

15 SP.

Vol 20 No 7

# THE RADIO CONSTRUCTOR

**FEBRUARY 1967**  
**2/6**

A DATA PUBLICATION

RADIO · TELEVISION  
ELECTRONICS · AUDIO

**High Sensitivity  
Transistor VHF Portable**



Radiogram  
Amplifier

• Audio Frequency  
Q-Multiplier

• Transistorised  
Grid Drip Meter

• Radar Speed  
Measurement

# Scottish Insurance Corporation Ltd

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## TELEVISION SETS, RECEIVERS AND TRANSMITTERS

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.

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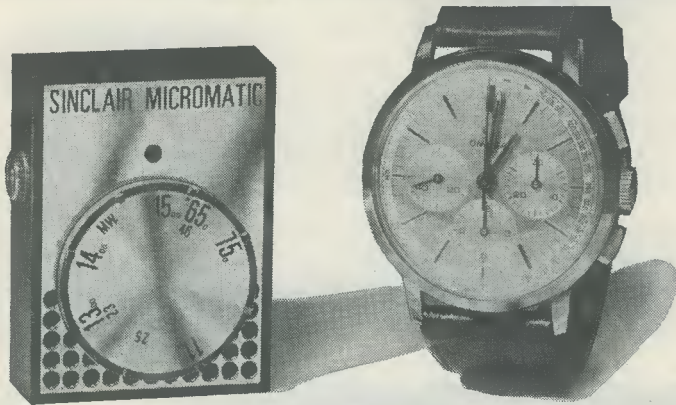
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*The  
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smallest  
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ACTUAL SIZE

- ★ ONLY ONE CONTROL
- ★ CALIBRATED DIAL
- ★ SIZE — 1½" x 1½" x ½"
- ★ POLISHED ALUMINIUM FRONT PANEL WITH SPUN ALUMINIUM DIAL
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- ★ NEW CIRCUITRY
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- ★ A.G.C.
- ★ IN KIT FORM OR READY BUILT
- ★ 5 YEAR GUARANTEE

## SINCLAIR MICROMATIC

Here is a brand new design from an organisation world-famous for its production of micro electronic equipment for the constructor. This new set, the SINCLAIR MICROMATIC reaches fantastically high standards of performance. In it, we have combined new circuitry with new elegance to make this set professionally right in every detail whether you build it yourself or buy it ready built. It is the perfect personal radio, ready to serve wherever and whenever required. Reception from a wide range of stations is assured with excellent selectivity and quality. The MICROMATIC is a set you will be proud to be seen using—and it makes an excellent gift too.

Six stage transistor circuit of remarkable power and sensitivity. Two R.F. stages are followed by double diode detector and 3 stages of audio-amplification A.G.C. counteracts fading from distant stations. Ferrite rod aerial and two Mallory cells type ZM. 312 are contained in the minute case. Tunes over M.W. Dial marked in Kc/s and metres. Inserting plug of earpiece switches set on.

Complete Kit inc. Case, Transistors, earpiece, and instructions.

**59/6**

Ready built in presentation case with earpiece

**79/6**

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Should you not be completely satisfied with your purchase when you receive it from us, your money will be refunded in full and at once without question. Please quote RC167 should you prefer to write your order instead of cutting out this coupon.

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**SINCLAIR MICRO FM 7** Transistor FM superhet for use both as a tuner and independent pocket radio. Easy to build. Needs no alignment. With telescopic aerial. Case size less than 3" x 2½" x ½". Complete kit inc. earpiece and instructions.

**£5.19.6**

**SINCLAIR Z-12 AMPLIFIER** Measures only 3" x 1½" x 1½" including integrated pre-amp. 12 watts R.M.S. output continuous sine wave. Ready-built with manual of input matching and control circuits. Ideal for hi-fi, guitars, P.A., etc., etc.

**89/6**

**SINCLAIR STEREO 25** De Luxe pre-amp/control unit for use with two Z-12s or any high quality stereo amplifier. Size 6" x 2½" x 2½". With brushed and polished aluminium front and solid aluminium knobs. Ready built.

**£9.19.6**

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SINCLAIR RADIONICS LTD., 22 NEWMARKET ROAD, CAMBRIDGE

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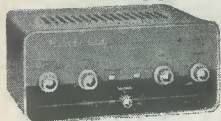
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# HI-FI AMPLIFIERS — TUNERS — RECORD PLAYERS



**3+3W  
STEREO  
AMP.  
S-33H**

**10W POWER AMPLIFIER. Model MA-12.** 10W output, wide freq. range, low distortion. For use with control unit. Kit **£12.18.0** Assembled **£16.18.0**

**3 + 3W STEREO AMPLIFIER. Model S-33.** An easy-to-build, low cost unit. 2 inputs per channel. Kit **£13.7.6** Assembled **£18.18.0**

**DE LUXE STEREO AMPLIFIER. Model S-33H.** De luxe version of the S-33 with two-tone grey perspex panel, and higher sensitivity necessary to accept the Decca Deram pick-up. Kit **£15.17.6** Assembled **£21.7.6**

**HI-FI STEREO AMPLIFIER. Model S-99.** 9 + 9W output. Ganged controls. Stereo/Mono gram., radio and tape inputs. Push-button selection. Printed circuit construction. Kit **£28.9.6** Assembled **£38.9.6**

**TRANSISTOR PA/GUITAR AMPLIFIER, PA-2.** 20W amplifier. Four inputs. Variable tremolo. **New Low Price** Kit **£39.19.0** Assembled **£54.10.0**

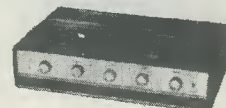
**50W VALVE PA/GUITAR AMP., PA-1.** Kit **£54.15.0** Assembled **£74.0.0**



**10W  
POWER  
AMP.  
MA-12**



**GARRARD  
PLAYER  
AT-60**



**20+20W  
STEREO  
AMP.  
AA-22U**

**TRANSISTOR MIXER. Model TM-1.** A must for the tape enthusiast. Four channels. Battery operated. Similar styling to Model AA-22U Amplifier. With cabinet. Kit **£11.16.6** Assembled **£16.17.6**

**20+20W TRANSISTOR STEREO AMPLIFIER. Model AA-22U.** Outstanding performance and appearance. Kit **£39.10.0** (less cabinet). Assembled **£57.10.0** Attractive walnut veneered cabinet **£2.5.0** extra.

**GARRARD AUTO/RECORD PLAYER. Model AT-60.** less cartridge **£13.1.7** With Decca Deram pick-up **£17.16.1** incl. P.T. Many other Garrard models available, ask for Lists.

**HI-FI MONO AMPLIFIER. Model MA-5.** A general purpose 5W Amplifier, with inputs for Gram., Radio. Attractive modern styling. Kit **£11.9.6** Assembled **£15.15.0**



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Easy-to-follow instruction manuals show you how to build the models

### INSTRUMENTS

**3" LOW-PRICED SERVICE OSCILLOSCOPE. Model OS-2.** Compact size 5" x 7 3/4" x 12" deep. Wt. only 9 1/2 lb. "Y" bandwidth 2 c/s-3 Mc/s ± 3dB. Sensitivity 100mV/cm. T/B 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**

**5" GEN-PURPOSE OSCILLOSCOPE. Model 10-12U.** An outstanding model with professional specification and styling. "Y" bandwidth 3 c/s-4.5 Mc/s ± 3dB. T/B 10 c/s-500 kc/s. Kit **£35.17.6** Assembled **£45.15.0**

**E LUXE LARGE-SCALE VALVE VOLTMETER. Model IM-13U.** Circuit and specification based on the well-known model V-7A but with many worth-while refinements. 6" Ernest Turner meter. Unique gimbal bracket allows operation of instrument in many positions. Modern styling. Kit **£18.18.0** Assembled **£26.18.0**

**AUDIO SIGNAL GENERATOR. Model AG-9U.** 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**

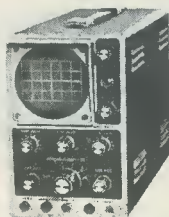
**VALVE VOLTMETER. Model V-7A.** 7 voltage ranges d.c. volts to 1,500. A.c. to 1,500 r.m.s. and 4,000 peak to peak. Resistance 0.1Ω to 1,000MΩ with internal battery. D.c. input resistance 11MΩ. dB measurement, has centre-zero scale. Complete with test prods, leads and standardising battery. Kit **£13.18.6** 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.; 0.2Ω to 20MΩ. 4 1/2" 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 Mc/s on harmonics. Up to 100mV 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 0.15μ 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 **£35.8.0** Assembled **£47.8.0**



OS-2



IM-13U



V-7A



MM-1U



IG-82U

Prices and specifications subject to change without notice

### 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 **£1.13.6** incl. P.T. IF/AF Amp. Kit **£11.3.6**

**Total Price Kit (excl. Loudspeaker) £12.17.0** incl. P.T. 8" x 5" Loudspeaker **£1.16.1** 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.



UXR-2

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



UXR-1

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.

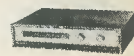
### STEREO TRANSISTOR FM TUNER. (Mono version also available)

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

Kit (Stereo) **£24.18.0** incl. P.T.

Kit (Mono) **£20.19.0** incl. P.T.

Cabin extra **£2.5.0**.



FM Tuner

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## TAPE AMPLIFIERS ~~~~~ TAPE DECKS ~~~~~ CONTROL UNITS



**FM  
TUNER  
FM-4U**



**MAGNAVOX  
DECK**

**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** (Multiplex adapter available, as extra.)

**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** (Multiplex adapter available, as extra.)

**MAGNAVOX "363" TAPE DECK.** The finest buy in its price range. Operating speeds: 1½", 3½" and 7½" p.s. Two tracks, "wow" and "flutter" not greater than 0.15% at 7½" p.s. **£13.10.0**  
MAGNAVOX deck with TA-IM Kit **£31.5.6**



**TRUVOX  
DECK**



**AM/FM  
TUNER**

**TRUVOX D-93 TAPE DECKS.** High quality stereo/mono tape decks. D93/2, ¼ track, **£36.15.0** D93/4, ¼ track, **£36.15.0**

**TAPE RECORDING/PLAYBACK AMPLIFIER**  
Mono Model TA-IM kit **£19.18.0** Assembled **£28.18.0**  
Stereo Model TA-IM 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**

# First in dependability - first in performance

Convenient credit terms available in U.K. over £10



**SSU-1**

### SPEAKER SYSTEMS

**HI-FI SPEAKER SYSTEM. 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 26" x 17" x only 7½" deep. Modern attractive styling. Excellent value.

Kit **£19.10.0** Assembled **£24.0.0**

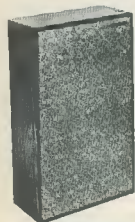
**COTSWOLD SPEAKER SYSTEMS.** Outstanding performance for price.

*MFS:* Size 36" x 16½" x 14" 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**



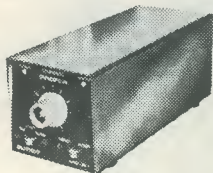
**Berkeley**

### 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. Styled to match Heathkit models FM-4U and AFM-1 Tuners.

Kit **£8.10.0** Assembled **£12.5.0**  
Styled to match British Heathkit models.



**SD-1**

### "AMATEUR" EQUIPMENT

**THE "MOHICAN" GENERAL COVERAGE RECEIVER. Model GC-1U.** With 4 piezo-electric transmitters, variable tuned B.F.O. and Zener diode stabiliser, this is an excellent fully transistorised general purpose receiver for Amateur and Short wave listeners. Printed circuits, telescopic aerial, tuning meter and large slide-rule dial.

Kit **£37.17.6** Assembled **£45.17.6**

**AMATEUR BANDS RECEIVER. Model RA-1.** To cover all the Amateur Bands from 160-10 metres. Many special features, including: half-lattice crystal filter; 8 valves; signal strength "S" meter; tuned R.F. Amp. stage.

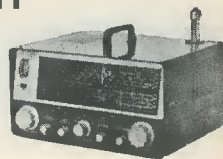
Kit **£39.6.6** Assembled **£52.10.0**

**160-10M TRANSMITTER. Model DX-100U.** Careful design has achieved high performance and stability. Completely self-contained.

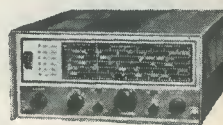
Kit **£81.10.0** Assembled **£106.15.0**

**COMMUNICATIONS TYPE RECEIVER. Model RG-1.** A high performance, low cost receiver for the discriminating listener. Frequency coverage: 600 kc/s-1.5 Mc/s and 1.7 Mc/s-32 Mc/s.

Kit **£39.16.0** Assembled **£53.0.0**



**GC-1U**



**RG-1**

### NEW! Hi-Fi Models. 'AVON' The Mini Speaker System with Hi-Fi performance.

Only 7½" wide x 13¼" high x 8¼" deep. Specially designed.

Walnut veneered finished cabinet kit **£8.18.0**.

Two speaker system and crossover network **£4.18.0**.

**Total price kit £13.16.0.**

### 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**.

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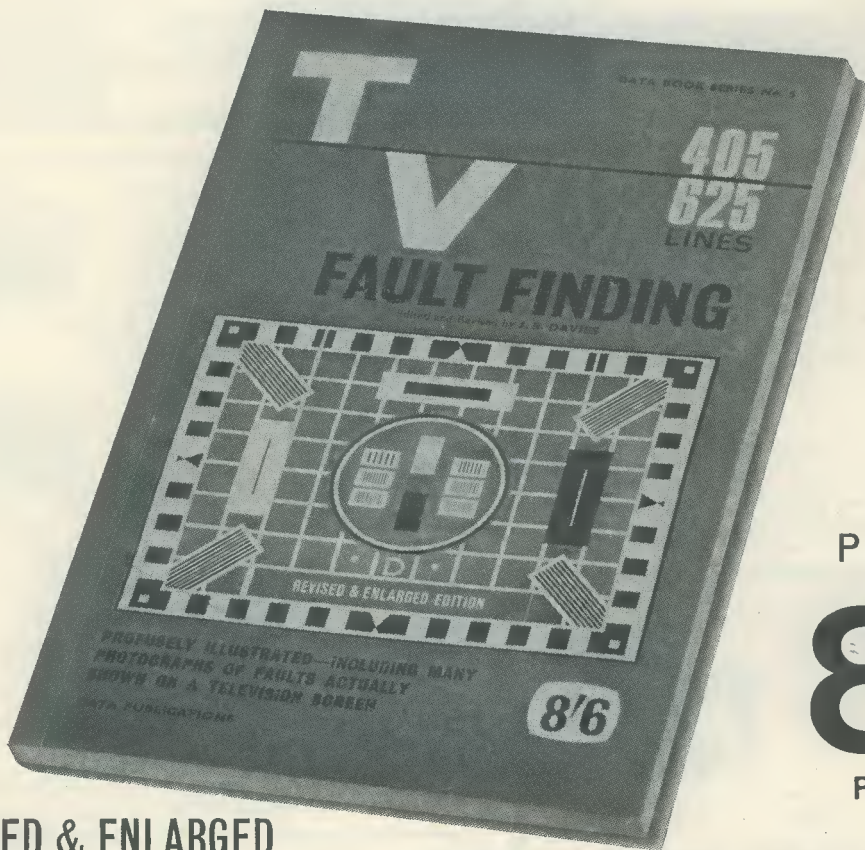
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# TV

# FAULT FINDING MANUAL for 405/625 LINES



PRICE

# 8/6

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## 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.

Please send me the 4th revised edition of TV Fault Finding, Data Book No. 5.

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**ALWAYS NEEDED—ALWAYS AVAILABLE FROM T.R.S.**

**RESISTORS** In preferred values and full ranges from 10Ω to 10 megohms. Modern ratings. Midget type.

**5% HI-STAB** ½ w. (100Ω—1 meg, each 6d) 1 w. Other values 9d.  
**10% STANDARD** ½ w., ½ w., each 4d. ¾ w. 6d  
**1% HI-STAB** ½ w. 1/6 (10Ω—100Ω 2/-)

**VOLUME CONTROLS**

All values 5K—2 megohms, 1½" dia., Long spindles. Log or Linear, less sw. 3/6. With DP. sw. 5/-. Centre tapped ½ meg log; 1 meg less sw. 5/-. **TWIN GANGED**, all values 5K to 2 meg. per section 7/6. Ditto 100K to 2 meg. with DP. sw., each 9/6. **STEREO BALANCE CONTROL**, Log/Anti-log. 5K, ½, 1 & 2 meg. each 9/-.

**ENAMELED COPPER WIRE**—2 oz. reels 14 g.-20 g. 3/1-22 g.-28 g. 3/6; 30 g.-34 g. 4/3; 36 g.-38 g. 4/9; 39 g.-40 g. 5/1, etc.

**TINNED COPPER WIRE**. 16-22 g. 4/- 2 oz. **BONDACUST Speaker Cabinet Acoustic Wadding** (1" thick approx.) 18" wide, any length cut, 6/-yd.

**VEROBOARD**—All sizes including 2½" x 5", 3/8; 2½" x 3½", 3/8; 3½" x 5", 5/2; 3½" x 3½", 3/8; 3½" x 17", 12/6. All accessories and tools in stock.

**ERSIN MULTICORE SOLDER**. 60/40 4d. per yard. Cartons 6d., 1/-, 2/6, etc.

**WIREWOUND RESISTORS**. 25 ohm to 10K. 5 w. 1/3, 10 w. 1/6, 15 w. 2/-. **CONDENSERS** Silver Mica. All values 2 pf. to 1,000 pf. 6d. ea. Ditto ceramics 9d. Tub. 450 v. T.C.C., etc. .001 mfd to .01 10d. and 1/250 v. 10d. .02 MF to 1.0 MF. 500 v. 1/-. .25 T.C.C. 1/9. .5 T.C.C. 2/-.

**CLOSE TOL. S/MICAS**. 10% 5 pf. 500 pf. 9d. 600-5,000 pf. 1/-. 1% 2 pf. 100 pf. 11d. 100 pf. 250 pf. 1/2d. 270 pf. 800 pf. 1/4. 800 pf. 5,000 pf. 2/-.

**ALUMIN. CHASSIS**. 18g. Plain undrilled folded 4 sides, 2" deep, 6" x 4", 4/6; 8" x 6" 5/9; 10" x 7", 6/9; 12" x 6", 7/6; 12" x 8", 8/1, etc.

**ALUMIN. SHEET**. 18 g. 6" x 6", 1/1; 6" x 9", 1/6; 6" x 12", 2/1; 12" x 12", 4/1, etc.

**TYGAN FRET** (Contem. pat.) 12" x 12", 2/-; 12" x 18", 3/-; 12" x 24", 4/- etc.

**TUNING COND.** Twin Gang by J. B. Plessey etc. 365 pf. Midget 8/6 each. .005 mfd Midget 7/6 each. .0005 mfd Stand. size with feet 8/6 each. Combined AM/FM Twin Gang 2 x .0005 mfd +2 x 25 pf. Neat and Compact 10/6 each.

**SINGLE TUNING COND.**—Reaction Type—Mica Dielectric .0001 mfd., .0003 mfd., .0005 mfd 1½" sq. 4/9 each.

**WAVECHANG SWITCHES**. Midget Type Single Wafer, ½ in. dia. Spindle. 2 pole 2 way 2/6 each. 1 pole 4 way 2/9 each. 1 pole 12 way, 2 pole 6 way, 3 pole 4 way, 4 pole 2 way, 4 pole 3 way 3/9 each.

**GARRARD UNITS & PLINTHS**

**LM.3000** charger with 7TA stereo cartridge. 8 gns. **AT.60** De-Luxe changer with 12" cast turntable, less cartridge. 9½ gns.

**SP.25** De-Luxe single player less cartridge. 9½ gns. Carr. and packing on above 7/6 each.

**GARRARD PLINTHS** suitable for any of above, with plastic cover 7/5. Carr. and packing 5/-.

**Garrard Mono Cartridges** from 15/-. Stereo from 25/-.

**T.R.S. STEREO DECODER KIT**

Based on a Mullard design.  
 6 Transistors, Printed Circuit size 5½ in. x 2½ in. 2 stage transistor. Stereo Beacon Indicator incorporated. 12v. supply.  
 Neg. Earth.  
 Basic Kit supplied suitable for Transistor Tuner input and Transistor Amplifier output. With simple mods (data supplied with Kit) easily adapted for Valve Tuners and Valve Amplifiers.  
 Kit and assembly instructions complete with Mullard specified Inductors Type WF2949 and WF2951. Bargain £4/19/6. Prealigned £5/5/- (p.p. 2/6).

**SINCLAIR KITS**

We carry full stocks of these famous designs as advertised.

**MICROMATIC**, New Six stage vest-pocket revr. (Kit) 59/6. **MICRO-FM** 7 transistor FM tuner-revr. (Kit) £5/19/6. **Z.12** combined 12 w. amp and pre-amp. built 89/6. **STEREO 25** de luxe pre-amp/control unit built £9/19/6.

**TAPE BARGAINS**

**1500' 7" REEL** American professional quality tape. 1½ hrs. playing at 3½ r.p.s. Leader and stop foils. In sealed boxes. 17/6 per reel (p.p. 1/- for first reel, 6d each after ordered at same time).  
**UNIQUE DOUBLE SIDED TAPE** on 5½" reels. Superb quality used normally. Ideal for experimenters too. 650' 9/6; 600' 8/6 (p.p. 1/- per single reel, 6d. for each additional).

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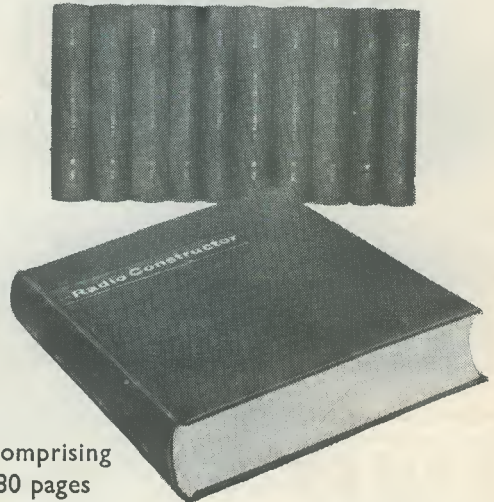
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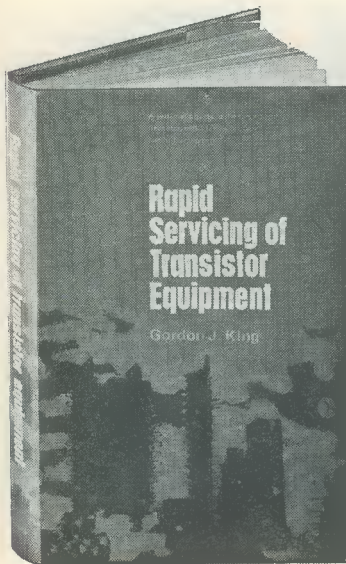
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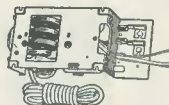
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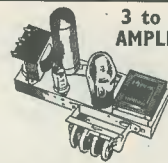
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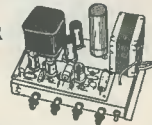
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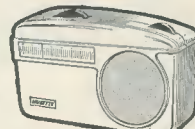
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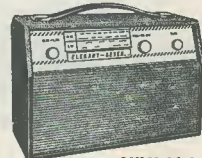
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# RADIOGRAM AMPLIFIER

by G. C. DOBBS, G3RJV

**A simple design, without complications, which is capable of offering a high quality output of 5 watts. The circuit includes a tone control and variable feedback, and sufficient reserve power is available to supply an f.m. or a.m. tuner unit**

THE AUTHOR WAS RECENTLY FACED WITH THE prospect of getting married and setting up a new home. The arrangements for the choice of furniture were left safely in female hands. However a radiogram was required and the author had to provide a suitable amplifier to go with an auto-changer deck and an f.m. tuner.

This amplifier had to be of reasonable quality with sufficient output to fill a fair sized room and also provide power for the f.m. tuner. A push-pull output circuit was dismissed as being too refined for the required output and quality. Eventually the circuit in Fig. 1 was evolved. This circuit, although not novel, is a simple "work first time" type of amplifier which uses easily obtainable components.

## Circuit Details

The input signal is applied to volume control VR<sub>1</sub> and thence to bass-boost control VR<sub>2</sub>, which functions in conjunction with C<sub>1</sub>. The signal on the slider of VR<sub>2</sub> is next passed to the EF86 pentode amplifier, V<sub>1</sub>.

The amplified signal at the anode of V<sub>1</sub> is next fed via C<sub>4</sub>, to the EL84 output pentode, V<sub>2</sub>. Resistor R<sub>x</sub>, is a grid stopper. This will not normally be required, whereupon the junction of C<sub>4</sub> and R<sub>6</sub> can be applied direct to the control grid of V<sub>2</sub>. If there appears to be evidence of high frequency instability, R<sub>x</sub> should then be inserted. Its value is not critical and may lie between 3.3kΩ and 10kΩ, and it should be mounted close to the valveholder tag. An alternative approach consists of fitting R<sub>x</sub> when initially wiring up the amplifier, after which it may be removed if it is found that no falling-off in performance occurs as a result. This alternative approach offers an insurance against any misleading shortcomings in performance which may be evident when trying out the amplifier circuit.

The output transformer is a Radiospares "Hy-grade" Universal component, which is rated at 60mA primary current and an overall power of 7 watts. The optimum anode load for V<sub>2</sub> is 5.2kΩ (transformer ratio 41 : 1 for a 3Ω speaker) and the transformer should be connected up to provide a load which is reasonably close to this value.

Negative feedback is obtained from the secondary of the output transformer by way of VR<sub>3</sub>, it being applied to the cathode circuit of V<sub>1</sub>. An unusual feature of the circuit is that VR<sub>3</sub> is a panel component and that the level of feedback is adjustable from the front of the amplifier cabinet. The control is set up to provide the desired quality of reproduction without too much loss in volume. If desired, a preset variable resistor may be used for R<sub>3</sub> instead of the panel control employed in the author's amplifier. The preset control is then set up for the quality/volume levels desired when the amplifier is initially brought into use, after which it may be left alone.

The h.t. supply is given by the circuit around V<sub>3</sub>, and h.t. current of 80mA at some 250 volts being available after smoothing choke L<sub>1</sub>. V<sub>1</sub> and V<sub>2</sub> require slightly less than 60mA, with the result that h.t. currents up to 20mA are available for a tuner unit. The h.t. feed to the tuner unit is passed via R<sub>11</sub> to the 4-way socket, Skt<sub>1</sub>. Resistor R<sub>11</sub> decouples the tuner unit supply from the amplifier h.t. line and should have a value in excess of 1kΩ. R<sub>11</sub> may also act as a dropping resistor if the tuner unit is intended to operate at h.t. voltages lower than 250. The value needed in R<sub>11</sub> can, of course, be worked out from Ohm's Law.

A 6.3 volt heater supply from T<sub>2</sub> is also fed to Skt<sub>1</sub>. The current rating of the 6.3 volt mains transformer winding specified in the Components List is 2 amps. Since V<sub>1</sub> and V<sub>2</sub> draw a total heater current of very slightly less than 1 amp, a heater



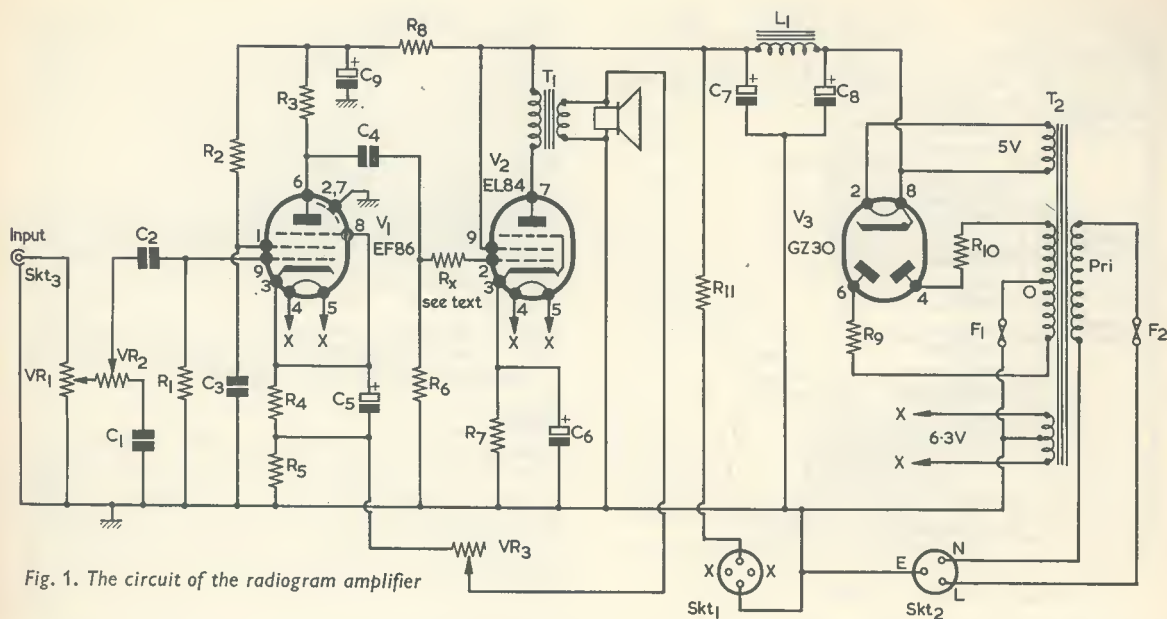


Fig. 1. The circuit of the radiogram amplifier

## COMPONENTS

### Resistors

(All fixed resistors  $\frac{1}{2}$  watt 10% unless otherwise stated)

R <sub>1</sub>	3.3M $\Omega$
R <sub>2</sub>	1M $\Omega$
R <sub>3</sub>	220k $\Omega$
R <sub>4</sub>	2.2k $\Omega$
R <sub>5</sub>	100 $\Omega$
R <sub>6</sub>	470k $\Omega$
R <sub>7</sub>	150 $\Omega$ , 1 watt
R <sub>8</sub>	100k $\Omega$ , 1 watt
R <sub>9</sub>	150 $\Omega$ , 1 watt
R <sub>10</sub>	150 $\Omega$ , 1 watt
R <sub>11</sub>	see text
R <sub>x</sub>	see text
VR <sub>1</sub>	500k $\Omega$ potentiometer, log track
VR <sub>2</sub>	500k $\Omega$ potentiometer, linear track
VR <sub>3</sub>	10k $\Omega$ potentiometer, linear track

### Capacitors

C <sub>1</sub>	390pF silver-mica
C <sub>2</sub>	0.02 $\mu$ F, 150V wkg.
C <sub>3</sub>	0.1 $\mu$ F, 350V wkg.
C <sub>4</sub>	0.01 $\mu$ F, 350V wkg.
C <sub>5</sub>	25 $\mu$ F electrolytic, 12V wkg.
C <sub>6</sub>	50 $\mu$ F electrolytic, 25V wkg.
*C <sub>7</sub>	16 $\mu$ F electrolytic, 350V wkg.
*C <sub>8</sub>	32 $\mu$ F electrolytic, 350V wkg.
C <sub>9</sub>	8 $\mu$ F electrolytic, 350V wkg.

