified have gone up in price recently and now cost the same (46s.) as the British-made type. It may be possible to locate a cheaper imported version, but Mr. Bollen has not been able to trace any at the moment. If constructors have difficulty in obtaining the 90AV, a 92AV may be employed instead. The 92AV supersedes the 90AV, has the same pin connections, and has very nearly the same characteristics.

New Photo-devices

And, finally, some notes on two new photo-devices which have been recently developed by American concerns. These are the General Electric "LASCs" and the Raytheon "Raysistor".

The word LASCs is an acronym for "Light Activated Silicon Controlled Switch". This device, like the silicon controlled rectifier, has a PNPN structure, but can be switched to the conducting state by a weak beam of light as well as by an electrical pulse. Separate external connections are made to each of the four layers for maximum flexibility of circuit design. These planar passivated devices can switch currents of up to 175mA, the maximum voltage rating being 40 volts.

LASCs may be used in industrial equipment for switching, machine tool positioning, for computer tape and card reading, in calculators, in electronic cash registers, optical encoders, etc. Further details may be obtained from the manufacturers, General Electric Semiconductor Products Department, Electronics Park, Syracuse, New York, U.S.A.

The "Raysistor" consists of a small lamp and a photoconductive cell in a single encapsulation. The lamp may be either a gas discharge source (designated by the letter 'N') or an incandescent filament type (designated by the letter 'I'). The Raysistor provides complete isolation between the input and output. These four-terminal devices can switch currents of up to 1mA and are rated at 40 volts. Further details can be obtained from the British agents of the Raytheon Company, Messrs. Walmore Electronics Ltd., 11-15, Betterton Street, Drury Lane, London, W.C.2.

MARCH 1967
A systematic guide to the servicing of transistor radio and television receivers, tape recorders and high fidelity equipment

**RAPID SERVICING OF TRANSISTOR EQUIPMENT**

Gordon J. King

160 pages
90 line and half-tone illustrations 30s.

Directed to the service technician changing from valves to transistors, students starting a career in electronics, and the enthusiastic amateur, it describes semiconductors and transistors, their operating principles and circuitry, together with basic test procedures, and then concentrates on fault diagnosis in the various fundamental types of circuit—audio and video amplifiers, R.F. circuits and oscillators—each section concluding with a Fault Diagnosis Summary Chart. Chapters are devoted to the ordinary transistor portable receiver and practical advice on repair procedures.

**CONTENTS**

- Transistor Fundamentals
- Preliminary Circuit and Transistor Tests
- Signal Conditions and Tests
- Fault-finding in Audio and Video Circuits
- Fault-finding in R.F. Circuits
- Fault-finding in Oscillator Stages
- Fault-finding in Transistor Radios and Hi-fi Amplifiers
- Practice of Transistor Equipment Servicing

**FROM YOUR BOOKSELLER**

or in case of difficulty, complete this order form

**ORDER FORM**

Please send me... copies of **RAPID SERVICING OF TRANSISTOR EQUIPMENT** at 30s. (add 2s. postage)

NAME: ________________________________
ADDRESS: ____________________________

Simple complete this form and send it with your remittance to George Newnes Ltd., Tower House, Southampton Street, London, W.C.1.

**IF YOU'RE BUYING A HOUSE**

**Mortgage Protection is the best Policy for you**

If you’re buying your house with the help of a Building Society or a private loan, a “Yorkshire” Mortgage Protection Policy will take care of your outstanding payment in the event of your premature death. And, if you wish, you can arrange a Protection “Plus” Policy, which gives you a substantial cash return at the end of the mortgage term. It costs so little yet means so much to your dependants. Leave them a home not a mortgage!

Please send for further details, without any obligation, of course.

**THE YORKSHIRE INSURANCE COMPANY LTD**

Chief Offices: Rougier Street, YORK
and Becket House, 36–37 Old Jewry, LONDON E.C.2

Please send me further particulars of the “Yorkshire” Mortgage Protection Policy

Name: ________________________________
Address: ______________________________

______________________________
J/B

**THE RADIO CONSTRUCTOR**
Loudspeakers and Loudspeaker Cabinets

A. Philips paperback
P. W. Van Der Wal

This book provides particulars of numerous different speaker boxes, and is intended to be a source of information on various matters which, although apparently incidental, must nevertheless be given due consideration if the best results are to be obtained. To enable the "do-it-yourself" enthusiast to deal with certain problems which may arise during the construction of the boxes, a chapter of practical hints is also included.

available from leading booksellers

ILIFFE BOOKS LTD.
DORSET HOUSE, STAMFORD STREET, LONDON, S.E.1.

