15 5p.

# THE Radio Constructor

RADIO
TELEVISION
AUDIO
ELECTRONICS

VOLUME 18 NUMBER 5
A DATA PUBLICATION
TWO SHILLINGS & THREEPENCE

December 1964

## constructing a solid bass GUITAR

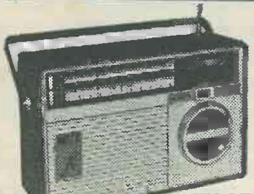
Portable P.A. Amplifier • • • "Magic" Switching for Christmas Lights • • • Electronic Locks and Anti-Thief Devices

# LASKY'S RADIO

FOR THE FINEST RANGE OF

# TRANSISTOR RECEIVERS

**We consider our construction parcels to be the finest value on the home constructor market. If on receipt you feel not competent to build the set, you may return it as received within 7 days, when the sum paid will be refunded, less postage.**



## THE SKYROVER Mk II

**Now supplied with redesigned cabinet, edgewise controls, new colour tuning scale and cabinet.in Siera Tan.** Controls: Waveband Selector, Volume Control with On/off Switch, Tuning Control. In plastic cabinet, size 10" x 6½" x 3½", with metal trim and carrying handle.

*Can now be built for*

**£8.19.6**

**H.P. Terms:—20/- dep. & 11 months at 16/6**

*P. and P. 5/– extra*

*All components available separately. Four U2 batteries 3/4 extra. Data for each receiver, 2/6 extra, refunded if you purchase the parcel.*

## The SKYROVER RANGE

**GENERAL SPECIFICATION.** 7 transi-tor plus 2 diode superhet, 6 waveband portable receiver. Operating from four 1.5V torch batteries. The SKYROVER and SKYROVER DE LUXE cover the full medium waveband and short waveband 31–94 M, and also 4 separate switched band-spread ranges, 13 M, 16 M, 19 M and 25 M, with band-spread tuning for accurate station selection. The coil pack and tuning heart is completely factory assembled, wired and tested. The remaining assembly can be completed in under three hours from our easy to follow, stage by stage instructions.

*SPECIFICATION:* Superhet, 470 kc/s. All Mullard transistors and diode. Uses 4 U2 batteries. 5" Ceramic Magnet P.M. Speaker. Easy to read Dial Scale. Band-spread Tuning. 500mW Output. Telescopic Aerial and Ferrite Rod Aerial.

## THE SKYROVER DE LUXE

Tone Control circuit is incorporated, with separate Tone Control in addition to Volume Control, Tuning Control and Waveband Selector. In a wood cabinet, size 11½" x 6½" x 3", covered with a washable material, with plastic trim and carrying handle. Also car aerial socket fitted.

*Can now be built for*

**£10.19.6**

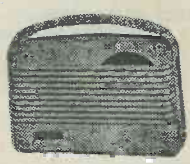
*P. and P. 5/– extra*

**H.P. Terms:—25/– deposit and 11 months at 20/–**

**★ LONG WAVEBAND COVERAGE IS NOW AVAILABLE FOR THESE WELL-KNOWN SETS.** A simple additional circuit provides coverage of the 1,100-1,950 metre band (including 1,500 metre Light Programme). This is in addition to all existing medium and short wavebands. All necessary components with construction data. **Only 10/– extra** **Post Free**
**This conversion is suitable for both models that have already been constructed.**

## REALISTIC SEVEN

★ 7-transistor Superhet. ★ 350 milliwatt output into 4" high flux speaker. ★ All components mounteo on a single printed circuit board, size 5½" x 5½" in one complete assembly. ★ Plastic cabinet with carrying handle, size 7" x 10" x 3½", available in Blue/Grey. Full L. & M. coverage ★ Easy to read Dial. ★ External socket for car aerial. ★ I.F. frequency 470 kc/s. ★ Ferrite rod internal aerial. Operates from PP9 or similar battery. ★ Full comprehensive data supplied with each receiver. ★ All coils and I.F.s, etc., fully wound ready for immediate assembly.



An Outstanding Receiver. **LASKY'S PRICE** for the complete parcel including Transistors, Cabinet, Speaker, etc., and Full Construction Data. Can be built for: **£5.19.6**

*P. and P. 4/6*

PP9 Battery, 3/9. Data and instructions separately, 2/6. Refunded if you purchase the parcel. All parts sold separately.

## REALISTIC 'Seven' De Luxe

With the same specification as standard model —PLUS a superior wood cabinet in contemporary styling. ALSO a full vision circular dial

FOR ONLY **£1** EXTRA

*P. & P. as std. model*

## SINCLAIR SUPER MINIATURES

### THE SINCLAIR SLIMLINE

The new 2-transistor pocket radio, size only 2¾" x 1⅝" x 1⅝". Micro alloy transistors and printed circuit. Easy to assemble.

**CAN BE BUILT FOR 49/6**

### THE SINCLAIR MICRO–6

Self-contained pocket radio. Size only 1⅘" x 1³⁄₁₀" x ½"–truly amazing performance. Without doubt the most advanced transistor circuit ever offered to home constructors—yet may be built in an evening. Complete with earphone and detailed construction data. Mercury cell 1/11 extra (2 required).

**CAN BE BUILT FOR 59/6**

### THE SINCLAIR X10

10 watt power amplifier fitted with integrated pre-amp. Requires only 1mV for an output of 10 watts undistorted. Frequency response is flat, ½dB from 5 c/s to 10 kc/s. Size only 6" x 3" x ¾", weight 5 oz., built on printed circuit. Operates from 12V d.c. at 75μA quiescent. Circuit uses 7 MATs and 4 r.f. power transistors.

**KIT PRICE £5.19.6** **READY BUILT £6.19.6**

3 pots. for volume, bass & treble, 7/6 the 3 extra.

### TRANSFILTERS by BRUSH CRYSTAL CO.

TO-01B 465 kc/s ± 2 kc/s
TO-01D 470 kc/s ± 2 kc/s
TO-02B 465 kc/s ± 1 kc/s
TO-02D 470 kc/s ± 1 kc/s
TF-01B 465 kc/s ± 2 kc/s
TF-01D 470 kc/s ± 2 kc/s

**6/6 each**
**P. & P. 6d.**

### PICK-UP CARTRIDGES

**Crystal P.U. Cartridges complete with stylii—at lowest prices ever!**

| | |
|---|---|
| Mono C.T.I. ... ... ... ... | 4/11 |
| Collaro Type C, stereo, 2 sapphires. ... | 15/– |
| Collel S.C.I. Stereo Diamond LP Sappl. std. ... ... ... ... ... | 17/6 |
| Sonotone 8T, stereo, 2 sapphires ... | 19/11 |
| Sonotone 2TA, mono, 2 sapphires ... | 15/– |

Postage 1/– each extra.

### 12" FANE HI-FI SPEAKER BARGAINS

**Type 122/17.** Power handling 25 watts—15 ohms imp. Flux density 17,000 gauss. Special anisotropic magnet. Listed at £11.17.6. *Limited stock*
**LASKY'S PRICE £5.19.6 P. & P. 5/–**

**WHARFDALE WNA12.** 12" 15Ω imp. Flux density 14,000 oer'ds. Max. input 15 watts RMS, 30 watts peak. Frequency range 25–4,000 cp.s. Cone fitted with roll surround.

**WHARFDALE SUPER 5.** 5" mid-range and high requency speaker. 15Ω imp. Frequency range 300–17,000 c.p.s. Aluminium voice coil. These two speakers provide an ideal matched pair for a full range hi-fi speaker system. Both brand new and individually boxed.
**LASKY'S PRICE £12.19.6 the pair.** P. & P. 10/–

**Sub-Min. Transformerless Transistorised Amps.**
British made, these sub-min. amplifiers come to you fully built and ready for immediate use. Thousands of uses in all branches of electronics: sound and signal amplification—models—electro medico equipment—pre-amps.—radio tuners—tape head amps., etc.. All use NPN–PNP circuit powered by 9V battery.

**PC1,** input 50mV, output 150mW at 40Ω, size 2" x 1" x ¾". **LASKY'S PRICE 29/6** P. & P. 1/–
**PC2,** input 1mV, output 400mW at 15Ω, size 2" x 2½" ¾". **LASKY'S PRICE 37/6** P. & P. 1/–
**PC3,** input 5mV, output 400mW at 15Ω, size 2½" x 1½" x ¾". **LASKY'S PRICE 37/6** P. & P. 1/–
**PC4,** input 150mV, output 400mW at 15Ω, size 2½" x 1½" x ¾". **LASKY'S PRICE** 37/6 P. & P. 1/–

### TAPE DECK MOTORS

Motors for the Collaro Studio Deck — new and unused. 200–250V A.C. Take-up and rewind. Listed at £2 5s. each. **LASKY'S PRICE 14/11 each.** *P. & P. 2/6.*

State motor required when ordering.

High quality tape deck capstan motor made by E.M.I. Holland. Bi-directional. Size: 4" dia., x 2" high. 1" x ½" spindle.
**LASKY'S PRICE 19/11.** *P. & P. 3/6.*

### RECORDING TAPE SPLICER

By famous manufacturer — all metal construction. Listed at 18/6 **LASKY'S PRICE 14/6** *Post Free*

### LAFAYETTE TAPE

**Famous American Brand—Fully Guaranteed at record low prices. In sealed cartons.**

| | |
|---|---|
| 5in double play, 1,200ft. Mylar base ... | 15/– |
| 5in long play, 900ft. Acetate base ... | 10/– |
| 5in standard play, 600ft. PVC base ... | 8/6 |
| 5¾in long play, 1,200ft. Mylar base ... | 15/– |
| 5¾in double play, 1,800ft. Mylar base ... | 22/6 |
| 5¾in long play, 1,200ft. Acetate base ... | 12/6 |
| 5¾in standard play, 850ft. PVC base ... | 11/6 |
| 7in standard play, 1,200ft. Mylar base ... | 12/6 |
| 7in long play, 1,800ft. Mylar base ... | 19/6 |
| 7in double play, 2,400ft. Mylar base ... | 25/– |
| 7in long play, 1,800ft. Acetate base ... | 15/– |
| 3in message tape, 150ft ... ... ... | 3/6 |
| 3in message tape, 225ft ... ... ... | 4/11 |
| 3in message tape, 300ft ... ... ... | 7/6 |
| 3in triple play, 450ft. Mylar base ... | 12/6 |
| 4in triple play, 900ft. Mylar base ... | 22/6 |
| 5in triple play, 1,800ft. Mylar base ... | 42/6 |
| 5¾in triple play, 2,400ft. Mylar base ... | 55/– |
| 7in triple play, 3,600ft. Mylar base. ... | 75/– |

*P. & P. 1/- extra per reel; 4 reels and over Post Free.*

### HI-FI TAPE RECORDER HEADS

High Impedance Record Play. Low impedance erase. Upper or lower track.
**LASKY'S PRICE 29/6** Post free per pair. State track required.
MARRIOTT "X" Type ¼ track heads. Record/Play and Erase.
**LASKY'S PRICE** 4 gns. pair
¼-Track heads Record/Play and Erase 59/6 pair

### TAPE POSITION INDICATOR

Open type—as used by most makers. With re-set knob:
3 DIGIT 7/6; 4 DIGIT 10/6. *P. & P. 9d. on each.*

### TRANSISTORS

**All New and Guaranteed**

GET.S1, GET.S5, GET.S6—2/6; 873A, 874P—3/6; OC.45, OC.71, OC.81D—4/6; OC.44, OC.70, OC.76, OC.81—5/6 (matched pair 10/6); AF.117, OC.75, OC.171, OC.200 — 6/6; OC.42, OC.43, OC.73, OC.82D—7/6; OCP.71—9/6; OC.28, OC.201, OC.204—15/–; OC.205, OC.206—19/6; OC.28—24/6.

**33 TOTTENHAM COURT ROAD · W1**
**2 mins. Oxford St. Nearest Station: Goodge St.**
**MUSeum 2605**

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**Few yards from Praed St.**
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**(ELECTRONICS Fleet St. Ltd) FLEet 2833.**
Open all day Thurs. Closed 1 p.m. Sat.

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## TAPE DECKS — CONTROL UNITS — TAPE AMPLIFIERS

MAGNAVOX

D-93

FM-4U

AM/FM

**MAGNAVOX "STUDIO" TAPE DECK.** The finest buy in its price range. Operating speeds: 1⅞", 3¾" and 7½" p.s. Two tracks, "wow" and "flutter" not greater than 0.15% at 7½" p.s. **£14.19.6**

**TRUVOX D93 TAPE DECKS.** High quality stereo/mono tape decks.

D93/2, ½ track, **£36.15.0** D93/4, ¼ track, **£36.15.0**

**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—£21.16.6). Printed circuit board, 8 valves. Covers L.W., M.W., S.W., and F.M. Built-in power supply. Total Kit **£26.10.0**

**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 amplifier unit, with power supply and valves (£13.3.0). Total Kit **£15.18.0**

**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

## "AMATEUR" EQUIPMENT

**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**

RA-1

**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 aerials, tuning meter and large slide-rule dial.
Kit **£37.17.6** Assembled **£45.17.6**

**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

SB-10U

**COMMUNICATIONS TYPE RECEIVER. Mode 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**

**SINGLE SIDEBAND ADAPTOR. Model SB-10U.** May be used with most A.M. transmitters. Less than 3W R.F. input power required for 10W output. Operation on 80, 40, 20, 15 and 10m bands on U.S.B., L.S.B. or D.S.B. Kit **£39.5.0** Assembled **£54.18.0**

Many other British 'Amateur' models. Send for Catalogue.

**AMERICAN HEATHKIT "AMATEUR" EQUIPMENT**

(As stocks in U.K. are limited, order as early as possible to avoid disappointment)

**80–10M RECEIVER. Model SB-300E.** This de luxe receiver offers unsurpassed value to the Radio Amateur. Of advanced design employing up-to-date construction techniques, its specification ensures unparalleled performance. Full details on request. Size 14¾" x 6¾" x 13¾". **Kit £133.14.0** (less speaker) plus import levy.

SB-300E

A fitting companion to this receiver is model **SB-400E TRANSMITTER:** Kit **£165.4.0** plus import levy.

**SEND FOR AMERICAN CATALOGUE. 1/- Post Paid**
**Deferred Terms available in U.K. on all purchases over £10.**
**Extended Deferred Terms available in U.K. over £75.**

## SPEAKER SYSTEMS

**COTSWOLD "MFS" SYSTEM.** Specially developed to give best possible results in small rooms. This minimum floor space model is based on standard Cotswold. Size: 36" high x 16½" wide x 14½" deep.
Kit **£23.4.0** Assembled **£30.15.0**

**THE "COTSWOLD".** This is an acoustically designed enclosure 26" x 23" x 15½" housing a 12" bass speaker with 2" speech coil, elliptical middle speaker together with a pressure unit to cover the full frequency range of 32–20,000 c/s. Capable of doing justice to the finest programme source, its polar distribution makes it ideal for really Hi-Fi Stereo.
Kit **£23.4.0** Assembled **£30.15.0**

MFS

**HI-FI SPEAKER SYSTEM. Model SSU-1.** Ducted-port bass reflex cabinet "in the white". Two speakers. Vertical or horizontal models with legs, Kit **£11.12.0**, without legs, Kit **£10.17.6** incl. P.T.

SSU-1

MALVERN

## HI-FI CABINETS

A wide range of equipment cabinets are available to meet the differing needs of enthusiasts. Designed for max. operating convenience or for where room space is an overriding consideration, this range includes kits, ready assembled cabinets or fully finished cabinets, and has at least one model to suit your requirements. Send for full details.

Prices from **£7.7.0** to **£37.16.0**

## SEND FOR FREE BRITISH HEATHKIT CATALOGUE

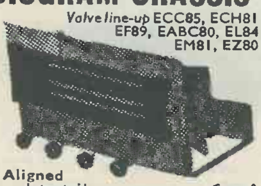
**American catalogue also available 1/- post paid**

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.12

# DAYSTROM LTD

DEPT. RC. 12
GLOUCESTER

# 7 VALVE AM/FM RADIOGRAM CHASSIS



*Valve line-up* 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.** **£13.10.0** *Carr. & Ins. 7/6.*

Comp. with 4 knobs—walnut or ivory to choice. Indoor FM aerial 3/6 ex. 3Ω P.M. Speaker only required. Recommended Quality Speakers 10″ Rola, 27/6. 13½″ x 8″ E.M.I. Fidelity, 37/6. 12″ R.A. with conc. Tweeter, 42/6. Carr. 2/6.

# ANOTHER TAPE RECORDER BARGAIN

**Manufacturers' end of production Surplus Offer**

A 24 gns. Tape Recorder offered at the bargain price of only **15** gns. plus 10/– carr. Supplied in 3 Units already wired and tested. A modern Circuit for quality recording from Mike Gram or Radio, using latest B.S.R. Twin Track Monardeck Type TD2. Valve line-up—EF86, ECL82, EM84, EZ80 and Silicon Diode. **Send for detailed list—3d. stamp.**

**Completed Kit** comprising items below

**BARGAIN PRICE 15 Gns.** + 10/– Carr.

| | |
|---|---|
| **2-tone Cabinet and 8″ x 5″ Speaker. Size 14″ x 10½″ x 7½″** ... | £3 10 0 + 5/– Carr. |
| **Wired Amplifier complete with 4 Valves, front Panel, Knobs, etc.** ... | £5 12 6 + 3/6 Carr. |
| **B.S.R. Monardeck Type TD2** ... | £7 7 0 + 4/6 Carr. |
| **Accessories: Mike, Tape, empty Reel, screened Lead and Plugs, Instructions, etc.** ... | £1 0 0 + 2/– Carr. |

**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 25 watt Inst., 22/6. Spare Elements, 4/6. Bits, 1/– 65 watt, 27/6 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.

# RECORDING TAPE

**Famous American Columbia (CBS) Premier quality tape at NEW REDUCED PRICES.** A genuine recommended Quality Tape—TRY IT Brand new, boxed and fully guaranteed. Fitted with leader and stop foils.

| Standard | | Double Play | | Long Play | |
|---|---|---|---|---|---|
| 5″ 600′ | 13/– | 1,200′ | 31/6 | 900′ | 17/6 |
| 5¾″ 900′ | 16/– | 1,800′ | 37/6 | 1,200′ | 19/6 |
| 7″ 1,200′ | 21/– | 2,400′ | 47/6 | 1,800′ | 28/6 |

Post & Package per reel, 1/– plus 6d. each for additional reels.

**SPECIAL OFFER.** 3″ Message tape 150′, 3/9; 3″ L.P. 225′, 4/9; 3″ D.P. 300′, 6/6. P. & P. per reel 6d.

**TAPE REELS.** Mnfrs. surplus 7″, 2/3; 5¾″, 2/–; 5″, 2/–; 3″, 1/3; Plastic spool containers, 5″, 1/9; 5¾″, 2/–; 7″, 2/3.

## New Boxed VALVES Reduced Bargain Prices

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

## 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. 10/–.

Illuminated Perspex escutcheon, 7/6 extra.

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/–.

## 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 5½″. A recommended Fidelity Unit for use with Mullard "3-3" or "5-10" Amplifiers. Available only at present as built-up units, aligned and tested ready for use.

**Bargain Price £12.10.0.** Carr. 5/–. **We hope to produce this popular unit in kit form very shortly.**

**Volume Controls**—5K–2 Megohms, 3″ Spindles Morganite Midget Type. 1¼″ diam. Guar. 1 year. LOG or LIN ratios less Sw. 3/–. DP. Sw. 4/6. Twin Stereo less Sw. 6/6. 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.

**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.

**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., ½W 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 ⅛″ x ⅛″ diamond mesh, 4/6 sq. ft., multiples of 6″ cut. Max. size, 4ft. x 3ft. 47/6. Carr. extra.

**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, 12″ wide, any length cut 1/6 per ft, 4/– per yd.

**ENAMELLED COPPER WIRE**—¼lb reels, 14g–20g, 2/6; 22g–28g, 3/–; 36g–38g, 4/3; 39g–40g, 4/6, etc.

**TINNED COPPER WIRE**—14–22g. 2/6 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 Ring, 1″ dia., 9d. each; 1⅛″, 1/– each; Brown or Ivory with Gold Centre, 1″ dia., 10d. each; 1⅛″ 1/3 each. LARGE SELECTION AVAILABLE.

## TRANSISTOR COMPONENTS

| | |
|---|---|
| Midget I.F.'s—465 kc/s $\frac{7}{16}$″ diam. | 5/6 |
| Osc. Coil—$\frac{7}{16}$″ diam. M/W. | 5/3 |
| Osc. coil M. & L.W. | 5/9 |
| Midget Driver Trans. 3.5:1 | 6/9 |
| Ditto O/Put Push-pull 3 ohms | 6/9 |

**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.

**Speakers P.M.**—2″ Plessey 75 ohms, 15/6. 2½″ Continental 8 ohms, 13/6. 7″ x 4″ Plessey 35 ohm, 23/6.

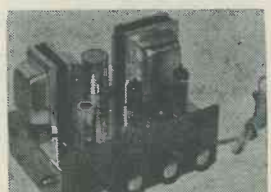
**Ear Plug Phones**—Min. Continental type, 3ft. lead, jack plug and socket. High Imp. 8/–. Low Imp., 7/6. High sensitivity M/coil 8–10 ohms, 12/6.

## JASON FM TUNER UNITS

Designer-approved kit of parts:
**FMT1,** 5 gns. 4 valves, 20/–.
**FMT2,** £7. 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. 48 hr. Alignment Service 7/6. P. & P. 2/6.

# MULLARD "3—3" HI-FI AMPLIFIER

## 3 VALVES 3 WATT



**3 ohm and 15 ohm Output.** 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 £6.19.6.** Carr. 5/–. **Wired and tested 8 gns.**

**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.**

**CONTROL PANEL KIT**

Bass, Treble and Volume controls with 4-position selector switch for radio, tape and pick-up and 11″ x 4″ escutcheon panel.

**Amplifier Kit and Control Panel Kit £11.19.6. Ditto ready wired £14.19.6.**

**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 2½″.

**Complete Kit £5.19.6.** Carr. 3/6. **Ready built £7.19.6.**

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.m., 1 p.m. Wed. Terms C.W.O. or C.O.D. Post and Packing up to ½ lb. 9d., 1 lb. 1/3, 3 lb. 2/3, 5 lb. 2/9, 8 lb. 3/6.*

# THE MOST OUTSTANDING

SINCLAIR

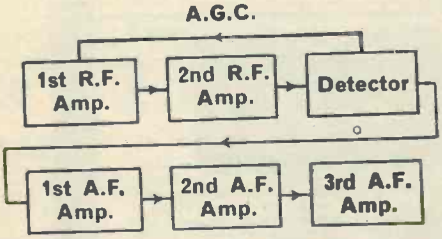
# 1 MICRO-6

## SIX-STAGE POCKET RECEIVER

***The smallest set in the world!***
***Easily built in an evening!***


THE 100% BRITISH DESIGNED SINCLAIR MICRO-6 continues unchallenged as the most remarkable receiver of its kind ever made available to the public anywhere in the world. It has special 6-stage circuitry and is, at the same time, the smallest set on earth. Everything except the lightweight earpiece is contained in the smart, minute white, gold and black case which is appreciably smaller than a matchbox, as the illustration shows. With vernier-type tuning control, bandspread over the higher frequency end of the medium waveband and powerful A.G.C. to ensure fade-free reception of the most distant stations, the Micro-6 provides remarkable standards of performance. Quality of reproduction is outstandingly good, and again and again the set is reported to give excellent results where other sets cannot be used at all. Order yours now and you will at once see why the Micro-6 cannot be too highly recommended, both as an intriguing design to build, and a most practical radio to use.

- SIZE 1⁴/₅" x 1³/₁₀" x ½"
- WEIGHS UNDER 1 OZ
- BAND SPREAD TUNING FOR EASY RECEPTION FROM LUXEMBOURG
- VERNIER-TYPE TUNING OVER MEDIUM WAVE BAND
- CHOICE OF MANY STATIONS
- BATTERIES AND FERRITE ROD AERIAL CONTAINED IN CASE




### SIX-STAGE POWER AND SELECTIVITY

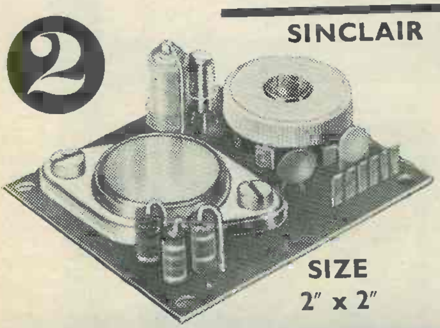
The Micro-6 uses *only three* Micro-Alloy Transistors in a unique and very efficient circuit as follows: Two stages of R.F. amplification are followed by an efficient double-diode detector which drives a high-gain 3-stage A.F. amplifier. Powerful A.G.C. applied to the first R.F. stage ensures fade-free reception from the most distant stations tuned in. Everything including ferrite-rod aerial and batteries is contained within the elegant tiny case.

Building is simple. All parts including lightweight earpiece, case and dial, and 8-page instructions manual come to

**59/6**

Sinclair "Transrista" well-styled, strong black nylon wrist strap **7/6**

Mallory Mercury Cell Type ZM312 (2 required) each **1/11** Pack of 6 **10/6**



SINCLAIR

# 2 TR750 POWER AMPLIFIER

## Designed specially for use with the Micro-6

SIZE 2" x 2"

THE TR750 enables the Sinclair Micro-6 Receiver to be used as a powerful car, domestic or portable loudspeaker set. A connecting plug is provided for this. The TR750 also has many other applications such as a record reproducer, intercom or baby alarm. An output of 750 milliwatts for feeding into a standard 25-30Ω loudspeaker requires only a 10mV input into 2kΩ. Frequency response 30-20,000 c/s ±1dB. Power required—9 to 12 volts.

*All parts with instructions come to*

**39/6**

*Ready built and tested with instructions*

**45/-**

sinclair

## SINCLAIR RADIONICS LTD

COMBERTON, CAMBRIDGE Telephone: COMBERTON 682

# DESIGNS OF THE YEAR

## 3 SINCLAIR X-10

### INTEGRATED 10-WATT HI-FI AMPLIFIER AND PRE-AMP WITH P.W.M.

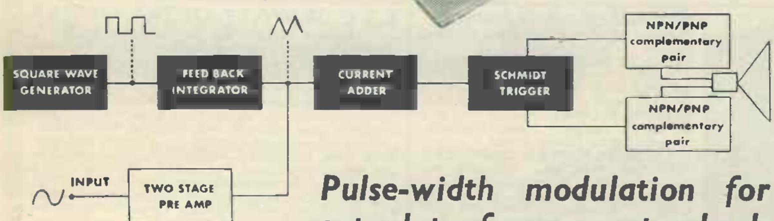
*Cost of all parts together with Instruction Manual*
**£5.19.6**

*Ready built and tested together with Instruction Manual* **£6.19.6**

*Mains power supply unit (A.C. 200-240 volt) to drive one or two X-10 amps.* **£2.14.0**

**The only design of its kind in the world**

**THE GREATEST ADVANCE IN AMPLIFIER DESIGN IN YEARS**




## *Pulse-width modulation for superb performance standards*

The principle of P.W.M., used in this remarkable amplifier which is complete with its own pre-amp stage and unique output stage, is briefly as follows: A square wave of constant voltage amplitude and with a frequency well above the highest audio-frequency to be reproduced, is applied to the terminals of the load. As the load has a high impedance at this frequency, negligible current flows through the voice coil of the speaker.

When an input signal is applied, the mark-space ratio changes with the result that there is a net current flowing through the voice coil which deflects the cone. When the input signal is at any frequency up to 20 kc/s the net current is an exact replica of the input signal and is independent of the transfer characteristics of the output transistors, making the distortion figures incredibly low. The output transistors act as switches and so dissipate negligible power. This enables us to use 5 Mc/s transistors for this with great savings in space, current consumption and costs. No heat sink is required.

- ★ 11 Transistors and no heat sink
- ★ Unique output stage
- ★ Add your own choice of tone control circuit
- ★ Input sensitivity 1mV into 1kΩ
- ★ Can be used with all types of inputs including low-output pick-ups and microphones
- ★ Total harmonic distortion <0.1%
- ★ Output power 10 watts
- ★ Frequency response 5-20,000 c/s ±0.5dB
- ★ Speaker impedance 15Ω
- ★ Damping factor—greater than 100
- ★ Quiescent consumption 75mA
- ★ Supply voltage 12 volts from batteries or mains supply unit
- ★ Size 6" x 3"

### SINCLAIR X-10 MANUAL

Explains how the amplifier functions and how you can add the correct tone and volume control system to suit your precise requirements. A variety of systems is shown, none of which will add more than a few shillings to the original cost of your Sinclair X-10, be it for MONO or STEREO.

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*If you are not completely satisfied with your purchase (and we are confident that you will be) your money will be refunded in full at once and without question.*

**Full Service Facilities always available to Sinclair Customers.**

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**DARLINGTON** 13 Post House Wynd (Half-day Wednesday)

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**LEICESTER** 32 High Street (Half-day Thursday)

**LEEDS** 5–7 County (Mecca) Arcade (No half-day closing)

**LIVERPOOL** 73 Dale Street (No half-day closing)

**LONDON** 238 Edgware Road (Half-day Thursday)

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**SHEFFIELD** 13 Exchange Street. Castle Market Bldgs. (Half-day Thursday)

## Fane Heavy Duty Hi-Fi Speakers

**12" 15 ohms. Cast chassis. Exceptionally robust 2" diam. Voice Coil Assemblies.** 122/10 20 watt, 5 gns.; 122/10A 20 watt, 6 gns.; 122/12 20 watt, 7 gns.; 122/12A 20 watt, 8 gns.; 122/14 22 watt, 9 gns.; 122/14A 22 watt, 10 gns.; 122/17 25 watt, £11.17.6.; 122/17A 25 watt, £12.17.6.

**15" 15 ohms. Cast chassis. Exceptionally robust 2" diam. Voice Coil Assemblies.** 152/12 20 watt, 12 gns.; 152/12A 20 watt, 13 gns.; 152/14 27 watt, 14 gns.; 152/14A 27 watt, 15 gns.; 152/17 35 watt, 16 gns.; 152/17A 35 watt, 17 gns.

"A" indicates duel cone type. 30–17,000 c.p.s. Send S.A.E. for leaflets. Terms available.

**FANE EXTRA HEAVY DUTY LOUDSPEAKER 15" TYPE 153.** 40 watts. Total flux 375,000 lines. Extremely high sensitivity. 15 ohm voice coil. Only 18 gns. or Deposit 37/6 and 12 monthly payments of 31/6.

## BASS-MAJOR 30 WATT GUITAR AMPLIFIER

**A MULTI-PURPOSE HIGH FIDELITY, HIGH OUTPUT UNIT FOR VOCAL AND INSTRUMENTALIST GROUPS**

**Eminently suitable for bass, lead or rhythm guitar**

*and all other musical instruments*

★ **Incorporating two 12" heavy duty 25-watt high flux (17,000 lines) loudspeakers with 2" diameter speech coils. Designed for efficiency handling full output of amplifier at frequencies down to 25 c.p.s.**

★ **Dual Cone in 2nd speaker reproduces frequencies up to 17,000 c.p.s.**

★ **Heavily made cabinet of convenient size 24" x 21" x 14" has an exceptionally attractive covering in two contrasting tones of Vynair.**

★ **For 200–250V, 50 c.p.s., A.C. Mains operation.**

★ **Four jack socket inputs and two independent volume controls for simultaneous connection of up to four instrument pick-ups or microphones.**

★ **Separate bass and treble controls providing more than adequate "Boost" or "Cut".**

★ **LEVEL frequency response throughout the audible range.**

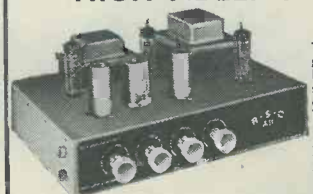
★ **SUPERIOR TO UNITS AT TWICE THE COST.**

**Send S.A.E. for leaflet OR DEPOSIT of £4.3.0 and 12 monthly payments of £3.9.11 Carr. 17/6.**

**39½ Gns.**

## HIGH FIDELITY 12–14 WATT AMPLIFIER TYPE A11

**PUSH-PULL ULTRA LINEAR OUTPUT "BUILT-IN" TONE CONTROL PRE-AMP STAGES**




Two input sockets with associated controls allow mixing of "mike" and gram., as in A10. High sensitivity. Includes 5 valves, ECC83, ECC83, EL84, EL84, EZ81. High Quality sectionally wound output transformer specially designed for Ultra Linear operation and reliable small condensers of current manufacture. INDIVIDUAL CONTROLS FOR BASS AND TREBLE "Lift" and "Cut". Frequency response—3dB 30–30,000 c/s. Six negative feedback loops. Hum level 60dB down. ONLY 23 millivolts INPUT required for FULL OUTPUT. Suitable for use with all makes and types of pick-ups and microphones. Comparable with the very best designs for **STANDARD or LONG PLAYING RECORDS.** For **MUSICAL INSTRUMENTS** such as **STRING BASS, LEAD OR RHYTHM GUITARS**, etc.

**OUTPUT SOCKET** with plug provides 300V 30mA, and 6.3V 1.5A for supply of a **Radio Feeder Unit.** Size approx. 12" x 9" x 7". For A.C. mains 200–250V 50 c.p.s. Output for 3 & 15Ω speaker. Kit is complete to last nut. Chassis is fully punched. Full instructions and point-to-point wiring diagram supplied. Only **8 Gns.** (Or factory built 51/– extra) Carr. 10/–

If required louvred metal cover with 2 carrying handles can be supplied for 18/9. **TERMS ON ASSEMBLED UNITS. DEPOSIT 24/9** and 9 monthly payments of 24/9. Send S.A.E. for illustrated leaflet detailing Cabinets, Speakers, Microphones, etc., with cash and credit terms.

## R.S.C. G5 GUITAR AMPLIFIER

5-watt high quality output. Incorporating high flux 12" 10 watt 12,000 line loudspeaker. Sensitivity 50mV. High impedance jack input. Handsome strongly made cabinet (size 14" x 14" x 7" approx.) finished in complementary shades of Rexine/Tygan. 200–250 A.C. mains.

**£9.19.6** Or DEPOSIT 22/3 and 9 monthly payments of 22/3. Carr. 7/6.

## LINEAR TREMOLO/PRE-AMP. UNIT

Designed for introducing the Tremolo effect to any amplifier which is fitted with a reserve power supply point for smoothed H.T. and 6.3V A.C. L.T. This applies to practically all amplifiers of our manufacture, and to those of several other manufacturers. The unit plugs into power supply point and any input socket or amplifier. Controls are Speed (frequency of interruptions), Depth (for heavy or light effect), Volume and Switch. Three sockets are for two inputs and Foot Switch. ONLY **4 Gns.**

## R.S.C. CORNER CONSOLE CABINETS

Polished walnut veneer finish. Pleasing design.

**JUNIOR MODEL.** Size 20" x 11" x 8" for 8"x5" or 10"x6" speakers, **£2.9.9.**

**STANDARD MODEL.** Size 27" x 18"x12" for 8" or 10" speakers, **£4.11.9.**

**SENIOR MODEL.** Size 30" x 20" x 15" for 12" Speaker. Suitable Speaker systems below. Only **7 gns.**

**R.S.C. BASS REFLEX CABINETS, JUNIOR MODEL.** Specially designed for W.B. HF1012 Speaker, but suitable for any good quality 10" speaker. Acoustically lined and ported. Polished walnut veneer finish. Size 18" x 12" x 10". Handsome appearance. Ensures superb reproduction for only **£3.19.6**

**STANDARD MODEL.** As above but for 12" speakers. Size 20" x 15" x 13". For vertical or horizontal use. **£5.19.6.** Set of legs with brass ferrules, **19/6.**

**AUDIOTRINE HI-FI SPEAKER SYSTEMS.** Consisting of matched 12" 12,000 line, 15 ohm high quality speaker, crossover unit (consisting of choke, condenser, etc.) and Tweeter. The smooth response and extended frequency range ensure surprisingly realistic reproduction. Standard 10 watt rating £4.19.9. Carr. 5/–. Or Senior 15 watt, £6.19.9. Carr. 7/6.

**HEAVY DUTY LOUDSPEAKERS in substantial Rexine cov. Cabinets.** Type BG1. Suitable for Bass Guitar. Speaker Unit 15", High Flux, 15Ω, 30W. Cabinet approx. 24" x 21" x 13". Only 19½ gns. Or Deposit 43/– & 12 monthly payments of 34/–.