\*C<sub>7</sub> and C<sub>8</sub> form a dual electrolytic capacitor

### Inductors

L <sub>1</sub>	Smoothing choke, 10H, 80mA
T <sub>1</sub>	Output transformer (to match 5.2k $\Omega$ to speaker) "Hygrade" Universal (Radio-spares)
T <sub>2</sub>	Mains transformer. Secondaries: 250-0-250 volts at 80mA; 5 volts at 2 amps; 6.3 volts, centre-tapped, at 2 amps.

### Valves

V <sub>1</sub>	EF86
V <sub>2</sub>	EL84
V <sub>3</sub>	GZ30

### Fuses

F <sub>1</sub>	100mA fuse and holder
F <sub>2</sub>	2 amp fuse and holder

### Sockets

Skt <sub>1</sub>	4-way power outlet socket, 4-pin or octal (with 4 pins unused) valveholder
Skt <sub>2</sub>	3-way mains connector (socket and plug) type P.340 (Bulgin) or similar
Skt <sub>3</sub>	Coaxial socket
	1 B9A valveholder with skirt and screen
	1 B9A valveholder without skirt
	1 Octal valveholder

### Miscellaneous

	Perforated strip and turret tags (see text)
	1 Stand-off insulator
	Aluminium chassis, 8 × 12 × 2½ins.

N.B. Radiospares components may only be obtained through retail channels.

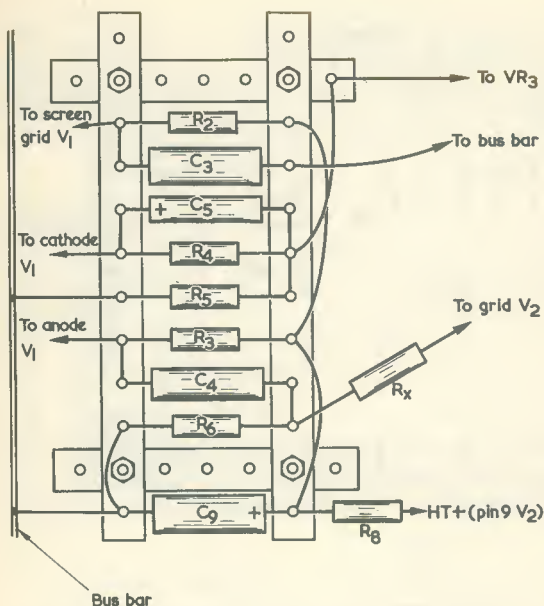


Fig. 2. The layout of the tagstrip assembly. As is discussed in the text,  $R_x$  may not be required

current of 1 amp becomes available for the tuner unit. It is important to note that the 6.3 volt transformer winding is centre-tapped. In consequence, neither side of the heater wiring in the tuner unit must be connected to chassis or damage will result.

$R_9$  and  $R_{10}$  are limiter resistors, and keep rectifier surge currents to a low level.

No on-off switch is shown in Fig. 1 since, in the author's version, the amplifier is turned on and off by a switch mounted elsewhere in the radiogram cabinet. This course has the advantage that mains wiring is kept away from the amplifier circuit proper, as would occur if any of the three panel controls were fitted with a switch.

The mains input connection is made by way of socket  $Skt_2$ . Care should be taken to ensure that the corresponding earth connector of the plug is reliably connected to the earth pin of the mains plug which fits into the supply socket in the room.

### Chassis Construction

As the amplifier was to be mounted in a reasonably large cabinet, a chassis giving plenty of room for construction was used. This was a commercially produced aluminium chassis measuring  $8 \times 12 \times 2\frac{1}{2}$  ins. with strengthened corners. In this age of miniaturisation this chassis may seem very large for a three valve circuit, but miniaturisation for its own sake is merely adding difficulties.

The chassis is divided into two by an aluminium (or tin plate) screen. The front half contains the amplifier wiring and the rear portion contains the power supply. The position of the screen is shown in Fig. 3. Fig. 4 shows the layout of the top of the

chassis; no dimensions are given as these will vary depending on the sizes of  $T_2$  and  $L_1$ . The valve holder for  $V_1$  is a skirted type which will take a screening can. The dual smoothing capacitor  $C_7$ - $C_8$  need not necessarily be the chassis mounting type, in which case there is ample room to mount it with a "Terryclip" under the chassis.

The power sockets are mounted with the fuseholders on the back of the chassis.  $F_2$  could be omitted but the cost of an extra fuseholder is justified by the added protection it affords. The transformer  $T_2$  must be firmly mounted, and if it is of the drop-through variety, with direct leads coming from the various windings, it is advisable to take any spare leads which are not required to a tagstrip to obviate the risk of short-circuits to chassis.

### Wiring

As is common practice in audio amplifier construction, a busbar is run round the amplifier section of the chassis to provide earthing points. This busbar is made of copper wire as thick and stiff as possible, and 14 s.w.g. or 16 s.w.g. wire would be suitable. The prototype used  $\frac{1}{4}$  in. copper strip. The position of this busbar is shown in Fig. 3. One end is fixed to a stout chassis tag on the side of the chassis, and this must make good contact with the chassis. The other end is taken to a stand-off insulator as shown. Chassis connections in the power supply section are taken to a stout chassis tag located near  $C_7$ - $C_8$ .

Most of the construction of the amplifier circuit is centred around a tagstrip assembly mounted in the centre of the chassis, as shown in Fig. 3. For this assembly, the writer used Radiospares Perforated

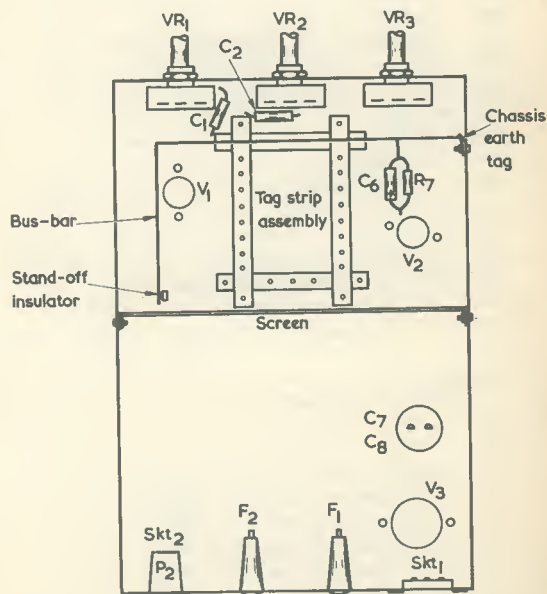


Fig. 3. The layout of the major components under the chassis



Strip and Turret Tags. The perforated strip has a hole spacing of 0.375in., and is supplied in 32-hole lengths. The turret tags are inserted where desired. Two lengths of strip with 12 holes and two with 7 holes are needed, these being assembled as shown in Fig. 2. Turret tags are fitted at the holes where, as is evident from Fig. 2, connections to the components are obviously made. The strips are secured on 6BA bolts 1in. long. The whole assembly is bolted to the underside of the chassis, with nuts under the strips to space the tags well away from the chassis. If the tags and strips used by the author are not available, a conventional group board could be employed instead.

The layout of components wired up on the perforated strip assembly is also shown in Fig. 2. If modern components are used there should be no difficulty in mounting them to the tags as illustrated. There is ample space for the wiring, and leads to the valveholders can take a route which avoids hum and prevents a "snake pit" appearance.

V<sub>1</sub> valveholder should be oriented such that its anode pin is closest to R<sub>3</sub>, and V<sub>2</sub> valveholder should be oriented such that its grid pin is closest to R<sub>6</sub>. R<sub>x</sub> may, or may not, be fitted as discussed earlier. The positions of C<sub>1</sub>, C<sub>2</sub>, C<sub>6</sub> and R<sub>7</sub> are shown in Fig. 3. R<sub>1</sub> may be conveniently mounted at V<sub>1</sub> valveholder, whilst a suitable h.t. positive anchoring point for R<sub>8</sub> (see Fig. 2) is given at pin 9 of V<sub>2</sub>.

The wiring to the three controls, to V<sub>1</sub> and V<sub>2</sub> valveholders, and in the power supply section, follows normal practice, and constructors may work from the circuit diagram of Fig. 1. Twisted wiring should be employed for the heater connections to V<sub>1</sub> and V<sub>2</sub>. V<sub>1</sub> is fitted with a screening can.

#### Feedback Check

Before the amplifier can be brought into service the feedback circuit should be checked to ensure that the voltage fed back from the secondary of T<sub>1</sub> is in correct phase. During construction, the connections to T<sub>1</sub> secondary should be of a temporary nature only, as it may be necessary to reverse them during the feedback check.

Connect a loudspeaker to the amplifier and adjust VR<sub>3</sub> so that it inserts maximum resistance into circuit. Switch on the amplifier and allow it to warm up. If it breaks into oscillation the feedback is positive, whereupon the amplifier must be switched off at once and the connections to T<sub>1</sub> secondary

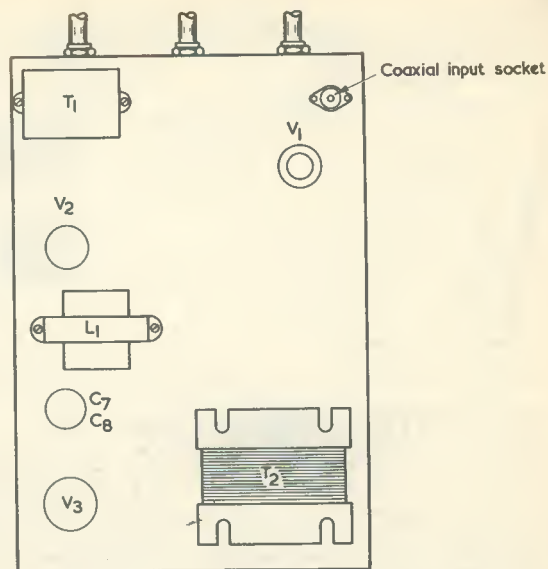


Fig. 4. The components above the chassis

reversed. If no oscillation occurs initially, reduce the resistance inserted by VR<sub>3</sub>. If this causes oscillation to occur (or gain to increase) then the amplifier must be switched off and the secondary connections of T<sub>1</sub> reversed. Correct feedback is given when a reduction in the resistance inserted by VR<sub>3</sub> causes a reduction in gain. This will also, incidentally, cause a variation in the tone of the reproduced signal.

It is important to note, when carrying out these tests, that the amplifier must be switched off immediately if oscillation becomes evident. The oscillation may be at high amplitude and, if allowed to continue, might damage the speaker.

#### Conclusion

In conclusion, the writer would like to state that the amplifier described here has, at the time of writing, been in use for six months and that it has given good service with both the record player deck and the f.m. tuner. The quality is adequate for the tastes of the family, which range from pop to Bach organ music.

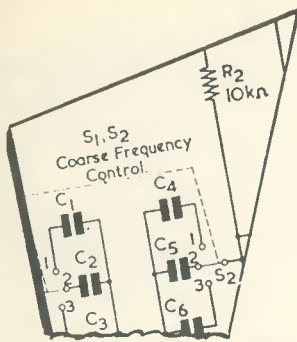


## 1967 International Radio Engineering and Communications Exhibition

From 1st January, 1967, the Radio Communications Exhibition will be renamed the International Radio Engineering & Communications Exhibition and will be at a new venue, The Royal Horticultural New Hall, this will double the space of the previous Exhibition at Seymour Hall.

A new opening date will be earlier than previous Exhibitions, this will be on Wednesday, 27th September and Dr. J. A. Saxton, C.B.E., D.Sc., Ph.D., A.R.G.S., M.I.E.E., Director of Radio & Space Research Station has kindly consented to open the Exhibition. The Exhibition closes on Saturday, 30th September.

The Manufacturers 1967 Silver Plaque is again to be won outright by the most outstanding radio equipment of the Year. Due to the success of the Closed Circuit Television display this will now be developed as part of the Educational feature.



# VISUAL SWITCHING INDICATOR FOR TRANSISTOR EQUIPMENT

SUGGESTED CIRCUIT No. 195

By G. A. FRENCH

A SHORTCOMING WITH BATTERY operated transistor equipment is that it is impracticable to fit a pilot lamp to give warning that the equipment is switched on, due to the relatively high current which such a lamp would draw continually from the battery. If, on the other hand, a pilot lamp is not fitted, it is possible to forget to switch the equipment off after use, whereupon current is once again unnecessarily drawn from the battery.

This month's Suggested Circuit offers a rather unusual solution to this problem, in so far that indication of switching on and off a piece of equipment is given by a flashing lamp. When the equipment is switched on the lamp flashes. It similarly flashes immediately after switching off. Thus, the lamp is only illuminated for very short periods and the current it draws from the battery is almost negligible. The writer feels that the combination of circumstances offered by the flashing indicator is much more liable to remain in the mind of the user of the equipment than would simple observation of, say, the position of a switch dolly. The equipment user is reminded of the presence of the flashing lamp on switching on, whereupon he is more likely to remember that the lamp has to flash again on switching off and to remember to carry out the actual switching-off operation itself. The flashing lamp type of indication can also be helpful if the switch is ganged with a miniature potentiometer. The switch toggle action of some miniature potentiometer-switch assemblies is very light, and does not give a positive indication that the switch has operated. The flashing lamp can

show that a component of this nature has switched off reliably.

For reasons that are explained later, the circuit cannot cause an effective switching-off flash to be given if the equipment has a high-value bypass capacitor connected across its supply lines. This rules out its use with many commercially manufactured transistor superhet radio receivers, but should not prevent its being employed with transistorised test equipment and the like which does not require a high-value bypass capacitance. The equipment circuits themselves form part of the circuit which causes the lamp to flash on switching off. Since it is impossible to foresee what form these may take up, the performance of the circuit cannot be guaranteed for any specific piece of equipment. It is necessary to check the circuit in experimental form first; if it then functions satisfactorily the circuit may be built permanently into the equipment.

The circuit can also be built up as a novelty device with which to mystify one's electronically-minded friends. Other applications in which a lamp flashes when two contacts are closed, and then flashes again when they open, may also suggest themselves to the reader.

As presented here, the circuit is intended for equipment which is powered by a 9-volt battery.

## The Circuit

The circuit of the visual switch indicator is given in Fig. 1. At the right of this diagram is the 9-volt battery which normally supplies the equipment. This is connected to the equipment on-off switch, after which two supply lines pass to the circuits of

the equipment, as is indicated by the arrows at the left. The components forming the visual indicator connect across the supply lines immediately after the on-off switch.

Let us commence by assuming that, in place of the equipment circuits, we have a fixed resistor of the order of 1kΩ. This can be considered as being a rough equivalent of the equipment circuits if the latter draw nearly 10mA at 9 volts.

When the equipment on-off switch is initially closed, the 9 volt supply is applied to the series combination given by the 3,200μF electrolytic capacitor, the 6 volt lamp and the diode. The diode is connected up with a polarity which enables a charging current to flow to the capacitor via the lamp. The charging current causes this lamp to flash, it becoming extinguished again when the capacitor becomes fully charged. This is the flash which indicates that the equipment is switched on.

At this stage the transistor has no effect on circuit operation. Due to leakage current in the capacitor and the small forward voltage dropped across the diode, the emitter of the transistor is more negative than its base and it is fully cut off.

Let us next switch the equipment off. As soon as the switch contacts open, the voltage from the battery ceases to appear in the circuit. The base of the transistor becomes, in consequence, connected to the upper supply line by way of the 1kΩ resistor which, we have assumed, is equivalent to the circuits of the equipment. This connection causes a relatively heavy base current to flow (from the charged capacitor) and the transistor becomes fully conductive. As a result the capacitor now dis-



charges into the lamp, causing it to flash a second time. The capacitor is then discharged, ready to charge again when the equipment switch is once more closed. During the switching-off period the diode has no effect on circuit operation. As soon as the base of the transistor goes negative of its emitter the diode is reverse-biased and does not conduct.

As we have seen, assuming that the equipment circuits are replaced by a resistor, the circuit of Fig. 1 causes the lamp to flash once when the on-off switch is closed, and to flash once again when it is opened. A double-pole on-off switch is shown in Fig. 1, but the circuit will function in the same manner if a single-pole on-off switch, inserted in only one of the supply leads, is used instead.

### Results With the Prototype

In practice, the circuits of the equipment to which the flashing indicator is connected will not function in exactly the same manner as a linear fixed resistor, and will tend to draw disproportionate currents as the voltage across the supply rails varies. This effect is unimportant provided that the equipment circuits draw sufficient current to cause the transistor of Fig. 1 to become conductive immediately after the on-off switch has opened. If, however, the equipment has a high-value bypass capacitor across its supply rails the voltage across this capacitor may fall too slowly after switching off, whereupon the requisite base current required by the transistor of Fig. 1 does not become available and the lamp does not flash.

The prototype circuit was checked with different values of fixed resistance to take the place of the equipment circuits. It was found that, with a fixed resistor of  $1.5k\Omega$ , the flash given on switching off was about 20% less bright and long as the flash given on switching on. This corresponds roughly to equipment circuits which draw a current of 6mA at 9 volts. Higher values of fixed resistor resulted in a weaker flash on switching off.

When a  $100\mu F$  capacitor was connected across the  $1.5k\Omega$  resistor, the flash given on switching off was noticeably weaker than the flash which appeared on switching on. This situation corresponds approximately to equipment circuits drawing 6mA at 9 volts, and having a  $100\mu F$  bypass capacitor across the supply rails.

With a  $910\Omega$  fixed resistor (corresponding roughly to equipment drawing 10mA at 9 volts and, also to the  $1k\Omega$  resistor we assumed when

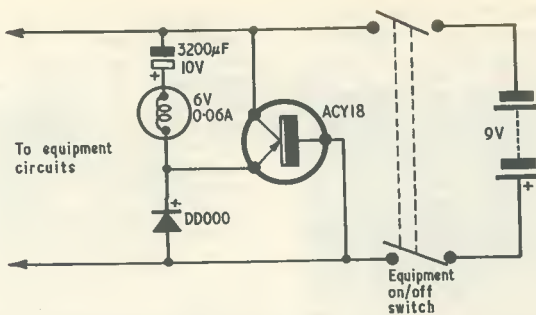


Fig. 1. The circuit of the flashing indicator. This connects across the supply lines immediately after the on-off switch of the associated equipment

describing circuit operation) the flash on switching off was very nearly the same as that given on switching on. When a  $100\mu F$  capacitor was connected across the  $910\Omega$  resistor, the flash on switching off was again weakened, although it was sufficiently bright this time to justify, as a border line case, the usefulness of the circuit under these conditions.

A resistor of  $470\Omega$  resulted in a flash on switching off which was virtually equivalent to that given on switching on. This resistor corresponds roughly to equipment circuits drawing 18mA at 9 volts. Connecting a  $100\mu F$  capacitor across this resistor resulted in a weaker flash on switching off, but the flash was bright enough for the circuit action to be considered usable.

This maximum average base current for the transistor employed in the Fig. 1 circuit is 250mA, and a current approaching this figure may flow momentarily if the equipment circuits are replaced by a  $36\Omega$  resistor. A resistor of this value was tried and the flash on switching off,

both with and without the  $100\mu F$  capacitor, was equivalent to that given on switching on. The use of the  $36\Omega$  resistor corresponds approximately to equipment drawing 250mA, and is representative of the highest current which should be allowed to flow in the base circuit of the particular transistor specified when switching off.

As is indicated by these results, the circuit should operate reliably with equipment circuits drawing 6mA or more at 9 volts, provided that bypass capacitance across the supply rails does not cause the drop in voltage on switching off to be too slow. As the current drawn by the equipment circuits increases, higher values of bypass capacitance can be tolerated. Working from results given with the  $470\Omega$  resistor, it would appear that it would be possible to get good results with equipment circuits drawing 18mA or more and having a bypass capacitance of up to  $100\mu F$ .

However, as was stated earlier, the equipment circuits cannot be precisely represented by a fixed resistor, and the only way of making

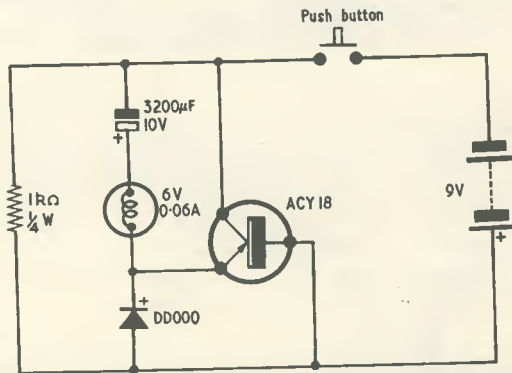


Fig. 2. A circuit which demonstrates the operation of the flashing indicator. The lamp flashes when the push-button is depressed, and similarly flashes when the push-button is released

entirely sure that the circuit will work with any specific item of equipment is to try it out experimentally with that item itself. If results are satisfactory, then the indicator circuit can be permanently installed.

Commercially manufactured transistor superhet radio receivers usually draw a quiescent current of some 10mA, and many models have a bypass capacitance across the supply rails of the order of 200 $\mu$ F. (Frequently, this is given by 100 $\mu$ F immediately after the on-off switch, with a second 100 $\mu$ F following a low value decoupling resistor). Such receivers will probably *not* allow the indicator circuit to give good results when switching off. Some receivers have lower bypass capacitances and these may give successful results with the circuit, although this point can, again, only be confirmed by an experimental check.

#### Components

A few words need to be stated concerning the components.

The capacitor may be any electrolytic component having a value of 2,500 $\mu$ F or more and a working

voltage of 9 volts or greater. The component used in the prototype circuit was a Mullard electrolytic capacitor in the C431BR series. This had a value of 3,200 $\mu$ F and a maximum voltage rating of 10 volts.

It is necessary to use a lamp which requires a low current for full illumination. The type specified here is a Radiospare 6 volt 0.06 amp component. This has the normal m.e.s. base and is available from Home Radio (Mitcham) Ltd., under Cat. No. PL7. The voltage initially applied to this lamp during a flash is in excess of 6 volts, but the brightness of the flash is similar to the brightness given when continually illuminated at 6 volts. It is probable that the voltage across the lamp is only slightly higher than 6 volts when its filament reaches full brightness during the flash.

The diode may be any silicon rectifier capable of passing 450mA or more. (This is a conservative rating which assumes 20 $\Omega$  cold resistance in the lamp). A convenient rectifier, which was used in the prototype, is the Lucas DDOOO which has a maximum forward

current rating of 500mA.

An ACY18 was employed in the prototype circuit, this being a small transistor which offers a reasonable gain and which has a maximum average collector current rating of 500mA. This transistor, or one having equivalent or better properties with respect to gain and maximum current ratings, should be employed in circuits made up to the design.

#### Novelty Device

The "novelty device" application referred to at the start of this article is shown in Fig. 2. This is the same as Fig. 1 with the exceptions that the on-off switch is now replaced by a single-pole push-button, and the equipment circuits by a 1k $\Omega$  resistor. When the push-button is pressed the lamp flashes, as it does when the push-button is released. The circuit may be used to intrigue electronically-minded friends if all the components except the push-button and lamp are enclosed in a box. The contacts of the push-button should be open to inspection.



## 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*

**Canadian VRL Receiver.**—S. Smith, 19 Hyde Road, Kenilworth, Warks—circuit or handbook for this 19 valve receiver.

\* \* \*

**Ferguson AM/FM Autoradiogram.**—O. E. Wynn, 13 Downsland Drive, Brentwood, Essex—circuit diagram (model 379RG, serial No: 4796), purchased in 1958.

\* \* \*

**Indicator Type CRT2.**—G. C. Willis, 2 Cedartree Gardens, Whitley Bay, Northumberland—circuit or any details.

\* \* \*

**Philips EL3531D Stereo Tape Recorder.**—L. F. Woods, 30 Beaumont Avenue, Richmond, Surrey—borrow or purchase circuit diagram or manual.

\* \* \*

**BT13A Brayhead Turret Converter.**—A. L. Tower, 16 Broomhill Gardens, West Hartlepool, Co. Durham—this converter has Band I Channel 5 and Band III Channel 8 coils and 10.5 Mc/s i.f. Coil winding data or source for purchase of coils for

Band II Pontop Pike requested, together with any other information regarding use as AM/FM sound tuner head.

\* \* \*

**No: 19 Set.**—A. Giles, 20 Fieldway, Dagenham, Essex—circuit diagram, willing to purchase.

\* \* \*

**Greyslaw CR50 Bridge.**—J. R. Wright, 156 Thompson Street West, Darlington, Co. Durham—circuit diagram.

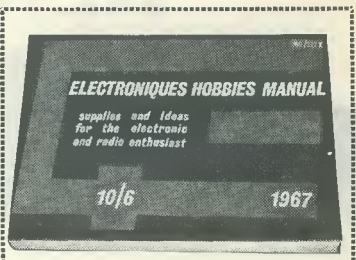
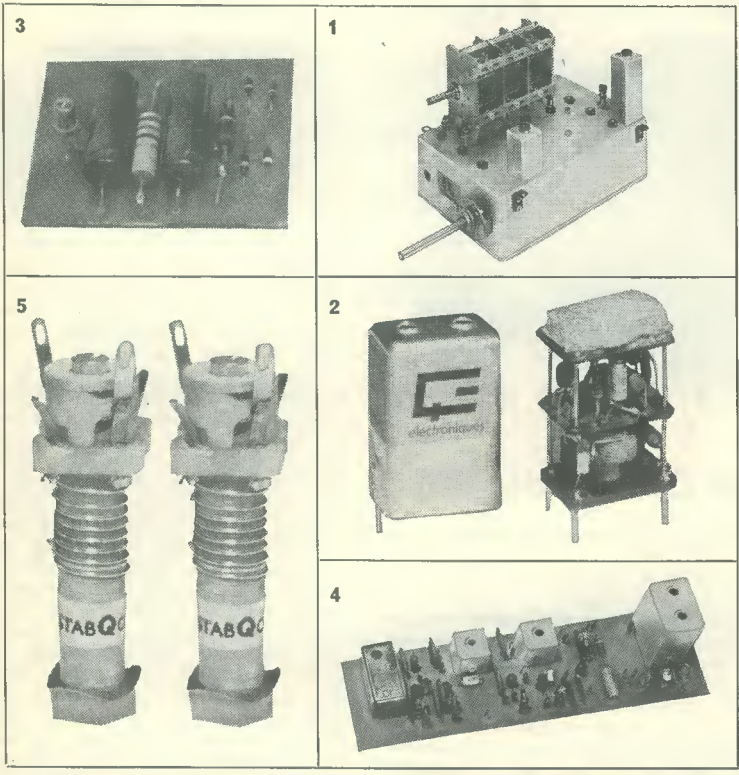
\* \* \*

**Cossor 339A Oscilloscope.**—A. Davenport, 1472 Ashtonold Road, Higher Openshaw, Manchester 11—any information, circuit or manual. Also circuit of Transwave 2-band transistor radio.

\* \* \*

**Admiralty Pattern A1211 Oscilloscope.**—A. E. Harvey, 39 Curlieu Road, Oakdale, Poole, Dorset—circuit or manual, loan or purchase. Made by E.M.I.E.D. Ltd, Wells, this unit bears the legend A/S386 Serial No: 1072.





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**1 Transistor Coil Packs**  
 These silicon transistor units are available in General Coverage and Hamband versions. The IF frequency is 1620 Kc/s, ready for use with our filters and IF amplifiers as well as existing receivers as the second IF. The Manual contains comprehensive technical data and other useful information on these items.

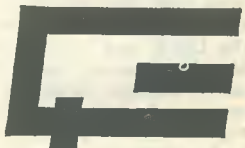
**2 Oscillator Modules**  
 Fully transistorised, these oscillator units can be used for BFO, VFO or CIO applications. The BFO units include a variable capacitance diode as the tuning element, permitting remote control by linear law potentiometer. Extremely stable (better than -002% per degree C), they have an exceptionally pure oscillator waveform.

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 These small stabilised power units operate directly from 6.3V AC heater supply. Two outputs available: 6.2V at 50mA Zener stabilised, and 9.0V at 70mA MAX unstabilised. Either polarity can be earthed providing AC supply is floating.

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 Two units are available—one at 1.62 Mc/s for use with Qoilpax, the other for use at 455 Kc/s as a second conversion IF strip or as a main 455 Kc/s unit. Both include a half lattice crystal filter AGC control AM and SSB detection and BFO injection for CW reception. A third unit, also at 455 Kc/s, uses a ceramic filter.

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 A comprehensive range of transistor coils is available for 455 Kc/s and 1.62 Mc/s, together with a complementary range of IF transformers. Send now for your Manual, on the coupon above, to this address: Electronics (Prop. STC Ltd.) Edinburgh Way, Harlow, Essex. Telephone: Harlow 26777.

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## High-performance Car Radio Kit

You can have a superb Long and Medium wave entertainment wherever you drive and more motoring pleasure with the small, compact, high-performance Heathkit Car Radio, CR-1. It can be fitted to any make of car having 12 volt positive or negative earth system.

A six-transistor and 2-diode circuit is used to give a high quality performance and ease of assembly is assured by the use of printed circuit techniques. No alignment is required—the tuning unit is supplied assembled and factory aligned, as are the transformers. An aerial trimmer is incorporated and is accessible beneath the radio in order to make adjustments for optimum reception after installation. High sensitivity and an extremely effective automatic gain control (a.g.c.) circuit ensure that reception of weak and distant stations is possible with minimum fading. Long or Medium wave is selected by a push-button switch and a third button (Tone) cuts off the higher audio frequencies when the button is pressed. This tone push-button therefore gives a choice of sound when listening to speech or music.

The tuning scale is illuminated and in addition a red "jewel" gives a clear indication whether the radio is on or off.

The front panel is finished in light and dark grey with a white tuning scale and is seated within a chromium escutcheon. The whole styling is pleasing and will enhance the facia of your car.

