THE Radio Constructor

RADIO
TELEVISION
AUDIO
ELECTRONICS

VOLUME 19 NUMBER 6
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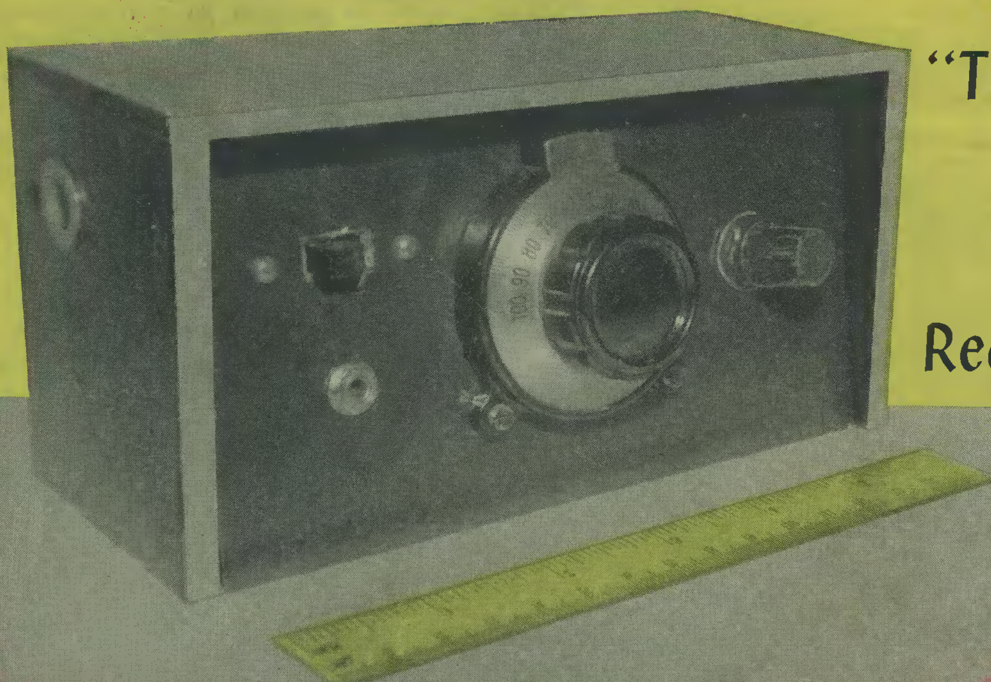
TWO SHILLINGS & THREEPENCE

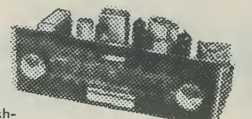
**January 1966**



"Two + Two" Receiver

Morning Radio Alarm ★ Stable R-C Oscillator ★ Transistorised Capacitance Relay ★ Improved Room Thermostat

## 6 VALVE AM/FM TUNER UNIT



Med. and VHF 190m–550m, 86 Mc/s–103 Mc/s, 6 valves and metal rectifier. Self-contained power unit, A.C. 200/250V operation. Magic-eye indicator, 3 push-button controls, on/off, Med., VHF. Diodes and high output Sockets with gain control. Illuminated 2-colour perspex dial 11½" x 4", chassis size 11¾" x 4" x 5¾". A recommended Fidelity Unit for use with Mullard "3-3" or "5-10" Amplifiers.

**Bargain Price:** Complete kit of parts, inc. Power Pack, **£10.19.6**, carriage and insurance, as illustrated. Ditto less Power Pack, **£9.19.6.** Carr. 7/6. Circuit and constr's details, 4/6 Free with kit.

## 7 VALVE AM/FM RADIOGRAM CHASSIS

New 1965 Model Now Available.

*Valves* ECC85, ECH81 EF89, EABC80, EL84 EM81, EZ80

**Three Waveband & Switched Gram positions.** Med. 200–550m. Long 1,000–2,000m. VHF/FM 88–95 Mc/s. Phillips Continental Tuning insert with permeability tuning on FM & combined AM/FM IF transformers. 460 kc/s and 10.7 Mc/s. Dust core tuning all coils. Latest circuitry including AVC & Neg. Feedback. 3 watt output. Sensitivity and reproduction of a very high standard. Chassis size 13½"x 6½". Height 7½". Edge illuminated glass dial 11¼" x 3½". Vert. pointer Horiz. station names. Gold on brown background. A.C. 200/250V operation. Magic-eye tuning. Circuit diag. now available.

**Aligned and tested ready for use. £13.19.6** *Carr. & Ins. 7/6.*

Comp. with Tape, O/P socket, ext. spk'r and P/U sockets and indoor F.M. aerial, and 4 knobs—walnut or ivory to choice. 3Ω P.M. Speaker only required. Recommended Quality Speakers 10" Elac, **27/6.** 13½" x 8" E.M.I. Fidelity, **37/6.** 12" R.A. with conc. Tweeter, **42/6.** Carr. 2/6.

**Jack Plugs.** Standard 2½" Igranic Type, **2/6.** Screened Ditto, **3/3.** Miniature scr. 1½", **2/3.** Sub-min. **1/3.** **Jack Sockets.** Open Igranic Moulded Type, **3/6.** Closed Ditto, **4/–.** Miniature Closed Type, **1/6.** Sub-min. (deaf aid) ditto, **1/6.** Stereo Jack Sockets, **3/6.** Stereo Jack Plugs, **3/6.** **Phono Plugs, 9d.** Phono Sockets (open), **9d.** Ditto (closed), **1/–.** Twin Phono Sockets (open), **1/3.**

**Grundig Continental.** 3 p. or 5 p. plug, **3/6.** Sockets, **1/6.** **Soldering Irons.** Mains 200/220V or 230/250V. Solon 25W Inst., **24/6.** Spare Elements, **5/6.** Bits, **1/3.** 65W, **29/6,** etc. **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/–,** etc. **Alumin. Sheet.** 18g. 6" x 6", **1/–,** 6" x 9", **1/6,** 6" x 12", **2/–,** 12" x 12", **4/6,** etc.

## L.P. RECORDING TAPE

*BARGAIN OFFER!*

*By leading British manufacturers—*

**PROFESSIONAL GRADE—DOUBLE-SIDED**

(each side coated) 5¾" reels only

**Special Price Offer** 1,450 feet (2 reels) **20/–** post free

Ideal for the experimenter who wants to record both sides, and a good L.P. Tape for the enthusiast who wishes to record single side only.

### New Boxed VALVES Reduced Bargain Prices

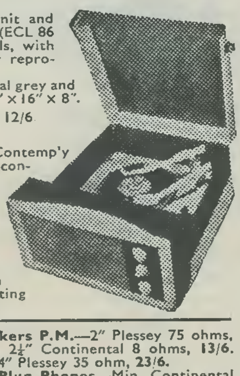
| | | | | | |
|---|---|---|---|---|---|
| 1T4 | 3/6 | EF80 | 7/6 | PCF80 | 8/– |
| 1R5 | 6/– | EF86 | 8/6 | PCL83 | 10/6 |
| 1S5 | 6/– | EL33 | 12/6 | PCL84 | 10/– |
| 3S4 | 7/– | EL34 | 12/6 | PCL85 | 11/6 |
| 3V4 | 7/– | EL84 | 7/– | PL36 | 10/6 |
| ECC81 | 7/– | EY51 | 9/– | PL81 | 9/6 |
| ECC82 | 7/– | EY86 | 9/– | PL83 | 8/– |
| ECC83 | 7/– | EZ80 | 7/– | PY33 | 10/6 |
| ECL80 | 9/– | EZ81 | 7/– | PY82 | 7/– |
| ECL82 | 10/– | GZ32 | 9/6 | U25 | 10/6 |
| ECL86 | 10/6 | PCC84 | 8/– | UL84 | 9/– |

### Electrolytics All Types New Stock

| TUBULAR | | CAN TYPES | |
|---|---|---|---|
| 25/25V | 1/9 | 8+8/450V | 4/6 |
| 50/12V | 1/9 | 16+16/450V | 5/6 |
| 50/50V | 2/– | 32+32/275V | 4/6 |
| 100/25V | 2/– | 50+50/350V | 6/6 |
| 8/450V | 2/3 | 60+250/275V | 12/6 |
| 4/350V | 2/3 | 100+300/275V | 12/6 |
| 16+16/450V | 5/6 | | |
| 32+32/450V | 6/6 | 2000+4000/6V | 3/6 |
| 1000/25V | 3/9 | | |

**Ersin Multicore Solder 60/40, 4d.** per yard. Cartons **2/6**, etc.

## DE LUXE R/PLAYER KIT



Incorporating 4 Speed Garrard Auto-Slim unit and Mullard latest 3 watt printed circuit amplifier (ECL 86 and EZ 80), volume, bass and treble controls, with 8" x 5" 10,000 line speaker. Superb quality reproduction.

Contemporary styled two-tone cabinet, charcoal grey and off-white with matching blue relief. Size: 17½" x 16" x 8".

**COMPLETE KIT £13.19.6** Carr. & ins. 12/6

Ready wired, **30/–** extra.

Illuminated Perspex escutcheon, **7/6** extra. 4 Contemp'y legs 6" **10/6,** 9" **11/6,** 12" **12/6,** ex. Catalogue & construction details **2/6** (free with kit).

## STANDARD RECORD PLAYER KIT

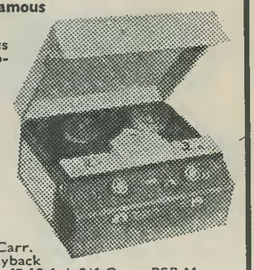
Using BSR UA14 Unit, complete kit **£11.10.0,** carr. 7/6. Ready wired Amplifier, 7" x 4" quality Speaker and O/P trans., **£3.19.6,** carr. 2/6. BSR UA14 Unit, **£6.10.0,** carr. & ins. 5/–. Rexine covered cabinet in two-tone maroon and cream, size 15¾" x 14¾" x 8½" with all accessories plus uncut record player mounting board 14" x 13", **59/6,** carr. & ins. 5/–.

**Condensers**—S/Mica all values 2pF to 1,000pF **6d.** Ditto Ceramic **9d.** each, .005, .01 and .1, etc., **1/–.** Paper Tubular 450V .001 mfd. to .01 mfd and .1/350V **9d.,** .02–.1 mfd **1/–,** .25 mfd **1/6,** 5 mfd **1/9.**

**Speakers P.M.**—2" Plessey 75 ohms, **15/6.** 2¼" Continental 8 ohms, **13/6.** 7" x 4" Plessey 35 ohm, **23/6.** **Ear Plug Phones**—Min. Continental type, 3ft. lead, jack plug and socket. High Imp. **8/–.** Low Imp., **7/6.** High sensitivity M/coil 8–10 ohms, **12/6.**

## ANOTHER TAPE RECORDER BARGAIN

**New re-designed contemporary Cabinet. Famous Mfrs. end of production Surplus Offer**



A 24 gns. Tape Recorder offered at the fabulous bargain price of **only 15 gns.** + 10/– Carr. Supplied in 3 Units already wired and tested—only simple inter-Unit connections necessary. A modern Circuit for quality recording from Mike, Gram or Radio, incorporating the latest BSR Twin Track Monardeck Type TD2. Housed in attractive two-tone Cabinet of contemporary design, size 14" x 13½" x 7½" complete with Tape and Mike storage pockets. Valve line up—EF86, ECL82, EM84, EZ80 and Silicon Diode.

**Complete Kit** comprising items below.

**BARGAIN PRICE 15 gns.** + 10/– carr.

Cabinet and 7" x 4" Speaker, **£3.5.0** + 5/– Carr. Wired Amplifier complete with Record/Playback Switching, 4 Valves, front Panel, Knobs, etc., **£5.19.6** + 3/6 Carr. BSR Monardeck Type TD2, **£7.7.0** + 4/6 Carr. **Accessories**—Mike, Tape, empty Reel, screened Lead & Plugs, Instructions, etc., **£1.0.0** + 2/– Carr.

**Volume Controls**—5K–2 Megohms, 3" Spindles Morganite Midget Type. 1⅛" diam. Guar. 1 year. LOG or LIN ratios less Sw. **3/–.** DP. Sw. **4/6.** Twin Stereo less Sw. **7/6.** D.P. Sw. **9/6** (100 k. to 2 Meg. only). ½ Meg. VOL Controls D.P. Sw. ½" flatted spindle. Famous Mfrs. 4 for **10/–** post free.

**COAX 80 OHM CABLE**

High grade low loss Cellular air spaced Polythene — ¼" diameter. Stranded cond. Famous mfrs. **Now only 6d. per yard.**

**Bargain Prices—Special lengths:**
20 yds. **9/–.** P. & P. 1/6.
40 yds. **17/6.** P. & P. 2/–.
60 yds. **25/–.** P. & P. 3/–.
Coax Plugs **1/–.** Sockets **1/–.** Couplers **1/3.** Outlet Boxes **4/6**

**Close Tol. S/Micas**—10% 5pF–500pF **8d.** 600–5,000pF **1/–.** 1% 2pF–100pF **9d.** 100pF–500pF **11d.** 575pF–5,000pF **1/6.** **Resistors—Full Range** 10 ohms–10 megohms 20% ¼ and ½W **3d.,** ditto 10% **4d.,** ¾W **5d.** (Midget type modern rating) 1W **6d.,** 2W **9d.** **Hi-Stab** 5% ¼–½W 100 ohms 1 megohm **6d.** Other values **9d.** 1% ½W **1/6.** **W/W Resistors** 25 ohms to 10K 5W **1/3,** 10W **1/6,** 15W **2/–.** **Pre-set T/V Pots. W/W** 25 ohms–50K **3/-.** 50K-2 Meg. (Carbon) **3/-.** **Speaker Fret**—Expanded gilt anodised metal ¼" x ⅛" diamond mesh, **4/6** sq. ft., multiples of 6" cut. Max. size, 4ft. x 3ft. **47/6.** Carr. extra. Ditto, finer mesh, **4/6** sq. ft. Multiples 12" only, max size 3ft x 2ft. **27/6.** Plus Carr.

**TYGAN FRET** (contemp. pat.) 12" x 12" **2/–,** 12" x 18" **3/–,** 12" x 24" **4/–,** 18" x 18" **4/6,** etc.

**BONDACOUST** Speaker Cabinet Acoustic Wadding, superior grade, 1" thick, 18" wide, any length cut **2/3** per ft, **6/–** per yd.

**ENAMELLED COPPER WIRE**—¼lb reels, 14g–20g, **3/–;** 22g–28g, **3/6;** 36g–38g, **4/9;** 39–40g, **5/–,** etc.

**TINNED COPPER WIRE**—14–22g. 4/– ¼ lb.

**PVC CONNECTING WIRE**—10 colours (for chassis wiring, etc.)—Single or stranded conductor, per yd., **2d.** Sleeving, 1mm. and 2mm., **2d.** yd., etc.

**KNOBS**—Modern Continental types Brown or Ivory with Gold Centre, 1" dia., **9d.** each; 1⅜", **1/3** each; Conc. knobs with gold centre 1½" dia., **2/9** per pair. Matching ditto, **2/6** each. LARGE SELECTION AVAILABLE.

### TRANSISTOR COMPONENTS

| | |
|---|---|
| Midget I.F.'s—465 kc/s ⁷⁄₁₆" diam., first, second or third | **5/6** |
| Osc. coil M. & L.W. ⁷⁄₁₆" diam. | **5/0** |
| Midget Driver Trans. 9:1 | **6/0** |
| Ditto O/Put Push-pull 3 ohms | **6/0** |

**Elect. Condensers**—Midget Type 15V 1mfd–50mfd, ea. **1/9.** 100mfd. **2/–.**

**Ferrite Aerial**—M. & L. W. with car aerial coupling coil, **9/3.**

**Condensers**—150V. wkg. .01 mfd. to .04 mfd., **9d.** .05 mfd., .1 mfd., **1/–.** .25 mfd., **1/3.** .5 mfd., **1/6,** etc.

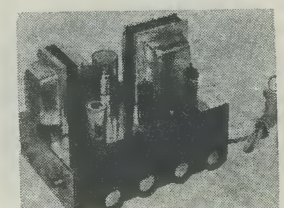
**Tuning Condensers.** J.B. "00" 208 + 176pF, **8/6.** Ditto with trimmers, **9/6.** 365pF single, **7/6.** Sub-min. ¾" DILEMIN 100pF, 300pF, 500pF, **7/–.**

**Midget Vol. Control** with edge control knob, 5kΩ with switch, **4/9,** ditto less switch, **3/9.**

**JASON FM TUNER UNITS**
Designer-approved kit of parts:
**FMT1, 5 gns.** 4 valves, **20/–.**
**FMT2, £7.10.0.** 5 valves, **35/–.**
**JTV MERCURY 10 gns.** 3 valves, **22/6.**
**JTV2 £13.19.6.** 4 valves, **28/6.**
**NEW JASON FM HANDBOOK, 2/6.** Prompt Alignment Service 7/6. P. & P. 2/6.

## MULLARD "3—3" & "5—10" HI-FI AMPLIFIERS

**3 OHM & 15 OHM OUTPUT**



"3–3" Amp. 3-valve, 3 watt, Hi-Fi quality at reasonable cost. Bass Boost and Treble controls, quality sectional output transformer, 40 c/s–25 kc/s ± 1dB. 100mV for 3W, less than 1% distortion. Bronze escutcheon panel.

**Complete Kit only 7 gns.** Carr. 5/–. **Wired and tested £8.10.0**

**MULLARD "5-10" AMPLIFIER**—5 valves 10W, 3 and 15 ohms output.

Mullard's famous circuit with heavy duty ultra-linear quality output tfr. **Basic amplifier kit price £9.19.6.** Carr. 7/6. **Ready built 11½ gns.**

**2-VALVE PRE-AMP. UNIT**
Based on Mullard's famous 2-valve (2 x EF86) circuit with full equalisation with volume, bass, treble, and 5-position selector switch. Size 9" x 6" x 2¼". **Ready built, wired and tested, £7.19.6.** Carr. 3/6.

Send for detailed bargain lists, 3d. stamp. We manufacture all types Radio Mains Transf. Chokes, Quality O/P Trans., etc. Enquiries invited for Specials, Prototypes for small production runs. Quotation by return.

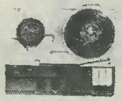
TRS Est. 1946

## RADIO COMPONENT SPECIALISTS

**70 Brigstock Road, Thornton Heath, Surrey**
THO 2188. *Hours; 9 a.m.–6 p.m., 1 p.m. Wed. Terms C.W.O. or C.O.D. Post and Packing up to ½lb. 1/–, 1 lb. 1/9, 3 lb. 3/–, 5 lb. 3/9, 8 lb. 4/6.*

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


FM TUNER FM-4U


NEW MAGNAVOX DECK


TRUVOX DECK


AM/FM TUNER

**HI-FI FM TUNER. Model FM-4U.** Also 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). Total Kit **£16.8.0**

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

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

**TRUVOX D-93 TAPE DECKS.** High quality stereo/mono tape decks. **D93/2,** $\frac{1}{2}$ track, **£36.15.0 D93/4,** $\frac{1}{4}$ track, **£36.15.0**

**TAPE RECORDING/PLAYBACK AMPLIFIER.** Thermometer type recording indicators, press-button speed compensation and input selection.
Mono Model TA-1M. Kit **£19.18.0** Assembled **£28.18.0**
Stereo Model TA-1S. Kit **£25.10.0** Assembled **£35.18.0**

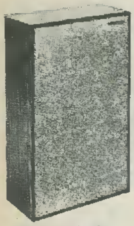
**MONO CONTROL UNIT. Model UMC-1.** Designed to work with the MA-12 or similar amplifier requiring 0.25V or less for full output. 5 inputs. Baxandall type controls. Kit **£8.12.6** Assembled **£13.12.6**

**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 **£19.10.0** Assembled **£26.10.0**

# *Enjoy yourself building a Heathkit model* Heathkit DAYSTROM

## SPEAKER SYSTEMS


SSU-1


Berkeley

**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.

**NEW! 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 7$\frac{7}{8}$" deep. Modern attractive styling. Excellent value.
Kit **£18.10.0** Assembled **£23.0.0**

**COTSWOLD SPEAKER SYSTEMS.** Outstanding performance for price.
*MFS:* Size 36" x 16$\frac{1}{2}$" x 14" deep.
Kit **£25.12.0** Assembled **£33.17.0**
*STANDARD:* Size 26" x 23" x 14$\frac{1}{2}$" deep.
Kit **£25.12.0** Assembled **£33.17.0**

## HI-FI CABINETS

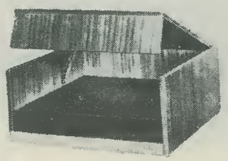
A wide range available including:

**PLAYBOX Table Player.** Available in walnut, mahogany or teak finish. Assembled **£10.10.0**

**GLOUCESTER.** Kit **£18.10.0** incl. P.T.

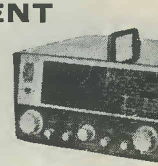
**MALVERN.** Kit **£18.1.0** incl. P.T.

**CHEPSTOW.** Kit **£11.12.6** incl. P.T.


PLAYBOX finished Cabinet

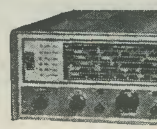
## "AMATEUR" EQUIPMENT

**THE "MOHICAN" GENERAL COVERAGE RECEIVER. Model GC-1U.** With 4 piezo-electric transfilters, 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**


GC-1U

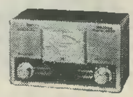
**AMATEUR BANDS RECEIVER. Model RA-1.** To cover all the Amateur Bands from 160–10 metres. Many special features, including: half-lattice crystal filter; 8 valves; signal strength "S" meter; tuned R.F. Amp. stage.
Kit **£39.6.6** Assembled **£52.10.0**

**160-10M TRANSMITTER. Model DX-100U.** Careful design has achieved high performance and stability. Completely self-contained.
Kit **£79.10.0** Assembled **£104.15.0**


RG-1

**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**

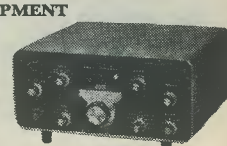
**REFLECTED POWER METER and SWR BRIDGE. Model HM-11U.** Indicates reliably, but inexpensively, whether the RF power output of your TX is being transferred efficiently to radiating antenna.
Kit **£8.5.0** Assembled **£10.10.0**


HM-11U

**AMERICAN HEATHKIT "AMATEUR" EQUIPMENT**

A wide range of American Amateur SSB equipment is now available in the U.K. Why not send for full details of range, for example:

**80-10M RECEIVER. Model SB-300E.**
Of advanced design employing up-to-date construction techniques, its specification ensures unparalleled performance.
Kit **£139.0.0** (less speaker) price incl. carriage, duty, etc.


SB-300E

**MANY OTHER BRITISH MODELS**
*Send for free Catalogue*

**Deferred terms available in U.K. over £10. Extended terms over £75. Send for details.**

**DAYSTROM LTD** DEPT. RC.1 GLOUCESTER

Without obligation please send me (Tick here)
FREE BRITISH HEATHKIT CATALOGUE ........
FULL DETAILS OF MODEL(S) ........
(Please write in BLOCK CAPITALS)
NAME ........
ADDRESS ........
........ DEPT. RC.1

# SPECIAL OFFER

1 Watt S.T.C. 300 Mc/s N.P.N. Silicon Planer 100% Transistors, £1 for 6.

3/– each OC44, OC45, OC70, OC71, OC81, OC81D, OC200, GET16, GET20.

4/– each AF114, AF115, AF116, AF117, OC170, OC171.

5/– each OC139, OC140, GET7, GET8, GET9, XC141, BY100, OA211.

**SUN SOLAR CELL KIT**

4 Sun Solar Cells plus 24-page Booklet on Experiments, 11/– set.

**G.P.O. DIAL TELEPHONES**

20/– each 35/– pair

Send 6d. for Full Lists including S.C.R. Zeners, etc.

# CURSONS

**78 BROAD STREET, CANTERBURY, KENT**

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Whatever your interest in transistor circuitry, you will find the Mullard "Reference Manual of Transistor Circuits" and "Transistor Radios—Circuitry and Servicing", valuable sources of reference.

The former describes more than sixty circuits for both domestic and industrial applications.

The latter is an introduction to the subject and describes the basic properties of semiconductors, their function, elementary circuitry and servicing.

| REFERENCE MANUAL OF TRANSISTOR CIRCUITS | TRANSISTOR RADIOS Circuitry and Servicing |
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| U.K. PRICE 12/6 Post extra 1/- | U.K. PRICE 5/- Post extra 6d. |

Mullard

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**FIRST QUALITY PVC TAPE**

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| --- | --- | --- | --- | --- | --- |
| 5¾" | Std. 850ft | 9/– | 5" | L.P. 850ft | 10/6 |
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| 3" | L.P. 240ft | 4/– | 5" | T.P. 1800ft | 25/6 |
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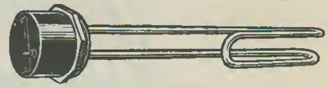

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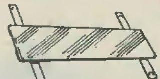

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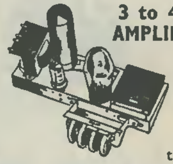

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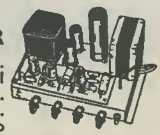

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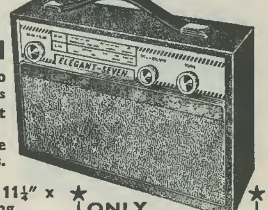


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# Practical Pulse Techniques for the Amateur

By A. Thomas

*A survey of simple pulse circuits of particular interest to the home-experimenter*

TRANSISTOR PULSE CIRCUITS HAVE MANY PRACTICAL uses for the amateur enthusiast, especially in the field of test equipment. The following review of the building blocks of pulse circuits will be practical and carried out with a minimum of mathematics. All the circuits and component values given have been proven by use. The majority of the circuitry is designed for single frequency operation but by the alteration of a capacitor or resistor the operating frequency may be modified.

### Multivibrator

The free running multivibrator or astable trigger is the basis of a range of similar circuits. The circuit of Fig. 1 shows it as a square wave generator The frequency of operation is given by the formula $f = \frac{1}{0.7\,(C_1 \times R_1) + 0.7\,(C_2 \times R_2)}$. If $C_1$ equals $C_2$ and $R_1$ equals $R_2$ then the output will be a 50:50 waveform. The ratio may be altered by increasing or decreasing either of the time constants, each time constant being calculated independently; i.e. if a negative-going pulse is required from output 1 with a duration of 0.1 seconds and off for 0.01 seconds, then $C_1 = \frac{t}{0.7\,R_1}$ where t=0.1 seconds and $R_1$= 0.015MΩ, whereupon $C_1$ 10µF. $C_2 = \frac{t}{0.7\,R_2}$ where t=0.01 seconds and $R_2$=0.015MΩ then $C_2$ 1µF.

The circuit as shown will, with changes in $C_1$ and $C_2$, generate square waves with frequencies from 1 cycle per minute to 50 kc/s. To generate lower frequencies than 1 c.p.m. the values of $C_1$ and $C_2$ become very large and the leakage current through the capacitor increases proportionally. The values of $R_1$ and $R_2$ may be increased but in doing so the base current is lowered and if the transistor gain is insufficient the circuit will not switch. The upper frequency limit is governed by the transistor type selected, if high frequency transistors are used the upper limit may be several megacycles.

The battery voltage may be from 4.5 up to 15 volts provided transistors of adequate ratings are employed, and the transistor $H_{FE}$ figure should be between 20 and 200 at a collector current of 10mA. The output from either collector may be fed into a load of 2kΩ minimum via a coupling capacitor.

### Monostable Trigger

This circuit is known as the monostable multivibrator, pulse generator, or delay generator. Its main function is in producing a known pulse width or a predetermined delay.

The circuit shown in Fig. 2 may be recognised as being similar to that of Fig. 1 except for the difference in the coupling from $TR_2$ collector to $TR_1$ base. The circuit may be triggered by a negative-going pulse on $TR_1$ base or a positive-going pulse on $TR_2$ base. Outputs may be taken from

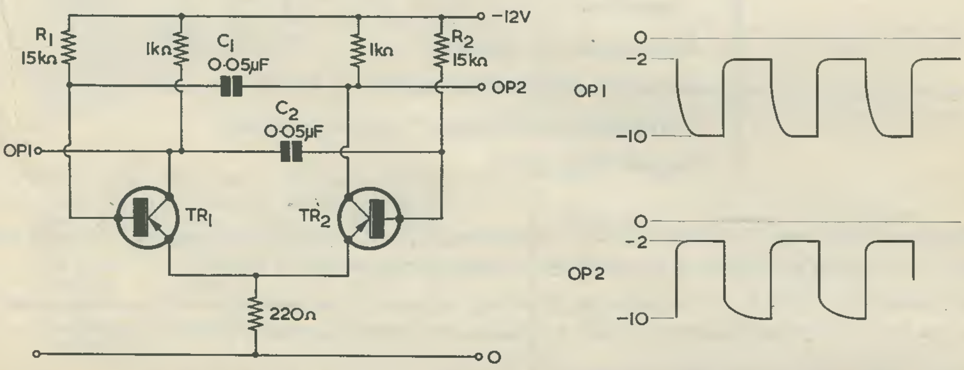



*Fig. 1. A multivibrator and the waveforms produced. (The circuit will also function with the 220Ω resistor omitted and the emitters taken direct to the positive supply line.) With the component values shown, f=1 kc/s*

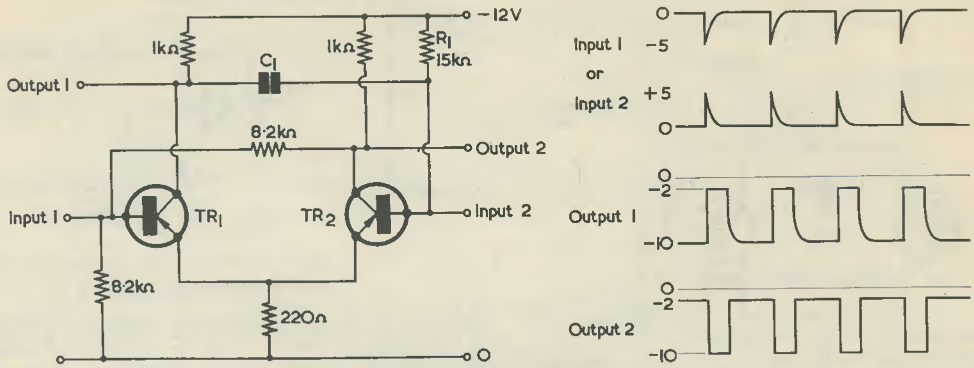



*Fig. 2. A monostable trigger*

either collector but $TR_2$ is preferred as it is a better pulse shape.

In the quiescent condition, $TR_1$ is cut off and $TR_2$ is conducting, this condition being maintained by the low collector voltage of $TR_2$ holding $TR_1$ base low, and the current through $TR_2$ emitter holding the 220Ω resistor at a voltage above that of $TR_1$ base, therefore reverse-biasing $TR_1$.