Radio Valve Data. Compiled by "WW" 8th ed. 9s. 6d. Postage 1s.
Transistor Pocket Book. By R. G. Hibberd. 25s. Postage 1s.
Questions and Answers Audio. By C. Brown 8s. 6d. Postage 8d.
Pick Ups the Key to Hi-Fi. By J. Walton 10s. Postage 6d.
Wireless for Beginners. By C. L. Boltz revd. by T. Roddam. 18s. Postage 1s.
Rapid Servicing of Transistor Equipment. By G. J. King. 30s. Postage 1s. 6d.
Tape Recorder Servicing Manual. By H. W. Hellyer. 63s. Postage 2s. 6d.
Guide to Amateur Radio. RSGB. 5s. Postage 9d.

TV Fault Finding 405/625 Lines. Edited by J. R. Davies. 8s. 6d. Postage 6d.
Questions and Answers Electronics. By C. Brown. 8s. 6d. Postage 8d.
Questions and Answers Transistors. By C. Brown. 8s. 6d. Postage 8d.
Radio Servicing Vol. 4. By G. N. Patchett 8s. 6d. Postage 6d.
Introduction to Lasers and Masers. By A. Lytel. 16s. Postage 1s.
Wireless Servicing Manual. By W. T. Cocking. 25s. Postage 1s. 6d.
Circuits for Audio and Tape Recording. By F. C. Judd. 7s. 6d. Postage 1s.
Valve and Cathode Ray Tube Manual No. 10. By Brimar. 7s. 6d. Postage 1s.

We have the Finest Selection of English and American Radio Books in the Country

19-21 PRAED STREET (Dept RC) LONDON W2
Telephone PADDington 4185

MARCH 1967
IMPROVE YOUR HOME RECEPTION

UNBEATABLE VALUE FOR YOU, AS A READER OF THE RADIO CONSTRUCTOR

THE NEW TOLTEC
HAIR DRYER

52/6
Add 4/6 for postage

SPECIFICATION
Moulded in beautiful symmetrical pastel blue impact resisting thermoplastic casing.
Quiet in operation.
Hot or cold air.
No radio or T.V. Interference—meets British standard specification.
Fitted with safety cut-out.
12 months & money refund guarantee.
Value 80/9 in the shops

Send the coupon below with the sum of only 52/6 (plus 4/6d to cover postage, packing and insurance, unless you are collecting personally) to:

THE TOLTEC ELECTRONIC & TRADING CO. LTD.,
HATTON HOUSE, HURST GREEN, SUSSEX

First
THE FAMOUS
KING V.H.F.
TELEBOOSTER

NOW THE
KING U.H.F.
TELEBOOSTER FOR B.B.C. 2

Simple Tuning and Excellent Stability by a quarter-wave resonator instead of coils. Low running costs—less than 2mA from PP4 or equivalent battery. Very Low Noise Design. Often eliminates snow and gives startling improvement to fringe reception. Brings outer fringe viewers within range of a UHF 625-line station.

Bandwidth: Four channels of a local group.
Channels: Blue Spot 25 to 45.
White Spot 45 to 65.
Both tunable.
Case and Dimensions: Plastic 3½" x 3½" x 2".
(M-K brown with cork base).

PRICE
£4-17-6
including P.P.4 BATTERY

£6-15-0
for self-contained mains version

POST FREE FROM:
NEWTRONICS
BRIDGE HOUSE, NEWTON ABBOT, DEVON - Telephone: 2457.

FREE inside
PRACTICAL WIRELESS

33½ rpm RADIO
FAULT-FINDING RECORD

Specially made to supplement a new PRACTICAL WIRELESS series on Repairing Radio Sets, enabling the reader to diagnose and remedy a wide range of radio receiver faults.

APRIL ISSUE Out 3rd March—2/6

THE RADIO CONSTRUCTOR

Toltec Hair Dryer Offer
VOUCHER WORTH 28/3

THE RADIO CONSTRUCTOR
SMALL ADVERTISEMENTS

Rate: 9d. per word. Minimum charge 12/-.
Box No. 2/- extra.

Advertisements must be prepaid and all copy must be received by the 4th of the month for insertion in the following month's issue. The Publishers cannot be held liable in any way for printing errors or omissions, nor can they accept responsibility for the bona fides of advertisers. (Replies to Box numbers should be addressed to: Box No.—, The Radio Constructor, 57 Malda Vale, London, W.9.)