## R.S.C. 30-WATT ULTRA LINEAR HIGH FIDELITY AMPLIFIER A10

A highly sensitive Push-Pull high output unit with self-contained Pre-amp. Tone Control Stages. Certified performance figures compare equally with most expensive amplifiers available. Hum level 70dB down. Frequency response ±3dB 30–20,000 c/s. A specially designed sectionally wound ultra linear output transformer is used with 807 output valves. All components are chosen for reliability. Six valves are used, EF86, EF86, ECC83, 807, 807, GZ34. Separate Bass and Treble Controls are provided. Minimum input required for full output is only 12 millivolts so that **any kind of microphone or pick-up is suitable.** The unit is designed for **Clubs, Schools, Theatres, Dance Halls or Outdoor Functions**, etc. For use with Electronic **Organ, Guitar, String Bass**, etc. For standard or long-playing records. **Output Socket** provides L.T. and H.T. for **Radio Feeder Unit.** An extra input with associated vol. control is provided so that two separate inputs such as Gram and "Mike" can be mixed. Amplifier operates on 200–250V 50 c/s. A.C. mains and has output for 3 and 15 ohm speakers. Complete Kit of parts with fully punched chassis and point-to-point wiring diagrams and instructions. If required, perforated cover with carrying handles can be supplied for 19/9. The amplifier can be supplied, factory built with EL34 output valves and 12 months' guarantee, for 14 gns. Send S.A.E. for leaflet. **TERMS: DEPOSIT 33/9** and 9 monthly payments of 33/9. Suitable mikes and speakers available at competitive prices.

**11 Gns.** Carr. 10/–

## R.S.C. SENIOR 15 WATT LEAD or RHYTHM GUITAR AMPLIFIER

High-fidelity push-pull output. Separate bass and treble "cut" and "boost" controls. Twin separately controlled inputs so that two instruments or "mike" and pick-ups can be used at the same time. Loudspeaker is a heavy duty high flux 12" 20 watt model with cast chassis. Cabinet is well-made and finished as Junior Model. Size approx. 18" x 18" x 8"

Carr. 10/–. Send S.A.E. for leaflet. Or DEPOSIT 39/11 and twelve monthly payments of 33/4.

Only **19 Gns.**

## R.S.C. B20 Bass Guitar Amp.

A highly efficient unit incorporating a massive 15" high flux loudspeaker specially constructed to withstand heaviest load conditions. Rating 25 watts. Individual bass and treble controls give ample "boost" and "cut". Two high impedance jack socket inputs are separately controlled. All controls are conveniently positioned in a recess on top of the cabinet. Cabinet is of substantial construction and attractively finished in two contrasting tones of Rexine and Vynair. Size approx. 24" x 21" x 13". Operation from 200–250V 50 c.p.s. A.C. mains.

Send S.A.E. for leaflet. Or Deposit £3.2.0 and 12 monthly payments of 51/8. Carr 17/6.

**29½ Gns.**

## 12 in. 10-WATT HIGH QUALITY LOUDSPEAKER

In walnut veneered cabinet. Gauss 12,000 lines. Speech coil 3 ohms or 15 ohms. Only £4.19.6. Carr. 5/–. Terms: Deposit 11/3 and 9 monthly payments of 11/3. **12" 20 WATT HI-FI LOUDSPEAKERS IN CABINETS.** Size 18" x 13" x 10" Finish as above. Terms: Deposit 17/9 and 9 monthly payments of 17/9.

Only **£7.19.6** Carriage 8/6

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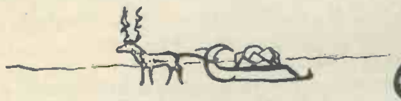
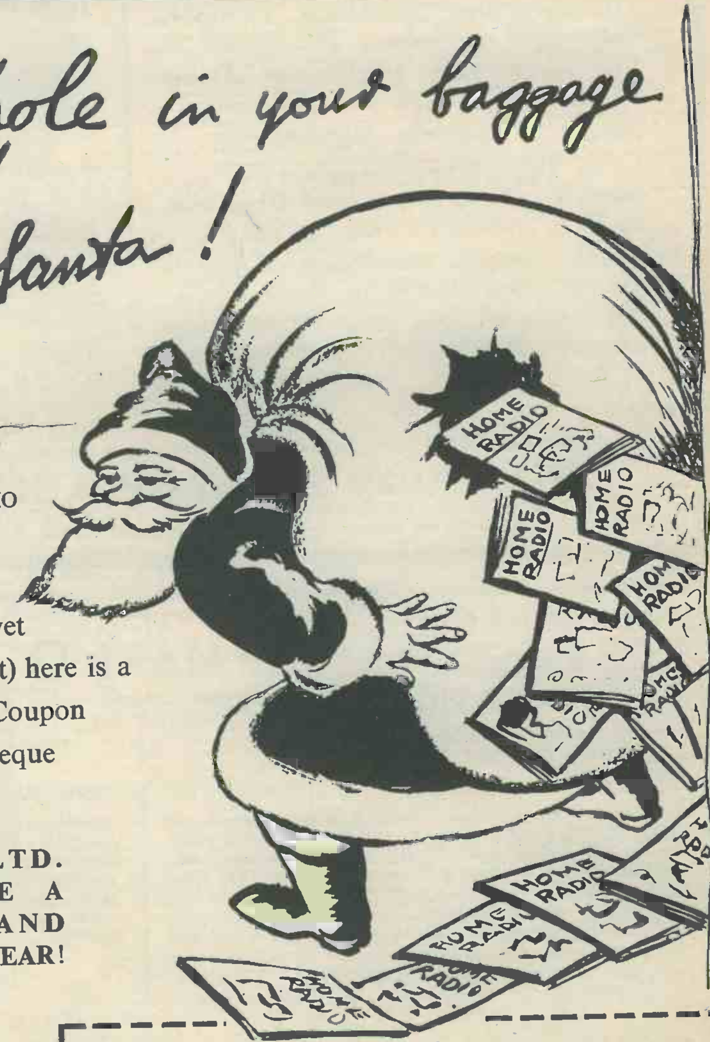
## There's a hole in your baggage Dear Santa! Dear Santa!






We trust that your HOME RADIO CATALOGUE is not among those giving Santa the slip! But just in case you haven't yet ordered one (dreadful thought) here is a gentle reminder. Fill in the Coupon and send it off today with cheque or P.O for 6/–.

**HOME RADIO LTD. WISHES EVERYONE A MERRY XMAS AND A HAPPY NEW YEAR!**

## Remember...

*For every complete £1's worth of Components you order from us you can enclose one of the Coupons from our Catalogue and deduct a shilling from your remittance.*

Enclose P.O. for 6/–

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*Incorporating THE RADIO AMATEUR*

## DECEMBER 1964

Vol. 18, No. 5
Published Monthly
(1st of month)

*Editorial and Advertising Offices*
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*Telephone*
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*Telegrams*
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V. E. HOLLEY

*An inexpensive 10 watt design incorporating readily available components*

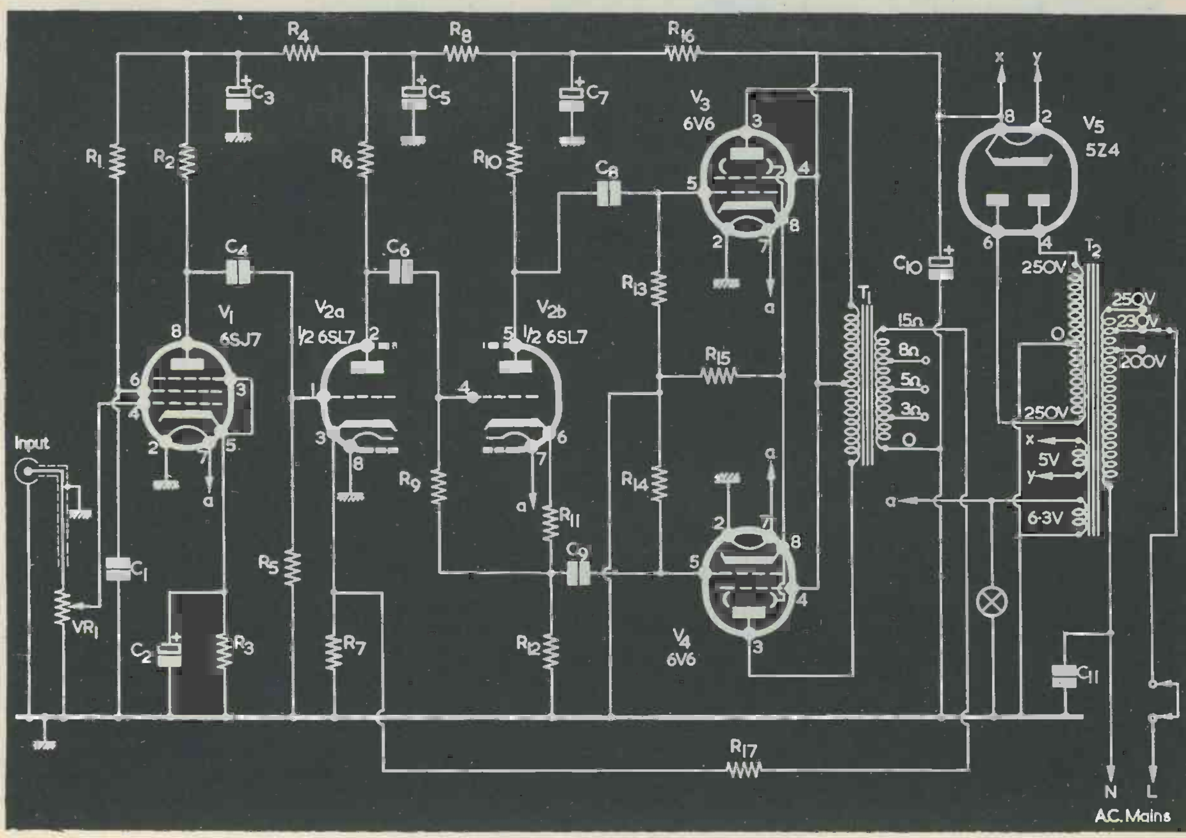



*Fig. 1: The circuit of the 10 watt amplifier*

THIS EQUIPMENT WAS DESIGNED AND BUILT FOR the use of a travelling lecturer who had, on occasion, to address large audiences. Though small in size and weight, it has an output of 10 watts and will give a good account of itself. The circuit is simple and the components few and inexpensive.

### Design Considerations

Minimum size and weight are the primary considerations and the completed amplifier can be enclosed in a carrying case measuring only 10 x 7 x 5in, with a total weight of 7 lb. The requirement for clean, crisp reproduction of speech is met by introducing some attentuation of the lower audio frequencies, but this is done entirely at the input and output. The amplifier itself is suitable for any service and it will, in fact, reproduce music at a very acceptable standard of fidelity. Space does not permit the introduction of tone controls.

### Circuit

The circuit is shown in Fig. 1. Surprise may be felt at the use of octal valves, but these are more robust and less likely to be dislodged from their bases than are the more modern all-glass variety. Such considerations outweigh the disadvantage of size in portable equipment.

### Power Supply

To keep the weight down, the power supply is obtained from a double wound mains transformer having a full wave h.t. secondary rated at only 250–0–250V, 80mA. Using a 5Z4 rectifier and a 32μF reservoir capacitor ($C_{10}$), a d.c. voltage of 300 is available at the reservoir under working conditions. This leaves no margin for voltage drop in smoothing components and so the output stage is fed direct from $C_{10}$. There is, of course, a large hum voltage at this point but since, with the push-pull connection, current flows through the two halves of the output transformer primary in opposite directions, it is largely cancelled out, leaving a satisfactorily low background level.

The mains transformer must have a 5V 2 amp. winding for the rectifier and a 6.3V winding for

### Components List

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

| | |
|---|---|
| $R_1$ | 1.2MΩ, high-stability |
| $R_2$ | 270kΩ, high-stability |
| $R_3$ | 1.2kΩ |
| $R_4$ | 47kΩ |
| $R_5$ | 1.2MΩ |
| $R_6$ | 100kΩ |
| $R_7$ | 3.3kΩ |
| $R_8$ | 22kΩ |
| $R_9$ | 1.2MΩ |
| *$R_{10}$ | 100kΩ |
| $R_{11}$ | 3.9kΩ |
| *$R_{12}$ | 100kΩ |
| *$R_{13}$ | 470kΩ |
| *$R_{14}$ | 470kΩ |
| $R_{15}$ | 270Ω, 2 watts |
| $R_{16}$ | 4.7kΩ |
| $R_{17}$ | 15kΩ |
| $VR_1$ | 2MΩ potentiometer, log track |

* Matched pairs.

*Capacitors*
(All capacitors 350V wkg. minimum unless otherwise stated—see text)

| | |
|---|---|
| $C_1$ | 0.01μF |
| $C_2$ | 25μF electrolytic, 12V wkg. |
| †$C_3$ | 8μF electrolytic |
| $C_4$ | 0.01μF |
| †$C_5$ | 8μF electrolytic |
| $C_6$ | 0.01μF |
| †$C_7$ | 16μF electrolytic |
| $C_8$ | 0.01μF |
| $C_9$ | 0.01μF |
| †$C_{10}$ | 32μF electrolytic |
| $C_{11}$ | 0.02μF paper, 250V a.c. wkg. |

† $C_3$ and $C_5$ are in a single can as are $C_7$ and $C_{10}$.

*Valves*

| | |
|---|---|
| $V_1$ | 6SJ7 |
| $V_2$ | 6SL7 |
| $V_3$ | 6V6 |
| $V_4$ | 6V6 |
| $V_5$ | 5Z4 |

*Transformers*

| | |
|---|---|
| $T_1$ | Mains transformer with tapped primary. Secondaries, 250–0–250V, 80mA; 6.3V, 2 amp; 5V, 2 amp. Upright mounting (see text) |
| $T_2$ | Output transformer. Push-Pull, 10–12 watts, 6V6 to 3, 5, 8 or 15Ω. (R.S.C. (Manchester) Ltd., 54 Wellington Street, Leeds, 1) |

*Speakers*
Re-entrant or cone units, as required

*Microphone*
Crystal microphone with floor stand

*Lamp*
M.E.S. indicator lamp, 6.3V, 0.3 amp.

*Plugs and Sockets*
1 octal plug
1 coaxial input plug
6 octal sockets
1 indicator lamp holder
1 coaxial input socket

*Miscellaneous*
Chassis, 16 s.w.g. aluminium (see Fig. 2)
1 2-way tagstrip
2 ¼in grommets
Wire, etc.

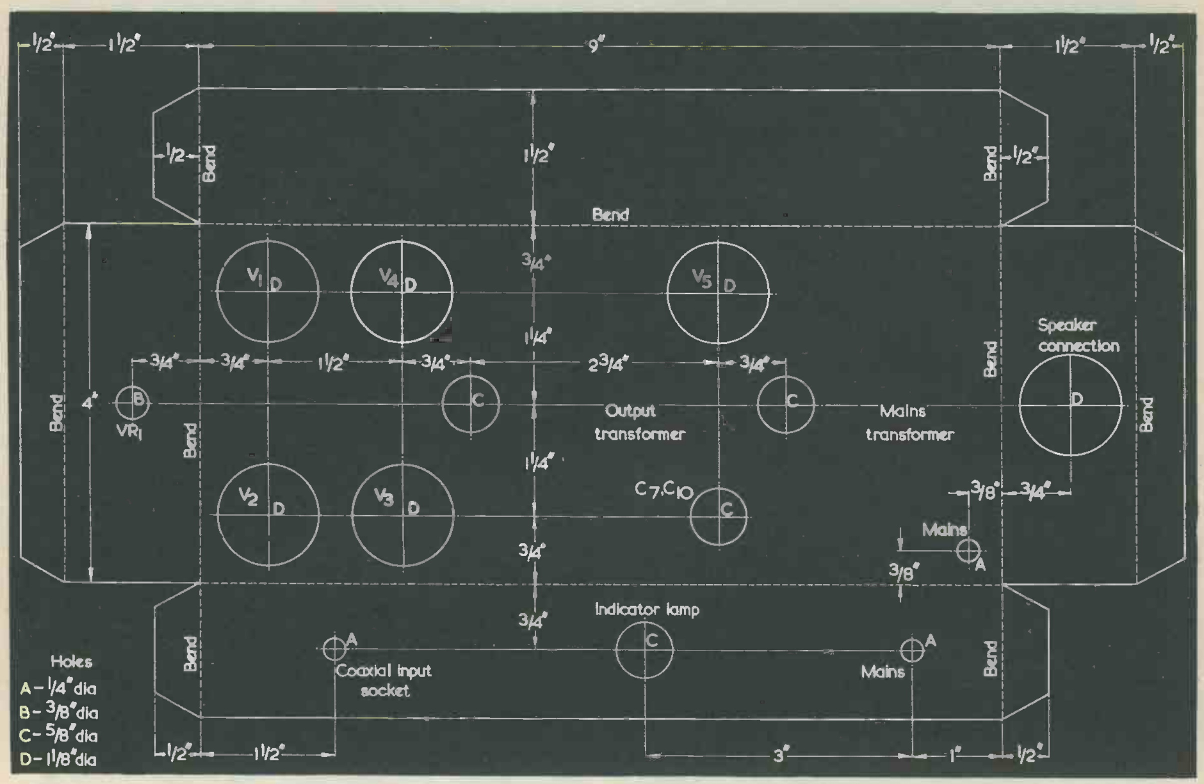



*Fig. 2. The dimensions and principal holes in the chassis. The ⅝in hole for $C_{7,10}$ may need to be larger for some components. Before drilling mounting holes for the valveholders, check against Fig. 3 for orientation*

the other valve heaters and indicator lamp, which together need 1.8 amp. No mains switch is provided but in order to avoid damage to the output valves should the amplifier be operated accidentally with no load, it is arranged that the withdrawal of the loudspeaker connecting plug shall interrupt the mains supply. It is convenient if the mains transformer has a mains voltage adjuster but if it has not, one can be fitted separately on the chassis in a position where it will be easily accessible in service.

Capacitor $C_{11}$, connected between the chassis and the neutral supply line, serves as an effective earth connection, as will be explained later. It may not always be needed.

**Output Stage**

The output stage employs a pair of valves type 6V6. The anodes and screen-grids are fed from the 300V h.t. line which, allowing for bias, provides about 280V, between these electrodes and the cathodes. The use of a common bias resistor, $R_{15}$, has two advantages. Firstly, because the signal currents through the valves cancel out at the cathodes, no bypass capacitor is required and, secondly, it tends to minimise differences between the valves so that exact matching is not necessary. It is well, though to check that the valves are not widely different. The value of $R_{15}$ is a little on the high side in order to keep the h.t. current within the capacity of the 80mA mains transformer secondary. The optimum anode-to-anode load is 8,000 ohms. The prototype uses one or two speakers (in series) of 7.5Ω impedance and the ratios provided by the output transformer are therefore 33:1 and 24:1. If it is desired to use a 3Ω speaker, a ratio of 50:1 will be needed.

**Phase Inverter**

For full loading, the output stage requires a signal of about 36V grid-to-grid and this is provided by $V_{2(b)}$ arranged as a phase inverter with equal anode and cathode loads of 100kΩ. These resistors, $R_{10}$ and $R_{12}$, must be matched as closely as possible as also must the grid resistors of the output stage, $R_{13}$ and $R_{14}$. The grid resistor for the inverter stage, $R_9$, is returned to the junction of the bias and cathode load resistors, and since $R_{11}$ is very small in relation to $R_{12}$, there is no point in bypassing it. The signal is applied to the stage between grid and earth so there is heavy negative current feedback and, as might be expected, the gain is low; it is in fact limited to 0.9 times each side or 1.8 times overall, so that an input of $\frac{36}{1.8}$ or 20V peak is needed. There will be no overloading with this large signal since most of it goes to counteract negative feedback in the cathode load. The power supply to this stage needs some smoothing, which is provided by $R_{16}$ and the associated 16μF capacitor, $C_7$.

**Voltage Amplification**

The signal required by the inverter is supplied by $V_{2,(a)}$ arranged as a resistance-capacitance amplifier with both current and voltage negative feedback. It will be noted that the cathode bias resistor consists effectively of $R_7$ and $R_{17}$ in parallel, and that a negative voltage feedback derived from the secondary of the output transformer is applied by way of $R_{17}$. This improves the response of the amplifier and removes any hum not eliminated by the push-pull connection in the output stage. If the greatest gain is required, the value of $R_{17}$ may be increased up to 33kΩ without raising the residual hum level unduly whilst, if quality be the aim, it can be reduced to 6.8kΩ, when hum will be almost completely inaudible.

Pre-amplification is needed to raise the microphone signal to a suitable level for injection to the grid of $V_{2(a)}$. This is provided by a high gain pentode, 6SJ7, again resistance-capacitance coupled, and having the volume control, $VR_1$ in its grid circuit.

The overall gain of the amplifier is fairly high, especially if a high value is assigned to $R_{17}$, and care is necessary in the selection of the resistors $R_1$ and $R_2$ which should be of the high stability noise-free type. The valve $V_1$ must be free from any tendency to microphony and its h.t. supply must be free from ripple. The latter point is taken care of by resistor $R_4$ and capacitor $C_3$.

**Frequency Response**

The desired frequency response for speech is achieved by using re-entrant speakers which have only a limited low frequency range and by employing at the input a crystal microphone, for which the recommended load is 5MΩ or more. Such an instrument may be regarded as an a.c. generator having in series with its output a small capacitance and it follows that, if the load resistance be reduced, so will be the output at the lower frequencies. $VR_1$ is therefore given a value of 2MΩ only.

**Components**

All the resistors can be ½ watt except $R_{15}$, which must be 2 watts, and all the capacitors except the electrolytics and $C_{11}$ should be ceramic so that they can be accommodated easily in the rather restricted space available below chassis around the valveholders. Capacitors connected to the h.t. circuits must be at least 350V wkg., and it is a good idea to use 500V wkg. components so that if the amplifier should by mistake be connected to 240V mains with the voltage adjuster set for say, 200V, the overload will not be likely to cause a breakdown. Capacitor $C_{11}$ should be rated for 250V a.c.

There is little room to spare on the deck of the chassis and unless the mains and output transformers are of the type shown in the illustration, it may be necessary to increase the size to accommodate them. The transformers should therefore be obtained before commencing construction.

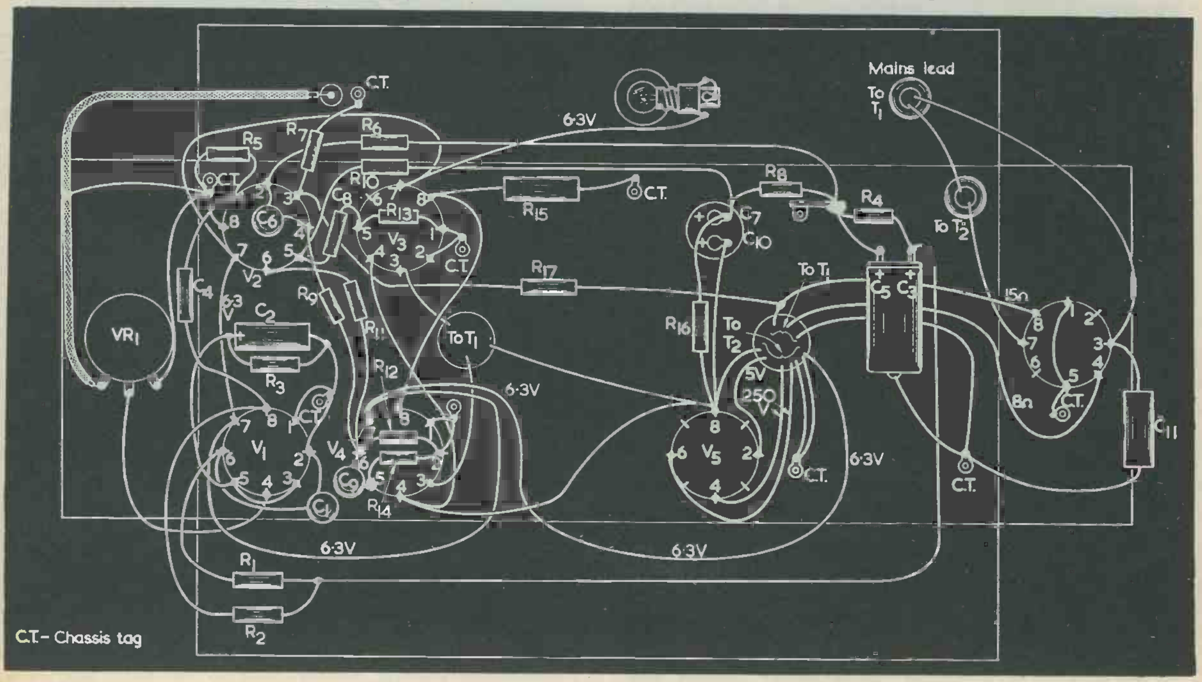



*Fig. 3. The components and wiring below the chassis. Pin 6 of $V_4$ valveholder is employed as an anchor tag*

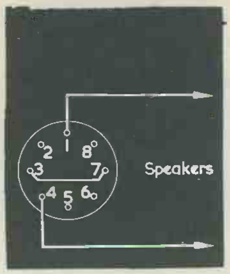



*Fig. 4. Connections to the octal speaker plug. These enable one of two impedances to be selected*

**Construction**

The amplifier is built on a chassis of 16 s.w.g. sheet aluminium measuring 9 x 4 x 1½in., a plan of which is given in Fig. 2. The work is quite straightforward and after the transformers and valveholders have been fitted, the wiring can proceed in any desired order. A wiring diagram is given in Fig. 3. The connections between the output transformer primary and the anodes of $V_3$ and $V_4$ should be sufficiently long to enable the leads to be changed over if, when the testing stage is reached, the feedback circuit is found to be positive. The speaker connection is made by way of an octal socket and this must be modified slightly by filing an additional keyway down the centre 180° opposite the existing one, i.e. between contacts 4 and 5. Check before fitting to the chassis that the modification permits the insertion of an octal plug in either of two positions, thus enabling the appropriate output transformer ratio to be selected according to the number of speakers in use. The wiring for the plug is shown in Fig. 4. The base of an unserviceable octal valve makes a good plug and the impedance can be painted on opposite sides of it so that the correct figure is at the top when in position.

When metal valves are used, pin 1 of $V_1$, $V_3$ and $V_4$ should be earthed, as shown in the wiring diagram.

**Testing**

When the wiring is complete and has been checked, connect a meter switched to a high resistance range between $C_{10}$ and chassis to verify that there are no short-circuits in the h.t. wiring. If all is well, power can be applied and the operating voltages checked at the valve electrodes. As the valves warm up, there may be instability. If this occurs the mains supply should be switched off at once and the connections to the anodes of $V_3$ and $V_4$ interchanged to make the feedback negative. Residual hum should now be very low and, with $VR_1$ at minimum, should be inaudible at more than several feet from the speaker.

**Carrying Case**

Fig. 5 shows the construction of a simple carrying case made of ⅜in plywood. No skilled carpentry is needed here, and simple butt joints secured with panel pins and glue are adequate. If the cover is made a good fit round the amplifier chassis, the latter will be secured very firmly in position by its flanges when the cover is screwed to the baseboard. Attention must be paid to ventilation and not less than three 1in holes are required on each side and in the top and bottom of the case. These may be covered on the inside with perforated zinc secured with a reliable impact adhesive. Four rubber buffers should be fitted to the bottom of the baseboard so that it is raised a little from the surface on which it stands, thus permitting some under-chassis ventilation. The carrying handle is fitted at the point of balance.

**Operation**

The accessories for portable service should include lengths of mains, speaker and microphone cables sufficient to meet any likely contingency and a good assortment of various plugs and adaptors for making connection to the mains. A "neon mains tester" screwdriver is practically indispensable for detecting live outlets. Three-point outlets are by no means universal in many of the older buildings, so there is no point in using 3-core mains cable.

When an amplifier is operated with a high impedance input, it is often necessary to have an earth connection in order to avoid electrostatic hum pick-up. This is difficult with portable equip-

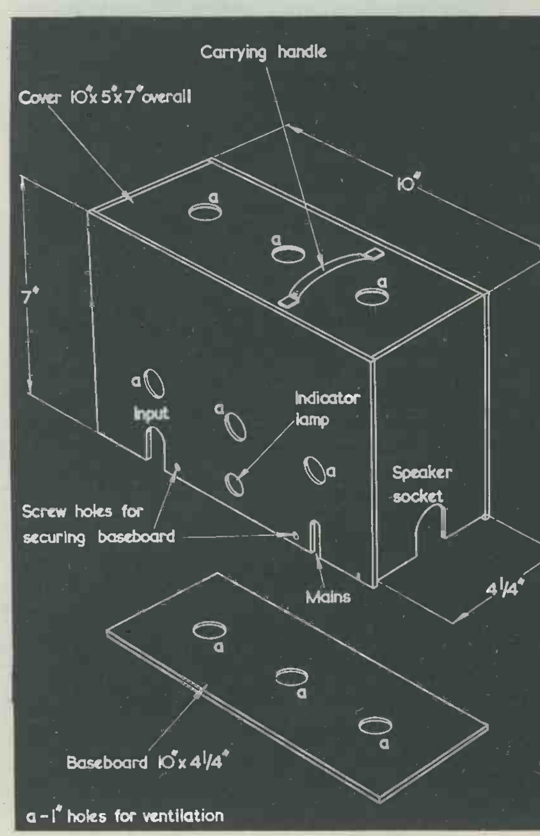



*Fig. 5. Dimensions for a suitable carrying case. The handle is mounted at the point of balance. The material is 5in plywood*

ment but an equivalent result can be achieved by coupling the chassis to the neutral side of the mains through a capacitor ($C_{11}$ in Fig. 1). Whether $C_{11}$ becomes connected to the live or neutral main is a matter of chance at each connection but it can be checked by applying the mains tester to the chassis; if the tester glows, reverse the connection.* The most convenient operational arrangement is to site the amplifier near the foot of the microphone stand so that the mike cable is of no great length. Under these conditions, $C_{11}$ may be found unnecessary and can be deleted. The re-entrant speakers have practically no output to the rear and may, if need be, be placed quite close to the microphone without fear of acoustic feedback.

**Input**

A cheap crystal microphone will provide a sufficient signal to load the amplifier fully. Alternatively, a moving-coil instrument may be used provided a suitable step-up transformer is interposed before $VR_1$. For reproducing music almost any high impedance pick-up is suitable and, as there is plenty of gain available, compensation for recording loss and a tone control may be added if desired. In designing such a network the aim should be to make the load on the pick-up at middle frequencies equal to that recommended by the manufacturer; $VR_1$ will of course be part of this load.

**Output**

The re-entrant type speakers recommended are very suitable for the reproduction of speech and have the advantage of small physical size but, if good fidelity is required for music, cone speakers should be used instead. Two 10in units will give excellent results. The re-entrants will, however, serve well enough for some purposes, such as background music at open-air functions. Speakers may be connected in series or in parallel according to their impedances, the series connection being preferable if there is a long run of cable. The recommended output transformer provides impedances of 3, 5, 8 and 15Ω, any two of which can be made available at the speaker socket.

When two or more speakers are used, results will be inferior unless they are correctly phased. In other words, all the cones or diaphragms must be moving in the same direction at any instant. The terminals of re-entrant speakers often bear "+" and "−" signs for this reason. With cone units, the proper connections can be determined by connecting a 1.5V dry cell to the speaker line; place a finger lightly upon the cone and note the direction of movement as the circuit is made.

* A capacitor such as $C_{11}$ between one side of the mains and an amplifier chassis is employed with some commercial designs in order to prevent hum pick-up. If the connection to the mains supply is such that the live side connects to $C_{11}$, it is possible to experience a mild "tingling" type of shock when touching metal at chassis potential if the operator is standing on damp ground, a concrete floor, or a similar relatively low resistance substance. Because of this it is preferable to employ a capacitor in this circuit position only when entirely essential and to make quite certain that it connects to the neutral side of the mains. If the mains transformer has an electrostatic screen between primary and secondaries, this should be connected to chassis, whereupon it will probably be found that $C_{11}$ is not needed. $C_{11}$ should also not be needed if the amplifier chassis can be connected to a reliable earth. When $C_{11}$ is fitted, it is essential that it be a completely reliable component with a minimum a.c. rating of 250V.—EDITOR.

# 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.*

**R109 Receiver.**—A. R. Brackenborough, 41 Poets Corner, Margate, Kent, requires any information on this receiver, also details of a suitable power pack.

* * *

**PCR2 Receiver.**—W. Burke, GM3TQH, c/o 6 Belgrave Terrace, Glasgow, C.2, would like the circuit and any other data.

* * *

**R1392.**—W. J. Butt, 1 Harcourt Villas, London Road, Teynham, Sittingbourne, Kent, would be grateful for any information on this unit.

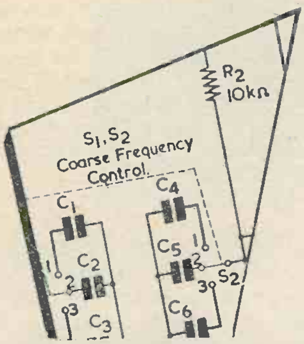
**Ekco TV Model 155.**—W. J. Robins, 7 Cedar Avenue, Birstall, Leicester, requires the circuit or any other information—particularly on the valve line-up.

* * *

**CR100 Receiver.**—B. Gordon, 72 Coldshott, Holland, Oxted, Surrey, requires loan or purchase of the manual for this receiver.

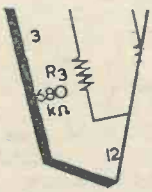
* * *

**BC620F and PSU.**—D. W. Viton, 169 Worthing Road, Laindon, Basildon, Essex, would like to obtain any information, service manual or circuits of this ex-U.S. Army transmitter/receiver.





**SUGGESTED CIRCUIT No. 169**





# Hybrid A.F. Mixer Circuit *for* VALVE AMPLIFIERS

*By* **G. A. FRENCH**

It is frequently necessary, with a.f. amplifiers, to cater for simultaneous amplification of two input channels. Gain controls are then required in each channel, and it is desirable for these to be completely independent of each other.

If cost is of importance the provision of separate independent controls is not always an easy matter, since the gain control circuits have to be completely isolated from each other. A typical solution, which assumes a valve amplifier, is shown in block form in Fig. 1. In this diagram each gain control is followed by a buffer amplifier valve, the two valves sharing a common load across which the two signals are developed. The controls are completely independent of each other, but two valves are needed for a total overall gain equivalent to that offered by one. Independent gain control operation is achieved, therefore, at the cost of one valve.

An alternative and less expensive approach consists of using a circuit of the type shown in Fig. 2, in which series isolating resistors are inserted after the sliders of the two gain controls. It is impossible to achieve complete isolation between the two controls here, because adjustment of one must inevitably alter the output level given by the other. The interdependence can be reduced to a fairly low level, however, by giving the series isolating resistors high values relative to the track resistance of the potentiometers, but limiting factors are imposed by the desirability (in most valve a.f. circuits) of having high values in the potentiometers and by the maximum external grid-cathode resistance specified for the following valve.

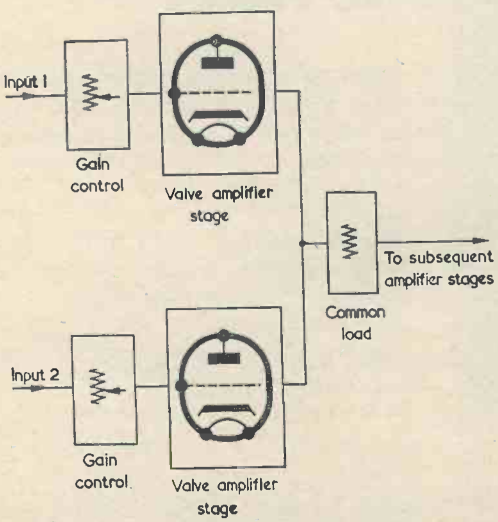




*Fig. 1. One method of obtaining independent gain control in two a.f. channels consists of inserting buffer amplifier stages before a common load*

### The Hybrid Circuit

An unusual approach to this problem is offered in the hybrid mixer circuit shown in Fig. 3, which forms the basis of this month's Suggested Circuit. As may be seen, one input channel is applied to the grid of a triode voltage amplifier valve in normal manner, whilst the second input channel is fed to the base of a p.n.p. transistor. The latter functions as an emitter-follower, and causes the a.f. voltage on its base to be applied to the cathode of the triode. An amplified version of the signal then appears at the anode of the valve, in company with an amplified version of any a.f. signal fed to the grid.

Although the two input signals appear across the same anode load, $R_4$, they are isolated at the input, and the operation of the two potentiometers is completely independent.