## Britain wins two gold medals at Leipzig Fair

Two British firms have won Gold Medals and Diplomas for outstanding products at the Leipzig Fair. They are Boosey & Hawkes Sales Ltd. of Edgware, Middx., whose award is for a B Flat and F Tenor Trombone Model International, made by Besson and Co., Edgware, and B.S.R. Ltd. of Old Hill, Staffs., whose award is for the UA 50 Mini-Changer which is the smallest portable record changer in the world.

The B.S.R. company started in a small way in 1932 making public address equipment. During the war it made equipment to counteract the acoustic mine, and also amplifiers and beat frequency oscillators for the Admiralty. Chairman is Dr. D. M. McDonald. Of total products, 55% are exported to the U.S.A. and another 24% to other markets. There are two factories in Northern Ireland, the firm being the biggest employer of labour in Londonderry, another factory at the new town of East Kilbride, Scotland, and two more at Stourbridge and Old Hill, Staffs., which is the Headquarters. Altogether, 5,000 people are employed in the U.K. There is another factory in Australia with sales offices there, and sales offices in France, West Germany, Italy, New Zealand, America and Canada.

## Safety Connections

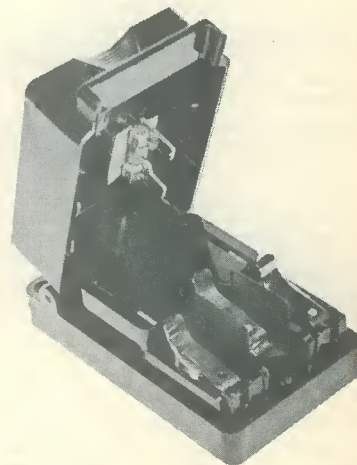
The Rendar Safebloc is an ingenious device to allow electrical equipment to be safely connected to the mains supply, *in seconds*.

Although the Rendar Safebloc has been known to the electrical trade for some years, the device has not previously been offered to the general public, and it is certain that many people using such electrical equipment as soldering irons, projectors, sewing machines or power drills will find it invaluable.

Basically, the unit consists of a black plastic casing, into which may be wired a length of cable and a plug suited to the users main supply socket. From this point on, the user need not attach plugs to any other equipment. When the lid of the Safebloc is opened, three colour-coded spring clips are revealed in the base, and a heavy gauge fused bridging piece may be seen attached within the lid. The action of opening the lid automatically cuts off the supply of current and the appropriate wires of the cable to the electrical apparatus may then be inserted into the spring clips. Closing the lid completes the circuit and the apparatus is then used normally.

The Safebloc can be fixed to a workbench or wall with the fixing screws provided, or may be employed at the end of a trailing lead for utmost versatility.

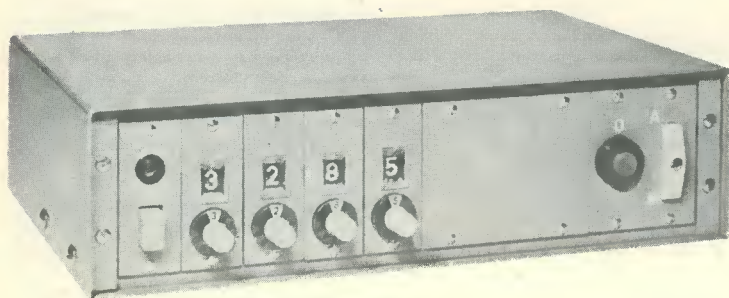
The Rendar Safebloc is available from Guildford Mail Order, 6 Leapale Road, Guildford, Surrey.



The Rendar Safebloc in the open position.



# COMMENT



## The "Radiatron" Batch Counter

Radiatron have developed and can now supply a fully automatic batch counter comprising four Elma single decade read-out counters and other modules. The unit can be pre-set to give a relay operation at any number and then either stop or automatically reset to zero and recommence counting—giving a relay operation at the end of each batch. The unit will operate direct from 220/240 volts, 50 c/s.

The number to be predetermined is set up on the rotary switches on the front plates of the counters. When the batch commences, the counters count up from zero, and on reaching the pre-set number energise relays. If the slide switch on the front is set to "A" for Automatic, the counters will automatically reset to zero, and after a delay of approximately  $\frac{1}{2}$  second will start counting up again. This process will repeat itself automatically. If the slide switch is set to "M" for Manual, the counters will stop when indicating the pre-set number. They can then be reset to zero by either pressing the push button on the front or by switching back to "A". Each time the counters reach the pre-set number, a relay changes over a set of contacts for external operation; (capacity 50 watts).

This unit is ideal for batching operations where very high speed operation is not required and expense is to be kept to the minimum. It will operate from impulse sources such as micro-switches; pressure switches; contact operations etc. as long as there is a minimum pulse length of 28 m.s. and a minimum pulse interval of 12 m.s. In addition to pre-determining the facility of electrical read-out when B4 counters are used, it enables remote indication or direct print out when required.

## Tool Kit for Transistorised Circuits

In the building, maintenance, and repair of transistorised circuits, the small size and inaccessibility of many of the components creates special problems for the technician. With this in mind, many new tools have been devised in recent years and a selection of those most frequently in demand is now available, in a neat zip-case, from Henri Picard & Frère Ltd.

This Transistor Tool Kit 1900 TR contains 18 tools held in cut-out plastic foam to eliminate retaining straps. The selection includes a 14mm magnifying contact mirror, a 30 watt soldering pencil, a flexible screwdriver, a screw-positioner, hook tweezers for removing excess solder and a special side cutting nipper. Amongst the more conventional tools are miniature screwdrivers in five sizes, 2 sizes of grub screw screwdrivers and one for Phillips screws, a crown shear and two pairs of specially shaped electrician's pliers.

The complete kit weighs just over 2lb and measures 10 x 13 x  $1\frac{1}{2}$  in. A large pocket is provided for documents and there is ample room for small additional accessories. The price is 10 guineas.

## TV Fault Finding

A new edition, the fourth revised edition, of our best seller *TV Fault Finding* is now available.

The book has been expanded and brought up to date where necessary, and now includes all the relevant information for finding faults on 625 as well as 405 lines.

Like the previous editions the book is profusely illustrated, including many photographs of faults actually shown on a television screen. All the principal features are retained, including the extremely useful fault finding guide which enumerates the faults, explains their probable cause, and is indexed to the relevant part of the book discussing the fault.

This latest edition, completely edited and revised by J. R. Davies the well known author of our *Understanding Television*, comprises 124 pages and costs only 8s. 6d., or 9s. 0d. by post.

The term "best seller" is no exaggeration in this connection, more than 90,000 copies have been sold of earlier editions.

## cartoonsmile



CUTTY

"... and to read today's short story we have Charles Duckworthy."



# AUDIO FREQUENCY Q-MULTIPLIER

by J. M. Cox, G8AFL

This ingenious approach enables a single b.f.o. tone to be boosted by way of a simple circuit using low-cost components

THE TECHNIQUE OF SHARPENING the response of a receiver i.f. amplifier by the use of a Q Multiplier is well known. In practice a high Q tuned circuit is effectively connected in parallel with an early i.f. transformer. At resonance the tuned circuit will allow signals to pass unattenuated, whilst at all other frequencies the signals are attenuated by an amount dependent on the Q of the tuned circuit.

If the tuned circuit is used in conjunction with a valve or transistor amplifier to which controlled positive feedback may be applied, then the effective Q of the tuned circuit will be multiplied by approximately the gain of the amplifier. In this way a Q of 2,000 or 3,000 may be obtained, so producing very narrow bandwidths.

For c.w. operation it is not always sufficient to have narrow i.f. bandwidths. Instead, a means of selecting the wanted audio difference frequency resulting from b.f.o. operation is needed. Typically this frequency may be 1,000 c/s.

To fulfil this requirement very narrow bandwidth audio filters are often employed, utilising large and expensive inductors. The circuit shown in Fig. 1 eliminates the need for these components and replaces them with a simple RC feedback network. As an extra bonus this arrangement provides a useful gain rather than the insertion loss introduced by a conventional bandpass filter.

The circuit will be recognised as that of the familiar phase-shift oscillator, the network comprising

$C_1, R_1; C_2, R_2;$  and  $C_3, R_3$  producing  $180^\circ$  positive feedback at a frequency depending on the value of R and C. This frequency may be found from the expression:

$$f(c/s) = \frac{1}{2\pi RC \sqrt{6}}$$

where R and C are in ohms and farads respectively.

Fig. 2 presents this equation in a somewhat more convenient form. For frequencies outside the range shown in Fig. 2 it is only necessary to remember that as CR decreases, frequency increases. For example, if a frequency of, say, 800 c/s is required, from Fig. 2 we see that for 80 c/s a CR of 0.81 is required, whereupon 800 c/s will require a CR of 0.081.

The attenuation of the feedback circuit is approximately 29 and if the amplifier has a gain in excess of this figure oscillation will take place. If however, the gain of the amplifier is less than that required to maintain oscillation, then with input and output connections as shown in Fig. 1 the device will behave as a narrow bandwidth selective amplifier. The halfpower bandwidth will be of the order of 20 to 25 c/s at a centre frequency of 1,000 c/s.

## A Practical Circuit

Typical component values are given with the practical circuit of Fig. 3. It should be noted that, since a transistor is used as the active element the feedback circuit has been rearranged to produce current feedback. The input and output series resistors,  $R_1$  and  $R_6$ , are included to prevent changes in load and source impedance from affecting the frequency of operation. The values used in the feedback circuit of Fig. 3 will provide  $180^\circ$  phase shift at a frequency of 650 c/s, but component tolerances and the load presented by the transistor will modify this somewhat. By using a twin gang variable resistor in place of  $R_4$  and  $R_5$  in Fig. 2, some measure of frequency adjustment may be obtained.<sup>1</sup>

The bandwidth of the device may be changed by the variable resistor in the emitter circuit. This control will also affect the amplitude of the output, and to some extent the centre frequency. The value of the fixed emitter resistor,  $R_7$ , should be chosen so that with the variable control,  $R_8$ , set for minimum bandwidth (i.e. maximum gain) oscillation

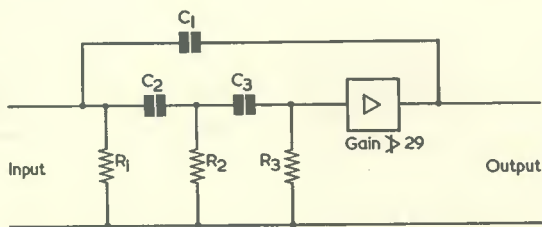


Fig. 1. A narrow bandwidth amplifier

<sup>1</sup> In Fig. 3 the phase-shift resistors are  $R_4, R_5$  and  $R_6$ . See, for instance, the section on phase-shift oscillators in the *Mullard Reference Manual of Transistor Circuits*.—Editor.



does not take place. In view of the wide gain spread of most suitable transistor types it might even be advisable to make  $R_7$  variable.

Fig. 4 shows the response of the amplifier. Curve A was obtained with  $R_8$  set to minimum resistance and curve B with a total emitter resistance of  $2k\Omega$ .

In common with all other narrow band filters this device should be used in the receiver circuit at a point where the signal level is low, preferably immediately following the detector. At minimum bandwidth settings of  $R_8$  there will be a tendency towards self-oscillation if the stage is overdriven.

#### Alternative Transistors

In view of the relatively high attenuation of the phase shift network (29), and to allow for losses due to the input and output impedances of the transistor, the small signal current gain ( $h_{fe}$ ) of the transistor should not be less than approximately 50 to maintain oscillation. In this particular application, it is not absolutely necessary for the transistor to be able to reach oscillation. Nevertheless, in the interests of high Q it is still desirable

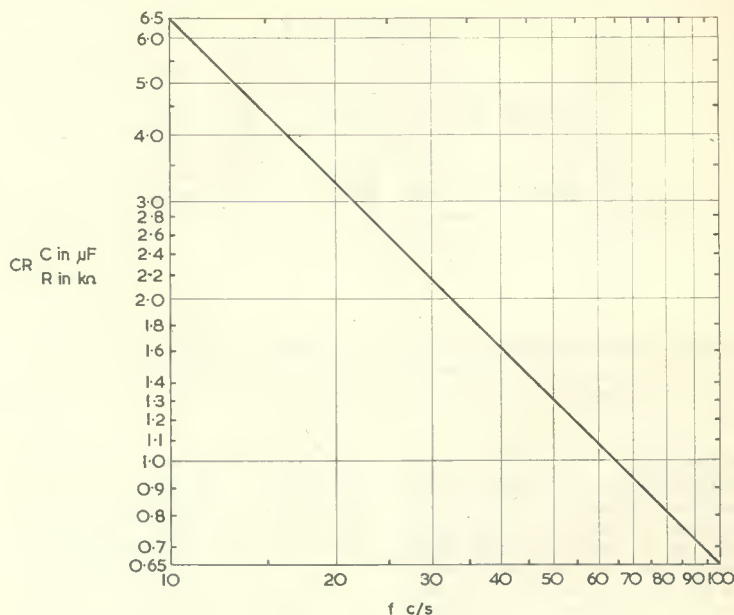


Fig. 2. Graph showing CR in terms of frequency for a  $180^\circ$  phase shift in a network having three equal resistances and three equal capacitances

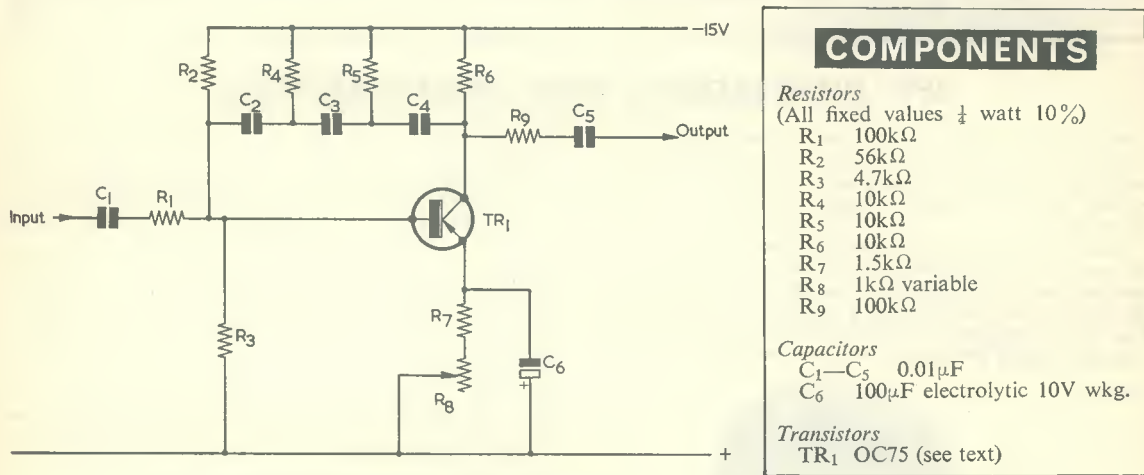


Fig. 3. The circuit of the audio frequency Q-Multiplier

to have as high a gain as possible without oscillation taking place. Some suitable transistor types are as follows: OC75, used by the author; NKT213; GET898; 2G308; 2N1309.

It should not be assumed that these transistors are equivalents since such is not the case; they merely have sufficiently high  $h_{fe}$  to operate satisfactorily in the circuit.

#### Power Supply

The power requirement of a device

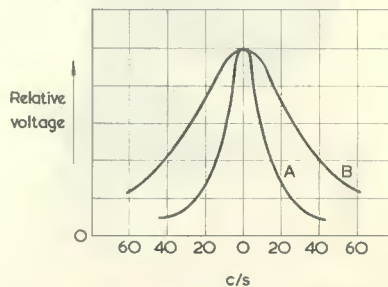


Fig. 4. Response curves obtained with the Q-Multiplier

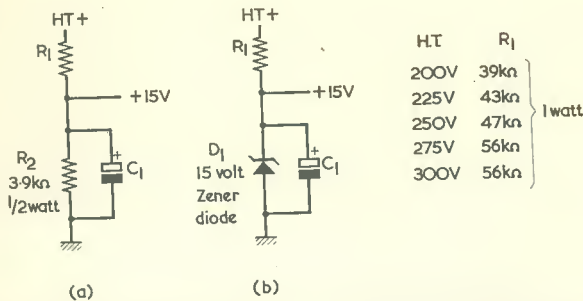


Fig. 5. Two methods of obtaining a power supply for the Q-Multiplier from a receiver h.t. rail. The values shown for R<sub>1</sub> apply to both (a) and (b). The 15-volt zener diode in (b) may be a Texas 1S7150 or an S.T.C. ZB15

such as this is very small. Using an OC75 the author recorded a battery drain of fractionally over 1mA at 15 volts. If the amplifier is to be used in a receiver using valve circuits then there are two possibilities for obtaining the required supply voltage. The obvious method is to use a resistive potential divider from h.t. positive to chassis as shown in Fig. '5a'. Don't use a simple resistive dropper if you want the transistor to live to a ripe old age! The altern-

ative to this potential divider method is shown in Fig. '5b'. Although a little more expensive, the use of a zener diode ensures stability of centre frequency should the receiver h.t. voltage tend to vary.

The second method of obtaining the necessary voltage is shown in Fig. 6. The cathode bias voltage developed by the audio output stage is "borrowed" to energise the Q Multiplier. Although usually somewhat lower than 15 volts the

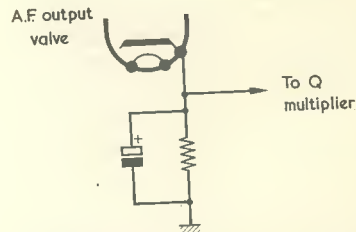


Fig. 6. An alternative method of obtaining the power supply. Care should be taken to ensure that the cathode voltage is not in excess of 15 volts

potential present at this point will give satisfactory operation with most of the transistor types mentioned. Beware however, of higher voltages such as occurs with the ECL82.<sup>2</sup>

Regardless of whether the supply is obtained from a battery or from the h.t. rail make sure that the correct polarity is obtained.

<sup>2</sup> A. J. McEvoy; "Tape Accessories without Batteries"; *The Radio Constructor*, June 1966.

## NEW MICRO-RECEIVER FROM SINCLAIR RADIONICS

With the introduction of their latest design, the Sinclair Micromatic, the initiative for micro-radio design can fairly claim to have passed into the hands of the well-known British Company, Sinclair Radionics Ltd., of Cambridge.

This new set is not only the smallest in the world; its new circuitry assures remarkable standards of performance whilst its appearance reveals all the advantages of having been designed by a leading industrial artist. The Sinclair Micromatic measures a tiny  $1\frac{1}{2} \times 1\frac{3}{16} \times \frac{1}{2}$  in and weighs just one ounce. The minute case houses the

batteries and ferrite rod aerial as well as the six stage transistor circuit itself.

The case is in black plastic and aluminium including an elegant polished aluminium front panel. The spun aluminium dial marked both in metres and kc/s, has a deep quartered rim for precise and easy tuning.

It is in actual use, however, that the remarkable qualities of this set show themselves. It has a range and power that assure choice not only of the three B.B.C. programmes but many other stations on the medium waveband. The Micromatic will be found capable of reception almost anywhere. It can be heard comfortably in cars, trains, buses, planes, etc. and since listening is by means of the lightweight earpiece provided with the set, the Micromatic is the perfect personal receiver. It can be used anywhere at any time without ever interfering with the privacy of others. Plugging in the inconspicuous earpiece switches the set on automatically.

The Sinclair Micromatic is powered by two tiny Mallory Mercury Cells, type ZM.312 or R.M.312 which are readily obtainable from radio shops or chemists anywhere for 1s. 7d. each. Since the batteries last for more than 70 playing hours the running cost is only  $\frac{1}{2}$ d. an hour.

This latest Sinclair set is available in kit form for the home constructor for 59s. 6d. complete with earpiece and easy to follow instructions. In fact, the set can easily be built in a single evening. The Micromatic is also available ready built with earpiece complete in presentation case for 79s. 6d. Whether purchased complete or in kit form, the Sinclair Micromatic is covered by a comprehensive five-year guarantee and is obtainable from the makers, Sinclair Radionics Ltd., 22 Newmarket Road, Cambridge and from radio stockists, stores, etc.





WITH THE METHOD OF CIRCUIT CONSTRUCTION about to be described, the appearance of the finished product is like that of a printed circuit; but since no masking or etching has been carried out, it is not a true printed circuit. The connections are made with narrow strips of engineers' "liner" brass. This is used to make shims for large bearings, etc., and is available from engineers' supply stores in various thicknesses. A suitable thickness for the present purpose is 0.005in or 5 thous, and it costs about one shilling for a foot length of 6in wide material. Since the connecting strips are only  $\frac{1}{8}$ in wide, a foot length will provide up to 48 feet of connectors, practically a life-time supply for an amateur.

### Practical Example

To illustrate the method, the production of the common circuit shown in Fig. 1 will be described. There are many ways of laying out the practical circuit, and one of these is shown in Fig. 2.

The procedure is as follows. Select the components to be used and start by drawing the practical arrangement on a piece of thin card or stout paper. Usually miniature resistors need holes at  $\frac{5}{16}$ in centres and miniature electrolytics need holes at  $\frac{3}{16}$ in and 1in centres depending on their value etc. When certain that the connections have been drawn correctly and that sufficient holes have been marked for input, output and battery connections (these can be easily forgotten), place the card over a suitable piece of thin Paxolin and prick through the holes so

# "LINER CIRCUITS"

by W. H. REYNOLDS

**Narrow strips of thin brass shim stuck to a sheet of Paxolin offer an alternative approach to conventional printed circuits. The materials and processes employed may preclude the use of the technique for circuits in which very high insulation resistances are required, but it should be adequate for normal medium and low impedance circuits**

as to mark their positions on the Paxolin. It will be found that a gramophone needle of the old fashioned acoustic type held in an "Eclipse" pin chuck is excellent for this job, but any other pricker can be used, such as a point of a pair of compasses.

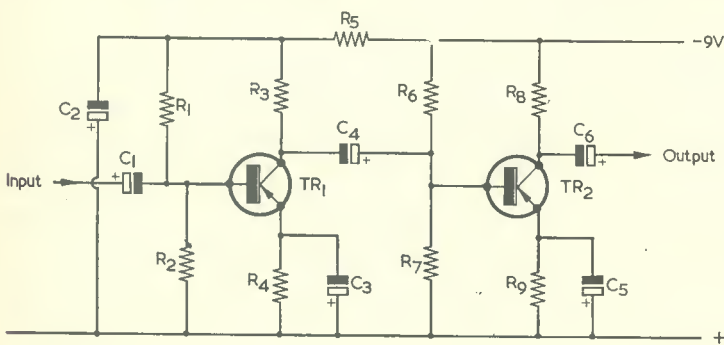
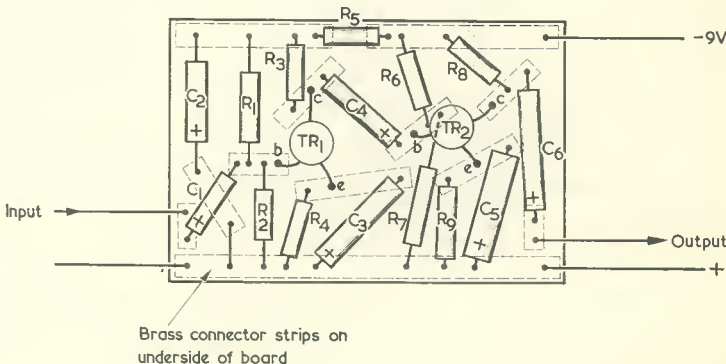


Fig. 1. A typical 2-transistor amplifier, which may be made up using the "liner circuit" technique

Fig. 2. How the circuit of Fig. 1 is assembled with "liner" strips. The board is 2ins wide by 3ins long



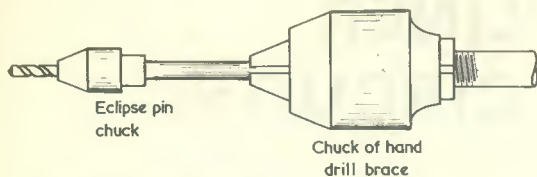


Fig. 3. Thin twist drills can be conveniently handled in the manner shown here

Next drill the marked holes with a  $\frac{1}{16}$  in dia. drill. A practical point, here, is that most small drills have fairly long shanks and flutes and it is very easy to break them. If the drill is mounted close to the point in an "Eclipse" pin chuck and the pin chuck held in the chuck of a hand drill brace, there is very little possibility of breakage. See Fig. 3. After the holes have been drilled, clean and smooth the surfaces of the Paxolin using carborundum paper to get rid of scratches, dirt and grease. Wash with warm detergent solution (washing up liquid) and dry thoroughly.

On the connection side of the board draw centre lines through the holes to be connected and mark the positions where the ends of the connections will appear, as shown in Fig. 4.

From the 0.005in liner brass cut strips  $\frac{1}{8}$  in wide. Use a steel rule and a sharp penknife to score one side of the brass fairly heavily. Then bend the brass to and fro against the edge of the rule until the strip breaks off. This method is better than cutting with a pair of scissors since it gives clean straight edges which are reasonably flat. Using the guiding centre lines on the Paxolin, cut various lengths of the strips as required. It is very helpful to number the positions on the board and lay the strips out

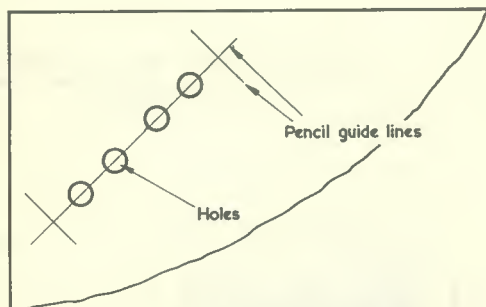


Fig. 4. Marking out the positions of a "liner" strip to which four lead-out wires will be connected. The strip should be laid along the long pencil line. The two short pencil lines indicate the positions taken up by the ends of the strip

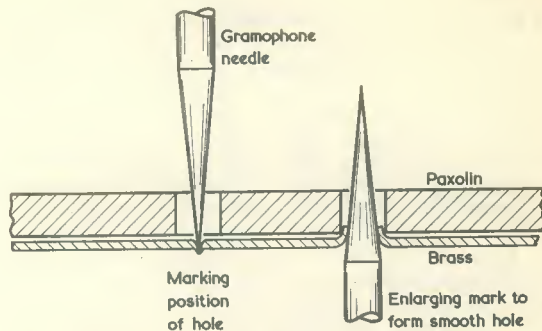


Fig. 5. How the holes in the strip are marked out and then enlarged to take a lead-out wire

in that order for easy subsequent identification.

#### Applying Adhesive

Put a thin coat of Durofix on the Paxolin board just over the positions where the strips are required. Don't use too much, and aim for a thin even coat without lumps just sufficiently wide to secure the  $\frac{1}{8}$  in strip. Coat one side of the brass strips with Durofix. Allow both to dry for at least 30 minutes.

Next, put a second coat of Durofix over connector position No. 1 on the board and a second coat on the brass strip No. 1. Using the pencil guide lines, fix the strip to the board and press firmly for a few moments until the strip is adhering well. Repeat for all the other strips and then allow the board to dry naturally for 24 hours. The connectors will then be firmly fixed to the board and their upper-surfaces can be cleaned with Duraglit or Brillo pads until bright and shiny. Wash thoroughly in warm water and dry naturally. This process will also remove any pencil lines which may be left on the board.

Place the board, connection side down, on a piece of flat wood and gently prick through the holes just sufficiently to mark the exposed surface of the connector. Turn the board over and using an acoustic gramophone needle, enlarge the marks until the resulting holes are smooth and large enough to accept the component wires. See Fig. 5. The board is now ready for use and components can be fitted and soldered in position in the same way as with a normal printed circuit.

Circuit boards are very cheaply produced by this method and the average cost of a board (excluding Paxolin) is about 3d. The writer has made dozens of boards of this type, both for transistor and valve circuits, and has never had any trouble with surface leakage or any similar effect.



## Wide-Band Photophone

Part 2 of the article Wide-Band Photophone by D. Bollen containing final details of the transmitter and a full description of the receiving equipment will appear next month.



IN LAST MONTH'S ARTICLE WE COMPLETED THE description of the second constructional project in the "Understanding Radio" series. This was a three-stage long, medium and short wave receiver in which the two triodes of a double-triode functioned as a grid-leak detector and a.f. voltage amplifier, these being followed by an output stage employing a 6BW6 valve. The receiver heater and h.t. supplies were obtained from the general purpose power supply which formed the first constructional project.

We now revert to technical matters for several issues in order to discuss r.f. amplification, after which we shall return to the receiver and give constructional details for the fitting of an r.f. stage.

#### Results With The Receiver

Readers who have built the three-stage radio will now be able to judge the sort of results which can be expected from a receiver of this class.

is added. The r.f. amplifier presents a fixed impedance to the coil in the grid leak detector stage, whereupon the latter can be designed to give optimum results both in terms of sensitivity and satisfactory reaction control. The present reaction circuit caters for all aerials likely to be encountered but it results in the grid leak detector offering reduced a.f. amplification at some reaction settings. When the r.f. stage is added, we shall also modify the reaction circuit so that the detector triode offers increased a.f. gain, with the consequence that volume well in excess of normal domestic requirements becomes available on the more powerful transmissions on all three bands covered. With the added r.f. stage, the aerial signal is applied to a tuned circuit at the input of the r.f. amplifier, but the coil required here employs coupling and tuned windings only without the complication of a reaction feedback winding.

If the reader is in a district which is very close

# UNDERSTANDING RADIO

## The Tetrode Valve

$$f = \frac{1}{2\pi\sqrt{LC}}$$






by W. G. Morley

As was emphasised in the introductory notes on the receiver in the November issue, the circuit employs a single tuned circuit only, whereupon the selectivity which it offers cannot possibly be as good as would be given by, say, a conventional superhet receiver. In consequence, it should be looked upon as a local station receiver only for medium and long wave reception. On the short wave band the receiver should give adequate reproduction of the more powerful short-wave transmissions.

It was mentioned last month that the use of a long aerial may, in some cases, result in break-through of a medium wave station on long waves should the effective tuned circuit offered by the aerial-earth capacitance and the aerial coupling winding of the long wave coil happen to be resonant at or near the frequency of the medium wave transmission. As was stated, this can be cleared by adding a low-value capacitor between the aerial and earth terminals to detune the effective tuned circuit. In less severe cases sufficient detuning will be given by the series 200pF capacitor which, it was suggested, should be inserted in series with a long aerial.