SERVICE SHEETS, 1925-1965. From 1s. Catalogue 6,000 models, 2s. 6d. S.A.E. enquiries.—Hamilton Radio, 13 Western Road, St. Leonards, Sussex.

EXCITING NEW ILLUSTRATED CATALOGUE NO. 17 of Government and manufacturers' surplus electronic equipment. Also a large selection of new miniature components and semi-conductors. Send for your copy now, price 3s. post free.—Arthur Sallis Radio Control Ltd., 93 North Road, Brighton, Sussex.


WANTED. Collector of early radio valves seeks specimen Marconi F.E.I. Box No. F282.


TECHNICAL DRAWINGS, Artwork, etc. Electronic and Radio Circuits a speciality. Moderate charges.—B. P. Meaney, 43 Forest Road, Worthing, Sussex.

ARE YOU A MOTORING ENTHUSIAST? The Seven Fifty Motor Club caters for all types of motor sport—racing, rallies, hill climbs, etc. Monthly Bulletin free to members. For full details write to: The General Secretary, Colin Peck, “Dancer’s End”, St. Winifred’s Road, Biggin Hill, Kent.

POSTAL ADVERTISING? This is the Holborn Service. Mailing lists, addressing, enclosing, wrapping, facsimile letters, automatic typing, copy service, campaign planning, design and artwork, printing and stationery. Please ask for price list.—The Holborn Direct Mail Company, 2 Mount Pleasant, London, W.C.1. Telephone: TErminus 0588.

continued on page 510

BENTLEY ACOUSTIC CORPORATION LTD.
28 Chalcot Road, Chalk Farm, LONDON, N.W.1.

BENILEACoustic CORPORATION LTD.
47 Norfolk Road, LITTLEHAMPTON, Sussex.

SMALL ADVERTISEMENTS

Rate: 9d. per word. Minimum charge 12/-.
Box No. 2/- extra.

Advertisements must be prepaid and all copy must be received by the 4th of the month for insertion in the following month's issue. The Publishers cannot be held liable in any way for printing errors or omissions, nor can they accept responsibility for the bona fides of advertisers. (Replies to Box numbers should be addressed to: Box No.—, The Radio Constructor, 57 Malda Vale, London, W.9.)

SERVICE SHEETS, 1925-1965. From 1s. Catalogue 6,000 models, 2s. 6d. S.A.E. enquiries.—Hamilton Radio, 13 Western Road, St. Leonards, Sussex.

EXCITING NEW ILLUSTRATED CATALOGUE NO. 17 of Government and manufacturers' surplus electronic equipment. Also a large selection of new miniature components and semi-conductors. Send for your copy now, price 3s. post free.—Arthur Sallis Radio Control Ltd., 93 North Road, Brighton, Sussex.


WANTED. Collector of early radio valves seeks specimen Marconi F.E.I. Box No. F282.


TECHNICAL DRAWINGS, Artwork, etc. Electronic and Radio Circuits a speciality. Moderate charges.—B. P. Meaney, 43 Forest Road, Worthing, Sussex.

ARE YOU A MOTORING ENTHUSIAST? The Seven Fifty Motor Club caters for all types of motor sport—racing, rallies, hill climbs, etc. Monthly Bulletin free to members. For full details write to: The General Secretary, Colin Peck, “Dancer’s End”, St. Winifred’s Road, Biggin Hill, Kent.

POSTAL ADVERTISING? This is the Holborn Service. Mailing lists, addressing, enclosing, wrapping, facsimile letters, automatic typing, copy service, campaign planning, design and artwork, printing and stationery. Please ask for price list.—The Holborn Direct Mail Company, 2 Mount Pleasant, London, W.C.1. Telephone: TErminus 0588.

continued on page 510
NEW STYLE
SELF-BINDER
for "The Radio Constructor"

The “CORDEX” Patent Self-Binding Case will keep your issues in mint condition. Copies can be inserted or removed with the greatest of ease. Rich maroon finish, gold lettering on spine.

Specially constructed Binding Cords are made from Super Linen of great strength, very hard twisted and twice doubled. They are attached to strong RUSTLESS Springs under tension, and the method adopted ensures PERMANENT RESILIENCE of the Cords. Any slack that may develop is immediately compensated for, and the Cords will always remain taut and strong. It is impossible to overstretch the springs, as a safety check-device is fitted to each.