The cathode bias voltage required by the triode is developed across the transistor, the actual voltage obtained being dependent upon the value of $R_3$. Thus, the transistor and $R_3$ replace the normal cathode bias resistor and bypass capacitor, and may occupy approximately the same space on the chassis. Also, since the transistor need only be an inexpensive a.f. type, cost is kept at a low level. The valve will offer slightly less gain to the signal applied to its grid than would occur if it had a normal cathode bias circuit, this being due to the degeneration given by the absence of a cathode bypass capacitor.

Whilst the circuit of Fig. 3 has a number of advantages, it suffers from two restrictions. Firstly, the voltage amplifier employed should not appear in the early stages of a sensitive amplifier. This is due to the risk of hum pick-up from the heater because of the unbypassed cathode. The voltage amplifier could not, for instance, appear in a microphone preamplifier stage. Secondly, the input impedance for the second channel signal is low, being of the order (at the transistor base) of 10 to 30kΩ only.

In order to assist in explaining the operation of the circuit, Fig. 3 includes an input potentiometer in each channel. In practice, however, it would be possible to have the gain controls at earlier stages in either channel, whereupon the circuit reduces to that shown in Fig. 4. This circuit illustrates the fact that the transistor, together with $R_3$ and $C_1$, could be incorporated in place of the cathode bias resistor and capacitor in an *existing* valve amplifier, thereby enabling a second channel to be injected without interfering with the functioning of the amplifier as it stands. The valve chosen for the modified cathode circuit could then be any voltage amplifier whose cathode may be left unbypassed without the onset of hum pick-up from the heater. As was mentioned earlier, there will be a slight reduction in gain due to the deletion of the cathode bypass capacitor. The relatively low input impedance offered by the transistor circuit would, incidentally, be no disadvantage if the equipment providing the second channel signal was, itself, transistorised.

The arrangement of Fig. 4 could be used for the injection of a vibrato voltage in a guitar amplifier.

In Figs. 3 and 4, the voltage amplifier is shown as a triode. The circuit would also function with a voltage amplifier pentode. However, the checks carried out by the writer on the usefulness of the circuit were made with triodes only, these being a ½12AX7 and a ½12AU7.

## Results with the Prototype

To check its usefulness, the circuit shown in Fig. 4 was made up in experimental form.

It was found that the transistor employed in the $TR_1$ position was in no way critical, and that satisfactory results were given by a variety of transistors ranging from an OC72 to an OC44. Each transistor required a different value in $R_3$ to enable the requisite cathode bias voltage to be applied to the valve.

First tests were made using one triode of a 12AX7. The h.t. positive supply voltage was 250.

With a 100kΩ anode load at this voltage, the cathode bias potential for the 12AX7 should be approximately 2 volts. The value of $R_3$ was then experimentally adjusted until this voltage appeared between cathode and chassis. In the writer's set-up the required value was, typically, 82kΩ for the OC44. The circuit was then checked under static conditions to ensure that the cathode of the valve "followed" a varying potential applied to the base of the transistor.

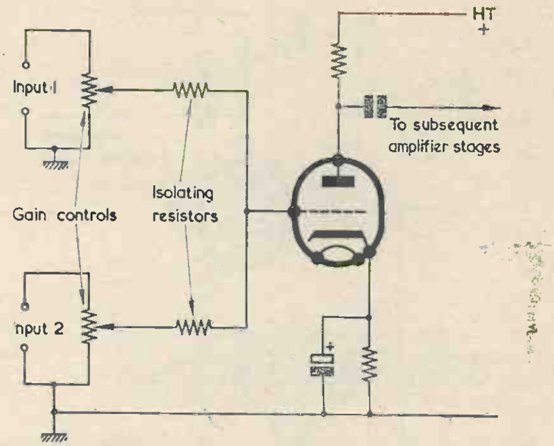



*Fig. 2. A less costly method of providing gain controls for two channels. In this instance some interdependence between the settings of the two potentiometers is inevitable*

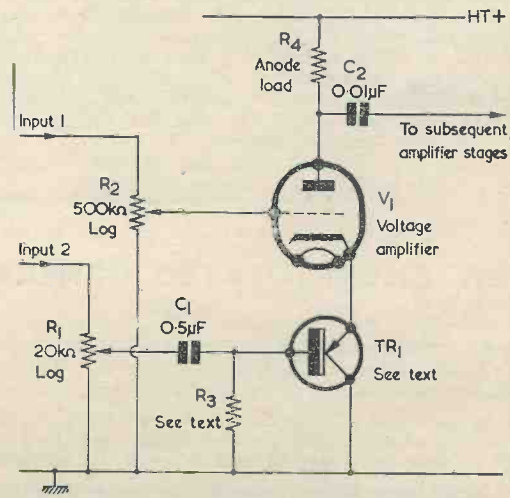



*Fig. 3. A hybrid circuit which enables independent gain controls to be used. The cathode bias voltage for $V_1$ is dropped across $TR_1$. At the same time this transistor, operating as an emitter-follower, injects the second input into the cathode*

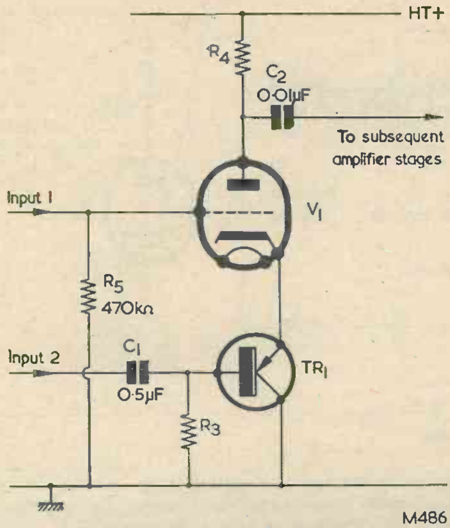



*Fig. 4. It is not essential for the potentiometers of Fig. 3 to immediately precede the valve or the transistor. This diagram illustrates the fact that $TR_1$, $C_1$ and $R_3$ can be added to an existing valve amplifier in order that a second input channel may be handled*

This occurred reliably over a swing from zero to +4 volts, relative to chassis. It could be assumed, therefore, that signals up to 4 volts peak-to-peak could be applied to the base of the transistor and be amplified satisfactorily. This is, of course, the maximum signal the valve can handle before the onset of grid current.

The ½12AX7 was then replaced by a ½12AU7. With a 250 volt h.t. supply and an anode load of 100kΩ, this valve requires 3.5 volts bias. Such a bias was obtained by adjusting $R_3$ to the typical value, for the OC44, of 91kΩ. A static voltage test then showed that the cathode "followed" the transistor base reliably for voltages from zero to +7 volts relative to chassis. A signal of 7 volts peak-to-peak could therefore be satisfactorily applied to the transistor circuit. Again, this is the maximum signal voltage the valve can handle without grid current.

Finally, music inputs were applied to both channels, the output across the anode load being fed to a subsequent amplifier. There was no evidence of distortion with either the 12AX7 or the 12AU7. It should be added that, although the value of $R_3$ was set up to give the correct bias voltage for each valve, no noticeable deterioration in quality was introduced when this value was shifted widely from its correct figure.

Practical voltage amplifier circuits may employ different anode loads and h.t. voltages from those used by the writer for these checks. They will, in consequence, require different cathode bias voltages across $TR_1$. Such bias voltages may be obtained by adjustment of $R_3$. The value of this resistor is in any event experimental, as it depends upon the characteristics of the transistor employed. The transistor should not, of course, be used in a circuit which causes its maximum voltage or dissipation figures to be exceeded; but such a likelihood is remote so far as conventional voltage amplifier stages are concerned.

**Further Points**

It is possible to obtain a rough idea of the input impedance offered by the transistor by multiplying the cathode input impedance of the valve by $\alpha'$. Assuming that input impedance is equal to the reciprocal of mutual conductance, the cathode input impedance of a 12AX7 is of the order of 800Ω. If $\alpha'$ is 50, then transistor input impedance becomes 40kΩ. Shunted by the bias resistor, the final figure comes to some 25kΩ. The corresponding figure with a 12AU7 triode is around 14kΩ. These figures are intended to be a guide only, and it is not really advisable to attempt to increase them by the use of additional transistor circuitry, since the resulting complication would be of at least the same order as that resulting from introducing a second valve, as in Fig. 1. Some alleviation in this respect can, however, be given by employing a transistor having a high value of $\alpha'$.

Since considerably less than half the supply voltage appears across the transistor in Figs. 3 and 4, there is no necessity to introduce d.c. stabilising components to prevent thermal runaway.

## NEW ENCAPSULATED GENERAL PURPOSE RECTIFIERS

Pursuing the trend towards inexpensive encapsulation for semi-conductor devices, Mullard now introduce a plastic encapsulated silicon rectifier type BYX10 for general use. The hard plastic encapsulation is so successful that it readily fulfils the stringent requirements of the accelerated damp heat tests recommended by the I.E.C.

Designed to operate with an average forward operating current up to 200mA, the BYX10 will withstand a repetitive peak reverse voltage of up to 1.6kV and momentary "switching on" surge currents of up to 15A—both very important properties for an item which may be used in heavily inductive circuits.

Used in a single phase half wave circuit with resistive load, the rectifier can supply 200mA at 250V. These figures can be doubled to 400mA at 500V by using four rectifiers in a single-phase full-wave bridge circuit.

The wide range of possible applications include: power supplies for transistor and valve instrumentation, rectifiers for d.c./a.c. low power converters, logic elements in electro-mechanical systems and blocking diodes in mains equipment safety circuits.

# Electronic Locks and Anti-Thief Devices

## Part 1

***by R. M. Marston***

### *Protect Your Home By Electronics*

THE ORDINARY TUMBLER LOCK IN GENERAL USE suffers from several disadvantages. Amongst these are the facts that skeleton keys can be made that will open any lock in a particular series, that most locks are easily picked by an expert, and that a wax impression of a key carelessly left about can easily and speedily be made, from which a replica of the original can be cut. All of these disadvantages stem from the fact that the "key" is a purely physical thing.

Electronic locks, on the other hand, suffer from none of these disadvantages. The "key" can be made a purely abstract thing, such as a series of numbers or letters carried around in one's mind. Or it can be some tangible but non-physical thing, such as a set of electronic signals, a combination of pre-determined voltages and currents, or a coded audio signal.

It must be pointed out at this stage that while ordinary locks usually combine both the lock and the latch mechanism, in the electronic device these two parts are considered as separate items, and it is only with the actual locks that this article is concerned. The latch itself may be a solenoid-operated unit that functions when the lock circuit is completed, or any other suitable device.

The only disadvantages of electronic locks are their cost and their vulnerability to electrical failure. By careful choice of components, cost can, however, be kept to a surprisingly low level, and the vulnerability to electrical failure can be eliminated by duplication of circuitry.

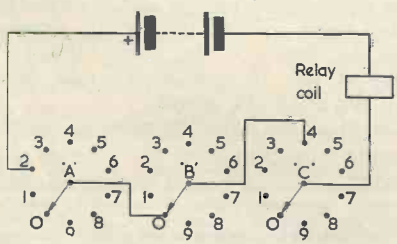



*Fig. 1. The basics of a simple 3-decade electronic lock. There are 1,000 possible combinations ranging from 000 to 999*

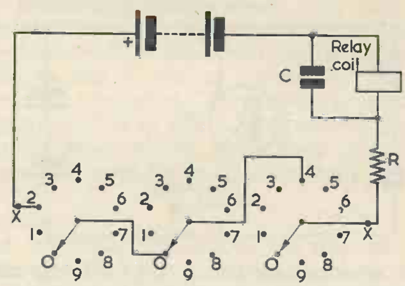



*Fig. 2. Adding a simple delay circuit to the relay coil. This necessitates waiting for the relay to operate after the correct combination has been selected, and makes "searching" for the combination much more difficult and time-consuming*

**Decade Switch Lock**

The simplest type of lock consists of a number of decade switches wired in series with the relay which controls the latch unit, as shown in Fig. 1. In order to complete the circuit and make the relay work it is necessary to put all three switches into the correct positions. Using only three decade switches there are a thousand possible sequences in which the switches can be arranged, while using a bank of six decades there are one million possible ways. We have, clearly, the basis of a combination lock.

The circuit shown in Fig. 1 has, however, a serious fault. In order to "crack" it, it is only necessary to "spin" the dials, first putting C and B at zero and running through the ten positions of A, and if the relay doesn't "click", setting B at 1 and spinning through A again, and so on, until the relay is heard to click over. This is because the relay operates so quickly that even the fraction of a second for which the circuit is completed by this method of "spinning" is sufficient to make it energise. Using this method, a three decade switch of the type shown can be broken in about one minute.

An effective way around this snag is to put a delay unit into the relay circuit. This can consist quite simply of a resistor in series with, and a capacitor wired across, the relay coils, as shown in Fig. 2. When the circuit is completed the current momen-

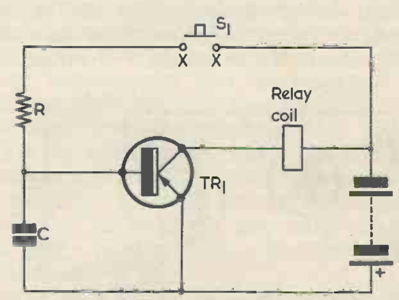



*Fig. 3. An alternative type of delay circuit employing a transistor. Switch $S_1$ may be assumed to replace the decade switches of Fig. 2*

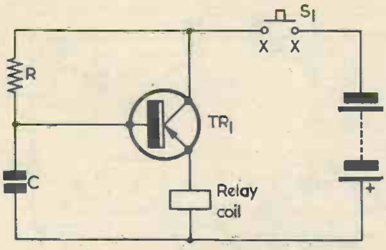



*Fig. 4. A further delay unit, in which the relay coil is inserted in the emitter supply lead*

tarily flows through the effective short-circuit of capacitor C and drops all of its voltage across R, so that the relay cannot operate. As C charges the voltage across it builds up until, after a predetermined time which is dependent on the component values, sufficient voltage becomes available to operate the relay. The actual values of R and C will depend on the time delay required, the rating of the relay, and the battery voltage, and are best found by experiment. A delay of about five seconds will normally be the most useful.

A roughly approximate indication of the components required for a given time delay is given by the simple formula for time-constant: $T=RC$, where $T$=time in seconds, $R$=resistance in ohms, and $C$=capacitance in farads.

Using a capacitor of 200$\mu$F, and a time delay of 5 seconds, it is found that a resistor of 25k$\Omega$ will be required. The fact that this resistor is in series with the relay coil resistance introduces another snag in that the resistor and the coil form a voltage divider, necessitating an increase in the supply voltage. A 500$\Omega$, 6 volt relay coil will require a supply of some 300 volts!

It is therefore essential to use expensive and very sensitive relays in this circuit. Surplus moving-coil relays are available, for example, that will work from as little as 140mV. These have a resistance of 350$\Omega$ and cost about 25 shillings. When used in the circuit of Fig. 2 with appropriate capacitance values, they could operate from a supply of 4.5 volts, and even as little as 1.5 volts.

**Transistor Amplifier**

Less sensitive and cheaper relays may be used in conjunction with a transistor amplifier, as shown in Fig. 3. $S_1$, connected at points x–x would, in the final circuit, be replaced by the decade switches. (See Fig. 2.) The input resistance of a transistor is generally in the order of about 100$\Omega$, and the voltage divider effect still occurs. This may be considerably reduced by inserting the relay into the emitter line, as shown in Fig. 4, this giving an effective increase to the input resistance in a manner similar to the cathode follower principle. When $S_1$ is closed current will flow through R to charge C. The capacitor will be an effective short circuit at the instant of closing $S_1$, and zero voltage will be presented to the base of the transistor. The voltage across C will slowly build up until, after a time determined by the component values, the relay will operate.

The actual component values used will depend on the transistor, the relay, the battery characteristics and the time delay required, and are best found by experiment. Almost any cheap transistor may be used, providing that its ratings are not exceeded.

The ultimate development along these lines is shown in the circuit of Fig. 5. Here a configuration known as a "super-alpha pair" is used. R and C form the time constant circuit. $TR_2$ is connected with the relay coil in its emitter circuit, thereby increasing the effective base or input resistance. This high input resistance is presented to the emitter of $TR_1$, making the effective base resistance of this transistor so high that it has virtually no voltage divider effect with R at all. In an experimental set-up a relay with a resistance of 670$\Omega$ and operating current of 14mA was employed in conjunction with a pair of "red spot" transistors using this circuit. These transistors cost only a few shillings each, and the writer obtained the relay for about five shillings. The complete circuit was built for about ten shillings, which is less than half the cost of the more sensitive relay described earlier.

Any of the four time delay circuits shown in Figs. 2 to 5 may be fitted into the locks to be described, the type employed being a matter of individual choice. Also, they may be used with the decade switches of Fig. 2 to provide an elementary back system on its own.

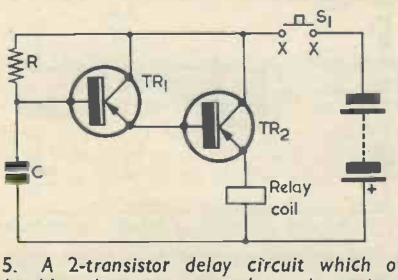



*Fig. 5. A 2-transistor delay circuit which offers considerable advantages over those shown in Figs. 3 and 4*

**Further Developments**

To return to the development of electronic locks, an additional switch may be added in the battery circuit. This must be closed before the unit can function, and it can also be used to feed an alarm circuit as a precaution against unauthorised tampering. The alarm circuit utilises an arrangement similar to that shown in Fig. 5, but having a longer time delay of, say, 10 seconds. Its relay is used to operate a bell or similar alarm.[1]

The circuit of the complete unit, as described so

[1] In the diagrams which follow, relays and their contacts are illustrated with the "detached" method of presentation. Relay coils are indicated by rectangles and are designated by a letter over a figure. The figure indicates the number of contacts possessed by the relay. The contacts may appear at any point in the diagram and are shown in the de-energised position. They are designated by a letter and a suffix number. Thus a rectangle indicated as, say, A/2 refers to the winding of relay A; the designation also carries the information that there are two sets of contacts. These contacts will be found elsewhere in the diagram designated A1 and A2.—EDITOR.

far, is shown in Fig. 6. $R_1$, $C_1$, $TR_1$, $TR_2$ and relay A2 form a 5 second delay circuit triggered by the combination switch chain, $S_1$, $S_2$ and $S_3$, these being connected to the battery via $S_4$ and $S_5$. Relay A/2 has two sets of contacts, A1 and A2. A2 is used to operate the latch mechanism.

$R_2$, $C_2$, $TR_3$, $TR_4$, relay B/2, and contacts B1 and A1 form the anti-thief alarm circuit with, say, a 10 second delay. Connection to the battery is made via A1, $S_4$ and $S_5$. Relay B/2 has two sets of contacts, B1 and B2. B2 is connected to the bell or alarm circuit.

The sequence of operations is as follows, $S_5$ is normally closed. In order to make the circuit work $S_4$ is also closed and voltage is applied to the anti-thief circuit via contact A1. Relay A/2, in the 5 second delay circuit, is de-energised, and will remain so for at least 5 seconds. Its contact $A_1$ is closed when the relay is de-energised, and *vice versa*. If the decade units are switched in the correct positions then the battery voltage will also be applied to the 5 second delay circuit and, at the end of this period, relay A/1 will energise. Contact A2 will close, operating the latch release solenoid, while at the same time A1 will open, cutting the battery supply to the alarm system and making it inoperative.

If, however, the decade unit is not switched to the correct combination within 5 seconds of closing $S_4$, contact A1 will remain closed for the full 10 seconds required to operate relay B/2 and the alarm will sound. The thief could, if B1 were not in the circuit, switch off $S_4$ as soon as the alarm sounded, thus restarting the cycle and giving himself a further 10 seconds to break the lock; and so on until the lock was finally opened. To prevent this, contact B1 is used, when closed, to bypass $S_4$ and connect the alarm circuit directly to the battery. The alarm circuit is thus made self-latching, and will continue to sound once it has started, even if $S_4$ is made open-circuit. The only way the alarm can be stopped is by opening $S_5$, which would be a press-button switch concealed inside the cabinet or protected enclosure, so that the correct combination must be found before the alarm can be stopped.

$S_1$, $S_2$, $S_3$ and $S_4$ are, of course, the only front panel mounted controls. The correct procedure for opening the lock is to first set the correct combination on the three switch dials, then close $S_4$ and wait 5 seconds until the latch slides back.

**Precautions**

Three important precautions are necessary when using the circuit of Fig. 6. First, the batteries must always be maintained at a satisfactory operating voltage. (As a safeguard, a pair of terminal points could be made available for the application of an external battery in parallel with that protected by the lock, a device such as a diode being incorporated to prevent connections of incorrect polarity from damaging the transistors.) Secondly, once the lock has been used it must be reset by opening $S_4$. The third point is that, once the lock has been used and the door is shut again, all three dials must invariably be turned out of the contact positions, otherwise the thief will merely have to close $S_4$ to open the lock again.

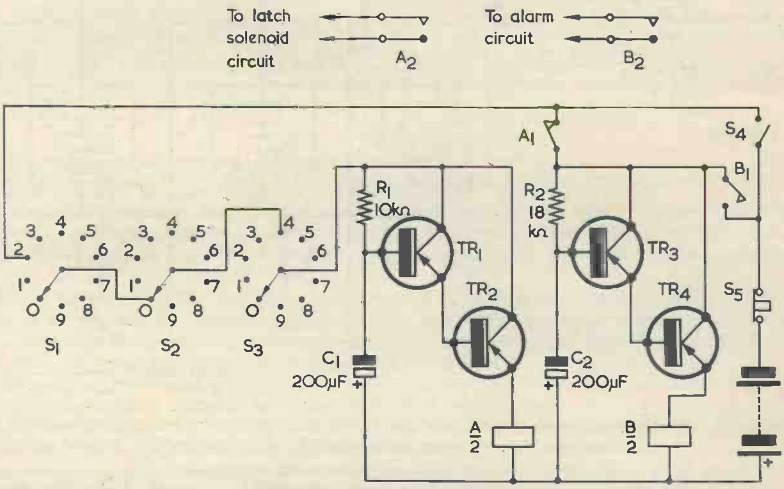



*Fig. 6. A comprehensive lock which sounds an alarm if the wrong switch combination is selected. The resistor and capacitor values shown in the diagram are those employed in the author's prototype, the two relays being 670Ω types energising at 14mA. The transistors can be OC72 or similar, the supply potential being 12 to 15 volts*

It may be felt by some readers that an insufficient number of combinations are provided, or that the necessity of changing the dial positions after use is asking too much of their memories. In this case, a further development can be employed. It is possible to arrange things so that the after combination has been correctly dialled the relay is used not to operate the latch but to change the combination and make a second set of delay units available. It is then necessary to dial a second set of combinations, which, if correctly set, may either operate the latch or give a further change of combination and delay units; and so on.

Fig. 7 shows a circuit designed to offer this kind of operation. Here, it is necessary to dial, in the correct sequence, three sets of three digit combinations, using only three panel mounted dialing

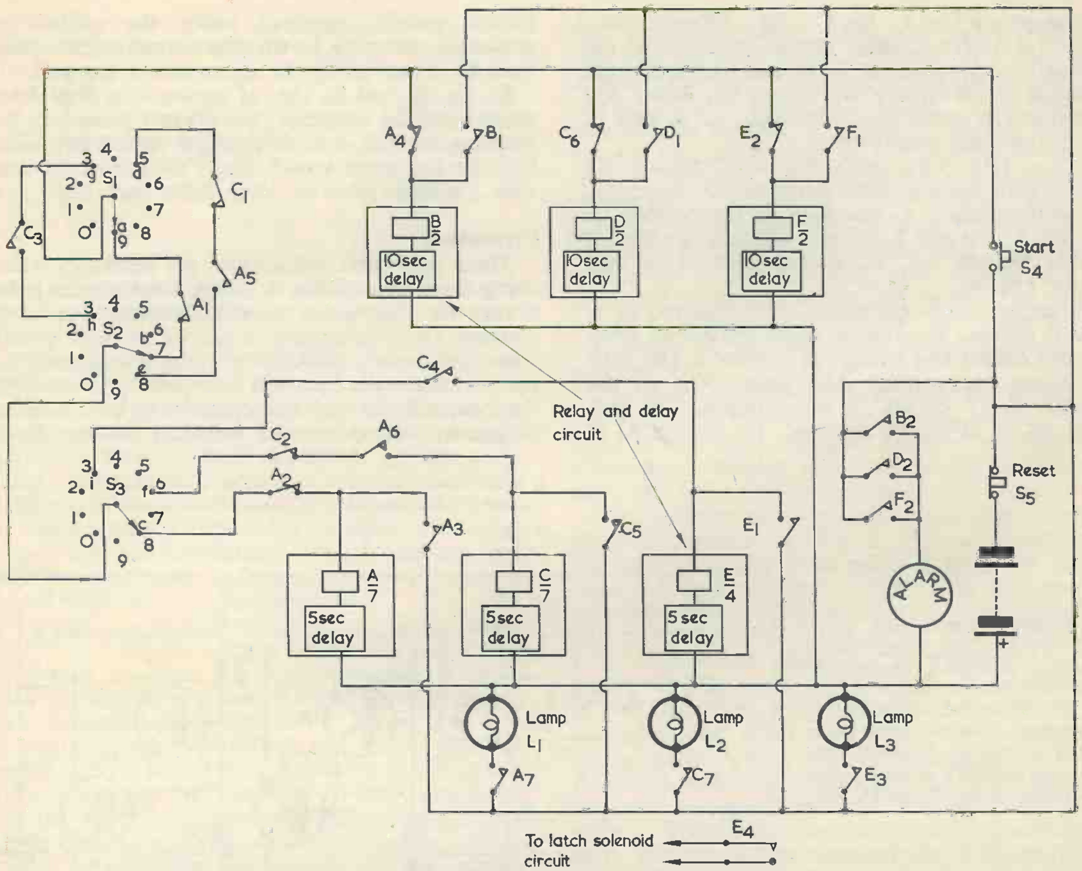



*Fig. 7. A comprehensive circuit wherein three combinations have to be switched in successively. The combination changes automatically after the first and second selections*

switches. There are thus one thousand possible combinations. It is possible to make only one attempt at opening the lock, after which either the latch will open or the alarm will sound. The odds against any unauthorised person opening the lock are therefore one thousand million to one. It should be noted that if the alarm is not fitted and any number of attempts can be made, it is possible to break the lock in, at most, three thousand attempts, it being necessary only to make up to one thousand systematic attempts at dialling to obtain the first three digits of the nine digit combination, and then, knowing this number, to make a further thousand attempts at finding the next three, and so on. It is therefore essential to the basic design of this and the earlier lock that the alarm system be fitted.

The operation of this lock, with reference to Fig. 7, is as follows. A three digit combination is selected via switches $S_1$, $S_2$ and $S_3$, and the start button, $S_4$, is pressed and held down. Voltage is applied, via contacts E2, C6 and A4 to relays F/2, D/2, and B/2, together with their 10 second delay circuits. With reference to the decade unit it is necessary, for correct operation, that a voltage be applied via the decade switches to one of the three relays A/7, C/7 or E/4 and their appropriate delay circuits. The path between contacts "d" and "e" of $S_1$ and $S_2$ has been made open-circuit by relay contact A5, whilst "g" to "h" is open-circuit by C3. Also, between $S_3$ and relays A/7, C/7 and E/4, "f" to C/7 is open-circuit by A6, and "i" to E/4 is open-circuit by C4. The only satisfactory positions for $S_1$, $S_2$ and $S_3$, therefore, are "a" via A1 to "b", through $S_3$, and "c" via A2 to relay A/7. If "a.b.c." has been dialled correctly, voltage will be applied to relay A/7 and its delay circuit, and after 5 seconds A/7 will energise. Contacts A1, A2, A5 and A6 will switch over and change the combination. Simultaneously, A3 will close, locking relay A/7 on, regardless of the states of $S_1$, $S_2$, $S_3$ and the start button $S_4$. Contact A7 will connect the supply to indicating lamp $L_1$, to indicate that the operation has occurred correctly, whilst A4 disconnects the supply to relay B/2 and its 10 second delay circuit.

The start button should be released as soon as lamp $L_1$ comes on. If the button is not released, but remains depressed for a further five seconds, relay D/2 and F/2 will operate and lock themselves on via their contacts D1 and F1, activating the alarm via contacts D2 and F2. If the correct combination has not been selected, relay A/7 will not operate, with the result that the supply will not be broken to relay B/2 before the 10 second period is up. The effect is the same as if the start button, $S_4$, were left depressed for too long and the alarm will sound.

If the first combination has been dialled correctly, the second one ("d.e.f.") can be set up and the start button depressed again, and a similar sequence will occur, only this time relays C/7 and D/2 will be used. If the combination is correct, lamp $L_2$ will come on and the combination will change again.

It is only after the third combination ("g.h.i.") has been dialled successfully that $L_3$ will come on and the latch will operate. If a mistake has been made at any time during the process and the alarm has sounded, the only way it can be stopped is by opening the lock and disconnecting the battery supply by pressing $S_5$, a push button reset switch concealed inside the safe or protected place. It will be necessary to reset the lock after use in any case, so it may be preferable to make $S_5$ a micro-switch which operates automatically when the door is opened.

It should be noted that with this circuit it is not essential to change the dial positions after use, as even if three of the nine digits in the combination are known, the odds are still one million to one against any unauthorised person finding the remaining six digits. The odds would in fact be even greater than this, as it is very unlikely that a thief would know how to operate the lock anyway, and even if he did, he would have no idea of the time delays involved. The time delays are, of course, a matter of individual choice, and need not even be the same between one relay and another, as long as the delay of the alarm relays is made appreciably longer than the longest delay given to the remaining circuits.[2]

To obtain the required number of contacts on relays A/7 and C/7, pairs of four pole relays may be coupled together.

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[2] A possible economy, in Fig. 7, could be given by dispensing with relays B/2 and D/2, relying only on relay F/2 for the alarm function. Relay F/2 will then energise if $S_4$ is held down for two long during the first or second dialling operations, or if $S_4$ is held down for too long before relay E/3 energises during the third operation.—EDITOR.

*(To be continued)*

## NEW PHOTOMULTIPLIER TUBE HAS FAST RISE TIME

First of a new range of fast photomultiplier tubes, suitable for use in nuclear physics and other applications where a fast rise time and high peak currents are required, is announced by EMI Electronics Ltd. The high-field focused dynode system of the Type 9594B tube employs antimony caesium secondary-emitting material to give maximum stability and minimum gain shift.

Fast rise time of 2½ nanoseconds is achieved by the use of an end-window with a concave inner surface, on which the semi-transparent photocathode is deposited, in conjunction with focus and deflector electrodes. These ensure good collection of photo-electrons into the first dynode and minimise the time spread of the output pulse. The fourteen-stage dynode structure gives an overall electron gain in excess of 100,000,000.

Flat external surface of the end-window facilitates coupling of scintillating crystals. The fast rise time, high gain and high peak currents make this tube particularly suitable for fast coincidence applications.

Variations of the basic type now in development include a tri-alkali cathode version for applications demanding an extended red response, and another with a quartz window for improved ultra-violet sensitivity.

## HEATHKIT MODEL SB-400 S.S.B. TRANSMITTER

The Heathkit Model SB-400 s.s.b. transmitter, illustrated herewith, covers all amateur bands from 3.5 to 30 Mc/s. Frequency stability is excellent, being less than 100 c/s drift per hour after 20 minutes warm-up under normal ambient conditions, and less than 100 c/s drift for $\pm 10\%$ line voltage variations. The types of emission are s.s.b. with selectable upper or lower sideband and c.w., the r.f. power output being 100 watts on 80 to 15 metres and 80 watts on 10 metres (50$\Omega$ non-reactive load). The visual dial accuracy is within 200 c/s on all bands and the electrical dial accuracy is within 400 c/s on all bands, after calibration at the nearest 100 kc/s point, backlash is no more than 50 c/s.

Carrier suppression is 55dB down from the rated output, harmonic radiation is 35dB below rated output, oscillator feedthrough or mixer products are 55dB below rated output (except at 3910 kc/s crossover which is 45dB). Unwanted sideband suppression is 55dB down from the rated output at 1,000 c/s and higher, third order distortion being 30dB down from rated p.e.p. output and noise level at least 40dB below rated carrier. The SB-400 s.s.b. transmitter is available at £165 4s., in easy-to-assemble kit form, carriage paid in U.K.

# NEWS AND COMMENT

### 60 Years Ago

The "Fleming Oscillation Valve", the forerunner of today's vast range of specialised valves, was discovered by Sir Ambrose Fleming just sixty years ago, in November 1904. Perhaps one of the most important electronic discoveries of the century, this invention heralded the birth of the electronics industry.

Today the transistor is fast replacing this early discovery, but it will be many years before the high power valves, handling many megawatts and using the same basic principle of cathodic emission as Fleming's valve, are replaced by solid state devices.

At the time of his discovery, Sir Ambrose was Professor of Electrical Engineering at University College, London, and since 1899 had been Scientific Adviser to The Marconi Company. He was very closely associated with Marconi himself and had played a leading part in the design of the powerful transmitting equipment at Poldhu in Cornwall, with which Marconi made his first successful wireless transmissiom across the Atlantic in 1901.

In his search for better methods of detecting electro-magnetic or wireless waves, Sir Ambrose, recalling the results of earlier research involving the passage of electric currents through rarefied gases, conducted a series of experiments utilizing some of his original apparatus. This new work led him to the discovery of the "Fleming Oscillation Valve", the first thermionic valve produced in the world. This was quickly recognised by The Marconi Company and the "valve" was soon put into full production.

During his years at University College, Sir Ambrose Fleming trained many hundreds of engineers who later made their names in the radio industry. He continued to lecture until ninety years of age!

Sir Ambrose died in his 96th year on 18th April, 1945.

### 100 Years Ago

From the issue dated 3rd November, 1863, of the *Lancet*, the famous medical journal:

"On Tuesday last the electric light was used in the operating theatre of the Royal Ophthalmic Hospital, Moorfields. . . . The excellence of the light for operations on the eye was well demonstrated, and we have no doubt that it will be shortly in use in most hospitals for operations by night or on dark days."

### Colour TV in 1967?

A report issued by the Heywood Electronics Information Centre expects colour television to take the air in a limited way during 1967. This belief is despite the high cost of receivers, expected to be four times that of black and white ones in the initial stages.

Further international discussion on colour television took place in London from 26th–29th October. Demonstrations were given by the B.B.C. and the British Radio Equipment Manufacturers' Association to the E.B.U. Colour Television Group.

These demonstrations mark a further step towards choosing a common colour system for Europe, the final decision on which is to be made at a meeting of the C.C.I.R. (International Radio Consultative Committee) in Vienna next March. The demonstrations compared colour pictures produced by the three systems, NTSC, SECAM and PAL, when transmitted over long international links, when recorded on video tape, and when transmitted direct to domestic receivers. They showed the effect of important improvements in colour television apparatus that have been made since the previous series of demonstrations in London last February.

### Education of Amateurs

The Radio Society of Great Britain has recently, we understand, been devoting considerable thought to the education of the younger generation in Amateur Radio as a hobby and as a basis for a career in electronics generally.

One of the stands which interested us at their International Radio Communication Exhibition, reported elsewhere in this issue, was the Society's educational stand where a series of most interesting demonstrations were given. We would like to have seen this stand more prominently sited, instead of at the far end of an annexe hall. Also badly sited, up in the balcony, was the stand of the British National Radio School. This was a pity as they were featuring a special Home Study Course covering the Radio Amateurs' Licence Examination.

We wonder whether the R.S.G.B. has considered holding the exhibition in London every other year, and in the alternate year holding a Hamfest with a small exhibition in centres of population other than London. The interest in the biennial exhibition in London would probably be greater and the provinces would feel that everything was not centred in London alone.

### B.A.R.T.G.

On the final night of the foregoing Exhibition, the British Amateur Radio Teleprinter Group held its Annual General Meeting and get-together at the "Olive Branch".

This event was apparently very successful, some 50 people attending including 6 Dutch RTTY enthusiasts. One change of note was the retirement as Honorary Secretary, of Arthur C. Gee, G2UK, the founder of the group and a pioneer of RTTY in this country. His services will not be lost however as he undertook the position of Honorary Treasurer.

Mr. Eric Yeomanson, a member of the group, was in charge of the RTTY Radio Station at the previously mentioned exhibition. We would like to take this opportunity of congratulating Mr. Yeomanson on his appointment as the 1965 President of the Radio Society of Great Britain.

### Phenomena

At some time or other, in connection with radio or television, most readers will have some across some example of freak reception or the like. In the writer's case, telephone conversations, which took place when a neighbour's radio was switched on, were clearly audible through its loudspeaker.