A negative pulse fed into $TR_1$ base will switch $TR_1$ on, and $TR_1$ collector will swing towards earth, $TR_2$ base will follow due to the coupling capacitor $C_1$, and $TR_2$ will then switch off. The base end of $C_1$ will then start to charge towards battery voltage via resistor $R_1$ until it reaches a point negative to that held by $TR_2$ emitter. $TR_2$ will then turn on and $TR_1$ will turn off.

The delay time is calculated from the formula $t=0.7\ C_1\ R_1$, and the circuit will operate over the range 10μS to 1 minute, the limits being as for the previous section.

To use this circuit as a delay generator, the delay time is determined and $C_1$ selected accordingly. The negative square pulse output from $TR_2$ collector can be differentiated by a capacitor and a resistor, these giving a negative-going and a positive-going spike; the positive spike is then used to carry out the function required, see Fig. 12.

The circuit may also be used to divide down the input frequency (e.g. 1 kc/s to 200 c/s). The practical maximum dividing factor is 5, beyond that the circuit may become erratic. If it is required to generate a 200 c/s waveform from 1 kc/s, then the capacitor $C_1$ will be five times the value it would be for a 50:50 waveform at 1 kc/s (i.e. 0.25μF).

**Bistable Trigger**

The bistable trigger is also known as the Eccles-Jordan trigger and binary divider. The circuit has two stable states and can remain in either state indefinitely. The triggering pulse may be fed into either side or into a common point. Referring to Fig. 3, if an input pulse is fed in at input 1 then a second pulse must be fed in at input 2 to return the circuit to its original state. Under these conditions the circuit may be used to gate another signal for the time interval between the two pulses.

If a train of suitable pulses is fed into the emitters at input 3, the circuit will switch from one state to the other for each input pulse. Therefore if the output is taken from either collector the frequency

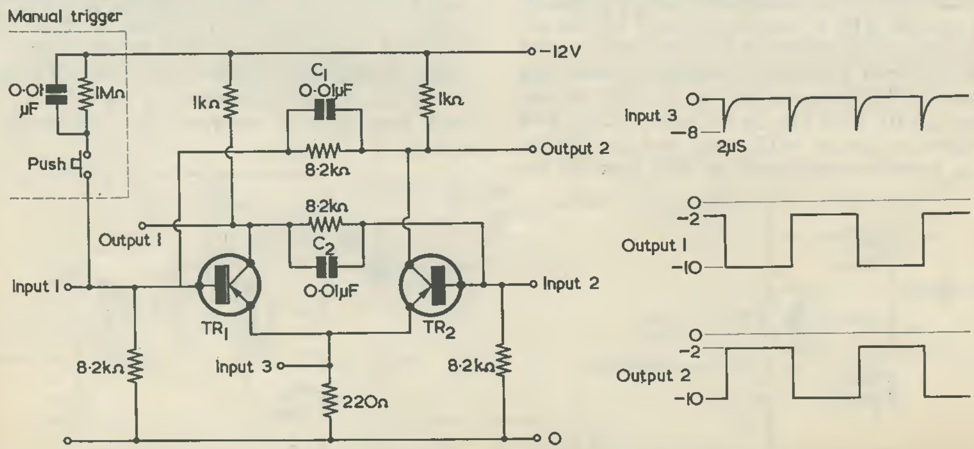



*Fig. 3. A bistable trigger*

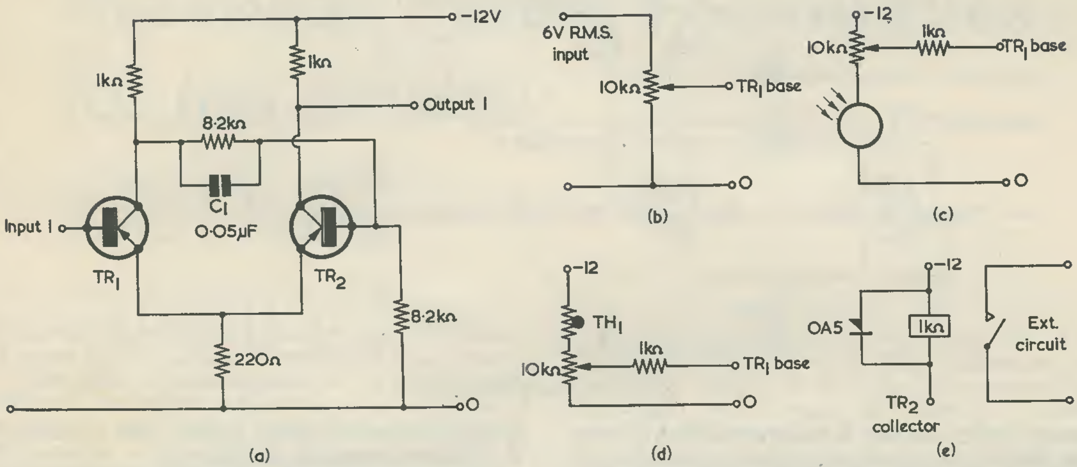



*Fig. 4 (a). The Schmitt trigger*
*(b). The input circuit required for sine wave squaring*
*(c). A photo-cell input circuit*
*(d). Thermistor input circuit*
*(e). Inserting a relay in the collector circuit of $TR_2$*

will be half of the input frequency. A second bistable trigger may be connected to the first via suitable coupling, whereupon the output from the second trigger will be a quarter of the frequency at the input to the first trigger. This may be carried out *ad infinitum*, each stage dividing by two. By suitable cross connecting, a train of binary dividers may be made to divide by 10 or other factors. The binary divider train can be used to count pulses and to stop the pulses when a predetermined number is reached. Six binary dividers can count up to 63 pulses and seven can count up to 127, etc. The collector-to-base capacitors are provided to assist in switching rapidly from one state to the other.

To understand more fully how the circuit of Fig. 3 can switch from one state to the other when a pulse is fed to the emitters, consider Fig. 3 when the circuit of Fig. 13 is coupled to it. In the quiescent condition assume $TR_1$ is conducting and $TR_2$ is cut off. A negative-going pulse at the emitter follower base (Fig. 13) will produce a negative pulse 2μS wide across the 220Ω resistor in Fig. 3. $TR_1$ is then driven into cut off and $TR_2$ is cut off harder. $TR_1$ collector rises to almost $-12$ volts, and this rise in potential is rapidly transferred to $TR_2$ base by the capacitor $C_2$. The potential at $TR_1$ base is held for a short time by $C_1$ at the same voltage as in the quiescent condition. At the end of the 2μS, $TR_2$ switches on due to the base being more negative than $TR_1$ base. $TR_2$ switching on results in cumulative action, and $TR_1$ is held off. The next negative pulse at the emitters results in a further change of state.

**Schmitt Trigger**

The Schmitt trigger is an extremely useful circuit. It has been found to offer a reasonably accurate method of measuring a voltage and causing a certain function to be carried out when a predetermined level is reached. It may also be used for pulse shaping or for squaring a sine wave.

Referring to Fig. 4 (*a*), in the quiescent condition and with no input, $TR_1$ is cut off and $TR_2$ is conducting. When the input potential reaches a certain negative level $TR_1$ starts to conduct, its collector voltage falls and takes $TR_2$ base with it. As $TR_2$ starts to turn off, the emitter voltage falls causing $TR_1$ to conduct more; this is a cumulative condition and results in a rapid transition between the two states. The circuit will remain in this condition until $TR_1$ input voltage falls slightly below that at which the circuit switched over. It will then switch rapidly back. The capacitor $C_1$ is a speed up element and may not be required at frequencies below 5 kc/s.

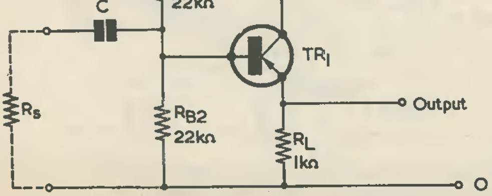



*Fig. 5. Emitter follower*

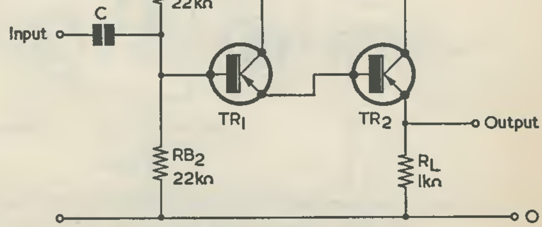



*Fig. 6. Darlington emitter follower*

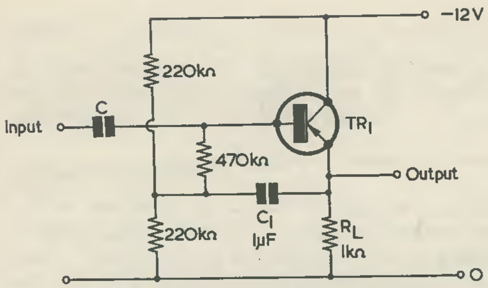



*Fig. 7. Bootstrap emitter follower*

Figs. 4 (*b*) to (*e*) shows various types of input for the circuit of Fig. 4 (*a*). Fig. 4 (*b*) shows the input circuit used for squaring a sine wave, where the trigger fires when the negative half-cycle of the sine wave reaches approximately 2 volts and returns to the quiescent condition as it passes through zero, therefore giving an 8 volt square wave at output 1. Fig. 4 (*c*) shows a means of detecting a change in light intensity by using the change of resistance of a photo cell. Fig. 4 (*d*) enables the circuit to fire at a predetermined temperature in the same way that a thermostat operates. Fig. 4 (*e*) shows the collector circuit of $TR_2$ modified to operate a relay.

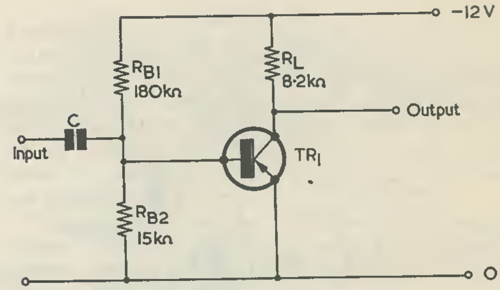



*Fig. 8. An inverter amplifier*

**Emitter Follower**

The emitter follower is a convenient method of impedance matching, the input impedance being high and the output impedance low. There is no voltage gain, the output voltage is slightly less than the input voltage, this being very similar to the valve cathode follower.

Fig. 5 shows an emitter follower circuit, the input impedance Z $\alpha' R_L$ and the output impedance Z $\frac{R_s}{\alpha''}$, where $\alpha''$ is the common collector current gain, this value being very similar to $\alpha'$, the common emitter current gain. $R_L$ is the emitter resistor and

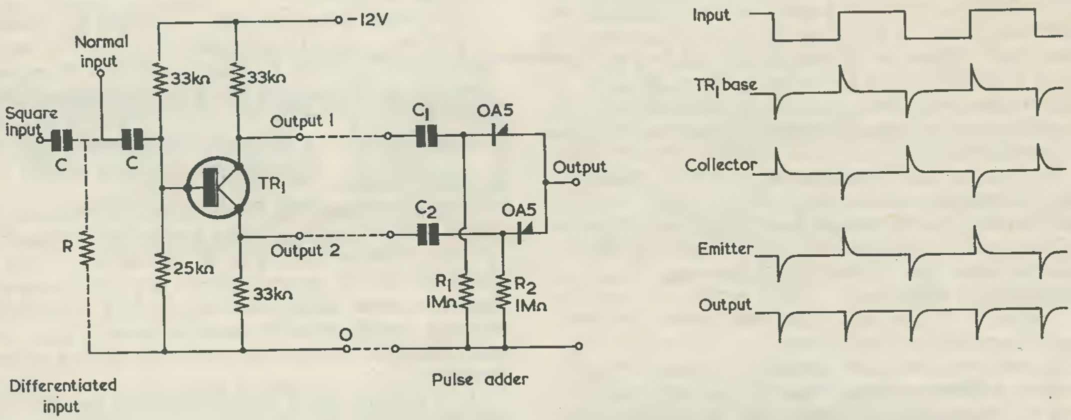



*Fig. 9. A phase splitter. By incorporating the diode pulse adder, frequency doubling may be achieved*

| f | $C_1$ (μF) | $C_2$ (μF) | $C_3$ (μF) |
|---|---|---|---|
| 5c/s | 2000 | 1000 | 500 |
| 50 | 200 | 100 | 50 |
| 500 | 20 | 10 | 5 |
| 5Kc/s | 2 | 1 | 0·5 |

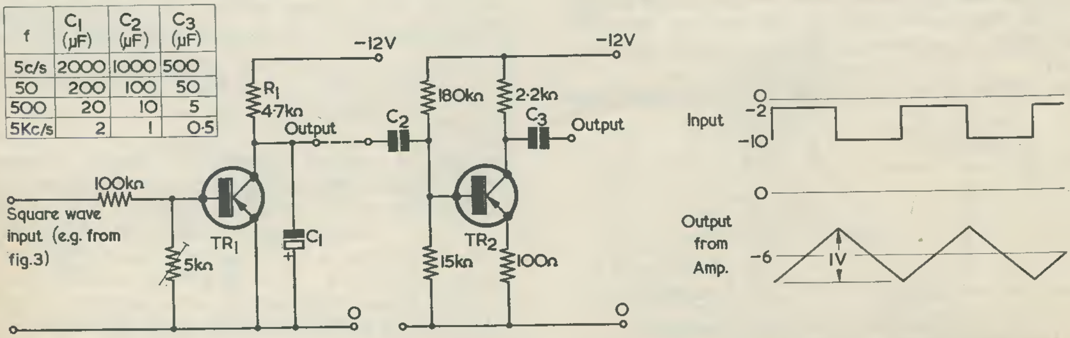



*Fig. 10. Triangular wave generator and amplifier. The 1 volt wave shown appears at the collector of $TR_2$*

| f | $C_1$ (μF) | $C_2$ (μF) | Reset pulse width |
|---|---|---|---|
| 10c/s | 100 | 10 | 1m/s |
| 100c/s | 10 | 1 | 100μS |
| 1Kc/s | 1 | 0·1 | 10μS |

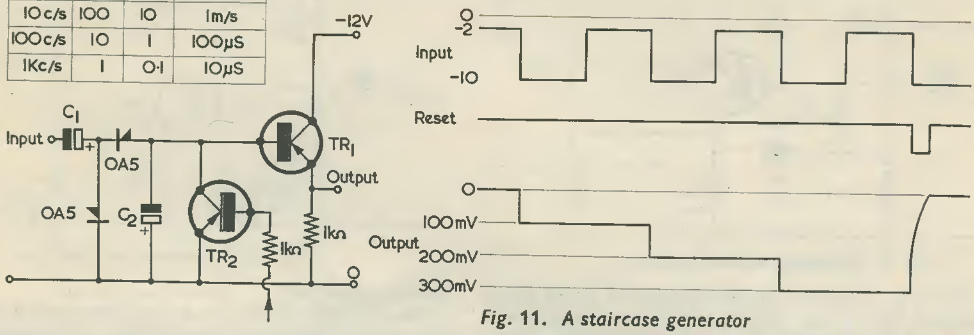



*Fig. 11. A staircase generator*

$R_s$ the source resistance. $R_b$ supplies base current to bias the emitter follower in the quiescent condition. With a suitable value in position $R_{b1}$, the stage may be turned hard on and the emitter will sit at almost −12 volts, a positive-going pulse at the base will then turn the stage off and a positive-going pulse will appear at the emitter. With a suitable value in position $R_{b2}$ the stage is normally held off, and a negative-going pulse at the base will turn on the transistor and a negative-going pulse will appear at the emitter.

With resistors in positions $R_{b1}$ and $R_{b2}$ the stage may be biased such that the emitter sits at −6 volts and the stage will accept both positive-going and negative-going signals. The resistors $R_b$ are in parallel with the input impedance and limit the range of this circuit.

**Darlington Emitter Follower**

The circuit of Fig. 6 shows a modified form of emitter follower, where the input impedance is greatly increased, it being the product of the individual gains of the transistors multiplied by the load resistance, $\alpha''_1 \times \alpha''_2 \times R_L$. This circuit suffers from the same disadvantage as the previous circuit, since $R_b$ is in parallel with the input.

**Bootstrap Emitter Follower**

The circuit of Fig. 7 shows a method of overcoming the disadvantage of the previous two circuits, the output signal being fed back to the input in such a way that the input current is fed mainly into the base and not into the biasing network. High input impedances may be obtained with this circuit.

The circuit is more suitable for audio signal use than pulse circuitry. The frequency response may be modified by changing the value of $C_1$.

**Inverter Amplifier**

The stage shown in Fig. 8 is used for inverting, amplifying and pulse shaping. By selecting suitable values for $R_{b1}$ and $R_{b2}$ the stage may be normally hard on or off, and the pulse at the base will appear inverted at the collector. The output pulse can be almost the same amplitude as the power supply.

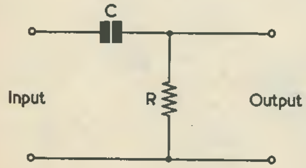
**Phase Splitter**

The circuit of Fig. 9 may be used for audio or pulse circuits and provides two output signals, one at the collector and one at the emitter. The two outputs will be approximately the same amplitude but the phase difference will be 180°. The circuit is very useful when a positive-going signal and a negative-going signal are required from a common source.

If a square wave is differentiated by the circuit shown in Fig. 12 and the output fed into the phase splitter, the negative or positive-going signals at the collector and the emitter may be added together via diodes thereby producing double the frequency of that at the input. This may then be fed into a monostable trigger for squaring.

**Triangular Wave Generator**

If a square wave is fed into the circuit of Fig. 10, and the preset potentiometer suitably adjusted, the output at the collector will be a triangular waveform. The product of $R_1 \times C_1$ should be approximately




| f (c/s) | C (μF) | R (kΩ) |
|---|---|---|
| 1 | 1 | 22 |
| 10 | 0·1 | 22 |
| 100 | 0·01 | 22 |
| 1K | 0·001 | 22 |
| 10K | 0·0001 | 22 |

*Fig. 12. A square wave differentiating network*

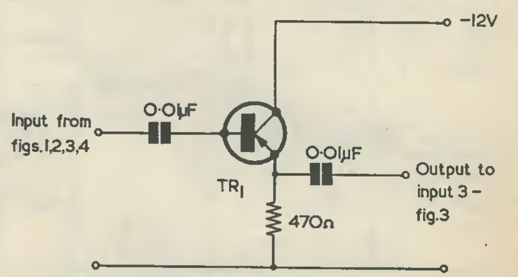



*Fig. 13. Emitter follower for coupling purposes*

equal to $\frac{20}{f}$ where $R_1$ is in MΩ, $C_1$ is in μF, and f is in cycles per second. The output signal amplitude will be linear with a peak value of 100mV at the collector of $TR_1$.

### Staircase Generator

If a sequence of events is required at different voltage levels, then the staircase generator may be used. The input is a train of square waves with fast rise and fall times and flat tops. This is fed via a capacitor and a diode into a storage capacitor. For each input pulse, the storage capacitor receives an additional charge. This is fed into an emitter follower stage $TR_1$. To discharge the storage capacitor, the low leakage silicon transistor $TR_2$ must be switched on by a negative-going pulse on its base. The discharge pulse may be generated after a predetermined number of pulses have appeared at the storage capacitor.

### Conclusion

In designing the circuits described above, the author has kept the basic circuits as simple as possible and almost any low power germanium p.n.p. transistor may be used. Also, n.p.n. transistors may be used if the power supply is made positive and the electrolytic capacitors and diodes are reversed.

When altering values of components given here, ensure that the transistor collector voltage and current ratings and the maximum power dissipation are not exceeded.

(A point to watch when using supply potentials higher than 9 volts or so is that the maximum reverse base-emitter voltage is not exceeded with transistors used in multivibrator-type circuits. Immediately after the change-over, the base of the turned-off transistor in such circuits is carried, by the coupling capacitor, over the same change of potential as the collector of the turned-on transistor. —EDITOR.)

# Morning Radio Alarm

By **W. BLACKBURN**

*This simple addition converts your transistor radio into a musical alarm clock*

FACED WITH AN EVER-INCREASING DIFFICULTY IN waking up in the morning, the author decided that the most suitable form of alarm would be a device that would switch on a transistor radio at a pre-determined time.

On investigation, it was found that Lasky's Radio, 207 Edgware Road, London, W.2, market a miniature clock movement with contacts that can be made to close at a pre-set time. This unit is the "Rotocontact" Miniature Clock/Time Switch, and it has a diameter of 1½in and a depth of ½in.

### Construction

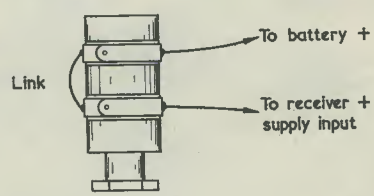
It was felt that it would be preferable not to fix the clock permanently to the radio, and so an adapter bush was made which enabled the clock to be mounted on the end of a standard jack plug. This bush may consist of either metal or plastic material. The clock contacts connect to the jack plug terminals, and care should be taken to ensure that the two connectors are not inadvertently short-circuited at the rear of the movement.

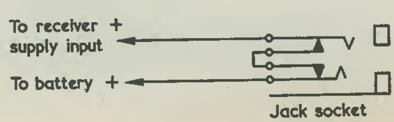
A jack socket is mounted at a convenient point on the receiver cabinet or back. This socket should be of the type whose contacts short-circuit when the jack plug is removed. The socket used by the author was an Igranic component wired up as shown in the accompanying diagram. The socket contacts are in series with the lead to the positive terminal of the internal battery. When the jack plug is removed, the battery circuit is completed by the socket contacts and the receiver can be operated in the normal way. When the jack plug with clock attached is inserted, the radio only switches on when the clock contacts close.

In use the clock is wound up and its bezel turned to set the alarm time. The radio is tuned to a suitable station and set to the desired volume. The jack plug is then inserted into the socket, whereupon the radio is automatically silenced until the pre-set time is reached. The clock contacts then close and the radio starts to operate again.

The movement used by the author completes the circuit for approximately 30 minutes before opening and recommencing another cycle. If desired, the clock can be made a permanent feature, with a switch to short-circuit the clock contacts when the radio is required for normal use.

It should be noted that the clock switch is intended for low voltage equipment. It should only be employed to control a battery transistor radio, and must *not* be used with a mains-operated receiver.



Jack socket circuit

# NEWS AND COMMENT . . .

## Rugby VLF Transmitter off the Air

During the first six months of 1966, the time signal service at present provided by the Rugby VLF transmitter GBR on 16 kc/s will be transferred to Criggion VLF transmitter GBZ on 19.6 kc/s.

Criggion will provide the service from 0001Z on 1st January, 1966, until approximately 30th June, 1966, when the time signal service will revert to Rugby, but users are advised to retain their capability for reception on 19.6 kc/s.

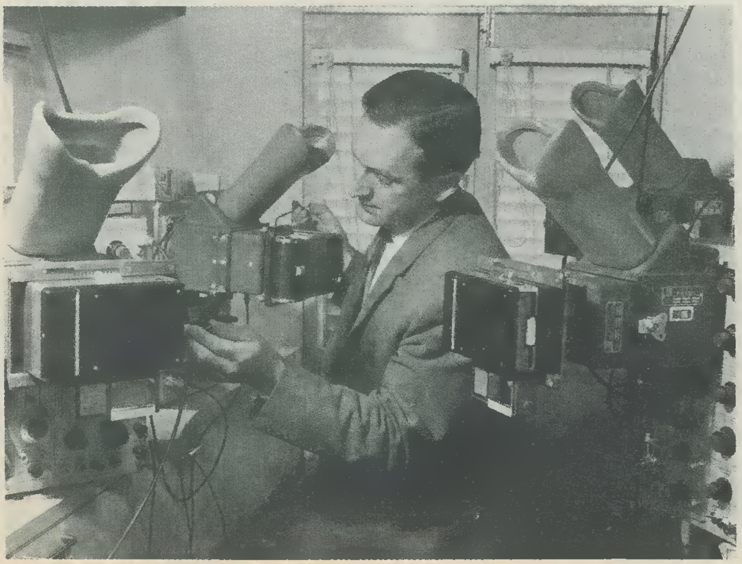
Rugby was last off the air in 1941 when there was a large fire at the station (not due to enemy action) and was out of action for several months. Apart from scheduled maintenance periods it has been in operation ever since.

The reason for the withdrawal of Rugby is to enable the transmitters to be modernised for frequency-shift keying.

In addition to the existing on-off morse code transmissions on 16 kc/s it is intended to transmit 50-band teleprinter signals (i.e. element length 20 millisec.) by frequency-shift keying. The lower frequency will be 15.95 kc/s and the upper one 16 kc/s. The present accuracy of the 16 kc/s carrier will be retained and measures are being taken to prevent a phase shift in the wave when the aerial is retuned to change from on-off to frequency-shift keying and vice versa.

The phase of each wave will be coherent throughout the transmission and there will be a smooth transition from one frequency to the other lasting for about 8 milliseconds, which is the response-time of the aerial. Therefore, if users of the constant-frequency service find it necessary to provide gating circuits in their receivers, there will be some 12 milliseconds of the required stable frequency available in each telegraph element.

It is not the present intention to generate the 15.95 kc/s frequency to as high an accuracy as the 16 kc/s, although presumably the G.P.O. could do this if required. This would enable a stream of timing marks at 20 millisecond intervals to be derived from the frequency-shift transmission. It would probably be necessary to synchronise a local 50 c/s oscillator to smooth out small fluctuations in the interval introduced by the keying circuits and to cover groups of telegraph elements lasting several multiples of 20 milliseconds on one frequency.



## OVER 600 ATTEND INAUGURAL MEETING

Addressing the Inaugural Meeting of the Institution of Electrical and Electronics Technician Engineers in London on 19th October, the Postmaster-General, The Rt. Hon. Anthony Wedgwood Benn, M.P., said that one of the major bottlenecks in the development of higher technology in this country has been the shortage of people qualified to carry design, development and maintenance further forward; therefore, the formation of the new learned society, and the contribution that it could make towards raising the status, efficiency and qualifications of the technician engineer was something that would be of great value.

Referring to the "enormous importance" of IEETE being set up, the Minister declared that it was much welcomed by the Government.

The lecture, "The Future of Telecommunications", was by Mr. D. A. Barron, C.B.E., Engineer-in-Chief of the General Post Office, who it may be recalled, opened the 1965 International Radio Communications Exhibition. Mr. Barron illustrated his paper with many practical demonstrations of technical innovations being applied by the G.P.O.

A capacity audience of over 600 attended the Meeting, held in the Lecture Theatre, The Institution of Electrical Engineers. The IEETE President, Sir Harold Bishop, C.B.E., was in the Chair.

## OSCILLOSCOPE CAMERAS RECORD SONIC BANGS

ABC oscilloscope cameras, marketed in this country by AVO (MI Group), are shown in the illustration alongside in use at the applied physics division of the Acoustical Section of the National Physical Laboratory.

Dr. J. Bowsher is shown in a mobile experimental vehicle, using four ABC cameras to record wave formations of sonic bangs from high speed aircraft.

These cameras enable distortionless photographs of oscillograms to be taken and prints to be produced in ten seconds by the Polaroid system.

## REDRESS

Although in the last two issues we have rather poked fun at computers we are, of course, not "agin" their use but it is, perhaps, salutary to remember that there are limits to the abilities of these, and indeed all, modern aids to efficiency.

In the next number of this magazine, on sale 1st February, the whole of the "In Your Workshop" feature will be devoted to the basic concepts of computer logic circuits. This article will enable readers to easily comprehend the basic groundwork of computer theory, and the linking dialogue between Dick and Smithy provides an entertaining background to this fascinating subject.

We are sure there will be those, in addition to our regular readers, who, either because of their employment or general scientific interest, will value the information given and the manner in which it is presented. You can recommend the article with confidence to any such; it is the best we have seen on the subject for the "ordinary bloke".

We can't resist another little joke: Loving Wife: "Had a good day at the office, Darling?" Husband: "No, dear, I had a bad day, I'm tired out." Wife: "Why, dear?" Husband: "The computer broke down and we all had to think!"

## FIRST EVER

In a report received from the Harlow and District Radio Society, we learned of a remarkable achievement by one of its members, Mr. G. E. Read, G3ERN. It is claimed that he is the first amateur in this country ever to make a two-way contact with the North American Continent using an experimental transistor transmitter powered by nothing more than a 3s. 6d. 9 volt dry battery, using five transistors. The size of the transmitter is about that of a pocket receiver and was designed by Mr. Read.

# Boat Powered by Sunshine

A boat powered entirely by solar energy has been demonstrated in the United States. It is a small lightweight craft of Haitian design, but the principle it uses can be readily applied to other types.

Two large panels of solar cells—one mounted over the hull and the other on the bow—convert the energy of sunshine into electricity. This can be used directly by a motor or indirectly by charging batteries from which the motor can then draw its power supply.

In practice, batteries are necessary to stabilise power supply—at such times as when the boat may be moving through shadow—though direct conversion has been used in demonstrations.

### Potential Uses in Developing Areas

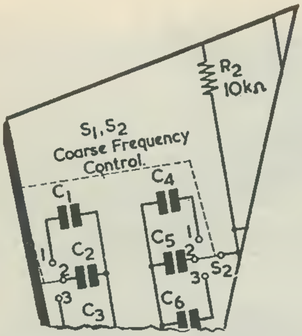
The boat was invented by John Hoke, an American, when he was serving in Surinam (Dutch Guiana) on the staff of the U.S. Agency for International Development (AID). His idea was that the boat would be useful in developing areas where fuel is scarce but sunshine is plentiful.

At present, the high cost of solar cells makes sunshine-powered boats an expensive proposition, but AID, which sponsored the prototype boat, is encouraging researchers to find ways to reduce costs.

The two panels of solar cells on the demonstration boat have a combined output of 150 watts in good weather. This means they could supply a total of 1,000 to 1,500 watts of power a day in good weather in the tropics, enabling the boat to operate on two motors at about five miles an hour.

There would also be enough power for communications equipment and for a few power tools.


*"You're right, Auntie, it is an old set."*




# Fixed Voltage Monitor

## SUGGESTED CIRCUIT No. 182

**By G. A. FRENCH**

There are a number of occasions when it is desirable to have a warning device which responds to a single fixed voltage only, and which switches to its alternative state for voltages which are either greater or lower than the fixed voltage. A typical instance is given by the soak testing of, say, an a.f. amplifier having an intermittent fault. It would be normally undesirable to have the amplifier in operation all the time whilst other work is in progress, because the continual sound from its loudspeaker would be a distraction. An alternative scheme consists of replacing the loudspeaker of the faulty amplifier by a suitable resistive load, applying a test oscillator to its input and a simple rectifier circuit to its output, and connecting the rectified output voltage to a fixed voltage monitor. Provided the rectified voltage from the amplifier applied to the monitor remained constant, the latter would indicate that the amplifier was working correctly. When the intermittent fault became evident, however, the amplifier output voltage would either increase or decrease, whereupon the monitor would at once give a visual or aural warning and the amplifier could then be examined whilst in the faulty condition.

Another application would be given by temperature checks for greenhouses and the like. A simple thermistor circuit could provide a voltage varying with temperature, whereupon a fixed voltage monitor could keep a check on this voltage. Should temperature either increase or decrease, the monitor would then give warning.

Further uses are given by the monitoring of power supply output voltages and similar applications.