For your other magazines see opposite

PRICE 15/- Post Free
Available only from:
Data Publications Ltd.
57 Maida Vale London W9

SMALL ADVERTISEMENTS
continued from page 509

“MEDIUM WAVE NEWS” Monthly during DX season—Details from: B. J. C. Brown, 60 White Street, Derby.

JOIN THE INTERNATIONAL S.W. LEAGUE. Free Services to members including Q.S.L. Bureau, Amateur and Broadcast Translation, Technical and Identification Dept.—both Broadcast and Fixed Stations, DX Certificates, contests and activities for the SWL and transmitting members. Monthly magazine, Monitor, containing articles of general interest to Broadcast and Amateur SWLs, Transmitter Section and League affairs, etc. League supplies such as badges, headed notepaper and envelopes, QSL cards, etc., are available at reasonable cost. Send for League particulars. Membership including monthly magazine, etc., 35s. per annum.—Secretary, ISWL, 60 White Street, Derby.


METERS. 0–500 microamps, 10s. 0–200mA, 5s. 0–20V d.c., 10s. 0–40mA, 10s. Heathkit Balun Coil Unit, £4. 0.5uF 3000V d.c. capacitors, 2s. each. Ink rollers for Creed Type 3 teleprinter, 2s. 6d. per bottle. Woden transformer 350–0–350V, 120mA; 6.3V, 4A CT; 5V, 2A, 50s. All plus postage. Box No. F285.

RECORDS. Unblemished. Cotton Club Days, Duke Ellington, Mono/AH23; The Golden Years, Ray Charles, TP365; This Wonderful World of Jazz, BBL7356; The Roaring 20’s, Mono WM4035; Show Souvenirs, Harry Secombe, BBL7532; At the Drop of a Hat, Michael Flanders, PMC1033; Dixieland Goes West, Lawson-Haggart Band, T215; The Roaring 20’s, Dinah Kaye, SOC913; Glenn Miller Soundtracks, TP223; Jazz Sebastian Bach, Swingle Singers, BL7572; all at 7s. 6d. each. One Dozen recent 45’s, £1. All plus postage. Box No. F286.


MESSERSCHMITT Four wheel TG 500 sports car. Enthusiast seeks damaged or part vehicles, spares etc. Details to C. E. Jaques, 33 Middleton Road, Shenfield, Essex.


BOOKS FOR SALE. Fundamentals of Modern Semiconductors, Kemp & McDonald, 13s., Understanding Electronic Circuits, Farl J. Waters, 12s. Wireless for Beginners, Boltz, 9s. Hi-Fi Projects for the Hobbyist L. Fieldman, 10s. Transistors Work Like This, Larsen, 5s. Good condition, prices 50% below cost. Box No. F288.

FOR SALE. Heathkit RA1. Unused. With xtal calibrator and speaker £40. Lovell, 5 Montpelier Road, Ilfracombe, Devon.

TORIOD COILS for sale. Suitable RTTY, etc. Mostly 88mH but some values above and below. SAE for details. 7s. 6d. each. Box No. F289.
SMALL ADVERTISEMENTS continued from page 510

FOR SALE. STROBOSCOPES No. 2, (663 rpm) and No. 4 (666.6 rpm), at 7s. 6d. 0-12 oz., tension gauge at 7s. 6d. Box No. F290.

WANTED. Glass paper-weights. Swap for radio gear or pay cash. Offers to:— Box No. F291.

FOR SALE. Rectifier Units, Type 43A. 50s. plus carriage. Box No. F292.

FOR SALE. Cossor 339 double beam scope £30. Thurlow, 210 Copnor Road, Portsmouth, Hants. (Tel: 64728).

MAN FROM UNCLE? Radio-microphone, could possibly be built in cigar tube. Circuit and details for 5s. Box No. F293.

BRIGHTEN UP YOUR ADVERTISING! Break the ice with a cartoon, “tailor made” for your product. Reasonable charges. Box No. F294.

WANTED. Model yacht about 4ft long, for conversion to radio control. Box No. F295.

TAPE RECORDER SPARES. All parts for any machine available. Send S.A.E. and requirements for quote to: Tape Service, 81 Lower Richmond Road, London, S.W.15.