A most unusual cause of TV interference has been reported in the *Daily Express*. In this particular case interference was caused because the next door neighbour was building up static electricity—by stroking her cat!

# Relay Binary Circuit

## "MAGIC" Switching for your Christmas Tree Lights

B. W. OSBORN

THE CIRCUIT TO BE DESCRIBED was designed to operate in conjunction with a photocell and light beam system to control a set of Christmas tree lights, apparently by magic, for the amusement of friends' children.

The photocell and light units were placed in front of the tree in such a position that a person approaching the tree interrupted the beam momentarily and produced a pulse from $TR_2$ which energised relay X. See Fig. 1. Similarly, a further pulse was produced as the person moved away from the tree.

The associated binary circuit, shown in Fig. 2, was required to turn the tree lights on at the beginning of the first pulse and off at the end of the second.

Fig. 1 shows the phototransistor and power supply circuits, both of which are conventional and need not be described in detail. The relay binary, or "divide by two" circuit has two stable states, i.e. the output relay contacts are either open or closed, an input pulse changing the circuit from one state to the other. The relay circuit operates in the following manner.

**Relay Operation**

Contact XI of relay X changes over for the period during which the light beam is interrupted, and relay A is energised via contact A1 and resistor $R_6$. Contact A1 provides a hold-on circuit for relay A whilst contact A2 prepares a path for the operation of relay B upon the subsequent release of relay X. The third contact of relay A connects the mains supply to the three lamps. When the person approaching the tree passes completely through the light beam relay X releases, causing the operation of relay B via contact A2. Contact B1 makes to provide a circuit which will short-circuit the coil of relay A when relay X re-operates (when the person moves away from the tree). When this occurs both sides of relay A coil are brought to the same potential and the relay releases. Relay B is maintained energised by a current flow through diode $D_1$, contact X1 (energised) and contact B1. The tree lamps stay alight due to the parallel mains supply path through contact B2. When the person has moved far enough back from the tree to clear the light beam, contact X1 returns to its original state and removes the supply from relay B coil. With relay B de-energised the circuit returns to the state shown in Fig. 2, and the tree lights are extinguished.

**Installation**

When in use both the phototransistor and light unit were hidden behind furniture and, as the phototransistor responded well into the infra-red region, a filter

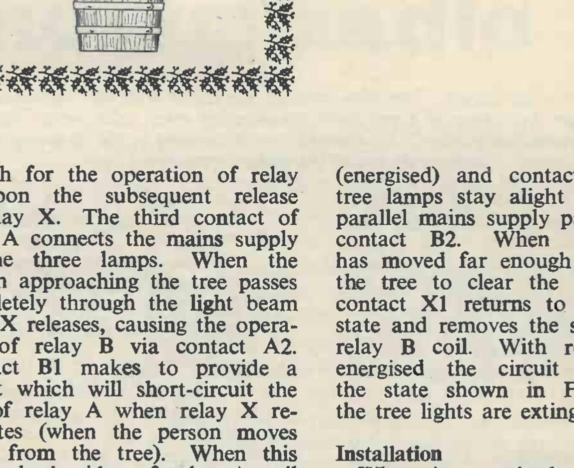



*Fig. 1. The power supply and light-operated section of the circuit. The lenses may be inexpensive "magnifying glasses", or similar*

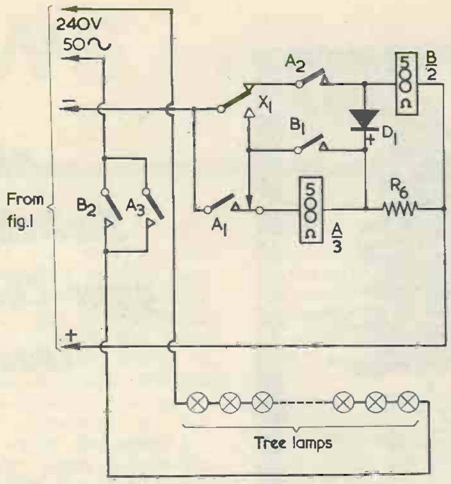



*Fig. 2. The relay circuit. The relay contacts are shown with the "detached" presentation, i.e. separate from the corresponding relay coils, which have the same letter designation. All contacts are illustrated in the de-energised state. Contacts A1 are of the make-before-break type*

was placed in front of the light source to remove visible light and avoid easy detection. The length of time for which relay **X** operates need be only a few milliseconds for satisfactory operation of the binary circuit, and the tree lights could be as easily operated by a wave of the hand through the light beam as by walking towards the tree.

Possible alternative uses of the system are.

(1) The automatic switching of bedroom or stair lights by a child old enough to get out of bed to visit the toilet, etc., but not tall enough to reach the light switch.
(2) Control of loft lights where access may be required when the hands are not available for operating the light switch.
(3) Operation of garage doors via a suitable actuator so that the doors open as the car approaches the garage and close as the driver leaves.

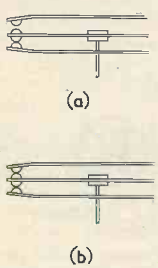



*Fig. 3. If a make-before-break contact set for A1 of Fig. 2 is not available, a changeover springset may be adapted. As shown in (a), the outer springs are bent inwards so that all springs connect together momentarily, as in (b), during the process of energising*

**Mechanical Details**

If a make-before-break springset is not available (for contact A1) a changeover set can be used if the outermost springs are bent slightly inwards so that all three springs are momentarily in contact as the relay operates. See Fig. 3.

The diode $D_1$ can be any general purpose type capable of passing 100mA with a p.i.v. rating of 150.

The 100Ω resistor $R_6$ should be a 2 watt type as the full low voltage supply appears across it during the period when the beam is interrupted prior to the release of relay B.

The relays, all of which are P.O. 3000 type, were held on a length of ½ x ⅛in thick aluminium bar by their 2BA coil fixing screws. The bar was bent into an inverted "U" form and screwed to a wooden baseboard, the relays being suspended from the bar with their tags uppermost. Power supply components were also mounted on the board.

The light unit was contained in an old cocoa tin, the lampholder being fitted through the lid, with the lens pressed into an opening cut in the bottom of the tin. A similar tin housed the phototransistor and its associated circuitry, both units being held in "U" shaped cradles which permitted the light source and phototransistor to be easily aligned.

EDITOR'S NOTE

Whilst the contacts of P.O. 3000 relays, as normally encountered, will cope with the switching of Christmas tree lamps at mains voltage, it should be remembered that the insulation between springsets and armature may not be intended for such an application. From the point of view of safety, therefore, it would be preferable to ensure that bulb $B_1$ and the circuitry around $TR_1$ are reliably insulated from the tins in which they are fitted. For a similar reason, the remaining low voltage components should be mounted in an insulated case which prevents their being accidentally touched.

**Components List**
**(Figs. 1 and 2)**

*Resistors*
(All resistors 10% ¼ watt unless otherwise stated)

| | |
|---|---|
| $R_1$ | 10kΩ |
| $R_2$ | 470Ω |
| $R_3$ | 10kΩ |
| $R_4$ | 1.2kΩ |
| $R_5$ | 100kΩ |
| $R_6$ | 100Ω 2 watts |

*Capacitors*

$C_1$ 1,000μF electrolytic, 20V wkg.

*Transformer*

$T_1$ Standard receiver mains transformer (h.t. windings not employed), with 6.3 and 5V secondaries connected in series

*Transistors*

$TR_1$ OCP71
$TR_2$ OC72

*Relays*
(All relays are P.O. 3000, with 500Ω coils)

$\frac{X}{1}$ 1 changeover springset

$\frac{A}{3}$ I make-before-break springset (see text), 2 make springsets

$\frac{B}{2}$ 2 make springsets

*Rectifiers*

$W_1$ 12V 1A selenium bridge rectifier (battery charger type would be suitable)
$D_1$ General purpose (see text)

*Bulbs*

$B_1$ 12V 6W
Christmas tree lamps

*Miscellaneous*

Bulb holder (for $B_1$)
Convex lenses (for $B_1$ and $TR_1$)
Lamp and phototransistor cases
Baseboard, relay mounting bar, etc.

INTRODUCING THE VALVE

# understanding radio

By W. G. MORLEY

*After dealing with final details on loudspeakers, "Understanding Radio" turns its attention this month to the valve, which it introduces in the form of the diode*

IN LAST MONTH'S ISSUE WE EXAMINED THE ELECTROSTATIC loudspeaker and the Ionophone. We have very nearly completed our discussion on loudspeakers and the only main aspects of this subject which are now left uncovered are the crystal loudspeaker and loudspeaker circuit symbols. After dealing with these, we shall introduce the valve.

**The Crystal Loudspeaker**

Certain crystalline substances, notably quartz and Rochelle salt, tend to exhibit deformation of shape if an e.m.f. is applied across two opposite surfaces. This effect, which is known as the *piezoelectric effect*, is most evident when sections having particular ngles to the crystal axes are cut from the crystal.[1] By suitably clamping a crystal section, or a combination of two crystal sections, it becomes possible to impart a bending or twisting motion to the unclamped portion when an e.m.f. is applied. The bending or twisting motion may then be coupled, via an arm, to a cone or diaphragm.

If an alternating voltage at audio frequency is applied to the crystal section, the cone or diaphragm moves in sympathy with the frequency and amplitude of the applied voltage, whereupon the device becomes a loudspeaker. The source of alternating voltage is normally applied to conductive coatings, or metal foil, on opposing faces of each crystal section.

Due to the fragility of the crystal, it is not possible to apply alternating voltages of high amplitude to it, with the result that the *crystal*, or *piezoelectric loudspeaker* is only really useful for relatively low power reproduction at the higher audio frequencies, i.e. as a tweeter. Because of its limitations, however, it is used very infrequently, even in this application. On the other hand, *crystal earphones* are quite often encountered, these having the same basic principle as for the loudspeaker.

Since the crystal sections exhibiting the piezoelectric effect are not conductors, no current flows through a crystal reproducer. Crystal reproducers present a relatively high impedance to the source of a.f. voltage, this being largely capacitive.

**Transducers**

The term *transducer* defines any device which converts power from one form to another. A loudspeaker is sometimes referred to as a transducer, because it converts electrical power into mechanical power.

Other types of transducer encountered in radio work are microphones, which convert mechanical power to electrical power, and gramophone pick-ups. The latter also convert mechanical power to electrical power, the mechanical power being imparted to the stylus by the groove of the gramophone record.

We have not dealt with either microphones or gramophone pick-ups at this stage but it is interesting to note, in passing, that these may employ the same basic principles, in reverse, that we have encountered in some of the loudspeakers we have considered. A moving-coil (or dynamic) microphone, for instance, has the same basic construction as the moving-coil loudspeaker. When sound impinges on its diaphragm, its coil moves in a magnetic field. A current which is proportional to the frequency and amplitude of the diaphragm movement is then

[1] The same crystal section will, conversely, cause a potential difference to appear across the faces if it is subjected to mechanical deformation. This is also a piezoelectric effect.

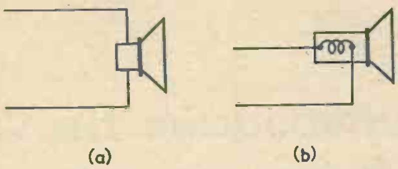



*Fig. 246. Circuit symbols for loudspeakers are, usually, immediately recognisable. A general symbol is shown in (a), whilst that in (b) applies specifically to the moving-coil loudspeaker*

induced in the turns of the coil, and may be amplified by a subsequent a.f. amplifier. Ribbon microphones, having the same basic assembly as the ribbon loudspeaker, may similarly operate in converse manner. So also may capacitor microphones (roughly equivalent to the two-electrode electrostatic loudspeaker) and crystal microphones. These microphones do not, of course, appear in the same physical form as the corresponding loudspeakers, because they are designed to do a different job.

Gramophone pick-ups commonly employ the piezoelectric effect to change the movement of the stylus to corresponding electrical voltages. An alternative design of pick-up employs the moving-coil principle.

**Circuit Symbols**

The generally employed circuit symbol for a loudspeaker is that illustrated in Fig. 246 (*a*). Other easily recognisable symbols may be encountered including, in particular, that shown in Fig. 246 (*b*). The symbol in Fig. 246 (*b*) refers to the moving-coil type only. Since the moving-coil loudspeaker is used much more frequently in practice than any other type it can generally be assumed that, unless specifically stated otherwise, the symbol of Fig. 246 (*a*) refers to the moving-coil version also.

**The Valve**

When, in the first article in this series[2], we examined the nature of electric current, we saw that the metals are good conductors because the electrons on the outer orbit shell of each metal atom are held insecurely to the nucleus. The result is that a number of *free electrons* move continually through the metal, joining first with one atom and then with another. The movement is random until a source of electromotive force is applied to two separate points on the metal, whereupon there is a general movement of the free electrons from the point of application of the negative pole towards the point of application of the positive pole. This flow of electrons constitutes an electric current.

[2] Published in the August 1961 issue.

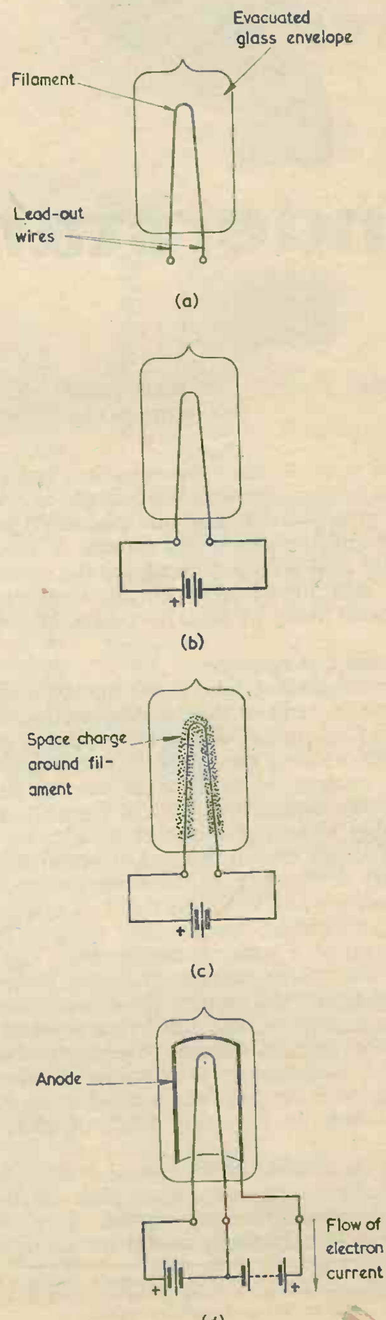



*Fig. 247 (a). A thin filament of wire mounted inside an evacuated glass envelope*

*(b). Applying a battery to the ends of the filament in order to raise its temperature*

*(c). If the filament is sufficiently hot, free electrons leave the metal and appear in a cloud, the "space charge", around it*

*(d). Adding an anode which, by means of a second battery is caused to be positive with respect to the filament. Electrons emitted by the cathode are now drawn towards the anode*

In the type of *valve* we shall now consider, a current is similarly given by a flow of electrons, but in this case the electrons do not flow through a conductor. They pass, instead, through a vacuum or, in other words, through empty space.

In Fig. 247 (*a*) we introduce a length of wire into a glass envelope from which all the air and any other gases have been evacuated. We next apply, in Fig. 247 (*b*), an external battery to the ends of the wire, this causing it to increase in temperature in just the same manner as does the filament of an electric light bulb. We can, indeed, call the wire a *filament* in the present instance. As the temperature of the filament increases, so also does the velocity of movement of its free electrons until, at a temperature which varies from material to material, they acquire enough energy to fly out of the metal into the space immediately around it. A relatively high temperature is required for this phenomenon to occur and it is necessary, in consequence, to employ a material having a high melting point for the filament. A good practical choice is given by using tungsten wire.

The electrons emitted from the filament take up the form of a "cloud" around it, some of these electrons falling back into the filament to be replaced by others. See Fig. 247 (*c*). Once established, the "cloud" of electrons tends to repel most of the further emitted electrons, which similarly fall back into the filament. Thus, a state of equilibrium is set up, and the quantity of electrons in the "cloud" remains virtually constant. As we have seen when we discussed capacitors, an excess of electrons constitutes a charge. We call the "cloud" of electrons around the filament a *space charge*.

In Fig. 247 (*d*) we introduce a metal *plate*, or *anode*, into the evacuated envelope and connect up a second battery in such a manner that this anode is positive relative to the filament. The electrons emitted by the filament now become attracted by the positive anode and flow towards it. An electric current flows, therefore, from filament to anode, this being provided by the flow of electrons through the empty space inside the envelope. Also, an electric circuit is set up. Electrons leave the filament and pass into the anode, after which they carry on to the positive terminal of the anode-filament battery; at the same time electrons leave the negative terminal of the battery and flow into the filament to replace those which have been lost to the anode.

If the battery connected between anode and filament has a sufficiently high voltage, the anode will be capable of attracting *all* the electrons emitted by the filament. In consequence, there is no space charge, since all electrons leaving the filament travel immediately to the anode. If the battery has a lower voltage, the attraction exerted by the anode is not sufficiently great to draw *all* the electrons towards it. The result is that a space charge is retained. Electrons then leave the space charge to travel towards the anode, the space charge being replenished by new supplies of electrons from the filament.

**Types of Cathode**

We have referred to the plate of Fig. 247 (*d*) as an "anode", because this is the term normally applied to an electrode (i.e. a conductor which provides electrical connection into a device) which connects to the positive terminal of an actuating source of e.m.f. The opposing term is "cathode". We may, therefore, refer to our filament as a *cathode*.[3]

It is not necessary for the cathode of our assembly to consist of a filament of wire. It may, instead, consist of a sleeve of metal inside which is placed a *heater*, as in Fig. 248 (*a*). This heater is coupled to a source of e.m.f. which raises its temperature. The heater, in its turn, then raises the temperature of the metal sleeve, whose outer surface finally emits the electrons into the empty space of the evacuated envelope. The heater is insulated from the metal sleeve in which it is inserted, and its purpose is merely that of raising the cathode to emitting temperature. Insulation is normally provided by a layer of tough heat-resistant material, such as magnesium oxide, coated over the wire of the heater. Two types of heater construction are illustrated in Figs. 248 (*b*) and (*c*).

[3] To be precise, the anode is the electrode via which "conventional current" flows into a device, and a cathode is the electrode via which "conventional current" flows out of the device. "Conventional current" is assumed to flow from positive to negative, even though this is opposite to the direction of electron flow.

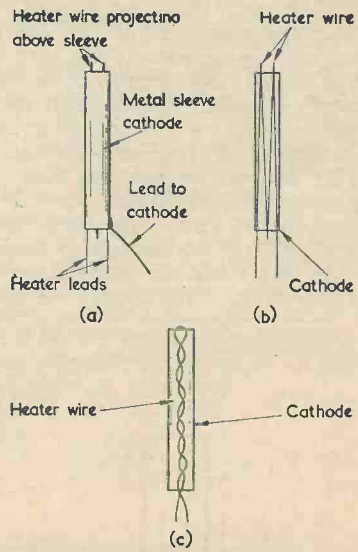



*Fig. 248 (a). If a metal sleeve is raised to emitting temperature by an internal heater it may function as a cathode*

*(b). The heater wire inside the metal sleeve cathode of (a). The heater wire is coated with a tough, heat-resistant, insulating material which prevents it short-circuiting against itself and which provides insulation from the cathode*

*(c). An alternative heater construction, in which a loop of the heater wire is twisted*

If both the cathode and heater are cold, as would occur if the source of e.m.f. for the heater had been disconnected or switched off for some time, a small period of time must elapse before the heater can raise the cathode to emitting temperature after its source of e.m.f. has been re-applied. This period is known as the "warm-up time" for the valve in which the heater and cathode are fitted. We are all familiar with the fact that a conventional valve radio receiver which draws its power from the mains supply takes a little time to come into operation after it has been switched on. The delay is due to cathode warm-up time in the valves employed in the receiver.

When we introduced the question of emission from the filament, it was stated that a good choice for the filament wire would be given by tungsten. Tungsten is, in fact, a perfectly practicable material for this purpose and was used extensively in the early days of radio. It needs, however, to be raised nearly to white heat (around 2,000°C or more) to provide an adequate emission of electrons. An alternative filament material is thoriated tungsten (tungsten with a small addition of thorium), and this offers improved emission at a somewhat lower temperature (of the order of 1,500°C). An alternative approach consists of coating the filament with a layer of rare-earth oxide[4] such as calcium oxide, barium oxide or strontium oxide. These oxides offer a very high emission at much lower temperatures (around 800°C) than are required by the tungsten or thoriated tungsten filaments.

The metal sleeve cathode of Fig. 248 (*a*) would not be expected to operate at the very high temperatures needed by the tungsten or thoriated tungsten filaments. Because of this, such cathodes are given oxide coatings, whereupon they are able to offer high emission at relatively low temperatures.

With Fig. 247 (*d*) we saw the case where the anode potential was sufficiently high to draw all the electrons emitted by the filament towards it. In practice it is generally undesirable to arrange circuit conditions in such a manner that the total emission of the cathode flows to the anode, and this point is especially important with the oxide-coated cathodes (whether these be filaments or separately heated) because such operation may cause permanent damage to the coating. When these cathodes are used, the electron flow to the anode has to be kept well below the possible maximum if the cathode is to have a long life. With the thoriated tungsten filament, electron flow to the anode has also to be maintained below the possible maximum if damage to the filament is not to occur. In this case, however, the maximum permissible electron flow may approach total emission much more closely than occurs with the oxide-coated cathode. With the tungsten filament, it is possible to allow all the electrons which are emitted to flow to the anode without risk of damage to the cathode.

It will be gathered from the preceding paragraph that the oxide-coated cathode must be operated such that it always has a space charge around it. The thoriated tungsten filament must similarly have a space charge, but this can be significantly smaller than that for the oxide-coated cathode.

Because of their high emission efficiency and low temperature requirements, oxide-coated cathodes are normally used in the valves found in domestic radio equipment. They are not suitable for use in applications where the associated anode has a very high voltage. High voltage applications arise mainly in radio transmitter circuits, and these use valves having tungsten or, preferably (because of their higher emission efficiency), thoriated tungsten filaments.

[4] An "earth", in this context, is an oxide of metal which is infusible and which is insoluble in water.

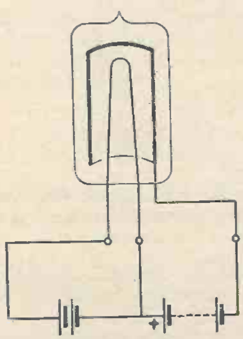



*Fig. 249. Connecting the anode-cathode battery of Fig. 247 (d) with reverse polarity. In this case no current flows*

**Reversing Anode Polarity**

In Fig. 247 (*d*) we applied a battery between anode and cathode such that the anode was positive of the cathode. As a result, an electric circuit was set up, with electrons flowing from the cathode to the anode and then, via the battery, back into the cathode.

In Fig. 249 we connect up our anode-cathode battery once more but with reverse polarity, so that the anode is *negative* of the cathode. The result is that the electrons emitted by the cathode are now repelled by the anode, and they remain in the space charge. There is, therefore, no flow of electrons to the anode at all, and the valve behaves as though it were an insulator.

We learn, therefore, that a valve employing a cathode and an anode in an evacuated envelope is a "one-way" device. If a source of e.m.f. is applied to it so that the positive terminal connects to the anode, current flows. If the source of e.m.f. is applied to it so that the negative terminal connects to the anode, no current flows. Current can only flow in one direction.

**Terminology**

Before we proceed further, it now becomes necessary to introduce a number of terms applicable to the valve.

We have already, of course, inferred that the assembly of cathode and anode in an evacuated container constitutes a "valve". The term "valve" applies also, however, to assemblies which have one or more further electrodes in addition to the cathode and anode; and it applies again to devices which manipulate electrons in other ways and whose electrodes are mounted in envelopes containing a gas. There is a very large family of "valves", in which the two-electrode device we have considered is just one member.

A valve having an evacuated envelope is referred to as a *vacuum tube* in American terminology. Alternatively, the term *tube* may be used to cover the same broad field as "valve".

A valve of the type we have discussed, with a cathode and an anode in an evacuated envelope, is known as a *diode*.

In Fig. 248 (*a*) the cathode is raised to emitting temperature by a separate heater, and it is described as an *indirectly-heated cathode*. On the other hand, the cathode of Fig. 247 (*d*) is also a filament through which passes the heating current, and it is referred to as a *directly-heated cathode*. The associated valve may be described as an *indirectly-heated valve*, or a *directly-heated valve*, according to the type of cathode it employs.

As we have seen, the cathode of Fig. 247 (*a*) may also be referred to as a *filament*, whilst the heating wire of Fig. 248 (*a*) is a *heater*. American terminology tends to favour "filament" for both cases.

The valve requires a source of e.m.f. to heat the cathode, and this is referred to as the *heater supply*, the *filament supply*, or the *l.t. supply*. A source of e.m.f. which causes the anode to go positive of the cathode is referred to as the *h.t. supply*. The letters "l.t." stand for "low tension", and the letters "h.t." for "high tension". American literature refers to the l.t. supply as the *A supply*, and the h.t. supply as the *B supply*.

Whilst we use the term "anode" almost invariably in this country, American usage favours the term *plate* for this electrode.

We have referred to the flow of electrons to the anode and, thence, into the h.t. battery. This flow of electrons constitutes the *anode current* of the valve. There is, also, a flow of electrons out of the h.t. battery into the cathode, and this forms the *cathode current* of the valve. In the case of the diode, the cathode current is equal to the anode current.

**Circuit Symbols**

The circuit symbol for a diode having a directly-heated cathode is given in Fig. 250 (*a*), whilst that

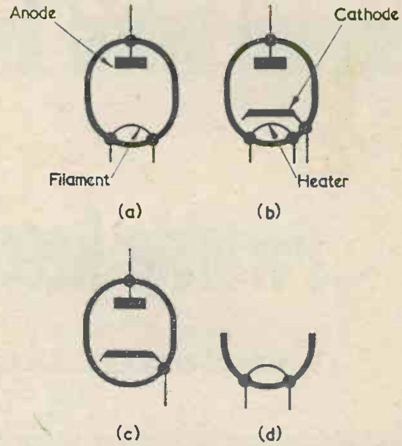



*Fig. 250 (a). The circuit symbol for a directly-heated diode*

*(b). An indirectly-heated diode*

*(c). Sometimes the heater is not included in the circuit symbol for an indirectly-heated valve*

*(d). The heater, suitably identified, may appear in a different part of the circuit diagram, as shown here. Only part of the "envelope" around the heater is drawn in, to indicate that a section of the valve is being depicted*

for a diode with an indirectly-heated cathode is shown in Fig. 250 (*b*). Frequently, the heater is omitted from the symbol for the indirectly-heated version, whereupon only the cathode and anode are shown, as in Fig. 250 (*c*). This symbol is employed either when the heater circuit is of no immediate interest or when, to avoid too many unnecessary lines crossing the circuit diagram, the heater is depicted elsewhere, as in Fig. 250 (*d*).

When there is more than one valve in a diagram, the individual valves may be identified by the letter "V" followed by a number, e.g. $V_1$, $V_2$, etc. In some cases more than one set of valve electrodes is enclosed in a single evacuated envelope, and the sections may then be referred to by an added suffix letter, such as $V_{1(a)}$, $V_{1(b)}$, etc.

**Next Month**

In next month's issue we shall examine further aspects of the diode valve, including its use as a rectifier.

*We wish all our readers a very Happy Christmas and a Prosperous New Year - Editor*

# Economical Hybrid Amplifier and Portable Receiver Circuits

**By SIR DOUGLAS HALL, K.C.M.G., B.A.(Oxon)**

IT IS, OF COURSE, TRUE THAT THE transistor is a more economical device than the valve. It is also true that, with modern transistor types, there is virtually nothing which can be done more effectively by valves. But the superior economy of the transistor can be exaggerated, and there is no question that most small Class B transistor amplifiers introduce a good deal more distortion than their Class A battery valve equivalents. This applies particularly when a miniature battery is used to power a device which, at peaks, draws up to 25mA or more.

### Amplifier Costs

This article describes a small amplifier designed by the author which will give about 200 milliwatts output through a Class A battery output valve. Circuitry is incorporated which reduces current consumption from a 90 volt h.t. battery to an average of about 2mA at low volume levels, 3mA at normal levels and about 4mA at maximum output. The overall average consumption over a long period will work out at about 3mA. An Ever Ready B103, or equivalent, 90 volt plus 1.5 volt battery is used which will last about 8 months at an average use of 2½ hours per day. A tuner is also described which will turn the amplifier into a very efficient and economical portable receiver of the larger, better quality, type, at virtually no increase in current consumption. Low tension consumption is about 50mA in the case of both amplifier and receiver circuits and the low tension section of the B103 battery will outlast the h.t. section at the current values involved. At the time of writing, the B103 battery costs 19s. 6d.

An equivalent transistor amplifier would have to use Class B output and might be expected to take an overall average of 15mA from a 9 volt battery. For it to be economical it may be assumed that a PP9 type of battery would be used costing, at present, 3s. 9d.

The Ever Ready Co. (Great Britain) Ltd. have informed the author that the h.t. section of a B103 battery may be expected to last 600 hours at 3mA, taking 1.1 volts per cell as the end point. They have also said that the l.t. section may be expected to give 1,500 hours use at 50mA. They estimate that a PP9 battery would last 250 hours at 15mA for a similar end point of 1.1 volts per cell.

Simple arithmetic shows that the amplifier to be described costs 0.39 pence per hour to run, and the transistor equivalent 0.18 pence per hour. Putting it another way and assuming an average use of 2½ hours

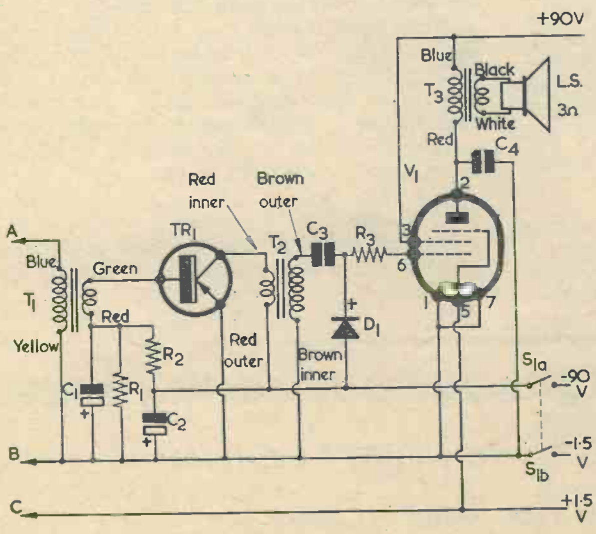



*Fig. 1. The circuit of the hybrid amplifier*

**Components List (Fig. 1)**

*Resistors*
(All resistors ¼ watt 10%)
- $R_1$ 1kΩ
- $R_2$ 39kΩ (see text)
- $R_3$ 100kΩ

*Capacitors*
- $C_1$ 100μF electrolytic, 6V wkg.
- $C_2$ 50μF, electrolytic, 15V wkg.
- $C_3$ 0.1μF paper
- $C_4$ 0.01μF paper

*Transformers*
- $T_1$ Miniature transformer type D102 (Ardente)
- $T_2$ 1:4 intervalve transformer (Henry's Radio Ltd.)
- $T_3$ Standard pentode 65:1 output transformer (Henry's Radio Ltd.)

*Valve*
- $V_1$ DL96

*Transistor*
- $TR_1$ OC75

*Diode*
- $D_1$ Westector type W6 (Henry's Radio Ltd.)

*Switch*
- $S_1$ d.p.s.t. on-off switch

*Speaker*
3Ω impedance

**Components List**
(Fig. 2)
(Additional components not common to Fig. 1)

*Resistors*
$R_4$ 1.8kΩ ¼ watt 10%
$R_5$ 6.8kΩ ¼ watt 10%
$VR_1$ 5kΩ potentiometer, linear track

*Capacitors*
$C_5$ 100μF electrolytic, 6V wkg.
$C_6$ 0.01μF paper
$C_7$ 0.001μF paper
$VC_1$ 150 or 160pF variable

*Inductors*
$L_{1,2}$ Medium wave ferrite aerial (see text)
$L_{3,4}$ Long wave, ferrite aerial (see text)

*Transistor*
$TR_2$ MAT101

*Diode*
$D_2$ OA81

*Switch*
$S_2$ d.p.s.t. wave-change switch

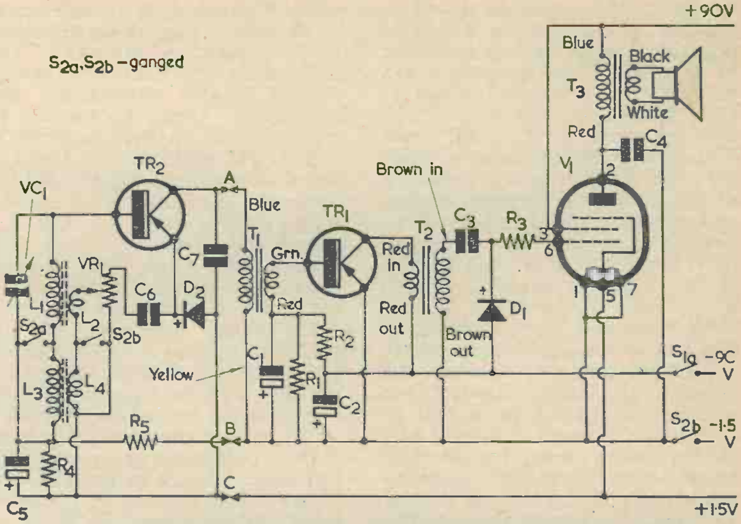



*Fig. 2. The hybrid amplifier of Fig. 1 coupled to a single-transistor medium and long wave tuner to form a complete portable receiver. If it is intended to employ the tuner as a separate unit, it may be coupled to the amplifier at points A, B and C*

per day, the author's amplifier will cost just under one penny per day, or half a crown per month, as against a little under one halfpenny a day, or one shilling and twopence per month for the transistor equivalent.

For those who do not want miniature equipment but need better quality from a larger instrument, be it amplifier or portable receiver, the extra cost of one shilling and fourpence per month would seem to be reasonable. And it should be remembered that comparisons have been made with transistor apparatus using one of the larger transistor batteries. The author's portable receiver is a good deal more economical with at least equal sensitivity, and will give far better quality than a pocket sized transistor superhet using a miniature battery.

**Amplifier Circuit**

Fig. 1 shows the circuit of the amplifier, and it will be convenient to study this from the output backwards.

$V_1$ is the output valve. Its grid is over-biased so that, under no-signal and very low signal levels, a total of 1.75mA is passed by the valve. $D_1$ which must be a Westector type W6 metal rectifier and not a crystal diode, rectifies a portion of the incoming signal and thereby applies positive bias to the grid. This cancels out some of the standing negative bias so that the valve passes more current and can therefore deal with the signal. $V_1$ passes a total of 6mA at maximum output.

The provision of standing bias poses a problem which exists with Class B or quiescent push-pull arrangements as well as with the circuit being described. The easiest method of providing bias is to use a separate grid bias battery; but this is untidy, and there is the difficulty that the voltage would need constant adjustment as the high tension battery aged. The obvious alternative might appear to be the standard bias resistor connected between h.t. negative and l.t. negative. But the difficulty here is that if a resistor is chosen to give a consumption of 1.75mA under no-signal conditions, the voltage across it will be more than trebled when 6mA is passed. The reverse bias produced by $D_1$ will be unable to cope with the situation, whereupon the h.t. voltage available for $V_1$ will be drastically reduced and the output of the valve will be hopelessly curtailed. What is required is a resistor which decreases in value as the current passing through it increases. Fortunately a transistor, wired on the common emitter principle and without any d.c. negative feedback, such as is normally provided by means of a resistor between emitter and earth, is just such a device. And the transistor can be used to give both voltage and current amplification of the signal, thus performing a useful duty as a driver for $V_1$ in addition to its function as the valves bias resistor. The requirements of the transistor are that it should have a good amplification factor and be capable of withstanding up to 8mA at 10 volts during momentary periods of overload. Normally the power handled will never exceed 6mA at about 9 volts. The OC75 has the characteristics needed.