The problems of obtaining a satisfactory aerial coupling completely disappear when the r.f. stage

to a medium wave transmitter, the signal from that transmitter may break through over a wide band of frequencies on either side of the correct tuning position. Should it occur, this break-through may be eased by inserting a parallel tuned circuit in series with the aerial input connection, as shown in Fig. 1. The inductor in the tuned circuit may be any medium wave tuned winding and the capacitor any convenient component which causes the tuned circuit to resonate at the frequency of the transmitter. The inductor and capacitor form a rejector tuned circuit offering maximum impedance at the resonant frequency, whereupon the amplitude of the transmitter signal reaching the receiver input terminals is greatly reduced. At the same time, signals at frequencies removed from the resonant frequency pass through the tuned circuit with little loss in amplitude. A tuned circuit employed in this manner is described as a *wave trap*.

Operation of the receiver will demonstrate the manner in which signal strength and selectivity are both increased by advancing the reaction control. When the reaction control is advanced beyond the oscillation point, audible *heterodynes* (or *beat notes*) are heard as the tuning control is adjusted on either side of the central setting. This effect was mentioned

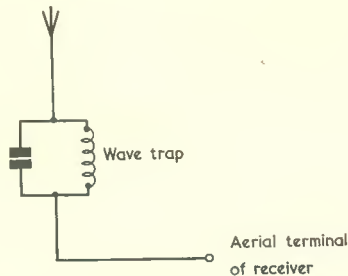


Fig. 1. Inserting a wave trap in series with the aerial terminal of a receiver. This offers maximum impedance at its resonant frequency

briefly in the August 1966 issue and is illustrated graphically in Fig. 2. If, with the reaction control beyond the oscillation point, the tuning control is adjusted towards a signal, the first effect is that a high frequency heterodyne becomes audible. The frequency then drops as the tuning control further approaches the correct tuning point, until it eventually becomes inaudible. It should be noted that the heterodyne does not *disappear* at this stage; instead, its frequency becomes too low to be perceived by the human ear. After passing through the correct tuning point a reverse process occurs; a low frequency heterodyne becomes audible which increases in frequency as the tuning control is further rotated.

The audible heterodyne is the result of two signals of different frequency being applied at the same time to the grid leak detector, and its frequency is equal to the differences between these frequencies. One of the two frequencies causing the heterodyne is provided by the detector itself since, due to the reaction control having been advanced beyond oscillation point, it has now become an oscillator. The other frequency is the carrier of the received transmission.

To take a numerical example, let us assume that the carrier of the received transmission is that of the

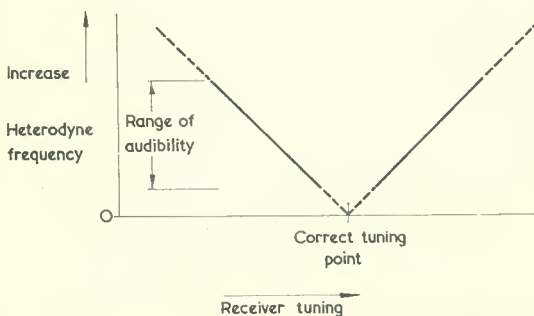


Fig. 2. Illustrating graphically the heterodyne produced when a receiver with reaction advanced beyond oscillation point is tuned through a carrier. The heterodyne still exists when its frequency is outside the human audible frequency range

long wave Light Programme transmission on 200 kc/s. At the same time, let us say that the tuned circuit of our detector, which has been made to oscillate by advancing reaction beyond oscillation point, is resonant at 190 kc/s. The resultant heterodyne will have a frequency of 10 kc/s. If the detector tuned circuit is adjusted nearer to the signal, say to 195 kc/s, then the heterodyne will have a frequency of 5 kc/s. If the detector tuned circuit resonant frequency is brought closer again, to 199.9 kc/s, the resultant heterodyne will be 100 c/s. At still closer frequencies the heterodyne will drop below the lower frequency limit of human hearing. The 100 c/s heterodyne will again reappear at a detector tuned circuit resonant frequency of 200.1 kc/s, the 5 kc/s heterodyne at 205 kc/s and the 10 kc/s heterodyne at 210 kc/s.

Thus, when two frequencies are applied to a detector circuit, a heterodyne, equal to the difference between their frequencies is formed. This fact can be observed by tuning over the crowded medium wave band in the evening or at night. Frequently, the carriers of two stations are so close together that a continual audible whistle, equal to the frequency difference between the carriers, is continually present with either station. This effect is most noticeable when both signals are received at about the same strength.

Heterodynes are not evident only in the audible frequency range, and they may appear at any frequency. This fact is of considerable importance as we shall see when, at a later date, we come to consider the superhet receiver.<sup>1</sup>

## RF Amplification

We now carry on to the subject of r.f. amplification.

We have already observed that a triode valve can offer a.f. amplification, so let us next see how it performs if we try to use it as an r.f. amplifier.

In an a.f. amplifier the triode appears in a circuit such as that shown in Fig. 3 (a). An a.f. input is applied to the grid and an amplified a.f. output appears across the anode load resistor. For r.f. amplification we need to amplify at a single fixed frequency, and so it would seem reasonable, at first sight, to put an input tuned circuit into the triode grid circuit, and an output tuned circuit into the anode circuit, as in the example shown in Fig. 3 (b). Both tuned circuits are resonant at the same frequency, whereupon greatest amplification should occur at that frequency.

There is one very serious disadvantage with the amplifier circuit of Fig. 3 (b); it is virtually the same as that for a tuned-anode tuned-grid oscillator! As we saw in the June 1966 issue, the tuned-anode tuned-grid oscillator has a tuned circuit in both the anode and the grid circuits, feedback being provided by way of the internal capacitance between anode and grid inside the triode. So our triode will

<sup>1</sup> The next constructional project after the addition of the r.f. stage to the present receiver will be an all-wave superhet. This will employ many of the components used in the present receiver.



offer no usable amplification at radio frequencies at all, since it is liable to start oscillating as soon as gain at any useful level is achieved. The situation remains the same if we alter the circuit by, say, coupling the anode to the output tuned coil by way of a coupling winding, as in Fig. 3 (c), since all that changes is that the coupling winding is added to the feedback path from the anode tuned circuit to the grid tuned circuit. The circuit of Fig. 3 (c) is still liable to start oscillating if the achievement of any useful level of amplification is attempted, as will also happen if any other similar coupling arrangements to the tuned circuits are employed.

One method of overcoming the instability (i.e. tendency to oscillate) offered by a triode when employed for r.f. amplification consists of using a *neutralising* circuit, of which a typical example is shown in Fig. 4. In this diagram the h.t. connection is made to a centre-tap in the anode coil with the result that, assuming zero internal impedance in the h.t. supply, the r.f. voltage at the upper end of the anode coil is equal to, and  $180^\circ$  out of phase with, that at the anode. This r.f. voltage is fed back to the grid by way of the variable capacitor, which has an adjusted value approximately equal to the internal capacitance between the anode and grid of the triode. This will usually be of the order of one or two picafarads. When the variable capacitor is correctly adjusted, the r.f. voltage fed back by the internal anode-grid capacitance of the valve is exactly neutralised by the equal and out-of-phase voltage fed back via the variable capacitor, whereupon the triode amplifier becomes stable (i.e. not liable to break into oscillation) and can offer the full amplification of which it is capable.

The particular neutralising arrangement shown in Fig. 4 is known as a *Neutrodyne* circuit. Other neutralising arrangements which apply equal and opposite r.f. voltages to the grid can also be employed, as can alternative circuits which apply neutralising voltages to the cathode. Neutralising circuits are not normally fitted to radio receivers because, as we shall see very shortly, it is possible to obtain r.f. amplification in such receivers much more conveniently by using a valve other than the triode. Neutralising circuits are, however, sometimes employed in television tuner units working at Bands I and III (Channels 1 to 13), or v.h.f. f.m. tuners, when these incorporate triode r.f. amplifiers working at signal frequency. A difficulty with neutralised triode circuits is that it is difficult to maintain the neutralising voltage at exactly the correct level if the associated tuned circuits are required to tune over a wide range of frequencies, as is common in radio receiver applications. Neutralised triodes are, on the other hand, frequently employed in radio transmitters, which are operated for long periods at a single frequency.

### The Tetrode

An alternative approach towards preventing oscillation in an r.f. amplifier circuit consists of

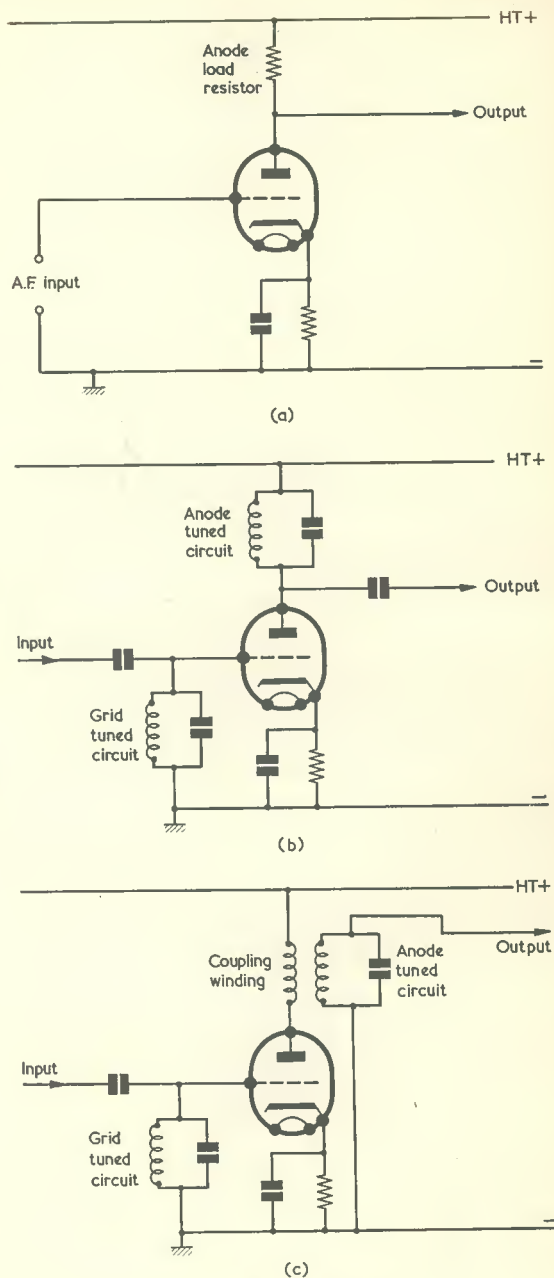


Fig. 3 (a). A triode employed as an a.f. amplifier. Cathode bias is assumed

(b). At first sight it might seem possible to similarly employ the triode as an r.f. amplifier, as shown here. Unfortunately, the circuit resembles a tuned-anode tuned-grid oscillator and will oscillate rather than offer useful amplification

(c). The tendency towards oscillation still remains if the anode is coupled to the output tuned circuit via a coupling winding

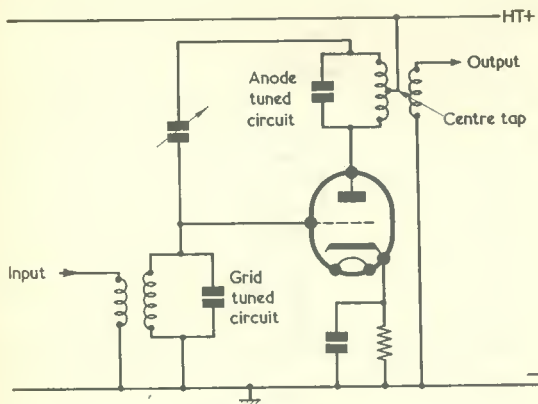


Fig. 4. The Neutrodyne neutralising circuit which, when correctly set up, enables a triode to amplify at r.f. It is assumed that coupling windings to the two tuned circuits are used for input and output connections

fitting a further electrode between the grid and anode of the valve, as in Fig. 5 (a). This new electrode is maintained at chassis potential so far as r.f. is concerned, and it may consist of closely spaced wires having the same basic construction as the grid, or of a coarse metal mesh. It is referred to as the *screen*, or *screen-grid*. A valve with a screen-grid is described as a *tetrode*, because it has four electrodes (the cathode, the two grids and the anode). Where there are more than one grid, as occurs here, it is common practice to refer to the grid nearest

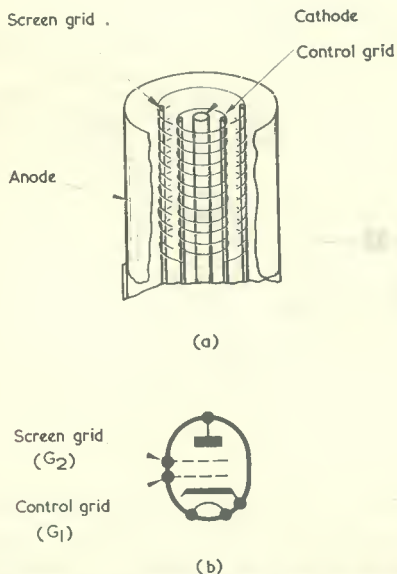


Fig. 5 (a). The screen-grid of a tetrode is interposed between the control grid and anode, as shown in this view of the electrode assembly. Parts of the anode and screen-grid are cut away for purposes of illustration  
(b). The circuit symbol for a tetrode

the cathode as the *control grid*. Again, the grids may be referred to by the letter *g* and a subscript number working out from the cathode. In the present case the control grid is then referred to as  $g_1$  and the screen-grid as  $g_2$ . The circuit symbol for an indirectly-heated tetrode is given in Fig. 5 (b).<sup>2</sup>

The screen-grid of the tetrode reduces the internal capacitance between anode and control grid to a very low value, whereupon the factor which prevents the triode from functioning as an r.f. amplifier (without neutralising) becomes eliminated in one single step. With the tetrode valve it is possible to have tuned circuits in both the anode and grid circuits without the risk of oscillation taking place.

The manner in which the screen-grid reduces the internal capacitance between anode and grid may be understood if we first look at the simple diagram of Fig. 6 (a). On the left of this diagram we have a tuned circuit designated "grid tuned circuit", of which the lower end connects to a chassis line, and the upper end to a metal plate. On the right-hand side of the diagram we have a second tuned circuit designated "anode tuned circuit", whose lower end connects to the same chassis line and whose upper end connects to a second plate. There must obviously be capacitance between the two plates, by way of which energy from the anode tuned circuit may be fed to the grid tuned circuit. The situation is analogous to that prevailing in the triode amplifier of Fig. 3 (b), in which the grid becomes equivalent to the left-hand plate and the anode to the right hand plate.

In Fig. 6 (b) we insert a screen between the two plates, this screen being connected to the chassis line. The result is that we now have two capacitors, one being formed by the left-hand plate and the screen, and the other being formed by the right-hand plate and the screen. An r.f. current from the anode tuned circuit can now flow by way of the capacitance between the right-hand plate and the screen, but all that happens is that a circuit is set up which includes this capacitance and the chassis line back to the anode tuned circuit again, as indicated by the right-hand curved arrow. R.F. current may similarly flow from the grid tuned circuit via the capacitance between the left-hand plate and the screen but the only result is that a circuit is set up which includes this capacitance and the chassis line back to the grid tuned circuit. We therefore have two separate circuits with no capacitive coupling between the two plates at all. The introduction of the screen has broken the capacitive link between the two plates and this second situation is analogous to that occurring in the tetrode valve, in which the screen grid is interposed between the anode (corresponding to the right-hand plate of Fig. 6 (b)) and the control grid (corresponding to the left-hand plate of Fig. 6 (b)).

The apertures between the wires of the screen-grid do not affect its screening ability, and they permit

<sup>2</sup> It should be mentioned that r.f. amplification in modern equipment is provided by the pentode valve, which is a development from the tetrode. However, the pentode cannot be introduced without initially explaining the manner in which the tetrode functions.



the flow of electrons to the anode. The screen-grid cannot be connected direct to chassis, as was the screen in our simplified diagram of Fig. 6 (b), because such a connection would repel electrons emitted from the cathode. It is, instead, connected to a source of h.t. potential somewhat lower than that which supplies the anode, so that electrons may travel to it and then pass on to the more positive anode. If we re-examine Fig. 6 (b) we will note that the two separate circulating currents from the tuned circuits share a common section of the overall circuit, this being the connection between the screen and the chassis line. It is important that this common section should have a very low impedance as, otherwise, an r.f. voltage may appear across it and the two tuned circuits will become coupled together once more. This very low impedance is provided in a practical tetrode circuit by coupling the screen-grid of the valve to chassis by way of a capacitor having a very low impedance at the particular frequency being handled. A basic tetrode amplifier is shown in Fig. 7, in which the screen-grid is maintained at a lower potential than the anode by means of a dropping resistor. The "bypass capacitor" is that which provides the low impedance to chassis. For long, medium and short wave applications, a typical value for the screen-grid bypass capacitor would be of the order of  $0.02\mu\text{F}$  to  $0.1\mu\text{F}$ .

It should be added that not all the electrons emitted by the cathode pass through the screen-grid apertures. Some strike the screen-grid itself, causing a screen-grid current to flow. This current enables the appropriate voltage to appear across the dropping resistor of Fig. 7.

### Characteristic Curves

If we wish to draw the characteristic curves of a tetrode, we may do so by using a test set-up such as that shown in Fig. 8 (a). Fig. 8 (b) illustrates a family of tetrode  $I_a V_a$  curves, each curve corresponding to a different control grid voltage. The screen-grid potential is maintained constant at the level indicated.

It will at once be seen that the curves of Fig. 8 (b) are quite different from the simple sloping  $I_a V_a$  curves which are given by a voltage amplifier triode, and which we saw in the December 1965 issue. For anode voltages from zero up to slightly above the screen-grid voltage, the curves show considerable non-linearity. To understand the reason for this non-linearity it will be helpful to consider what happens when, starting from zero volts at the left, we increase anode voltage.

As anode voltage increases from zero there is, initially, a rapid increase in anode current. This is due to the fact that electrons have already been attracted from the cathode towards the positive screen-grid with the result that a relatively large proportion are available for the anode. The presence of the screen grid ensures that there is a source of electrons close to the anode. The rapid increase in current ceases as the anode voltage reaches a level at about point A on the  $V_a$  axis. Indeed, between

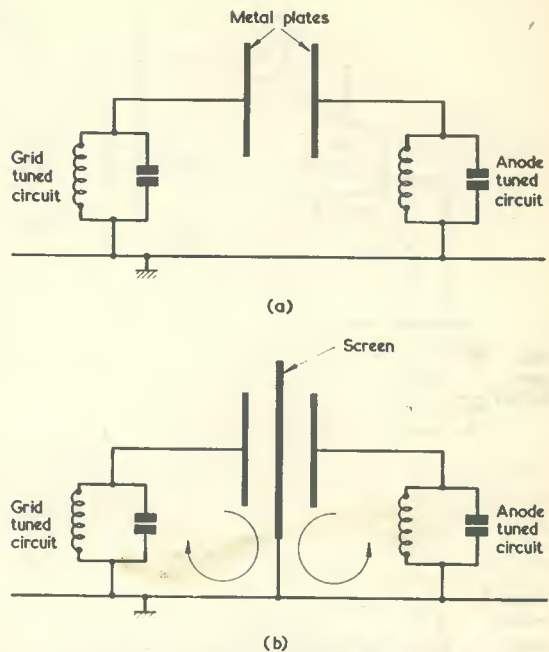


Fig. 6 (a). The two metal plates shown here are representative of the anode and grid of a triode (b). Interposing a screen between the two plates is analogous to inserting the screen-grid in a tetrode

points A and B the curves drop, instead of rising, as anode voltage increases. This is an unusual effect because what is happening is that an *increase* in anode voltage results in a *decrease* in anode current. Such a state of affairs is exactly opposite to that given in a normal resistor; and we say that the curves, between points A and B, exhibit *negative resistance*.

The negative resistance section of the curve is the result of a phenomenon known as *secondary emission*. When an electron strikes an anode it

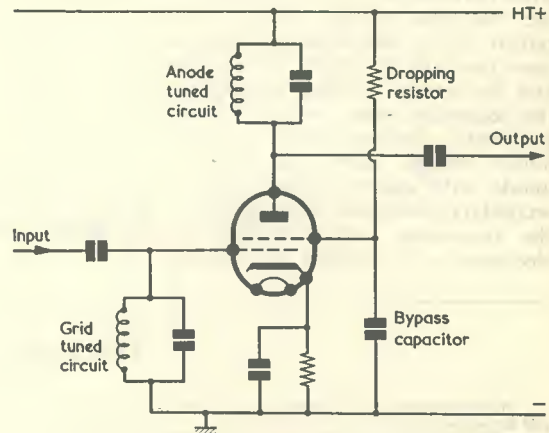
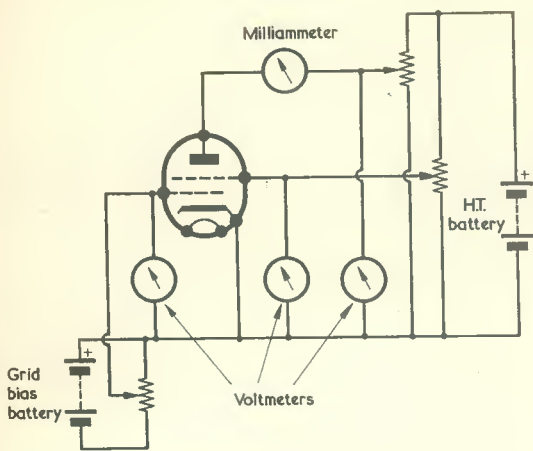
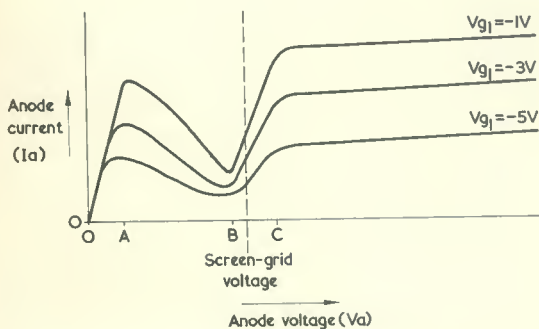


Fig. 7. The basic tetrode r.f. amplifier circuit



(a)



(b)

Fig. 8 (a). A test set-up which enables the anode characteristic curves of a tetrode to be drawn. Direct voltage sources other than batteries can, of course, be used  
(b). A representative family of  $I_a V_a$  curves for a tetrode

can cause one or more electrons to be released from that anode. This effect occurs in a triode, but the electrons emitted due to secondary emission return to the anode again and do not affect the operation of the valve. In the tetrode, however, and for anode voltages between points A and B, the secondary electrons are attracted towards the positively charged screen-grid. An increase in anode voltage causes the electrons to strike the anode with greater velocity and to release more secondary electrons. After point A of the curves, the increasing anode voltage causes secondary electrons to be emitted at a greater rate than the

rate of electrons arriving from the cathode, with the result that the total anode current drops. This effect continues until we reach a voltage level at about point B, where the anode voltage is only slightly lower than the screen-grid voltage. At this point, many of the secondary electrons are now being attracted back to the anode again, and fewer pass to the screen-grid. In consequence, the negative resistance section of the curves comes to an end and anode current reverts to normal conditions, in which an increase in anode voltage results in an increase in anode current. As the anode voltage rises to around point C, slightly above the screen-grid voltage, the loss of secondary electrons to the screen-grid drops dramatically, and there is a considerable increase in anode current.

For anode voltages above point C the secondary emission loss to the screen-grid becomes negligibly low because the screen-grid is now significantly more negative than the anode. To the right of point C the curves become very nearly flat, with only a slight increase in anode current for increase in anode voltage. This type of curve shape is similar to that given by *saturation*<sup>3</sup>, which term defines the state where very nearly all the electrons emitted by the cathode travel towards the anode, and where an increase in anode voltage results in only a small increase in anode current. But it is quite evident that the present curves are not the result of saturation because we still obtain an obvious change in anode current for a change in control grid voltage. The reason for the "flatness" of the curves is that the space charge around the cathode is screened from the anode by the screen-grid, and so changes in anode voltage have little effect on the quantity of electrons leaving the space charge. It will be remembered that, with the diode and triode, the positive anode exerts a direct electrostatic attraction on the electrons in the space charge. With the tetrode, the screen-grid prevents this direct electrostatic attraction. In effect, the anode has to work (at voltages above point C in Fig. 8 (b)) with the quantity of electrons which have been obtained for it by the screen-grid.

### Next Month

In next month's article we shall complete our present theoretical discussion by seeing how the curves of Fig. 8 (b) affect the performance and amplification factor of the tetrode, after which we shall introduce the pentode. In the succeeding issue we shall return to the three-stage receiver, to describe how a pentode r.f. amplifier may be added to it.

<sup>3</sup> See "Understanding Radio" in the July 1965 Issue.

## The Radio Constructor

May we bring to the attention of new readers that *The Radio Constructor* is published on the first of every month and is available from Newsagents and Booksellers throughout the country.

Where difficulty is experienced, copies can be obtained direct from us (Data Publications Ltd., 57 Maida Vale, London, W.9.) single copies at 3s. post paid or, if required, on annual subscription at 36s. post paid.



# MULTI-PURPOSE TUNER PRE-AMPLIFIER

by Sir Douglas Hall  
K.G.M.G., M.A. (Oxon)

This little unit functions as medium wave receiver, tuner, a.f. pre-amplifier and record player amplifier. And the only switch in the circuit is the one that switches the battery on and off!

THE LITTLE UNIT TO BE DESCRIBED has many uses, and it performs its different functions without any switching other than that for the battery. It may be used for the following purposes:—

- a. As a personal receiver in quiet surroundings for local stations.
- b. As a tuning head for a valve driven amplifier.

c. As a tuning head for a tape recorder.

d. As a pre-amplifier for a valve driven amplifier.

e. As a pre-amplifier for a tape recorder.

f. For personal listening at a good volume level to gramophone records. Two can be used for stereo records.

## COMPONENTS

### Resistors

(All fixed values  $\frac{1}{2}$  watt 10%)

- R<sub>1</sub> 5.6M $\Omega$
- R<sub>2</sub> 15k $\Omega$
- R<sub>3</sub> 1.5k $\Omega$
- VR<sub>1</sub> 5k $\Omega$  potentiometer, linear track

### Capacitors

- C<sub>1</sub> 100pF
- C<sub>2</sub> 2,000pF
- C<sub>3</sub> 0.01 $\mu$ F
- C<sub>4</sub> 2,000pF
- C<sub>5</sub> 100 $\mu$ F electrolytic, 3V wkg
- C<sub>6</sub> 100 $\mu$ F electrolytic, 12V wkg
- VC<sub>1</sub> 500pF variable

### Inductors

- L<sub>1,2</sub> See text
- T<sub>1</sub> Transformer type TT53 (Repanco)

### Transistors

- TR<sub>1,2</sub> OC44

### Diode

- D<sub>1</sub> OA81

### Switch

- S<sub>1</sub> s.p.s.t. (may be combined with VR<sub>1</sub>)

### Sockets

- Input and output sockets. Phono type

### Ferrite Rod

- 2-off, 4 $\times$  $\frac{3}{8}$ in (see text)

### Battery

- 9-volt battery

### The Circuit

The circuit is shown in Fig. 1. TR<sub>1</sub> is a common collector high frequency amplifier. The signal is picked up by a ferrite rod aerial, L<sub>1</sub>, feedback for reaction being taken from the emitter of TR<sub>1</sub> and controlled by VR<sub>1</sub>. At low volume levels VR<sub>1</sub> tends to short-circuit L<sub>2</sub> and so acts as a true volume control. Demodulation is by crystal diode D<sub>1</sub>, and TR<sub>2</sub> acts as a common collector low frequency amplifier. With an average current gain of 100 for an OC44, and bearing in mind that the output impedance of a common collector amplifier is roughly equal to input load divided by amplification factor, an impedance of about 150 $\Omega$  may be expected across the primary of T<sub>1</sub>. (The small winding is used as the primary with this

circuit). T<sub>1</sub> has a turns ratio of 1:25 and so an impedance of about 150 $\times$ 25<sup>2</sup>=94k $\Omega$  may be expected across the secondary. This is suitable for a crystal earphone connected at the output socket. The red and blue leads are connected to the large winding of T<sub>1</sub>.

In poor reception areas an increase in sensitivity may be obtained by connecting a few feet of wire to the centre of the input socket, leaving the outside connection unattached.

The output socket may be connected to the input of a valve amplifier. If there is any question of the input to the amplifier being at mains potential it is essential that the link should be made through two 0.01 $\mu$ F capacitors rated at 250 volts a.c. working. Similarly, the unit may be connected to a tape recorder for direct recording of local stations. In this event the link may be made to the microphone input socket of the recorder if maximum sensitivity is required, though in most cases there will be enough signal available to enable the radio input socket to be used.