The “CORDEX” Patent Self-Binding Case will keep your copies in mint condition. Issues can be inserted or removed with the greatest of ease. Rich maroon finish. Specially constructed Binding Cords are made from Super Linen of great strength, very hard twisted and twice doubled. They are attached to strong RUSTLESS Springs under tension, and the method adopted ensures PERMANENT RESILIENCE of the Cords. Any slack that may develop is immediately compensated for, and the Cords will always remain taut and strong. It is impossible to overstretch the springs, as a safety check-device is fitted to each.

PRICE 14/6 Post Free

Available only from:—

Data Publications Ltd.
57 Maida Vale London W9

Components for High Sensitivity V.H.F. Portable Receiver (See this and previous issue).

Condensers—S.M. 4d. to 1/-; Ceramic 6d.; Poly. 9d. to 2/—;
Elecr. 1/- to 4/—; German 2-gang tuner 15pF + 15pF with slow motion tuning 7/6; AF114, 115, 116, AC127 all 7/- ea.; AF117 5/-;
OC44, 81, 81D 3/6 ea.; speaker 7½" x 4" 12/6; aerial 7½" to 40" 7/6;
Cabinet and motif 15/-, All plus postage 6d. small packet to 3/6 cabinet. S.A.E. for full price list of above and free catalogue of push-button stereogram chassis at £17.17.0. etc.
Type Y all-screwed construction.

Type Z has removable back and front panels.

Type Size

Retail enquiries to:—

— the Universal Wiring Board—

obtainable from your local retailer

VEROBOARD

Technical enquiries to.—

CHASSIS

BLANK CHASSIS—Same Day Service

Of over 20 different forms made up to YOUR SIZE. 

(Maximum length 35", depth 4")

SEND FOR ILLUSTRATED LEAFLETS or order straight away, working out total area of material required (including waste) and referring to table below which is for four-sided chassis in 16 s.w.g. aluminum

Type U

48 sq. in. 7/6
114 sq. in. 7/2
144 sq. in. 8/6
192 sq. in. 9/6
272 sq. in. 13/10
368 sq. in. 17/10

Type Z

80 sq. in. 8/10
208 sq. in. 11/2
336 sq. in. 16/6
688 sq. in. 30/10

Discounts for quantities. More than 20 different sizes kept in stock for callers.

FLANGES (¾" or 8") 6d. per bend.

STRENGTHENED CORNERS, 1/- each corner.

PANELS

Any size up to 3ft at 6/- sq. ft. 16 s.w.g. (18 s.w.g. 5/3).

Plus postage and packing.

HUNDREDS OF TRANSISTORS, DIODES, UJT's, FET's, SCR's and other semiconductor devices, are available from:

M. R. CLIFFORD & COMPANY (CSC)

209A, MONUMENT ROAD, EDGBASTON, BIRMINGHAM, 16.

Send 6d. stamps for competitive quotations, or send 2/- P.O. for current price list of over 1,500 transistors, and inclusion on our Mailing List.

TYPICAL PRICES: 2N 697, 9/9; 2N 765, 5/9; 2C 302, 3/4; NKT 271, 3/4; BC 108, 7/6; 2N 2926 (orange), 4/3; 2N 2926 (Yellow) 4/6; etc.

FIELD-EFFECT TRANSISTORS. C 86 37/6; C 94 & C 95, 75/- ea.

TANTALUM CAPACITORS. A range of 40 values including the following: 0.1uF/35v; 0.5uF/35v; 1uF/35v; 20uF/35v; 50uF/35v; 100uF/35v; 150uF/10v; 500uF/20v; 680uF/25v; 5uF/20v; etc.

CARBON FILM RESISTORS. ± 5% Tolerance. Sizes: 10mm x 4mm dia.

Electrolytic Capacitors. Comprehensive range available.

TUNNEL DIODES. A wide range of tunnel diodes is now available at low cost. EX-STOCK.

Mail order only please. TERMS C.W.O.

Please add 1/- P. & P. on all orders of £2 or less.


Send 6d. stamps for competitive quotations, or send 2/- P.O. for current price list of over 1,500 transistors, and inclusion on our Mailing List.

Other Yukan Air Drying Aerosols include:

Zinc Chromate Primer.

Clear Lacquer.

Anti-Tarnish Gold and Nickel finishes.

SPECIAL OFFER: I can plus optional snapp-on trigger handle (value 5/-) for 18/11, carriage paid. Choice of 13 self-spray plain colours and primer (motor car quality) also available.

Please enclose cheque or P.O. for total amount to:


Open all day Saturday. Closed Thursday afternoons.