**Bias Circuit Operation**

If Fig. 1 is examined it will be seen that the cathode current of $V_1$ passes through $TR_1$ and the primary of $T_2$. The value of $R_2$ is chosen to ensure a current of 1.75mA through $V_1$ and $TR_1$ when no signal is being received. When a signal arrives at

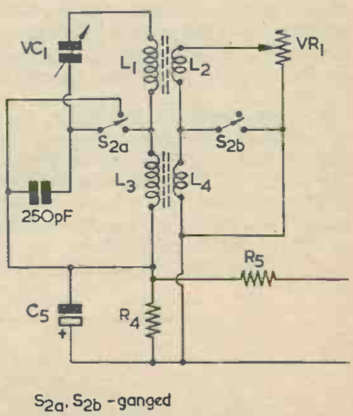



*Fig. 3. A modified circuit which may be used if there is a tendency towards more treble on medium waves than on long waves. See "Additional Note"*

the grid of $V_1$ a part of it will be rectified by $D_1$, and this will be in opposition to the voltage occurring as a result of the transistor's d.c. resistance. The current through $V_1$ and $TR_1$ will increase and this will tend to cause a rise in voltage across $TR_1$. But the rise in current through $TR_1$ will decrease its d.c. resistance so that the voltage between collector and emitter will tend to fall. Thus, the voltage across $TR_1$ will remain fairly constant and $V_1$ will be able to draw the extra current it needs to deal with a large input without being frustrated by an increase in standing negative grid bias voltage.

$TR_1$ will not be able to hold the voltage absolutely steady, but whereas an increase in current of three times through a normal bias resistor would result in a threefold increase in voltage across it, measurements with the prototype showed that when the current through $TR_1$ was trebled, the voltage across it only rose by less than one third. In practice it will be found that $V_1$ is able to receive the bias it needs for all circumstances.

Although $TR_1$ is deliberately arranged to be unstable as far as d.c. is concerned, there is no danger of damage due to thermal runaway as the current which can pass through $V_1$ is limited by the characteristics of the valve; and the current passing through $V_1$ is, of course, the current passing through $TR_1$ also.

The value of $R_2$ is fairly critical and if a milliammeter is available it is useful to insert it in one of the h.t. battery leads to check the current, which depends on the exact characteristics of $TR_1$. If the current passing is less than about 1.5mA, $R_2$ may be decreased, slightly, in value; if the current is above about 2mA, $R_2$ should be increased. The author tried three different specimens of OC75, and in no case had to make any alteration to $R_2$.

The requirements for $T_2$ are that it should provide a step-up of voltage from the collector of $TR_1$ to the input of $V_1$, which is of very high impedance. Its primary should have a low resistance for d.c.—200Ω is ideal, 500Ω permissible—so as not to upset the voltage regulating effect of $TR_1$, and the winding should be capable of passing 6mA without the core becoming saturated. The transformer specified has proved suitable in all respects for this application. Connections to $T_1$, $T_2$ and $T_3$ should be made as shown in Fig. 1. If, with the full portable circuit, there is instability on the long wave band, the long wave aerial rod, complete with $L_3$ and $L_4$, should be turned through 180 degrees. This is only likely to prove necessary if the loudspeaker or $T_3$ are close to the long wave aerial rod.

The input impedance of the amplifier at points A and B is about 1MΩ, and it is therefore suitable for use after a crystal pick-up. If there is no volume control in the record player or other apparatus being used, a 1MΩ potentiometer can be used. Its slider connects to point A and its lower end to point B, the input being applied across the potentiometer. It will be seen that a third input point, C, is taken from the l.t. positive line. This makes it possible for the l.t. section of the battery to be used to power a tuner. The latter will need to have a high impedance output, as is given by a common base amplifier, in order to match into the primary of $T_1$ at the input of the amplifier.

**Adding a Tuner**

This amplifier lends itself very well to the construction of a portable receiver of the larger type, using a fair sized loudspeaker with which it will give excellent quality and good volume. To match the dimensions of the B103 battery, an 8 x 5in loudspeaker suggests itself. The prototype has been built into such a portable receiver, the tuning unit of which consists of a single MAT101 transistor wired on the "Spontaflex" principle which gives very sensitive results with a 1.5 volt power supply. The Spontaflex circuit has been described before by the author,* and it will suffice to say that it consists of a stage of common collector high frequency amplification with reaction, followed by demodulation and a stage of common base low frequency amplification. The complete portable circuit is shown in Fig. 2. If, alternatively, the amplifier is to be built into a record player case and it is more convenient to have the radio tuner separate, the tuner circuit can be built into a small case of its own, coupling to the amplifier at points A, B and C.

The prototype uses two different ferrite rods for medium and long waves. $L_1$ and $L_2$ have 60 and 10 turns respectively of 32 s.w.g. enamelled wire close-wound on a ⅜in by 8in ferrite rod, the windings being separated by ¼in. The long wave windings are on a large 9½in x ⅝in rod, as the portable receiver is used in a place where the long wave Light programme is badly screened. $L_3$ has 220 turns and $L_4$ 35 turns of 38 s.w.g. enamelled wire. In many places a more normal ⅜ x 8in rod will be found entirely satisfactory. An efficient arrangement with the smaller rod is to use 32 s.w.g. enamelled wire to give a long winding of 300 turns for $L_3$, $L_4$ having 50 turns of the same wire separated from $L_3$ by about half an inch. All windings should be in the same direction.

The prototype of the portable receiver gives splendid results in S. Devon, many stations being available after dark at good volume, and a choice of four or five programmes during daylight.

**Additional Note**

Since the above was written, it has been found that there is a tendency towards more treble on the medium waveband than on long waves. This is because the relatively large impedance of $L_3$ provides negative feedback at high audio frequencies. Many constructors will prefer the deeper tone, and the effect can be obtained on the medium waveband by using a double pole, double throw switch for $S_2$(a), (b). The junction of $C_5$, $R_4$, $R_5$ and $L_3$ is disconnected from the moving contact of $S_2$(a) and taken to the new contact. A 250pF capacitor is shunted across these two contacts. The modified section of the circuit is shown in Fig. 3.

* See the article by Sir Douglas Hall in the June 1964 issue, and our note on page 56 of the August 1964 issue.

## DENCO CT7B TURRET

In response to a continuing demand for these turrets, we are informed by Denco (Clacton) Ltd., that a further batch are being produced but that with material delays they will not be available until the end of this month.

The CT7B turret was featured in communication receiver designs in our November and December issues 1963, also in the May 1964 issue. It is also currently specified in our Data Book 14—*Short Wave Receivers for the Beginner.*

# TWO-WAY HOME Telephone System

## J. N. Price

THE AUTHOR WAS ASKED TO DESIGN AND BUILD a two-way telephone system by a neighbour who wished to be able to communicate between his house and garden shed-cum-workshop some 25 yards distant. The system described in this article was devised and the total cost was only just over £2. As the neighbour was non-technical (though, being a carpenter, he constructed the boxes) it was decided that the units should be identical and that operation should be as simple as possible. Unfortunately, this enables his two children to use the system!

### Ex-G.P.O. Handsets

As readers will probably know, ex-G.P.O. handsets are available quite cheaply from surplus dealers. These handsets suffer from the disadvantage of a common connection between the microphone and earpiece. This leads to slight, though not unsurmountable, difficulties in design. Although

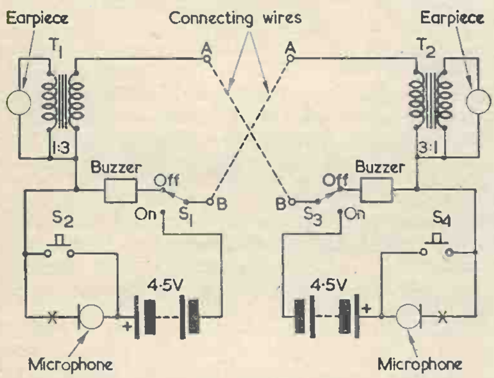



*Fig. 1. The circuit of the telephone system*

**Components List**
**(Fig. 1)**

2 ex-G.P.O. Handsets (see text)
2 4.5V buzzers
2 Intervalve transformers, 3:1 (see text)
2 s.p.d.t. switches
2 Push button switches (1 make contact)
2 4.5V batteries (Ever-Ready type 1289)

experiments with one of these earpieces showed that they could operate satisfactorily with a direct current flowing in them, it was decided to use isolating transformers so that the d.c. necessary for the carbon microphone was kept away from the earpieces. The author tried an old intervalve transformer and, whilst it did not give the correct impedance match, operation was satisfactory.

Buzzers were used for signalling as the neighbour already had a door bell and a telephone. Buzzers are also smaller than bells. Two small 4.5V buzzers were procured together with two 3:1 intervalve transformers, two panel mounting push buttons and the remaining components. The author then decided that each unit could be accommodated in a box measuring about 6 x 4 x 2½in deep, whereupon

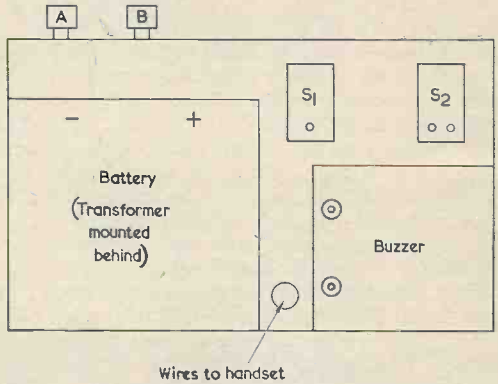


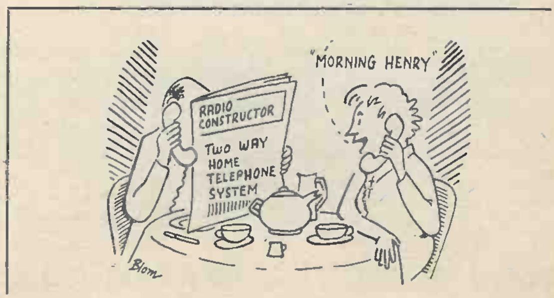

*Fig. 2. The layout adopted by the author for each station*

the neighbour provided two beautifully finished boxes with neat dovetail joints. It was only with much regret that the author drilled the necessary holes in them.

### Circuit

The circuit of the system is shown in Fig. 1. The layout of components is not critical and any convenient mounting system can be used. A word of caution about the leads provided with the handsets is necessary. The pre-formed loops should not be disturbed as the wire will probably be of the tinsel variety which is almost impossible to solder properly.

The two line wires should be brought out to two terminals on the top of the case. It is important to



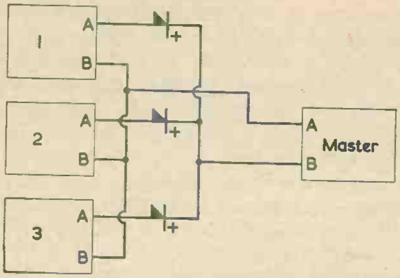



*Fig. 3. A modification which allows multi-station operation to be achieved. Each station may, on its own, call the master station*

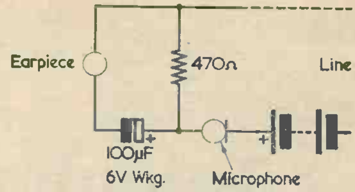



*Fig. 4. An experimental circuit which obviates the necessity for the transformer*

identify these correctly, as A of one unit has to be connected to B of the other, and vice versa. The batteries can be fixed by small blocks of wood glued in position or by any other convenient method. With the author's units, contact was achieved by small brass strips screwed to the box, these being so positioned that the battery could not be reversed. If required, $S_1$ and $S_3$ may be operated by lifting the appropriate handset, but in the author's case ordinary toggle switches were used.

When the two units have been completed, it is suggested that they should be wired together on the bench for testing, as this saves much walking if any faults exist. If $S_1$ is operated, and then push button $S_2$ is pushed, the buzzer in the other station should operate. This can be silenced either by releasing $S_2$ or by operating $S_3$. Whilst the buzzer is operating, the user of Station 1 will hear a tone in his earpiece due to the a.c. component of the current flowing in the primary of $T_1$ to the buzzer at Station 2. He should release $S_2$ before, or as soon as possible after, this tone ceases. After $S_3$ has been operated, the two users can speak to each other. When the conversation is over $S_1$ and $S_3$ must be returned to their Off positions. The method of calling from Station 2 is exactly the same. $S_2$ and $S_4$ should not be touched during the conversation as, apart from short-circuiting the microphones, pressing them together can cause an excessive current to flow through the transformers.

If, whilst the units are still on the bench, the handsets are placed together (microphone of one to earpiece of the other, and vice versa) a loud whistle will probably result. This can cause no damage, but indicates the carbon microphone's property of functioning as an amplifier.

**Installation**

The system may now be installed. Almost any insulated wire is suitable for wiring up, and the author used bell flex. It must be remembered that the wires must be identifiable, e.g. one black and one red.

The units should be given a final test in their permanent positions. It may be found that some microphones cause a crackling noise to be produced in the earpiece. This is due to excessive d.c. in the microphone, and may be reduced by inserting a resistor and capacitor in parallel at point X. The resistor should be sufficient to reduce the current to about 5 to 8mA and the capacitor should have a low impedance compared with the resistance at the lowest frequency to be catered for.* (The commercial telephone system usually has a bandwidth of 300 c/s to 3.5 kc/s.)

**Modifications**

There are one or two modifications which the constructor may like to make. For instance, if a 4-wire cord is supplied with the handsets, the common connection between transformer primary and secondary may be omitted.

Two or more stations may be operated from the same master station by means of the simple modification shown in Fig. 3. The diodes can be of any small type sufficient to carry the current for the buzzer. Extensions cannot talk to extensions using this system, as this is difficult to arrange on a 2-wire basis.

**Alternative Circuit**

Since the installation described in this article was put into operation, the writer has been experimenting with a transformerless unit. This has been satisfactory for speech transmission and employs the circuit given in Fig. 4.

The transformerless circuit has not been checked with the full signalling facilities, but these should not offer too many difficulties. The switching arrangements will be the same as for the circuits previously described.

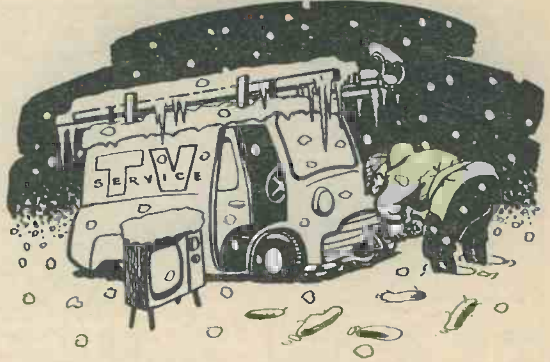
EDITOR'S NOTE

The ex-G.P.O. handsets employed by the author were obtained from Duke & Co. (Romford) Ltd., 621–3 Romford Road, Manor Park, London, E.12. The d.c. resistance of each earpiece was 60Ω. The transformers had a d.c. resistance of 30Ω in the winding connected to the earpiece and 225Ω in the winding connected in the microphone circuit.

* A capacitance of 25μF or more should be adequate in practice.—EDITOR.

**Next Month: THE "TRANSIVOX" MONOPHONIC ORGAN**

# IN YOUR WORKSHOP




*Transistorised u.h.f. tuners for television receivers will be introduced in quantity in 1965. In this episode Smithy the Serviceman, aided as always by his able assistant Dick, takes time out before the Christmas holiday to describe the basic design features of this important new development*

"*I lift up my finger*—"
"*She loves you*—"
"*And I say*: *Tweet, Tweet*—"
"*Yeah, yeah, yeah*—"
"*Shush, Shush*—"
"*She loves you*—"
"*Now, Now*—"
"*Yeah, yeah, yeah*!"
"*Come, Come*!"

Thus, respectively, sang Smithy and Dick as they clattered busily about their duties in the Workshop. For this was the afternoon of Christmas Eve and their hearts were full of joy and gladness, together with a stern determination to get the Christmas rush of faulty receivers cleared out of the way as soon as this could possibly be achieved.

Evidence of the festive scene was clearly visible about the Workshop. Dick's bench exhibited a magnificent array of Christmas Cards from his various aunts, whilst Smithy presented a more modest collection from his trade associates, these depicting in turn a robin perched on a television set, a robin perched on a radiogram, a robin perched on a transistor radio and a robin perched on a line output transformer. There was always a strange consistency in Smithy's Christmas Cards. Last year they had all been candles. This year they were all robins.

### Transistors at U.H.F.

The singing of Dick and Smithy was continually interrupted by the sounds coming from the sets they were repairing. There was the wail of the signal generator, the whistle of the unstable i.f. amplifier and, after the triumphant fixing of the fault and the final test, the inevitable sound of Christmas music.

All of a sudden the bustle ceased, and Dick and Smithy found themselves gazing at the now-empty "For Repair" racks.

"We've cleared them!" they exclaimed exultantly.

With one accord they sat down and allowed the feeling of pride in work well done to spread over them.

"And that," remarked Smithy with immense satisfaction, "is that. Another Christmas rush over!"

"It seems to have been easier this year," said Dick. "Either that, or I'm getting used to it."

"I think we've been luckier than usual," commented Smithy. "All the snags were nice easy ones. No intermittents or anything like that."

"Did you get any u.h.f. tuner faults?" asked Dick.

"Nary a one."

"Neither," said Dick, "did I. These u.h.f. tuners seem to be a lot more trouble-free than I thought they'd be when they first came in."

"They'll be even *more* trouble-free in the coming year and afterwards."

"How's that?"

"Because," replied Smithy, "they'll all be changing over from valves to transistors."

"That sounds interesting," said Dick enthusiastically. "What advantages do transistors give?"

"They give less noise at u.h.f. than valves do," replied Smithy. "And they also make it possible to design tuners which are simpler from the mechanical point of view."

"This *is* interesting," repeated Dick. "Have you got any gen on them?"

"Quite a bit," replied Smithy. "It's pretty certain that the transistorised u.h.f. tuners in Britain will follow Continental practice in much the same manner as the valve types have done. What I've been doing, therefore, is to keep a close watch on Continental journals and publications, and to keep my ear down to the ground so far as things in this country are concerned. In consequence, I can give you some really reliable background gen on the form transistorised u.h.f. tuners will take up."

A thought occurred to the Serviceman, and he turned a suspicious gaze on his assistant.

"How is it," he asked, "that you're so enthusiastic about this new application for transistors? Last month you were screaming up the wall because British manufacturers have started introducing n.p.n. transistors into their radios!"

"That's different," replied Dick promptly. "In that case, I got the information *after* I'd tried to fix the sets which had the transistors in them. In this case, I'm getting the information before I have to tackle the sets."

"I suppose," said Smithy doubtfully, "that there is a certain amount of logic in what you say. Anyway, pop the kettle on and I'll collect my thoughts on this tuner business."

### U.H.F. Oscillator

Obediently, Dick walked over to the sink to fill the battered Workshop kettle and prepare the teapot, after which he returned to Smithy's bench. Smithy had, in the meanwhile, commenced to scribble out a circuit diagram, to which he was now putting

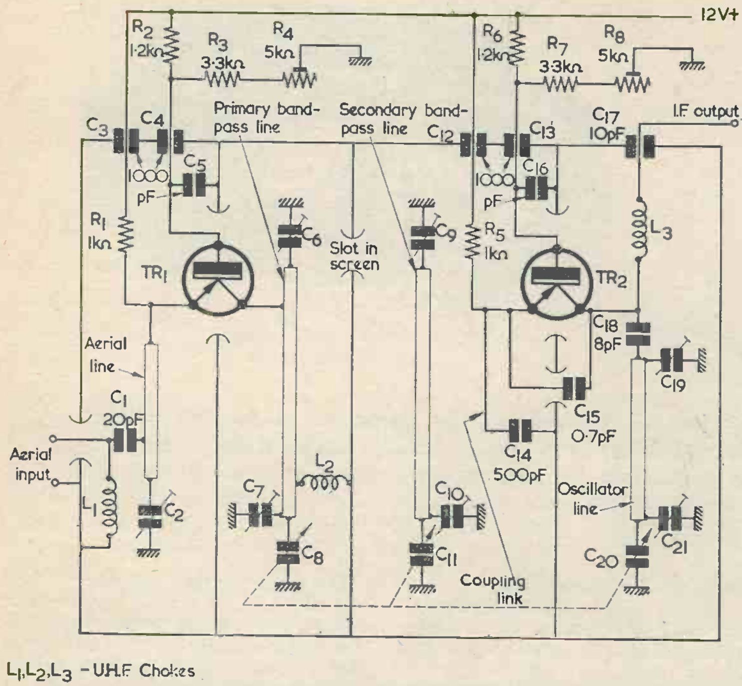



*Fig. 1. Basic circuit diagram for a transistorised u.h.f. tuner, following Continental practice. Component values are representative and half-wave lines are employed in the bandpass and oscillator tuned circuits. Trimmer values will be of the order of 0.4 to 4pF. $TR_1$ and $TR_2$ may be, typically, AF139s*

the finishing touches. (Fig. 1.)

"Here we are," he announced triumphantly, as he put his pencil down on the bench. "This is the basic circuit for one of the two varieties of transistorised u.h.f. tuners which are knocking around these days. It's typical of Continental design approach and is, also, very similar to the valve tuners you find in current TV sets. It makes a good introduction, therefore, to the transistorised u.h.f. tuner. We've already nattered at quite some length about the valve u.h.f. tuner in the past, so I don't need to go over all that again. In any case there is an excellent description in '*Understanding Television*'* which covers the ground completely."

Smithy cleared his throat, and prodded his finger at the circuit he had sketched out.

"In this circuit," he remarked, "you will note that there are two transistors. One of these, $TR_1$, is the r.f. amplifier, whilst $TR_2$ is the oscillator-mixer."

"Just the same," remarked Dick, "as you have with valves."

"That's right," confirmed Smithy. "Also, and in just the same manner as you have with the valve tuner, you have two bandpass tuned lines between the r.f. amplifier and the mixer-oscillator. There are, again as in the valve tuner, screened compartments. The aerial tuned circuit appears in one screened compartment, the primary bandpass line in the next screened compartment, the secondary bandpass line in the third, and the oscillator line in the fourth. (Fig. 2.) Valve u.h.f. tuners normally have a fifth compartment for the i.f. coil following the mixer, but this practice doesn't seem to be followed in the transistor versions. With these, the i.f. coil is normally mounted outside the case."

"What mode are the transistors connected in?"

"They're connected in grounded base," replied Smithy. "Transistors working in grounded base can amplify at much higher frequencies than when they are connected in the grounded emitter configuration. Another point to watch is that the supply to the tuner is positive of chassis, since it will normally be taken, via a potential divider, from the television receiver h.t. line. A common type of transistor employed in u.h.f. tuners for both r.f. amplifier and mixer-oscillator is the AF139, although you may, of course, encounter other types which are similarly capable of working at these frequencies."

"Those supply circuits look a little complicated," commented Dick.

"They're quite easy when you get down to them," said Smithy, "as will shortly be revealed unto you. Before going further I should just spend a little time on the principle of operation of the tuned lines. The lines in the bandpass and oscillator compartments are of the order of half a wavelength long. They could thus become resonant at the frequency whose wavelength is twice their length, and you would have opposite voltage polarities at each end, as occurs with a tuned circuit. Actually, however, the lines are slightly shorter than a half wavelength at the highest frequency to be handled. This has the same effect as reducing their inductance, and so the lines can be made to resonate at frequencies lower than their natural resonant frequency by adding capacitance at both ends."

"Which is," commented Dick, "similar, once more, to what happens in the valve tuner."

"Exactly," agreed Smithy. "Let's now start off at the aerial input connection. In the tuner unit circuit I've drawn here the aerial goes into an aperiodic input circuit which is broadly tuned over the whole of Bands IV and V. Just so that we can keep in mind the frequencies we are dealing with I should add incidentally that, in the U.K., Band IV is 470 to 582 Mc/s and Band V is 614 to 854 Mc/s."

"Valve u.h.f. tuners," interrupted Dick, "don't have an aperiodic tuned circuit in the aerial input stage. It's tuned by the ganged variable capacitor."

"In this country it is," Smithy corrected him, "and that's because, due to the spacing between channels adopted for single transmitters over here, you need a high level of second channel rejection. The official quoted figure is, in fact, a minimum of 53dB. The second channel interference problem is not so acute on the Continent, and so they can get by with an aperiodic aerial stage. In the U.K., on the other hand, a tuned aerial stage is necessary to give the requisite second channel rejection. Or, at least, it is in valve tuners anyway."

"In the circuit you've just drawn,"

* *Understanding Television*, by J. R. Davies, Published by Data Publications Ltd.

Dick reminded Smithy, "the aerial stage is aperiodic."

"I know it is," replied Smithy, a little heatedly. "But as I said at the beginning I'm showing you a typical Continental design approach. British transistorised tuners will probably incorporate a tuned aerial input stage in just the same manner as current valve tuners do."

"Good," pronounced Dick with great satisfaction. "I'm glad we've got *that* little point settled."

"With all these interruptions of yours," complained Smithy, "I've forgotten where I'd got to!"

"We'd bunged the aerial signal," offered Dick helpfully, "into the input circuit. Presumably we next turn to the first transistor."

"Ah, yes," said Smithy. "The first transistor. Now this is connected, as I said just now, in grounded base, and we should next take a butcher's at the manner in which power is applied to it. We have a 12 volt positive point outside the tuner, this being taken from the receiver h.t. supply. The chassis of the tuner is, therefore, the negative supply rail. The r.f. amplifier transistor is a p.n.p., and so its collector wants to go to negative. This it does via the primary bandpass line and the u.h.f. choke $L_2$, the latter completing the circuit to chassis. The base of the transistor is grounded to chassis, from the point of view of r.f., via the 1,000pF capacitor $C_5$, which has to have a very low inductance. This component could, in practice, be a ceramic disc capacitor with one surface soldered direct to the screen between compartments. It would, also, be positioned very close to the transistor. The base needs a negative bias, and this is provided by the potential divider given by $R_4$, $R_3$ and $R_2$."

"$R_4$," interjected Dick, "is a preset pot. Why do you have a preset pot here?"

"It's intended to provide adjustment of base bias," explained Smithy. "It's set up at the factory for optimum transistor performance."

"Having preset pots," commented Dick, "is rather a new idea in tuners, isn't it?"

"The scheme seems to be quite common," replied Smithy, "so far as the present generation of transistor u.h.f. tuners is concerned. They all seem to have preset pots for getting the transistors on to the best operating points."

"Isn't this rather an expensive approach?"

"Not really," replied Smithy. "The tiny little preset potentiometers that are used these days don't cost a great deal to produce. I should imagine, though, that when manufacturers have had a bit more experience of making u.h.f. tuners, the pots will disappear and be replaced by ordinary fixed resistors. For the time being, however, they seem to be used pretty universally."

"I see," said Dick. "What about the supply to the emitter?"

"That," replied Smithy, "comes from the 12 volt positive point via $R_1$. Once you've got used to the idea of chassis being negative, the whole supply business becomes very simple. The collector goes to negative via the primary bandpass line and $L_2$. The base receives bias from the negative chassis via $R_3$ and $R_4$, whilst the emitter goes to positive via $R_1$. You'll note, also, that this set-up gives you the standard stabilising circuit which is needed to prevent thermal runaway."

"Fair enough," commented Dick. "Let's carry on to the primary bandpass line."

**Bandpass Circuits**

But any reply that Smithy could have made was drowned by a piercing whistle from the kettle. Hastily, Dick got up and made his way to the sink, to undertake the ceremonial brewing of the Workshop tea. After briskly stirring the contents of the teapot with a hacksaw blade, he carefully poured out the precious fluid. He then returned, and placed a blue plastic beaker alongside the Serviceman.

"Dash it all," complained Smithy, "haven't we any cups?"

"Cups?" exclaimed Dick. "*Cups?* We haven't had a cup in the Workshop for the last three years!"

"What happened to that old tin mug of mine, then?"

Dick shuddered as a mental picture rose before him of Smithy's insanitary drinking vessel.

"That filthy object," he announced in a tone of revulsion, "is now reposing in our dustbin. It's sprung a leak."

"Sprung a leak? How come?"

"I accidentally," stated Dick, "drilled six ¼in holes in the bottom of it."

"Well, that's a nice Christmassy action, I must say," grumbled Smithy. "Talk about the season of goodwill!"

"Blimey," said Dick, "I'd forgotten all about it's being Christmas. Just a minute!"

He hurried over to his bench, opened a drawer and extracted a limp brown paper parcel. Returning, he handed this over to the Serviceman with a flourish.

"Here we are, Smithy," he pronounced, "and a Merry Christmas, too!"

"Well, this is very good of you," said Smithy, unfastening the parcel. "Very good of you, indeed."

He removed the last piece of paper and gazed uncertainly at its contents.

"Ah yes," he remarked dubiously, "now this is just what I've always wanted!"

"I'm glad you like it," said Dick, pleased.

"I'm delighted with it," replied Smithy.

There was an awkward silence for

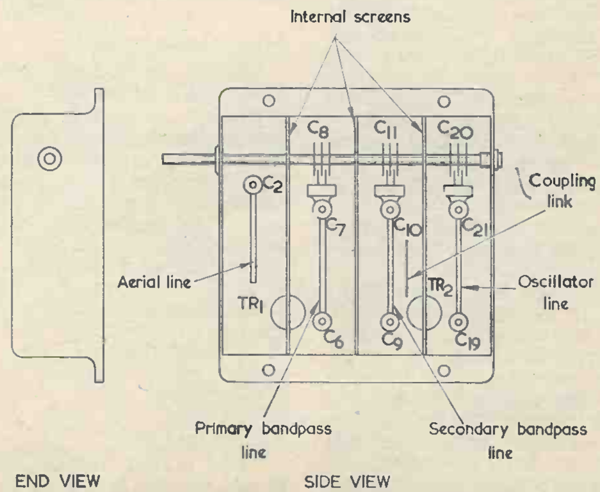



*Fig. 2. Layout of the principal components of the tuner of Fig. 1. The trimmers are concentric types with internal adjusting screws, and are soldered to the chassis of the tuner. The transistors appear in slots in the screens, with their leads projecting upwards*

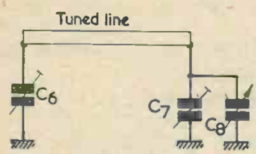



*Fig. 3. The tuned lines, with capacitance at either end provided by the tuning capacitor and trimmers, enter pi tuned circuits. The components shown here apply to the primary bandpass line*

a moment.

"Don't you want to try it on?"

"Try it on?"

"Yes," said Dick impatiently, "to see what it looks like."

"Where," asked Smithy doubtfully, "shall I put it?"

"Around your neck, of course."

"Oh," exclaimed Smithy, "it's a *tie*!"

"Of course it's a tie," replied Dick, reproachfully. "And I should add that I spent a lot of time choosing it for you, too."

"It seems to be very narrow."

"It's *meant* to be narrow," said Dick impatiently. "That's the modern idea. And the puce shade is just the thing right now. That tie, Smithy, is the snazziest one I've seen for ages."

"I'm certain it is," said Smithy. "And I'm very grateful to you for giving it to me as well. Thank you very much, indeed."

"Aren't you," persisted Dick, "going to try it on?"

"Not for the moment," replied Smithy, carefully. "It'll mean undoing all my collar studs and things."

"As you like," said Dick, disappointedly. "Later on perhaps."

"Yes, of course," said Smithy hastily. "In the meantime, how about getting back to this transistorised tuner of ours?"

"Okeydoke," said Dick, forgetting the tie for the moment. "Let's carry on to the bandpass lines."

"Right," said Smithy, manifestly relieved at the change in subject. "As you will probably have noticed, the bandpass lines are pretty well the same as those you find in valve tuners. The collector of the first transistor couples directly into the primary bandpass line. Since this collector is at fairly low impedance, it taps into the line a little of the way from the end to get optimum matching. You may find other ways of coupling the collector into the primary bandpass line, but the method I've shown here is pretty representative. The primary bandpass line has, in just the same manner as occurs with valve u.h.f. tuners, a trimmer at the tuning capacitor end, and a second trimmer at the other end."

"So making," chimed in Dick, "a pi circuit (Fig. 3). The trimmer at the tuning capacitor end is adjusted when the latter is at minimum capacitance, and the trimmer at the end remote from the tuning capacitor is adjusted when the latter is at maximum capacitance."

"That's the idea," agreed Smithy. "These adjustments are made at the factory and they enable all the lines in the tuner to be accurately tracked with each other over the swing of the variable gang capacitor. So there's nothing new there."

He paused and took a sip from his plastic beaker.

"We next," he continued, "carry on to the secondary bandpass line. The primary line is coupled to the secondary line in the same manner as you have with valve tuners. There may be a slot in the screen between the two compartments, or you may, for example, have an adjustable wire loop (Fig. 4). Also the same as in the valve tuner is the fact that the secondary line couples to the emitter of the mixer-oscillator via a coupling wire link."

"In the valve version," said Dick, "that link couples to the cathode of the mixer-oscillator valve."

"Exactly," replied Smithy. "And as you can see, things are very much the same here. The secondary bandpass line has, of course, the regulation pair of trimmers at each end."

**Mixer-Oscillator Stage**

"How," asked Dick, "does the mixer-oscillator oscillate?"

"That," commented Smithy, "is one of the delightful things about the transistorised u.h.f. tuner. Like the r.f. amplifier, the mixer-oscillator transistor is connected in grounded base. This means that the emitter and collector are in phase. When the emitter goes negative so, also, does the collector. To make the transistor oscillate, therefore, all you need to do is to couple its collector to a tuned line and, also, to the emitter via a capacitor of about 0.7pF. In my circuit this capacitor is $C_{15}$. And what could you have simpler than that?"

"That *is* neat," agreed Dick. "I should imagine that this also means that you've got to keep the stray capacitance between collector and emitter to an absolute minimum if you *don't* want oscillation to take place."

"You're dead right there," agreed Smithy. "Such feedback could cause instability with the r.f. amplifier transistor, and it's necessary to provide very adequate screening between emitter and collector in that stage. Returning to the mixer-oscillator transistor, you'll notice that the collector couples to the oscillator tuned line via the 8pF capacitor, $C_{18}$. The emitter is not at chassis potential so far as r.f. is concerned, because of the impedance offered by the coupling line."

"What about supplies to the mixer-oscillator transistor?" asked Dick. "There doesn't, for instance, seem to be any d.c. connection to the collector."

"What actually happens there," said Smithy, "is that the collector connects to chassis via an external i.f. coil which I haven't shown. $L_3$ is merely a u.h.f. choke which prevents the i.f. output feed-through capacitor, $C_{17}$, from affecting u.h.f. operation. In combination with that feed-through it will also, of course, prevent u.h.f. signals getting out into the i.f. circuits. The base receives its bias via the potential divider given by $R_8$, $R_7$ and $R_6$, $R_8$ being preset to enable the transistor to be set to optimum working conditions. And the emitter connects to the 12 volt positive point via $R_5$. This has a resistance of 1k$\Omega$ and doesn't affect u.h.f. signals. At the same time, in combination with $R_8$, $R_7$ and $R_6$, it provides stabilisation."

Smithy drained his beaker.

"And that," he remarked with an air of finality, "is that. More tea, please!"

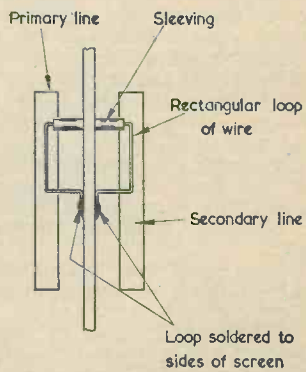



*Fig. 4. A method of providing adjustable coupling between primary and secondary lines. The loop connects to the internal screen only at the points where it is soldered. Coupling is varied by bending the sides of the loop closer to, or further away from, the lines*

"Do you mean to say," gasped Dick incredulously, "that that is all there is to transistorised u.h.f. tuners?"

"That's all there is so far as basic circuit operation is concerned," confirmed Smithy. "If you've followed what I've said up to now, you'll have a very good idea of how these tuners function."

"They're a piece of cake!" exclaimed Dick. "They're much simpler than valve u.h.f. tuners!"

"I wouldn't go so far as to say that," commented Smithy warily. "They may *look* a little simpler in circuit form, but that's mainly because they haven't got any heater wiring or heater chokes. More tea, please!"

"How do you get," persevered Dick, "the 12 volt supply?"

"A man," grunted Smithy, "could die of thirst in this Workshop!"

Hastily, Dick picked up Smithy's beaker and took it over to the sink to replenish it.

"But how *do* you," he persisted, over his shoulder, "get that supply?"

"There are several ways in which it can be done," replied Smithy. "One simple method would consist, for instance, of taking a dropping resistor from h.t. positive down to a 12 volt zener diode (Fig. 5). This would be economical of h.t. current, as the zener diode would only need a few milliamps to bring it on to the flat part of its characteristic. The remaining current in the dropping resistor would then be that used by the tuner itself. Which would be of the order of 10 to 20mA or so. At last!"

Smithy took the tea from his assistant and drank deeply.

"That's a point," remarked Dick impressed. "You're only working at 12 volts, and yet the current drawn is still just about the same as for a valve u.h.f. tuner."