(Continued on page 422)

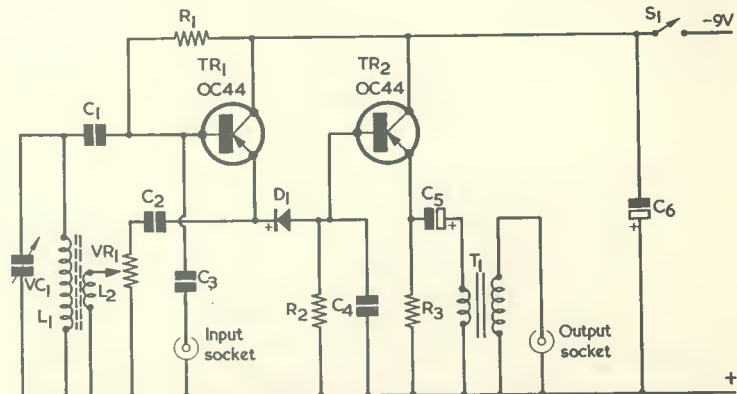
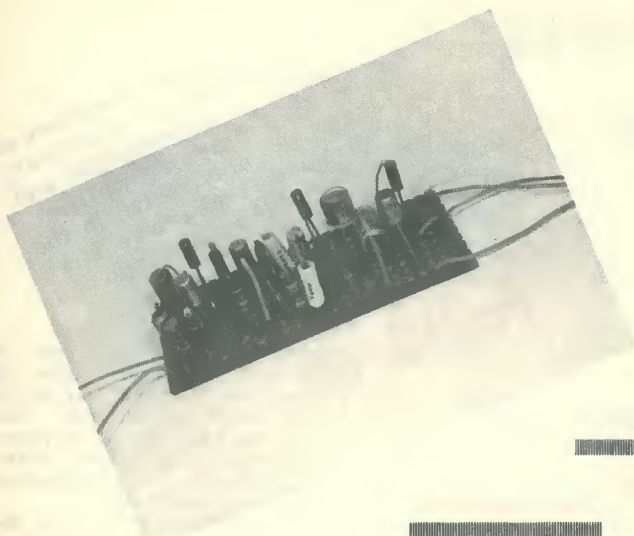


Fig. 1. The complete circuit of the unit. Tuning capacitor VC<sub>1</sub> may be a solid dielectric component

# Super-Sensitive

by

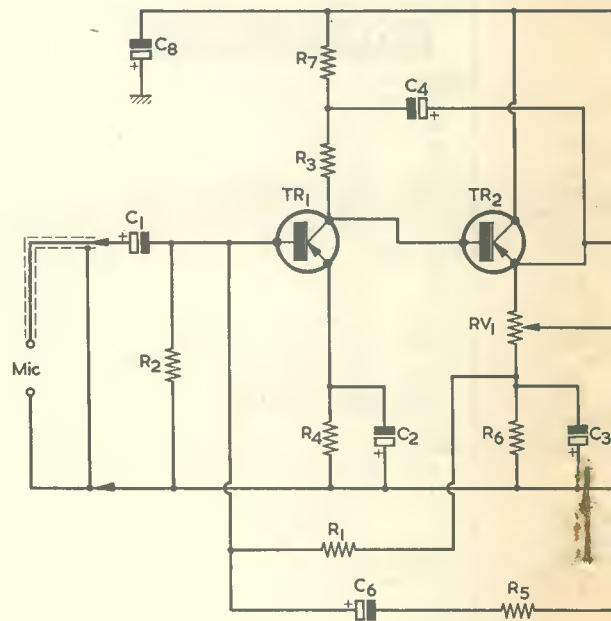


Bootstrapping techniques enable a high degree of a.f. gain to be achieved in this neat and efficient unit

ONE OF THE MOST USEFUL, BUT LEAST USED, of all electronic devices is the so-called sound operated switch. Here, the sound is converted into an electrical signal by the microphone and this signal is then amplified and rectified by electronic circuitry, the final d.c. output being used to operate a relay and thus control external circuits and devices, such as motors, alarms, or lights, etc.

Quite clearly, although the unit is referred to as a "sound operated switch", it is in fact operated by an alternating input current or voltage, and the device can thus be activated by any signal that can be converted into a.c. In other words, the switch can be made to operate from changes in hydraulic pressure, air pressure, gravity, sound, earth tremors, etc., by merely using a suitable pick-up or transducer between the source and the switch.

In spite of the vast number of applications for this type of unit it has achieved little popularity with the home constructor, the main reason being that hardly any really good circuits have been published in the past. The main problem here is that, for positive relay operation, an exceptionally high order of amplification is required if the unit is to be fed with low sound input levels. Using conventional circuitry, this very high order of amplification can only be achieved by employing a large number of transistors, with consequent difficulties in construction, expense and stability.



In the unit that forms the basis of this article, these snags have been overcome by moving away from the more conventional methods of signal amplification and using sophisticated techniques that take advantage of the full capabilities of the semiconductors, thereby obtaining an amplification that approaches the theoretical maximum.

The complete unit comprises only 4 transistors, together with 11 resistors and 8 capacitors. Also, the circuit is exceptionally stable, and presents no constructional problems. Sensitivity is such that the relay can be operated by low-level voices at a



# Positive Sound Switch

by R. M. MARSTON



Special Feature

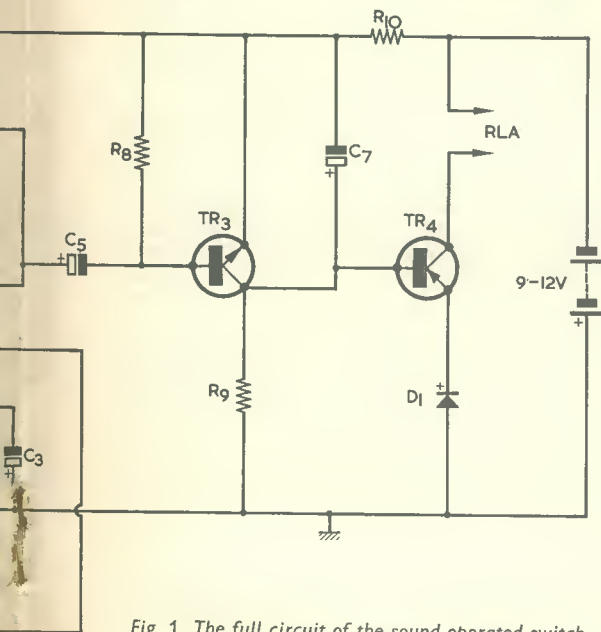


Fig. 1. The full circuit of the sound operated switch.

range of 15 feet, and by normal voice levels at about 30 feet.

## Applications

The best known application of the sound operated switch is that of automatic switching of a tape recorder. In this instance, the switch operates the recorder only when a signal input is available, and thus cuts out the long pauses that normally occur between speech inputs. This results in an economy in tape and power requirements, a feature which is of particular value with dictaphones.

## Resistors

(All fixed values  $\frac{1}{4}$  watt 10%)

R <sub>1</sub>	47k $\Omega$
R <sub>2</sub>	10k $\Omega$
R <sub>3</sub>	22k $\Omega$
R <sub>4</sub>	1k $\Omega$
R <sub>5</sub>	10k $\Omega$
R <sub>6</sub>	4.7k $\Omega$
R <sub>7</sub>	12k $\Omega$
R <sub>8</sub>	8.2k $\Omega$
R <sub>9</sub>	5.6k $\Omega$
R <sub>10</sub>	1k $\Omega$
RV <sub>1</sub>	5k $\Omega$ potentiometer, skeleton preset

## Capacitors

(All sub-miniature electrolytic, 15V wkg.)

C <sub>1</sub>	16 $\mu$ F
C <sub>2</sub>	16 $\mu$ F
C <sub>3</sub>	16 $\mu$ F
C <sub>4</sub>	16 $\mu$ F
C <sub>5</sub>	8 $\mu$ F
C <sub>6</sub>	16 $\mu$ F
C <sub>7</sub>	50 $\mu$ F
C <sub>8</sub>	50 $\mu$ F

## Semiconductors

TR <sub>1</sub>	NKT675 (or AF114, 2G401, 2G416)
TR <sub>1</sub>	OC75 (or NKT274)
TR <sub>3</sub>	NKT773 (or NKT713, 2N1304)
TR <sub>4</sub>	NKT271 (or OC81, 2G381, 2G382)
D <sub>1</sub>	OA200 (or similar silicon diode)

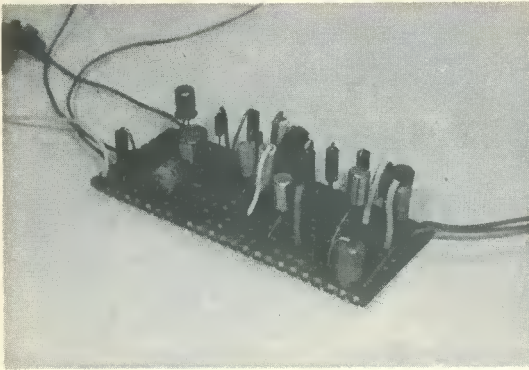
## Battery

9 or 12 volt battery

## Veroboard

0.15in matrix,  $3\frac{5}{8}$  x  $1\frac{3}{8}$ in (9 strips x 24 holes)

COMPONENTS



Another view of the switch

The same idea can be used for automatic operation of an amateur radio transmitter, or for the opening of doors. In addition, the sound operated switch can be used to operate a burglar alarm, to give warning of the crying of a child, or to indicate the ringing of a door bell or phone in a remote part of a house.

If the input is fed from an inductance or capacitance bridge, the switch may be operated by the presence of small pieces of metal in the ground or by large masses of metal (such as a motor car, giving automatic opening of garage doors); or the switch may be operated by the capacitance change caused by the presence of people or animals (giving automatic opening of doors, etc.). In these particular applications one arm of the bridge is used as a "sensor" and the bridge is energised by a.c., the switch being used as the detector. The bridge is adjusted to give a normal "null", whereupon the switch is off. When the inductance or capacitance of the sensor is altered, the bridge goes out of balance and the switch relay operates.

Similarly, when the switch circuit is fed from an a.c. driven Wheatstone or resistance bridge, the unit may be operated by moisture, by heat, by light, or by any other quantity that can be represented by a resistance.

### Circuit Operation

The full circuit diagram of the unit is shown in Fig. 1, and the rather complex configuration used may be unfamiliar to some readers. The basic theory of the amplifier section ( $TR_1$  and  $TR_2$ ) is of considerable interest and, particularly for the benefit of those with a theoretical turn of mind, will now be explained in some detail.

Fig. 2 (a) shows a conventional 2-stage common emitter amplifier, in which  $TR_1$  has collector load  $R_3$ . Now, it will be realised that the greater the *effective* value of the collector load, the greater becomes the voltage gain, and thus the power gain, of the amplifier. The important point to appreciate here is that it is the *effective*, or a.c., value of the load that dictates the gain, and *not* the d.c. or true value of the collector resistor.

In Fig. 2 (a), for example, the real value of  $R_3$  is 6.8k, but at a.c. this is effectively shunted by  $R_5$  and  $R_6$ , the base-bias resistors of the following transistor, and by the input impedance to the base of the following transistor, which will be in the order of 1k $\Omega$ ; Thus, the *effective* value of  $TR_1$  collector load is equal to  $R_3$ ,  $R_5$ ,  $R_6$  and the base input impedance of the second transistor, all in parallel, giving a final value of effective collector load of approximately 800 $\Omega$ . The gain of  $TR_1$  is thus considerably reduced by the loading effect of the following stage and, in practice, a voltage gain of only about 16 times can be expected from each stage of the amplifier.

One way of overcoming this difficulty is to interpose an emitter follower ( $TR_2$ ) between the first amplifier and the following stage, as shown in Fig. 2 (b), to overcome the shunting effect. The emitter follower gives a high input and a low output impedance, and thus enables  $R_3$  output to be fed to the following stage without appreciable loss of gain. The effective value of  $TR_1$  collector load is thus virtually the same as the d.c. or real value, i.e. 6.8k $\Omega$ . It is interesting to note that, although the emitter follower ( $TR_2$ ) itself gives unity voltage gain, its use enables the voltage gain of the combination to be increased to 136 times, i.e. by a factor of approximately 8 times.

Clearly, the gain can be increased even more by increasing the real value of the collector load,  $R_3$ , but limits are normally set here by the d.c. and temperature requirements of the transistors. If a very high value is used for  $R_3$ , a small change in leakage currents due to temperature variations may cause such a large change in the mean collector voltage that the transistor will bottom and cease to amplify. This trouble can be overcome to a large degree by modifying the circuit as shown in Fig. 2 (c). Here, the emitter load of  $TR_2$  is split into two parts,  $R_5$  and  $R_6$ , the junction being bypassed to a.c. by  $C_3$ . The base-bias of  $TR_1$  is taken from this junction via  $R_1$ , and a d.c. negative feedback loop is thus set up. The emitter of  $TR_2$  "follows" the voltage at  $TR_1$  collector so that if  $TR_1$  leakage current rises due to an increase in temperature, the voltage at  $TR_1$  collector and, hence, at  $TR_2$  emitter and at the  $R_5$ - $R_6$  junction, will fall. This will in turn reduce the bias to  $TR_1$  base, thus reducing  $TR_1$  collector current and tending to counteract the original change at  $TR_1$  collector. Using this technique, collector loads in the order of 30k $\Omega$  to 40k $\Omega$  may be used, with consequently high gain.

The ultimate in achieving high voltage gains from the circuit involves increasing the *effective*, rather than the real, value of the collector load, and here the technique known as "bootstrapping" is used, as shown in Fig. 2 (d). This circuit is similar to that of Fig. 2 (c), except that the  $TR_1$  collector load has been split between  $R_3$  and  $R_7$  and capacitor  $C_4$  has been connected from  $TR_2$  emitter to the  $R_3$ - $R_7$  junction. Thus, when an input is applied to the circuit, the signal appearing at  $TR_2$  emitter (which is of the same form and phase as that at



TR<sub>1</sub> collector) is fed to the R<sub>3</sub>-R<sub>7</sub> junction, so that similar *alternating* voltage signals appear at both ends of R<sub>3</sub>, and virtually no alternating signal current flows in this resistor. The resistor thus reacts in the same way as would a very high impedance. By using this bootstrapping technique, the effective value of R<sub>3</sub> is increased by a factor of greater than 10, without affecting the real value of this resistor.

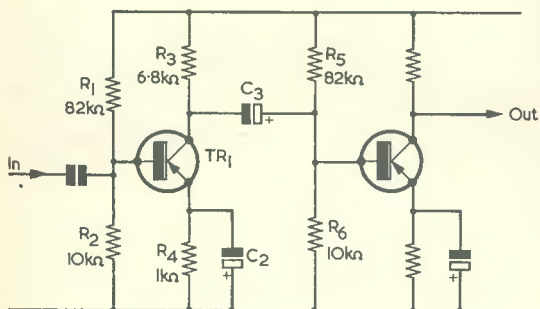
On the prototype, the measured voltage gain of this circuit, when feeding into a 1kΩ load, is 1,000 times; this is, of course, considerably better than the 16 x 16 (=256) times that would be obtained using a conventional 2-stage common emitter amplifier. A most important additional point is that, with the conventional amplifier, the output would be in phase with the input signal, and there would be some risk of instability through positive

feedback. In the amplifier described here, however, the output is in antiphase to the input, and no possible danger of instability exists.

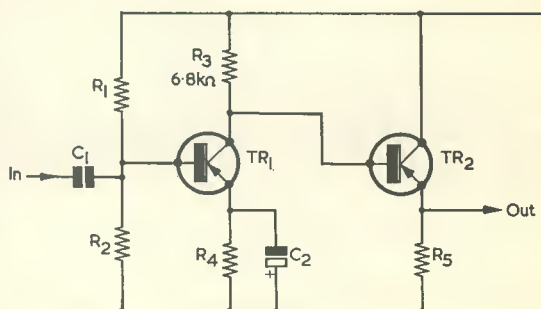
### The Full Circuit

Referring now to the full circuit diagram of the sound operated switch shown in Fig. 1, the TR<sub>1</sub>-TR<sub>2</sub> amplifier can be seen to be the same as that of Fig. 2 (d), with the exception that RV<sub>1</sub>, in the emitter circuit of TR<sub>2</sub>, R<sub>5</sub> and C<sub>6</sub> have been added. These three components enable the gain, or sensitivity, of the amplifier to be preset by controlled negative feedback.

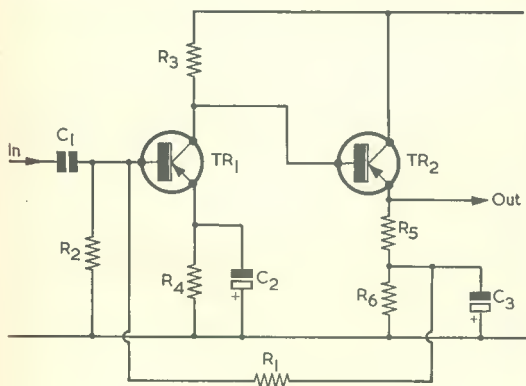
The output from TR<sub>2</sub> emitter is fed to the base of TR<sub>3</sub> via C<sub>5</sub>. Basically this transistor is wired as an n.p.n. common emitter amplifier, but it should first be noted that the base is clamped to the negative supply rail by R<sub>8</sub>, so that the transistor is normally



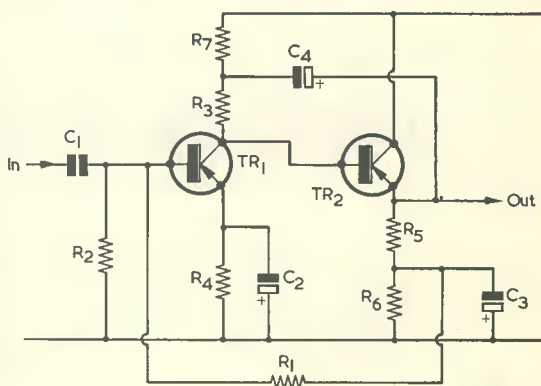
(a)



(b)



(c)



(d)

Fig. 2 (a). In this conventional 2-stage amplifier, the effective value of R<sub>3</sub> is reduced to approximately 800Ω by the shunting of the following circuit, and the voltage gain is reduced  
 (b). An emitter follower, TR<sub>2</sub>, may be used as a buffer between R<sub>3</sub> and the following stage to overcome the shunting effect  
 (c). A d.c. negative feedback loop gives improved temperature stabilisation when very high values are used for R<sub>3</sub>  
 (d). Here, the value of TR<sub>1</sub> collector load is increased artificially by bootstrapping

near cut-off. Thus, TR<sub>3</sub> acts as a rectifier-amplifier, being fully cut off by negative half-cycles, and driven on by positive half-cycles which are amplified across collector load R<sub>9</sub>. It should secondly be noted that TR<sub>3</sub> collector is bypassed to the negative rail by C<sub>7</sub>, so that the signal appearing across R<sub>9</sub> is not the instantaneous value of the a.c. input signal, but a corresponding d.c. value. Thus, the TR<sub>3</sub>-R<sub>8</sub>-R<sub>9</sub>-C<sub>7</sub> combination acts as a composite rectifier-amplifier-smoothing circuit.

Since TR<sub>3</sub> is normally biased off, negligible current flows in R<sub>9</sub>, and the collector of this transistor is normally at near ground (positive) rail potential, the collector becoming negative as the input signal increases. The collector is direct coupled to the base of TR<sub>4</sub>, which is wired as a d.c. common emitter amplifier, with relay RLA as its collector load. Diode D<sub>1</sub> is inserted in the emitter circuit of TR<sub>4</sub> to give a small amount of emitter bias, ensuring that this transistor is cut off when no

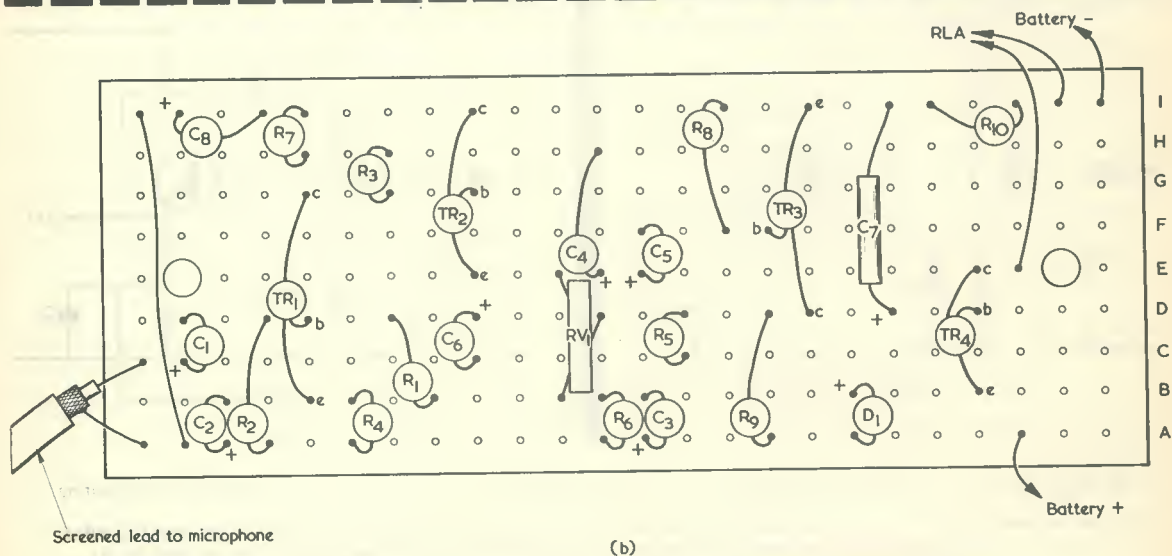
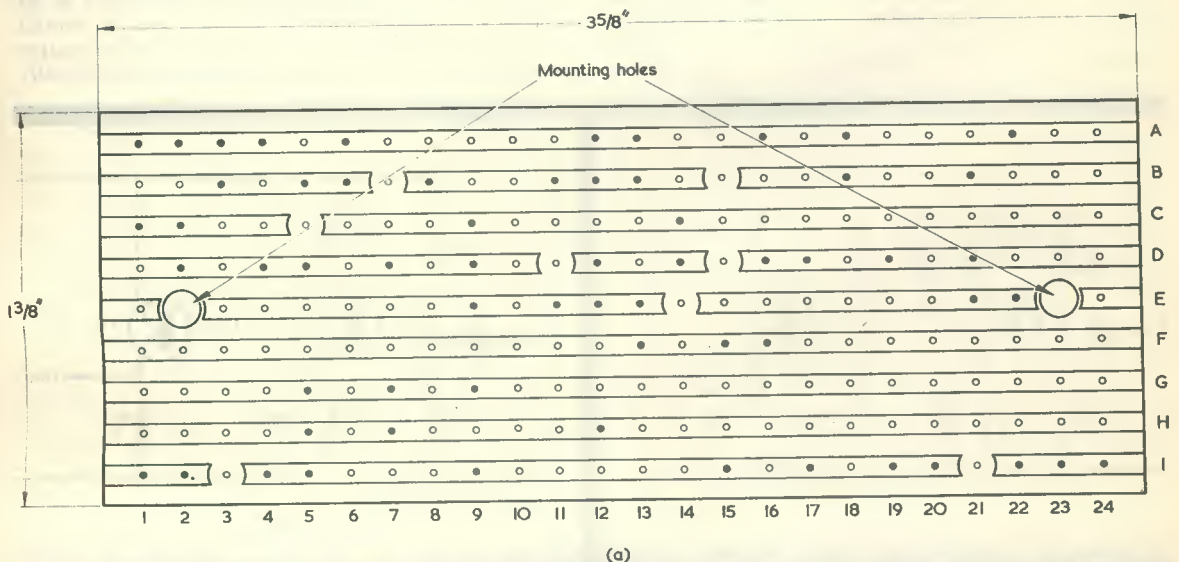


Fig. 3 (a). The copper side of the Veroboard (b). The components mounted above the Veroboard



input is applied to TR<sub>3</sub> base.

The decoupling network given by R<sub>10</sub> and C<sub>8</sub> is inserted in the negative supply rail between the TR<sub>3</sub> and TR<sub>4</sub> stages. This prevents any instability that might otherwise occur when the batteries age, giving a consequent high internal resistance.

### Construction

For ease of construction, the unit is wired up on a small piece of Veroboard panel, thus retaining all the advantages of printed circuit construction without the difficulties of marking out and etching, etc., that are normally involved with printed circuit techniques.

Start construction by cutting the Veroboard panel to size, as shown in Fig. 3 (a), and then break the copper strips with the aid of a small drill, a pen-knife, or the special cutting tool that is available, at the points indicated. If the completed unit is to be mounted to a chassis or sub-panel, drill the two small mounting holes, to clear 6BA screws, where shown. Cut back the copper strip around these last two holes so that short circuits cannot occur when the mounting screws are inserted.

Now turn the panel over and assemble the components and leads on the blank side, as shown in Fig. 3 (b). Note that all components, other than C<sub>7</sub>, are mounted vertically. The legs of RV<sub>1</sub>, the preset skeleton potentiometer, should be reduced in width with the aid of a small file so that they fit easily in the holes in the Veroboard panel, before attempting to solder this component in place.

Care should be taken to ensure that all capacitors are fitted in place with the polarity shown, and heat shunts should be used when soldering the semi-conductors in place. Particular care must be taken to ensure that the n.p.n. transistor, TR<sub>3</sub>, is fitted with the correct orientation. Insulated sleeving should be used wherever there is any risk of component lead-outs short-circuiting together.

When assembly is complete, connect the relay to the two leads marked for this component, connect a microphone to the input leads, and then connect the battery and carry out a simple functional check to make sure that the unit is working. If sensitivity proves to be lower than expected, make sure that the gain has not been reduced by the setting of RV<sub>1</sub>.

The microphone may be a moving-coil type connected directly to the input of the sound operated switch without a matching transformer. A moving-coil speaker will similarly function as a microphone, this also being connected directly to the switch input. The lead to the microphone (or speaker) should normally be screened, the screening connecting to the positive supply line of the switch unit. Unscreened leads to the microphone may be used if these are short, and provided that there are no strong mains fields in the vicinity. If an input matching transformer is employed it *must* be fully screened. The use of the transformer may, however, result in excessive sensitivity in the switch, causing this to operate from very low-level sounds, such as those given by the motors of a tape recorder.

If the test with the microphone has been satisfactory, the unit is now complete and ready for use.

### Notes On Components

When building the unit, it is important to note that transistors TR<sub>1</sub> and TR<sub>2</sub> must be of the types specified, or near-equivalents, if best results are to be obtained in terms of sensitivity. The design is such, however, that any a.f. or r.f. germanium p.n.p. transistors may be used for TR<sub>1</sub> and TR<sub>2</sub> if some loss of sensitivity can be tolerated. TR<sub>3</sub> may be any n.p.n. germanium transistor, and TR<sub>4</sub> may be any p.n.p. germanium transistor that is capable of meeting the dissipation requirements of the relay with which it is used.

Relay RLA may have any coil resistance greater than 200Ω; a coil resistance of 670Ω was used on the prototype. It is important that the relay should be capable of operating positively from a voltage of at least two-thirds of the supply rail potential, and preferably from half of the supply voltage. If, for instance, a 12 volt supply is used, the relay should be capable of operating from at least 8 volts, and preferably from 6 volts.

So far as sensitivity is concerned, a sensitive high resistance relay will give far better results than one with a low resistance coil. As was mentioned earlier, the input to the unit may be taken from either a moving-coil microphone or from a speaker (used as a microphone), but the former will give the best results.



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## The New Electronics

A new series on modern solid state electronic devices called "The New Electronics" started on Sunday, 8th January (B.B.C.-1). Integrated circuits, Gunn oscillators, silicon-controlled rectifiers, field effect transistors. These are some of the newest devices in a technology which was almost unknown ten years ago. They are all semi-conducting devices. They all depend on the production of very pure solids in very exact crystalline forms. Impurities are added to these in amazingly small concentrations to make the P-type and the N-type materials which are the basis of the devices themselves.

The electronic engineer can now begin to order microscopic integrated circuits tailored exactly to his needs. Radar sets costing £20 each, match box size computers, improved telephone systems are now possibilities which depend for their realisation on knowing how the devices work and what we should be trying to make them do.

Power systems, micro-wave systems, and optical devices are extending the uses of semi-conductors into fields where thermionic valves have always been needed in the past. Even television cameras and receivers may soon be made using solid state devices instead of cathode ray tubes.

These ten programmes which are intended for electrical engineers, teachers in schools and colleges, undergraduates and sixth forms explain how the devices are made, how they work and some of their uses.

## Multi-Purpose Tuner Pre-Amplifier

(continued from page 415)

### Use As A.F. Pre-Amplifier

In order to use the unit as a pre-amplifier for a tape recorder, a crystal microphone should be connected to the input socket, the output socket of the unit being connected to the microphone input of the recorder. The microphone will cause sufficient damping of the tuned circuit to cut out all radio signals, and TR<sub>1</sub> will now act as a common collector audio frequency amplifier, feeding into TR<sub>2</sub> as a second similar amplifier. Internal impedances will probably prevent the full transformation of 100×100 times which might appear possible, but it may be expected that there will be an input impedance of the order of 1MΩ.

The increased sensitivity given to a tape recorder when this unit is used is very high, and the microphone will need to be positioned several feet from the recorder in order to prevent its picking up

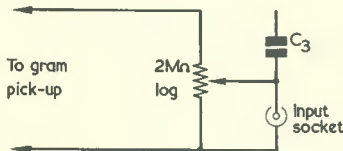


Fig. 2. If desired, a volume control may be added at the a.f. input

quite a large signal from the motors. It will be found possible to pick up speech at a distance at which it is not clearly audible with the human ear, provided that other noises in the vicinity are at a low level.

When TR<sub>1</sub> is working as an audio frequency amplifier the only effect of D<sub>1</sub> is to reduce, very slightly, the voltage available for TR<sub>2</sub> (it acts as the upper arm of a potentiometer with R<sub>2</sub> as the lower arm) and to increase, very slightly, the d.c. passed through TR<sub>2</sub> when a signal is being passed. This second effect, which is of little practical importance, is due to rectification of a part of the signal and a consequent increase in negative bias on the base of TR<sub>2</sub>.

### Pickup Amplifier

If the crystal pickup of a gramophone is connected to the input of the unit it is possible to listen to records with a crystal earpiece connected to the output. With two units stereo records may be listened to, but in this case a volume control to the input of each unit is essential to provide for proper balancing. A suitable circuit is shown in Fig. 2. In any event, a volume control is useful if the unit is to be used for listening to records as the amplification offered may be too high in some cases.

The author has had very pleasing results from stereo records by using one earpiece of a pair of low resistance headphones (DLR5) to each of two units, the earpieces being connected across the primary of T<sub>1</sub> and not the secondary.\*

If the units should be needed for no other purpose, the transformers T<sub>1</sub> need not be obtained. But results are good with crystal earpieces and, with T<sub>1</sub> available, the unit is more versatile.

### The Ferrite Aerial

In the prototype the ferrite aerial uses an 8 by 3/8in piece of rod, snapped in two, with the two halves strapped together to make a double rod 4in long. L<sub>1</sub> has 40 turns of 32 s.w.g. enamelled wire close-wound on this double rod, and L<sub>2</sub> has 7 turns close-wound of the same wire, separated from L<sub>1</sub> by about 1/4in. Phasing is as indicated in Fig. 1.

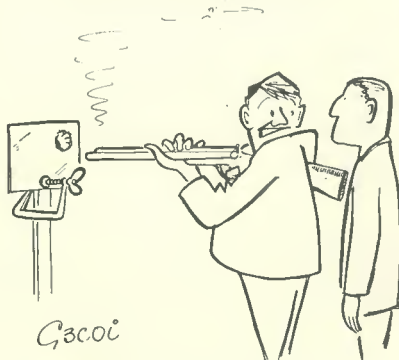
The layout of the components is in no way critical and, as current consumption is a little under 1mA, a very small 9V battery can be used with all parts contained in a small case.