The fixed voltage monitor which forms the subject of the present article is capable of operating with any pre-determined voltage over a range of zero to 8 volts. The device provides an "on" current which illuminates a bulb (or operates a relay) at a pre-determined input voltage, sensitivity being such that the 50% points of the "on" current are about 1 volt apart.

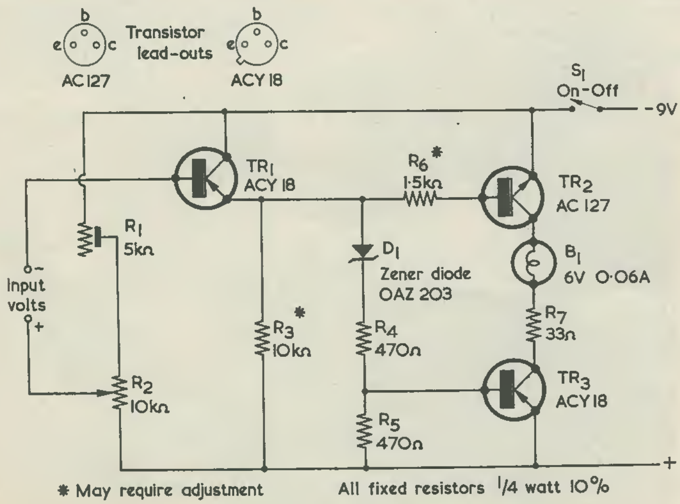



*Fig. 1. The circuit of the fixed voltage monitor*

### The Circuit

The circuit of the fixed voltage monitor appears in Fig. 1. It will be helpful at this stage to ignore $R_1$ and $R_2$, and to assume that a voltage increasing from zero to 9 volts negative (relative to the positive supply line) is applied to the base of $TR_1$.

Let us commence with zero volts applied to $TR_1$ base. Although $TR_1$ looks at first sight as though it were an emitter follower it cannot, with zero volts on its base, carry out such a function. This is because $TR_1$ emitter is held negative of its base due to the forward current flowing through the base-emitter junction of the n.p.n. transistor $TR_2$. Assuming conventional current (from positive to negative), the current in the base-emitter junction of $TR_2$ follows three routes. The first of these is via $R_3$ and $R_6$. The second is via $R_5$, $R_4$, zener diode $D_1$ and $R_6$. The third is via the base-emitter junction of transistor $TR_3$, $R_4$, zener diode $D_1$ and $R_6$. The sum of these three currents flows through $R_6$ and the base-emitter junction of $TR_2$, with the result that about 2 volts is dropped across these two circuit elements. The emitter of $TR_1$ is, therefore, held negative of the positive supply rail by about 7 volts. At a base voltage of zero $TR_1$ is, in consequence, cut off, and it cannot operate as an emitter follower.

As was just stated, with zero volts on the base of $TR_1$, part of the current which flows in the base-emitter junction of $TR_2$ is passed via the base-emitter junction of $TR_3$.

This current is too low, however, to allow $TR_3$ to pass any appreciable collector current.

For all negative voltages at the base of $TR_1$ up to about 7 volts, the circuit remains in the same condition, since the base of $TR_1$ continues to be positive of its emitter. At about 7 volts the base voltage for $TR_1$ becomes the same as the emitter voltage and, above this voltage, it is negative of the emitter. When 7 volts negative is reached, $TR_1$ commences to function as an emitter follower.

As the base of $TR_1$ rises negatively above 7 volts, its emitter goes similarly negative. This causes a greater voltage to be dropped across $R_4$ and $R_5$, with the result that increased current flows in the base-emitter junction of $TR_3$. The collector current of $TR_3$ now commences to increase. At the same time the voltage at the junction of $TR_1$ emitter and $R_6$ starts to go negative, causing a reduction in the current in the base-emitter junction of $TR_2$. As the voltage applied to the base of $TR_1$ goes further negative, these two effects continue; that is, the current in the base-emitter junction of $TR_3$ increases whilst the current in the base-emitter junction of $TR_2$ decreases. When about 8 volts is applied to the base of $TR_1$, the base-emitter currents in $TR_2$ and $TR_3$ are such that these two transistors are both capable of passing a collector current of 60mA, whereupon the bulb $B_1$, in their common collector circuit, glows at full brilliance.

Negative voltages at the base of $TR_1$ which are greater than 8 result in a further reduction in base-emitter current in $TR_2$, and this transistor then becomes unable to pass sufficient collector current to keep the bulb illuminated.

Summing up the above explanation, it can be said that, for negative input voltages below about 8 volts at the base of $TR_1$, a relatively high current flows in the base-emitter junction of $TR_2$. This transistor could pass a high collector current but is unable to do so because of limited collector current in $TR_3$. At negative input voltages at $TR_1$ base above about 8 volts, it is $TR_3$ which passes a relatively high base-emitter voltage, but this transistor is prevented, in its turn, from passing a high collector current because of limited collector current in $TR_2$. At about 8 volts input voltage the base-emitter currents in both $TR_2$ and $TR_3$ are such that each transistor passes 60mA collector current, and the bulb in their common collector circuit then becomes fully illuminated.

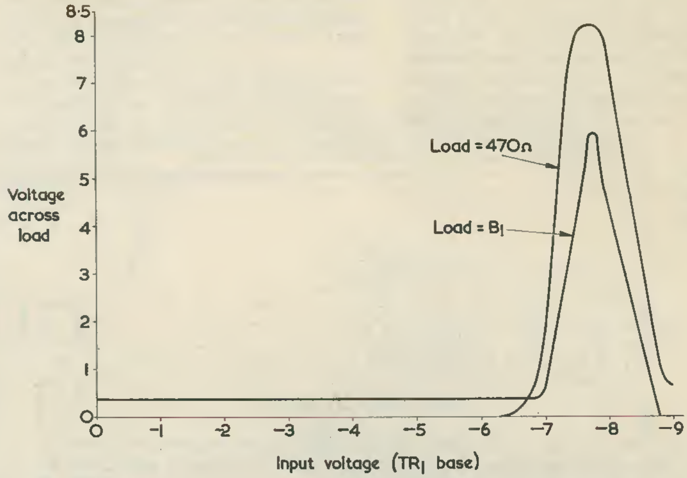



*Fig. 2. Curves showing load voltage for differing voltages at the base of $TR_1$ relative to the positive supply line. The curve for the 470Ω load is given when a resistor of this value replaces $B_1$ and $R_7$. In the prototype, $R_6$ had to be changed to 3.9Ω to cater for the 470Ω load*

**Voltage Curves**

Fig. 2 gives two curves for load voltage against input voltage, as obtained with the prototype, and the curve which should now be examined is that designated "Load$=B_1$". This curve shows the voltage across bulb $B_1$ for differing negative voltages at the base of $TR_1$. For input voltages below 7, the voltage dropped across the bulb is 0.4, this resulting from the small current which is allowed to flow in the base-emitter junction of $TR_3$. A voltage of 0.4 is, of course, too low to cause the bulb to show any illumination. After 7 volts input voltage the voltage across the bulb rapidly increases, rising to 6 volts for an input voltage of 7.8. After 7.8 volts, the voltage across the bulb decreases just as rapidly, falling to zero ($TR_2$ cut off) at an input voltage of 8.8. As will be seen, bulb illumination decreases rapidly for both increases and decreases in input voltage about 7.8 volts, this being the figure which corresponded to maximum bulb illumination with the prototype components.

Two further curves, also obtained from the prototype, are given in Fig. 3, and these show base current in $TR_2$ and $TR_3$ for input voltages from zero to 9 volts. Again, the same pattern is demonstrated. Up to 7 volts, $TR_3$ passes a low base-emitter current. After 7 volts, base current in $TR_3$ increases. At the same time, $TR_2$ passes a high base-emitter current up to about 7 volts, after which this decreases. At 7.8 volts, the figure for maximum bulb illumination with the prototype, base currents are such that both transistors can pass 60mA collector current. The two base current curves do not cross exactly at the 7.8 volt co-ordinate because the two transistors will not have exactly the same gain.*

**Notes on Components**

We have not, as yet, considered the functions offered by all the components in the circuit, and this we shall next proceed to do.

$R_7$, in series with bulb $B_1$, is merely a dropping resistor. Nearly 8 volts appear between the two collectors when $TR_2$ and $TR_3$ pass 60mA, whereupon $R_7$ ensures that 6 volts appear across the bulb under these conditions. $B_1$ is a Radiospares 6V 0.06A pilot light.

The function of $R_3$ is to ensure that sufficient current is drawn through the base-emitter junction of $TR_2$ to enable it to pass an adequate collector current. The current flowing through the zener diode circuit is not, on its own, sufficient for this purpose. The base current readings obtained by the author indicate (working from published transfer characteristics) that the particular AC127 selected for the prototype circuit was in the middle

* Although this is not evident from Fig. 3, the directions of the two currents whose curves are shown are opposite. The curve for $TR_2$ was obtained with the meter negative terminal connected to the base, and that for $TR_3$ with the meter positive terminal connected to the base. The two curves are drawn on the same side of the graph in Fig. 3 to show their mutual effect more clearly.

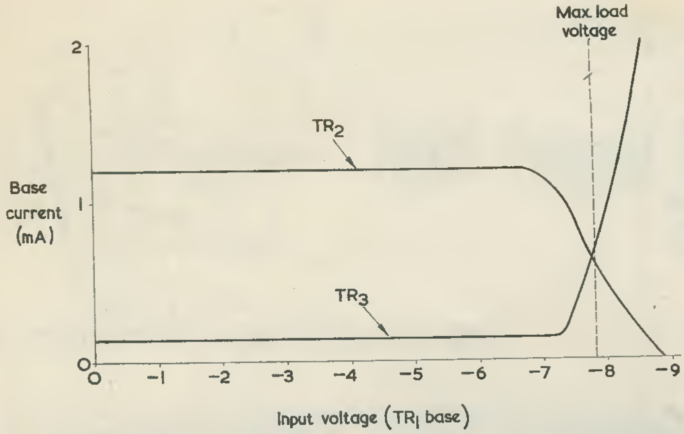



*Fig. 3. Base current in $TR_2$ and $TR_3$ for differing voltages at the base of $TR_1$. With the prototype circuit, maximum bulb illumination was given at 7.8 volts*

of spread for gain at 60mA collector current. If a low gain AC127 is used, there is a slight possibility that $R_3$ may have to be reduced in value a little to compensate.

It will have been noticed that the zener diode is employed here as a component which drops a fixed voltage. It functions as a fixed voltage zener device for all input voltages at the base of $TR_1$.

Resistor $R_6$ is critical in value and it will very probably require adjustment to suit the characteristics of the transistors used and, in particular, the voltage dropped (within its tolerances) by the zener diode. If $R_6$ is too high in value, the peak common collector current will be less than 60mA. If it is too low, the current passed by $TR_3$ for input voltages below 7 at $TR_1$ base will be too high. With the prototype, a value of 1.5kΩ gave the best compromise results, as shown by the $B_1$ curve of Fig. 2. When making up the circuit, it might be preferable to commence with a variable resistor set to around 1.5kΩ in the $R_6$ position and to adjust this for best results when the circuit has been completed. The variable resistor may then be replaced by a fixed resistor of appropriate value. It should be added that the particular zener diode used in the prototype dropped 6.5 volts at 1mA.

The total dissipation in $TR_2$ and $TR_3$ when the bulb is fully illuminated is well within the maximum dissipation figure of either. It was found, with the prototype, that rather more voltage appeared across $TR_3$ than across $TR_2$ and it would, despite the fairly low dissipation figure, be wise to fit $TR_3$ with a cooling fin.

As so far discussed, the circuit of Fig. 1 enables a warning bulb to glow at full brilliance when about 8 volts negative (7.8 volts with the prototype) is applied to the base of $TR_1$, this bulb extinguishing when the input voltage increases or decreases. Thus the circuit is capable of acting as a monitor at this particular voltage. $R_1$ and $R_2$ enable similar facilities to be provided for any other voltage within the range. With the input terminals of Fig. 1 short-circuited and $R_2$ slider at the upper end of its track, $R_1$ is adjusted for the condition of maximum illumination. All input voltages from zero up to about 8 may then be monitored by appropriate adjustment of $R_2$.

A limiting factor with the circuit is given by the current drawn from the source of input voltage if this voltage goes considerably negative of that needed for maximum illumination of the bulb. A curve showing input current for input voltages up to 9 at the base of $TR_1$ is shown in Fig. 4. Below 7 volts there is a reverse leakage current of some 4μA, this changing over to normal base current as 7 volts is reached. The current increases to 75μA at 9 volts negative and (not shown in the diagram) to about 0.5mA at 12 volts negative. As is illustrated by the curve, the source of input voltage is called upon to supply about 40μA at the voltage which gives maximum illumination of the bulb, and less than 40μA at voltages below. At higher input voltages the current demand increases rapidly, reaching 0.5mA at 4 volts negative of the voltage which gives maximum illumination. If it is felt that the voltage being monitored may go negative by more than 4 volts above the required figure, it might be advisable to insert a limiting resistor in series with the input connections. Such a resistor should not unduly reduce sensitivity at voltages near that which causes maximum illumination of the bulb, because current demand is much lower at this voltage.

**Alternative Load**

The fact that indication of correct input voltage is given by illumination of a bulb results in a fairly heavy consumption from the 9 volt supply. For economic reasons, it would be preferable to use a mains power supply unit rather than batteries when the bulb is employed. Since the supply is "floating" relative to the input connections, neither side

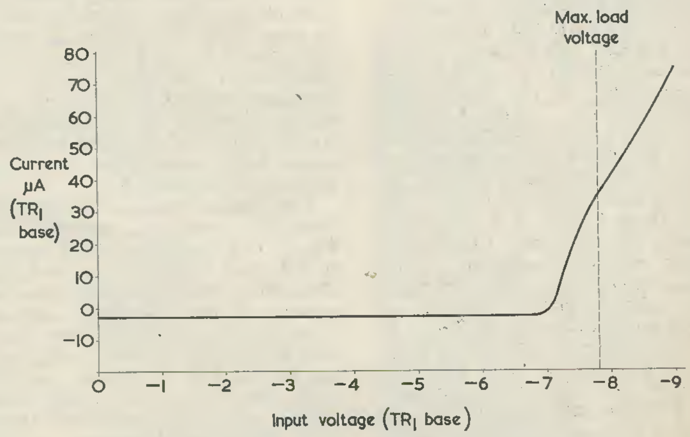



*Fig. 4. Input current at $TR_1$ base for varying input voltages*

of the power supply output should be earthed.

The circuit will, however, work just as well with loads consuming less current than the bulb. The writer checked this point by replacing the bulb and $R_7$ with a 470Ω resistor, whereupon the second curve shown in Fig. 2 ("Load=470Ω") was obtained. It was necessary to adjust $R_6$ by quite a considerable amount to enable the circuit to cope with this new load, the altered value of $R_6$ being 3.9kΩ.

As will be seen from Fig. 2, the voltage across the 470Ω resistor rose, for 7.8 volts at $TR_1$ base, to 8 volts. This would be adequate to energise a small relay, the current at 470Ω being of the order of 16mA. This relay could then operate a warning lamp or bell when it energised or de-energised, according to the particular application envisaged. It would not be necessary to fit $TR_3$ with a cooling fin if a load of this nature were employed.

# ONE MINUTE "WINKER"

**By J. P. CREAN**


THERMAL DELAY SWITCHES, IN WHICH A BIMETAL strip is raised in temperature by a heater, are normally employed for providing a delay between the application of heater voltage and anode voltage with mercury vapour rectifiers. In this design, two thermal delay switches are used to make a "winker" with an overall cycle of about two minutes, i.e. one minute on and one minute off.

The thermal delay switches used by the author were S.T.C. type VLS631. These have glass envelopes similar to those of valves, and fit the standard B7G base. The pin connections are: heater, 1 and 7; bimetal strip, 3; stationary strip, 4. There are internal connections to pins 2 and 6, and pin 5 has no connection. When a standard 6.3 volt supply is applied to pins 1 and 7, the bimetal strip short-circuits to the stationary strip after about one minute.

### The "Winker"

In the accompanying circuit diagram, two thermal delay switches type VLS631 are connected up as shown. The circuit is intended to run from a 6 volt car battery.

When the battery is initially connected, the relay contact is at position A, whereupon the 6 volts from the battery is applied to the lamp and to the heater of thermal delay switch $DS_1$. After a minute, the contacts of $DS_1$ close, providing a circuit through the relay coil and $R_1$ to the 6 volt supply. The relay then operates, whereupon its contact moves to position B, latching it on. The relay contact also breaks the circuit to the lamp, which extinguishes, and to the heater of $DS_1$, which now commences to cool. At the same time, the relay contact maintains the supply (originally given by $DS_1$) to the heater of $DS_2$, which starts to warm up.

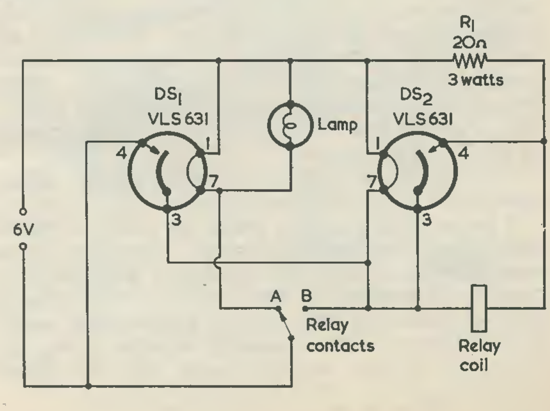
After a further minute the contacts of $DS_2$ close. The relay coil is then short-circuited, whereupon it de-energises and its contact returns to position A. Another cycles then commences.

Resistor $R_1$ is included in circuit to prevent $DS_2$ putting a short-circuit across the supply.

**Editor's Note**

The VLS631 thermal delay switches used in this circuit have a rated heater voltage of 6.3 at a nominal current of 0.5 amp. The delay time at 20° C ambient is specified at 44 seconds minimum to 66 seconds maximum. Maximum contact current on make is 1 amp (surge, 5 amps). The switches are available to private individuals from the Sales Department of Standard Telephones and Cables Ltd., Valve Division, Brixham Road, Paignton, Devon.

The relay employed should, of course, be capable of energising when 6 volts is applied to the coil via a 20Ω resistor.



# A STABLE R-C OSCILLATOR

**By G. E. DIXEY, A.M.I.E.R.E.**

*Designed originally for radio control, this oscillator has many other applications. It offers very low frequency drift over a wide range of ambient temperatures*

The oscillator circuit described in this article was developed originally as a stable tone generator for radio control systems but it is not, of course, limited to this application. Other possibilities include the a.c. source for a bridge or for signal tracing in audio circuitry.

**Stringent Specification**

For its original requirement the oscillator had to conform to a fairly stringent specification. The main points of this specification were:

1. It should maintain the set frequency within ±1% for a temperature range of 0–60° C. In case this temperature range may be thought rather wide it should be considered that, as the component part of a transmitter, it might be enclosed in a metal case with little or no ventilation and be exposed to wintry conditions or several hours of sunshine between periods of use. Under these circumstances the temperatures stated could well be realised. For single-tone radio control working a fair degree of frequency drift is permissible, but when the receiver incorporates tuned reeds or filters even small changes of frequency can cause control to be lost.
2. For cost and convenience the circuitry should be as simple as possible.
3. It should be capable of delivering its output into a wide range of impedances.

It is possible, and very usual, to design a stable oscillator around an L-C circuit. However, in the writer's opinion, this idea conflicted with requirement 2. Therefore, it was decided to investigate ways of achieving the required performance using R-C techniques. Two possible circuits spring to mind—the ladder network type and the Wien bridge type.

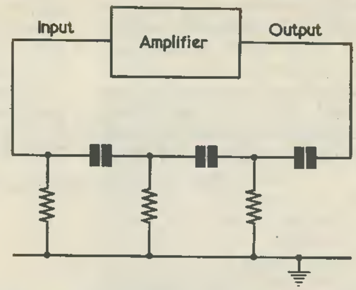



*Fig. 1. Representation of ladder oscillator*

After various experiments it was decided to concentrate on the ladder network in spite of the fact that the amplifier has to cover greater losses in the feedback network than in the Wien bridge circuit. It was found that this apparent drawback could be easily overcome and that frequency control could be obtained by varying a single resistor.

**Development Stages**

Before examining the final working model it will be instructive to consider the various stages in its development. It is assumed that it is understood that any oscillator is basically a feedback network providing 360° of phase shift between input and output at the oscillation frequency, with an amplifier to compensate for the losses that occur in the network. In practice some of the phase shift takes place within the amplifier.

Fig. 1 shows a 3-stage ladder network connected between the input and output of an amplifier. A feature of the ladder network is that, at one particular frequency, the phase shift across it is 180°. If then the amplifier has a phase shift of a further 180°, and sufficient gain to make good the losses, we have an oscillator.

Fig. 2 shows a simple, single transistor amplifier with the ladder network connected between the base (input) and the collector (output). A circuit of this type does work, but it has the disadvantage that the output is loaded directly by the ladder network, which reduces the gain of the amplifier quite appreciably. This means that it becomes necessary to select transistors of high gain. If we use a second common emitter stage following the first we create sufficient gain overall, but now introduce a further

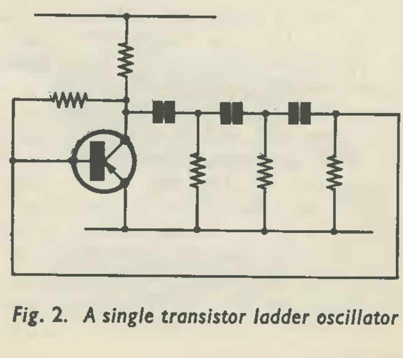


*Fig. 2. A single transistor ladder oscillator*

## Components List

*Resistors*
(All fixed values ¼ watt)

| | |
|---|---|
| $R_1$ | 5.6kΩ 10% |
| $R_2$ | 2.7kΩ 10% |
| $R_3$ | 1.8kΩ 5% |
| $R_4$ | 180kΩ 5% |
| $R_5$ | See text |

*Capacitors*

| | |
|---|---|
| $C_{1,2,3}$ | 0.1μF paper or polyester (see text) |
| $C_4$ | See text |

*Transistors*

| | |
|---|---|
| $TR_{1,2}$ | OC202 |

180° phase shift so that the condition for oscillation disappears.

We get around this quite simply by making the second stage not common emitter but common collector, the latter introducing no additional phase shift. It may be asked what is the use of introducing the common collector stage since it has a voltage gain of 1, i.e. no gain at all! The answer is that the common collector stage is the transistor equivalent of the cathode follower and, as such, has a very high input impedance and a very low output impedance. The high value of input impedance helps us because it does not appreciably load the output of the preceding stage; and the latter is able, therefore, to provide its full gain. In other words, instead of connecting the ladder network directly to the collector of $TR_1$ we insert a "buffer", $TR_2$, which removes the loading effect. The complete circuit is shown in Fig. 3.

### Circuit

In Fig. 3, $TR_1$ is the amplifier proper, its collector load being $R_1$. For economy of components this stage is direct-coupled to $TR_2$. The bias for $TR_1$ is produced, by $R_4$, from $TR_2$ emitter. This "bias loop" has a phase shift of 180° for d.c. and provides temperature stabilisation. The ladder network consists of $C_1$, $R_3$, $C_2$, $R_5$ (the frequency control), $C_3$ and (further economy!) the input resistance of $TR_1$.[1]

For maximum stability the transistors employed were silicon types such as the Mullard OC202 but if some reduction in stability can be tolerated (or alternatively high stability with a narrower temperature range) then germanium r.f. transistors such as the OC45 or similar can be used without modification to the circuit.

[1] In order to obtain a stable frequency for wide changes in temperature it is necessary for capacitors $C_1$, $C_2$ and $C_3$ to have good temperature coefficients. In this respect the author informs us that the components used in his original circuit were Wima Tropyfol M polyester capacitors, which have a temperature coefficient of +1% for a rise of 60° C. These are not "special" components, and to quote another manufacturer, namely Telegraph Condenser Co. Ltd., it is possible to obtain T.C.C. Duomold (+0.6% at 60° C), T.C.C. Polyester (+0.6% at 60° C), T.C.C. Metallised Polyester (+0.9% at 60° C), and T.C.C. Metamold (+0.6% at 60° C). All of these would be suitable for use in the circuit. The use of the input resistance of $TR_1$ (which will be non-linear and could change with battery voltage) has negligible effect on frequency in practice, owing to the d.c. feedback loop.—EDITOR.

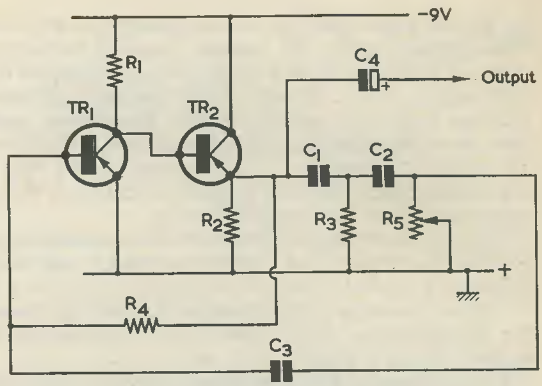



*Fig. 3. The circuit of the oscillator described in this article. $C_4$ is shown as an electrolytic component, but it may be a paper capacitor if the oscillator feeds into a high impedance circuit*

The only other comments that need to be made with regard to the components concern $R_5$ and $C_4$. Considering $R_5$ first, the resistance variation offered by a 10kΩ potentiometer gives a frequency range from 200 to 600 c/s[2] but the relationship is not a linear one, i.e. equal changes in resistance do not produce equal changes in frequency. The effect of this is that if a 10kΩ potentiometer is used as the frequency control, its setting becomes rather critical at the low resistance end of the travel. If one particular frequency is required the necessary value of resistance can be found by experiment and a fixed resistor of appropriate value wired in. A number of spot frequencies can be selected by means of a multi-way switch and a bank of resistors. If a single frequency is required, say for the a.c. supply to a bridge, then it is worth knowing that a value

[2] This is the useful range offered by the 10kΩ potentiometer. Oscillation will, of course, cease when $R_5$ closely approaches zero. However, the slider travel between zero ohms and the 600 c/s point is very small, and so there is little wasted track.—EDITOR.

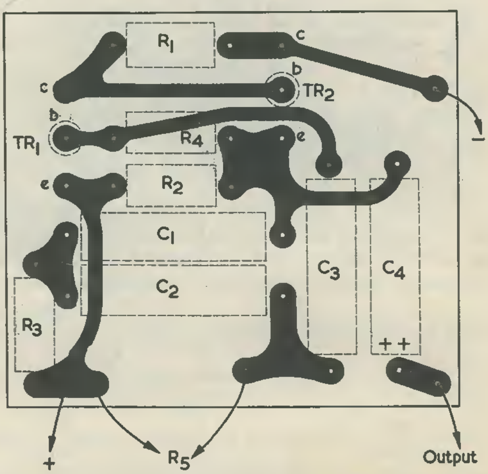



*Fig. 4. A suitable printed circuit layout. This is reproduced full-size, and may be traced*

in $R_5$ of 470Ω will set the frequency to 400 c/s. With regard to $C_4$, the output coupling capacitor, this can have one of two values depending upon the application of the circuit. If the output is fed into another transistor or into a low impedance, such as is given by a bridge, the value can be 2μF at, say, 12 volts d.c. working. If the output is fed into a high impedance, such as a valve amplifier, a 0.1μF paper capacitor will be satisfactory.

The current consumption of the oscillator at 9 volts is 2.5mA, $TR_1$ drawing 1mA, and $TR_2$ drawing 1.5mA.

Fig. 4 shows a printed circuit layout (full size) for the oscillator, since this type of construction is popular these days.

Fig. 5 shows the relationship between the output voltage from the oscillator and the value of load into which it is working.

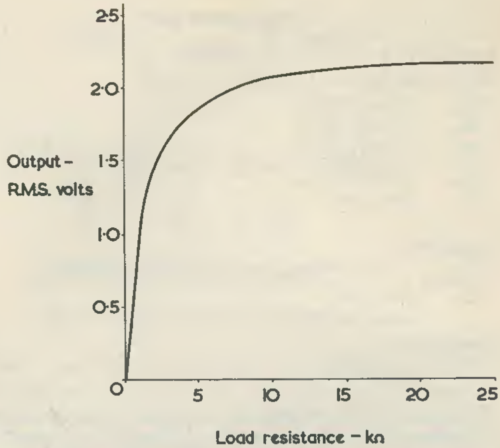



*Fig. 5. Curve showing the relationship between output voltage and load resistance at 400 c/s*

# The Use of Zener Diodes with Voltmeters

## By M. J. DARBY

*Zener diodes can expand or compress part of the scale of a voltmeter. They may also provide overload protection which is quicker-acting than any mechanical device. Suitable circuits for these applications are discussed in this article*

Although it is usually desirable to use voltmeters which have a linear scale starting at zero, it is sometimes very convenient to be able to expand any part of the scale. Alternatively one may wish to "suppress the zero". For example, one may require a meter reading from 8 to 10 volts instead of 0 to 10 volts. The methods by which these requirements may be accomplished with zener diodes will be discussed, and a method will be given in which a zener diode is used to protect the movement of a moving-coil voltmeter against accidental overload.

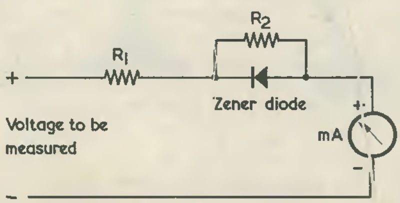



*Fig. 1. Expansion of the upper part of the scale*

### Upper End Expansion

The circuit of Fig. 1 may be used when it is desired to expand the upper end of the scale of a voltmeter whilst still allowing approximate measurements to be made in the lower part of the scale. The nominal voltage of the zener diode should be approximately equal to the voltage at which it is desired to change from a compressed scale to an expanded scale. The value of the resistor $R_1$ is selected so that the full scale deflection of the meter is equal to the desired value, whilst $R_2$ is selected so that the desired amount of lower end compression is attained.

The use of the Fig. 1 circuit will obviously necessitate a specially calibrated meter scale.

### Upper End Compression

The circuit of Fig. 2 may be used to compress the upper end of a meter scale when accurate readings are required over the lower part of the scale and approximate readings over the upper part. As the input voltage increases, almost all of the current flowing will initially pass through the meter. When the potential across the zener diode has reached a certain value, however, it remains almost constant as the current passed by the device increases. Thus, if $R_3$ is fairly small, the potential across the series combination of Z and $R_3$ will only increase slowly as the current passing through these components rises. It is this potential which drives a current through $R_2$

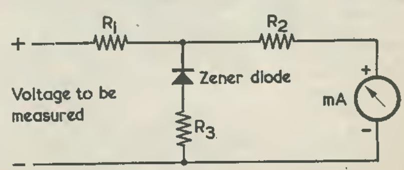



*Fig. 2. Expansion of the lower part of the scale*

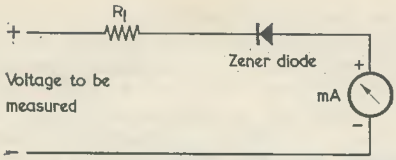



*Fig. 3. "Suppressing" the zero*

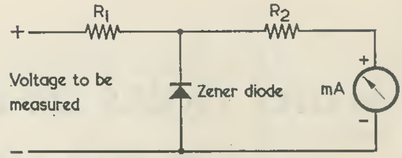



*Fig. 4. A circuit which protects the meter against overload*

and the meter. At input voltages exceeding a certain value, the meter current therefore rises only slowly with further increases of input voltage. The input voltage at which this first occurs will be that which produces a voltage across the zener diode which is equal to the normal operating voltage of this diode, $V_Z$. This input voltage is equal to:

$$\left(\frac{R_1+R_2+M}{R_2+M}\right)V_Z$$

where M is the resistance of the meter.