"Exactly," said Smithy, smacking his lips. "And just think how much less heat is dissipated in the transistor tuner unit than in the valve version. One result of the reduced heat is that oscillator drift with warm-up is liable to be considerably lower."

## Quarter-Wave Lines

Smithy took a further draught from the beaker and held it up in front of him.

"How," he asked, "did you come by this beaker?"

"I got it free," explained Dick, "with a large tube of Alka-Seltzers."

"Dash it all," said Smithy, glancing over at Dick's bench, "you've got one, too."

"I know," replied Dick. "But don't forget that we're not only on the threshold of Christmas. There's New Year's Eve to come as well!"

Smithy chuckled.

"You seem to be stocking up well in advance," he grinned. "Which reminds me that I've got a present for you, too."

Smithy rummaged beneath his bench, and the second brown paper parcel of that afternoon made its appearance. Eagerly, Dick tore off the wrapping.

"They're very nice," he remarked with a puzzled frown as he surveyed Smithy's present. "Do you know, they're just what I wanted!"

"I thought you'd be pleased with them," commented Smithy with a benign smile. "Slip them on and see if they fit."

"Slip them on?"

"Yes, of course."

Once again, there was an embarrassed silence.

"How do you mean, slip them on?" queried Dick. "I can't think of any part of me that they'd fit."

"You put them on your shoes, you buffoon," exploded Smithy. "They're galoshes!"

"Galoshes?"

Smithy turned his eyes towards the ceiling.

"Haven't you ever heard," he snorted, "of galoshes?"

"I'm awfully sorry, Smithy," said Dick contritely, "but I honestly haven't."

"You put galoshes over your shoes to keep the wet out."

"Well, I'm blowed," exclaimed Dick. "What a knobby idea! And do people walk around with shoes on *and* galoshes?"

"Of course they do."

"Well, I'm blowed," repeated Dick. "Do you know, Smithy, I honestly didn't know that until now."

"Well, you do now," said Smithy, mollified.

"I think they're an excellent idea," said Dick enthusiastically. "I'll try them out on the way home. And thank you very much indeed."

"Not at all."

"They're a smashing present."

"Don't mention it."

"What an excellent Christmas Eve this is," remarked Dick, having satisfactorily discharged his obligations in the way of thanks. "Here we are, all the work is done, and we're just sitting around nattering with nothing else to do."

"It *is* pleasant," agreed Smithy. "Incidentally, I haven't finished giving you all the gen on this transistorised u.h.f. tuner unit business."

"Oh, of course you haven't," said

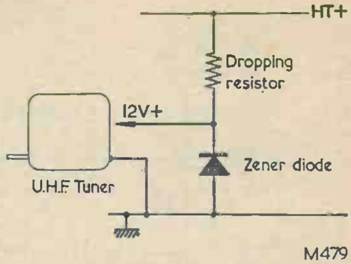



*Fig. 5. A simple method of providing the 12 volt supply for the u.h.f. tuner. The tuner chassis is at the same potential as the receiver chassis, and the zener diode stabilises at 12 volts*

Dick, as a sudden thought occurred to him. "You said at the beginning that you were referring to one of the two varieties of Continental tuner. What's the second variety like?"

"Much the same as the first," replied Smithy, "except it doesn't use half-wave lines."

"What does it use, then?"

"Quarter-wave lines."

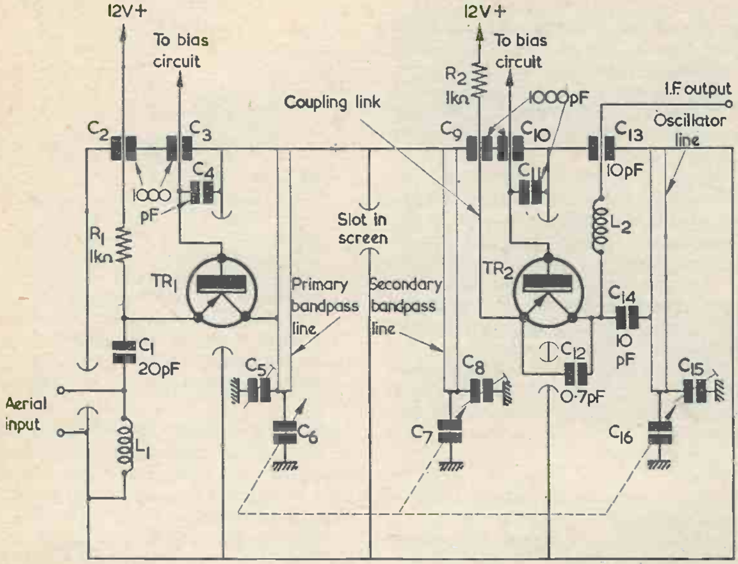
Dick looked bewildered.

"I don't get it," he said. "I can understand how a half-wave tuned line works, because I've got used to it with valve tuners and in the transistorised tuner we've considered up to now. How does this quarter-wave business fit in?"

"To explain that," said Smithy, pulling over his pad of papers, "I'll have to draw you another circuit."

There was silence for several minutes as Smithy sketched out a second tuner unit circuit (Fig. 6).

"There we are," he said, laying his pencil down. "And, once more, we'll start at the aerial input end. Again, we have an aperiodic aerial input circuit, only in this case the aerial goes straight into the emitter of the r.f. amplifier without any line at all. I must emphasise once more that this is Continental practice, and that the corresponding British versions may have a tuned aerial input stage to satisfy the second channel rejection requirement. You will note that the emitter of the r.f. amplifier, $TR_1$, connects to the 12 volt positive point via the 1k$\Omega$ resistor, $R_1$. The base is grounded to chassis via $C_4$, and bias can be applied by external components in the same manner as occurred with the previous tuner we discussed. The collector connects to the primary bandpass line, which terminates directly to chassis and thereby provides the negative supply. The primary line couples to the secondary bandpass line via a slot in the screen between them or by any other coupling device, and this sec-




$L_1, L_2$ -U.H.F. Chokes

*Fig. 6. The basic circuit of a u.h.f. tuner employing quarter-wave resonant lines, with representative component values. The tuned lines terminate at the chassis*

ondary line also terminates at the chassis."

"There's only one trimmer on those lines," objected Dick. "The lines in the previous tuner had a trimmer at both ends."

"I know," said Smithy. "But don't forget that, in this instance, the end of the line remote from the tuning capacitor connects to chassis, and so there's no point in putting a trimmer there in any case! Now, the secondary line couples to the mixer-oscillator transistor via a coupling link, as before. The earthy end of the coupling link passes through the bypass feed-through, $C_9$, and carries on to the 12 volt positive point via the 1kΩ resistor $R_2$. The base of $TR_2$ is grounded via $C_{11}$ and connects, externally, to the same sort of bias network as we had with the previous tuner. To obtain oscillation, the collector is coupled back to the emitter via a low-value capacitor, and it couples to the oscillator tuned line via the 10pF capacitor, $C_{14}$. It couldn't connect directly because, like the bandpass lines, the oscillator line is terminated at the chassis, and a direct connection would short-circuit the i.f. output. The collector connects to the u.h.f. choke $L_2$, and thence, via feed-through capacitor $C_{13}$, to an external i.f. coil. The latter provides the chassis connection, with the result that the mixer-oscillator collector has the negative supply that it needs, as well."

"I'm still," said Dick, "not at all clear about those tuned lines."

"Well," replied Smithy, "as I said just now, they're quarter-wave lines. In just the same manner as the half-wave lines were slightly shorter than a half wavelength at the highest frequency to be covered, these are slightly shorter than a quarter wavelength at the highest frequency to be covered."

"In that case," Dick pointed out, "you must lose a fantastic amount of inductance. Do the variable capacitor sections or the trimmers have a higher capacitance than occurs in the half-wave tuner?"

"Those capacitances," said Smithy, "are about the same."

"Then how," asked Dick despairingly, "can you tune over the same band of frequencies with a line that's only half as long?"

"It's because," explained Smithy, "the line is terminated at a nodal point for voltage."

"That," snarled Dick, sarcastically, "answers all my questions! I'll now be able to go all through Christmas realising that a line of half the length resonates at the same frequency because it's terminated at a nodal point for voltage!"

"But that," protested Smithy, "is perfectly true."

"I don't even know," wailed Dick, "what a nodal point is!"

"Oh, I see," replied Smithy. "Perhaps that *is* something of a disadvantage."

He scribbled on his pad.

"I've just drawn," he continued, "a half-wave dipole. When this is resonant we have a voltage and current distribution along it in which voltage is highest at the ends and zero at the centre, and in which current is zero at the ends and highest at the centre (Fig. 7). This corresponds to the condition under which the half-wave lines of the first tuner work. O.K.?"

"O.K. up to now," qualified Dick cautiously.

"Right," said Smithy. "Now, the term 'node' defines the position where an alternating quantity has zero amplitude. With the half-wave line, the voltage has zero amplitude at the centre. So this is the nodal point for voltage."

"That does at least," conceded Dick, "explain the nodal point business."

"Fair enough," said Smithy. "If, halfway along the line, we have zero voltage, the line at that point is at chassis potential. In consequence, there's no point in continuing the line any further and it can be terminated at the chassis itself."

Dick gazed at Smithy with agonised concentration.

"I'm sorry," he said eventually, "but I just don't get it. You can talk till you're blue in the face about nodal points and all that, but I'm right out of my depth here. So far as I can make out, we can cut a line in half and yet it's still resonant at the same frequency!"

"Have you ever heard," asked Smithy, "of a quarter-wave aerial?"

"Of course I have," replied Dick indignantly. "It's a quarter-wave rod stuck up over a flat metal plate. The plate provides a reflection of the rod, so that the whole thing functions in pretty well the same manner as a half-wave dipole."

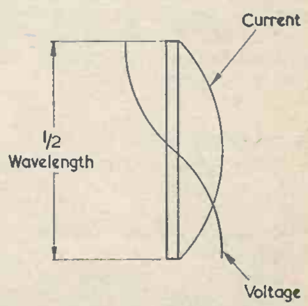



*Fig. 7. The voltage and current distribution in a half-wave conductor at resonance*

"Well?"

"I still don't see the connection," remarked Dick thoughtfully. "Wait a minute, though! The quarter-wave line in the tuner terminates at the chassis. Could you say that the chassis offers a reflection of the quarter-wave, so that the whole thing acts in the same way as a half-wave line?"

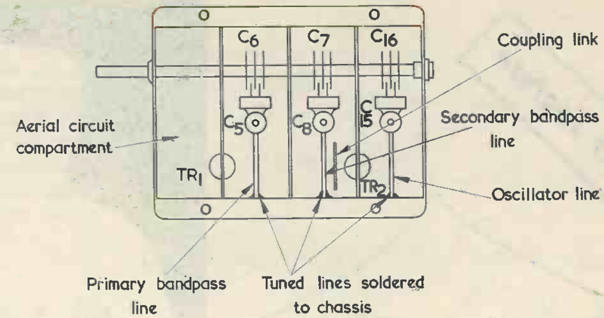
"What's good enough for aerials," pronounced Smithy, "is good enough for tuners! And your assumption is quite reasonable as a means towards understanding how the quarter-wave lines work. In practice, the quarter-wave lines of the tuner are soldered direct to the chassis side to which they are perpendicular (Fig. 8 (*a*)). You could say, therefore, that the metal side of the chasis offers reflections which make each line look like a half-wave line (Fig. 8 (b)). Which is all there is to it. By using the quarter-wave scheme, you get a lot of advantages. These include a simplified tuner assembly, shorter lines, a smaller chassis, and fewer components, all of which add up to a very sizeable saving in costs."

"There's one snag, though."

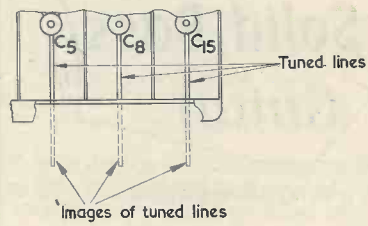
"What's that?"

"You've only got one trimmer for each line," said Dick. "The half-wave lines have two trimmers, which enable them to be easily tracked up. How can you make tracking adjustments with only one trimmer?"

"Tracking *is* more difficult with one trimmer," replied Smithy. "But don't forget that there are split end-vanes on the variable capacitor sections. With the quarter-wave tuner, tracking adjustments can be made by bending these out as required. You'll probably find much more evidence of factory adjustment of the end-vanes in a tuner using quarter-wave lines than in one using half-wave lines."




(a)




(b)

*Fig. 8 (a). The layout of the principal components in the circuit of Fig. 6. The ends of the tuned lines are soldered direct to the lower side of the chassis*

*(b). Remembering that a quarter-wave aerial is "reflected" by the flat screen on which it is mounted, it can prove helpful to look upon the quarter-wave tuned lines as being "reflected" by the side of the chassis, so that they take up the appearance of half-wave lines*

**Final Ceremony**

With an air of finality, Smithy pushed his pad of papers away from him and rose from his stool. He wandered thoughtfully to the cupboard in which the service manuals were kept.

"You'll be running out of hiding places, soon," chuckled Dick.

Ignoring his assistant's comment, Smithy returned with a bottle and two glasses.

"Here we are, my boy," he said, handing a charged glass to his assistant. "And all the very best!"

"The same to you," responded Dick, appreciatively, "and a Merry Christmas, too."

Smithy held up his glass.

"A Merry Christmas to you as well."

The pair rose.

"We must also," continued Smithy, "wish a Merry Christmas to the readers who've put up with our antics over the past twelve months. A very Merry Christmas to you all!"

"And let us end," chimed in Dick, "as we have ended in all the previous years, by saying 'God Bless Us, Every One'!"

## Liverpool Airport has EMI Closed-Circuit TV

Visitors to Liverpool Airport can now see arrival and departure board information displayed on closed-circuit TV receivers at several points in lounges and restaurants throughout the main airport building. As subcontractor to Standard Telephones and Cables Limited, EMI Electronics Ltd. has installed three type 6 cameras, four monitors and a control console in a soundproofed studio.

One camera transmits picture of the arrival and departure boards. Another televises the girl announcers who make special announcements from time to time. The third camera transmits advertising slides.

Three monitors give preview pictures of the flight board, the announcer and the next advertising slide. The announcer, who sits at the control console, selects the picture to be transmitted and this appears on the fourth monitor.

Cover Feature

# Constructing a Solid Bass Guitar

by Angus Geddes

ONE OF THE MOST POPULAR OF ELECTRONIC musical instruments is the solid bass guitar, in which the vibration of the strings is reproduced and amplified entirely by electronic means. In the traditional type of guitar the sound was magnified acoustically by resonance in the hollow body of the instrument. A later development was to fit a pick-up so that it picked up the tones from the resonant body and fed them to an electronic amplifier for subsequent playing at greatly increased intensity via a loudspeaker. The constructor of this type of instrument needed the woodworking skill of a professional musical instrument maker, but the assembly of the "solid" type is well within the capabilities of the average home constructor.

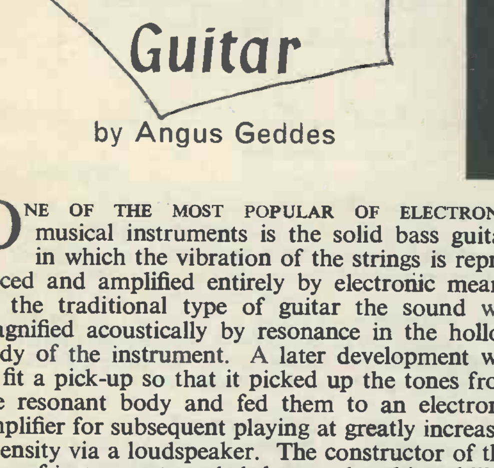



*Fig. 1. The general appearance, with dimensions, of the completed guitar*

The bass guitar was originally designed to take the place of the double bass in jazz or pop groups, as the double bass is such an awkward instrument to carry about. Prices of commercially manufactured bass guitars can range from 40 to 160 guineas. As a reasonably efficient bass guitar of the solid type can be constructed comparatively easily, it is well worth considering the construction of such an instrument oneself. As can be seen from the illustrations and diagrams, construction of a presentable and efficient instrument can be carried out relatively easily and at the small cost of some £10 to £15 for materials and parts.

**Materials**

The materials required are as follows:

One piece of softwood, 12 x 18in in length and approximately 1½in thick. This is to form the body section and pine is a suitable wood for the purpose. One piece of oak, 30in long, 3in wide and 1in thick, for the arm. One piece of oak-faced ply, 22in long and 2½in wide, for the fretboard. One piece of Formica to cover part of the body, as shown in Fig. 1. One bass guitar pick-up, four bass guitar machine heads, one tail piece and bridge, four electric bass guitar strings and 4ft of fret wire. One jack socket.

Most of these items should be obtainable locally. The wood and Formica may be purchased from a good hobbies shop or, separately, from timber merchants and hardware stores. The pick-up, bass guitar machine heads, bridge and tail piece, strings, etc., can be purchased from a good music or record shop. The bridge and tail piece should be bought at the same time as the pick-up, so that the two match; i.e., the strings are held in such a position by the tailpiece and bridge that they come directly over the centre of the pole pieces of the pick-up unit. There are various makes available, and the constructor is advised to seek the advice of his dealer, or advertisers in this magazine, for particulars of what is available. It should be noted, too, that the impedance of some pick-ups can be quite low, and that impedance varies from model to model. A pick-up should be obtained which offers a fairly reasonable match with the amplifier which is to be used.

**Construction**

First, with a fretsaw, cut the softwood to the rough shape of the body as indicated in Fig. 1. Then, with a coarse file, smooth down to the final desired shape. If desired, round off the edges, thus giving a better appearance to the finished instrument.

Next make up the arm. The section forming the fret board should be 22in long, with the remaining 8in shaped, with saw and file, into the head portion. Some constructors may feel it desirable to make the head section slope slightly backwards so that the strings are held reliably in the grooves of the "nut". This is not really necessary, however, as the "nut" shown in the model described here provides the necessary clearance, particularly if the surface of the head is well sanded down so that it slopes away slightly from the surface of the arm to which the fretboard is attached.

The fret board section of the arm should be $1\frac{3}{4}$in wide at the "nut" and $2\frac{1}{4}$in wide at the join of the body. The strip of ply should be shaped to the fret board section and glued on.

The body and the arm now have to be *very firmly* joined together. This is done by dovetailing them together, gluing and screwing the joint. The details of this joint are shown in Fig. 2. Care must be taken in this operation not to make the body section dimensioned "A" too thin, when cutting out, or the joint will be weak. The actual thickness of the section shown at "A" in Fig. 2 depends on the thickness of the wood forming the body. In the author's instrument it is about $\frac{1}{2}$in. Put the screws in from the underside of the body, and screw well home into the dovetail of the arm. Sink the screw heads just below the surface and cover their heads with plastic wood. When dry, sand the excess of the latter away, so that a smooth surface is available on the underside of the body for subsequent painting.

After this, the Formica is cut to the required shape for the pick board, which should be fairly large so as to cover the wires leading to the pick-up from the jack socket. The latter is mounted in a small cavity, gouged out of the rear of the body, as shown in Fig. 3. File a "flat" on the edge of the body near the cavity and drill through to take the mounting bush of the jack socket. Fill up the cavity with plastic wood and cover with a small piece of Formica, after having of course connected the pick-up wires to the connection tags on the socket.

The pick-up should be mounted after the top side of the body has been covered with Formica. Whilst the latter (shown in Fig. 1 as the "Formica pick board") is primarily for decorative purposes, it also helps to give the pick-up unit a good, firm, foundation. The pick-up should be fitted after the strings have been positioned, so that the pole pieces are directly under the strings. It may be necessary to pad the pick-up unit up a little, so that there is a gap of not more than $\frac{1}{4}$in between the taut strings and the ends of the pole pieces. The pick-up is screwed, through holes in the Formica, into the wood of the body. Use screws long enough to give a good firm fixing.

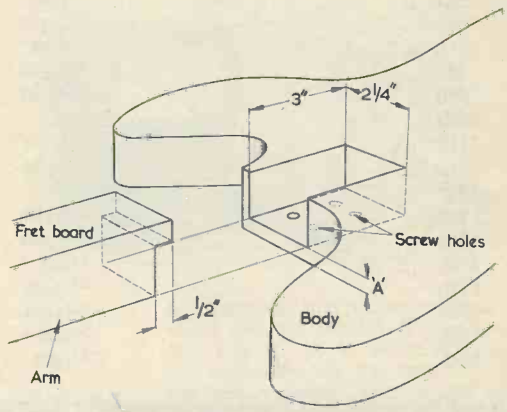



*Fig. 2. Detail illustrating the manner in which the arm is secured to the body. For reasons of clarity, the arm is not shown rounded off*

**Fitting the Frets**

The next step is to fit the frets. These *must* be fitted accurately, so as to obtain a perfect note. The following dimensions are measured from the "nut" to the fret, then from the first fret to the second, and so on:

| | |
|---|---|
| 1st fret | $1^{13}/_{16}$in |
| 2nd ,, | $1^{5}/_{8}$in |
| 3rd ,, | $1^{9}/_{16}$in |
| 4th ,, | $1^{7}/_{16}$in |

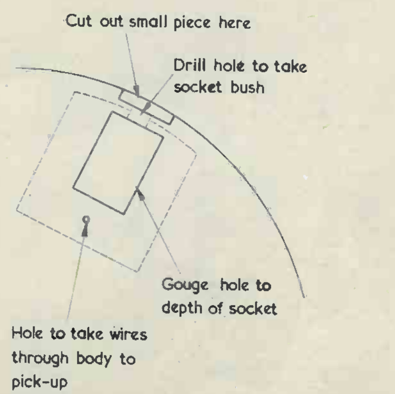



*Fig. 3. View of the underside of the body, showing the fitting of the jack socket. The area within the dotted line is finally covered with Formica*

| | |
|---|---|
| 5th „ | $1^{3}/_{8}$in |
| 6th „ | $1^{9}/_{32}$in |
| 7th „ | $1^{1}/_{4}$in |
| 8th „ | $1^{5}/_{32}$in |
| 9th „ | $1^{3}/_{32}$in |
| 10th „ | 1in |
| 11th „ | $^{31}/_{32}$in |
| 12th „ | $^{15}/_{16}$in |
| 13th „ | $^{7}/_{8}$in |
| 14th „ | $^{13}/_{16}$in |
| 15th „ | $^{25}/_{32}$in |
| 16th „ | $^{3}/_{4}$in |
| 17th „ | $^{23}/_{32}$in |
| 18th „ | $^{11}/_{16}$in |
| 19th „ | $^{5}/_{8}$in |
| 20th „ | $^{9}/_{16}$in |

It will be noted that there is a progressive decrease in the distance between successive frets from the outer to the inner end of the arm. At the lower end, this progressive decrease becomes very small and it is difficult to measure the position of these frets with accuracy. Fortunately, this end of the scale is very little used and discrepancies here are not of quite as much importance. The point is to make each fret just a little closer to its adjacent one than was the previous one. From about the 15th fret onwards, the decrease is in $\frac{1}{32}$in steps, which are not easy to mark with accuracy. If the constructor finds difficulties in cutting and fixing the frets over this section of the scale, he should not worry too much and should attempt to mark to as high an accuracy as he can, bearing in mind the progressively decreasing spacings between frets.

To fit the frets, saw into the fret board with a fine saw so making narrow grooves into which the fret wire, cut into suitable lengths, can be pressed. It is important to note that these fret dimensions are only for an instrument which has its *bridge 31in from its "nut"*

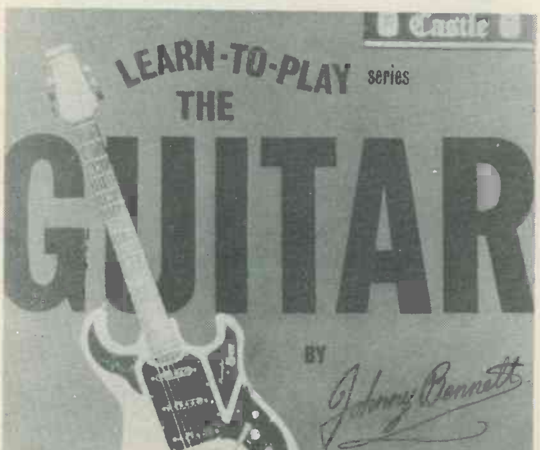
**Finishing**

Having completed the instrument up to this stage, the body should now be painted. When it is quite dry several coats of either clear varnish or plastic varnish should be applied.

Finally, fit the bass guitar machine heads, tail piece and bridge, bass pick-up and the four electric bass guitar strings. Tune the guitar to the notes E, A, D and G, and the instrument is complete.

Readers familiar with this type of musical instrument will know that, to get the best out of it, it must be used with an electronic amplifier suitable for the bass guitar. The instrument, as described, can be tested out on any amplifier with suitable input, the "Gram" input on some radiograms being suitable. But for the full capabilities of the bass guitar to be realised, an amplifier offering 20 to 50 watts is required, this being coupled to speakers capable of handling such an output. For those not already equipped with such an amplifier, one would mention that they can frequently be picked up secondhand and the writer would recommend the "Small Ads" columns of this magazine as a good place to advertise one's requirements. Alternatively, several firms offer amplifiers of this type in kit form, and these are well within the capability of anyone who is able to make up the instrument itself. The reader is referred to the advertisement pages of this journal for details of such equipment.

## LEARN TO PLAY THE GUITAR




Having read how to make a guitar, it is most likely that many readers may now like to learn how to play it! Castle Records have just recently released the first of their "Learn to Play" series, the disc being entitled "The Guitar".

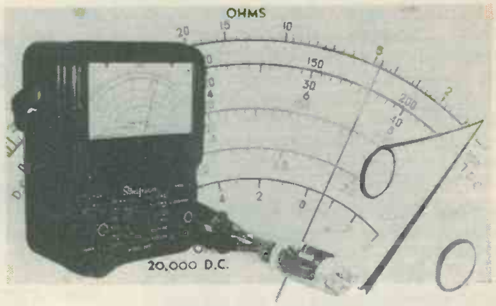
This 10in LP disc has six complete lessons from tuning to modern beat rhythms and from this recording one can learn tuning, chords, plectrum technique, modern beat and blues rhythms. No musical knowledge is required—Johnny Bennett, top guitarist with many world famous vocal stars and orchestras, conducting the lessons. Electric guitar techniques have been used throughout the recording using a Burns guitar.

Each record is complete with modern chord guides, practice and tuning charts.

Record No: LPG.1, which also includes multi-track guitar recordings one can practice with, is available at 21s. (including tax), special packing and postage 3s. (applicable to U.K. only) direct from Recorded Tuition Ltd., 174/6 Maybank Road, South Woodford, London, E.18.

# ERRORS IN MEASUREMENT

JAMES ROBERT SQUIRES




*Whether we are interested in electronics from the amateur or the professional point of view, we must inevitably base much of our work on electrical measurements. Our contributor, resident in the United States, presents an overall view of the field of electrical measurement, and draws attention to sources of error which are often overlooked*

The most important argument for considering errors in measurement is the time and money that can be saved through an understanding of their effects. In the shop or laboratory, measurements are a big time consumer each and every day. Which measurements are useless? Which cause more damage than good? Which measurements lead the operator down the wrong path? Answers to these questions and others may be supplied by an understanding of the mechanics of error. Those readings you feel you must take regardless of the instrument used will consume precious time. You will want to draw full value from those few readings. A wet finger in the lamp socket no longer completes the measurement tools, nor does the accompanying shock complete the analysis of that measurement.*

There are many reasons for false readings. For our purposes they can be divided into two classes. Errors over which we have little or no control fall into the first class. Errors that we can take steps to eliminate or circumvent are in the second class, and are of special interest to those who must make measurements every day.

* We must hasten to point out that, whilst a wet finger in the lamp socket may be an accepted approach with American 117 volt mains, we do *not* recommend the practice with British mains voltages!—Editor.

### Limits Of Error

Each piece of test equipment will have its own limits or error. By knowing these limits of error, found either in the equipment handbook or stated on the equipment itself, we can evaluate a particular instrument for a particular job. Usually, the smaller the limit of error the more expensive the instrument. Often, money is wasted buying instruments too precise and too accurate for the measuring job at hand. Each person must decide his own measurement needs. Many instrument manufacturers often mark the accuracy of the equipment right on the meter face or instrument panel. It is possible that all of these precautions against gross errors might lead some into a false sense of security. There are, however, many steps in error reduction that can economise on indicator readings.

At the present state of the art, it is not possible to measure energy values without drawing some energy from them. This changes the original energy by the amount needed to operate meter movements, oscilloscope amplifiers, and so on. For example, it is not possible to find voltmeters that have infinite internal resistance. Nevertheless, there are some neat tricks that can be used to reduce errors or bypass them.

Suppose, for example, we wanted to measure the voltage across a load, and the current in that load. See Fig. 1. Is it better to place the voltmeter on the load side or the power supply side of the ammeter? In this case it would depend on the limit of error of the instruments used. Generally the more accurate of the two instruments (that is, the instrument drawing the least circuit energy) would be placed nearer the load. A 1,000Ω per volt meter on the load side of the ammeter would draw appreciable current for its own meter movement and the ammeter would monitor load current plus voltmeter current. If the 1,000Ω per volt meter were replaced by the 5MΩ input of an oscilloscope, it should be connected nearer the load. The error in the ammeter reading would then be greatly reduced. This line of thought can be applied throughout much of the spectrum of instrument measurements.

### Voltage Divider

If we had a voltage divider of series resistors of 20% tolerance and we wanted to know the voltage drops at the junctions with respect to ground, there are a number of ways in which those can be measured or calculated. First, let us measure the current in the divider line then, from the body of each resistor, read its resistance. By using Ohm's Law (E=I x R), the voltage drop

ERRORS IN MEASUREMENT

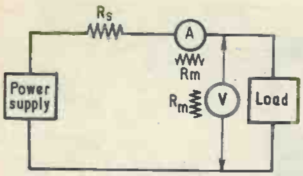



*Fig. 1. Measuring the current and voltage applied to a load. On which side of the ammeter should the voltmeter be connected?*

across each resistor can be determined. However, each voltage value may be in error by as much as 20%. This may or may not be a problem depending on the measurement goals. A second method of finding the voltage at each terminal of the divider would be to measure the actual voltage drop across each resistor and sum the drops. This technique accumulates the errors picked up at each voltage measurement. A third, and perhaps best, method would be to clip one lead of the voltmeter to ground and measure the voltage at each terminal. This method involves no calculations and it estimates the errors of the other two methods. This example may be over-simplified, yet it illustrates how both component tolerances and cumulative errors can be minimised. It is evident, then, that a measurement can be planned ahead of time to keep errors at a minimum.

Ideally, it is best to match the test instrument to the job. This is often impractical or too expensive, as we must make do with whatever test equipment we have. This approach will work fine as long as the error of the equipment being used is known and its effect on the circuit under measurement is understood. For example, let us take four 10kΩ resistors and apply 40 volts d.c. across this series string as illustrated in Fig. 2. The problem is to measure the voltage drop across the top resistor in the string, There will be 1mA flowing through the resistors.

If $\dfrac{1}{\text{ohms/volt}}$ = basic meter movement current on your voltmeter, and you know either the basic meter movement current or its ohms per volt rating the other unknown can be found. Say that you know that your basic meter movement is 1mA. Then

$$\frac{1}{10^{-3}} = 1000 \text{ ohms/volt.}$$

Using the 50 volt range, the voltmeter resistance will be 50kΩ. When the meter is connected across the top 10kΩ resistor, the resistance changes from 10kΩ to

$$\frac{50k \times 10k}{50k + 10k} = 8.33k\Omega$$

The new current is 40/38.33k = 1.044mA. The voltage across the top resistor with the voltmeter connected is now

$$8.33 \times 1.044 = 8.7 \text{ volts}$$

and the percentage error is

$$\frac{10 \text{ Volts} - 8.7 \text{ Volts}}{10 \text{ Volts}} \times 100 = 13\%$$

error.

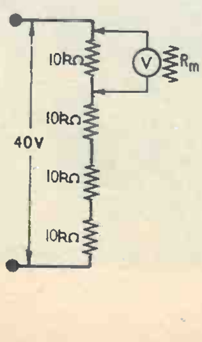



*Fig. 2. When a voltmeter is connected across part of a voltage divider, it may introduce a greater error than is generally realised*

A 13% error is very poor but is no reason to reach for the panic button. Herein is perhaps the message of the entire discussion on measurement errors. Once you know that this high error is present in the measurement, either mental or mathematical corrections can be taken. The point is that you can live with it. In this example the resistance of the voltmeter was only five times as large as the resistor developing the voltage of interest. Generally speaking, the voltmeter should, if possible, have at least ten times the resistance of the circuit across which it is connected.

If four 100Ω, 20%, resistors are connected as a series voltage divider, what would be the largest error in total resistance of the voltage divider? Each resistor may be as much as 20Ω in error. If all four resistors were off 20% in the same direction, the total error of the divider would not be 80% but still 20%. Here is how it works.

To find the total error in percentage, use the formula

$$\frac{\text{Marked Value} - \text{Measured Value}}{\text{Marked Value}}$$

x 100 = Total percentage error in measured value.

$$\frac{400-(4 \times 80)}{400} \times 100 = \frac{8000}{400} = 20\%$$

This indicates that the total error is not the sum of the errors of the individual resistors.

### Parallax

Equipment manufacturers have long been aware of parallax as a cause of error introduction in indicator readings. Parallax is the viewing angle error illustrated in Fig. 3. This viewing angle introduces either too high or too low an apparent reading. Meter manufacturers have installed a mirror behind the needle to be used as a means of parallax correction. The needle is lined up in the mirror until the needle blade reflection disappears behind the needle, and this positions the operator perpendicular to the meter face. Also to overcome parallax errors, oscilloscope manufacturers are now imbedding the graticule in the c.r.t. face. Again, moving light indicators for galvanometers appear brightest when viewed perpendicular to the galvanometer face.

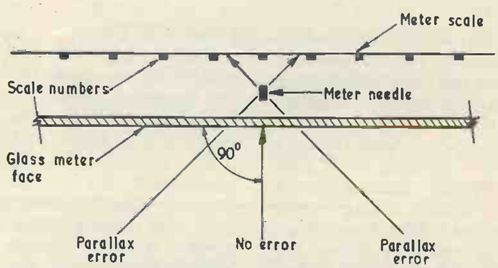



*Fig. 3. Illustrating errors caused by parallax*

Let us look at some other oscilloscope errors that crop up. On the 20 volt per centimetre scale, the trace may be approximately 1 mm. thick (depending on the oscilloscope). This means that the oscilloscope trace is 2 volts thick. For a 50 volt per cm. scale, the trace would be 5 volts thick. Any attempt to measure values to better than $\pm 5$ volts on this scale becomes questionable, and this does not take into question the internal inaccuracies of the oscilloscope.

Trace thickness errors are also present when there is excessive noise on the signal. All trace thickness errors can be minimised by selecting a particular point of the thick beam (such as the uppermost part of the trace, for example) as the index level. Always use this same point, of course, to prevent the introduction of further reading errors.

**How Many Readings?**

There are times when all of us are sufficiently interested in the accuracy of a measurement to take a number of readings. How many readings are enough? If we took 10 readings of a value and then took 90 more, would the extra 90 readings be worth the time taken? The answer is no. From the statistics of probable error it can be shown that those extra 90 readings would only be twice as valuable as the original 10 readings. Time and therefore money can be saved by a working understanding of this fact alone.

Mechanical errors or calibration errors build up as the weeks wear on. Continued use of equipment often prevents us from noticing day-to-day slips in calibration or adjustment. There are errors that crop up in almost all types of instruments. Frequency errors occur when we attempt to use test gear above or below its frequency limits. There is a certain amount of estimating error always present when we have to read between the lines on any scale. We always live with errors introduced by temperature, with hour-to-hour changes during our data recording. When a reading is made more than once, there may repeatedly be error. This is the frictional error present where mechanisms are involved in measurement. Errors introduced due to signal dynamics are more involved. The effects of noise riding on a signal waveform (already mentioned) or of one wanted frequency and one unwanted frequency superimposed on each other all tend to give false or incorrect readings. These types of error strongly point to the need for every individual who has occasion to use test gear to know its limits and know its capabilities. For each of these measurement errors, it is up to the individual to cast out unimportant readings, decisions being based on experience or a past history of readings. In all cases the cast-outs are dropped on the basis of the things being measured and the overall goal of the measurements.