THE RADIO CONSTRUCTOR

ANNUAL SUBSCRIPTIONS to this magazine may be obtained direct from the publishers ONLY 36/- per year, post free

Please send remittance with name and address and commencing issue required to:

DATA PUBLICATIONS LTD 57 MAIDA VALE LONDON W9

Please mention THE RADIO CONSTRUCTOR when writing to advertisers.
TV FAULT FINDING MANUAL for 405/625 LINES

REVISED & ENLARGED
EDITED BY J. R. DAVIES

124 pages
Over 100 illustrations, including 60 photographs of a television screen after the appropriate faults have been deliberately introduced.

Comprehensive Fault Finding Guide cross-referenced to methods of fault rectification described at greater length in the text.

FROM YOUR BOOKSELLER

PRICE

8'6

PER COPY

OR POST THIS COUPON TOGETHER WITH REMITTANCE FOR 9/- (TO INCLUDE POSTAGE) TO
DATA PUBLICATIONS LTD.

Please send me the 4th revised edition of TV Fault Finding, Data Book No. 5.
I enclose cheque/crossed postal order for ..............................................

NAME .................................................................
ADDRESS ..............................................................
........................................................................
........................................................................
........................................................................
........................................................................

BLOCK LETTERS PLEASE
MAYFAIR PORTABLE ELECTRONIC ORGAN

Build the World’s first All-Transistor Portable Electronic Organ Kit

- Plug-in printed circuit
- 170 transistors and devices
- 10 selected tone colours
- Fully sprung keyboard
- Vibrato
- 6 Octaves of generators
- Simple locked-in tuning
- 110/250 volt mains unit
- Cabinet size 30" x 15½" x 9"  Weight 35 lb. Cabinet with detachable legs, music stand and foot swell pedal
- Fully detailed building manual with photos, drawings and full circuits. All parts sold separately.

COMPLETE RANGE OF ELECTRONIC ORGAN COMPONENTS IN STOCK

CALL IN FOR DEMONSTRATION

10 & 20 W Mono & Stereo Transistor Amplifiers

- 10 watts RMS output, 100mV input
- 30 dB to 20 kHz ± 1 dB, 6-Transistor circuit, 5 x 34/6 in.
- 1.5MF 100ohms, 100mA output. Mains input and Mains Unit. Output up to 150mV RMS.
- £4.10.0, p.p. 2/6

PREAMPLIFIERS, 8 input selector, Treble, bass, volume, filter controls. 14mV to 250mV input. Battery operated or from Mains Unit. Output up to 150mV RMS.
- £5.19.6, p.p. 3/6

5 WATT AMPLIFIERS

- 3 watts Push-pull, 3 ohms, 6mV into 1K, 12/18V supply, 22 to 1.4k.
- £4.10.0, p.p. 2/6

BUILD AND TESTED

- Complete kit with 1/2 gns.
- £6.19.6

5 TRANSISTOR FM. Uses pot

- £5.19.6, p.p. 2/6

TO BUILD

- £9.19.6

TUNNEL DIODES

- 1mA 22/6; 5mA 15/-
- £15/- 15mA 12/6.

FOR BUILDING

- £22.6/6

2000 WATT AMPLIFIER

- 500W Mono, 250W Stereo
- £27.10.0

2000 MONO & STEREO 25 WATT AMPLIFIERS

- £7.19.6

SILENT AND HIGH FIDELITY AT UNBEATABLE PRICES

ALL UNITS BUILT AND TESTED

DETAILED BOOKLET FREE ON REQUEST

(f) GARRARD BATTERY

- Brand New with R/P head, erase/osc. head, tape cassette. Specifications and oc. circuits. 2 speed 4-track 9 volt operated. List Price 13 gns.
- £15.19.6

(9) GARRARD DECKS—BRAND NEW FULLY GUARANTEED

- £5.19.6, p.p. 2/6

(1) REGENT-6 MW/LW

- £1.9.6

TO BUILD

- £69/6

10 & 20 W Mono & Stereo Transistor Amplifiers

- £7.19.6

TO BUILD

- £9.19.6

401 less cart./arm £27.10.0

GARRARD DECKS

- £27.10.0

- £20/- extra

HENRY'S RADIO LTD.

- 303 Edgware Road, London, W.2

1967 CATALOGUE

Have you a copy?

Fully detailed and illustrated. Over 200 pages of components, equipment, etc.

Over 5,000 stock items. PRICE £6/6, post paid.

Free discount vouchers, value £10/6, with every order.

We can supply from stock most of the components specified on circuits in this magazine. Send for quotation.