**Suppressed Zero**

The circuit of Fig. 3 may be employed when it is desired to completely suppress the meter zero. The circuit is the same as that of Fig. 1 except that the resistor $R_2$ of Fig. 1 is omitted. In Fig. 3 the resistor $R_1$ is used to convert the milliammeter into a voltmeter. No appreciable current will flow through the meter until the voltage to be measured exceeds the normal operating voltage of the zener diode.

Let us suppose that we wish to convert a 0–1 milliammeter into a voltmeter reading from 8 to 10 volts. In this case we would use an 8 volt zener diode. At input voltages exceeding 8 volts, the voltage across the zener diode will be equal to 8 volts. Thus the resistor $R_1$ must be chosen so that if it alone were placed in series with the meter, the latter would become a voltmeter reading from 0 to 2 volts. Thus the total circuit resistance required ($R_1$ plus the meter resistance) is equal to 2,000Ω in this particular case.

**Meter Movement Protection**

Zener diodes can be used to protect the movements of moving-coil meters used as voltmeters against accidental overloads. A typical circuit is shown in Fig. 4. If a large voltage is applied across the input terminals, the zener diode prevents the potential across $R_2$ and the meter from rising above the normal operating potential of the diode. The zener diode can be selected so that it is impossible to obtain a deflection of the meter greater than full scale. However, it is generally advisable to design the circuit so that a maximum deflection of 5 or 10% above the full scale deflection can be obtained, since this greatly improves linearity at the upper end of the scale.

Let us assume that it is required to protect a 0–1 milliammeter which is to be used as a 0–10 voltmeter. The circuit may be designed so that the zener diode conducts when 1.1mA passes through the meter; the current will then never be permitted to exceed this value by any appreciable amount. The voltage $V_Z$ at which the diode conducts is given by the following equation (which is obtained by applying Ohm's Law to the right hand part of the circuit):

$$(R_2+M)\,(1.1\times10^{-3})=V_Z$$

M is the meter resistance. A zener diode with a working voltage of 7 or 8 volts is suitable for this application. If $V_Z$=7 volts, $R_2$+M should be 6.3kΩ; hence $R_2$ may be found if the meter resistance is known.

The value of $R_1$ can be found from the following equation which is the normal one used for converting a milliammeter into a voltmeter (except that there are two external resistors instead of one):

$$(R_1+R_2+M)=\frac{10}{10^{-3}}$$

The quantities on the right hand side of this expression are derived from the fact that a full scale deflection of 10 volts is required when 1mA ($=10^{-3}$ amp) passes through the meter.

This simple circuit can provide full meter protection which operates much more quickly than mechanical devices.

**Conclusion**

The small size and long life of zener diodes make them ideal devices for incorporating into the cases of meters. By the use of suitable circuitry almost any part of the scale can be expanded or compressed and moving coil meters can be protected. It should be noted that the circuits given apply only to voltmeters.

## SOLID-STATE STABILISED POWER SUPPLY

A fully enclosed, solid-state stabilised power supply, which operates from mains supplies and gives an output with very low ripple, is now available from EMI Electronics Ltd.

Unit Type 845 operates from mains voltages of 100 to 140 or 200 to 240 at frequencies from 50 c/s to 60 c/s. It makes available a stabilised d.c. output of 20V at 500mA for supplying EMI transistor sound modules and other similar equipment.

On the front panel is an aperture which permits access to a pre-set voltage control, and two sockets at which the output potential can be measured.

Locating spigots at the rear of the unit prevent incorrect engagement of the connecting plug. The unit can be mounted in the Rack Mounting Frame Type 187 or a similar frame.

Height of the unit is 3.5in (8.9cm), width 2.12in (5.4cm), depth 9.5in (24.1cm). Weight is 2lb 8oz (1.13kg).

# Further Notes on the "CRYSTARLET"

By SIR JOHN HOLDER, Bt.

*The final chapter in the Crystella/Crystarlet Saga. Many readers have obtained excellent results with these crystal-controlled f.m. tuners and their designer now lists several modifications which will enable the "Crystarlet" (and in some cases the "Crystella") to peak performance under certain reception conditions. Also described are home-constructed i.f. coils and a home-constructed discriminator transformer*

THE "CRYSTARLET"[1] WAS DESIGNED WITH EASE OF adjustment and low cost in mind and, for a "little 'un" it was very successful; but the author has always felt that there would be readers who would want to "de-compromise" it and go for ultimate performance. These notes explain how this process can be carried out. It involves the substitution of alternative components which require individual adjustment; but this is rendered easier if they are installed, one at a time, in a "Crystarlet" which is already in working order.

[1]Sir John Holder, "The 'Crystarlet' Crystal-Controlled F.M. Tuner", *The Radio Constructor*, February and March, 1965. Further information is also given in "The 'Crystella' F.M. Tuner", February and March, 1963; "Notes On The 'Crystella' Tuner", January, 1964; and "A Crystal Controlled Oscillator For F.M.", August and September, 1961. All these are by Sir John Holder.

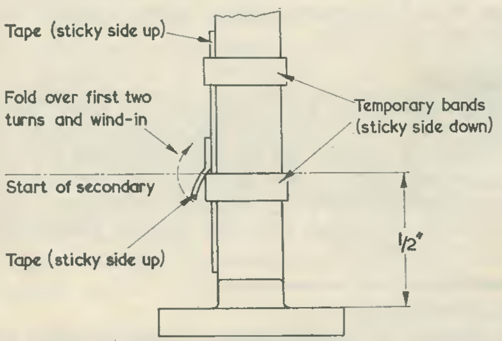



*Fig. 1. How the windings of the home-constructed i.f. transformers are secured. Narrow lengths of sticky p.v.c. tape are employed. The two temporary bands are removed after the coil has been wound, whereupon the ends of the long length of tape may be stuck down on the outside of the winding to give the result shown in Fig. 2. This diagram shows preparations for the secondary winding*

## Change of Limiter

For the reader who lives in a region of powerful signal strength, little more is involved than a change to the type of limiter which was used in the "Crystella", and an alteration of the detector to a phase discriminator. These two modifications together afford considerably greater audio output, with less distortion. If the reader lives further away from the transmitter, it may be necessary to look for more i.f. gain, because, unlike the ratio detector, the phase discriminator must have a powerful signal free of amplitude modulation, and this involves the use of a full-limiter which, in turn, must be fed with a powerful input if it is to be effective. Fortunately, the i.f. gain can be considerably increased by using one or more home-constructed transformers which will be described.

The i.f. transformers originally specified have relatively large tuning capacitors which, amongst other things, confer the advantage that little or no departure from factory adjustment is needed. Raising the L/C ratio has the effect of raising the operating-Q at the expense of the no-adjustment feature; but it can also materially increase the stage gain.[2]

The range, output and freedom from distortion of the fully modified "Crystarlet" are remarkable; and some idea of what will actually be needed in any given locality can be gained by noting what value has to be used for $R_{17}$ of the standard limiter. If 33kΩ can be used, there may be sufficient signal there already, or a change from a picture-rail dipole to a good 3-element loft aerial may do the trick, and so on; but the best guide is to fit the "Crystella"

[2] It should be pointed out that the alternative home-constructed i.f. transformers will very probably have a sharper response curve than those they replace and, whilst this is, of course, acceptable with a crystal-controlled receiver, it could make tuning difficult and subject to what would normally be negligible amounts of oscillator drift in a manually-tuned receiver.—EDITOR.

type limiter (as is described later) and see what happens. If, having done this, the ratio detector still functions satisfactorily, the phase discriminator will be better still. It should be noted that the anode resistor, $R_{17}$, should always be 47kΩ for the "Crystella" type limiter.

If, for any reason, a fully-modified "Crystarlet" is to be used in a region of powerful signal strength, it should be fitted with automatic gain control. With an f.m. signal, this will have no effect on audio output, but it will prevent possible damage to the diodes through overloading. If the tuner is to be operated in a region where there is only just sufficient signal, there is no need to fit a.g.c. (Nevertheless, if it *is* fitted it will do no harm, because the limiter modification makes it possible to use a circuit which has no effect when a weak signal is being received.)

One or two other minor modifications will also be described and, for the sake of completeness, a home-constructed phase discriminator transformer. This means that every coil in the tuner can be home-constructed.

### Improved Heater Filtering and Increased Bass

There are two modifications from which all "Crystarlets" and "Crystellas" will benefit. The problem of i.f. harmonic feedback causing instability was mentioned in the original articles. It has been found that the heater connections to the limiter valve are extra "hot" in this respect. The cure is close-up filtering, so $L_8$ and $L_9$ should be transferred to positions directly on top of pins 4 and 5 of $V_4$ (of the "Crystarlet"). $C_{24}$ should also be transferred to connect between pins 5 and 6 of $V_4$. This leaves the external heater leads of the tuner in a "hot" condition; but it can be removed by transferring $C_{22}$ so as to connect between pins 4 and 1 of $V_3$, also $C_{23}$ to connect between pins 5 and 9 of $V_3$. These capacitors may straddle the $V_3$ valveholder. $V_5$ of the "Crystella" can be treated in a similar manner, using "Crystarlet" type chokes.

Compact 0.22μF paper capacitors are now available and substituting one of these for $C_{20}$ may give slight bass improvement.

### "Crystella" Type Limiter

Provided sufficient signal is available, the change from the standard "Crystarlet" limiter to a full-limiter is very simple. Fit a 47kΩ 1 watt resistor in the $R_{17}$ position, remove bias resistor $R_{24}$, capacitor $C_{27}$ and connect pin 3 of $V_4$ directly to chassis via the valveholder spigot. Remove the EF89 valve and substitute an EF80. The grid circuit time-constant must also be halved by changing $C_{26}$ to 47pF. Provide "Test Point 1" by temporarily connecting a 100kΩ resistor to pin 1 of $L_6$. The cores of $L_6$ should now be checked, in order to see that a B.B.C. signal gives maximum negative voltage with respect to chassis at "Test Point 1" (which is the free end of the 100kΩ resistor).

### Higher-Q. I.F. Transformers

The materials required for the home-constructed i.f. transformers are Bakelite formers 2.4in long

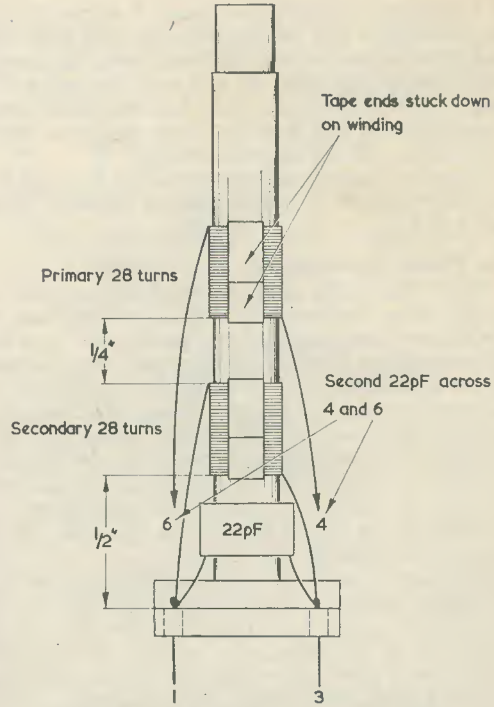



*Fig. 2. The completed i.f. transformer. Both windings are wound in the same direction. A second 22pF capacitor (not shown) connects across terminals 4 and 6*

(Denco Ref.: 5000B/4 or /6E) with screening cans to suit and v.h.f. iron dust cores, Denfix polystyrene solution and a supply of 38 s.w.g. d.s.c. copper wire.[3] The author has successfully wound coils using enamelled wire stripped from an old medium-wave tuning coil; but this is not recommended because it is difficult to see the dark coloured wire against the Bakelite former. All tuning capacitors should be 22pF silver mica (if possible the miniature red types with side connections).[4]

Fig. 1 shows one method of securing the ends of the windings. An advantage of this method is that, if the primary has slipped at all during winding, it can be carefully slid along the former so as to make the separation between windings exactly ¼in. Fig. 2 shows the completed transformer. The secondary should be wound first, starting at the bottom. It will be found easiest to hold the former still and wind the wire round it so that successive turns touch one another. Narrow strips of p.v.c. insulating tape can easily be cut if the tape is temporarily stuck to a piece of glass. Ordinary Sellotape should not be used. The windings should be finally fixed in place

[3] The author obtained the 38 s.w.g. d.s.c. wire from Post Radio Supplies, 33 Bourne Gardens, London, E.4.

[4] A range of silver-mica capacitors with side wires, including 22pF, 33pF, 47pF and 50pF (the latter three values are required for the home-wound or modified discriminator transformer), are listed under Cat. No. C81 by Home Radio (Mitcham) Ltd.—EDITOR.

by a coating of polystyrene dope. It is best to dope the non-taped side of the coil first and wait until it is hard before doping the taped side, because the dope loosens the tape. In this way, the coil will be held in place until the tape has hardened again. The capacitor tags are left long so as to act as connecting pins for the transformer.

If two of these transformers are to be used, it is advisable to add a 100kΩ resistor between pins 1 and 3 of $L_4$.

**The Phase Discriminator**

Fig. 3 shows the phase discriminator circuit, the layout being indicated in Fig. 5. Note that the diodes are now connected in "push-push" and that the connection between primary and the mid-point of the secondary is via a capacitor, instead of via the small tertiary winding. Being coupled, as it were, to one side of the circuit instead of to a neutral point, the external connections are "hotter", as regards i.f. feedback than in the case of the ratio detector. Trouble from this course can be prevented by keeping the wiring as short as possible and the components close to the chassis.

There is no need to buy a transformer, because the ratio detector transformer specified for the "Crystarlet" can be converted by the simple expedient of removing the tertiary winding (the small one wound over the top of the primary), removing sufficient turns from the top of the primary to leave a total of 20 turns (count them, using a needle and a magnifying glass), altering the primary tuning capacitance to 33pF and adding a coupling capacitor between pins 2 and 3. The prototype used 50pF mica for this, but 47pF should serve. The two ends of the secondary which were previously connected to the tertiary must be connected to pin 2 and the shortened end of the primary to pin 1. (For pin layout, see $L_7$, Fig. 5.)

The connections of the finished coil are the same as in Fig. 4, except that the secondary winding direction and primary connections are reversed.[5]

This detector has no "Testpoint 2" so, to adjust the primary, it is necessary to throw the secondary slightly out of tune, whereupon a B.B.C. signal will cause a d.c. voltage with respect to chassis to appear at "Testpoint 3". This can be used to peak the primary and it should take place with the slug partially into the coil. If the coil will only peak with the slug in the centre, or between the coils, too much wire has been removed and one or two turns should be re-fitted. After peaking the primary, re-adjust the secondary to give zero volts.

Although there is no "Testpoint 2", we now have a "Testpoint 1" which can be used for any tuning adjustment prior to that of the detector.

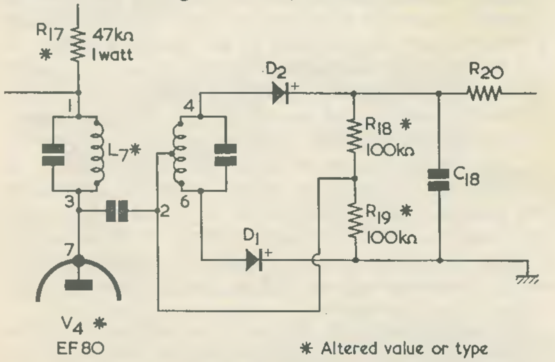



*Fig. 3. The phase discriminator circuit. With this, $C_{15}$, $C_{16}$, $C_{17}$ and $R_{23}$ from the previous "Crystarlet" circuit are omitted*

**Automatic Gain Control**

The recommended a.g.c. circuit is shown in Fig. 6. $C_9$ and $C_{9A}$ should be carried on two additional two-tag tagstrips, with one tag of each strip earthed. Mount these under the left-hand fixing bolts of $L_4$ and $L_6$ ($S_1$ towards reader). The strips should be positioned so that the non-earthy tag is towards the front of the chassis. $R_{14A}$ is connected between the two non-earthy tags, with its body close to the rear one. The long connection from this resistor to the front non-earthy tag should be covered with sleeving.

[5] It must be pointed out that changes in production design can occur with manufactured coils and that there is, in consequence, some risk that the modification just described might not always be fully effective. An alternative approach would consist of employing the home-constructed phase discriminator transformer shown in Fig. 4.—EDITOR.

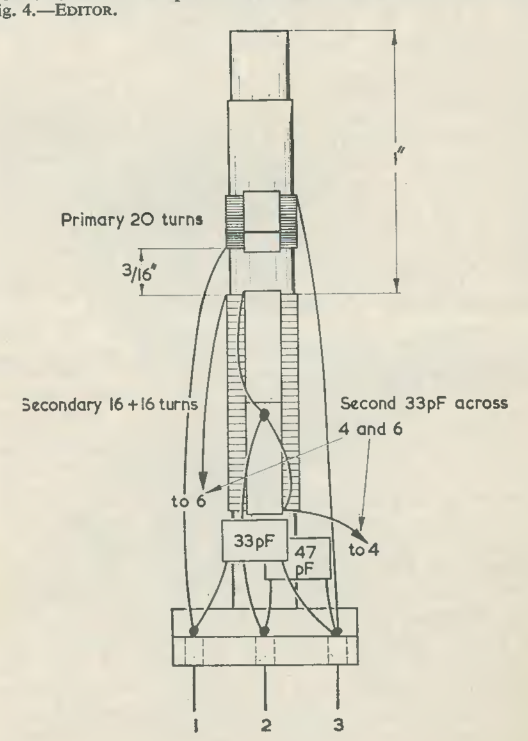



*Fig. 4. The home-wound phase discriminator transformer. Primary and secondary are wound in opposite directions. A second 33pF capacitor (not shown) connects across the secondary at terminals 4 and 6*

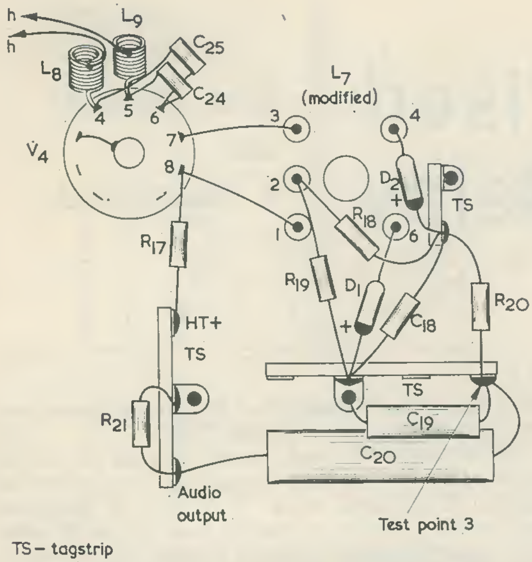



*Fig. 5. Changes resulting from the modified layout around $V_4$ and the phase discriminator transformer*

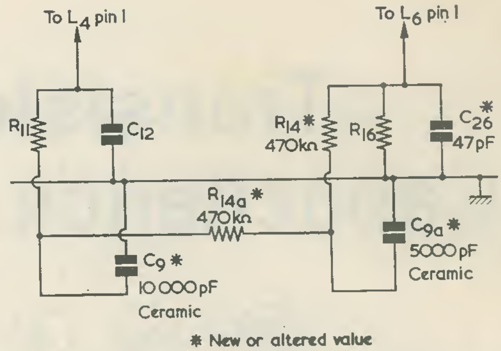



*Fig. 6. The automatic gain control circuit*

### Home-Wound Detector Transformer

A satisfactory home-constructed phase detector transformer can be wound on to a Denco former, type 5000B/6E, using 38 s.w.g. d.s.c. copper wire. Details are shown in Fig. 4. The external connections and pin layout are as shown in Fig. 5. The bifilar secondary is constructed by winding on four wires (turns touching) and removing two after doping, so as to leave two evenly-spaced interleaved windings. Winding should start at the top of the secondaries and it is, in this case, easier to rotate the former. The primary is wound in the ordinary way, except that its direction is opposite to that of the secondaries. When completed, use a continuity tester to find the start of one secondary and the end of the other. Solder these together and connect them to pin 2. The chassis holes will need slight alteration. Adjustment is by the same method as that just described for the converted transformer, except that it is first necessary to find the secondary null. Audio sound from the loudspeaker is an additional guide. The performance is about equal to that of the converted transformer; but it has the added attraction that it enables the constructor to say "all my own work"!

### Note—Partition Screen

In Fig. 7 (*b*) of the "Crystarlet" article (page 543, March 1965 issue) a "bend down" line should be added to the partition screen ⅜in above, and parallel with, the bottom of the plate. The fact that the screen should be bent along this line is, however, fairly obvious from its dimensions.

# 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*

**109 Receiver.**—R. Crisp, 55 Longman Road, Barnsley, Yorks.—circuit and Part 2 of manual. Also details of conversion from 6 volts to a.c. mains operation.

* * *

**P104 or P38.**—F. H. Hicowe, P.O. Box 15, Sorrento, Victoria, Australia—handbook or circuit and components list or photostats.

* * *

**I.F. Amplifier Unit Type 600.**—C. Hall, 90 Edmund Road, Birmingham 8—circuit diagram of this unit (A.M. ref. 1OU/16861, 15.25 Mc/s).

* * *

**TV Conversion for Dx.**—D. Bowers, 95 Grenfell Avenue, Saltash, Cornwall—borrow or buy any copy of *The Radio Constructor* with details of conversion of TV set for reception of TV Dx.

* * *

**Wavemeter SLC No. 1.**—R. W. Jones, 24 Forest Avenue, Foresthall, Newcastle-upon-Tyne—would welcome any information on this unit.

* * *

**AVO.1 LC and R Bridge Tester.**—R. Wilson, 38 Pakefield Road, Kings Norton, Birmingham 30—purchase of manual.

* * *

**Telefunken Tape Recorder Model KL65**—Dr. B. B. Rafter, 18 South Road, Oundle, Peterborough—loan or purchase service sheet or circuit diagram.

# Transistorised Capacitance Relay

By A. FRASER and R. MARSHALL

The authors are interested in the "gadgets" side of electronics as well as in the more customary projects. One of the most interesting gadgets is the capacitance relay. This is a device that operates a relay when a hand approaches a metal plate, and may be used for automatic ringing of doorbells or many other applications. There are a number of circuits for valve operated capacitance relays, but neither of the authors has seen a circuit for a transistorised one.

## Circuit

The circuit of such a device can be broken up into two sections:

(1) The r.f. oscillator.

(2) The relay amplifier.

In the accompanying circuit diagram, the oscillator output is rectified and is applied to the relay amplifier. Since it is rectified to give a positive voltage at the base of $TR_2$, it holds the relay off as the amplifier will not conduct. However, if the output from the oscillator is cut off (this is done by the extra capacitance to earth given by the proximity of a hand at the sensing plate) the bias on the amplifier goes negative, causing the amplifier to conduct and the relay to close.

In the circuit diagram, $TR_1$ appears in a form of the Colpitts oscillator circuit. In the prototype a Wearite PA2 coil was used. This is a medium wave component and it might be better to use a Wearite PA1—the long wave equivalent. The latter would stop the oscillator radiating on the medium wave band and causing unwanted interference. However, radiation would be negligible if the oscillator were mounted close to the plate.

The transistor used in the $TR_1$ position in the prototype was a Mullard OC171, although any r.f. transistor would be suitable. The diode $D_1$ may be any germanium diode.

## Relay Amplifier

The relay amplifier is quite simple and a surplus relay was used in the prototype. The transistors must be fairly good quality types. Surplus transistors were tried in the $TR_2$, $TR_3$ and $TR_4$ positions, but were replaced by Mullard OC77's as the relay was inclined to pull in without any triggering bias due to the "leakiness" of the surplus transistors. OC71's should suit admirably.*

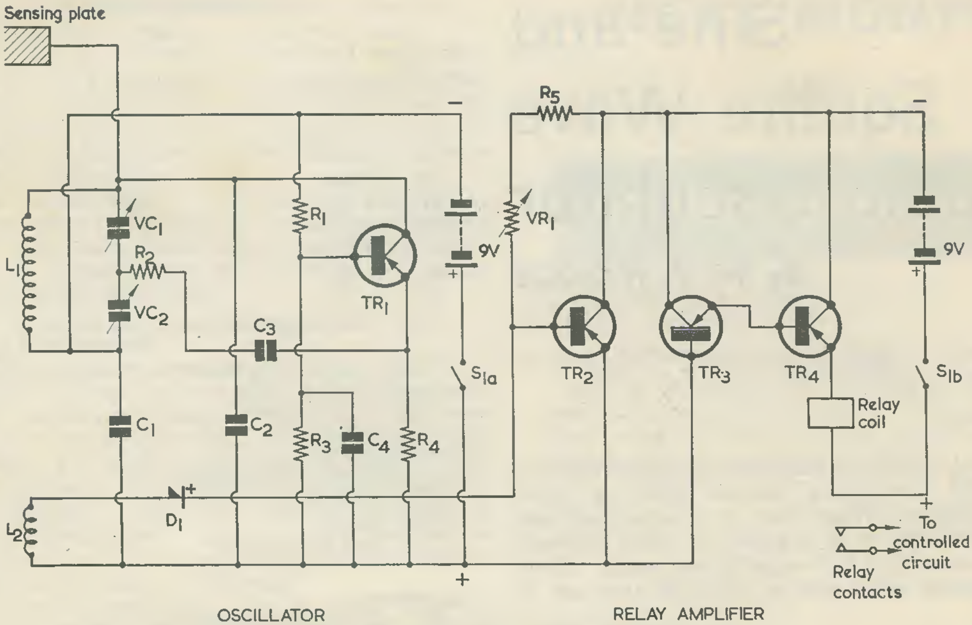
No attempt was made to miniaturise the device as it was desired to keep the cost as low as possible, all the components being "in stock". It would no doubt be possible to make quite a small unit, the largest components being the coil and the relay. The dimensions of the case used in the authors' prototype were 7 x 7 x 3¾in. This provided plenty of room to work in, and permitted the use of fairly large batteries, in case the unit was to be used for long periods. It should be noted that *two* batteries are necessary. The current drain is not very great and if a miniature unit was required, smaller batteries could be used.

## Construction

The circuit was built as two separate units, the r.f. oscillator and the relay amplifier. Both were built on small pieces of Perspex, the relay being mounted by means of a couple of Terry clips. The controls can be mounted on the front of the case. On the authors' model a wander-plug socket was provided for the lead from the sensing plate. Another improvement would be to line the front panel with tin-foil, as this would limit hand capacitance effects when the controls were adjusted. The tin-foil could then be earthed to the positive line of the oscillator circuit. Care would have to be taken in the mounting of $VC_2$ to ensure that it was insulated from the tin-foil.

The function of $VC_1$ is "rough" control of the oscillator output, while $VC_2$ is used for "fine" control. For this reason it is advisable to fit a slow-motion drive to $VC_2$. $VR_1$ is used to adjust the negative bias on the base of $TR_2$. This causes the relay to pull in when the positive bias from the oscillator is cut off.

* If an OC71 is employed in the $TR_4$ position, relay coil current is limited to a maximum of 10mA only. The writers state that they found that a surplus P.O. relay with a 1,000Ω coil worked satisfactorily in the circuit, and this would meet the 10mA requirement. A transistor capable of passing a heavier current might be preferable for $TR_4$, and an OC72 would for instance enable much higher relay energising currents to be obtained. It may be added that a non-surplus relay having an energising voltage of 7 to 9 and a coil resistance of 670Ω is the Cat. No. Z70B from Home Radio (Mitcham) Ltd. This would draw 13mA at 9 volts and therefore requires a transistor having a lightly higher collector current rating [illegible] he OC71. EDITOR.




*The circuit of the transistorised capacitance relay*

**Components List**

*Resistors*
(All fixed values ¼ watt 20%)
- $R_1$ 4.7kΩ
- $R_2$ 470Ω
- $R_3$ 1kΩ
- $R_4$ 1kΩ
- $R_5$ 100kΩ
- $VR_1$ 500kΩ, potentiometer, linear track

*Capacitors*
- $C_1$ 0.1μF paper
- $C_2$ 100pF silver-mica
- $C_3$ 0.1μF
- $C_4$ 0.1μF
- $VC_1$ 800pF compression trimmer
- $VC_2$ 150pF air-spaced panel-mounting trimmer. Type C.804 (Jackson Bros.)

*Inductors*
- $L_{1,2}$ Type PA2 coil (Wearite); $L_1$ tuned winding, $L_2$ coupling winding

*Semiconductors*
- $D_1$ Any germanium diode
- $TR_1$ OC171 (see text)
- $TR_2$ OC71
- $TR_3$ OC71
- $TR_4$ OC71 (see text)

*Switch*
- $S_1$, (a), (b) d.p.s.t. on-off switch

*Relay*
- Surplus relay (see text)

*Batteries*
- 2 9-volt batteries

*Drive*
- Epicyclic slow motion drive (for $VC_2$)

The layout of the unit is not critical.

The sensitivity depends on the size of the capacitance plate and on the adjustment of the controls, this being quite critical. A suggested way of tuning the unit would be to advance $VR_1$ (i.e. decrease its resistance) until the relay just pulled in. Next decrease the capacitance of $VC_1$ until the relay de-energises and adjust $VC_2$ to the most sensitive point.

No detailed constructional information is given since it is thought that the experienced constructor will wish to build it in a form to suit his own needs. Also, with units of this kind, it is sometimes desirable to fit it into the piece of equipment which it is to operate.

# Sine and Square Wave Audio Oscillator

## By W. V. WOODS

*This simple circuit gives low-distortion sine or square waves at the touch of a switch*

THE UNIT TO BE DESCRIBED HAS PROVED EXTREMELY useful for testing various types of audio amplifiers. When used in conjunction with an oscilloscope it is possible to trace different types of distortion both quickly and easily. There are numerous other uses to which the unit can be put.

### The Circuit

In the circuit diagram $V_1$, a 6C4, is employed as the sine wave oscillator. The frequency of oscillation should be approximately 1 kc/s, this depending on the exact characteristics of the transformer used in the $T_1$ position. $T_1$ may be any small intervalve coupling transformer, the component employed by the writer having been taken from an ex-disposals amplifier. If necessary, the desired frequency can be obtained by connecting a small capacitor across one of the transformer windings.