**Human Factor**

If all readings could be made by computers, much of the human factor of error could be eliminated. There has been a great deal done to improve readout instruments as these represent a weak link in the man-machine relationship. Often there is compromise between cost of equipment and its readability. It is known that certain panel layouts cause an increase in operator error while others have a tendency to minimise these errors. Once the operator is aware of the problems that do exist, he is more tolerant of the shortcomings of the equipment. Included in the list of man-machine readout error causes are parallax (already mentioned), distance from readout to man, brilliance of indicator lamps, unwise use of colour, and other items too numerous for mention here. Often some emotional problem may upset us to the point that we misinterpret readings upon returning to the shop. Not too much can be said, however, in the area of errors arising out of emotional stress. We can only caution against them and watch for their influence on some measurement.

Another point is that the general professional appearance of an instrument may cause the operator to put more faith in its accuracy than the instrument warrants. Some instrument manufacturers are now including switches or push-buttons that allow selection of an exact value of frequency, voltage, etc., rather than continuously variable controls.

To sum up, errors will always be present in every measurement. We should always decide on two things. First, we should know how large the errors are, and second, we should determine if the errors are sufficiently significant to affect the reading materially. Today's instruments have forced a change in the outlook of 20 years ago, as is typified by currently available precision instruments which are low in error and high in readability.

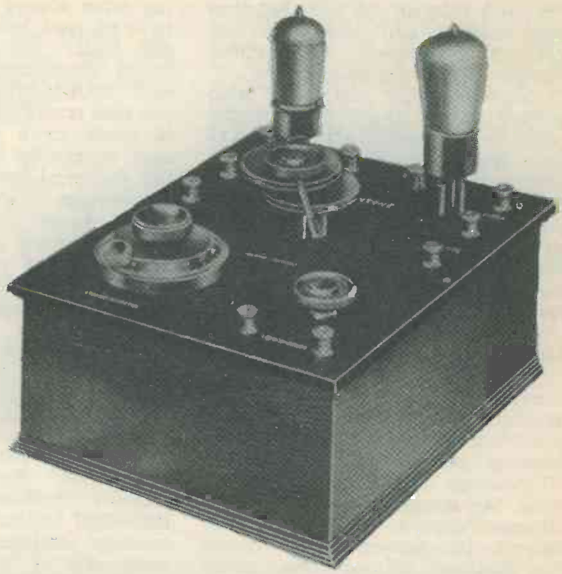
## HEATHKIT MODEL SB-300 S.S.B. RECEIVER

*The Heathkit Model SB-300 s.s.b. receiver, shown here, is capable of receiving s.s.b., a.m. and c.w. signals on all amateur bands from 3.5 to 30 Mc/s. The pre-assembled and pre-aligned linear master oscillator and crystal-controlled heterodyne oscillators ensure highly accurate and stable operation, the use of circuit boards providing a clean chassis layout. A separate crystal filter may be obtained and is switch-selected from the front panel for each of the modes of operation to provide optimum selectivity. In the absence of the optional filters, a.m. stations are received using the exalted carrier method and c.w. may be received in either s.s.b. position.*

*Other features of this receiver are special aerial and power connections for v.h.f. converters, a 100 kc/s crystal calibrator, provision for transceiver operation with a compatible transmitter, and a smooth, virtually backlash free, dial tuning mechanism. The transformer-operated, silicon diode power supply is a long-life, low-heat power source. The SB-300 s.s.b. receivable is available at £133.14.0., in kit form, carriage paid in U.K.*

*Experiences of an*

# *Early Amateur*



***The Concluding Article in this Series***

***by C. H. Gardner***

IN THESE ARTICLES AN ATTEMPT HAS BEEN MADE to give an impression of the atmosphere surrounding the activities of an enthusiastic amateur of the early days. Little has been said so far about transmitting activities because, although many of us operated our own transmitters, a great deal of our operations were confined to short distance transmissions of speech and gramophone records. The gramophone pick-up had not yet arrived, and the usual method of transmitting these records was by placing a microphone close to the trumpet of the gramophone. Some of these early transmissions must have been borderline cases for the P.M.G.'s licence conditions. One particular individual came on the air most Sunday afternoons and opened proceedings by calling up a long list of friends and relatives by name: Alf, Bert, Bill, Grandma, and others. His next announcement was "I am now going to put on some gramophone records for you." After half an hour's somewhat painful transmission of "music" he would sign off "Well, goodbye Grandma, Alf, Bert, Bill, (etc.). As we were restricted to working on a given frequency, performances of this nature interfered with the activities of many others in the vicinity. In general, though, most amateur transmitters co-operated enthusiastically in experimental work, this being of a rather more serious nature.

**Erecting the Aerial**

Severely limited by regulations as to the amount of power that we might use and restricted as to frequency, our attempts to improve range had to be largely confined to increasing efficiency, whereupon two major parts of the installation received attention: the aerial and the earth. As I mentioned in the first article in this series, one enthusiast even dug a trench down the middle of a rather lovely lawn and buried in it a 50 yard length of solid copper stick 1in wide by ¼in thick. This ran directly under his aerial. I must report that his results were so good that the Post Office sent an inspector, as they could not believe that he was restricting his power to the limit imposed. But the aerial problem was mainly concerned with height, and this brought forward the mast problem, with its attendant difficulties of expense and erection. The first 30 feet was not too difficult, but a 50-foot mast was quite another thing.

After due consideration of the expense and erection questions, my first personal choice fell upon a latticework wooden mast which was well advertised at that time. This duly arrived in three sections complete with jointing pieces, which had to be fastened together by short wooden strips and wood screws. It seemed fairly obvious that the mast could not be assembled in a vertical position and would have to be put together whilst lying on the ground. How to haul it into a vertical position was quite another problem. This was finally "solved" by calling in a number of friends to hold or pull on the stays. The first attempt was quite abortive, so one helper climbed a high tree and provided an upward pull to the top end. This worked well up to a point, but difficulty was encountered in keeping the foot of the mast on the ground. After some deliberations, an elderly and weighty relative finally agreed to sit astride the foot until the mast had become sufficiently vertical to enable this to be placed in position. All went well until a certain angle had been reached (a somewhat critical angle as we discovered) whereupon the foot of the mast, complete with elderly relative, suddenly rose twelve feet from the ground. With encouraging cries of "Ride him, cowboy" the writhing and snaking mast was gently and safely lowered once again to the ground.

The mast was eventually hoisted and the worst twists and bends removed by adjustment of the guys but, alas, some structural damage must have occurred. A few months later the whole contraption blew down and was reduced to firewood in a gale, whereupon the cost and labour had to be written off as experience gained. It was finally replaced by a 40 foot steel mast erected by the manufacturers. This was still standing some years later when I left the district.

### A Series of Broadcasts

In those days any real enthusiast with a few years of wireless experience behind him was labelled an "expert" and was often invited to talk to local budding radio societies and the like. Quite a proportion of B.B.C. listeners had a technical interest in their equipment and it thus came about that I was invited, over the years 1925 to 1927, to give a number of talks from the B.B.C. Birmingham Station on technical matters at the large fee of one guinea per half-hour's talk. The fee may not have been very attractive but there was the advantage that the talks enabled me to participate (without fee) in the "Children's Corner" and (again without fee) in the Studio Christmas parties, and also to make very many good friends amongst the grand people who appeared on both the technical and studio sides. The whole experience was thoroughly enjoyable and one which I shall never forget.

During these talks I dropped one real clanger. The Station Director, the late Mr. Percy Edgar, insisted upon one of the talks being concerned with the simple crystal receiver, since so many of these were still in use. The talk was not intended to tell the listener how the receiver worked or how to make it, but to tell him how to maintain it and get the best results from it. Crystal receivers have distinct limitations in this direction, and it may be remembered that the crystal detector of that period consisted of a copper cats whisker which had to be adjusted to make contact with a sensitive point of the crystal in use. In the course of time the cat's whisker point became oxidised, and this could cause a serious falling off in the sensitivity of the receiver. I felt therefore that it would be useful to suggest that clipping off the point of the cat's whisker in order to provide a fresh end might often improve results. Alas, part of my information was not up to date. I had not been aware of a considerable sale in the district of a number of expensive cat's whiskers with platinum tips which, as a result of my broadcast, were promptly snipped off.

Studio matters were not quite so formal as they are today. The engineer in control was able to view proceedings through a small glass window, through which he passed sign language "comments". These were apt at times to be a trial of one's self-control, because the engineer in question and myself both happened to have a similar sense of humour. It will take me a long time to forget the silent panic and activities of studio officials as they endeavoured to capture the station cat who had somehow strayed into the studio, and who had decided to accompany a somewhat large and pompous tenor in his broadcast.

### A "Portable" Receiver

Another series of talks, on "Reality in Broadcast Reception", was illustrated by demonstrations with gramophone records and a large bass drum. These were, perhaps, not too kind to makers of equipment whose normal range of reproduction was limited to the *very* middle frequencies but the only actual complaint came for an entirely different reason, from the maker of a "portable" receiver. This receiver, contained in a heavy wooden case and measuring approximately 2ft by 1ft by 1ft 6in, also required the use of another large wooden case holding a six volt accumulator and a hefty high tension battery. The illustrated advertisements showed the receiver being carried but omitted to show the battery case or loudspeaker.

In one of the talks in my series I dealt with the possibility of the future production of truly portable sets, and I warned listeners about illustrations showing portable receivers being carried but which omitted to show the elephant following behind to carry the ancillary equipment. As a result I was asked to attend an interview between the Station Director and the manufacturer, who claimed that I had undoubtedly described and criticised his portable receiver with consequent damage to his sales. At the interview I could not refrain from asking him if, as he said, my description was accurate, why he did *not* show the elephant carrying the ancillary equipment. It transpired that he felt that he was entitled to have a half-hour free of charge to broadcast an advertisement of his equipment. Needless to say, he did not get this.

### In Conclusion

I mentioned, at the start of this article, that this series represents an attempt to give an impression of the atmosphere surrounding the activities of the early amateurs. In the space available I have only been able to give a few examples of this atmosphere, but it is hoped that these may have provided at least an impression of those early days.

At the beginning the attraction was purely technical. Later, many recruits appeared by reason of the fact that only by home construction could receiving equipment be obtained. In a still later phase, enthusiasts found that cheaper and, in some cases, better equipment could be constructed than was available from manufacturing sources. This situation fairly soon became reversed (some hi-fi enthusiasts may not entirely agree with this) and radio amateurs adopted the hobby either because they desired to undertake serious experimental work in communications or because of their love of constructional work.

Today, extensive research and experimental work by highly qualified graduates in the laboratories of manufacturers and universities has altered the picture. Television, u.h.f., long distance communications and hi-fi reproduction still provide plenty of scope for the enthusiast, but they require a greater depth of pocket than was necessary for the early amateur. Nevertheless, the fascination of building one's own equipment, whether for special purposes or for the reception of broadcast sound or vision, will remain for a long time to come.

To the younger generation I can only say that time spent on this work will be far from wasted, and that practical experience of this nature is very valuable. The radio and electronics industries require all the enthusiastic recruits they can obtain, and the well-being and future prosperity of our nation may well lie in their hands.

# THE NEW DUAL-STANDARD TV SETS

**By Gordon J. King, Assoc. Brit. I.R.E., M.T.S., M.I.P.R.E.** **PART 8**

*This article, the eighth in our series on 405–625 line receivers, is devoted to the operation of the locked oscillator discriminator both on a.m. and f.m. A full description is given of the functioning of the discriminator with the frequency modulated intercarrier signal*

LAST MONTH WE INVESTIGATED THE SOUND channel of a dual-standard set in which is used a ratio detector for the 625 f.m. sound and an ordinary diode for the 405 a.m. sound. We also looked briefly at a circuit in which a type EH90 heptode valve is employed as the f.m. detector on 625 lines and as an a.f. amplifier on 405 lines, a diode being used in the latter case as the detector.

This circuit was given in Fig. 25 of last month's article, to which reference should preferably be made now. One feature of this circuit is that only a single sound amplifier stage is used, as against the two stages in the circuit of Fig. 24 (also published last month). It will be recalled that the required sound channel gain is determined (*a*) by the sound take-off point in the vision i.f. channel on 405 lines and (*b*) by the intercarrier take-off point on 625 lines. Greater gain of the sound channel is required when (*a*) is from the output of the tuner direct and (*b*) is from the vision detector, while less gain is required when (*a*) is after the first vision i.f. stage and (*b*) is from the video amplifier output.

$V_6$ in Fig. 25 is the sound amplifier which receives either 38.15 Mc/s a.m. signals or 6 Mc/s f.m. signals. This amplifier is responsive to signals at either of these frequencies, as was explained last month. On 405 lines, transformer $T_4$ is operative, and it feeds the a.m. detector $GR_2$. The audio from this detector is coupled to the interference limiter diode $GR_3$ and its associated circuit through $C_{71}$.

The "limited" audio is redeveloped across $R_{63}$, from whence it is coupled to grid 1 of the heptode $V_7$, via $C_{73}$ and the low impedance (to audio) of the secondary of $T_6$. Note that, on "405 lines", $SW_{2-1}$ simply couples the top (dead to signal) end of the primary of $T_4$ to chassis via $C_{74}$. On "625 lines" it short-circuits the a.m. audio coupling circuit and, as we shall see later, brings the secondary of $T_6$ into action, so that $V_7$ can work as an f.m. detector instead of as an a.f. amplifier only.

### Heptode as A.F. Amplifier

On the a.m. service, therefore, the audio is fed to grid 1 of $V_7$, and this valve operates as a reasonably conventional a.f. amplifier in spite of its multiple grids. The audio is developed across the anode load $R_{68}$, and is coupled to the volume control $P_6$, from whence the required level is tapped off and fed to the control grid of the output pentode in the ordinary way. Points to note here are firstly, that no a.f. triode is used, and that the triode section of $V_8$ is employed in another part of the circuit, This implies that the audio from the heptode is at a level similar to that which would be obtained from the conventional a.f. triode. The second point is that the volume control is interposed *after* the a.f. amplifier and not before it as is conventional when a triode-pentode valve is used.

On the f.m. service the heptode is arranged to serve not only as a detector but also, in effect, as an a.f. amplifier so that, on f.m. as well as on a.m., the audio at the anode is of a suitable level to drive an output pentode (via the volume control) without additional a.f. amplification. Switching is, therefore, eliminated subsequent to the heptode.

Switching is required at the front of the heptode, however, to change its action from that of a pure a.f. amplifier to that of an f.m. detector/amplifier, and we shall now consider this latter function of the stage.

### Heptode as F.M. Detector

Fig. 26 shows the heptode arranged in the rôle of f.m. detector/amplifier, as when $SW_{2-1}$ of Fig. 25 is in the "625" position. The two electrodes fundamental to the operation of the valve as an f.m. detector are grids 1 and 3. These two grids can, in fact, be considered as control grids. That is, anode current is influenced by a potential change on either grid.

However, the valve is arranged so that anode current flows only when both grids are biased positively with respect to cathode. If grid 1, for instance, is biased positively and grid 3 is biased negatively, then there is no anode current. Similarly, anode current is zero in the converse sense; that is, when grid 3 is biased positively and grid 1 biased negatively. This implies that the electrons from the cathode to the anode are blocked by either grid being negative. It needs both grids to be positive before the flow is restored.

**Short Grid Base**

Moreover, the valve possesses a short grid base at each grid. Let it be assumed that grid 3 is biased positively, then the excursion of signal at grid 1 is limited in terms of anode current. It requires only a small change in grid voltage to give an anode current swing from cut-off to saturation, which describes the term "short grid base".

The same characteristic is exhibited with grid 1 biased positively and the signal applied to grid 3. The valve has a large slope or gm.

Thus, whenever a signal which exceeds the grid base is applied to either grid (assuming that the one without a signal is positively biased), the resultant signal at the anode is limited on its positive half-cycles by anode current cut-off and on its negative half-cycles by anode current saturation. If the grid signal is a sine wave, then both the positive and negative peaks are clipped by the action of the valve and the signal at the anode has some of the characteristics of a square wave.

In Fig. 26 it will be seen that the 6 Mc/s f.m. intercarrier signal is applied to grid 1 via the coupling transformer $T_1$. This transformer is tuned to the nominal 6 Mc/s "carrier". The amplitude of the intercarrier signal at grid 1 is such that it easily exceeds the grid base of the valve, meaning that in the event of grid 3 being positive, clipped pulses will appear at the anode, as has been described.

For the sake of simplicity of description, let it be supposed that the applied intercarrier signal is unmodulated. That is, it is a pure sine wave. The clipped or square wave pulses thus occurring at the anode simply charge the anode capacitor $C_1$ and a steady d.c. "signal-less" voltage is developed across it.

Even if the intercarrier signal were modulated under the existing conditions, there would still be no audio output at the anode, since the clipped pulses would simply change in frequency. More has to happen if the circuit is to work as an f.m. detector.

**Grid 3 in Action**

This is where grid 3 comes into action. Fig. 26 shows that this grid is connected to a tuned circuit $L_1$, $C_2$. This circuit is also tuned accurately to 6 Mc/s and, because of the "space charge" coupling between grid 1 and grid 3, $L_1$,$C_2$ is also caused to oscillate at 6 Mc/s.

The situation due to the application of an unmodulated intercarrier signal at grid 1 is now that both grid 1 *and* grid 3 are in receipt of signal. The effective signal at grid 3 also exceeds the grid base so, if it were possible to "kill" the signal at grid 1 and bias that grid positively, clipped pulses would again occur at the anode, across $C_1$.

Of course, signal at grid 3 cannot be present without the application of signal at grid 1, since the signal at grid 3 is caused by coupling in the electron

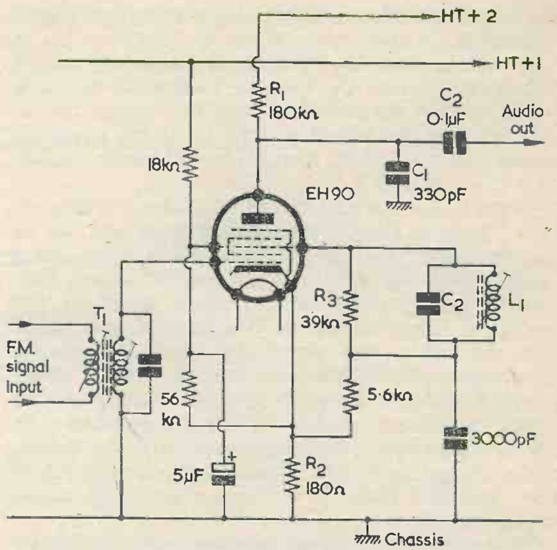



*Fig. 26. Circuit of the heptode locked oscillator detector. This is fully described in the text*

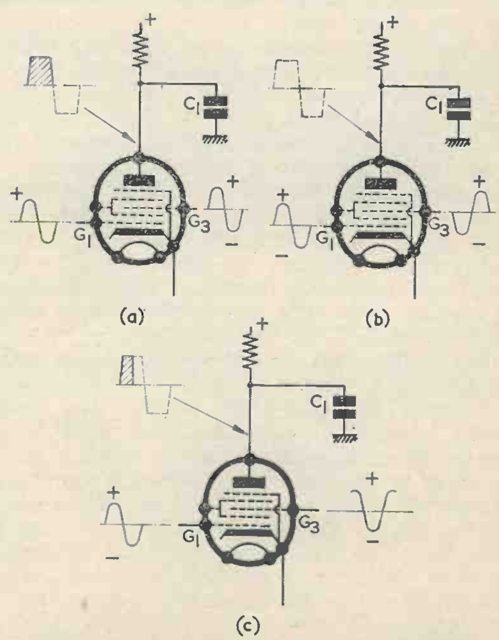



*Fig. 27. The pulse width across the integrating capacitor $C_1$ is governed by the relative phase of the signals at grid 1 and grid 3 of the heptode valve*

stream of the valve inciting $L_1$, $C_2$ into sympathetic oscillation.

It will be understood that an oscillatory signal will appear across $L_1$, $C_2$ only when that circuit is tuned, within its so-called "pull-in" range, to the frequency of the signal at grid 1. If the circuit is considerably detuned, then there will be no oscillatory effect at grid 3.

Now, if the rise and fall of oscillatory voltage at grid 1 were in exact phase with the rise and fall of the oscillatory voltage at grid 3 (both grids going positive and negative together—i.e. in phase), full-width squared pulses would again occur at the anode, as happened before when grid 1 had signal and the other was positively biased. Actually, assuming that the anode current is cut off completely as soon as the grids go from positive to zero signal and below (negative), only the positive half-cycles of signal would cause anode current response, as shown in Fig. 27 (*a*). When both grids fall below zero potential towards negative, then there is no anode output.

If one grid were to go negative while the other went positive, such as would occur if the signals on grids 1 and 3 were 180° out of phase with each other, there would be no anode output over the whole cycle, since one grid would always be at a negative potential. (Fig. 27 (*b*).)

If the signals were 90° out of phase with each other, as shown diagramatically in Fig. 27 (*c*), both grids would be positive together only over a quarter of a cycle, and a half-width pulse of current would occur at the anode, as compared with the full-width pulse at (*a*). The active current pulses are shown shaded at both (*a*) and (*c*), with the dotted lines signifying the full cycle.

Actually, the space-charge or electron coupling within the valve gives rise to condition (*c*). That is, the oscillatory signal at grid 3 is 90° out of phase with the applied signal at grid 1. This is a natural characteristic of this mode of coupling between two tuned circuits resonated at the same frequency.

In effect, then, we get a "locked" oscillatory condition relative to the tuned circuit on grid 3, for which reason the circuit is often called the "locked oscillator f.m. detector or discriminator". The "oscillator" frequency "locks" to the frequency of the applied signal—but only over a limited range, called the "pull-in" or "deviation" range.

Thus, as the result of an unmodulated intercarrier signal at grid 1, there is an anode current consisting of a series of equal-width pulses. The anode current is constant and establishes itself at an average value, depending upon the exact width of the pulses in the chain. $C_1$ in Fig. 26 charges, as has been described, due to the anode current in the load resistor $R_1$ giving a voltage drop of constant value. It can be said that $C_1$ acts as an integrating capacitor, which is really what it is, since it adds or "integrates" the voltage pulses appearing across the load resistor.

**Conditions of Modulation**

We must now consider the action of the circuit when the intercarrier signal applied to grid 1 is frequency modulated.

Let us suppose that the modulation causes the intercarrier signal to go *above* its nominal value of 6 Mc/s. Here we get the effect of a phase change between the two tuned circuits which causes the condition illustrated at Fig. 27 (*c*) going more towards that at (*b*). The voltage pulses across $C_1$ thus become narrower, depending upon the extent of the frequency deviation.

When the modulation causes the intercarrier signal to go *below* its nominal 6 Mc/s value, the effective phase change makes the nominal condition illustrated at Fig. 27 (*c*) go more towards that at (*a*). This, then, makes the voltage pulses across $C_1$ wider, again depending upon the extent of the frequency deviation.

It should be noted that the amplitude of the voltage pulses (resulting from the anode current pulses) remains the same from one deviation extreme to the other. The fundamental action of the circuit is that the pulses vary in width at a *rate* governed by the deviation frequency, while the *extent* of their width variation is governed by the "depth of modulation" (called "frequency deviation" f.m.-wise) of the intercarrier signal.

Since the voltage amplitude across $C_1$ is a function of the width of the pulses (i.e. a chain of narrow pulses will integrate to give a lower capacitor charge —or voltage—than a chain of wider pulses), it follows that the voltage across the capacitor will, in fact, vary in amplitude in sympathy with the modulation frequency.

Thus, produced across the capacitor is an audio signal corresponding in overall amplitude to the extent of frequency deviation of the inter-carrier signal and in frequency to the rate at which the pulses are varied in width.

This audio is fed through $C_2$ to the output pentode since, as we have already seen, its amplitude is large enough to drive such a valve without further voltage amplification. $C_1$ also serves as a de-emphasis component, which is a requirement of all f.m. receiving circuits where pre-emphasis is applied at the transmitter.

To provide the necessary high amplitude audio at the anode, the load $R_1$ is sometimes fed from the boosted h.t. line.

**Amplitude Limiting**

The circuit also provides automatic amplitude limiting, and in some sets using the circuit there may not be an amplitude limiter in the sound channel. Amplitude limiting occurs in three ways. One, owing to the "gating" action of the valve in terms of anode current which renders the detector somewhat insensitive to amplitude modulation. Two, at signal levels where the signal *amplitude* at the first grid exceeds the amplitude of the oscillator signal at the third grid there is a flow of grid current, and the resulting grid-to-cathode "diode" action of the valve tends to suppress amplitude disturbances in the normal "limiting" manner, without affecting the process of f.m. detection. Three, any a.m. on the input signal is detected and appears as degenerative audio across the cathode resistor $R_2$, thereby further decreasing the output to a.m. signals.

The circuit is relatively easy to align compared with the phase discriminator and the ratio detector. Assuming that the intercarrier tuned circuits are all set up to 6 Mc/s, it is necessary only to adjust $L_1$ (Fig. 26) for maximum output consistent with minimum distortion.

# A REPEATER TIMER

A. P. AINGE

*The timer described in this article offers continual "on" and "off" cycling without attention, both the "on" and "off" periods being adjustable over a very wide range. It must be pointed out that the circuit is experimental since it is necessary to adjust some of the component values, and it should not be tackled by the beginner who requires all values to be specified categorically before starting on a project. The main interest of the circuit lies in the use of two capacitors to control two neons which, in turn, control a relay*

The timer which is to be discussed here is capable of switching external circuits on and off completely automatically. Both the "on" and the "off" periods are adjustable, the range of adjustment depending upon the components employed in the time constant circuits.

### Components List

Component values not listed here are discussed in the text.

*Resistors*
- $R_1$ 5kΩ ½ watt 20%
- $R_6$ 33Ω 1 watt 20%
- $R_8$ 33kΩ ¼ watt 20%

*Capacitors*
- $C_3$ 1,000μF electrolytic 25V wkg.

*Transformer*
- $T_1$ Mains transformer. Secondary voltages: 250 to 300V; 6.3V; 6.3V.

*Light Dependent Resistor*
- L.D.R. ORP12

*Rectifiers*
- $MR_1$ Suitable for 300V at 40mA.
- $MR_2$ Suitable for 18V at 40mA.

*Relay*
- See text for coil resistance and energising current. Fitted with 3 sets of changeover contacts

*Switch*
- $S_1$ d.p.s.t. toggle

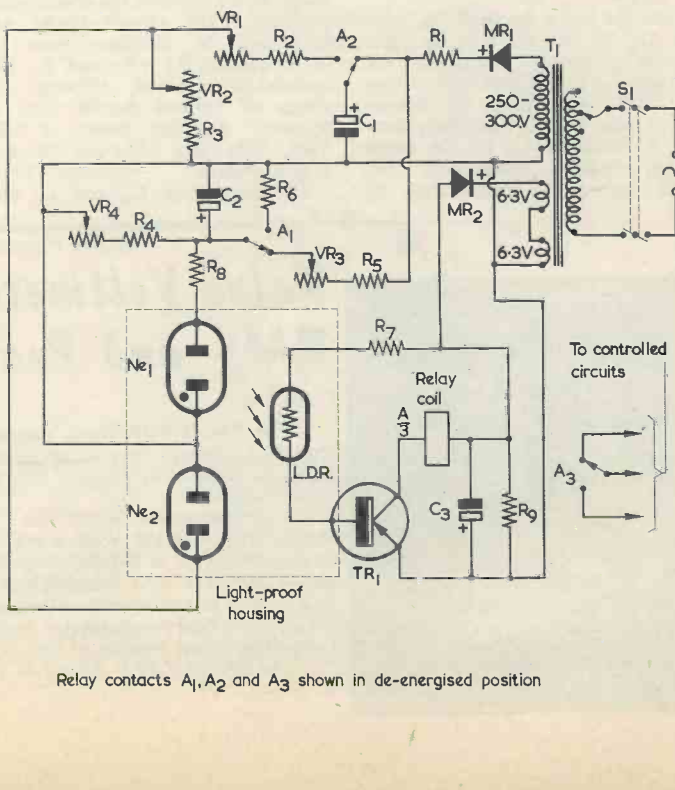
*Neons*
- $Ne_1$, $Ne_2$ Wire-ended, equivalent to type NE2 (Henry's Radio Ltd.)

### Circuit Operation

The circuit of the device accompanies this article. It will be helpful to commence a description of its operation at the instant when the mains on-off switch, $S_1$, is closed. At this instant all capacitors are discharged.

When $S_1$ closes, an alternating voltage is applied from the 12.6 volt mains transformer secondary (two 6.3 volt windings in series) to $MR_2$. This rectifies, causing a d.c. potential to appear across $C_3$ which is then applied to the transistor and relay circuit. However, the light dependent resistor in the base circuit of the transistor is not illuminated and it exhibits a high resistance. In consequence, the transistor passes a low collector current and the relay remains in the de-energised condition.

At the same time, a high alternating voltage is applied to rectifier $MR_1$. This voltage is fed, via limiter resistor $R_1$, to capacitor $C_1$, which becomes charged. The




Relay contacts $A_1$, $A_2$ and $A_3$ shown in de-energised position rectified voltage is also fed, via $R_5$ and $VR_3$, to $C_2$, which commences to charge at a slow rate. When the potential across $C_2$ reaches a sufficiently high level, $Ne_1$ strikes and illuminates the light dependent resistor. It should be noted that the time taken for the neon to strike is controlled by the values presented to the circuit by $C_2$, $VR_4$, $R_4$, $VR_3$ and $R_5$.

As soon as $Ne_1$ strikes, the l.d.r. offers a reduced resistance, thereby causing the collector current of the transistor to increase. The relay energises, and its contacts A1, A2 and A3 change over. Contacts A2 connect the fully-charged capacitor $C_1$ to the circuit offered by $R_2$, $VR_1$, $VR_2$ and $R_3$. The values here are such that neon $Ne_2$ strikes and also illuminates the l.d.r. At the same time, contacts A1 disconnect the positive plate of $C_2$ from $VR_3$ and connect it to $R_6$. $C_2$ discharges quickly into $R_6$ and $Ne_1$ becomes extinguished.

The relay still remains energised, however, because the l.d.r. is now illuminated by $Ne_2$, the latter receiving its voltage from $C_1$. After a period, $C_1$ discharges sufficiently to cause neon $Ne_2$ to extinguish. The l.d.r. now assumes its previous high resistance, and the relay de-energises. It should be noted that the time taken for $Ne_2$ to extinguish is controlled by the values presented to the circuit by $C_1$, $R_3$, $VR_2$, $VR_1$ and $R_2$.

When the relay de-energises, contacts A1, A2 and A3 take up their previous positions. Contacts A2 reconnect $C_1$ to the rectified voltage from $MR_1$, whereupon it charges quickly once more. Similarly, contacts A1 connect $C_2$ to the same rectified voltage, whereupon this second capacitor commences to charge at a rate dependent upon the values of the resistors in its immediate circuit. Thus, another cycle has commenced.

Summing up the operation of the circuit, it will be seen that the length of time during which the relay remains de-energised is controlled by the values presented to the circuit by $C_2$, $VR_4$, $R_4$, $VR_3$ and $R_5$. Similarly, the length of time during which the relay is energised is controlled by the values presented to the circuit by $C_1$, $R_3$, $VR_2$, $VR_1$ and $R_2$.

The relay has a third set of contacts, A3. These are used to control the external circuit.

**Components**

Components values in part of the circuit are experimental, but the following notes will help so far as their selection is concerned.

The fixed resistors in series with the variable resistors, i.e. $R_2$, $R_3$, $R_4$ and $R_5$, could have a value of 20kΩ. $R_3$ and $R_4$ could be omitted if desired, as they merely limit the lowest resistance inserted by the combinations $R_3$ $VR_2$ and $R_4$ $VR_4$. Their omission reduces, however, the useful track range of the variable resistors. $R_2$ is necessary, since it prevents a direct connection between the fully-charged $C_1$ and neon $Ne_2$. It is desirable to retain $R_5$ since it limits the initial charging current which can be passed by $VR_3$ when contacts A1 move to the de-energised position. The circuit could also be made to function with the combinations $R_3$ $VR_2$ and $R_4$ $VR_4$ completely omitted, although the range of control would then be reduced. Suitable values of $VR_1$, $VR_2$, $VR_3$ and $VR_4$ are between 1 and 10MΩ.

The capacitors $C_2$ and $C_3$ may have values of the order of 200μF at 300V wkg.

By suitable choice of components it should be possible to obtain timing periods for both the "on" and "off" periods, which range from several seconds to greater than 5 minutes.

The two neons are inexpensive wire-ended types. They are mounted in very close proximity to the sensitive area of the l.d.r., the three components being housed in a light-proof case.

As with the resistors previously discussed, the value of $R_7$ is also experimental, in that it controls the transistor collector current and, hence, the relay operating current. The l.d.r. is an ORP12 and it would be preferable not to exceed its 50° C dissipation rating of 100mW. This requirement will be met if $R_7$ has a value in excess of some 680Ω. The writer obtained satisfactory relay operation with values much higher than this.*

The transistor should be capable of passing sufficient current to energise the relay. An OC72 could be employed here with a relay capable of energising at some 10 to 20mA. When an OC72 is used, relay coil resistance should be 500Ω or higher.

The low voltage winding feeding $MR_2$ consists of two 6.3 volt windings in series. The value of $R_9$ is such that the rectified voltage across $C_3$ does not rise above the limiting collector potential for an OC72 of 16 volts when the relay is de-energised.

* More reliable operation of the circuit over long periods may be achieved by connecting a resistor between base and emitter of the transistor. The resistor should have as low a value as possible, commensurate with correct circuit functioning. —EDITOR.

# Valve Voltmeter with both RMS and Peak to Peak Scales

The PACO V.70 Valve Voltmeter is a versatile and rugged instrument that is a "must" in the workshop, school or electronics laboratory. Its balanced valve bridge circuit assures maximum sensitivity and stability for all measurements.

This instrument, which has 7 d.c. ranges from 0–1,500 volts and 7 a.c. ranges from 0–1,500 volts r.m.s. and 0–4,000 volts peak to peak plus an ohmmeter range of 0–1,000 Megohms and decibel range of −6dB to +66dB, comes complete with detachable 3-way probe to permit rapid, accurate tests on all types of equipment. Also available for use with the V.70 are the Model AV.1 High Frequency crystal probe and Model AV.2 High Voltage probe permitting direct reading of high voltages up to 60kW.

The PACO V.70 is priced at £22 12s., or may be purchased in kit form at £20 8s.

# 500 kc/s Crystal Frequency Marker

Wallace Studley

*In this article the author describes an effective and simple transistor operated frequency marker complete with an audio modulator stage which should prove of interest to the s.w.l. and beginner alike*

THE USEFULNESS OF A SIGNAL GENERATOR FOR receiver alignment and calibration is limited by its accuracy, and the simpler types often used by experimenters can rarely be relied upon when precise work needs to be done. Short wave listeners in particular are well aware of this and frequently make use of crystal controlled oscillators which confer a very high degree of accuracy indeed.

**Components List** (Fig. 1)

*Resistors*
(All resistors $\frac{1}{8}$ watt 10%)
- $R_1$ 15kΩ
- $R_2$ 3.3kΩ
- $R_3$ 1.5kΩ
- $R_4$ 1.2kΩ

*Capacitors*
- $C_1$ 100μF electrolytic 9V wkg.
- $C_2$ 3,000pF ceramic or paper
- $C_3$ 0.01μF ceramic or paper
- $C_4$ 100pF ceramic or silver mica

*Transistor*
- $TR_1$ OC44 (or OC45—see text)

*Transformer*
- $T_1$ I.F. transformer type P50/3CC (Weymouth)

*Crystal*
- 500 kc/s fundamental, type 10X (Henry's Radio Ltd.)

*Miscellaneous*
- s.p.s.t. on-off switch
- 6 volt battery
- Coaxial output socket
- Tagboard, case, etc.

In amateur circles crystal frequency markers are well-known, and they enable the user to check a transmission or calibrate a receiver scale very accurately.

A "marker" is really nothing more than a radio frequency generating device which operates at a single set frequency determined by the crystal it contains. By taking advantage of the harmonic content of a crystal marker signal, signals may be picked up at odd and even multiples of the fundamental frequency, these becoming progressively weaker as harmonic order increases. For example, if the crystal is a 1 kc/s type, this frequency, plus signals at 2 kc/s, 3 kc/s and so on, may be tuned in on a suitably coupled receiver. If the receiver is sensitive, harmonics may be heard up to around 30 Mc/s, and this range is usually adequate for s.w.l. requirements.

Marker points spaced at 1 kc/s intervals are hardly adequate though and, because of this, a 100 kc/s crystal is frequently preferred. On the 80 metre band, a 100 kc/s crystal gives indications at 3.5, 3.6, 3.7 and 3.8 Mc/s. On the 40 metre band there would be indications at 7.0 and 7.1 Mc/s, which offers an excellent state of affairs.