Using a 500pF tuning capacitor a tuning range from 145 to 565 metres is obtained with the prototype. Some of the low wavelength end of the tuning range is lost if an aerial is used connected to the centre contact of the input socket. Provided however, that not more than about 8ft of wire is employed it will still be possible to tune in the Third programme on 194 metres if a transmitter is in the neighbourhood.

\* The DLR5 headphones are ex-Government moving reed types with an impedance of about 60Ω per earpiece.



## cartoonsmile



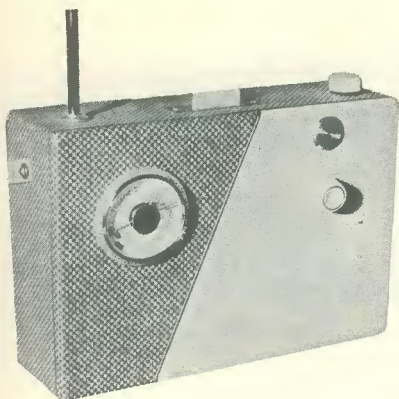
"This saves quite a bit of drilling . . ."

## Marconi Marine Branch at Maldon

The Marconi International Marine Co. Ltd., recently acquired premises at Maldon, Essex, to accommodate the growing activities of its Elettra Sound Systems division which is now well established in the field of supplying comprehensive intercommunication, voice reinforcement, and electronic alarm installations for hospitals, schools, churches, factories, oil refineries, etc., as well as for ships of all types.

The new branch premises consist of a new two-storey block at The Causeway, Maldon, with a floor area of approximately 7,000 square feet which will house offices and assembly workshops. They will be occupied by present Elettra Sound Systems personnel who will be augmented to deal with the increasing business of the division.





Cover Feature



## High Sensitivity Transistor VHF Portable

### PART 1

by T. Snowball

This article, the first of a 2-part series, describes a double superhet receiver for reception of the B.B.C. f.m. broadcasts. Noteworthy features are double superhet working, a pulse discriminator circuit, high input sensitivity, optional a.f.c. and tuning indicator, and an a.f. output in excess of 1 watt. The discriminator offers excellent linearity and the design, up to the a.f. volume control, may also be used as an f.m. tuner in a high fidelity system. The receiver is intended for the advanced constructor who is capable of making up his own layout to general constructional information, and it is necessary to have an r.f. signal generator covering 10 to 11 Mc/s and 80 to 110 Mc/s. An oscilloscope is also helpful

The receiver described in this 2-part series offers a combination which the author has not, at the time of writing, encountered in composite form. The r.f., i.f. and discriminator sections are based on designs previously published separately, these being combined here in the one receiver. The r.f. and 10.7 Mc/s i.f. stages are based on a design appearing in *Mullard Technical Communications*<sup>1</sup>, whilst the second mixer and 200 kc/s pulse discriminator circuits are based on designs by E. D. Frost and J. C. Hopkins previously published in *Wireless World*.<sup>2,3</sup>

In this month's article we shall commence by giving a brief overall description of circuit operation, following this by full details of stage-by-stage functioning. The concluding article, to be published next month, will be devoted to constructional points together with optional a.f.c. and tuning indicator circuits.

#### Overall Operation

To give the reader an initial picture of overall circuit operation we shall now consider the functions carried out by each stage, following the circuit diagram shown in Fig. 1.

The signal is collected by the extending aerial or, via a co-axial socket, from a normal v.h.f. aerial, and is applied to a wideband transformer in the emitter of the r.f. amplifier TR<sub>1</sub>.

The collector circuit of TR<sub>1</sub> is tuned by one gang of the tuning capacitor, C<sub>1(a)</sub> (b), and from here the signal is capacitively coupled to the emitter of the mixer/oscillator transistor TR<sub>2</sub>. The self oscillating mixer has the oscillator tank circuit and the first i.f. transformer at 10.7 Mc/s coupled to its collector circuit.

The mixer is followed by two stages, TR<sub>3</sub> and TR<sub>4</sub>, of i.f. amplification at 10.7 Mc/s, with an overall bandwidth of about 250 kc/s. The signal at 10.7 Mc/s is mixed with a 10.5 Mc/s oscillator, TR<sub>5</sub>, in transformer IFT<sub>4</sub>, and is applied to the second mixer, D<sub>2</sub>, to provide a second i.f. at 200 kc/s.

TR<sub>6</sub> and TR<sub>7</sub> are a feedback pair covering the second i.f. band of 100 to 300 kc/s.

#### HEADING ILLUSTRATION

The receiver in its cabinet. A home-inscribed scale is employed instead of the medium and long wave scale provided with the cabinet. The volume control is to the right of the tuning knob, a decorative motif appearing above it. The tone control is at the right hand end of the top panel of the cabinet. The push buttons at the centre of the top panel may be used for on-off switching. They may also be employed for a manual/a.f.c. circuit, which is described in Part 2

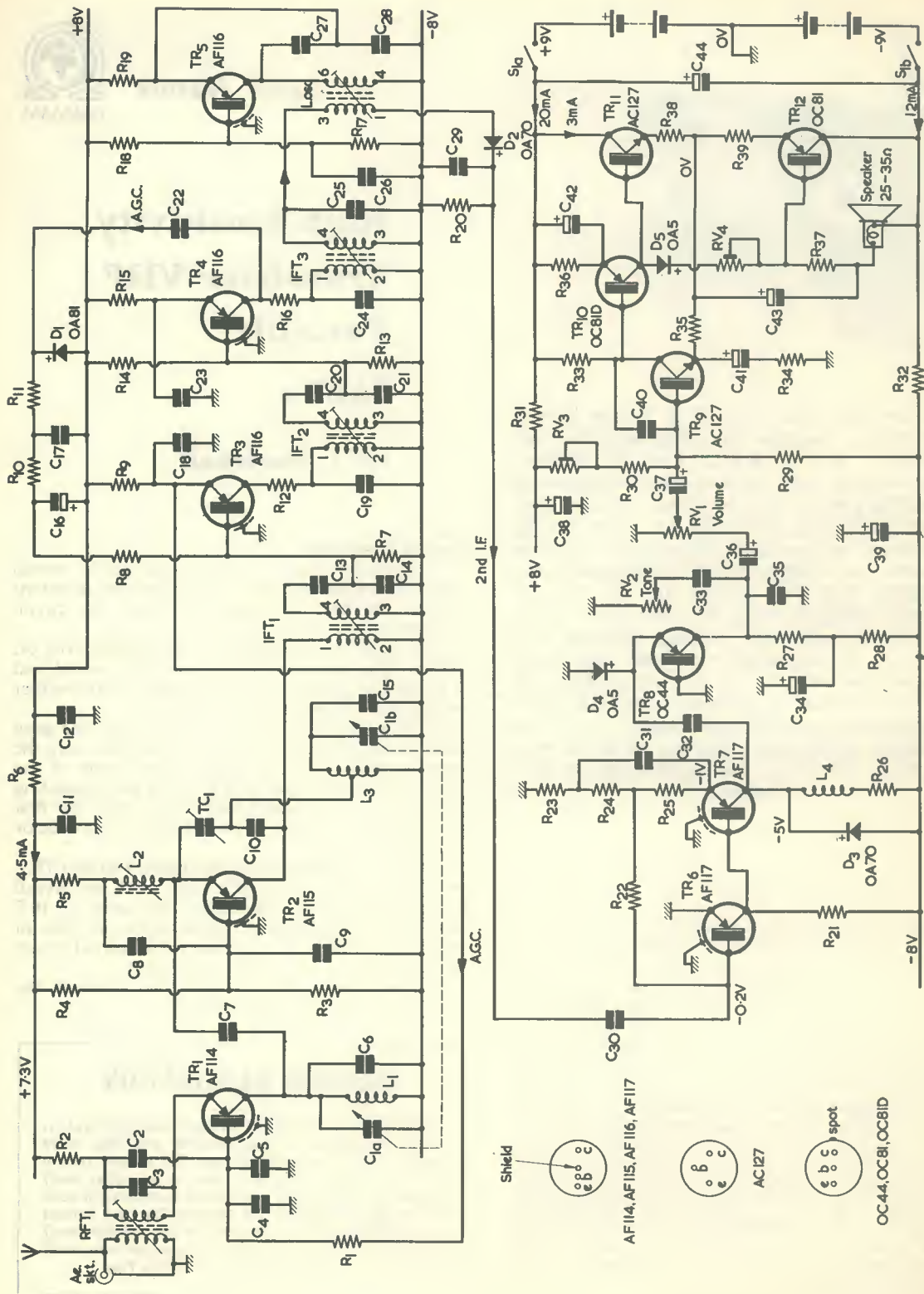


Fig. 1. The circuit of the complete receiver. The pin numbering for IFT<sub>1</sub>, IFT<sub>2</sub> and IFT<sub>3</sub> corresponds to a coil former with 4 tags





**Resistors**

(All fixed values 1/4 watt 10%)

- R1 1kΩ
- R2 560Ω
- R3 6.8kΩ
- R4 1.5kΩ
- R5 560Ω
- R6 150Ω
- R7 68kΩ
- R8 15kΩ
- R9 1kΩ
- R10 1.5kΩ
- R11 3.9kΩ
- R12 220Ω
- R13 22kΩ
- R14 5.6kΩ
- R15 470Ω
- R16 220Ω
- R17 56kΩ
- R18 22kΩ
- R19 3.9kΩ
- R20 4.7kΩ
- R21 18kΩ
- R22 68kΩ
- R23 100Ω
- R24 220Ω
- R25 220Ω
- R26 1.8kΩ
- R27 4.7kΩ
- R28 6.8kΩ
- R29 22kΩ
- R30 12kΩ
- R31 100Ω
- R32 120Ω
- R33 560Ω
- R34 15Ω
- R35 1.5kΩ
- R36 56Ω
- R37 1.5kΩ
- R38 2.2Ω
- R39 2.2Ω

**Capacitors**

(Key: C=ceramic  
E=electrolytic  
SM=silver-mica  
P=polystyrene  
M=metallised polyester or polyether)

- C1(a)(b) 15+15pF two-gang, 00 type A with slow motion tuning. (Henry's Radio Ltd.)
- C2 0.001μF C
- C3 33pF SM or P
- C4 0.001μF C
- C5 0.01μF M
- C6 10pF SM or P
- C7 4.7pF SM or P
- C8 330pF SM or P
- C9 0.001μF C
- C10 68pF SM or P 5%
- C11 0.01μF M
- C12 0.047μF M
- C13 620pF SM or P 5%
- C14 1800pF SM or P
- C15 6.8pF SM or P
- C16 10μF E. 3V
- C17 0.02μF M
- C18 180pF SM or P 5%
- C19 620pF SM or P 5%
- C20 1800pF SM or P
- C21 4.7pF SM or P
- C22 0.1μF M
- C23 180pF SM or P 5%
- C24 470pF SM or P 5%
- C25 0.01μF M
- C26 150pF SM or P 5%
- C27 1500pF SM or P
- C28 0.001μF C or SM
- C29 0.01μF M
- C30 2.2Ω

- C36 2.0μF E. 10V wkg.
- C37 2.0μF E. 10V wkg.
- C38 100μF E. 10V wkg.
- C39 100μF E. 10V wkg.
- C40 0.001μF C or M
- C41 200μF E. 3V wkg.
- C42 100μF E. 3V wkg.
- C43 350μF E. 10V wkg.
- C44 500μF E. 20V wkg.

TC1 2-8pF trimmer, Mullard concentric  
Note. C13 and C20 may be 470pF and 150pF in parallel.

**Transistors**

- TR1 AF114, AF102, OC171, NKT675
- TR2 AF115, OC171, NKT675
- TR3 AF116, OC170, NKT676
- TR4 AF116, OC170, NKT676
- TR5 AF116, OC170, NKT676
- TR6 AF117, NKT677
- TR7 AF117, NKT677
- TR8 OC44, NK1142
- TR9 AC127, OC139, NKT1713
- TR10 OC81D, OC72, NKT222
- TR11 AC127, OC140, NKT1713
- TR12 OC81, OC72, NKT222

Note. Both TR11 and TR12 require heat sinks.

**Diodes**

- D1 OA81
- D2 OA70
- D3 OA70
- D4 OA5, OA10
- D5 OA5, OA10

- RV1 50kΩ potentiometer, log track
- RV2 5kΩ potentiometer, linear track
- RV3 10kΩ potentiometer, linear track, pre-set, miniature
- RV4 220Ω potentiometer, linear track, pre-set, miniature

**COMPONENTS**

**Switch**

S1(a)(b) d.p.s.t., on-off (see note below)

**Miscellaneous**

Cabinet assembly (see note below)  
Loudspeaker, 25-35Ω, 7 x 4in or 6 x 4in  
Knobs (for RV1 and RV2)  
Coaxial socket  
Telescopic aerial, 8 3/4in closed, 38 1/2in extended,  
Type B (Henry's Radio Ltd.)  
Printed circuit board, 10 x 6 1/2in  
Insulated lead-throughs  
Cabinet, etc.

Note. The cabinet (with push-button switch, tuning knob and decorative motif) employed by the author is available from Gladstone Radio, 66 Elms Road, Aldershot, Hants., as part of their "Super 6" radio kit. The switch may function as on-off.)

**Coil Components**

(Winding details are given in Part 2. L1 is air-spaced and has no former)

- RFT1 Alladin former, 7/8 x 1/4in dia. 1 core
- L2 Alladin former, 3/8 x 1/4in dia. 1 core
- L3 Alladin former, 1/8 x 1/4in dia. polystyrene. No core
- IFT1, IFT2, IFT3 Alladin former, 1 3/8 x 1/4in dia, 4 or 6 tags. 2 cores. Fitted with screening can
- L-osc Alladin former, 1 3/8 x 1/4in dia, 6 tags. 1 core fitted with screening can

**Batteries**

2 9-volt batteries type PP9 (Ever Ready)

**Choke**

L4 R.F. Choke, 1.5mH, type FCC 4. (Electronics)

The output of the second i.f. section consists of square waves with an amplitude of about 7V peak-to-peak. The frequency of this square wave is detected by the diode/transistor pump circuit D<sub>4</sub>, TR<sub>8</sub>, giving a mean current proportional to the frequency of the carrier.

This mean current is of course the audio signal. The intermediate frequency is filtered out in the collector of TR<sub>8</sub>, leaving the audio signal to be passed on, via the volume and tone controls, to the audio amplifier.

TR<sub>9</sub> to TR<sub>12</sub> exemplify the latest in complementary circuit design, similar to that used in the latest commercial radios.

Frequency response is 80 c/s to 12 kc/s with an output power of over 1 watt into a 35Ω loudspeaker.

The design, although somewhat uneconomical in transistors, is very well suited to amateur construction because no difficult transformers are used, such as are given with the normal ratio detector. Also, there is no high degree of gain at any single frequency, thus providing a stable design which can be built without too much restriction upon component layout. Some care is, of course, still needed in the r.f. and first mixer stages because these operate at 100 Mc/s.

The high overall gain given by this receiver allow its use as a portable in most "awkward" locations, such as steel framed buildings or deeply ridged country situations. The receiver has been checked in deep valleys at distances of up to 50 miles from the transmitter, although at this range some care seems necessary in siting the set. Under these conditions the interference level is still negligible. In terms of voltage, a signal amplitude of about 1 to 5μV is required to give a signal-to-noise ratio of some 20 to 30dB.

#### Detailed Circuit Description: The R.F. Stage

We shall now proceed to a detailed description of circuit operation, commencing with the r.f. stage.

The input transformer, RFT<sub>1</sub>, is heavily damped. by the aerial and input impedance of the transistor, so that the bandwidth is at least 10 Mc/s. In consequence, fixed tuning is used in this position.

The r.f. transistor offers lowest noise at an emitter current of approximately 1.4mA; this is set by the voltage at the far end of R<sub>1</sub>, which makes the base of TR<sub>1</sub>, about 0.9V negative of the positive line for the r.f. stages, and gives about 0.8V across R<sub>2</sub> with 1.4mA flowing through TR<sub>1</sub>. R<sub>2</sub> and C<sub>2</sub> decouple the positive supply to TR<sub>1</sub>. This type of decoupling is used in all the r.f. and 10.7 Mc/s i.f. stages, showing the advantage of a positive supply line with p.n.p. transistors. As can be seen, the components that are necessary from the d.c. point of view also do decoupling work and help the overall stability.

In the collector of TR<sub>1</sub> is a high "Q" tuned circuit with a loaded bandwidth of about 1.5 Mc/s, so this has to be tuned to keep in track over the v.h.f. band. The 10pF padding capacitor C<sub>6</sub> is inserted to help in providing good tracking and may need adjustment in the final setting up. C<sub>7</sub>, 4.7pF, couples

the output of the r.f. stage to the low input impedance of the mixer.

#### The Mixer/Oscillator Stage

TR<sub>2</sub> is a combined mixer and oscillator giving an intermediate frequency of 10.7 Mc/s. The oscillator should run at frequencies between 97.7 Mc/s and 107.7 Mc/s for signal frequencies of 87 to 97 Mc/s.

This is a complicated stage to understand, and it will be helpful to start with the r.f. signal entering through C<sub>7</sub>. L<sub>2</sub> performs two functions here: it acts as an r.f. choke to the 87-97 Mc/s aerial signal and so directs that signal into the emitter, and it also resonates with C<sub>8</sub> to form a series tuned circuit at 10.7 Mc/s between the base and emitter of TR<sub>2</sub>. This means that any 10.7 Mc/s interfering signal entering through C<sub>7</sub> cannot affect TR<sub>2</sub>. Similarly, if any 10.7 Mc/s feedback occurs from the collector through C<sub>10</sub> and TC<sub>1</sub>, it is removed by L<sub>2</sub> and C<sub>8</sub>. C<sub>9</sub> decouples the base to chassis, and makes the transistor work in grounded base for both oscillation and mixing.

For the oscillating condition, IFT<sub>1</sub>, primary acts as an r.f. choke and C<sub>10</sub> passes the 97.7-107.7 Mc/s oscillation frequency to the tuned circuit given by L<sub>3</sub> and C<sub>1(b)</sub>. The small trimmer TC<sub>1</sub> provides positive feedback to the emitter, where L<sub>2</sub> again acts as an r.f. choke. TC<sub>1</sub> thus sets the feedback level and is adjusted to the minimum value which still allows oscillation to occur at about 5V supply. Too large a value for TC<sub>1</sub> may cause oscillator squegging.

The oscillator coil is centre tapped to reduce the effect of transistor capacitance changes and to raise the "Q" of the coil, thus improving oscillator stability.

The 10.7 Mc/s signal is picked out by C<sub>10</sub> resonating with the primary of IFT<sub>1</sub>. The one or two turns of the oscillator coil in series with C<sub>10</sub> offer very low reactance at i.f. and, in effect, C<sub>10</sub> is connected directly across IFT<sub>1</sub> primary to tune it to 10.7 Mc/s.

So far as the d.c. conditions of the stage are concerned, R<sub>3</sub> and R<sub>4</sub> set the base at 6.0V giving an emitter current of 2.0 mA. This is found to give best oscillator stability with supply voltage variation.

#### The 10.7 Mc/s i.f. Stages

Using AF116 transistors the maximum safe gain without neutralization is about 18-20 dB. To achieve this gain and also the correct 250 kc/s bandwidth in three i.f. transformers, it is necessary to use coils with undamped Q's of about 70 and then damp them to give a working Q of about 50, as well as providing critical coupling between primary and secondary. This all sounds rather difficult for the home constructor to arrange, but details of these coils are available in the Mullard publication referred to earlier, and the coils employed in this receiver use the information given in that report.

TR<sub>3</sub> and TR<sub>4</sub> have their bases capacitively tapped into the i.f. transformer secondaries, so that their input impedance presents the same damping to the coils as do their collectors, which are effectively connected directly across the primaries.



The emitter current of TR<sub>3</sub> should drop 1.5V across R<sub>9</sub> and this is used as bias for the r.f. stage. The a.g.c. diode D<sub>1</sub>, rectifies the 10.7 Mc/s signal at TR<sub>4</sub> collector and the rectified direct current flows in opposition to the bias current for TR<sub>3</sub>. Thus, as the signal strength increases, the current supply to TR<sub>3</sub> base is reduced. This reduces the gain of TR<sub>3</sub> by decreasing its emitter current, whereupon the emitter voltage goes positive and reduces the gain of TR<sub>1</sub> by way of its base resistor R<sub>1</sub>.

If, with R<sub>12</sub> and R<sub>16</sub> out of circuit, large signals were received, the collectors of TR<sub>3</sub> and TR<sub>4</sub> could bottom. The collector capacitance would then rise sharply, the high frequency cut-off of the transistor would fall, and there would be a risk of instability. The inclusion of R<sub>12</sub> and R<sub>16</sub> prevents this trouble.

The d.c. conditions of TR<sub>4</sub> are different from those for TR<sub>3</sub>. More emitter current, 3 mA, is provided by R<sub>13</sub> and R<sub>14</sub> to help the stage drive the a.g.c. diode. The secondary of IFT<sub>3</sub> is not capacitively tapped because the second mixer presents a high impedance to the coil, unlike a transistor base which, in the case of TR<sub>3</sub> and TR<sub>4</sub> offers some 400Ω only.

#### The Second Oscillator and Mixer Diode

TR<sub>5</sub> oscillates at 10.5 Mc/s and a few turns on its coil (between terminals 1 and 3) couples this frequency, together with the 10.7 Mc/s signal from TR<sub>4</sub>, to the second mixer, D<sub>2</sub>. The second i.f. is produced at 200 kc/s across R<sub>20</sub>, while the 10.7 Mc/s signals are filtered out by C<sub>29</sub>. The capacitors C<sub>27</sub> and C<sub>28</sub> form a tap across the oscillator tuned coil, with the lower impedance capacitor at the chassis end, so that a small amount of energy is fed back in phase to the emitter to maintain oscillation. The emitter current is set at 0.6 mA by biasing the base at 2.5V negative of the positive supply line.

#### The Second i.f. Stage

TR<sub>6</sub> and TR<sub>7</sub> are d.c. coupled as a feedback pair to reduce variations in gain and to save components. As the v.h.f. signal has ±75 kc/s modulation this stage has to deal with 200 kc/s ±75 kc/s, but to allow for some mistuning a minimum bandwidth of 200 kc/s is desirable.

The aim of this stage is to produce enough gain to ensure that the smallest signal always fully drives the amplifier output from one voltage extreme to the other, so producing a square wave output of 7V peak-to-peak amplitude.

The circuit in the collector of TR<sub>7</sub> is helpful in this respect. The coil L<sub>4</sub> presents a high impedance to any sharp increase of current in TR<sub>7</sub>, while the resistor R<sub>26</sub> is included to prevent undue rise of current during the pulse when TR<sub>7</sub> is on. The function of diode D<sub>3</sub> is to clip the negative overswing which would otherwise occur when TR<sub>7</sub> is turned off. The inductance of the coil is not very critical, and any value between 0.8mH and 2.5mH has been found satisfactory. Recommended is Type No. FCC4-1.5mH by Electroniques, which is available from

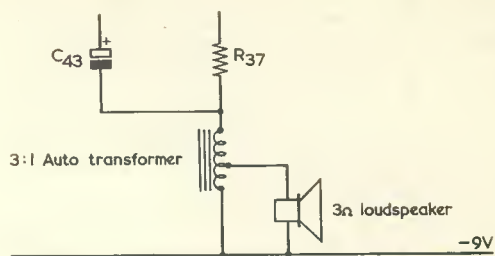


Fig. 2. A 3Ω loudspeaker may be accommodated by using an autotransformer, as shown here

Home Radio (Mitcham) under Cat. No. CHF12. Alternatively, the constructor may wind his own coil, and details are given next month for this.

The frequency of the square wave at TR<sub>7</sub> collector varies, of course, with the amplitude of the a.f. modulation on the transmitted signal. The loudest sounds cause the maximum variation, from 125 kc/s to 275 kc/s. At the same time, the frequency of the a.f. controls the number of times per second that the frequency of the i.f. changes from one extreme to the other.

Circuit design of the second i.f. stages TR<sub>6</sub> and TR<sub>7</sub> starts by assuming a maximum voltage at TR<sub>7</sub> emitter of -1.0V, this then gives an available output swing of very nearly 7V when the supply is 8V. As, from the switching speed point of view, a suitable collector load is 1.8kΩ, then to set the collector at about -5V, roughly halfway between the emitter and supply rail, the value of collector current is 1.8 mA, causing some 3 volts to be dropped across R<sub>26</sub>. To give -1.0V at the emitter, the total value of R<sub>23</sub>, R<sub>24</sub> and R<sub>25</sub> should be  $\frac{1}{1.8} = 555\Omega$ .

R<sub>23</sub> is the feedback resistor and is set by the gain required to 100Ω. This leaves a value of 450Ω for R<sub>24</sub> and R<sub>25</sub> which is split equally to help set up the d.c. conditions for TR<sub>6</sub> and TR<sub>7</sub>. These d.c. conditions will be discussed next.

TR<sub>6</sub> emitter is at chassis potential, therefore its base will be at about -0.2V. Its collector must, of course, be more negative than the base. TR<sub>6</sub> collector connects directly to TR<sub>7</sub> base, which has been fixed at -1.2V, whereupon, because there are no large voltage swings at TR<sub>6</sub> collector, its voltage requirements are met very nicely. TR<sub>6</sub> collector current should be about 300μA to give adequate gain and low noise. Too low a current will give low gain (about 75 is typical for an AF117 at 300μA) whereas too high a current will increase the noise contributed by this stage. So, with -1.2V on the collector/base junction of TR<sub>6</sub> and TR<sub>7</sub>, R<sub>21</sub> comes out at the preferred value of 18kΩ when the collector current of TR<sub>6</sub> is made 360μA and the base current of TR<sub>7</sub> is 20μA. This makes TR<sub>6</sub> base current about 5μA if the gain is taken to be 75, but to obtain this by connecting R<sub>22</sub> direct to TR<sub>7</sub> emitter, would give a very high value for R<sub>22</sub>, so high in fact that transistor leakage current would defeat the issue. So R<sub>22</sub> is taken to a

lower voltage produced by the two resistors  $R_{24}$  and  $R_{25}$ , this being nominally 0.6V due to  $TR_7$  collector current. A voltage of 0.4 across  $R_{22}$  at a current of  $5\mu A$  result in a calculated value of  $80k\Omega$ . In practice the author used  $68k\Omega$  because, as can be seen from the preceding discussion, transistor parameters and resistor tolerances affect the final answer. But the above design calculations still have to be done to get one into the right street. The constructor is advised to check the collector voltage of  $TR_7$  and adjust  $R_{22}$  if this is outside the limits  $-3.5$  to  $-6.5$  volts. The author's  $68k\Omega$  resistor gave exactly  $-5.0V$  at  $TR_7$  collector.

#### Diode/Transistor Pump Circuit

Diode  $D_4$  and  $TR_8$  turn the varying 200 kc/s square wave into a signal which varies at a rate proportional to the audio modulation.

If no modulation is present, the steady second i.f. of 200 kc/s causes a pulse of current to be pumped into the emitter—base diode of  $TR_8$  each time the collector of  $TR_7$  goes positive. Each time  $TR_7$  collector goes negative the diode  $D_4$  catches, and allows  $C_{32}$  to charge again.

Thus, into the emitter of  $TR_8$  passes the charge that is stored in  $C_{32}$  each time  $TR_7$  collector goes through its swing of 7V. The charge stored in  $C_{32}$  is CV multiplied by the number of times per second that the charge is inserted.

$$\begin{aligned} \text{In this case: } C &= 270 \times 10^{-12} \text{ Farads} \\ V &= 7V \\ F &= 200 \times 10^3 \text{ c/s} \\ \therefore I &= 270 \times 10^{-12} \times 7 \times 200 \times 10^3 \times 10^3 \text{ mA} \\ I &= 0.38 \text{ mA} \end{aligned}$$

With the maximum audio modulation on the carrier, F becomes 125 and 275 kc/s making the emitter current 0.24 mA and 0.52 mA.

The aim of feeding this current to the emitter rather than to a base is to avoid bringing the current gain of the transistor into the calculations. Since the collector current is almost equal to emitter current, and since the emitter current for any given i.f. is known, the collector current can be readily changed to a known voltage for use with a tuning meter or a.f.c. circuit. On the other hand, if the pulses were fed into a base, the corresponding collector current could easily vary by 3:1 for different transistors.

The collector current for  $TR_8$  in the present design is developed across two resistors  $R_{27}$  and  $R_{28}$ . De-emphasis and tone control are also carried out in this section of the circuit.

At a second i.f. of 200 kc/s, the voltage drop across  $R_{27}$  and  $R_{28}$  will be  $TR_8$  emitter current times current gain times  $(R_{27} + R_{28}) = 0.38 \times 0.98 \times 11.5 = 4.3$  volts. So the collector voltage for a correctly tuned signal ought to be about  $-3.7$  depending upon resistor tolerance and transistor leakage. Transistor leakage should be negligible because  $TR_8$  is an RF type in grounded base configuration.

The de-emphasis time constant for f.m. reception is given as  $50 \mu s$ . The B.B.C. boosts the higher audio frequencies when transmitting and so, to get a level

response on reception, a top cut of 3dB at 3 kc/s, continuing to fall at 6dB per octave, must be introduced. This response is given by  $R_{27}$  and  $C_{35}$ , and an additional top cut available as a tone control is put in by  $C_{33}$  and  $RV_2$ . These last two components enable a more balanced reproduction to be achieved with the small  $7 \times 4$ in. loudspeaker used in the portable version.

#### The Audio Amplifier

From  $TR_8$  the a.f. signal passes to a simple volume control, which is isolated with two capacitors. This practice may seem wasteful, but the capacitors stop d.c. flowing through the volume control, which may otherwise cause noisy operation after use.

The output stage can deliver the required power by either providing a high current at low voltage or a high voltage at less current. The latter alternative is used here, and it means that over 1 watt can be easily achieved with peak currents below 300 mA.  $TR_{11}$  and  $TR_{12}$  can alternatively swing the positive plate of  $C_{43}$  almost to the limits of the full supply line, giving a peak-to-peak swing of nearly 18V.

This results in an r.m.s. output of  $\frac{V_{pk}}{2} \times 0.707 = 6.3V$ . If the loudspeaker has an impedance of  $35\Omega$ , then the r.m.s. wattage will be  $\frac{V^2}{R} = 1.2W$ .