### Components List

*Resistors*
(All fixed resistors are ½ watt 10%)

| | |
|---|---|
| $R_1$ | 47kΩ |
| $R_2$ | 4.7kΩ |
| $R_3$ | 100kΩ |
| $R_4$ | 1MΩ |
| $R_5$ | 47kΩ |
| $R_6$ | 220kΩ |
| $R_7$ | 33kΩ |
| $R_8$ | 1.8kΩ |
| *$R_9$ | 18kΩ |
| $VR_1$ | 500kΩ potentiometer, log track |

* *May need adjustment for varying h.t. supply voltages.*

*Capacitors*
(All capacitors 350V wkg.)

| | |
|---|---|
| $C_{1,2}$ | 0.01μF |
| $C_{3,4}$ | 0.1μF |
| $C_5$ | 8μF electrolytic |

*Transformer*

$T_1$ Intervalve transformer (see text)

*Valves*

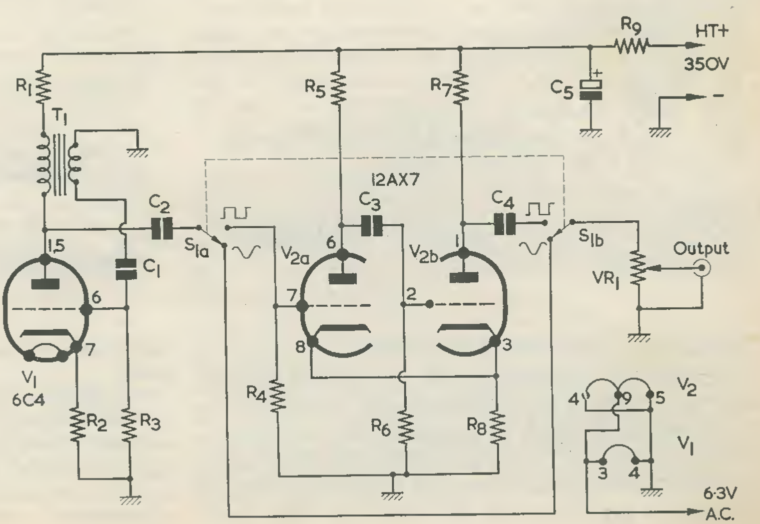
| | |
|---|---|
| $V_1$ | 6C4 |
| $V_2$ | 12AX7 |

*Switch*

$S_{1(a),(b)}$ d.p.d.t. switch

*Sockets*

1 B7G valveholder
1 B9A valveholder
1 Coaxial output socket




*The circuit of the sine/square wave oscillator. $T_1$ may be a 1:3 to 1:5 intervalve transformer, with the winding having the larger inductance in the anode circuit of $V_1$. The correct tone may then be obtained experimentally by connecting a fixed capacitor (having a value between 100pF and 0.01μF) across one of the windings. If it is difficult to obtain reliable oscillation, reverse $T_1$ so that the winding with the larger inductance is in the grid circuit of $V_1$*

$R_2$ is included to limit the anode current of $V_1$. Its inclusion also ensures a cleaner waveform.

The square wave output is achieved by feeding the sine wave from $V_1$ into the clipper circuit given by $V_{2(a)}$ and $V_{2(b)}$. These two triodes are greatly over-driven and, with the positive feedback between the two cathodes, produce a square wave output at the anode of $V_{2(b)}$.

The switch sections $S_{1(a)}$ and $S_{1(b)}$ select either sine or square wave output as desired, and potentiometer $VR_1$ serves as an output attenuator. Both sine and square waves are extremely clean when viewed on an oscilloscope.

**Power Requirements**

H.T. and heater requirements for the unit are very low, and can, in most cases, be taken from the main oscilloscope supply. The circuit will work with any voltage (across $C_5$) between 175 and 300, although the output will decrease slightly with lower voltages. The value of $R_9$ (which is suitable for a 350 volt supply) may have to be altered to suit different supply voltages. H.T. current is only 5mA with 350 volts applied. Heater requirements are 6.3 volts at 0.45 amps.

Alternative valve types can be tried. For $V_1$, a 6J5, or ½12AU7 or ½6SN7 may be used without any circuit changes. Similarly, a 6SL7, or two 6AT6's or 6AV6's may be tried in the $V_2$ position. Types such as the 12AU7 and 12AT7 have been checked for $V_2$, but a sloping of the square wave occurred with these valves.

Physical layout is not critical. The original was constructed on an old TV turret tuner chassis, although it has since been re-built on a more suitable chassis.

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# IN

# THE Radio Constructor

**"3 From 1" Short Wave Circuit**

Another ingenious circuit in which one triode-pentode functions as a periodic r.f. amplifier and triode detector with reaction, after which the pentode section doubles as a reflexed triode output valve. Coverage of the receiver is from 3.5 to 20.6 Mc/s.

* * *

**Photo-Sensitive Switch**

One method of obtaining a swift-acting light controlled switching circuit which operates at a specific illumination level could consist of coupling a phototransistor to a Schmitt trigger. In this article the author takes this idea one stage further by having the phototransistor enter the Schmitt trigger circuit itself!

* * *

**Field Effect Transistors**

The latest important semiconductor device to emerge from development at a price suitable for the pocket of the home experimenter is the field effect transistor. In this article our contributor discusses the exceptionally high input impedance of the F.E.T., together with its operation in typical amplifier circuits.

* * *

**Communication by Modulated Arc Beam**

Our previously published articles on modulated light systems all employed transmitting lamps whose filament current was modulated by the audio signal to be transmitted. A disadvantage with all these systems is the thermal inertia of the filament, which limits the maximum frequency the system can handle. The author has overcome this problem by using an arc lamp as light source, whereupon a maximum frequency of 10 kc/s is capable of being transmitted. Tests with the prototype resulted in clear reception of the modulated beam at a distance of nearly a quarter of a mile in daylight.

# In Your Workshop

*This month Dick and Smithy enter the New Year with rather less than their customary elan. Nevertheless, they are still able to look into the mysteries of transistor dissipation and to devote some time to valve and transistor reflexed amplifiers*

And, now, we are again over the threshold of the New Year. It is the early morning of 1st January and laid out before us are twelve unsullied months, months which are filled with the promise of greater action and achievement, of greater joy and accomplishment and of greater endeavour and consummation. On 1st January we rise anew, like the phoenix, from the ashes of last year's disappointments, to face a New Year replete with glittering expectation and radiant promise.

Thus should it have been with Smithy the Serviceman as, at least half an hour after official starting time on the New Year's Day on which our story commences, he inserts a trembling key into the lock of the Workshop door. As he opens the door and stumbles in, we search for signs of the newly arisen phoenix, to be rewarded only by a wild and bloodshot stare which could, were we to strain credulity to the limit, just conceivably have resulted from too close a contact with the flames.

As our central character shuffles aimlessly about the stage there is a further fumbling at the door. Eventually, this opens, and a second, more youthful, figure staggers in. Again we watch for the phoenix, but all we find is an unkempt disorder which, by the exercise of all our charity, we might just possibly ascribe to the rigours of escape from the pyre. But only just.

Without a word, our two players now break into a shambling *pas de deux*, lurching and pitching about each other as they endeavour to divest themselves of their outer clothing. At last their efforts prove successful and they flounder in unison towards the Workshop door, their faltering hands raising their raincoats towards the coat-hooks affixed thereto. Relieved of their burdens, they weave uncertain paths towards their respective benches, eventually blundering into their stools, on which they sink with manifest relief.

The moments pass, and then the younger of the two gives voice.

**Getting To Grips**

"Corluvaduck," breathed Dick. "What a hell of a New Year's Eve I had last night!"

Smithy winced.

"Must you," he groaned, "shout your head off about it, then?"

Dick grimaced.

"I'm only," he complained, "trying to be chatty. After all, it *is* New Year's Day."

As Smithy raised a trembling hand to his brow, a thought suddenly occurred to his assistant. Reaching down, he opened a drawer in his bench and produced a tube of Alka-Seltzers, after which he went to the Workshop sink, to return with a cup and a tin mug both half-filled with water. Opening the tube he dropped two tablets in each of the utensils, then immediately clapped his hands over his ears.

Smithy had already covered his eyes.

When the tablets had dissolved, Dick lowered his hands, nudged Smithy, and passed the tin mug to him.

"I had to cover my ears," he explained, "it's that deafening hiss they make when you drop them in the water."

"What disturbs me more," replied Smithy, "is their blinding whiteness."

Silently the pair drank.

"Ah," said Smithy after a moment. "Now *that's* better. I feel like a new man already."

"So," said Dick, "do I."

A troubled expression spred over Smithy's face.

"I suppose," he said hesitantly, "we *should* be thinking of doing a bit of work."

"There's nothing to do," replied Dick happily. "We cleared everything out yesterday."

Smithy heaved a loud sigh of relief.

"Thank goodness for that," he remarked. "I didn't get to bed till the early hours this morning and, right now, the idea of stabbing away at a flimsy printed circuit board doesn't appeal to me one little bit."

"Nor me," confirmed Dick. "Besides, I'm a bit worried about something."

"Oh yes," said Smithy, "and what's that?"

"This dissipation business."

Smithy turned a rheumy eye upon his assistant.

"Dissipation?" he repeated. "A young lad like you worrying about dissipation? It's when you get to my age, boy, that you have to start worrying about dissipation!"

Dick threw a helpless glance at the ceiling.

"There are times, Smithy," he remarked, "when I really despair for the future of your generation. The dissipation I'm thinking of is transistor dissipation."

"Oh," said Smithy weakly. "*Transistor* dissipation."

"That's right," confirmed Dick. "What's been puzzling me for ages now is why you get less dissipation if you use a transistor as a switch than when you use it as a normal amplifier. Like, for instance, when you use a transistor as a switch in the output stage of a pulse-width modulated a.f. amplifier."

Smithy collected his thoughts.

"I suppose," he said resignedly, "that if there's no work to do I might as well answer your questions as do anything else. Fortunately, this dissipation business isn't too difficult to explain. We'd better start off with a spot of simple basic."

Smithy settled himself more comfortably on his stool.

"Let's assume," he continued, "that you've got a battery, and you connect across it a fixed resistor and a variable resistor in series. We can take easy figures for voltage and resistance values so let's say that the battery gives 10 volts, that the fixed resistor, which I'll call $R_1$, is 10Ω, and that the variable resistor, which I'll call $R_2$, is 100Ω. Fair enough?"

Dick pulled his notepad towards him and sketched out the circuit that Smithy had described. (Fig. 1.)

"Has the battery," he asked, "any internal resistance?"

"No," replied Smithy. "It has zero internal resistance and the only resistance in circuit is given by the actual resistors $R_1$ and $R_2$. What we must next set out to do is to find the value of $R_2$ which causes maximum power to be dissipated in it. This is rather difficult with simple algebraic equations, so we'll do the next best thing and take numerical examples instead. Let's start off with the case where $R_2$ is set to insert 1Ω in circuit. The total resistance in the circuit is then 11Ω, which means that a current of $^{10}/_{11}$ of an amp flows through the two resistors. Power is given by $I^2R$, so the power dissipated in $R_2$ is $^{10}/_{11}$ squared, multiplied by 1. Which, near as dammit, comes to 0.8 watts. O.K.?"

Distrustfully, Dick scribbled the figures down on his pad.

"You're quite right," he said, after a moment. "That's what I get, too."

"Good," said Smithy. "Now let's put $R_2$ up to 100Ω. This time the total resistance in circuit is 110Ω, so that the current from the battery becomes $^{10}/_{110}$ of an amp. The power in $R_2$ is now $^{10}/_{100}$ squared, multiplied by 100. If you work it out, you'll find that *that* is about 0.8 watts, too."

Dick once more returned to his pad.

"You're right again" he said. "It comes out to the same figure as before."

"Right-ho," said Smithy, now firmly launched on his explanation. "The next step consists of setting $R_2$ so that it inserts 10Ω into circuit, and therefore becomes equal to $R_1$. The total resistance in the circuit is now 20Ω, with the result that the current is 0.5 amps. The power in $R_2$ is, therefore, 0.5 squared times 10 which is equal to 2.5 watts. And that's quite a bit higher than the 0.8 watts dissipated in $R_2$ when it's set to 1Ω or 100Ω. If we carry on by making $R_2$ equal to 9Ω, the total resistance becomes 19Ω, the current becomes $^{10}/_{19}$ amp, whereupon the power in $R_2$ is $^{10}/_{19}$ squared, multiplied by 9. What does that come to?"

An agonised frown spread over Dick's brow as he worked on the figures.

"It comes," he announced eventually, "to 2.49 watts."

"Right," said Smithy. "Let's make $R_2$ equal to 11Ω. The total resistance then becomes 21Ω, the current becomes $^{10}/_{21}$ amp, and the power dissipated by $R_2$ becomes $^{10}/_{21}$ squared times 11. Could you oblige?"

Dick's agonised frown deepened as he applied himself to this new calculation.

"Here we are," he remarked triumphantly after some moments. "It's 2·49 watts again."

"Good show," commented Smithy. "Let's sum up what we've done up to now. We've taken values for $R_2$ of 1Ω, 100Ω, 10Ω, 9Ω, and 11Ω, and we've found that the value for $R_2$ which causes greatest power to be dissipated in it is 10Ω. At resistances in $R_2$ close to 10Ω the power is just below the power at 10Ω, and at resistances far removed from 10Ω the power is considerably lower than that for 10Ω. There's nothing to stop you calculating the power dissipated in $R_2$ for other values of resistance but, whatever figure other than 10Ω you choose, you'll always find that the dissipation is lower than that at 10Ω. If we take this statement a stage further, we can say that, whatever the value of $R_1$, greatest dissipation occurs in $R_2$ when it is equal to $R_1$."

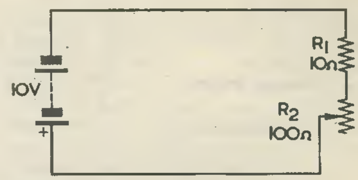



*Fig. 1. A circuit in which a battery having zero internal resistance is connected to a fixed resistor and a variable resistor in series. Maximum power is dissipated in $R_2$ when the resistance it inserts into circuit is equal to $R_1$*

"I've followed all this up to now," said Dick, "but where do transistors come in?"

"They come in at this very moment," replied Smithy. "What we next do is to replace $R_2$ by a transistor connected in the earthed emitter mode, whereupon $R_1$ becomes its collector load. (Fig. 2.) The power dissipated in this transistor is well-nigh equal to collector current multiplied by the voltage between collector and emitter. If collector current is such that the emitter-collector voltage is half the supply voltage, then equal voltages are dropped across the load resistor and the transistor. The effective resistance of the transistor is then the same as the load resistor and so it suffers maximum dissipation."

"Oh, I see," said Dick. "What this means is that you get maximum cooking effect in the transistor when half the supply voltage appears across it."

"You've got it," confirmed Smithy. "Now, if you next assume that transistor base current is raised until the transistor bottoms and becomes fully conductive, very little voltage will appear across it and it will exhibit a low effective resistance.

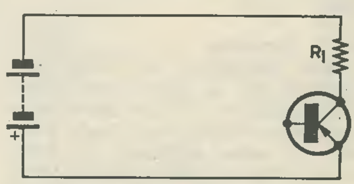



*Fig. 2. If $R_2$ is replaced by a transistor it follows that maximum dissipation occurs in the transistor when half the supply voltage appears across it*

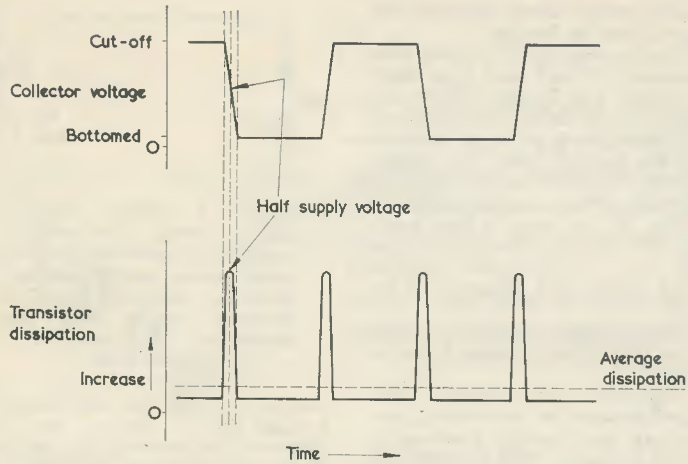



*Fig. 3. When a square wave is applied to the base of an earthed emitter transistor causing it to be alternately cut-off and bottomed its collector voltage may take up the waveform shown here. Transistor dissipation reaches maximum at the half supply voltage points during the transition from cut-off to the bottomed state and vice versa. (It is assumed here that dissipation levels for the cut-off and bottomed conditions are equal. In practice these dissipations, whilst low, will normally be dissimilar)*

The effect is similar to that when we made $R_2$ equal to 1Ω, and the dissipation in the transistor becomes considerably less than the figure given for half supply voltage working. If, alternatively, we reduce base current until the transistor is cut-off, then practically all the supply voltage will appear across it and it will exhibit a high effective resistance. As occurred when we increased $R_2$ to 100Ω, the power dissipated in the transistor becomes considerably less than is given when half the supply voltage appears across it. In practical circuits the ratios of effective transistor resistances for the bottomed, the half supply voltage and fully cut-off states will be a lot wider than the simple 1:10:100 figures I've used for explanation. Which means that dissipation at bottoming and cut-off will be a lot lower again than is indicated by the figures I quoted in the resistance example for 1Ω and 100Ω."

## Quick Transition

"I'm beginning to understand what all this is about now," said Dick, excitedly. "If you use a transistor as a switch you arrange it so that it's either bottomed or fully cut-off. And in both instances it will only dissipate a small amount of power."

"That's right," confirmed Smithy. "Don't forget, of course, that you've got to change the transistor from the bottomed to the cut-off condition, or vice versa, when a change in switching is required. If the transition from one condition to the other is made very quickly, the transistor passes through the half supply voltage point where maximum dissipation takes place in a very short space of time, so that average dissipation is only slightly higher than the low figures given for bottoming and cut-off. In a pulse-width modulated amplifier, the output transistors are switched continually from bottoming to cut-off and back again, because what is very nearly a square wave is applied to their bases. In consequence, they spend nearly all their time either at bottoming or at cut-off, and only a relatively short time passing through the high dissipation half-voltage state. (Fig. 3.) The average dissipation is, therefore, relatively low."

"It seems to me," said Dick thoughtfully, "that transistors are more useful as switches than as ordinary amplifiers where they're mid-way between bottoming and cut-off."

"I wouldn't go so far as to say that," replied Smithy cautiously, "but it's certainly true to say that the transistor forms an excellent switch for computer work and similar applications. This half supply voltage business doesn't, by the way, apply only to transistors. If, for instance, you're knocking up a circuit using a phototransistor, such as the OCP71, or a photoconductive cell, such as the ORP12, you're almost bound to connect it to a d.c. supply in series with a resistor, or in series with a component having resistance such as a relay coil. (Fig. 4 (*a*).) Varying light intensities then cause different voltages to appear across the resistor. In a circuit of this type you should always give values to the supply voltage and series resistance which ensure that the dissipation in the phototransistor or photoconductive cell at half-supply voltage is less than the maximum figure specified by the manufacturer."

"But," asked Dick, puzzled, "won't that involve a lot of experimental work?"

"How d'you mean?"

"Well," replied Dick, "you'd have to experimentally illuminate the phototransistor or photoconductive cell so that just half the supply voltage appeared across it, then measure the current which flowed through it."

This time, it was Smithy's turn to direct a helpless glance at the ceiling.

"If," he said despairingly, "this is a sample of what life is to be like in the New Year, I'd prefer to go back to the old one."

"Come off it," said Dick, incensed at Smithy's reaction. "There's no need to be like that. It was a perfectly straightforward question."

"I suppose it was," replied Smithy resignedly. "Although, if you'd listened properly to what I've been saying, you wouldn't have had to ask it. Anyway, let's take an example. Let's assume that we have an ORP12 in series with a 25kΩ resistor and with an applied voltage of 50." (Fig. 4 (*b*).)

"Okey-doke," said Dick obligingly. "Let's assume that."

"What," asked Smithy, "will be the effective resistance of the ORP12 when half the supply voltage appears across it?"

"That's what I meant just now," said Dick. "You'd have to illuminate it to find out."

"You great roaring twit," exploded Smithy. "You'd have to do nothing of the sort! haven't we just been saying, when we were talking about transistors, that half the supply voltage appears across the transistor when it has the same effective resistance as its load?"

"I suppose so," replied Dick uncertainly.

"The same thing," continued Smithy, glaring irately at his assistant, "applies to the ORP12. Which means that, at half the supply voltage, the resistance of the ORP12 will be 25kΩ"

Smithy paused.

"Doesn't it?" he asked belligerently."

"Yes," replied Dick unhappily. "I suppose it does."

"So what," went on Smithy, "is the power dissipation?"

"Well," said Dick hastily, "it will be the power given by 25 volts across 25kΩ. Which, from $\frac{E^2}{R}$, is 25 squared over 25. Why, it's 25 watts!"

"Watts?"

"25 watts."

"*Watts*?"

"Dash it all, Smithy," said Dick. "Don't keep saying 'what' all the time."

"I didn't *say* 'what'," snarled Smithy. "I said 'watts'."

"Oh, I'm sorry," replied Dick. "But why 'watts'?"

"Why what?"

"Why 'watts'?"

"Why 'watts'?" repeated Smithy. "Because the answer should be in *milliwatts*, that's why. The dissipation in the ORP12 is 25 milliwatts, and this is its maximum possible dissipation in the circuit because it occurs at half supply voltage. Also, incidentally, it's well below the maker's maximum figure of 200 milliwatts at 40°C. And how I've managed to remember *that* after what must have been the most asinine bit of conversation that's ever taken place in this Workshop I'm darned if I know!"

Smithy fell silent and brooded over his grievances.

"I've got an idea," said Dick suddenly.

Smithy grunted.

"How about," continued Dick brightly, "getting the old kettle on for tea?"

The mention of the life-giving liquid brought about an immediate change in Smithy's expression, and there was a perceptible softening in his voice as he replied.

"Now, *that*," he remarked, "is the first sensible thing you've said this year!"

As Dick busied himself at the sink, the accustomed clatter of the variegated utensils was patently music to the Serviceman's ears and, when his assistant deposited a steaming hot mug on his bench, it was obvious that he had almost returned to his usual self.

"Ah," he said with great satisfaction, as he drank the first of the fluid from his disgraceful tin mug, "that's what I've been wanting ever since I got here!"

"What time," queried Dick, "did you get to bed this morning?"

"I don't," replied Smithy cautiously, "actually remember *going* to bed. Nevertheless, I think it would be safe to say that I retired very shortly after three twenty-three."

"If you don't remember getting into bed," asked Dick, puzzled, "how on earth can you be so exact about the time?"

"It's the time," explained Smithy, "which the alarm clock hands were pointing at when I picked the pieces up from the hall floor this morning."

"But don't you keep the alarm clock up in your bedroom?"

"Yes," replied Smithy.

The Serviceman took a further draught from his mug.

"What time," he asked, "did *you* get into bed?"

"Earlier than that," said Dick, "about half-past one or thereabouts. I needed to, after all the social drinking I'd had to go through because it was New Year's Eve."

"Social drinking?" queried Smithy, casting a censorial glance at Dick.

"Yes," said Dick, with a wry face. "We had a folk session down at Joe's Caff and I must have got through at least twelve pints of that coffee of his before I left. My insides must be like mahogany at the time being."

"I thought Joe's Caff was a Chinese Restaurant these days."

"Not now," said Dick. "When the folk-song business got going he changed it all round again. Nowadays, he dishes up the nosh wearing a Donovan cap, and he's altered the name to 'The Pallid Ballad'."

"Dear me," said Smithy. "Quite like the old days."

"Isn't it?" agreed Dick enthusiastically. "Last night we had our Monster New Year's Eve Folk Song Composing Contest. Smashing, it was."

"Did you win a prize?"

Dick's face fell.

"No such luck," he grumbled. "My entry was disqualified on three counts. First of all, I didn't put enough 'uh-huh's' in. Secondly, they found that one of the lines scanned. And, thirdly, there was a distinct hint of two line-ends rhyming halfway through the second verse. You know, Smithy, these folk-songs are jolly difficult to compose."

"I should imagine they are," replied Smithy sympathetically.

A frown appeared on Dick's brow.

"I've just remembered," he remarked. "There's another thing that's worrying me as well."

"What's that?"

"This reflex business."

"I'm not surprised," said Smithy mildly. "If you absorb a gallon and a half of coffee in one evening it would be doubtful if you *had* any reflexes left."

"Dash it all, Smithy," expostulated Dick. "You're not half non-electronically orientated this morning. I mean reflex *circuits*!"

"In radio sets?"

"That's right."

"Well," said Smithy, "there's nothing very complicated about them. A reflex stage in a receiver is one which amplifies the same signal twice, the signal having been changed in some way before it is re-applied. A *possible* example of a reflex amplifier in a superhet could be a valve or transistor which amplifies the r.f. signal as received on the aerial as well as the i.f. signal which appears after the frequency-changer. In practice, however, this is not an attractive proposition, unless you can be certain that the aerial signal frequencies do not fall on the harmonics of the i.f. What *is* an attractive idea for a reflex stage is to have it first amplify an r.f. or i.f. signal, and then the a.f. signal following the detector. This is quite a feasible proposition and you'll en-

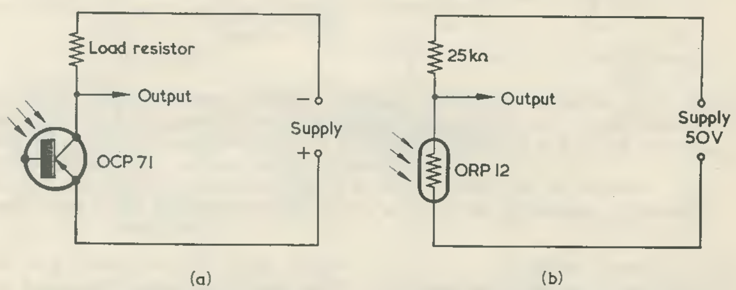
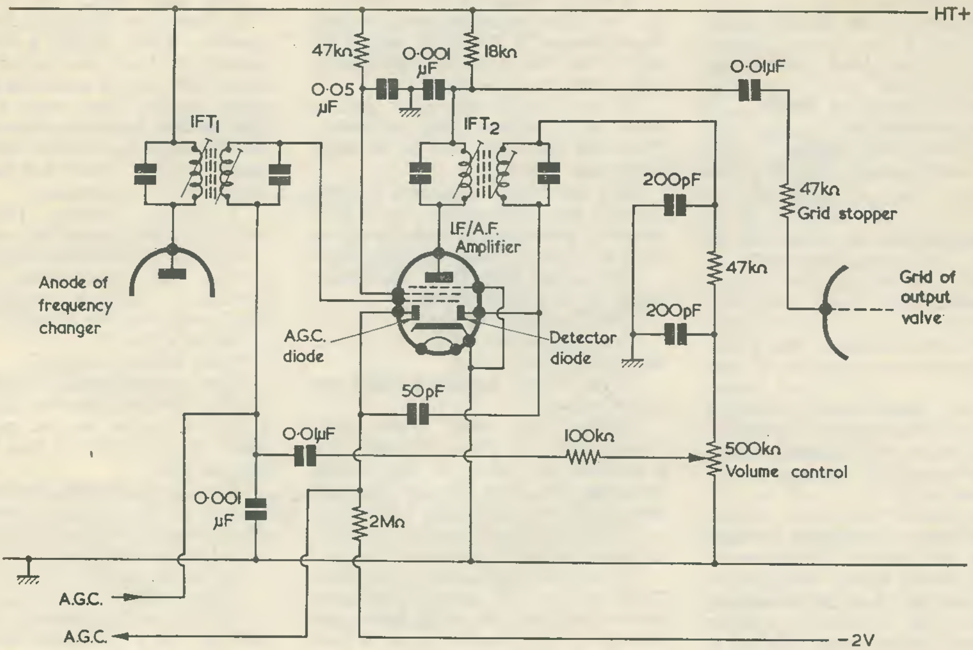
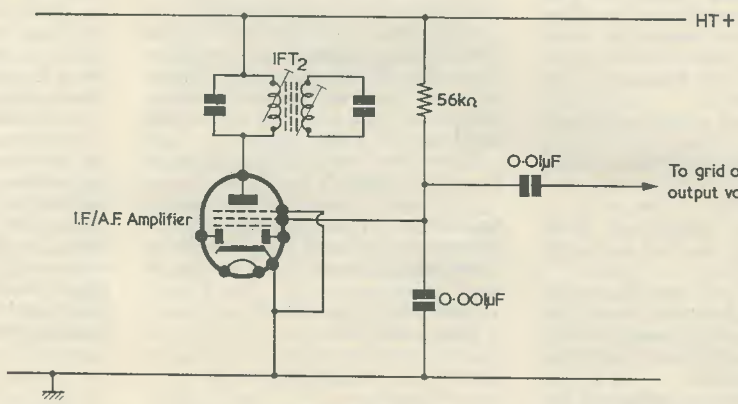



*Fig. 4 (a). Usually, a phototransistor or photoconductive cell is connected in series with a load offering resistance, as in the example shown here (b). A photoconductive cell connected in series with a 25kΩ resistor with 50 volts applied. Maximum dissipation occurs in the cell when half the supply voltage appears across it*




(a)




(b)

*Fig. 5 (a). A typical valve reflex circuit in which the pentode section of a double-diode-pentode functions both as i.f. and a.f. amplifier. The 2MΩ resistor coupling to the −2V line is the a.g.c. diode load. Full a.g.c. is applied to the frequency changer but only a fraction is applied to the reflexed pentode. The −2V is obtained from an auto-bias circuit in the power supply section of the receiver. The pentode is a variable-mu type*
*(b). A variant on the reflex circuit of (a). The methods of applying detected a.f. back to the pentode grid and of obtaining a.g.c. remain the same as in (a), but the amplified a.f. is taken from the screen-grid of the pentode instead of the anode*

counter it quite often."

"So far as I can see," commented Dick, "reflex circuits seem to be used by home-constructors only."

"They appear," replied Smithy, "in some commercially made sets as well. There were quite a few commercially made radios before the war which used reflex circuits, and in these the i.f. amplifier functioned as an a.f. amplifier as well."

Smithy took his stool and mug of tea over to his assistant's bench and pulled Dick's notepad towards him.

"I don't want to spend too long talking about these old sets," he remarked. "But the basic ideas they used are very useful as an introduction to the principles involved in more modern receivers. This circuit I'm scribbling out now (Fig. 5 (*a*)) is for a reflex stage in a valve superhet. In this, the anode of the i.f./a.f. amplifier valve goes to the primary of the second i.f. transformer in the normal way, the upper end of this primary being bypassed to chassis via a 0.001μF capacitor. The secondary of the i.f. transformer then couples to a diode, which is in the same envelope as the i.f. pentode, and you get a detected a.f. voltage across the volume control in the usual manner. The a.f. tapped off by the slider of the volume control is then fed back to the lower end of the first i.f. transformer secondary, this also being bypassed to chassis via a 0.001μF capacitor. The reactance of this 0.001μF capacitor is fairly high at audio frequencies, and so most of the a.f. from the volume control is applied to the grid of the i.f./a.f. pentode. The valve now proceeds to amplify the a.f. signal. The amplified a.f. at the anode is then picked off from the top of the second i.f. transformer primary and applied to the grid of the output valve. You'll note that the secret of success in the circuit is the use of bypass capacitors which offer a low reactance at i.f. and a high reactance at a.f. In this circuit the two 0.001μF capacitors carry out this function."