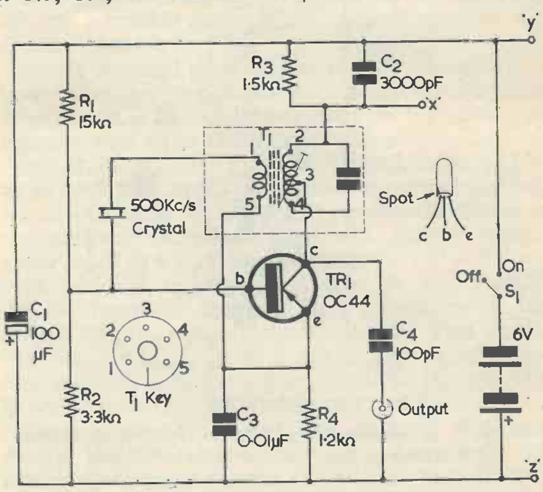



*Fig. 1. The circuit of the crystal frequency marker. $R_3$ and $C_2$ can be omitted if the oscillator is not to be modulated, whereupon $T_1$ connects directly to the negative supply line*

Many crystal markers employ valve circuits but benefits are conferred by transistorised versions, particularly since the physical size is reduced. Complete portability is also possible.

### A Practical Circuit

The circuit of one model recently constructed by the writer is given in Fig. 1. Here $TR_1$ operates in the common-emitter mode and oscillations are obtained at 500 kc/s. Due to $T_1$ and the crystal, energy is fed back from the collector to the base of $TR_1$ in the correct sense for oscillations to occur. An OC44 is specified for $TR_1$, but an OC45 will probably work equally well.

Use of a fundamental frequency of 500 kc/s results in "markers" at 3.5 and 4 Mc/s on "80" and 7.0 and 7.5 Mc/s on "40" and this is often adequate for s.w.l. needs. The particular crystal frequency chosen also permits the use of a readily obtainable phase-shifting transformer. Care should be taken, if the circuit is duplicated, to ensure that a transformer of the type quoted is employed.

Resistors $R_1$ and $R_2$ form the base feed potentiometer which, in conjunction with $R_4$, ensures temperature stability. Resistor $R_3$ and capacitor $C_2$ could be omitted if it is intended to employ the oscillator without modulation.

In use the marker circuit consumes some 2mA from a 6 volt d.c. supply. There is no warm-up time to worry about and the unit functions immediately it is switched on. Battery replacement is required only rarely.

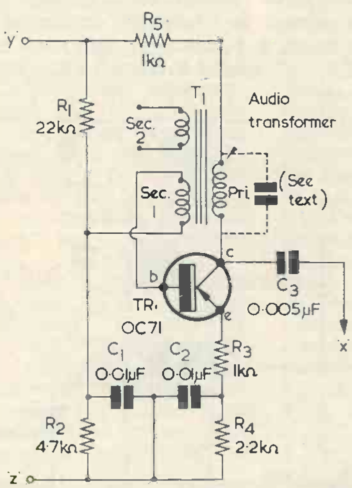



*Fig. 2. A suitable a.f. oscillator. This is coupled into the circuit of Fig. 1 at points "x", "y" and "z"*

**Constructional and Setting-up**

A small item of this kind can be easily built on a small piece of tagboard, and $2\frac{1}{2}$ x $1\frac{1}{2}$in is a suitable size for the present unit. The trial model used a 10X crystal obtained from Henry's Radio Ltd., and this, together with the transformer can, transistor body and switch, occupied the flat side of the board. The tags on the other side of the board retained the resistors and capacitors, etc. The complete assembly can be placed in a small plastic box and the only visible components need be the switch dolly and the output socket.

An oscilloscope is useful for setting up the unit. Alternatively a receiver of the communications type may be used, the presence and amplitude of oscillation being indicated with the aid of the b.f.o. and S-meter. On the lower frequency bands coupling should be as loose as is possible compatible with adequate signal injection, and an insulated lead from the marker output socket twisted around another plugged into the receiver aerial socket is usually adequate. Alternatively, a 30pF concentric trimmer may be used. Very tight coupling might tend to damp transformer $T_1$ excessively.

It was found that the core setting of $T_1$ was moderately critical. The core should not need a great deal of adjustment, its final position being slightly out of the windings. In the test model the onset of oscillation was sudden as the core was rotated clockwise out of the windings. Oscillation was then apparent over two whole turns but further manipulation caused the non-oscillating condition to return.

Calibration of the marker can be made against MSF transmissions on either 2.5 or 5 Mc/s.

**Signal Recognition**

On the lower frequency bands it is easy to identify the marker harmonic signal but, as the receiver is tuned to higher frequency ranges, detection is not so simple because of harmonic tail-off and the fact that carriers are heard even when no aerial is connected. A signal due to the marker will of course fade out if $S_1$ is opened momentarily, but it is more helpful, for the purpose of identification, to add a modulator stage to make the signal audible. A simple circuit that may be tried is shown in Fig. 2 where $TR_1$ functions as a conventional a.f. feedback oscillator in conjunction with $T_1$. The stability given by the bias components is excellent and the circuit is very easily set up.

The audio transformer, $T_1$, may be a type used for Class B "driver" applications, such as the Weymouth LFDT4. Transformers of this type have two separate low impedance windings and a ratio of about 4:1+1. One secondary winding is left disconnected. The windings used must be connected in the correct sense or the circuit

**Components List (Fig. 2)**

*Resistors*
(All resistors $\frac{1}{8}$ watt 10%)

| | |
|---|---|
| $R_1$ | 22kΩ |
| $R_2$ | 4.7kΩ |
| $R_3$ | 1kΩ |
| $R_4$ | 2.2kΩ |
| $R_5$ | 1kΩ |

*Capacitors*

| | |
|---|---|
| $C_1$ | 0.01μF paper |
| $C_2$ | 0.01μF paper |
| $C_3$ | 0.005μF paper |

*Transistor*
$TR_1$ OC71

*Transformer*
$T_1$ Class B driver transformer (see text)

will not function. If no oscillations result when the unit is first switched on, reversal of the connections to the primary winding is usually sufficient to cure the trouble.

The frequency is controllable—within limits—in various ways, this being done either by altering the emitter or collector circuits. For example, a capacitor across $T_1$ primary winding lowers the operating frequency whilst a resistor of the order of 68kΩ raises it. In the emitter circuit the frequency of operation is increased as $R_4$ is made larger and, although amplitude is adversely affected, a purer waveform results. The unbypassed resistor $R_3$ also contributes to waveform purity, due to the a.c. feedback it introduces.

Adequate injection into the crystal controlled circuit results by completing the connections "x" of Figs. 1 and 2, but a high level audio signal can also be obtained—for Morse code practice perhaps—by extracting it from points "x" and "z". This means that points "x" and "z" may be used initially to check the circuit merely by connecting to them the leads from a pair of high-impedance phones. It should be noted however that, if this audio oscillator is used for Morse practice, it is impracticable to key the transistor supply voltage because the build-up time will not permit crispness. Usually it is convenient to key the output.

***TRADE NEWS . . .***

# The Sinclair "X-10" Integrated Amplifier

HAVING ESTABLISHED A NAME FOR THEMSELVES IN radio receiver design with the Micro-6 receiver, Sinclair Radionics Ltd., have now introduced a new type of transistor audio amplifier.

The Sinclair "X-10" is a high fidelity integrated power amplifier and pre-amp using 11 transistors and having a transformerless output of 10 watts for feeding into a 15Ω loudspeaker system. It requires only the addition of tone and volume controls plus a 12 to 15 volt d.c. power supply to make it a complete mono high fidelity assembly. Stereo is achieved by using two X-10 amplifiers, and ganged or separate controls. Input sensitivity is sufficient for crystal or magnetic pick-ups and the manual supplied with the "X-10" gives detailed instructions for connecting the controls and for using the amplifier in a wide variety of applications.

This radically new transistor amplifier (patents applied for) is claimed to be the first marketed anywhere in the world using the pulse width modulation principle (P.W.M.). This technique permits a considerable reduction in the power dissipation in the output transistors of an amplifier; and in the case of the Sinclair "X-10", the output efficiency is stated to be about 95% as compared with about 60% for conventional class B output stages. This immediately results in the following advantages:

(1) No heat sink is required for the output stage, and small high frequency transistors can be used in place of the conventional low frequency power transistors. Four transistors are used in the output stage of the Sinclair "X-10" and, as their cut-off frequencies are 5 Mc/s or more, the high frequency performance of the amplifier is exceptionally good and remains flat at high power levels.

(2) The high efficiency of the Sinclair "X-10" means that less current is required from the power supply. Two ordinary lantern batteries costing 4s. each, for example, will power the amplifier for about three months in normal use. A mains power pack may also be used, and one is available from Sinclair at £2 14s.

(3) The absence of heat sinks and the use of small transistors makes the amplifier very light, compact and easy to fit.

(4) As none of the transistors in the Sinclair "X-10" has to dissipate excessive heat the reliability of the amplifier is excellent, and it should last indefinitely.

(5) It is stated that the use of P.W.M. assures a better transient response than is possible with other amplifiers and that it adds greatly to the quality of reproduction from the louspeaker.

(6) Harmonic distortion is claimed to be so low as to be totally negligible and cross-over distortion, which can cause such marked unpleasant effects in conventional transistor amplifiers, simply cannot occur at all in a P.W.M. amplifier.

In addition to the use of P.W.M., the Sinclair "X-10" amplifier employs four transistors in the output stage in place of the usual two. This means that the amplifier, which is completely transformerless, requires no coupling capacitor to the speaker. It also halves the required supply voltage.

Sinclair Radionics Ltd. are making this new design available as a complete instrument, or separately in parts for the constructor to build and assemble for himself.

**Principal Specifications of the Sinclair "X-10"**

Number of transistors: 11.
Overall size: 6 x 3 x ¾in.
Input sensitivity: 1mV.
Total harmonic distortion: less than 0.1%.
Output power: 10 watts.
Frequency response: 5 c/s to 20 kc/s ± 1dB.
Speaker impedance: 15Ω
Damping factor: greater than 100.
Quiescent consumption: 75mA
Supply voltage: 12 to 15 volts.
Price (post free): £5 19s. 6d., parts and instructions; £6 19s. 6d. built and tested.
Mains power supply (for 1 or 2 amplifiers): £2 14s.

# RADIO TOPICS . . .

## by Recorder

"WELL, HOW WOULD *you* LIKE to be painted gold all over?"

Any James Bond fan who, like myself, overhead this extraordinary question outside a cinema could at once assume, rightly, that the film being shown was "Goldfinger". I need hardly add that the Bond films represent, of course, a self-mocking send-up of all the spy stories ever written, and that they can offer quite a lot of fun if you're prepared to enter into the spirit of the thing.

Some of the minor points about these films which tickle my sense of humour are the delightful small electrical or electronic "devices" which the intrepid 007 employs in his war against the baddies of his world. Each gadget must be assembled by the prop-man with loving care, and nearly always incorporates a little battery clipped neatly into position and bearing a well known trade name such as "Ever Ready". This represents a touch of genius, because the familiar bright label links the everyday world of the shop battery counter to the fantasy scene being enacted on the screen.

Such an approach is to be expected from the electronically-minded makers of the Bond films. In "Goldfinger" a laser is used, very nearly, on the master-spy himself. Later, it is employed to burn out the doors of the U.S. gold repository at Fort Knox.

I had better cease on this subject now, however, because it is possible that some readers may look upon the Bond films with disfavour. To them, 007 is not a preferred number!

### Hum on F.M.

A reader, R. G. Young of Peacehaven, Sussex, has sent us some interesting details of a possible cause of modulation hum in f.m. receivers.

The cause of the modulation hum is stated to be direct magnetic interaction between the mains transformer and the ratio discriminator coils. Mr. Young says that the hum, which has a rather high harmonic level, is liable to occur if the mains transformer is mounted close to the discriminator transformer and that it can be cleared by re-mounting the transformer well away. Alternatively, our correspondent's "private cure" can be employed. This consists of fitting a hum-bucking coil around the discriminator transformer screening can and moving it around for minimum hum. The coil can have about 8 to 10 turns (in bad cases up to 20 turns may be needed) and is connected in series with one of the valve heaters. The turns of the hum-cancelling coil can be held in place by tying with cotton.

It seems feasible to me that a modulation hum effect of this type could occur if the dust core of the frequency-sensitive winding of the ratio discriminator transformer (e.g. the secondary in a conventional component having primary, secondary and tertiary windings) is acted upon by a strong magnetic field varying at 50 c/s. The incremental permeability of the core could then alter according to the strength and polarity of the field. Mr. Young hazards a guess that the field may have an effect on the performance of the diodes.

### Micro-Soldering Irons

Light Soldering Developments Ltd., of 28 Sydenham Road, Croydon, Surrey, announce that their "Adamin" range of high performance micro-soldering instruments, which were introduced a few years ago, has just recently been re-styled and technically improved.

All "Adamin" instruments are now fitted with a completely new handle which is injection moulded in nylon type 66. This new handle has an attractive bright red colour, is extremely light (it weighs 5 grams) and comfortable to hold, and is stated to be so tough that it is absolutely unbreakable. Furthermore, it is unaffected by most chemicals and solvents, withstands considerable heat without softening and is self-extinguishing.

Modifications have been made to "Adamin" elements to improve performance and reliability, particularly in the case of the two mains voltage models in this range. One of these, the type C1OL is considered to be the smallest mains voltage instrument in the world.

"Adamin" copper bits are now heavily chromium plated to prevent surface scaling and wetting of the sides by solder; preservation of the surface finish in service is an important factor in maintaining bit temperature.

The accompanying illustration shows an "Adamin" instrument with the new handle, and amply demonstrates its small size and ease of handling.

### Thou Shalt Not . . .

Several readers have written in to tell me that my explanation of the "two equals one" calculation is not as accurate as I had fondly imagined it to be. I published the "proof" in the September and October issues, saying in the latter that it falls down on the third line because both sides are equal to zero.

Not so, declare my correspondents. The fallacy lies in going from the fourth to the fifth line, where both sides are divided by $(x-y)$. Since it is assumed that x is equal to y this is equivalent to dividing by zero whereupon, as one reader puts it, the fundamental rule that "thou shalt not divide by nought" is broken. It is after this particular step that the "proof" becomes nonsense.

I am indebted to the readers who have pointed this out, and so enabled me to get the matter straight.

My next trick, ladies and gentlemen, will be impossible . . .

### Slightly Over-Run

I see that, elsewhere in this issue, Dick and Smithy are delving into the mysteries of transistorised u.h.f. television tuners. When I see new devices like this being accepted for everyday use, I sometimes wonder what would have been our reactions if they had suddenly been presented to us some 20 years or so ago. If at that time we had been shown a small unit having hardly any components, and certainly no valves, and had been told that it could amplify over the range of 470 to 854 Mc/s we would have raised, at the least, an unbelieving eyebrow. The added statement that only a 12 volt supply was needed would have finally brought forth our complete incredulity.

Looking back, though, we did some pretty incredible things with valves 20 years ago. Off duty, that is.

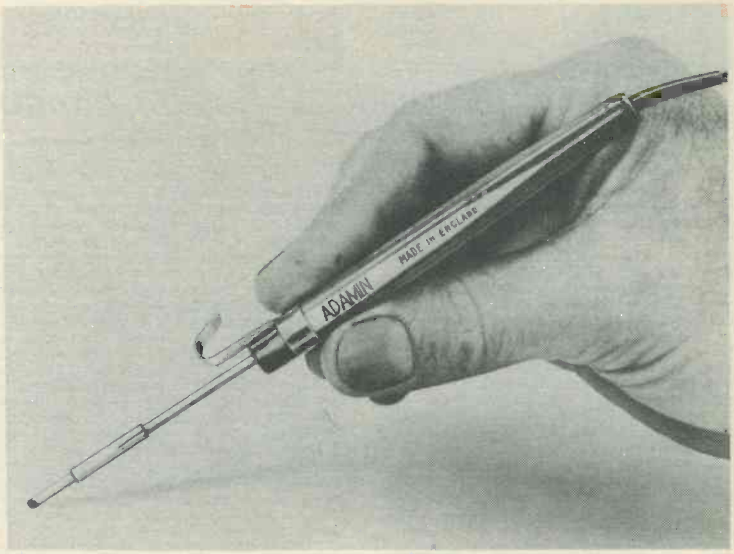
In that year of the war I was stationed in Italy, and I eventually managed to scrounge enough parts to knock up a short-wave receiver covering 5 to 18 Mc/s in order that we could pick up the B.B.C. Overseas broadcasts. Because I had come by a 6K8 frequency-changer (a great prize) a superhet became feasible, and this used the line-up: 6K8, 6K7, 6Q7 and 6V6. I had also managed, by means of some rather weird and wonderful modifications to a component not intended for the job, to make up a mains auto-transformer which stepped the local 150 volt a.c. mains up to around 270 volts. There was, also, just sufficient room under the laminations to squeeze in a single 6.3 volt heater winding.

What was finally required was a half-wave h.t. rectifier. But this proved to be completely unobtainable, and I eventually decided to make do with a metal 6N7 Class-B double triode output valve having all grids and anodes strapped together to act as a single rectifier anode.

Believe it or not, but that shockingly maltreated 6N7 pressed on quite happily as a rectifier for at least 18 months. In common with the other valves, its heater was at chassis potential, whilst its cathode had a potential which lay anywhere between 200 to more than 300 volts positive of chassis according to the voltage provided by the highly unpredictable local mains. The cathode fed directly into the electrolytic reservoir capacitor and, as a precaution, I originally inserted a torch bulb in series to act as a fuse. The ripple current was sufficient to make this glow brightly when the mains voltage was high. But it burnt out so frequently that I put a short-circuit across it, and ran the circuit without a fuse.

At the end of the 18 month period I mentioned just now I was posted home, and I passed the set on to a friend, complete with its 6N7 with the mammoth performance and in full working order.

They certainly made valves tough in those days!




*One of the micro-soldering instruments in the re-styled "Adamin" range manufactured by Light Soldering Developments*

**Ferroxcube Aerial Rods**

In the September issue I referred to my experiences in repairing the broken ferrite rod of a portable transistor receiver. Referring to an article in *Mullard Outlook*, I said that no adhesive requiring heat should be employed for joining the mating surfaces. I also said that the heat would impair the magnetic qualities of the rod.

I have since been informed by Mullard Ltd. that this is an incorrect reference to the effects of temperature on ferrite rods when using hot setting adhesives. Mullard pass on the further information:

"We feel that it should be made clear that ferrite properties are likely to be adversely affected by temperatures of 400°C or greater. As most hot setting adhesives do not require curing temperatures of anything greater than 120°C there will be no detrimental effects on the ferrite. If rods exceed their Curie temperatures (greater than 130°C in the worst case, but for normal radio aerial material, greater than 250°C), the properties would return to normal upon cooling."

**December Once More**

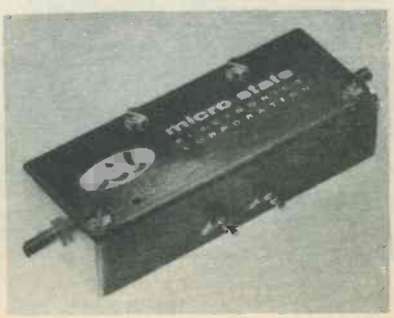
And so we come to yet another December issue.

It has certainly been a lively year for us in the Editorial offices, and it looks as though next year is going to be even livelier. At the time of writing we have already started our planning for the earlier part of 1965, and I can assure you that there is plenty of really good stuff to come!

With which happy thought I must now add my sincere wish that you all have a really Happy and Merry Christmas.

See you in January!

## MINIATURE TRANSISTOR AMPLIFIER FOR I.F. AND U.H.F. Applications




Introduced by Micro State Electronics Corporation, the new MTQ series of miniature transistor amplifiers provides many advantageous features. The series includes five models, designed for use as low noise i.f. and r.f. amplifiers covering all frequencies in the 30 Mc/s to 300 Mc/s range.

The features include: extra-small size; low noise figure; high gain; wide bandwidth; rugged construction and solid state reliability. Amplifiers are available also with built-in video detectors and a.g.c. circuitry.

The package size is a small 27mm x 19.1mm x 77.8mm (less connectors); r.f. connectors are Omni Spectra OSM; d.c. requirements: 20 volts at 35mA; the operating temperature range is from −50°C to +75°C.

For additional information contact Ad. Auriema Ltd., 125 Gunnersbury Lane, Acton, W.3, England.

1964

# International Radio Communications Exhibition

The 1964 International Communications Exhibition was again held this year at the Seymour Hall, W.1., and was opened by Mr. E. D. Whitehead, M.B.E., B.Sc., M.I.E.E., Director of Electrical Inspection at the Ministry of Aviation.

The writer, probably in common with many other enthusiasts, made a tour of the exhibition viewing the equipment on the various stands and, at the same time, meeting some old friends. Particularly of interest were those items of equipment that were new—at least as far as the writer was concerned.

The Radio Society of Great Britain stand, with its display of working and somewhat humorous models—including a much harassed treasurer and also a non-stop pedal cyclist complete with mobile radio equipment—was again complete this year with a fine array of home-constructed units. Those noted, amid many other fine examples, were a Communications Receiver prototype Mk. II by A. H. Shepherd, G3RKK; a Linear Amplifier by M. D. Mason, G6VX; a 1.8 and 144 Mc/s Transmitter by H. Rogers, G3NHR; a V.H.F. Multiband Receiver by P. J. Sterry, G3CBU and, last but not least, a 3-Band Crystal Mixer Transmitter by Members of the Basingstoke Amateur Radio Club. The writer was left with the distinct impression that items of home-constructed equipment improve year by year and that displayed in this exhibition in many instances measured up well with commercially produced units.

K. W. Electronics, Ltd., featured their well-known KW77 and KW707 Communications Receivers, the KW 500 Linear Amplifier and the KW One-Sixty Transmitter. The latter, as its name implies, has been specifically designed for the frequency range 1.78 to 2.1 Mc/s with a p.a. input of 10 watts (15 watts maximum) c.w. or phone. Break-in operation is permissible, the v.f.o. being keyed and a buffer between the v.f.o. and the p.a. assuring stable and "chirp-free" keying. The output impedance is 70–300Ω with pi output, the modulation is high level plate and screen, up to 100%. The transmitter is very compact (10 x 9 x 6in—panel 10 x 6in) and has a self-contained power supply. The valve line-up is EF80 oscillator, EF80 buffer, PL81 p.a., 6BR7 speech amplifier, 12AX7 audio amplifier and phase splitter, two 6BW6's modulator and an OA2 stabiliser. The controls are v.f.o. tune, p.a. tune, aerial coupling, off/phone/c.w. and net on/off. The KW2000C Transceiver was also in evidence and this is a complete unit providing transmission and reception of single sideband suppressed carrier, compatible amplitude modulation and continuous wave telegraphy on any four pre-selected channels in the range 1.6 to 30 Mc/s.

Daystrom Ltd, (Heathkit) presented a comprehensive display of their well-known excellent kits and showed many of them in completed form. The attractive appearance of their range has always impressed the writer and particular attention was paid (for personal reasons) to the Model MM–1U Multimeter and the R.F. Signal Generator Model RF–1U. The sensitivity of the former instrument is 20kΩ-per-volt d.c. and 5kΩ-per-volt a.c., and the function and range switches offer full-scale settings (a.c. and d.c.) of 0–1.5, 5, 15, 50, 150, 500 and 1,500 volts. Current ranges are 0–150μA, 15mA, 150mA, 500mA and 15A d.c. only. The resistance ranges are R x 1 (15Ω centre scale), R x 100 (1,500Ω centre scale), and R x 10kΩ (150,000Ω centre scale). This instrument will measure from 0.2Ω to 20MΩ. A large 4½in 50 micro-ampere meter, a dB range of −6 to +58dB, a polarity reversing switch and test leads are other features of the instrument. The R.F. Signal Generator provides a frequency coverage in 6 bands from 100 kc/s to 100 Mc/s on fundamentals and up to 200 Mc/s on calibrated harmonics. The dial has 6 large scales allowing precise frequency settings and a 2% accuracy is achieved through the entire coverage. Modulated or unmodulated r.f. output of at least 100 millivolts is available, this being controlled either by fixed step or by continuously variable output attenuators. A 400 c/s audio signal with 10 volts output is provided for audio tests. Many other test instruments, receivers, transmitters, audio equipment, etc., were also presented to make an enviable (at least to the writer) display.

The Hammarlund stand (K.W. Electronics Ltd) featured many of their world-famous receivers and transmitters. Those noted particularly were the dual-conversion HQ–145X 12 valve communications receiver covering the range 540 kc/s to 30 Mc/s. This receiver has an improved noise limiter; dual-conversion from 10 to 30 Mc/s, a directly calibrated electrical bandspread on the 80, 40, 20, 15 and 10 metre amateur bands; crystal filter with 6-position switch; adjustable slot filter with up to 60dB attenuation for elimination of adjacent channel interferences; S-Meter; temperature compensated b.f.o. for s.s.b. and c.w. reception and a high precision crystal controlled channel for any point within the entire frequency range. The triple-conversion HQ-170 was also in evidence and this receiver has so many excellent features that it is impossible to list them all here. Sufficient to say that it has a line-up of 17 valves, slot filter, separate vernier tuning, separate linear detector, tuned i.f. amplifier, selectable sideband, crystal calibrator, automatic noise limiter and a dial scale reset control. An optional extra is the telechron clock-timer, a combination clock and automatic timer fitted as an aid to meeting pre-arranged schedules.

Webbs Radio presented yet another very interesting display of the Eddystone receiver range. Of note here were two receivers of some interest, the first being the EC10 transistorised Communications Receiver. This has a frequency coverage of from 550 kc/s to 30 Mc/s in five bands and tuning is controlled by a gear drive having a reduction ratio of 110 to 1. The tuning scales have a length of 9in and are marked directly in frequency to an accuracy of within 1%. The transistor line-up for the following stages are all OC171's—r.f. amplifier, mixer, local oscillator, 1st i.f. amplifier, 2nd i.f. amplifier, b.f.o. and audio amplifier. The audio driver is an OC83, the push-pull audio output stage consisting of two OC83's. The a.g.c. attenuator diode is an OA70, and an OA90 acts as the detector and a.g.c. with an OAZ203 performing the function of a voltage stabiliser. The power supply is derived from six U2 type cells housed in a separate detachable compartment which is easily accessible from the rear of the cabinet. The 940, 830/2 and the EA12 Communications Receivers, among others, were also to be seen and inspected.

The Codar Radio Co., provided a range of equipment that was well worth inspection. A t.r.f. receiver having a coverage of from 10 to 2,000 metres was on view, this being a most useful design specifically offered to the beginner or short wave listener. The CR66 Communications Receiver, the RQ10 "Q" Multiplier and the PR30 Pre-selector unit were to be seen. Of new interest here was the AT5 Miniature 12 watt Transmitter which, like the aforementioned equipments, was attractively styled. This transmitter operates on the 80 and 160 metre amateur bands and is designed for both mobile or fixed station operation. It is certainly miniature, being only some 8½ x 5 x 4in but it has a line-up of EF80, EF80, 6BW6, 12AX7 and 6BW6. A new modified Vackar type v.f.o. circuit, developed by Codar and providing extreme stability, is included in the design. A calibrated circular dial (1.8 to 2.0 Mc/s and 3.5 to 3.8 Mc/s) is fitted with a ball-bearing slow motion drive, free from backlash. A plug changeover for 6 or 12 volt heater supply is provided and this allows the heaters to be run from either a 6 volt transformer supply for fixed use or from a 12 volt battery supply for mobile operation. A matching stabilised power unit is available separately and a mobile 12V transistor power supply will be available shortly.

Electroniques (Felixstowe) Ltd., had many interesting items on show, including their range of coils, coilpacks, dials, complete a.m. and c.w. detector and a.g.c. units and i.f. transformers, etc. A brand new development on this stand was the combined pre-selector/converter fitted with a peak and notch i.f. filter. For the first time the functions of a converter and pre-amplifier have been combined and additionally, a "Q" multiplier and notch filter, of new design have also been incorporated. The unit is self-contained having its own regulated power supply. A 3-position push button unit selects either the pre-selector or the converter function and, when used as a converter, the other two buttons select either the peak or the notch functions. The i.f. output frequency is 1.620 Mc/s although an alternative output of 1.5 Mc/s can be supplied. An aerial tuning control, gain control and multiplier peak/notch control, plus the 6 waveband switch, are all contained on the front panel in addition, of course, to the main tuning control. Two models will be available (in date rotation from March onwards) these being the Model PC166HB (6 bandspread amateur bands) and the PC166GC (6 band general coverage). Both models have a tunable i.f. whistle filter input circuit feeding into a high gain EF183 r.f. stage, this feeding an ECH81 combined mixer/oscillator.

The National Radio Co., presented a range of their latest designs among them being the NC-77X, NC-121, NC-140 and NC-90 communications receivers. Of note here however were two new designs, the NCX-5 All-Band-Transceiver and the HRO-500 receiver. The NCX-5 has been designed as an amateur station in one cabinet and covers the 10 to 80 metre bands. A separate power supply is required. The design incorporates a linear solid state v.f.o. and dial calibration is by means of a digital counter, the read-out being accurate to 1 kc on each band with additional counter calibration to 100 cycles. The transmit and receive selectivity is by means of a new 8-pole crystal lattice filter and filter bandwidth is 2.8 kc/s at 6dB with a 6–60dB shape factor of 1.7:1. Types of emission are s.s.b. (selectable upper or lower sideband) a.m. and c.w. The circuit contains 20 valves and 15 semiconductors. The National HRO500 Communications Receiver provides solid state circuitry and operates from 12V d.c. batteries (current drain 200mA) or 115/230V a.c. 50–60 c/s sources. The receiver covers the entire v.l.f. and h.f. bands continuously from 5 kc/s to 30 Mc/s in 60 500 kc/s bands, the tuning rate, stability and dial calibration being 1 kc throughout. All facilities necessary for s.s.b., c.w., f.s.k. and a.m. reception are incorporated. The frequency is determined by a phase-locked crystal frequency synthesiser which eliminates multiple crystal oscillators for high frequency oscillator injection. All high frequency oscillator signals are synthesised from the output of a single 500 kc/s master crystal oscillator for maximum stability and the elimination of band-to-band recalibration. The line-up consists of 37 transistors and 20 semiconductors.

**Green and Davis Ltd.**, currently offered a 2 Metre Converter Mk. IV, this being a high sensitivity, low noise factor converter with internal mains supply. Frequency coverage is 144 to 146 Mc/s with i.f. outputs at 1.8–3.8, 4–6, 24–26 and 28–30 Mc/s with other frequencies available to order. The noise factor is better than 2.6dB. The size of the unit is 6 x 4 x 5in and the line-up is 6060 overtone oscillator/frequency multiplier, two 6CW4's cascode r.f. amplifiers and a 6CW4 mixer. Other items to be seen were a 70 cm Nuvistor Converter, the 2M1000 150 watt 2 Metre Transmitter having 70cm capabilities, the 2M15 20A (Falcon) 20 watt Mobile or Mains Transmitter for 144 Mc/s with 420 Mc/s facilities, the CTX2 18 watt Transmitter for 2 metres which may be also used as a driver for 70cm and the Green and Davis 500 watt Single Sideband Linear Amplifier PGLA1.

**E. J. Philpott's Metalworks Ltd.**, presented a wide range of well designed modern styled metal cabinets finished in a selection of colours to suit most individual tastes. This firm specialises in producing metalwork to individual specifications and some examples of this were to be seen, together with cabinets having a two-tone colour scheme which was certainly most pleasing to the eye. The popular "S" line style of cabinet was predominantly evident.

**Partridge Electronics Ltd.**, were showing their unique "Joystick" all-band aerial suitable for both receivers and transmitters. The "Joymast", specially produced for use with this aerial system, raises the "Joystick" to a height of some 31ft 6in when used as an aerial but the unit itself is designed primarily for mounting in a roof space or even within the "shack" itself. The "Joymatch" aerial tuning units were also to be seen and these are of various types. Type 1 is a general purpose tuner whilst type 2 is specifically for use on the medium waveband with type 3 having a pi circuit and catering for the short wavebands. Type 6 is, in effect, a do-it-yourself tuner unit, having a tapped inductance with a shorting lead and two variable capacitors, these providing an individually chosen circuit within a few seconds.

**Formica Ltd.**, provided a most interesting display of various copper-clad laminates showing the separate stages of production. Used extensively for printed circuit boards, especially with solid state devices, the static display showed two major methods of manufacture whilst a colour film ("Current Trends") was screened continuously showing in detail the production processes employed in the production of printed circuitry.

**C & N (Electrical) Ltd.**, offered their Uniframe Modular Rack and Panel System based on a new approach to the construction and assembly principles. Consisting of strongly made vertical and horizontal members, capable of being easily and quickly bolted together to form the framework of a standard size instrument case, it may be extended to a height of 6ft and horizontally to any desired length in multiples of the original module. A basic kit of parts is available as a basic rack without side or back panels if desired and panels may be provided in a wide range of colours, being attached to the frame in relation to slide-on corner trims by alternative methods, thereby offering a choice of both style and colour in the completed assembly.

**Ray Cross Electronic Co. Ltd.**, produced for inspection two communications receivers of great interest. The RCX505 is the first available British designed receiver to employ a linear balanced mixer system with no r.f. stage in order to give excellent protection against cross modulation. With conventional r.f. stages and non-linear mixers, trying to receive a weak signal some few kc/s adjacent to a powerful transmission often becomes impossible by virtue of the cross modulation that is apparent. Having no r.f. stage but with a linear balanced mixer provides excellent protection against this fault. The receiver features double conversion using 14 valves and 5 diodes and covers all the amateur bands from 10 to 160 metres in 9 bands. Switchable selectivity employs a Collins mechanical filter for s.s.b., crystal lattice filter for c.w., bandpass coupling for a.m. and a slot filter being tunable across the i.f. passband. The first oscillator is crystal controlled for maximum stability. An internal 100 kc/s crystal calibrator; amplified a.g.c. with selection of fast, slow or off positions; product detector for s.s.b. reception and separate diode detector for a.m.; adjustable noise limiter; large illuminated 3½in "S" meter; a.f. filter for c.w.; an a.f. output of 2 watts and a precision geared tuning drive having no backlash and a 100–1 ratio are other features of this design. The dial provides an accuracy of frequency read-out, after standardising against the 100 kc/s calibrator, to the nearest kilocycle using the kilocycle counter facilities on the main tuning control. Due to the 1 kc calibration marks being ¾in apart, frequency shifts of 250 c/s are easily read. The RCX-606, with direct digital frequency read-out, has identical specifications to that of the RCX505 but with the addition of electronic vernier tuning; tuneable a.f. filter for c.w.; precision geared tuning drive system with all rotating spindles being fitted with miniature ball-bearings driving a precision high speed digital counter; the calibration of this digital read-out being every 250 cycles with an accuracy of better than 1 kc. Both the RCX505 and the RCX606 have a 6:1 ratio reduction drive on the b.f.o. control, and slot filter and aerial trimmer controls are provided for ease of adjustment.

**British National Radio School**, the only privately run British home study Institute specialising in electronic subjects only, displayed some examples of their courses. Offering home study training for all subjects in TV, radio, etc., especially for the City and Guilds examinations, the Grad.Brit.-I.R.E., the Radio Amateurs licence, P.G.M. Certificates and R.T.E.B. Servicing Certificates, etc., the Institute has over 20 years of experience in this type of tutorship.

It is impossible in a short review of this nature to mention all of the stands—least of all every, or even most, of the equipments on show. There were, as the above review shows, many new items to be seen and the overall trend towards miniaturisation continues apace. The increasing use of semiconductors, either in whole or in part, of many of the circuits is also a sign of the times.

The stands of the respective services, the various societies devoted to specialist radio interests and those not specifically mentioned here, were all of interest and well worth a close inspection. Altogether an interesting exhibition and one that is an annual pilgrimage for all those interested in amateur radio in all its various aspects.

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*continued on page 357*

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*continued from page 355*

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*continued from page 357*

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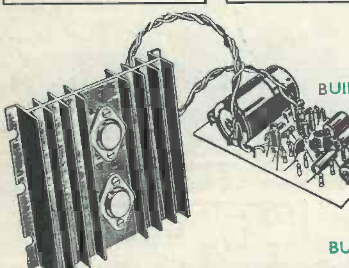

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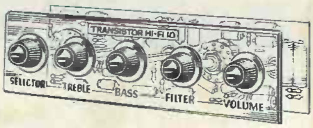


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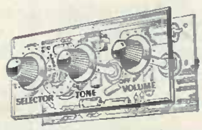


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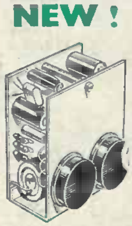

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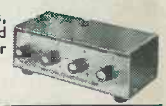

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