$TR_9$  and  $TR_{10}$  are both d.c. coupled to  $TR_{11}$  and  $TR_{12}$ , d.c. feedback being taken through  $R_{35}$ . A.C. feedback also passes through  $R_{35}$  and is decoupled by  $C_{41}$  in series with  $R_{34}$ , these components controlling the level of the a.c. feedback. Without  $R_{34}$  no a.c. feedback could appear on  $TR_9$  emitter, and full gain with evident distortion would occur. The feedback raises the input impedance of  $TR_9$  which is useful so far as the loading on  $TR_8$  at full volume is concerned.

Circuit details are worked out in the following manner. If the output swing is to be symmetrical, then the junctions of  $R_{38}$  and  $R_{39}$  must be at 0V in the quiescent condition. All the emitter current of  $TR_9$  must flow through  $R_{35}$  and, for good gain, should be a minimum of 1mA; whereupon the requisite voltage across  $R_{35}$  becomes 1.5V, resulting in a voltage at  $TR_9$  base of about +1.7V. The  $TR_9$  base voltage is obtained simply by  $R_{29}$  and  $R_{30}$ ,  $RV_3$  being included to allow for component tolerances. Note that  $RV_3$  and  $R_{29}$  are taken from the decoupled sides of  $R_{31}$  and  $R_{32}$ ; this is done to avoid supply line fluctuations which are often evident in Class B output stages due to the high peak currents in the output transistors.

If, assuming a  $30\Omega$  loudspeaker, the peak current in the output transistors is about  $\frac{9V}{30\Omega} = 300 \text{ mA}$  then

since their gain may be 50 only, the base drive should be about 6 mA. This sets the value of  $R_{37}$  because 6 mA must flow through  $TR_{10}$  when no input signal is applied, so that all the 6 mA can flow into the output transistor when  $TR_{10}$  is cut off on a large signal. Very nearly 9V appears across  $R_{37}$  in the quiescent condition, so that this resistor has a value



of  $\frac{9V}{6mA} = 1.5 \text{ k}\Omega$ .  $D_5$  and  $RV_4$  also have this 6mA flowing through them, and they develop a voltage to forward-bias the bases of  $TR_{11}$  and  $TR_{12}$ , thus setting up a steady current through them in the quiescent condition. The quiescent current can often be as low as 2 to 3 mA but this all depends on how well the output transistors are matched; increasing the quiescent current will allow the use of transistors with a 2:1 mismatch.

The 6mA flowing in  $TR_{10}$  passes through  $R_{36}$  developing a voltage of 0.35 across this resistor. It might be thought that  $R_{36}$  and  $C_{42}$  are not really needed, but without them the base of  $TR_{10}$  must be about 0.2V negative of the positive supply line. Assuming a typical gain of 60 in  $TR_{10}$ , this gives a base current of  $\frac{6mA}{60} = 100\mu A$ ; which means that the current through  $TR_9$ , already set at 1mA, must be shunted away through  $R_{33}$ , giving  $R_{33}$  a value of  $\frac{0.2V}{0.9mA} = 220\Omega$ . This is less than half the value that is obtained by inserting  $R_{36}$  and  $C_{42}$ , so the gain of  $TR_9$  is halved because its gain is roughly proportional to the value of its collector resistor. Working in the other direction, too large a value in  $R_{36}$  reduces the voltage swing available at  $TR_{10}$  collector because, obviously,  $TR_{10}$  collector cannot rise more positive

than its emitter; and as the output transistors are in emitter follower configuration, this results in a direct loss of output voltage.

$C_{40}$  provides a calculated amount of top cut, about 3dB at 10 kc/s and finally removes any of the second i.f. which may still be present.

If a 3 $\Omega$  loudspeaker is to hand it is quite in order to use it with the aid of a small autotransformer as shown in Fig. 2. To step up the impedance of a 3 $\Omega$  speaker an autotransformer of ratio 1:3 gives an impedance of  $3 \times 3^2 = 27\Omega$ . A suitable transformer is the type TT39 3.1:1 by Repanco Ltd.

Alternatively the constructor can wind his own transformer. Obtain any small speaker transformer with a core area of at least 0.4 sq. in., strip it down and wind on enough turns to fill the bobbin with a tap at one third. Some experimenting may be necessary, but start by using about 26 s.w.g. and aim at least 250 turns total.

The circuit description is now complete, and the next article will deal with constructional details.

#### References

- 1 "F.M./A.M. Transistor Portable Receiver", *Mullard Technical Communications*, Vol. 6 No. 58, June 1962. Authors: L. E. Jansson, B. R. Baker, A. Sargood and H. A. Heins.
- 2 J. C. Hopkins, "A Simple Transistor FM Tuner". *Wireless World*, September 1965.
- 3 E. D. Frost, "Pulse-Counting FM Tuner". *Wireless World*, December 1965.

(To be concluded)



## Transistorised Grid Dip Meter for the Experimenter

by D. Burge

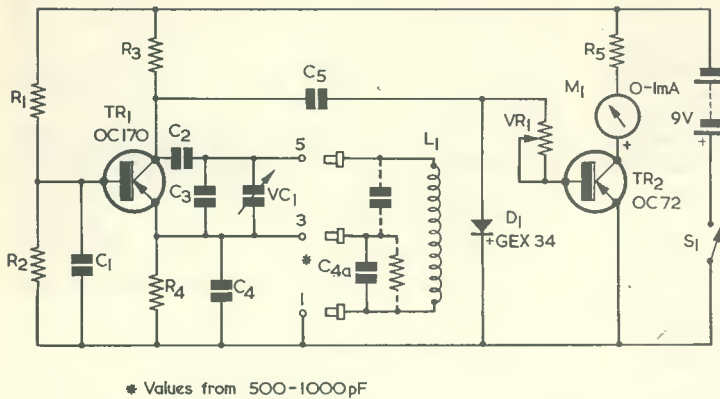
A neat battery-operated design which offers continuous coverage from 325 kc/s to 29 M/cs

HAVING DECIDED THAT A GRID dip meter would be a very useful piece of test equipment to have on hand, the relative merits of various published designs were investigated. While these would undoubtedly serve the purpose in mind, it was considered that a transistorised version would have advantages in some applications as well as eliminating the bugbear of mains power supplies and trailing mains leads. It was also felt that the problems and

experience involved in building the instrument from scratch would be of interest to other constructors, particularly as the finished instrument was finally made for very little cost, maximum use being made of components on hand.

Various oscillator circuits were tried without a great deal of success, for one reason or another. A circuit that worked well at low frequencies was useless at high frequencies, or would only operate over a limited

range. Finally a Colpitts circuit was used with the tank coil effectively connected between the collector and base of an OC170, and the tuning capacitor connected between collector and emitter. A 500pF variable capacitor with an integral slow motion drive was employed in this position and although it was not of the modern miniature variety, it fitted very conveniently on the front panel. The output from the oscillator was taken direct from the collector of the OC170 via a small coupling capacitor to a GEX34 diode, followed by a meter amplifier consisting of an OC72 with a 0-1mA meter in the collector circuit, sensitivity being controlled by means of a variable resistor in series with the base. This control is  $VR_1$  in the circuit diagram of Fig. 1. Adjustment of the sensitivity control has a slight effect on frequency but this was not more than 10 kc/s within the range at which the pointer would be set and was not therefore considered detrimental for the kind of use to which the instrument would be put. In any case matters are improved if the instrument is calibrated with the sensitivity control set to about two-thirds full scale reading, where it would be set in the normal course of use. The coupling capacitor,



\* Values from 500-1000pF

Fig. 1. The circuit of the transistorised grid dip meter. C<sub>4a</sub> is fitted in the coil assembly

C<sub>5</sub>, was found to be critical, inasmuch that it had a definite effect on the degree of amplitude of oscillation as the tuning was varied from maximum to minimum. A value of 25pF was finally found to give a reasonable compromise.

The shield lead-out from the OC170 is not connected to the positive supply line as it was found that such a connection gave a reduction in oscillator amplitude. This reduction could be easily tolerated at the middle frequencies but not at the high frequency end of the overall range.

The layout of the oscillator and meter amplifier components is shown in Fig. 2. The construction of the coil units is illustrated diagrammatically in Fig. 3. Components shown dotted will in some cases not be necessary. These were adjusted by trial and error methods, and were found to improve matters at the extreme high and low frequency ranges of the instrument. More details on the coils are given later in this article.

#### Construction

The finished instrument was fitted

## COMPONENTS

### Resistors

(All fixed values  $\frac{1}{4}$  watt 10%)

- R<sub>1</sub> 15k $\Omega$
- R<sub>2</sub> 3.3k $\Omega$
- R<sub>3</sub> 3.9k $\Omega$
- R<sub>4</sub> 2.2k $\Omega$
- R<sub>5</sub> 1.5k $\Omega$
- VR<sub>1</sub> 100k $\Omega$  potentiometer, linear track

### Capacitors

- C<sub>1</sub> 0.01 $\mu$ F ceramic
- C<sub>2</sub> 0.05 $\mu$ F ceramic
- C<sub>3</sub> 75pF silver-mica
- C<sub>4</sub> 330pF silver-mica
- C<sub>4(a)</sub> See text
- VC<sub>1</sub> 500pF variable, with drive and scale

### Semiconductors

- TR<sub>1</sub> OC170
- TR<sub>2</sub> OC72
- D<sub>1</sub> GEX34

### Meter

- M<sub>1</sub> moving-coil meter, 0-1mA

### Switch

- S<sub>1</sub> s.p.s.t. switch

### Miscellaneous

- 9-volt battery and connectors
- Octal socket (see Fig. 2) and octal bases
- Coil formers and coil wire
- Material for case, etc.

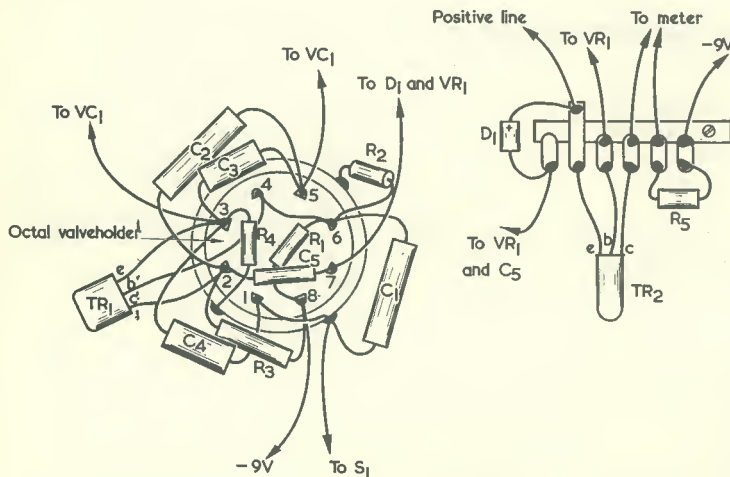


Fig. 2. The components in the oscillator circuit are fitted around the octal valveholder, which should be a ceramic type. The valveholder employed in the prototype had a metal fixing plate with earthing tags. The output from pin 7 connects to D<sub>1</sub> on the 6-way tagstrip and to VR<sub>1</sub> (mounted on the opposite end plate). As shown in Fig. 1, the slider and other end of VR<sub>1</sub> track then connect to TR<sub>2</sub> base. The shield lead-out of TR<sub>1</sub> is not connected into the circuit

into a case measuring approximately  $6\frac{1}{2} \times 3 \times 3$  in. Some reduction in size could have been achieved by using miniature components, but as the front panel could not be made much smaller and still have a reasonable sized dial, it was decided to employ what components were on hand rather than go to the added expense of purchasing new ones.

Power requirements being very small, a miniature type 9 volt transistor radio type battery is used, this being conveniently fitted in a tool type clip mounted on the end panel. The top panel is made of Formica,\* whilst the end panel carrying the coil holder and oscillator components is made of  $\frac{1}{4}$  in Perspex. The opposite end plate is made of aluminium and carries the sensitivity control and battery clip. In the instrument built by the writer the on/off switch is mounted on the front panel but could probably be more conveniently mounted on the

\* Avoid using the heat-resistant grade of Formica, which may have a thin metal lamina in its structure.—Editor.



end plate, together with the battery and sensitivity control. The 6-way tagstrip of Fig. 2 may also be fitted to this end plate.

The cover plate was made of aluminium in the shape of a U with the top edges bent over by  $\frac{1}{4}$  in to enable self tapping screws to be used to fix it to the top panel. The general idea is shown in Fig. 4, with approximate dimensions. These may be altered, as desired according to the constructor's requirements. The variable dial capacitor with its associated dial and, also, the meter movement were mounted on the top panel. All the oscillator components are wired as shown in Fig. 2, round a ceramic octal valveholder mounted in the Perspex end plate. The series capacitors across the tank coil are made up of VC<sub>1</sub> in parallel with C<sub>3</sub>, which was found necessary to maintain amplitude of oscillation at the high frequency end of each range, while the lower end of the feedback combination is made up of C<sub>4</sub> and C<sub>4(a)</sub>, these being effectively in parallel since C<sub>4(a)</sub> is wired between pins 1 and 3 on the coil assembly. This arrangement assisted in adjusting the degree of feedback and also to some extent the frequency range of each coil.

It will be obvious to the reader that tags numbered 1, 3 and 5 on the valveholder should not be used as anchoring points for any other components than those shown in the diagram.

### Coils

The coils were made up from materials on hand, the bases being cut off old octal valves which the writer had been wondering what to do with for some considerable time. All the coils recommended in this article are air cored, it being found that iron-cored coils, tried on the extreme low frequency range, gave erratic results. Initially, coils were made up by taking advantage of the properties of the instrument. With a low frequency coil plugged into the meter and the meter tuning capacitor set to the high frequency end of its range, an external tuned circuit was made up with another 500pF tuning capacitor and the coil intended for the range immediately above. This last coil was adjusted until it gave a dip with its tuning capacitor set to a high capacitance, whereupon it was capable of providing the next range for the instrument. This procedure is mentioned as it will prove helpful to the experimenter who wishes to design his own range of coils.

Details of the coils finally develop-

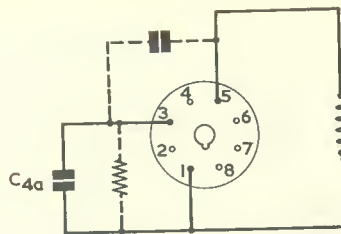


Fig. 3. Each coil is wired between pins 1 and 5 of its octal base, C<sub>4a</sub> having a value which enables optimum feedback conditions to be provided. With some coil assemblies, either the resistor or the capacitor shown in dotted line is also added

ed by the writer are given in the Table, and it will be seen that seven coil assemblies give the complete coverage from 325 kc/s to 29 Mc/s. All coils were wound on formers of  $\frac{3}{8}$  in diameter, 2 in long. With the

exception of the coil for the lowest frequency range, each coil was assembled to its octal base by means of two lengths of 22 s.w.g. tinned copper wire. These were soldered to pins 1 and 5, the other ends con-

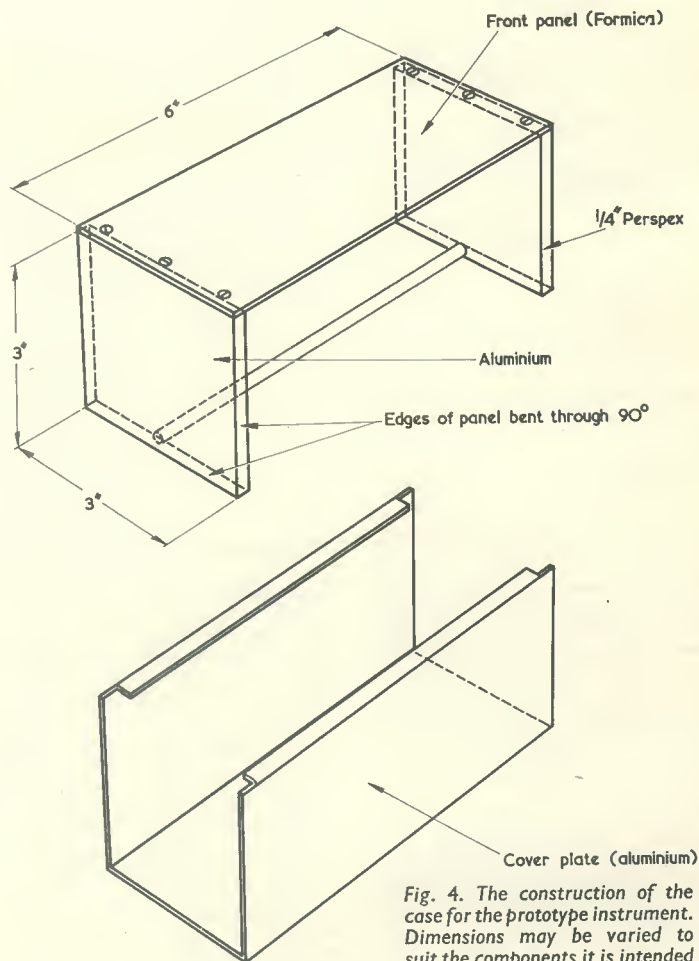


Fig. 4. The construction of the case for the prototype instrument. Dimensions may be varied to suit the components it is intended to use

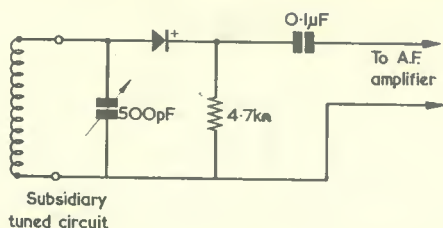


Fig. 5. This simple circuit arrangement may be used for calibrating the meter at frequencies which are not covered by a receiver

### Calibration

Various methods of calibration can be used, the simplest consisting of employing a receiver and signal generator and tuning to zero beat. A subsidiary coil or tuned circuit can be used for coupling the grid dip meter coil into the receiver, a capacitive or inductive coupling being obtained from the signal generator. If a receiver covering all the frequencies is not available, the subsidiary tuned circuit can couple to a germanium diode followed by a 4.7kΩ diode load, the output being fed to an a.f. amplifier to give indication of zero beat. The arrangement is shown in Fig. 5.

TABLE  
Details of Coils

Formers:  $\frac{1}{2}$ in diameter, 2in long. All windings connected to pin 1 and started at end of former remote from base, then wound back towards base and connected to pin 5.

Range	Turns	Wire Gauge (s.w.g.)	Winding	C <sub>4(a)</sub> pin 1-pin 3	R pin 1-pin 3	C pin 3-pin 5
325 kc/s-580 kc/s	280	Litz (see text)	4 piles, each 70 turns	1,000pF		100pF
570 kc/s-1,150 kc/s	160	38 s.c.c.	5 piles, each 32 turns	680pF		
1,150 kc/s-2.2 Mc/s	54	38 s.c.c.	3 piles, each 18 turns	680pF		
2.2 Mc/s-4.4 Mc/s	31	30 enam.	close-wound	1,000pF		
4.2 Mc/s-7.5 Mc/s	22	26 enam.	space-wound 1in long	500pF		
7.5 Mc/s-14.5 Mc/s	9½	22 enam.	space-wound ¾in long	500pF	2.2kΩ	
14.5 Mc/s-29 Mc/s	3½	18 enam.	space-wound ½in long	500pF	2.2kΩ	

necting to two tags at each end of the former, between which the coils were wound. A small amount of glue between the bottom of the former and the valve base made a secure assembly. The coil former for the lowest frequency range had four tags at one end, these being soldered to pins 1, 3, 5 and 8. No coil connection was made to the tag soldered to pin 8.

Other means of assembly can be employed. The methods just describe were used by the writer to suit coil formers which were already on hand, and offer a guide to the intending constructor.

The circuit is very tolerant and almost any type of coil will oscillate satisfactorily in the middle ranges.

The lowest frequency coil had to be wound with 7-strand litz wire before satisfactory results could be obtained. The highest frequency coil required some adjustment of spacing to obtain the correct frequency range of 14.5 to 29 Mc/s.

As an experiment, a loop of wire about 3in long was connected to pins 1 and 5, and a 2.2kΩ resistor between pins 1 and 3. The results were erratic over the tuning range, but oscillation was nevertheless obtained up to 45 Mc/s. This leads the writer to believe that, if miniature components had been used in the oscillator circuit, together with close attention to wiring, it could be possible to obtain useful operation up to 45 Mc/s.

### Results

Results obtained with the meter on various tuned circuits are very good. In fact, to obtain an accurate reading when the tuned circuit being checked is not heavily damped, it is necessary to hold the meter from one to two inches away from the tuned circuit. Tuning must of course be carried out fairly slowly, otherwise the dip can be missed altogether, particularly on the low frequency ranges. This applies also when calibrating the instrument, since, if the output from the signal generator is set too high or the probe put too near the subsidiary tuned circuit, one is liable to get an increase in reading on the meter instead of a dip at zero beat!





# In Your Workshop

Owing to heavy last-minute pressure on space, we had to attenuate the "In Your Workshop" feature in our last issue. However, the irrepressible Dick and Smithy cannot be kept down for long, and they return to the fray this month to conclude their discussion on hints received from readers

"NOW THIS," REMARKED DICK, as he settled himself comfortably on his stool, "is a bit of all right, isn't it?"

"How come?"

"Well, we've got hints from readers going for two months running. Just the job!"

Smithy grinned and sipped at his lunch-break tea.

"I think we took up a bit too much space in the magazine last month," he chuckled, "and so we've had to conclude our readers' hint sesh in the present issue."

A thought occurred to Dick, and he frowned.

"I'm not entirely certain," he said darkly, "that there isn't a plot behind our being cut last month. How do we know that someone isn't trying to get at us?"

"Don't be silly," retorted Smithy. "Who on earth would want to do a thing like that?"

But Dick was not to be denied his suspicions.

"I'll bet it's that G. A. French who's behind it all," he pronounced in a sepulchral tone. "He's trying to hog more space for those 'Suggested Circuits' of his!"

"I've never heard such nonsense," snorted Smithy, shocked. "And if you've quite finished attempting to blacken the reputation of your betters, we'll start off with the next hint from our readers."

## Printed Circuit Valve Connections

"Okey-dokey then," said Dick, setting aside his suspicions. "I'm all ears!"

"Well, this one," replied Smithy, picking up a letter from his bench, "describes a neat little test terminal gadget which enables you to make connections to valve pins in printed circuit receivers. I don't have to remind you that it can sometimes be a dickens of a job to make a temporary connection to a valve pin for a signal generator or a voltmeter."

"True enough," agreed Dick. "I sometimes have to temporarily solder a short lead to the circuit on the copper side of the board, and then connect the signal genny or the testmeter to that."

"The little device described here," said Smithy, showing Dick the drawings accompanying the letter he had selected (Fig. 1), "overcomes this problem quite neatly. The complete test terminal consists of a piece of tinned copper wire soldered to a curved metal plate which fits snugly against the side of the valve-holder. As you can see, the eye at the end of the wire makes contact with the pin of the valve, whilst the curved plate is notched to take the wire. The two are soldered together, care being taken to ensure that no solder blobs appear on the inside surface of the curved plate. The function of the curved plate is, of course, to prevent the wire connection from moving sideways and touching an adjacent valve pin. A short test lead can be soldered to the outside end of the connecting wire."

"Well, that's settled my first job for now," remarked Dick. "Which will consist of making up two of those valve pin connectors!"

"Two?"

"Of course," replied Dick. "One for B7G valves and one for B9A valves."

"Two?"

Smithy sounded quite hurt.

"Oh, all right," said Dick, "four, then. Two more for you!"

"Ah," remarked Smithy, pleased.

"It is nice to be offered these odd little servicing aids. I'm certain I'll be using them quite often, too. Now let's take a gander at the next hint."

Smithy examined the next letter.

"Now this," he remarked, "is a very neat idea, and it is very definitely aimed at the home-constructor. Quite a lot of home-constructors use super-regenerative receivers, including the one that was described in *The Radio Constructor* of May 1965. The gain of a super-regenerative receiver depends on the ratio between the signal frequency and the quench frequency, and for best results the quench frequency should not be higher than about 10 kc/s. This is particularly the case when the signal to be received is lower than 2 Mc/s or so. Unfortunately, most people can hear a 10 kc/s whistle, and young listeners can find it actually unpleasant if its intensity is high. The hint describes a parallel tuned circuit filter which has a high Q and which eliminates the whistle very



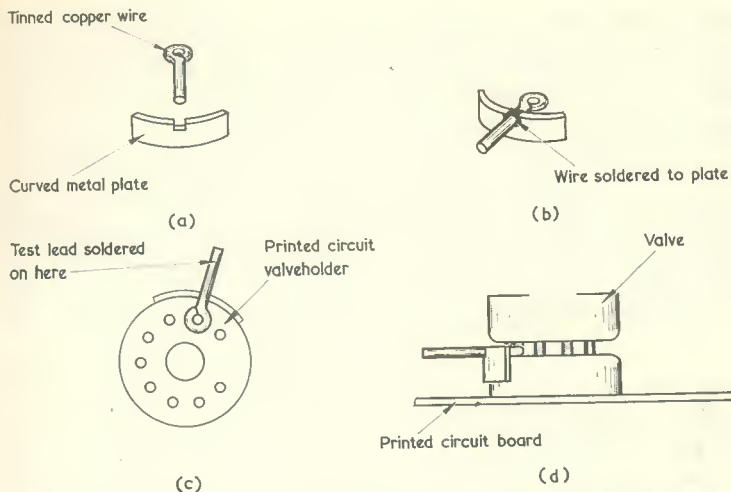


Fig. 1 (a). The two parts of a connector which allows test coupling to a valve pin  
 (b). The two parts soldered together  
 (c). The connector in position on a valveholder before the valve is inserted  
 (d). Side view with the valve inserted

effectively. There are some drawings with this letter also."

Smithy laid the drawings out on the bench in front of Dick. (Fig. 2).

"The coil in the filter," Smithy carried on, "consists of 1,000 turns of 38 s.w.g. enamelled wire pile-wound to a length of about 1 inch on a paper tube  $1\frac{1}{2}$  inches long. The internal diameter of the tube allows a piece of  $\frac{3}{8}$  inch ferrite rod to slide in and out. This rod may be about 3 inches long. The position of the rod should be adjustable, preferably with a panel control since the filter tunes quite sharply and the frequency of the quench whistle in a super-regenerative receiver varies a little with the setting of the receiver controls. The filter must be fitted in a low frequency stage, but not too close, circuit-wise, to the quench oscillator or there may be interaction. Assuming a transistor receiver, a useful position is between the collector of the output stage and the speaker or, if a Class B output stage is used, in the collector circuit of the driver stage. If the filter is fitted to a receiver which employs a supersonic quench frequency, this frequency can be reduced to about 10 kc/s and the filter adjusted to cut out the whistle. The filter has been found very effective in the medium and long wave superhet I referred to just now."

"It should be jolly useful also," remarked Dick, "for receivers which aren't super-regenerative. It could,

for instance, cut out some of the inter-station whistles you get on medium waves. Or the whistle you get on the long wave Light Programme due to interference from TV timebases."

"Good point," confirmed Smithy. "I know that TV timebase interference with the long wave Light Programme is supposed to have pretty well disappeared these days. But it still proves troublesome in areas where the Light Programme signal is fairly low. However, let's get on to the next hint."

Smithy extracted a further letter.

"This," he said, "is rather an off-beat one. The idea is for a trimming tool for those little  $\frac{1}{8}$  inch i.f. transformer dust cores you get in small transistor radios. These are the ones with a rectangular slot for adjustment, and it is quite possible to get into trouble if you don't have the correct trimming tool to hand. The idea behind the hint is to make up a trimming tool from an ordinary resistor. A 1 watt high stability type is preferable because it has a long

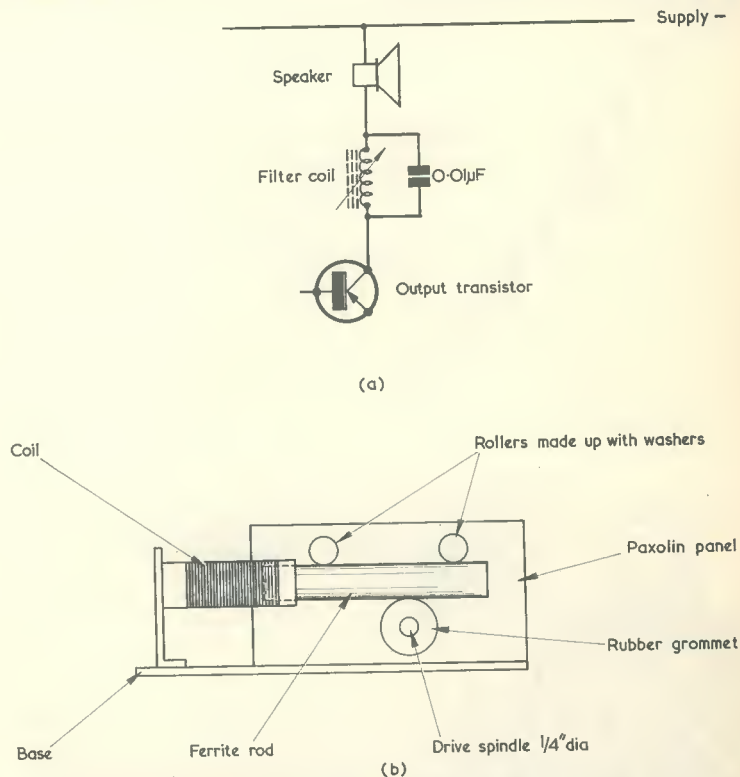


Fig. 2 (a). The 10 kc/s filter inserted in the collector circuit of an output transistor. The filter consists of the coil and the parallel 0.01µF capacitor  
 (b). How a panel control of filter resonant frequency may be achieved. The amount of ferrite rod insertion in the coil is controlled by rotating the drive spindle



body and provides a better grip. You cut off one lead-out wire and gently hammer the end of the other lead-out wire until it's about  $\frac{1}{16}$  inch wide. This end then fits into the slot of the core. The best wire length is about 1 inch. (Fig. 3). If used correctly, this simple makeshift tool will last for quite a while."

#### Packing In

"That," commented Dick, "is certainly a novel idea. It's jolly useful, too, for those occasions when you get stuck."

"It is, indeed," replied Smithy, rising and returning the letters to a drawer in his bench. "And that will have to be the end of readers' hints for a little while. We'll be having another go at them fairly soon."

"Good show," said Dick. "I'll certainly be looking forward to that."