Smithy commenced to draw another circuit on Dick's pad. (Fig. 5 (*b*).)

"Here," he announced, "is a variation on the theme. This time the amplified a.f. is taken from the screen-grid of the i.f./a.f. amplifier. The screen-grid is bypassed by a 0.001μF capacitor and the a.f. signal on the screen-grid is then fed to the grid of the output valve. So you get i.f. amplification by a pentode, and a.f. amplification by the effective triode given by the cathode, grid and screen-grid. Quite a knobby idea, isn't it?"

"It *is* neat," confirmed Dick.

"One important point with circuits like these," said Smithy, "is that it isn't desirable to apply a high level of a.g.c. to the i.f./a.f. valve, because this would introduce a.f. distortion with signals giving a high a.g.c. voltage. Even more disturbing is the fact that you'd obtain an effect where a strong signal caused a *reduction* in a.f. amplification. As a result, sets of this type had circuits which ensured that only about one tenth of the a.g.c. voltage was applied to the reflex valve."

**Reflex Transistor Stages**

"What," asked Dick, "was the main advantage of these circuits?"

"A valve was saved," replied Smithy. "And the saving of a valve in those days, when there weren't any of the modern types which combine an a.f. triode and output pentode in one envelope, was well worth-while. Still, that's enough about old radios. Let's get on to something a bit more modern."

Smithy pondered for a moment, then commenced to draw a further circuit. (Fig. 6.)

"You mentioned home-constructor reflex circuits just now," he said. "So let's just take a brief glance at one home-construction reflex arrangement which has become a standard in the amateur field and which is, I think, due to D. J. French.* This is a simple but very effective circuit, and it has formed the basis of a considerable number of small home-constructor transistor designs ever since it first appeared. What happens in the circuit is that the signal picked up on the ferrite rod aerial is passed to the base of the transistor via a tap in the tuned coil which matches into the transistor's low input impedance. The transistor then functions as an r.f. amplifier, the amplified r.f. being passed to the two diodes via the 500pF capacitor. The r.f. choke prevents the r.f. being applied to the following a.f. stages in the receiver. The two diodes are in a voltage doubler rectifier circuit so that you get nearly twice as much detected a.f. as you would with a single diode. The detected a.f. is then passed back to the base of the transistor via the tuned coil."

Smithy indicated the lower section of the tuned coil with his pen.

"An ingenious little feature," he continued, "is the 100kΩ resistor which connects between the negative supply line and the positive end of the second diode. This provides base bias for the transistor and it also makes the two diodes slightly conductive. Thus, they are ready to detect any signal no matter how low its amplitude. There is also a 0.04μF capacitor between the positive end of the second diode and the positive supply line. This capacitor acts as r.f. filter capacitor for the detection circuit and r.f. bypass for the lower terminal of the tuned coil. At the same time it causes only slight attenuation of the detected a.f. signal. This a.f. is next amplified and then applied, via the r.f. choke, which offers negligible impedance at a.f., to the following a.f. stages."

"It really *is* ingenious," said Dick, who had been following Smithy's explanation closely.

"Definitely," agreed Smithy. "There have, incidentally, been quite a few more ingenious transistor reflex circuits in the home-constructor sphere recently, including in particular those designed by Sir Douglas Hall. Reflex circuits offer a wide field for experiment."

"There don't," commented Dick, "seem to be many reflex circuits in commercially manufactured *transistor* radios. It looks as though the do-it-yourselfers are keeping that wide field of yours all to themselves!"

"Don't you believe it," chuckled Smithy. "Reflexed stages are beginning to appear in commercially manufactured transistor receivers as well. In the pre-war valve receivers I was talking about just now, the reflexed stage was the i.f. amplifier. I've recently bumped into some commercially made transistor superhet receivers which follow the same idea, the reflexed stage being the i.f. transistor. There is, for instance, a range of car radios in which a single

* D. J. French, "The 'Ranger-3' Personal Transistor Receiver", *The Radio Constructor*, March 1961.

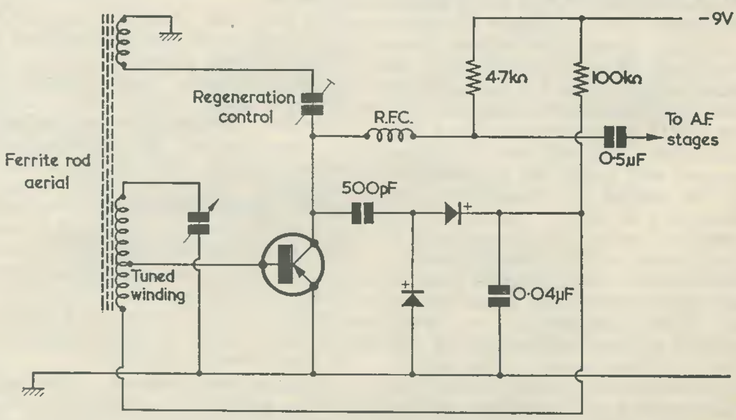



*Fig. 6. A basic reflex circuit which has appeared in many home-constructor designs. Usually, coverage is medium wave only. The r.f. choke has an inductance around 2mH, and the transistor should be an r.f. type*

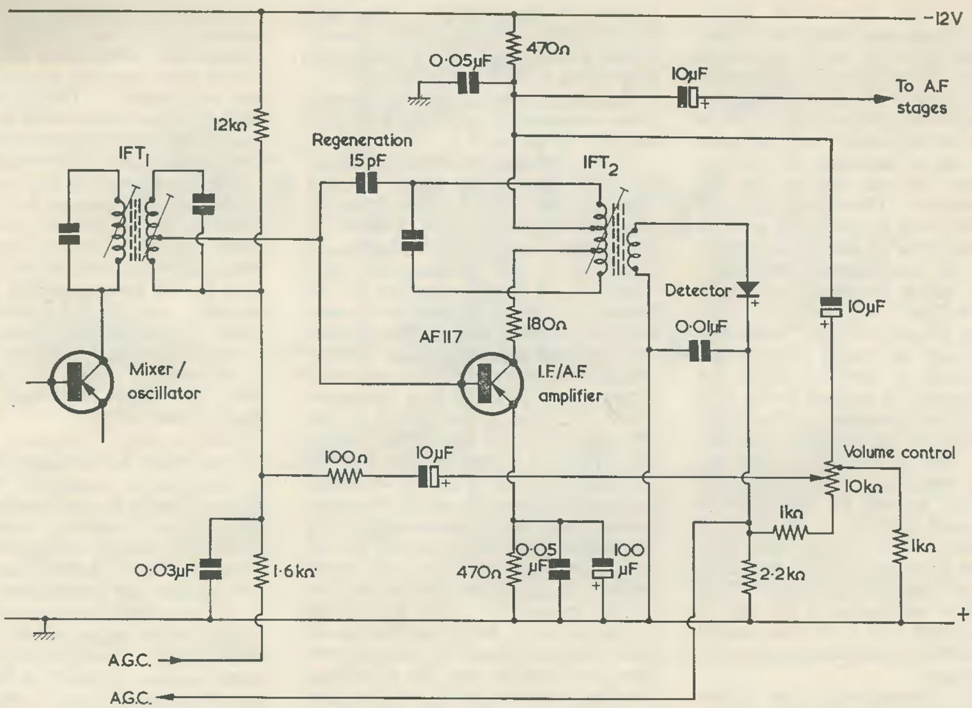



*Fig. 7. A commercial approach to the reflexed i.f./a.f. amplifier in superhet transistor receivers. This diagram offers a slightly simplified version of current circuit techniques*

transistor doubles as i.f. amplifier and as a.f. amplifier."

Smithy got up and walked over to the cupboard in which the service sheets were kept. He extracted a manual and returned to Dick, opening it out at the circuit diagram. (Fig. 7.)

"Here's a typical case in point," he announced. "And don't forget that this is in a receiver which is currently available. The basic operation of the reflexed stage is quite simple. The i.f. output from the mixer-oscillator is applied, via the first i.f. transformer, to the i.f./a.f. transistor. This amplifies in normal manner and passes the amplified i.f. to the second i.f. transformer, the secondary of which couples to the detector diode. The detected a.f. is then passed to the volume control, the slider of which couples back to the base of the i.f./a.f. transistor via a 10μF electrolytic, a 100Ω resistor and the secondary of the first i.f. transformer. The 0.03μF capacitor at the junction of the 100Ω resistor and the secondary of the first i.f. transformer acts as an i.f. bypass but offers a relatively high reactance at audio frequencies. The i.f./a.f. transistor now functions as an a.f. amplifier, the amplified a.f. appearing across the 470Ω resistor in its collector circuit. You'll note that there is a 0.05μF bypass capacitor at the junction of this resistor and the primary of the second i.f. transformer. This capacitor functions as an i.f. bypass, but doesn't cause too much attenuation of a.f. voltages."

"I see," said Dick. "There are a lot of bits in the circuit you haven't fully explained, though."

"True enough," agreed Smithy. "For a start, there's that 15pF capacitor coupling from the top end of the second i.f. transformer primary to the base of the i.f./a.f. transistor. Since, due to the upper earthy tap into this primary, the top end of the primary is out of phase with the collector, this 15pF capacitor provides a spot of regeneration and hots things up a bit. The 180Ω resistor in the collector circuit should enable the level of regeneration to be maintained accurately."

"The volume control," observed Dick, pointing a finger at the appropriate part of the circuit, "has a fixed tap in its track."

"That's right," agreed Smithy. "If you look carefully you'll see that, when the slider is at the top end of the track—which corresponds to minimum volume—it couples to the 470Ω a.f. collector load via a 10μF capacitor, thus coupling this load back to the base of the i.f. transistor. This causes very heavy a.f. degeneration. Without such an arrangement you might get breakthrough at the minimum volume setting with certain signals. The resulting i.f. signals would become detected in the transistor due to non-linearity in its characteristics; and the detected a.f. would then pass through to the following audio stages even though the volume control was set to minimum."

"What," asked Dick, "about a.g.c. circuits?"

"Those," replied Smithy, "don't really enter into our present discussion. Suffice it to say, though, that the a.g.c. circuits that are used in receivers like this will be such that only a small proportion of the a.g.c., if any, is applied to the reflected transistor. This is for the same reasons as occurred with those old reflex circuits using valves."

**1966 And All That**

"Well," said Dick, "it all seems to be fairly simple."

"Reflex circuits aren't too bad," agreed Smithy. "The one we've been looking at here is representative of commercial approach to reflexed stages in transistor radios at the time being. I should imagine that the use of reflexed stages in transistor radios will increase as time goes on, and they're pretty sure to follow the basic principles of the circuit we've just been discussing."

With these words, Smithy pushed the service manual to one side and drained his mug. It was obvious that discussion on reflex circuits had now come to an end.

"I must admit," commented Dick, as he obligingly picked up Smithy's mug and carried it over to the sink, "that 1966 doesn't look *quite* as bad as it did when I first came in this morning."

"Nor does it with me," said Smithy. "Now that I've had a cup of tea and bit of a natter I feel nearly back to normal."

"The trouble with New Year's Day," observed Dick as he returned with Smithy's mug, "is that it follows too closely after New Year's Eve. They ought to space them out a bit."

"They should," agreed Smithy, taking the fully charged mug from his assistant. "Still, we *have* made an appearance. And, as you said earlier on, it *does* happen that there's no work to do."

"So?" asked Dick expectantly.

"So," continued Smithy, "I suggest that we finish off our tea and then pack it in for the day."

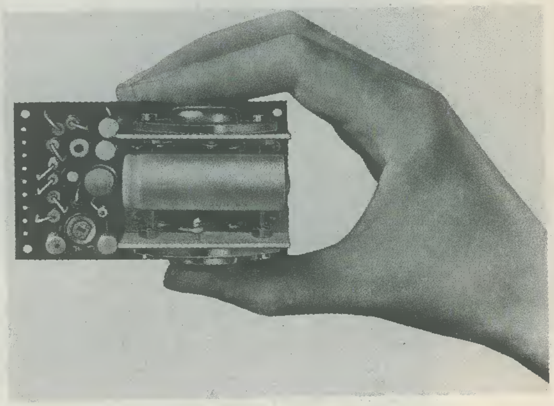
"That's my guv'nor," responded Dick warmly. "And I sincerely hope you have the Happiest of New Years, and that it's brim-full of sensible New Year resolutions just like that one!"

## New Product

# VERSATILE NEW AMPLIFIER FROM SINCLAIR

Sinclair Radionics make another radical departure in audio amplifiers with their latest design, the Sinclair Z-12. This is a conservatively rated 12 watt r.m.s. amplifier of exceptionally small size and full high fidelity performance.

In conformity with the now familiar Sinclair practice, the Z-12 incorporates a high quality pre-amplifier to which the user adds tone and volume control circuitry to suit his own particular requirements. Measuring only 3 x 1¾ x 1⅓in, the Z-12 weighs a mere 3 ounces. Add to the size and weight of this remarkable unit the fact that it will operate satisfactorily from any power supply between 6 and 20 volts d.c., and it becomes clear that the Z-12 is going to prove very popular not only with the modern hi-fi enthusiast who wants both quality and compactness, but also with guitar players, motorists, public address users and all others with a need for high power from a very small amplifier. For its power, this must be one of the smallest amplifiers in the world.



The manufacturer's specifications of the Z-12 include the following:

Frequency response—15 to 50,000 c/s ±1dB.
Signal to noise ratio better than 60dB.
No. of transistors—8.
INPUT—2mV into 2kΩ.
OUTPUT POWER—
12 watts continuous sine wave (24 watts peak).
15 watts music power (30 watts peak).
OUTPUT IMPEDANCE VALUES—Suitable for one or two 3Ω loudspeakers (two can be used in parallel) or 7.5 or 15Ω. Useful power from the amplifier is in proportion to the impedance of the speaker used and is at its greatest with a 3Ω system.
Quiescent current consumption—typically 15mA. This makes the Z-12 eminently suitable for battery operation.
Size—3 x 1¾ x 1⅓in.
Weight—3 oz.
Tone and volume controls—These are added as required. A manual is supplied with the amplifier which details a number of circuits from which the user can choose the one best suited for the equipment he is going to use with the Z-12. Both mono and stereo requirements are catered for.

The Sinclair Z-12 is supplied ready built, tested and guaranteed. It costs 89s. 6d. and is obtainable from Sinclair Radionics, Ltd., Comberton, Cambridge, post free.

A mains power supply unit, the Sinclair PX.10 is available, price £2 14s. 0d.

# Marconi Marine's "Raymarc" Radar

For the past few months two major British shipowners have been evaluating Marconi Marine's latest transistorised "Raymarc" radar, the Esso Petroleum Co. Ltd., aboard their tanker *Esso London*, and Hain-Nourse Ltd., aboard their cargo-liner *Trevaylor*; and as a result both companies have now placed substantial orders with Marconi Marine for the supply of "Raymarc" radar to a further nine Esso tankers, in which it will be used as a secondary installation, and to ten Hain-Nourse vessels.

Throughout the evaluation period the master of both *Esso London* and *Trevaylor* expressed complete satisfaction with the performance of the equipment. The captain of *Esso London* endorsed his latest report, "Very satisfactory in performance at all times", while *Trevaylor's* captain, concluding a detailed report on the installation said:

"The 'Raymarc' fitted aboard *Trevaylor* has been entirely to my satisfaction and I am very pleased with the performance all round."

*Cover Feature*

# THE "TWO + TWO" RECEIVER

## By WALLACE STUDLEY

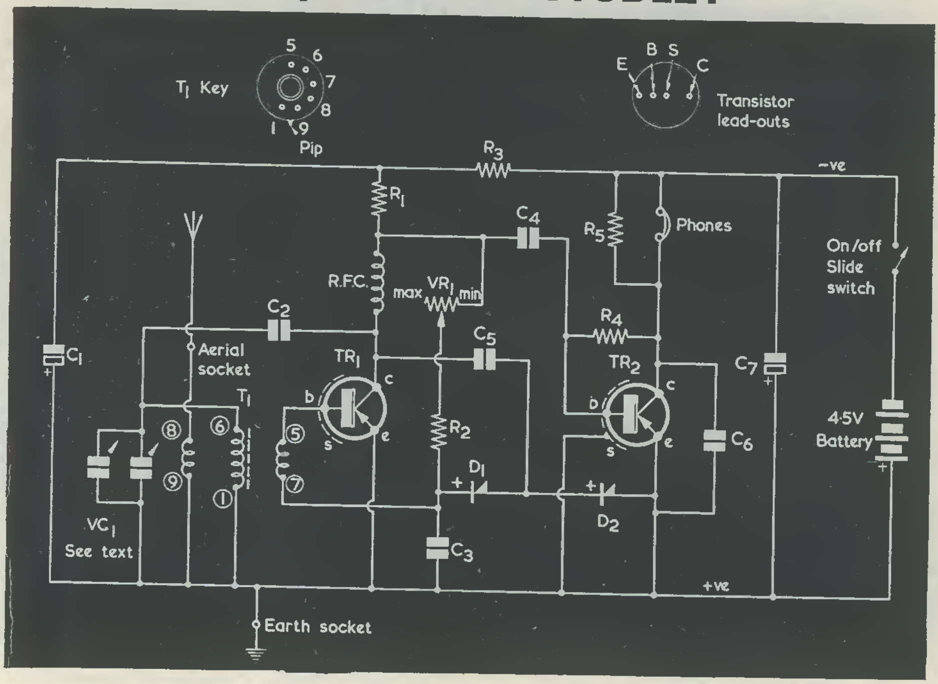



*Fig. 1. The circuit of the receiver. The screen of TR1 is left disconnected*

*A miniature short and medium wave receiver which fits into a cabinet measuring some 6 x 3¼ x 2⅝in, and which draws a current of only 1mA from an internally fitted 4.5 volt torch battery, represents an attractive proposition. Tuning is carried out by a twin-gang capacitor and maximum frequency coverage is offered by connecting its two sections in parallel. If, however, there is a particular interest in part of a band only, it is possible to obtain reduced coverage by using either the front or rear section of the capacitor on its own*

THIS RADIO RECEIVER USES FOUR SEMICONDUCTORS and is capable of tuning over a frequency range of 480 kc/s to 15 Mc/s whilst drawing a current of only 1mA from a 4.5V supply! Two transistors, two diodes and a handful of small components make it possible; and the circuit of the simple receiver is illustrated in Fig. 1. Here, $TR_1$ provides r.f. and a.f. amplification simultaneously, whilst diodes $D_1$ and $D_2$ give demodulation. Transistor $TR_2$ gives additional audio amplification and any signals initially presented by the aerial may be clearly heard in high impedance headphones connected in the collector circuit of the transistor. The receiver is easily duplicated and no alignment problems whatsoever present themselves. Ready-made plug-in aerial transformers are used, three in all being required.

### Frequency Coverage and Band Changing

The actual frequency coverage obtained depends partly upon the wishes of the contructor, for not only is it possible to vary within limits the inductance values of the aerial transformers but it is also possible to utilise the tuning capacitor $VC_1$ in different ways.

The tuning capacitor is, in fact, the popular Jackson "00" twin-gang unit, the front section of which has a maximum capacitance value of 208pF. The other section has a value of 176pF and either section may be used alone. Alternatively, the two sections may be strapped to provide a maximum capacitance of 384pF. Considering these three values and allowing some 40pF for circuit "strays" we can calculate coverages. These are detailed in the accompanying Table.

Band changing is effected by plugging the required transformer into a B9A valveholder and since each transformer is fitted with an inbuilt "pip" (see inset diagram and key in Fig. 1) incorrect positioning is unlikely. Each transformer carries three windings and these are identified in Fig. 1 by circled numerals corresponding to their pin numbers.

### Sensitivity, and Some Circuit Considerations

Simple receivers of this type can never approach communications receiver sensitivity; they can, however, be "pepped up" somewhat. In the present circuit, enhanced sensitivity is achieved by returning part of the r.f. present at $TR_1$ collector to the base circuit, in order to provide regeneration. Fixed capacitor $C_2$ performs this duty and effectively connects the tuned winding between collector and base. The degree of regenerative feedback depends partly on the setting of $VR_1$ which can be adjusted for maximum sensitivity by maintaining the transistor at the brink of oscillation. To assist in the regenerative action the screen lead-out of $TR_1$ is left open-circuit.

Both transistors derive the necessary bias potentials from resistors which are simply connected between base and collector. In the case of $TR_1$ the value of the appropriate resistor ($R_2$) is made rather low to increase collector current sufficiently for oscillation to take place when $VR_1$ is set to "Min". By moving the slider of $VR_1$ towards "Max", however, additional resistance is effectively added to $R_2$ and a point is eventually reached where oscillation just ceases. At this "peak point" sensitivity is at its greatest but will fall off rapidly if $VR_1$ slider is further adjusted in the direction of "Max". Keeping $VR_1$ set to the "peak point" is of great importance, and it must be emphasised here that if "Min" is approached excessively signals will be replaced by whistling, whilst if "Max" is approached excessively no signals whatsoever may be heard. Unfortunately, $VR_1$ cannot be pre-set and left; it must be reset whenever tuning is varied for the circuit constants are then being changed. This

### Components List

*Resistors*

(All fixed values ⅛ watt 10%)

| | |
|---|---|
| $R_1$ | 3.9kΩ |
| $R_2$ | 68kΩ |
| $R_3$ | 1kΩ |
| $R_4$ | 100kΩ |
| $R_5$ | 5.6kΩ (see text) |
| $VR_1$ | 100kΩ, potentiometer, linear track |

*Capacitors*

(All capacitors modern miniature types)

| | |
|---|---|
| $C_1$ | 100μF, electrolytic, 6V wkg. |
| $C_2$ | 6pF, ceramic or silver-mica |
| $C_3$ | 0.02μF, paper |
| $C_4$ | 0.1μF, paper |
| $C_5$ | 220pF, silver-mica |
| $C_6$ | 0.01μF, paper |
| $C_7$ | 100μF, electrolytic, 6V wkg. |
| *$VC_1$ | 208+176pF. Type "00" twin-gang (Jackson Bros. Ltd.) |

*Semiconductors*

| | |
|---|---|
| $TR_1$ | AF115 |
| $TR_2$ | AF117 (see text) |
| $D_{1,2}$ | OA70 |

*Coils*

| | |
|---|---|
| $T_1$ | Aerial transformer. Transistor Dual Purpose Coils, Blue, ranges 2T, 3T and 4T (Denco) |
| RFC | R.F. choke type RFC5 (Denco) |

*Sockets*

1 B9A socket
1 Aerial-earth socket strip
1 Phone jack

*Miscellaneous*

29 hole x 9 strip (including end strip—see text and Fig. 3) piece of Veroboard, 0.2 x 0.2 in hole matrix
Paxolin, 6 x 3¼ x $\frac{1}{16}$in
Vernier dial, Model T502 (Henry's Radio)
Miniature slide switch, s.p.s.t.
4,000Ω headphones with jack plug
¼in knob
4.5 volt battery type 1289 (Ever Ready)

* If supplied with trimmers, these should be set to minimum capacitance.

feature is common to all such simple circuits. Please note that the terms "Min" and "Max" refer to the amount of resistance in circuit. Note also that, due to its very low d.c. resistance, the r.f. choke plays no significant part in the bias arrangement for $TR_1$. To clarify this latter point it can be said that $TR_2$ receives base bias simply from $R_4$, whereas base bias for $TR_1$ base is provided via $R_2$ and $VR_1$, the choke having negligible d.c. resistance.

The prime purpose of the r.f. choke is to obstruct the passage of the received radio frequency signals

**TABLE**
**Approximate frequency coverages obtainable in Mc/s using "00" twin-gang tuning capacitor**

| Maker's range No.—$T_1$ | L($\mu$H) Tuned winding | Coverage— Rear section, $VC_1$ | Coverage— Front section, $VC_1$ | Coverage— Both sections strapped |
|---|---|---|---|---|
| 2T | 271.0 | 0.65– 1.5 | 0.615– 1.5 | 0.48– 1.4 |
| 3T | 27.2 | 2.10– 5.0 | 1.90 – 5.0 | 1.50– 4.3 |
| 4T | 2.9 | 6.50–15.0 | 6.0 –15.0 | 4.50–13.5 |

*Note:* An approximate $\pm 15\%$ variation of tuning inductance is obtainable via core adjustment.

appearing at $TR_1$ collector. These can more readily pass via $C_5$ to the diodes where demodulation takes place. The audio frequency resulting from demodulation is then re-introduced to $TR_1$ via the low impedance winding of the aerial transformer (pins 7 and 5) and reappears amplified at the collector. The audio signals now see $C_5$ as a high impedance and the choke as a low one and are thus able to pass via $C_4$ to the base of $TR_2$ for further amplification. The fact that $TR_2$ is a type normally employed for r.f. work is of small consequence; it could, perhaps, be exchanged for a OC71. Use of the specified types is recommended, however, and this applies particularly to $TR_1$.

Re-considering the demodulation process momentarily, it is interesting to observe that due to the way the diodes are connected a d.c. potential is developed across $C_3$ that is dependent on the strength of the received signal. Slight irregularities are smoothed out by $C_3$ to leave a potential which tends to drive the base of $TR_1$. The result is that a simple automatic gain control system is set up which assists to some extent in counteracting fading; at the same time the need for a blocking capacitor is removed.

Since the receiver is to be used mainly for short

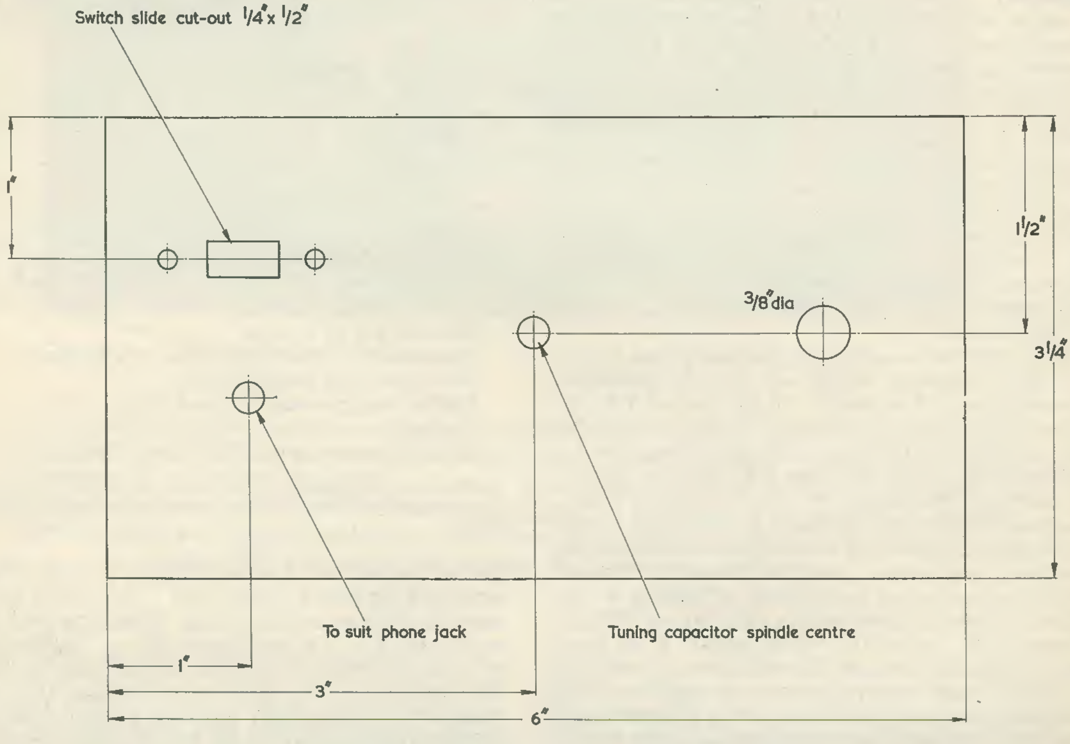



*Fig. 2. Essential drilling dimensions for the front panel. Extra mounting holes will be required for the tuning drive, and these may be marked out from the drive itself. The dimensions shown for the slide switch may vary with some types, and this point should be checked before drilling and cutting out. The material is $\frac{1}{16}$in polished Paxolin*

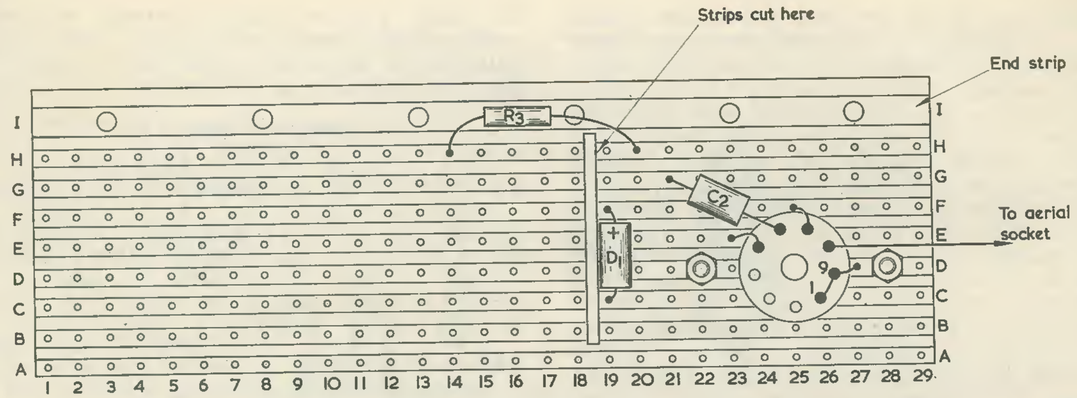



*Fig. 3. Wiring on the conductor side of the Veroboard. Note that a connection from D28 to D19–22 is carried over by the metal frame and mounting nuts of the coil holder. The nuts should not short-circuit against strips C or E*

wave listening an aerial is essential. An earth is also beneficial but not absolutely necessary. It should also be noted that a direct tuning drive is entirely unsatisfactory—hence the inclusion of a vernier reduction drive unit. Decoupling is adequate and the test model is 100% stable. Simple t.r.f. receivers do, nevertheless, tend to be temperamental, and this point should be borne in mind. Resistor $R_5$ is not really essential but it is interesting to note that, if it is retained in circuit, the receiver can be used to drive a separate transistorised audio amplifier merely by removing the headphones and lifting the "cold" end of $C_6$, connecting this to the amplifier input. In this case $R_5$ is left *in situ*; an additional lead is also used to interconnect the positive supply lines of the two units.

**Construction**

Mechanical details are given in Figs. 2 to 5. Briefly, a piece of $\frac{1}{16}$in thick Paxolin forms a front panel (see Fig. 2) which carries the various controls and to this is affixed a rectangle of Veroboard. Veroboard is made of pre-fabricated Paxolin which is fitted with parallel copper conductor strips on one side and is plain on the other. The strips are pierced with small holes in a regular pattern and enable low voltage circuits to be rapidly constructed to form what are virtually "printed circuit" assemblies.

The section of Veroboard required, together with all details relating to the conductor side, is shown in Fig. 3. As may be seen, twenty-nine holes over each of the nine strips are needed. These have been given imaginary letter and numeral designations to

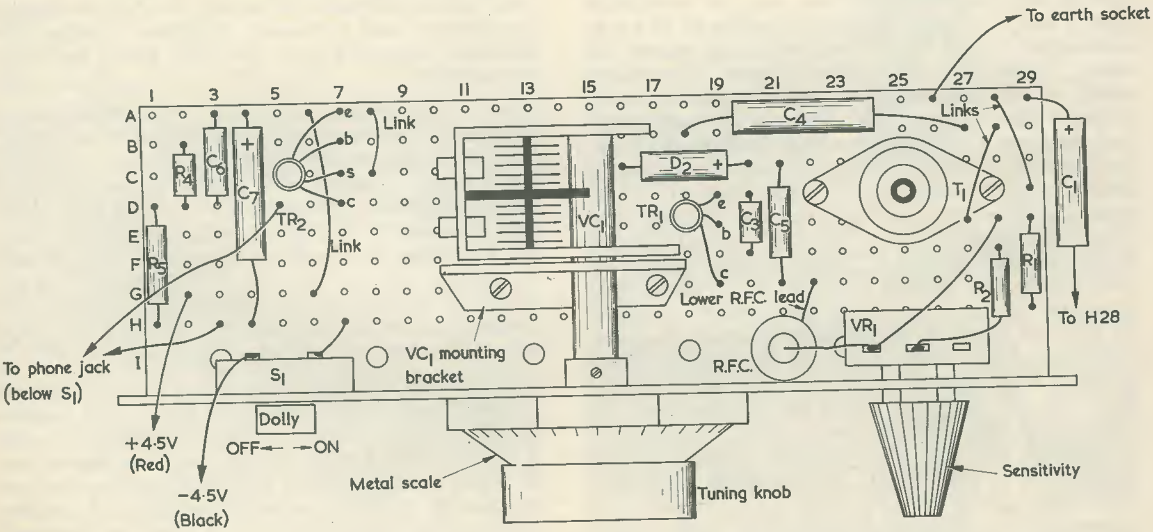



*Fig. 4. The layout above the board. The tuning capacitor frame is earthed via its metal bracket and mounting nuts and bolts to strip G. Ensure that the mounting bolts pass through the board at positions G12 and G17 and that the nuts do not contact strips F or H*

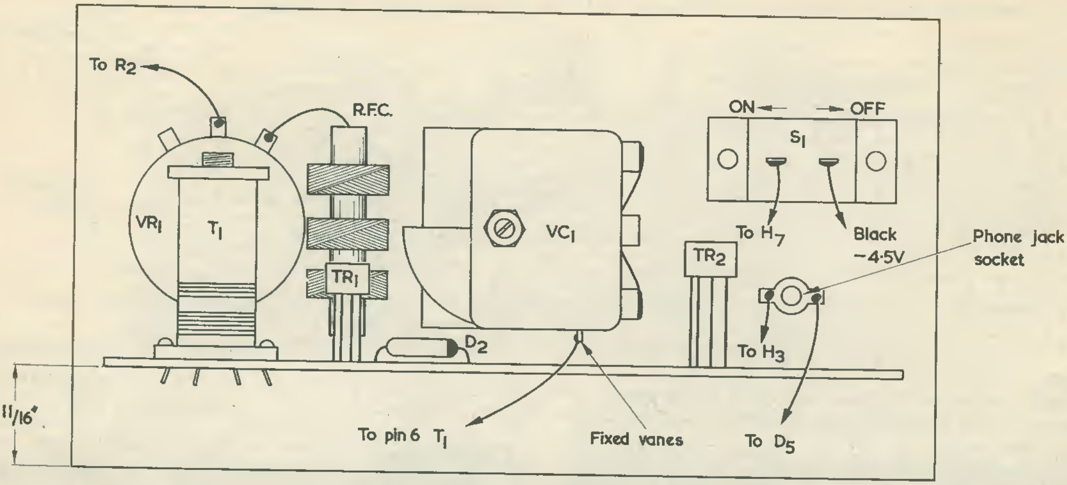



*Fig. 5. A rear view above the chassis. The layout of switch tags may vary from that shown here, according to the type of switch employed. As is explained in the text, the connection from $VC_1$ fixed vanes may be taken from the first section, the rear section, or both sections connected together*

aid construction. Strip "I" is slightly wider than the others and is found at the edge of a new section of the board. The holes in strip "I" are larger and if two thin "butts" of wood are glued firmly to the inside of the front panel small screws may be passed through these holes to provide a rigid assembly. A cut-out for the B9A valve-holder is made as shown and a slit made across seven of the strips (to break their continuity) as indicated. Two resistors and a diode are also soldered to this side of the board.

The majority of the items are fitted to the plain side of the board however as may be seen from Figs. 4 and 5. A small L-shaped bracket of 16 s.w.g. aluminium is also needed with which to mount the tuning capacitor. This should have dimensions which enable the capacitor spindle to pass centrally through the appropriate hole in the front panel, and these may be taken from the component itself. Position the bracket as indicated, with the mounting holes at "G12" and "G17". The frame of $VC_1$ is then automatically earthed, via the bracket and mounting nuts, to strip "G1–18". Four linking wires are also necessary. Some care is needed to ensure that the moving vanes of $VC_1$ cannot foul transistor $TR_1$. In any case the transistors should be the last items to be soldered in, their lead-out wires being held firmly with stiff tweezers or pliers to shunt away the damaging effects of heat from the iron. In the diagrams $C_1$ is shown displaced for clarity and the metal casing appears unconnected —although this can be connected to the positive supply line at hole "D21" if considered beneficial. An Aerial/Earth socket strip may initially be connected via flying leads and later fixed to the cabinet side. For these leads use blue and yellow wires, or any other colours *except* black or red.

**Completing and Testing the Receiver**

After connecting a flying lead with red insulation to hole "G2", solder a similar lead, but with black insulation to the tag of $S_1$ as indicated in Fig. 4. To prevent accidental damage, check with a meter set to read 0–10 volts d.c. the polarity of the 1289 battery terminations, whereupon it should be found that the long one represents negative and the short one positive.* Label these clearly then fashion a pair of clips from brass or tin which will slide over the terminations. Keeping them free of the battery, solder one each to the red and black flying leads already fitted. Fit the positive one to the battery then set the testmeter to read 0–10mA and connect its negative lead to battery negative. Connect the testmeter positive lead to the black flying lead from the receiver.

At switch-on and with one of the transformers plugged in approximately 1mA should be indicated; if much higher, say 10mA, switch off and investigate for a fault. If all is well, careful manipulation of the tuning knob and sensitivity controls will enable transmissions to be heard immediately the headphones, aerial and earth are connected. $VR_1$ should be adjusted to maintain the first transistor on the brink of oscillation for normal a.m. signals; for listening to c.w. it will be found beneficial to allow a small amount of oscillation to occur.

Finally the meter may be removed and a simple cabinet constructed. This must have a lid capable of being raised in order to allow bandchanging, and it should be just deep enough to allow the battery to stand upright against the back. It may be held in place by a simple clamp or, since the low current consumption means that it will rarely be replaced, even glued in position!

* The polarity is normally marked on the seal of a new battery. —EDITOR.

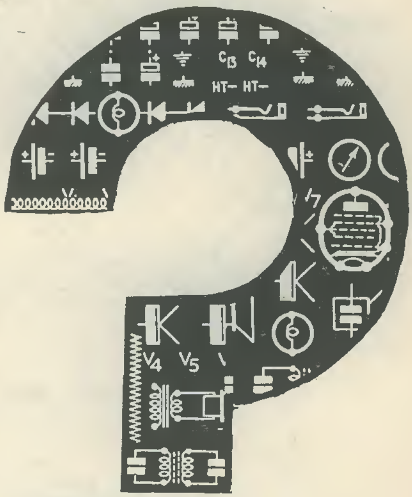
# understanding

## How to use Voltage Amplifier Loadlines

**By W. G. Morley**

In last month's article in this series we examined the last of the three important constants of the valve, this being amplification factor, or $\mu$. We saw also the relationship between the constants, as is given by $\mu = gm.r_a$, $gm = \frac{\mu}{r_a}$ or $r_a = \frac{\mu}{gm}$. We next discussed a method of finding the dynamic voltage gain of a valve under working conditions when an anode load is included in the circuit, and found that this is equal to $\frac{\mu R_L}{R_L + r_a}$ where $R_L$ is the anode load.

We shall now proceed to an alternative method of finding voltage gain under dynamic conditions.




# radio

### The Loadline

A simple, and accurate, method of finding dynamic voltage gain under working conditions employs a graphical treatment applied to the published $I_aV_a$ curves for the valve.

Fig. 331 (*a*) shows a triode voltage amplifier, and we shall assume for the purpose of explanation that its anode load has a value of 100kΩ, and that the h.t. voltage applied to the circuit is 300. A set of $I_aV_a$ curves for the triode is shown in Fig. 331 (*b*).

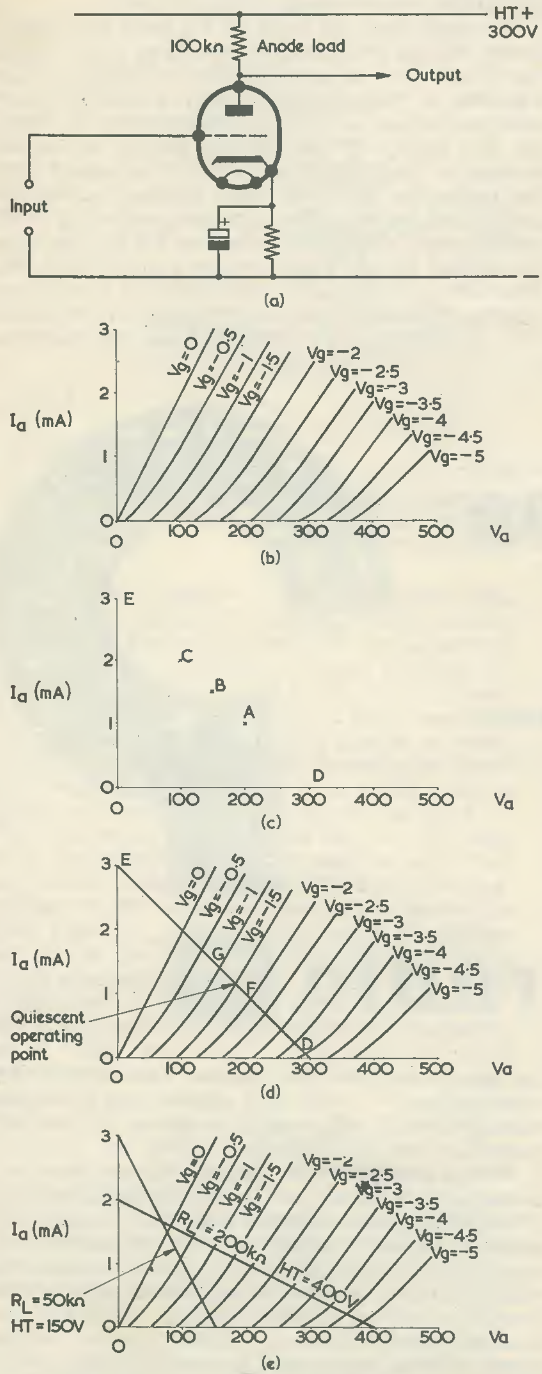
When the triode passes anode current, its anode voltage must obviously be lower than that at the h.t. positive supply terminal because of the voltage dropped in the anode load. Indeed, it is the function of the anode load to *cause* a voltage to be dropped, thereby enabling an alternating voltage to appear at the anode which is an amplified version of the alternating voltage applied to the grid.

Since the anode voltage depends upon the voltage dropped across the anode load resistor, it becomes possible to draw an anode current-anode voltage curve based on this single factor alone. In Fig. 331 (*c*) we commence to plot such a curve, and we use the same anode voltage and anode current axes (that is, zero to 500 volts and zero to 3mA respectively) that we employed in Fig. 331 (*b*).

We could start our work on the curve by plotting anode voltage for an anode current of 1mA. From the Ohm's Law relationship, E=IR, we know that a current of 1mA flowing through a 100kΩ resistor causes a voltage of 100 to appear across it. Since the h.t. voltage is 300 this means that an anode current of 1mA results in an anode voltage of 200, the remaining 100 volts being dropped across the anode load resistor. The appropriate plotting point on the graph, designated A in Fig. 331 (*c*), can thus be marked in. At 1.5mA anode current there will be a voltage drop of 150 volts across the anode load resistor, resulting in an anode voltage which is also 150. This gives us plotting point B in the diagram. An anode current of 2mA results in a drop of 200 volts across the anode load resistor and an anode voltage of 100. The result is shown as plotting point C.

As we continue this process it soon becomes evident that what we are actually doing is making plotting points for a straight line. The fact that the curve is a straight line is to be expected, when we consider the simple direct relationship between the voltage dropped across the anode load resistor and the anode current (E=IR), because equal changes in anode current cause equal changes in the voltage across the load and, hence, in anode voltage.

Since our curve is a straight line, only two plotting points are really needed on the graph. All that is then required is to draw a straight line through these two points and the curve becomes complete. Armed with this knowledge we can, further, choose




figures for the plotting points which are even simpler and quicker to find than those we have just employed. We now obtain our first plotting point by considering the case which exists when anode current is zero. If anode current is zero, the voltage dropped across the anode load resistor will also be zero, whereupon the anode voltage will become the same as the h.t. supply voltage. In our present example the h.t. voltage is 300, and we can consequently plot point D in Fig. 331 (*c*). Point D corresponds to 300 volts on the $V_a$ axis, and to zero on the $I_a$ axis. The next step is to find the anode current which would flow if the anode voltage were zero. (In practice, this would be the current which flowed through the anode load resistor if the anode and cathode of the valve were short-circuited together). Keeping to the figures in our present example, 300 volts would then appear across the 100kΩ load resistor with the result that (from $I=\frac{E}{R}$) a current of 3mA would flow. Thus, zero anode voltage corresponds to 3mA anode current, providing us with plotting point E in Fig. 331 (*c*). It will be seen, incidentally, that points D and E are directly in line with the previously obtained points A, B and C.

Let us now superimpose the information resulting from points D and E of Fig. 331 (*c*), which apply to an anode load of 100kΩ and an h.t. voltage of 300, on to the $I_aV_a$ curves of Fig. 331 (*b*). This we do in Fig. 331 (*d*). We mark our plotting point D and our plotting point E, and we then draw a straight line between them. Whatever the grid voltage of the valve (and assuming there are no components external to the circuit which may alter the effective value of the anode load) the anode voltage and anode current *must* lie on the line DE because of the presence of the 100kΩ anode load resistor and the 300 volt h.t. supply. We can put the line DE to good use by observing the anode voltages which correspond to different grid voltages. Thus, the $V_g=-2$ curve cuts line DE at point F, which corresponds to 205 volts on the $V_a$ axis. The $V_g=-1$ curve cuts line DE at point G, which corresponds to 160 volts on the $V_a$ axis. So, with an h.t. voltage of 300 and an anode load of 100kΩ, a grid voltage of $-2$ causes the anode voltage to become 205, and a grid voltage of $-1$ causes the anode voltage to become 160. We also learn that a change of grid potential of 1 volt (from $-2$ to $-1$) results in a change of anode voltage of 45 (from 205 to 160). The voltage gain with the 100kΩ anode load resistor is therefore 45.

In a practical circuit, the valve will require a fixed grid bias voltage, and a suitable value may be obtained with the aid of a graph such as that of

*Fig. 331 (a). A triode voltage amplifier. Cathode bias is assumed*
*(b). A set of $I_aV_a$ curves, as could be given by the triode of (a)*
*(c). Plotting an anode voltage and anode current curve for an anode load of 100kΩ and an h.t. voltage of 300. The curve turns out to be a straight line*
*(d). Line DE, from (c), superimposed on the $I_aV_a$ curves of (b), provides a loadline for an anode load of 100kΩ and an h.t. voltage of 300*
*(e). Loadlines may be drawn for any reasonable anode load resistance and h.t. voltage. Two examples are shown here*

Fig. 331 (*d*). It is usual to have a grid bias voltage which causes the anode voltage to lie between about 0.4 and 0.8 of the h.t. supply voltage. Also, and particularly if the alternating voltage applied to the grid has a relatively high amplitude, it is desirable to ensure that the consequent changes in anode voltage are proportional to the changes in grid voltage. Otherwise, the alternating voltage at the anode will be a distorted version of that applied to the grid. Proportional changes in anode voltage will occur if there is equal spacing between the points where the $I_aV_a$ curves of the valve cut line DE. Under the circumstances shown in Fig. 331 (*d*) a grid bias voltage which would satisfy both these requirements is −1.5 volts. This cuts the line DE at a point corresponding to about 0.6 of the h.t. voltage, and changes in grid voltage up to nearly 1.5 volts in either direction cause changes in anode voltage which, by visual inspection, appear to be almost exactly proportional. So the valve, if operated with −1.5 volts grid bias, could handle signals up to 1.5 volts peak, and the corresponding amplified signals at the anode should be nearly identical in waveform to those at the grid.

The point where the −1.5 volt $I_aV_a$ curve cuts line DE signifies the conditions which exist when no signal is applied, and it is identified in Fig. 331 (*d*) as the *quiescent* (i.e. no-signal) *operating point*. We find also that at the quiescent operating point the anode current, drawn from the h.t. supply via the anode load, is 1.2mA.

The line DE, which has enabled us to find out a considerable number of facts concerning the working operation of the valve, is described as a *loadline*. Loadlines may be conveniently drawn on any set of $I_aV_a$ curves and their purpose is to specify the anode voltages and anode currents which exist for a particular h.t. voltage and a particular value of anode load resistor. To draw a loadline representing a resistive anode load, all that is required is to identify the h.t. voltage on the $V_a$ axis, and to identify on the $I_a$ axis the current which flows through the load resistor when the full h.t. voltage is applied across it. The line joining these two points then constitutes the loadline. To provide further illustrations, Fig. 331 (*e*) shows the same set of $I_aV_a$ curves with two more loadlines, the first of these corresponding to a 50kΩ load at 150 volts h.t., and the second to a 200kΩ load at 400 volts h.t.

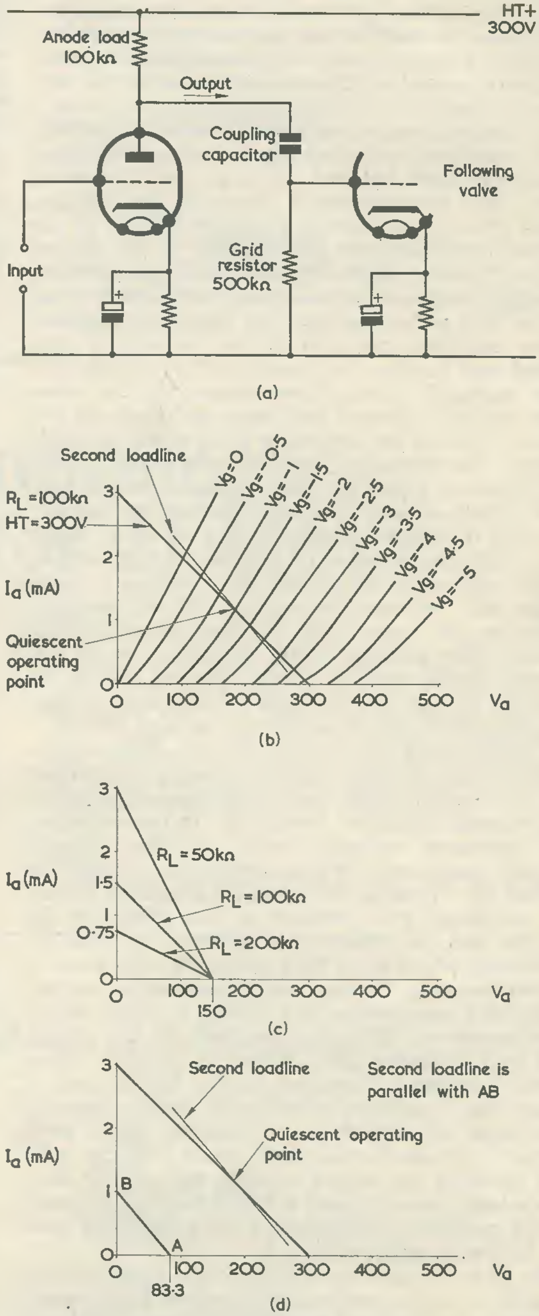



*Fig. 332 (a). In practice, a voltage amplifier will normally be followed by a coupling capacitor and grid resistor*

*(b). The second loadline illustrated here results from the presence of the following 500kΩ grid resistor*

*(c). Illustrating the fact that loadline slope is proportional to load resistance*

*(d). A simple method of constructing the loadline of (b). Line AB has a slope corresponding to the resistance of the anode load and following grid resistor in parallel, and the second loadline CD is drawn parallel to it. To show the construction more readily, the $I_aV_a$ curves are omitted here*

**The Following Grid Resistor**

The loadlines of Figs. 331 (*d*) and (*e*) enable an accurate assessment to be made of a valve's performance as a voltage amplifier under working conditions and are very useful for this purpose. For approximate work involving voltage amplifiers it is reasonably adequate to work to a single anode loadline, as we have done up to now, to ascertain the performance of a valve under working conditions. However, the loadlines we have considered do not take into account the effect of components to which the output signal is applied and this factor will next be discussed.

It is usual for a voltage amplifier to be coupled, via a capacitor having a low reactance at the signal frequencies to be handled, to the grid of a following valve. The arrangement is shown in Fig. 332 (*a*), which shows that there is a further resistor in the circuit, this being the grid resistor of the second valve. So far as alternating voltages are concerned, this grid resistor is in parallel with the anode load of the first valve, because the coupling capacitor offers negligible reactance at the frequencies concerned and because the source of h.t. voltage will have negligible internal impedance. At the same time, the grid resistor will have no effect on the anode circuit of the preceding valve so far as direct voltages are concerned, because it is isolated from the preceding anode by the coupling capacitor.

To obtain a really accurate picture of the manner in which a voltage amplifier works we must, therefore, take into account any following grid resistor which appears in the circuit. The process is quite simple and we can illustrate it with an example based on the curves and loadline shown in Fig. 331 (*d*). The loadline in Fig. 332 (*b*) is for an h.t. voltage of 300 and an anode load of 100kΩ, as occurred in Fig. 331 (*d*), and we will assume that the subsequent grid resistor has a value of 500kΩ.

The following grid resistor has no effect on the anode voltage so far as direct voltage is concerned and so it cannot affect the voltage appearing at the anode under quiescent conditions. In consequence, the "quiescent operating point" of Fig. 331 (*d*) remains unaltered. When, however, a signal is applied to the valve, the coupling capacitor causes the following grid resistor to be effectively in parallel with the anode load resistor. To find the conditions which then hold good, we next draw a second loadline through the quiescent operating point, this second loadline having a slope which corresponds to the resistance given by the anode load and following grid resistor in parallel. This second loadline is illustrated in Fig. 332 (*b*), and it defines the conditions which exist under dynamic conditions when there is a following 500kΩ grid resistor. Anode current and anode voltages will then lie along the *second* loadline, because the true anode load, when a signal is being handled, is given by the parallel combination of the anode load and the following grid resistor.

We have, in introducing this second loadline, had to jump a step in explanation, since we have stated that the new loadline has a certain "slope" without describing what that "slope" is or how it is derived. A glance at Figs. 331 (*d*) and (*e*) will, however, help to explain this new concept. In Fig. 331 (*d*) we have a loadline corresponding to an anode load resistor of 100kΩ, and in Fig. 331 (*e*) two loadlines corresponding to loads of 50kΩ and 200kΩ respectively. It can be seen that the slope of the 50kΩ loadline is greater than the slope of the 100kΩ loadline and that the slope of the 100kΩ loadline is, in its turn, greater than that of the 200kΩ loadline. If the three loadlines were drawn for a single h.t. voltage, say 150, we would have the result shown in Fig. 332 (*c*). The reason for the different slopes then becomes readily apparent. The left hand plotting point for the 50kΩ loadline, along the $I_a$ axis, is 3mA, the left hand plotting point for the 100kΩ loadline is 1.5mA, and the left hand plotting point for the 200kΩ loadline is 0.75mA. If we were to move the right hand plotting point of any of the loadlines to a higher h.t. voltage along the $V_a$ axis, its slope would still remain the same because its left hand plotting point on the $I_a$ axis moves up to compensate. The slope of the loadline is, therefore, a measure of the resistance of the anode lead.

A simple construction can be used to draw our second loadline of Fig. 332 (*b*). We could start by initially drawing a line corresponding to the slope of the parallel combination of the anode load and following grid resistor. In our example, these components have values of 100kΩ and 500kΩ respectively, with the result that, from the expression for two parallel resistors, $\frac{R_1R_2}{R_1+R_2}$, their parallel combination gives us a value of $\frac{500\times100}{500+100}$kΩ, which is equal to 83.3kΩ. A convenient right hand plotting point for a line having a slope corresponding to 83.3kΩ would be 83.3 volts on the $V_a$ axis, as is given by point A in Fig. 332 (*d*). Such a point is convenient because it enables our left hand plotting point along the $I_a$ axis to be (from $I=\frac{E}{R}$) $\frac{83.3}{83.3}$m A and saves us the both of dividing by an "awkward" figure for R! The left hand plotting point, B in Fig. 332 (*d*), then becomes 1mA.

We now have a line, AB, whose slope corresponds to a resistance of 83.3Ω. All we finally have to do is to draw a line parallel to it through the quiescent operating point to obtain the second loadline. This is done in Fig. 332 (*d*), in which the second loadline is the same as that of Fig. 332 (*b*). The second loadline defines the anode voltage and anode current conditions for the triode of Fig. 332 (*a*), when it has an h.t. voltage of 300, an anode load of 100kΩ and a following grid resistor of 500kΩ; and it is referred to as the *dynamic loadline* for these conditions. (In Fig. 332 (*d*) the $I_aV_a$ curves of Fig. 332 (*b*) are omitted to enable the loadline construction to be shown more clearly.)

The loadlines and loadline construction we have described in this month's article apply to voltage amplifiers having resistive anode loads and whose output is coupled to following grid resistors. We have used numerical examples to illustrate the manner in which the loadlines may be drawn, but it will be apparent that the principles involved can be applied to any reasonable values of anode load and subsequent grid resistor. In general, the procedure to be adopted consists of drawing the anode loadline, as dictated by the h.t. voltage and the resistance of the anode load, and of then finding the quiescent operating point which sets the optimum value for grid bias. To obtain a complete picture of valve performance, the dynamic loadline, whose slope corresponds to the parallel combination of anode load and following grid resistor, is then drawn through the quiescent operating point. Frequently, the following grid resistor will have a value which is three or more times greater than that of the anode load, and the dynamic loadline will not indicate results which are very different from those indicated by the anode loadline. On the other hand it can also happen that the points where the $I_aV_a$ curves cut the dynamic loadline are not as equally spaced as occur with the original anode loadline. It may be desirable, then, to alter the values of the circuit components or the position of the quiescent operating point to obtain best results as prescribed by the dynamic loadline. If the quiescent operating point is moved, its new position will then correspond to a new value of grid bias for the particular voltage amplifier under consideration.

### Next Month

In next month's article we shall pass on to the characteristics of practical triode valves, as will be encountered by the home constructor, student and service engineer.

# Crystal Controlled Converter for 21 Mc/s.

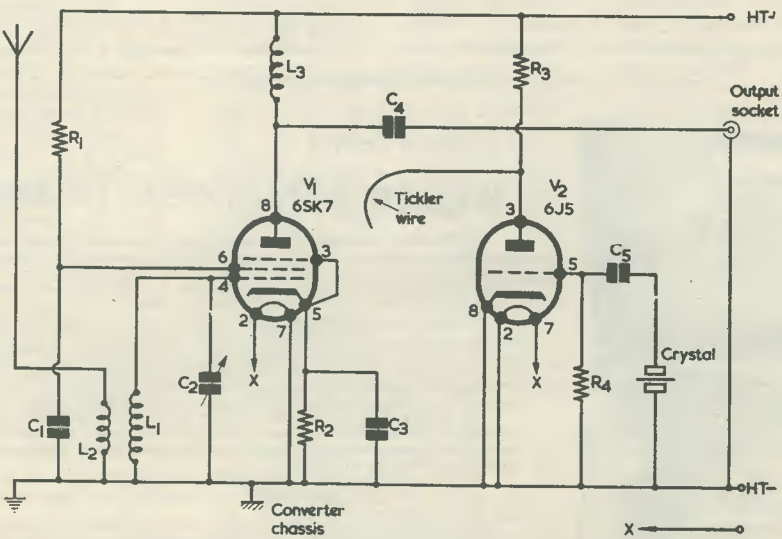
## By S. G. WOOD, G5UJ

It is generally agreed among amateurs that the crystal controlled converter is undoubtedly superior to the older tunable type. This article, therefore, may be of interest where the building of this particular type of unit is contemplated. The converter described is intended for reception on the 21 Mc/s band. As will be noted, the circuit is singularly straightforward, and the number of components needed is comparatively few!

In the writer's own version, a crystal having a frequency of 5725 kc/s was employed, but any other frequency in close proximity would do as well. The circuit employs a simple triode oscillator, $V_2$. A 6J5 was used in the prototype but if miniature valves are preferred a 6C4 would answer.

### Mixer

The mixer valve, $V_1$, was a 6SK7 but, here again,




*Theoretical circuit of the 21 Mc/s converter. The output socket couples to the aerial and earth terminals of the main receiver*

### Components List

*Resistors*
(All resistors ½ watt 20%)

| | |
|---|---|
| $R_1$ | 470kΩ |
| $R_2$ | 180Ω |
| $R_3$ | 47kΩ |
| $R_4$ | 100kΩ |

*Capacitors*

| | |
|---|---|
| $C_1$ | 0.01μF paper |
| $C_2$ | 50pF variable (air-spaced trimmer) |
| $C_3$ | 0.05μF paper |
| $C_4$ | 500pF ceramic or silver-mica |
| $C_5$ | 500pF ceramic or silver-mica (see text) |

*Inductors*
(Details of inductors are given in the text)

| | |
|---|---|
| $L_1$ | 21 Mc/s tuned coil |
| $L_2$ | aerial coupling coil |
| $L_3$ | $V_1$ anode load |

*Valves*

| | |
|---|---|
| $V_1$ | 6SK7 |
| $V_2$ | 6J5 |

*Crystal*
5725 kc/s crystal (see text)

*Sockets, etc.*
2 octal valve holders
1 coaxial output socket

an EF80 would work satisfactorily too. The coil, $L_1$, consists of 11 turns of 18 s.w.g. enamelled copper wire (spaced 16 turns to the inch) on a ⅜in former, and is tuned by the small air-spaced trimmer $C_2$. All the remaining components are the usual run-of-the-mill type, and the resistors may be of ½ watt rating. The inductor $L_3$, which forms the anode load of the mixer, may consist of a small medium wave coil with some 10 to 12 turns removed. Everything else is more or less self-explanatory. It should be emphasised that the whole unit must be carefully wired with the components closely grouped together, thus avoiding long leads.