He fell silent for a moment, obviously deep in concentration. Suddenly his furrowed brow cleared. Recognising the signs, Smithy steered

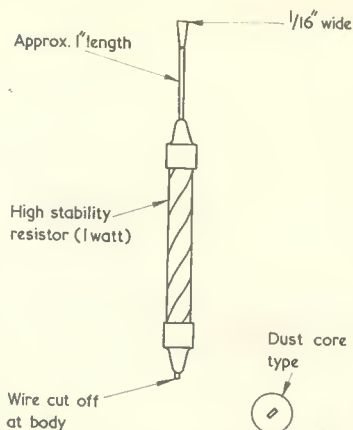


Fig. 3. In cases of difficulty, a standard resistor can be pressed into service as a trimming tool for miniature slotted dust cores

himself for his assistant's latest excursion into doggerel.

"Just a minute, Smithy," said

Dick excitedly. "How about this!

*"If you've got a little hint,  
Why not get it into print?  
Anyone can have a bash,  
And we'll pay for it in cash!"*

And even Smithy had to privately admit that Dick had the ability, sometimes, to round off a little gession very nicely.

#### Editor's Note

As Dick states, further hints for "In Your Workshop" are welcomed, and payment is made for all that are accepted. The hints discussed this month were submitted by M. N. Hutchinson, Sir Douglas Hall and N. Garland. (The super-regenerative receiver referred to is "Super-regenerative Transistor Circuit For Medium And Long Waves" by Sir Douglas Hall, *The Radio Constructor*, May 1965.)

Dick and Smithy will be back at full strength next month, when Smithy will introduce Dick to the binary number system used with digital computers.

## KIT REVIEW

### The 'Mayfair' Portable Electronic Organ

It is hardly necessary, in this review, to stress the keen interest in electronic organs that exists amongst home-constructors. The introduction of modern electronic techniques to the traditional field of organ building provides, in itself, a source of considerable fascination. There is then the added attraction that a well-designed electronic organ can give justifiable pride when it has been built at home. Perhaps most important of all is the aesthetic pleasure resulting from the wide range of music which it can produce.

#### Main Features

The "Mayfair" Portable Electronic Organ, available in kit form from Henry's Radio Ltd., is designed to provide a high level of performance with a large number of stops whilst, at the same time, employing assembly methods which can be carried out by any constructor. Indeed, the instructions which accompany the kit are aimed at the beginner who is just acquiring the ability to solder.

The major electrical features of the organ are as follows:

**Supply.** This may be 100 to 250 volt a.c. mains, or 15 to 18 volt battery (current consumption 300mA).

**Output.** Up to 0.5 volt. is available for any external amplifier. Two output sockets are provided.

**Tone generation.** This is provided by master oscillators and frequency dividers. Six octaves are generated.

The main musical features are as follows:

**Keyboard** This is a 49-note C-C manual, fully sprung and adjusted for depth of touch.

**Expression.** A foot-control swell pedal is incorporated.

**Switchable vibrato.** This is available with adjustable speed and depth.

**Tone colours.** Ten tabs are provided, these giving



Small Flute 16ft, Flute 16ft, Flute 8ft, Flute 4ft, Diapason 8ft, Diapason 4ft, String 4ft, Oboe 4ft, Horn 8ft, and Clarion 4ft.

The organ employs semiconductors throughout (170 transistors and diodes), and uses printed circuit panels to simplify construction. It is housed in a portable cabinet finished in two-colour Vynair and having detachable legs and music stand.

An important feature of the design is that the organ is fully polyphonic. Each key has its own signal input and full chords can be played over the entire keyboard.

#### Circuit

The tone generating section of the organ employs master oscillators and frequency dividers, there being a printed circuit tone generator strip (comprising oscillator and dividers) for each of the 12 notes in the chromatic scale. The master oscillator in each strip runs at 2 octaves above the highest key of the appropriate note on the manual, this being followed by six bistable multivibrators operating as divide-by-two frequency dividers. It is only necessary to set up the master oscillator on each strip; all the octaves below are then automatically tuned to correct frequency. The master oscillator coils are dust core tuned. Outputs are taken from all divider circuits following the master oscillators and are applied to the contacts of the corresponding keys of the manual. Thus, the keys control signals which are rich in harmonics, key outputs being taken along three separate busbars to the tone forming unit. The key contacts are gold plated and a rhodium earthing busbar is incorporated.

An additional divider is required to cater for the bottom C on the keyboard, and this is made up on a separate printed circuit board.

Outputs from the tone generator strips are taken from transistor bases instead of collectors, since this technique obviates key-clicks. The output of the switchable vibrato oscillator (a phase-shift oscillator running at 6 to 9 c/s with controllable speed and output) is applied to all the master oscillators.

The tone forming unit employs filters to provide the various tone colours selected, these taking their input from one or more of the three busbars from the keys. Comprehensive resistance-capacitance or choke-capacitance circuits are employed here, being switched in or out as desired by the stop tabs. The output from the

filters passes to a single transistor amplifier, which then provides the final output for the organ. This output may be applied to any a.f. amplifier or may be used to operate headphones for practice work.

The mains supply unit has a double-wound mains transformer with primary taps at 110 volts, 200 volts, 220 volts and 240 volts. The secondary feeds into a bridge rectifier offering a rectified output of 15 volts.

#### Construction

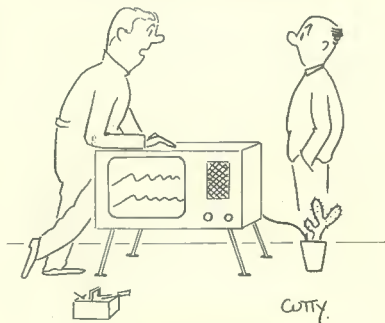
A praiseworthy feature of the organ is the extremely neat manner in which the various sections are housed in the cabinet. There is no crowding, all parts fitting neatly into the cabinet with little wastage of space. The cabinet design, whilst being smart and presentable, is also completely functional in two ways. First, the keyboard and stop tabs are positioned to provide the performer with maximum comfort and accessibility. Second, the cabinet shape is such that all the component parts are accommodated without excessive cabinet volume. This last point is, of course, of particular importance in a portable design.

The instruction book provided with the kit gives a brief introduction to organ musical terms, then proceeds to a description of the circuit followed by constructional details. A number of very clear and detailed photographs give views of the components parts and the final assembly of the instrument. It is suggested that beginners who do not feel too confident about their soldering ability should first commence by assembling one of the master oscillator and divider strips. This may then be sent to the service department of Henry's Radio Ltd., where it will be checked and any faulty soldering corrected. Also the constructor's attention will be drawn to any other errors, so that he may avoid these in future. No charge is made for this particular service, but return postage should be enclosed. The larger units in the organ are connected into circuit by means of plugs and sockets, thereby enabling such units to be conveniently sent in, if necessary, for service.

The designer of the "Mayfair" organ kit is L. W. Roche, and the suppliers are Henry's Radio Ltd., 303 Edgware Road, London, W.2. Sections of the kit may be bought separately, or the complete kit with instructions can be purchased for 99 guineas (carriage 30s.). Optional extras include a built-in Percussion Unit and a 13-note Pedal Board.



## cartoonsmile



"Is the set earthed?"

## Instant Deep-Freeze from EMI

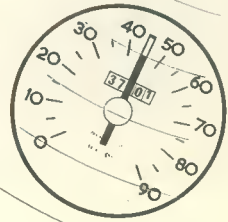
A refrigerator which cools things from room temperature to minus 186° Centigrade within two seconds. For military purposes EMI Electronics Ltd. have developed a rapid cooling cryostat which is now available as the EMICOOLER for commercial applications where rapid cooling is essential and space is restricted. It is only  $\frac{1}{16}$  in deep and  $1\frac{1}{2}$  in in diameter, and works on the principle of a high-pressure gas expanding at an orifice; the expanded gas is made to cool the incoming gas, and this process continues until liquid is formed. Suitable gases are nitrogen, oxygen, air (with water and carbon dioxide removed) and argon. The fastest cooling time is achieved when argon is used.





# RADAR SPEED MEASUREMENT

by J. B. Dance M.Sc.



One recently introduced feature of the current motoring scene is that of radar speed measuring equipment. Such equipment is evidently here to stay, and our contributor gives a detailed description of its application and functioning

**R**ADAR SPEED MEASURING INSTRUMENTS DEPEND on the Doppler effect for their operation. When the speed of an object is to be measured, a beam of high frequency radio waves is directed towards the object and the difference in frequency between the reflected and transmitted waves is found. This frequency difference is proportional to the velocity of the object.

Radar speed meters employing this principle have been used in the United States for over fifteen years, but it is only during the last six years or so that they have been widely used in the United Kingdom. The early models used in the United States employed a beam which was transmitted directly at the oncoming traffic. More than one vehicle could therefore be present in the beam at any one time and this led to ambiguous readings on many occasions.

## The Marconi Equipment

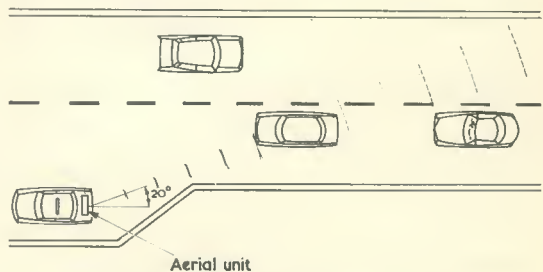
In the Marconi speed measuring equipment, a narrow beam of radiation about  $4^\circ$  in width is directed across the road from a slotted waveguide at an angle of  $20^\circ$  to the direction of travel of the vehicle. The equipment is known by the name "PETA" (Portable Electronic Traffic Analyser, type S530). Each vehicle passes through the beam for a short time (about one quarter of a second) and vehicles which are more than about eight feet apart produce separate indications on the meter.

A typical arrangement for the use of the speed meter from a lay-by is shown in Fig. 1. Alternatively it may be situated at a slight right hand bend or just off the main road in a convenient gateway.

The aerial may be placed in the open boot of a car or on a small table at a height of eighteen to thirty inches above the road surface. The working range is fifty yards, but the indicating meter may be situated at any distance up to 150 yards from the aerial.

## Modes of Operation

Two modes of operation are provided in the PETA equipment. In the "Hold-off" mode an indication of the vehicle speed is given for the time that the vehicle is actually in the radar beam. In the "Hold-on" mode the meter will give an indication of the speed for about  $1\frac{1}{2}$  seconds after the vehicle has passed through the beam; if another vehicle enters the beam during this time, it is not detected and does not affect the reading of the meter. Greater accuracy can be obtained by the use of the "Hold-on" mode of operation and this is therefore recommended for police work. How-



The use of Marconi PETA equipment from a car parked in a lay-by



The PETA equipment in use by Essex police from a parked car. (Photographs in this article—Marconi's Wireless Telegraph Co. Ltd.)

ever, the "Hold-off" mode is the more useful one for general traffic speed analysis or when vehicle counts or average speeds are required.

If a permanent record of the vehicle speeds is required, a pen recorder may be employed. The chart, which is produced by an electro-chemical recording technique in the PETA equipment, shows the vehicle speeds as peaks. The unit may be left unattended by the roadside to record vehicle speeds over a long period.

The power supply used is normally a 12 volt car battery which supplies the 42 watts required by the equipment. The instrument itself consists of a power supply unit, an aerial unit and the meter display unit; the total weight is a little over 30lb. The meter itself is illuminated for night time use. Printed circuit boards are employed together with 26 transistors and 3 valves.

### Principles of Operation

The aerial is powered by a reflex klystron, type K357, operating in the X band in the range 10,675 Mc/s to 10,699 Mc/s; the power fed to the aerial is about 8 milliwatts. The reflected signal is received by the common transmitting/receiving aerial and is mixed with some of the transmitter frequency energy by means of a semiconductor diode. The audio difference signal is amplified, filtered by a low pass circuit (to reduce the bandwidth and hence to increase the signal to noise ratio) and is then passed to the meter unit. The latter is a frequency sensitive circuit, or ratemeter, calibrated in vehicle speeds.

A vehicle speed of 80 m.p.h. will produce a difference frequency of 2.4 kc/s and this will result in a full scale deflection. The scale is a linear one and the accuracy is better than  $\pm 2$  m.p.h.

### Calibration

For police use, it is obviously vital that the presence of any fault in the equipment should be easily detected. Two sources of calibrating signals are incorporated into the equipment and provide

readings of 40 m.p.h. and 70 m.p.h. respectively. In addition a built-in wavemeter enables the transmitted frequency to be checked easily. As a further check a police car is usually driven at a known speed through the beam before and after a series of speed measurements takes place.

### Alignment

The aerial unit is designed so that when the long axis is placed perpendicular to the road, the beam emerges in the required direction of  $20^\circ$  to the road. Small errors in the direction of the setting of the beam will not cause an appreciable error in the indicated speeds. The frequency,  $f_r$ , of the waves reflected from a vehicle is related to the angle of the beam to the road,  $\Psi$ , by the following equation:

$$f_r = f V K \cos \Psi$$

where  $f$  is the transmitted frequency,

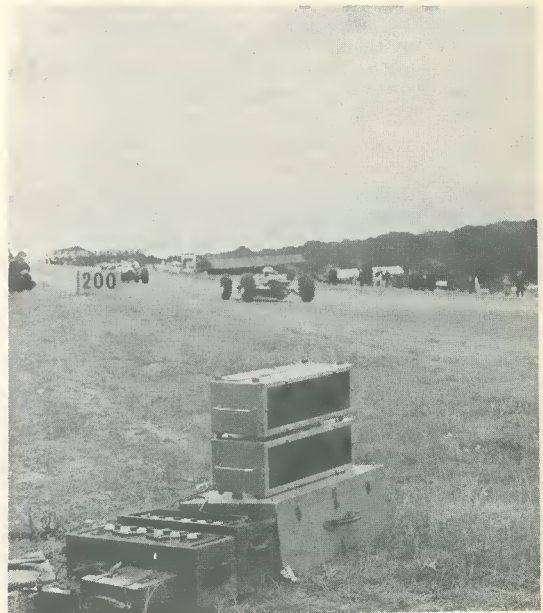
$V$  is the vehicle speed,

and  $K$  is a constant.

Thus if the beam were set up so as to point directly along the road (an alignment error of  $20^\circ$ ), the error in the indicated speed would be only 3 m.p.h. in the case of a vehicle travelling at 50 m.p.h.

### Motor Racing

For speed measurement in motor races, the scale of 0-80 m.p.h. is inadequate. If a beam angle considerably larger than  $20^\circ$  is chosen, the equipment may be used to measure the speeds of vehicles up to at least 160 m.p.h. However, any small errors in the beam alignment will then cause a considerable error in the indicated speed. Alternatively, the equipment can be modified to indicate higher speeds at the  $20^\circ$  angle.



PETA equipment in use at Brands Hatch. The speeds were passed to a commentator high in the stand, who relayed them to the spectators



### Other Uses

The principle of measuring speeds by means of the Doppler frequency shift of a radar beam can be employed to determine the speeds of many objects other than vehicles. The objects need not be large; for example, equipment has been designed to measure the muzzle velocity of projectiles emerging from the barrels of guns. An accuracy of the order of one tenth of 1% can be obtained in this case. Speeds of aircraft on landing and take off can be measured.

### Conclusion

The radar method of vehicle speed measurement

is a very convenient one which does not require very large apparatus or entail any difficulties such as laying wires across a road. In spite of what motorists convicted of speeding offences may think, it is also quite accurate when correctly used and is being adopted by many police forces throughout the world.

### Acknowledgement

The writer is indebted to Marconi's Wireless Telegraph Company Ltd. of Chelmsford for providing the photographs used in this article, together with the information concerning their PETA equipment. \*

## Elma Impulse Transmitters

Radiatron now have available a range of Elma synchronous motor driven impulse transmitters type G. These are constructed on a plug-in module basis and have a front panel measuring 56 x 69mm. The principle of operation is that a mains operated synchronous motor drives a specially shaped cam which operates either a micro-switch or a sealed reed relay. Frequencies from 20 pulses per second up to one pulse per minute are available.

The range of impulse frequencies makes these units ideal for use in digital clocks using the Elma single decade read-out counters. They can also be used with Elma counters to construct elapsed timers, control timers, etc. Further details can be obtained from: Radiatron, 7 Sheen Park, Richmond, Surrey. Tel: RIC 3285.

## RADIO CONSTRUCTOR



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# RADIO TOPICS . . . .

by Recorder

Will computers ever exhibit character?

This question is not intended to be an introduction to a discourse along science-fantasy lines. It is meant quite seriously.

Computers at present work with binary digits, or bits, which represent the minimum possible amount of information which a system can store or carry. Our own brains also deal with information and it seems reasonable to assume that the ultimately smallest operation carried out during thought is similarly of a binary nature.

In the binary notation, it may be remembered, there are only two digits, these being 0 and 1. In consequence, a single unit under binary conditions can only exist in one or the other two of two alternative states.

So far as our senses are concerned human perception does not, it would appear at first sight, follow simple binary rules. Our response to such stimuli as light or sound covers a wide range of intensities, and nature has seen to it that the response is logarithmic in order to obtain a high level of discernment within the range over which the perceptive system is capable of functioning. If, incidentally, our responses followed a linear law, all stimuli at low levels of intensity would be cramped together at the minimum end of the range instead of being "opened out" as does, in actual fact, occur.

## Binary Reactions

But lower levels of life, and we ourselves, also respond to simple binary situations. We become hungry, and so we search for food. This condition could correspond to binary 0. We obtain food, eat it, and in consequence are not hungry any more. Binary 1. The idea of a crowd of binary 0's going into Joe Lyons' and coming out as binary 1's may seem fanciful, but the binary situation still exists. In more simple life-forms we find other binary circumstances, such as the definite movement of an insect towards a light when the light is present, as opposed to random movement in the absence of light.

Returning to the human level again, Hamlet's "To be or not to be?" represents what must surely be the ultimate binary question involving the choice of two states.

All this is intended to demonstrate that the world we live in can, when reduced to the lowest measure, be shown as being subject to purely binary laws. A thing is, or it is not. It could well be that our thought processes are, in their finally basic form, also binary in character; and that, in choosing the binary system for computer calculations, engineers have unwittingly chosen the data-handling process which has greatest similarity with the processes which occur in the human brain.

The computer, in its present form, is not a *thinking* machine; it is a machine for handling data under instructions. But it carries out many operations which (ignoring the relatively inefficient calculating machines which preceded it) were hitherto only undertaken by the human mind. A computer works in binary because this is the most convenient manner of making use of the semiconductors which process the data it handles, but it accepts numbers in decimal and prints out answers in decimal. The processes involved in making a computer add 9 and 7 are relatively fairly complicated because both numbers are first changed to binary, added, and the answer converted back to decimal.

There is no reason to believe that the basic steps involved in adding 9 and 7 in our own minds may not be equally complicated; nor is it unreasonable to assume that the individual basic steps may also be binary in character. Those who protest that the addition of the two numbers is really the result of our brains being programmed through continual experience of decimal addition do not entirely clinch an anti-binary argument. Does a *single* brain cell perceive the figure 9 or the figure 7? Isn't it more probable that a group of cells perceives *patterns* which correspond to 9 or to 7? The computer perceives the figure 9 as binary 1001, and the figure 7 as binary 111. It seems probable that patterns in the human

brain which correspond to 9 and 7 may also be made up from basic binary states.

The digital computer can evaluate *quantity* in terms of binary digits. This process is, indeed, carried out in "hybrid" computers, in which the output of an analogue computer is coupled to a digital computer by way of an analogue-to-digital converter. The possible parallel here is the conversion of human stimuli levels to a basic binary form in the brain.

## Microminiature Circuits

To those of us who solder the odd transistor into a standardized circuit, the present state of development in the computer field is already little short of fantastic. I mentioned last month that one manufacturer of integrated circuits looks forward to something like 2,000 components per microminiature chip by 1970. With component availability of this nature, it becomes practicable to pack very much more calculating power into an economic computer than is possible at present.

And this is where the question of character comes in. As the circuits of computers become smaller and smaller, and the number of components becomes larger, it becomes completely impossible to examine or test any single component or part of the computer. We all know that mass-produced products of some complexity, such as motor-cars or television receivers, tend to show vague character patterns insofar that some models are more prone to a particular fault than are others which have come off the same production line. How much more possible, and how much more difficult to isolate and track down, will be the "character faults" which may appear in the computers of the future! These character faults, or trends, could be due to components fault, or to groups of components with values at extremes of tolerance, and their causes would be as difficult to pin-point as are those which produce character trends in human beings. A computer might show unwillingness to accept certain programme instructions in the same manner as a recalcitrant child refuses to be instructed. Or the computer might continually revert to a previous calculation process in the same way that human beings continually revert to the telling of a favourite story or the pursuance of a favourite pastime.

Let's take the analogy between the future computer and the human brain a little further. With human



beings, the most prolific creative thinkers are often those who most differ, in terms of character, from their fellows. When we start making computers with many more components than is currently envisaged, the stage may be set for computers which exhibit exceptionally marked character trends.

One of these computers might be the odd-ball machine which settles down, one quiet day, to a really *serious* bit of creative thinking . . . .

#### Zecons

Turning to other matters, you may have encountered yet another new name in semiconductor electronics over the last year or so. This is the "Zecon", the word being an abbreviation for a range of Zener ECONomy diodes introduced by the International Rectifier Company. These diodes have a power rating of 1 watt and can be obtained with voltage ratings within the range 3.9 to 30 volts. They are priced at a figure which is well within the pocket of the average amateur enthusiast, and they have a tolerance on voltage rating of  $\pm 20\%$ .

#### Wiring Experimental Circuits

Following my remarks last November about using tagstrips for quickly making up experimental circuits, I have received details of an alternative approach from reader A. Dunn of Preston.

"After reading your comments on experimental circuits," writes Mr. Dunn, "I thought you might like to hear of my own method of assembly. I have found it much more

convenient for transistor circuits than tagstrips.

"The materials used are perforated plastic board and Veroboard terminal pins. The pins are pushed through the board and components soldered to them.

"The method has several advantages over tagstrips, and allows a circuit to be built up very rapidly. For simple 1-transistor circuits the layout can be planned as the pins are pushed in, and the circuit is ready to switch on within half an hour. As the board is perforated every  $\frac{1}{8}$  inch pins can be placed in any position, allowing critical wiring to be easily accomplished. There are four 6BA holes on the edge of the board and these can be used to hold tuning capacitors or small aluminium panels carrying potentiometers, etc. When the circuit is finished with, the connections can be easily unsoldered and the pins removed by pulling them out with pliers. The board and pins are not spoilt by frequent use, and a packet of pins lasts a long time.

"I obtain the board from Henry's Radio, Ltd. It is known as 'Punch Board' and a piece measuring  $4 \times 1\frac{1}{2}$  ins costs 2s. 6d. plus 6d. post and packing. This works best with the Veroboard pins, which are also obtainable at Henry's Radio at 3s. 3d. for a packet of 36".

This is certainly a neat approach, and I am indebted to Mr. Dunn for passing it on. The prices quoted are those in the current Henry's Radio catalogue at the time of writing.

#### Amateur Radio Astronomy

There is a considerable interest

in the U.K. in amateur radio astronomy, and it is pleasant to note the existence of a Society whose specific function is to cater for this particular pursuit.

One of the difficulties of amateur radio astronomy in practice is that it is not always a simple matter for a single person to set up and operate suitable equipment on his own. Also, it is unusual for a person having experience in optical astronomy to be equally at home with the fairly advanced electronics required for radio astronomy. Again, suitable sites for setting up the equipment may not be available to a single enthusiast, and he may also lack the mechanical skill to construct the aerial arrays. Obviously, this is a field where best results are most likely to be obtained when a group of people gets together to work in unison, each person contributing his own specialised skill or facilities.

The Society For Amateur Radio Astronomers has, as its policy, the encouragement and help of local groups of this nature. In addition, the Society can offer assistance to school groups who, due to lack of contact with professional electronics engineers, may not be too strong on electronic know-how.

The Society has been in existence since January 1st, 1966, and publishes a journal entitled *Radio Sky* which provides latest information on technical and Society matters. Readers who are interested in radio astronomy should write for further details to the Hon. Secretary, Society For Amateur Radio Astronomers, at 9 Sutherland Road, London, W.13. A stamped addressed envelope for reply should be enclosed.



## BBC MEDIUM-WAVE SERVICES

The number of European stations broadcasting in the medium waveband is continually increasing and has almost doubled during the last ten years, but the number of channels available for them to operate on remains the same and is insufficient to meet the present-day demands. Because of this, many of the newer continental stations have been brought into operation on wavelengths which provide the coverage needed locally irrespective of the interference that may be caused in other parts of Europe; as can be seen from the list below, almost all the B.B.C.'s medium-wave services suffer interference.

The interference is most serious during the hours of darkness when a medium-wave station can be heard at great distances, so the effect is worst during the winter months when darkness coincides with peak listening hours. Everything possible has been done both technically and by international representation to minimise the interference but with the present overcrowding of the medium waveband there is little or no more that can be done.

This situation was foreseen many years ago by the B.B.C., and the VHF sound service was introduced to provide an alternative service which does not suffer from this type of interference. The VHF service is now available to nearly the whole population of the United Kingdom—to more people, in fact, than could satisfactorily receive the medium-wave services in the absence of interference. More local VHF relay stations are planned or under construction to bring the service to the maximum possible number of people; the coverage at present is approximately 98.7% and will eventually be more than 99% of the population.

HOME SERVICE	Wavelength (metres)	Interfering Stations	West of England	285	Titograd (U.S.S.R.)
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Northern	494	Wachenbrunn (East Germany)			Tetuan (Spanish Morocco)
	261	Cluj (Roumania)	LIGHT PROGRAMME	247	Skutari (Albania)
Northern Ireland	224	Hungarian relay stations	THIRD PROGRAMME & NETWORK	THREE	
Scottish	371	Skoplje (Yugoslavia)		464	Simferopol (U.S.S.R.)
		Seville (Spain)		194	Seelow (East Germany)
Welsh	341	Berlin (East Germany)			Vinnitsa (U.S.S.R.)

**Queries.** We regret that we are unable to answer queries other than those arising from articles appearing in this magazine nor can we advise on modifications to equipment described. Queries should be submitted in writing.

**Correspondence** should be addressed to the Editor, Advertising Manager, Subscription Manager or the Publishers as appropriate.

**Opinions** expressed by contributors are not necessarily those of the Editor or proprietors.

**Contributions** on constructional matters are invited, especially when they describe the building of particular items of equipment. Articles should be written on one side of the sheet only and should preferably be typewritten, diagrams being on separate sheets. Typewritten articles should have maximum spacing between lines. In handwritten articles, lines should be double-spaced. Diagrams need not be large or perfectly drawn, as our draughtsmen will re-draw in most cases, but all relevant information should be included. Sharp and clear photographs are helpful, where applicable. If negatives are sent, we usually work from these rather than from prints. Colour transparencies normally reproduce badly—black and white photographs are very much better. Details of topical ideas and techniques are also welcomed and, if the contributor so wishes, will be re-written by our staff into article form. All contributions must be accompanied by a stamped addressed envelope for return, if necessary, and should bear the sender's name and address. Payment is made for all material published.

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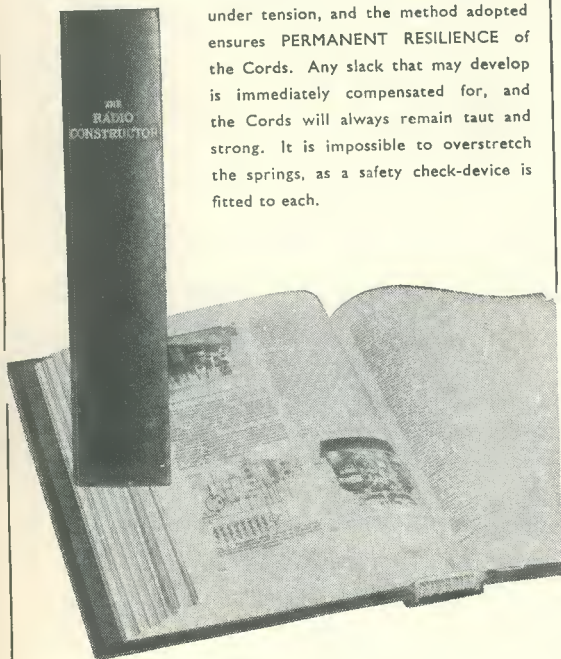
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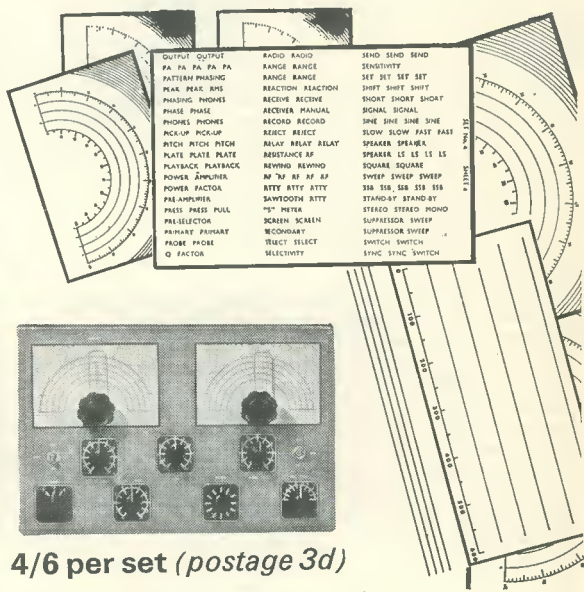
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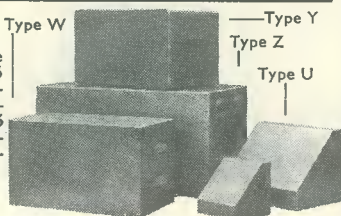
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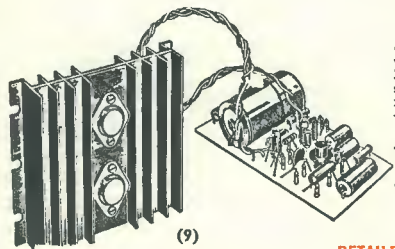
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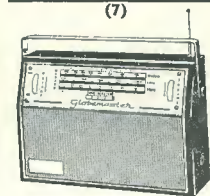
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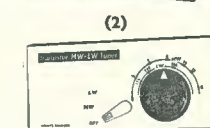
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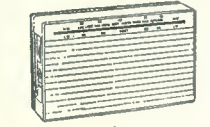


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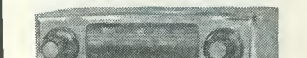
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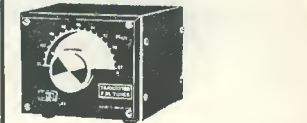
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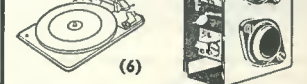
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