The aerial may be coupled to $L_1$ via $L_2$, as shown in the circuit. $L_2$ should consist of 2 to 3 turns of 18 s.w.g. enamelled copper wire coupled *loosely* to the earthy end of $L_1$. The writer has also obtained good results by coupling the aerial directly to the upper end of $L_1$ via a capacitor having a value of 5 to 10pF.

The value specified for $R_1$ (470kΩ) may appear rather high, but it was found that no appreciable advantage was obtained by reducing it. Indeed, reduced values in this resistor caused an increase in noise level.

The position of the tickler wire is a matter for experiment. It should be found that adequate coupling is achieved by hooking the free end of this wire around the control grid pin of $V_1$. The tickler wire is, of course, insulated.*

Power supplies for the converter may be obtained from a simple power pack or, if sufficient current is available, from the associated receiver. Heater consumption is 0.6 amps at 6.3 volts. H.T. voltage may be between 175 and 250 volts, h.t. current being of the order of 5 to 10mA.

**Results**

With the values and components specified, it will be found that the 21 Mc/s band—for which the unit is designed—will be tunable around 1.85 to 1.45 Mc/s on the main receiver. Quite a short aerial will suffice, and some really hot Dx can be copied when conditions permit.

This compact and efficient little unit will well repay any any time or money spent on its construction.

* It should be noted that the oscillator circuit will probably function without the grid capacitor $C_5$, the upper terminal of the crystal connecting directly to the grid of $V_2$.—EDITOR.


## *Trade News*

## WELLER INSTANT-HEAT SOLDERING IRON

The Weller instant-heat soldering gun, illustrated herewith, is one of a family of soldering instruments which have just been released on the home market. The complete kit shown contains the 8100D 120 watt soldering gun, 240V a.c. only, supply of resin cored solder, 2 spare soldering bits, brush, spanner and soldering aid—these being vacuum packed on polystyrene foam within a handy carrying case.

This soldering gun has been designed for fast, easy and safe soldering, the finger-tip trigger control providing virtually instant heat at the bit. After operating the trigger switch the tip is hot within 3–4 seconds and cools, when the trigger is released, within 8 seconds. The two main benefits deriving from this are (*a*) waiting time is saved (2–5 minutes for larger orthodox irons) and (*b*) danger from a hot idling iron, remaining switched on by virtue of the long warm-up time of conventional irons, is avoided.

The compact feel and balance of the gun considerably aid precision soldering and we particularly liked the prefocused spotlight fitted below the soldering bit, this aiding the making of a sound soldered joint in that dark awkward chassis corner which most of us experience from time to time.

Accessory and replacement tips are available for this gun, one type of tip being provided for use on plastic and plastic tiles, whilst a further type is for use in repairing plastics, toys and damaged woodwork.

The 8100D soldering gun is available from retailers at 57s. 6d. whilst the kit shown is priced at 72s. 6d. Each soldering gun carries a 12 months' guarantee. Further details may be obtained from the manufacturers, Weller Electric Corporation, Blatchford Close, Horsham, Sussex.

# RADIO TOPICS . . .

## by Recorder

If you are plagued with intermittent faults that cannot be hunted down on the work-bench, a new product which was introduced several months ago may well provide the answer to your problem.

The new product is a chemical preparation called "Freeze-It" and it is supplied in 8oz aerosol tins complete with 6in applicators. The applicator is a 6in length of narrow-bore plastic tubing which enables the contents of the aerosol to be applied to components in any piece of equipment being checked.

"Freeze-It" comprises a blend of volatile liquids of low boiling point, the liquids and their vapours having high dielectric strength and being virtually non-conducting. They are, also, non-toxic and non-inflammable. If "Freeze-It" is applied to any object, the latter is immediately cooled (down to some −50° C) due to the heat taken up as the liquids evaporate.

A typical application of "Freeze-It" occurs with equipment whose faults clear, come on, or otherwise alter in nature after warming up. The preparation is sprayed on any suspected component which will then, if faulty, revert to its low temperature performance.

I have checked a sample of "Freeze-It" and it really is most effective in its cooling action. A 2-second squirt on the bulb of a 12in laboratory thermometer brought the mercury scuttling down from the ambient temperature of 20° C to well below the bottom graduation of 0° C. It is advised that "Freeze-It" be sprayed on the suspected component (which in many cases will have a lower thermal inertia than the bulb of the thermometer I checked with) after which one waits until a frost appears. One short squirt was all that was needed to cause the frost to appear almost immediately with a small transistor, which then became very cold to the touch.

To my mind, "Freeze-It" can be a valuable weapon in the service engineer's armoury. It is available from Servisol Ltd., Coopers Buildings, Church Street, Liverpool 1, and the 8oz aerosol, with applicator, costs 12s. 6d.

**Pink Boxes**

In our present age of computers and automation, we are gradually approaching the stage where the black box reigns supreme. And, of course, I hardly need to tell you that, in this context, a black box is any complex electronic device whose function is to provide computer or automatic control of an involved industrial process.

The Central Electricity Generating Board is currently investigating the possibility of using black boxes to control power station start-up and grid switching, and I was intrigued recently to hear that some of their engineers talk of their black boxes as being the successor to pink boxes. Pink boxes, I should hasten to add, are men.

**Something To Guard Against**

Beware of the door-to-door salesman who has subscriptions to journals to sell. A letter we have received from one of our regular contributors describes the sort of thing one has to be on guard against. I quote from the letter.

"I would take the opportunity of mentioning a most underhand form of salesmanship with respect to journals (including some electronics journals) so that you can consider the possibility of warning readers in your pages. I recently answered a knock on our door to find an apparently friendly young man who told me a long tale about being engaged on a world travel competition and that a neighbour of ours (whose name he mentioned) had suggested I might be able to assist him. During a somewhat vague conversation, which lasted about half an hour, I initially gathered that he was asking me to award him some marks for his friendliness in conversation, etc. He even produced a one-dollar note (and said he intended to win another 999 of them to enable him to travel) and some 'document' which he said would prove his authenticity. Eventually it came out that to award him 'marks' in the competition, I would have to take one or more journals (at a slightly reduced rate). Earlier he had asked me about my interests in an apparently friendly way, so the journals he suggested were electronics ones. Immediately I told him I was not interested in taking other journals and that I deplored such methods of underhand salesmanship and time wasting, his politeness declined somewhat and he left immediately. I later found that the neighbour whose name he had mentioned had not, in fact, sent him to me. The two electronics journals were American, but I am not sure whether the others on his list were American. I do feel that you would be doing readers a service if you could warn them of the real object of these people."

**Switch-Off Reminder**

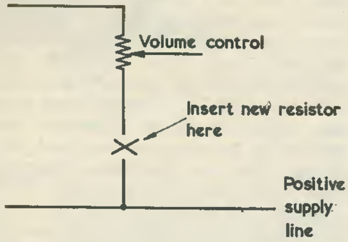
A minor snag with transistor radios is that their quiet output at low volume settings occasionally results in their being left switched on for quite considerable periods of time. What happens is that one occasionally neglects to turn the volume control down sufficiently far to actually switch the set off, with the result that the receiver continues to draw current from its battery without giving any audible indication that it is doing so.

We have published two articles in the past which discuss methods of overcoming this problem, these being "2mA Indicating Lamp for Transistor Radios" by R. M. Marston in the March 1964 issue, and "Switch-Off Indicator for Transistor Radios" by G. A. French in the November 1964 issue. A reader, Malcolm Hill of Newcastle-upon-Tyne, has now sent us details of an alternative approach. And a very simple approach it is, too!

Mr. Hill states that his scheme is even more effective than the previous ones—after all, one may not happen to glance at a lamp until too late—and requires only one solitary resistor.

"The idea", continues Mr. Hill, "is to prevent the radio being turned all the way down unless switched off. When the knob is turned right down, the sound remains very quietly there—just loud enough to draw attention to the fact that the set has been left on, but quieter than needed for 'personal' listening.

"A resistor of about 330Ω is inserted in the bottom end of the volume control which would normally go direct to the positive supply line or a similar earthy point. The resistor may be soldered directly to the right-hand tag (viewed from the front with tags upwards) after removing the wire which formerly was connected to the tag. The wire is now connected to the free end of the resistor.




*Adding a resistor to the volume control circuit of a transistor radio ensures that a low level signal is heard even with the control turned right down. See "Switch-Off Reminder"*

"The optimum value for the resistor is that which gives about 26dB ($^1/_{20}$) reduction in sound volume compared to normal listening level. For sets which need to be turned almost all of the way up for normal listening level, a resistor of about $^1/_{50}$ of the volume control resistance works very well.

"More sensitive sets which are usually turned only a fraction of the way up will require proportionately less.

"As mentioned before, 330Ω seems to be about right for the radios which I have modified, but it's not in the least critical and the reader should remember that a 50% increase or decrease in resistor value gives a change in sound level only just noticeable to most people. It is rather pointless therefore to alter the value in steps of less than this."

The simple circuit involved is shown in the accompanying diagram. And they don't come much simpler than that!

**January Again**

When you read these notes 1965 should just have expired, leaving the stage to 1966. I have little doubt that the New Year will mark the appearance of even further important developments in this fascinating world of electronics. Our forward planning at *The Radio Constructor* already extends quite a way into the year, and I can assure you that we have plenty of interesting and really exciting projects lined up for your pleasure.

Happy New Year!

# An Improved Room Thermostat

## *By* W. H. REYNOLDS

*The popularity of small-bore central heating increases as its advantages become more generally known, and our contributor describes how he improved the performance of his own installation by incorporating an inexpensive thermostat with a simple auxiliary heater. Readers wishing to try the additional thermostat circuit should first of all ensure that it is suitable for use with their own particular heating systems*

THERE HAVE BEEN SEVERAL ARTICLES RECENTLY in do-it-yourself journals concerning thermostats, but not very much information about the temperature differentials one can expect from them. The writer's central heating system had no room thermostat fitted, and the room temperature was controlled by the setting of the thermostat on the boiler, which also supplied the hot water system. This was by no means an ideal arrangement, because if the accelerator pump ran continuously at a setting suitable for hot water (150 to 160°F) then the rooms became overheated during mild spells. One had either to operate with low temperature or run around altering radiator valves with changes of the weather.

**Thermostat Differential**

Thinking to overcome these difficulties, a cheap thermostat was obtained and its differential checked. This seemed to be about 3°F. However, when it was wired in series with the electric supply to the accelerator pump motor, conditions in the rooms were not ideal. The family complained of the cold, although the thermometer showed a drop of only 2°F at times. On the heating cycle, when the thermostat eventually cut out after about 2 hours of heating, the room felt just right. Before it cut in again, 1½ hours later, the room felt decidedly chilly. A more sensitive thermometer was used but this only confirmed that the room varied between 65 and 68°F.

A little investigation showed that the discomfort came not from the marginally lower ambient temperature, but from the loss of radiation from the radiators. If one sat near a radiator, and it was difficult not to, then one grew accustomed to its surface temperature and felt nice and warm. If the radiator no longer radiated heat, one felt cold.

There seemed to be two alternatives, these consisting either of obtaining a more expensive thermostat with a differential of about 0.5°F, or of making the cheap one cut in and out more quickly. Research revealed that some commercial room thermostats use an auxiliary heater to do just this; and they work in the following manner.

The temperature sensitive element is enclosed in a small box with a small heater. Starting from the moment the boiler is lit, the room is cold and the thermostat box is at the same temperature. The accelerator pump starts pumping first warm, then hot water round the radiator circuit and, at the same time, the auxiliary heater starts heating up the air in the box. The time taken for the box and thermostat to reach the cut out point depends on:

(*a*) the rate at which heat is provided by the heater,
(*b*) the rate at which heat is lost by the box into the colder room.

The size of the heater is carefully chosen so that, under these first heating conditions, the thermostat cuts out after about 30 minutes. With the hot water circulation stopped by the stoppage of the pump, and with no heater inside the box, the temperature sensing device and its box now loses heat into the cooler room until the contacts close again. Now the room is warmer than it was at the start and of course the box is too, so that the auxiliary heater has less work to do to warm the box up to cut out temperature and the loss of heat to the room is also less. The factors combine to allow the contacts to open sooner than they did at the first heating. When the contacts open, the warmer room and warmer box and even lower radiation losses ensure that the contacts stay open longer. Thus the cycles are repeated with shorter heating times and longer cooling times until an equilibrium position is reached when the contacts are open and closed for approximately the same periods of time, say about 10 minutes each. This speedy operation keeps the surface temperature of the radiators almost constant and the body feels comfortable.

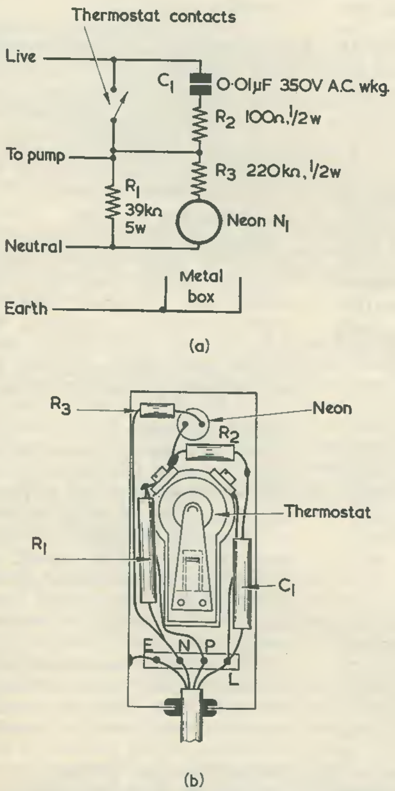



*Fig. 1 (a). The circuit of the thermostat with its auxiliary heater. The latter consists of resistor $R_1$ (b). The layout of components inside the thermostat box*

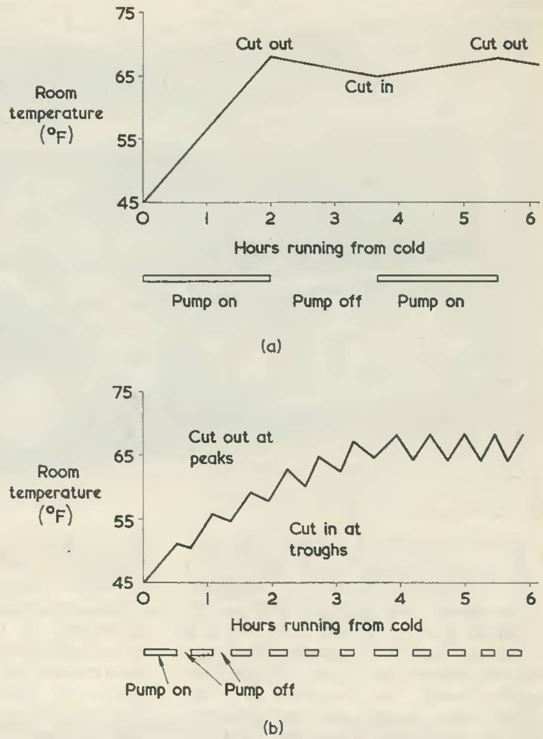



*Fig. 2 (a). The results obtained with the original room thermostat having a differential of 3° F*
*(b). Adding the auxiliary heater to the thermostat afforded a considerable reduction in the on and off periods, giving the results shown here*

**Practical Results**

To put this idea in practice, a small box was obtained and the thermostat mounted in it. The circuit shown in Fig. 1 (*a*) was connected up. $R_1$ is the auxiliary heater in parallel with the pump motor, whilst $R_2$ and $C_1$ are for suppressing any electrical interference. A small neon fed by $R_3$ was used to check on the operation of the thermostat, and to time the periods of heating and cooling.

The most suitable value of resistor for $R_1$ was found to be 39kΩ. A vitreous 5 watt resistor was used. The unit was mounted on a wall in a position where it was affected by the temperature of the rooms downstairs, and has now been working for several months with complete success. The total cost was 16s., and apart from better temperature conditions in the rooms, there should be a lower fuel bill because of the more economical running of the boiler and pump.

Fig. 2 shows the results obtained before and after the auxiliary heater was added to the room thermostat.

Although the unit was for a room thermostat in a hot water heating system, the same principles can be applied to any application where rapid operation of a thermostat is required.


# Introducing the Eddystone "EB-35" Receiver

The Eddystone "EB35" broadcast Receiver is a fully transistorised model of compact dimensions and operating from an internal battery power unit. It is a versatile receiver giving coverage on the long wave band, the medium wave band, the majority of the short wave bands, and the international v.h.f./f.m. range of 88 Mc/s to 108 Mc/s, with a high performance throughout.

Features standard to Eddystone receivers are incorporated. The flywheel-loaded tuning knob controls a finely engineered gear drive with a reduction ratio of 110 to 1, resulting in smooth, precise tuning. The main scales occupy a length of 9in and are clearly marked directly in frequency. Tuning to a given frequency is a comparatively simple matter and a useful additional feature is the provision of a logging scale to permit settings of preferred stations to be recorded for future reference.

The versatility of the "EB35" extends further than the wide range of frequencies covered. A socket is provided from which the signal can be fed to a high fidelity amplifier and the receiver can thus be used as a tuner unit in conjunction with a "hi-fi" system, still retaining the advantage of having a large number of stations from which to choose. The same socket serves when it is desired to use a tape recorder. A second socket enables the audio frequency stages of the receiver to be used as an amplifier with a record player.

An internal speaker is fitted and the headphone jack on the panel can be used either with a pair of low impedance headphones (preferably of the high quality type) or with a large external speaker.

Power is normally derived from a battery of U2 type cells housed in a detachable compartment. An alternative unit (Cat. No. 924), operating direct from a.c. mains and providing the correct voltage and current, is available separately and is readily interchangeable with the battery unit.

The "EB35" receiver is housed in a metal cabinet, and, with robust construction throughout, it will stand up to hard usage over a long period with a high degree of reliability. Chromium-plated handles are fitted and the finish is an attractive combination of dark green and beige. The receiver is suitable for use in all parts of the world.

**General Information**

**Frequency Coverage**

| | | | | |
|---|---|---|---|---|
| Range 1 | 8.5 Mc/s | to | 22 Mc/s. |
| Range 2 | 3.5 Mc/s | to | 8.5 Mc/s. |
| Range 3 | 1.5 Mc/s | to | 3.5 Mc/s. |
| Range 4 | 550 kc/s | to | 1,500 kc/s. |
| Range 5 | 150 kc/s | to | 350 kc/s. |
| VHF/FM | 88 Mc/s | to | 108 Mc/s. |

**Tuning System**

The scales are horizontal, occupying a length of approximately nine inches. Frequencies are clearly marked to a calibration accuracy within 1%. The tuning control is flywheel-loaded and operates a gear drive with a reduction ratio of 110 to 1. A logging scale and auxiliary vernier allow dial settings to be recorded.

**Controls**

Six conveniently placed and clearly marked controls as follows: on/off switch; volume; tone; wavechange; tuning; dial lights.

**Circuitry**

A total of thirteen transistors, five diodes and a Zener stabiliser is used. A radio frequency amplifier is effective on all frequencies, leading to high sensitivity. The discriminator is of the Foster-Seeley type, for minimum distortion of the FM signal.

**Power Supply**

Power is derived from a battery of six U2 type cells, housed in a separate compartment and readily detachable. Voltage stabilisation, where required, is achieved with a Zener diode, which feature leads to a constant performance up to the end of the useful life of the battery.

**Special Features**

Two sockets are provided at the rear. One is for taking a signal from the detector stage, at moderate impedance, for feeding into either an external amplifier or into a tape recorder. The second socket accepts a signal from a record player and, with a plug inserted, the earlier stages of the receiver are muted.

Dial lamps are provided for occasional use, the switch being of the self-return type, to avoid unnecessary drain on the battery.

**Dimensions and Weight**

Height 6$\frac{3}{8}$in (16.2 cm)
Width 12$\frac{1}{2}$in (31.7 cm)
Depth 8 in (20.3 cm)
Weight (less battery) is 12$\frac{3}{4}$lb (5.8kg.) with battery 14lb (6.3kg)

### Technical Performance Figures

The following figures are provided for those wishing to have full technical information on the performance of the "EB35" receiver. In plain language, it can be taken that the receiver has high sensitivity and is designed to give good separation between stations transmitting on adjacent channels. The audio output is ample for the majority of domestic requirements and is of good tonal quality. When desired, a larger cabinet type of speaker (of 10Ω nominal impedance) can be used, the lead being plugged into the socket on the front panel.

To allow the receiver to make the most of the incoming signal, an outdoor aerial (not necessarily long), erected in the clear, is recommended, and this will help also the level of local electrical interference. On v.h.f./f.m., an aerial designed for reception on these frequencies should be used.

### Sensitivity

For 15dB signal-to-noise ratio, sensitivity is better than 5 microvolts on ranges 1 to 3, and better than 15 microvolts on ranges 4 and 5. On v.h.f./f.m., sensitivity is 20 microvolts at 22.5 kc/s deviation for a 20dB signal-to-noise ratio.

### Selectivity

On ranges 1 to 5, the bandwidth is 5 kc/s at the 6dB points and 25 kc/s at the 40dB points. F.M. band width is 250 kc/s at the 6dB points.

### Spurious Responses

The image rejection is approximately 50dB at 2 Mc/s and 15dB at 18 Mc/s. Breakthrough at the i.f. of 465 kc/s is at least 85dB down on ranges 1 to 3 and greater than 65dB down on ranges 4 and 5.

On the v.h.f./f.m. range, the image ratio is better than 25dB. and i.f. breakthrough better than 50dB.

### Audio Output

The maximum output approaches 750 milliwatts. A 5in speaker is built-in and a jack on the panel is for use with low impedance headphones. Frequency response is level within 6dB over the range 100 to 10,000 cycles.

### Aerial Input Impedances

On ranges 1 to 3, the input impedance is nominally 75Ω, balanced or unbalanced, to allow the use of a dipole or single wire aerial. On ranges 4 and 5 the input impedance is nominally 400Ω.

A standard unbalanced coaxial socket, with a nominal impedance of 75Ω, is provided for connection of the feeder from a v.h.f. aerial for f.m. reception.

A comprehensive instruction manual is supplied with the receiver together with a 12 months guarantee against faulty workmanship or components (excluding semiconductors). List price of the EB35 receiver in the U.K. is £71 5s. 0d. (purchase tax included) and the a.c. supply unit (Cat. No. 924) £5 0s. 0d.

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# Recent Publications . . .

**TECHNICAL TOPICS FOR THE RADIO AMATEUR.** By Pat Hawker, G3VA. 104 pages, 7¼ x 9½in. Published by Radio Society of Great Britain. Price 10s.

This well-produced book is, in the main, a collection of circuits and data which have previously appeared in the *RSGB Bulletin* under the title of "Technical Topics" during the period 1958–1965.

The book has been logically arranged in sections: Semiconductors; Components and Construction; Receiver Topics, Oscillator Topics; Transmitter Topics; Audio and Modulation; Power Supplies; Aerial Topics; and Fault Finding and Test Units, the whole being liberally illustrated with some 237 circuits and line diagrams.

For those interested in obtaining a permanent record of interesting new ideas and circuits, many of which may be incorporated in existing equipment, this book will undoubtedly find an almost permanent place on the workbench —hardly ever on the bookshelf!

**RSGB AMATEUR RADIO CALL BOOK 1966 EDITION.** Compiled by John Clarricoats, O.B.E., G6CL. 96 pages, 7¼ x 9¾in. Published by Radio Society of Great Britain. Price 6s.

This latest edition of the *RSGB Amateur Radio Call Book* records the many changes that have taken place since the 1965 edition was published; more than 1,000 new callsigns being listed. Of these additions, 800 are in the G3AAA series and 225 in the G8AAA series. In addition, calls in the new G6AAA/T series are also listed. The G8AAA series are issued to holders of the new Amateur (Sound) Licence B, this authorising the use of phone only on frequencies above 420 Mc/s and does not require the licensee to possess a knowledge of the Morse Code. The G6AAA/T series are issued to holders of the Amateur (Television) Licence and replace the old-type /T calls.

In addition to listing the new calls, the 1966 edition also records well over 1,500 changes of address that have occurred during the year.

**HAM ANTENNA CONSTRUCTION PROJECTS.** By J. A. Stanley. 160 pages, 5½ x 8¾in. Published by Foulsham-Sams Technical Books. Price 24s.

Most of the books dealing with amateur transmitting aerials read so far, deal thoroughly with the theory of antenna radiation, and in some cases give good ideas on the constructional side, but most leave the reader with a sort of hiatus between theory and practice.

The present title, however, takes the reader gently through elementary theory to its application in practical aerial systems, with plenty of contructional information to help the inexperienced. The book commences with the most elementary type of transmitting aerial for the lower frequency bands, viz., a dipole for 80 metres, and concludes with v.h.f. aerials and special purpose antennas for the Dx enthusiast. Full constructional details are given for all the aerials and their tuning units, throughout the book.

Whilst originally written for the American radio amateur, this book is equally of value to the British reader, as is explained in the foreword by W. Oliver, G3XT.

This book makes an excellent introduction to the often bewildering field of antenna construction for the transmitting radio amateur. Any beginner who works through the projects detailed in this volume will learn a great deal about transmitting aerials and should have a most interesting and instructive time on the air.

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**FOR SALE.** Genuine Mullard BY100 *and* resistor 6s. Also BVA, EF80, ECC81, EBF89, etc., 5s. Lists free—Messrs. E. A. Johnson, 12 Pank Avenue, New Barnet, Herts. Mail only.

**SPEED SERVICING** with a stage substitution analyser made from surplus 2 band T.V. receiver. Descriptive leaflet. Diagrams 5s. 6d. inc. postage.—Moore, 40 Carleton Road, Higher Poynton, Cheshire.

**STEREO RECORDS FOR SALE.** *Marches from Operas*, AF.FCS 50008; *Bob Sharples and His Music*, Decca SKL 4110; *Tchaikovsky in Phase Four*, Decca PFS 4044. All unblemished at 15s. each.—Box No. F246.

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*continued on page 397*

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| 6BJ6 | 5/6 | 20P3 | 12/– | ECC81 | 3/6 | EL86 | 7/3 | PCL83 | 9/6 | UCH21 | 8/– |
| 6BQ7A | 7/6 | 20P4 | 13/– | ECC82 | 4/6 | EL95 | 5/– | PCL84 | 7/6 | UCH42 | 8/– |
| 6BR7 | 12/– | 20P5 | 11/6 | ECC83 | 4/6 | ELL80 | 13/6 | PCL85 | 8/6 | UCH81 | 6/6 |
| 6BW6 | 7/6 | 30C15 | 10/– | ECC84 | 5/6 | EM34 | 11/6 | PCL86 | 8/9 | UCL82 | 7/3 |
| 6CD6G | 18/– | 30C17 | 11/9 | ECC85 | 5/9 | EM71 | 15/6 | PEN45 | 7/– | UCL83 | 9/3 |
| 6CH6 | 6/6 | 30C18 | 9/3 | ECC88 | 8/9 | EM80 | 6/3 | PL36 | 9/– | UF41 | 6/9 |
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| 6L1 | 10/– | 30P12 | 7/6 | ECH21 | 10/– | EY51 | 5/6 | PL84 | 6/3 | UF89 | 5/6 |
| 6L6GT | 7/3 | 30P19 | 12/– | ECH35 | 6/– | EY81 | 7/3 | PM84 | 9/3 | UL41 | 7/– |
| 6L18 | 10/– | 30PL1 | 9/6 | ECH42 | 8/– | EY83 | 9/3 | PY33 | 8/9 | UL84 | 5/6 |
| 6LD20 | 6/6 | 30PL13 | 10/6 | ECH81 | 5/9 | EY84 | 9/6 | PY80 | 4/9 | UM80 | 8/3 |
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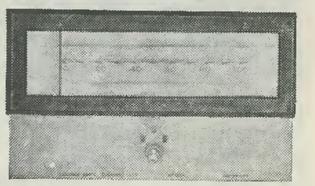

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*continued on page 397*

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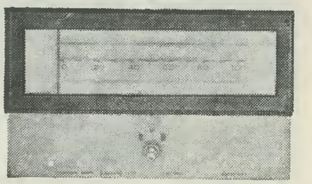

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*continued on page 397*

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*continued from page 395*

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*continued on page 399*

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*continued from page 397*

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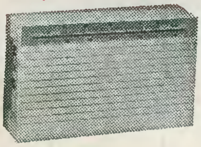

TOTAL COST TO BUILD
**85/–** P.P 2/–
(Battery 2/6 Phone 5/–)
★ All parts sold separately.

★ 6-Transistor design. Push-pull output.
★ 2¼" Cleartone speaker. Printed circuit.
★ Attractive moulded cabinet.
★ Slow motion tuning.
★ Full medium and long waves.
★ Size: 5" x 3" x 1¼".
● AMAZING SENSITIVITY AND SELECTIVITY ●

★ 6-Transistor push-pull design.
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★ Double tuned IFT's.
★ Chromed front panel plate.
★ Size: 7" x 4" x 2". Fits any car.
★ Pre-built units sold separately.

TOTAL COST TO BUILD
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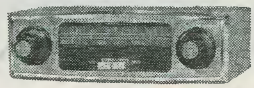
P.P. 3/6



(7" x 4" speaker with car fixing kit and baffle board 20/– extra.)

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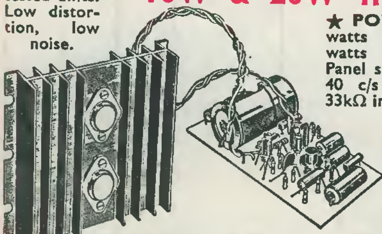
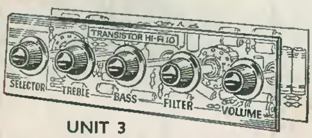


UNITS 1 & 2


UNIT 5

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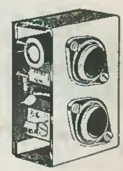

★ 6-Transistor push-pull printed circuit designs
★ Size only 2¾" x 2" x 1½".
★ 5 watt 18 volt, 1½ watt 12 volt
★ For 3 to 5 ohm speakers
★ 7mV into 1kΩ 30 c/s to 16 kc/s
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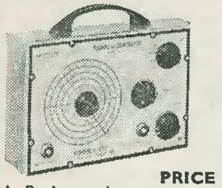

All units size 6⅝" x 4⅝" x 2¾".
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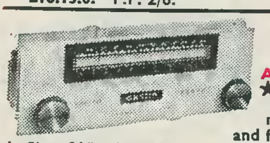

★ Two pre-built plus metal work and front panel.
Total Cost £12.17.6 P.P. 2/6
★ Size: 9½" x 3½" x 4"
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★ 100mV to 100kΩ output
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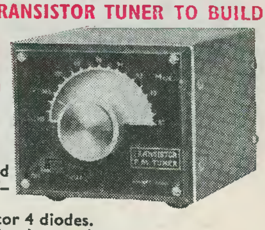
(complete with frontplate)
(Gold sprayed cabinet 20/– extra).



★ 5-Transistor 4 diodes.
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