# PRACTICAL WIRELESS

MAY 1969

3'0

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PULSE CIRCUITS IN OPERATION

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| | | |
|---|---|---|
| Rod Aerial | RA2W | 12/6 |
| Driver Transformer | LFDT4/1 | 9/6 |
| Output Transformer | OPT1 | 10/6 |
| Printed Circuit | PCA1 | 9/6 |

## I.F. TRANSFORMERS FOR "PRACTICAL WIRELESS" CIRCUITS

Components for several receivers are available, including the following for the "Clubman".

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| T41/3T | B.F.O. Coil | 10/6 |

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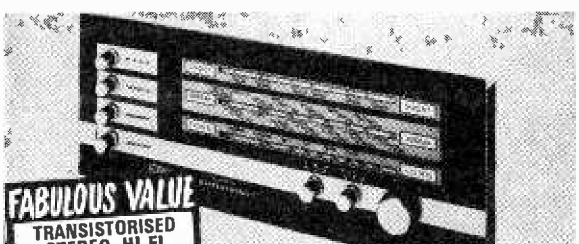

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| LEAK Stereo 30 in teak case ... | £58 10 0 | £48 14 0 |
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| QUAD 33 Preamplifier | £43 0 0 | £36 11 9 |
| QUAD 303 Stereo Main Amplifier ... | £55 0 0 | £46 15 0 |
| ROGERS Cadet Mark III ... | £33 15 0 | £28 14 0 |
| ROGERS Cadet Mark III in teak case ... | £37 10 0 | £31 17 6 |
| ROGERS Ravensbourne 50w. Stereo | £59 10 0 | £50 12 0 |
| ROGERS Ravensbourne in teak case | £64 0 0 | £54 8 0 |
| LINEAR LT.66 Stereo Amplifier ... | £15 15 0 | £13 10 0 |
| PHILIPS GH.925 Stereo Amplifier | £26 0 0 | £21 9 0 |
| F.A.L. 50 watt Guitar and Public Address Amplifier ... | Slashed to | £30 9 0 |
| TRUVOX TSA.100 | £51 9 0 | £42 9 0 |
| DULCI 207 Stereo Amplifier ... | £19 10 0 | £14 10 0 |
| DULCI 207M stereo/ Amplifier takes magnetic P/U ... | £23 10 0 | £17 10 0 |

## TUNERS

| | Rec. Retail Price | Comet Price |
|---|---|---|
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| LEAK FM Troughline | £35 15 4 | £30 10 4 |
| LEAK Troughline Tuner with multiplex ... | £50 11 4 | £42 19 6 |
| GOODMANS Stereomax AM/FM Stereo Tuner ... | £80 19 0 | £70 19 0 |
| QUAD Stereo FM Tuner ... | £50 0 0 | £44 15 0 |
| ROGERS Cadet Mark III Tuner ... | £20 12 6 | £17 13 0 |
| ROGERS Ravensbourne Tuner with Decoder ... | £60 15 3 | £52 2 0 |
| TRUVOX FM Tuner | £35 5 0 | £30 0 0 |
| DULCI FMT.7 FM Tuner ... | £22 1 0 | £19 0 0 |
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| ARENA 2500 complete with Decoder ... | £97 0 0 | £79 0 0 |
| WIEN with Stereo Decoder ... | £43 0 0 | £29 0 0 |
| ARENA 2400 with Decoder ... | £90 6 0 | £75 0 0 |
| TELETON 70 watt Stereo Tuner/ Amplifier with Multiplex Decoder | £75 10 5 | £64 0 0 |
| TELETON MX.990 Stereo Tuner/ Amplifier with with AM/FM Multiplex Stereo Radio c/w two Speakers, each speaker containing 8in. bass, 2in. tweeter ... | £64 13 2 | £54 16 0 |
| TELETON 602X FM. Multiplex Stereo Tuner/Amplifier 70 Watts RMS ... | £92 11 9 | £75 0 0 |
| TELETON 502X AM/ FM Stereo Tuner/ Amplifier 40 Watts RMS ... | £107 8 3 | £64 0 0 |
| TELETON 302X AM/ FM Stereo Tuner/ Amplifier 20 Watts RMS ... | £72 7 0 | £59 19 6 |
| TELETON F.2000 AM/FM Stereo Tuner/Amplifier 2 x 5 watts RMS with silicon transistors ... | £43 0 0 | £37 0 0 |
| TELETON R.8000 AM/FM Stereo Tuner/Amplifier 2 x 6 watts RMS, complete with 2 speaker boxes ... | £60 19 6 | £52 15 0 |
| TELETON CMS.400 AM/FM Multiplex Tuner/Amplifier with 2 speaker boxes and turntable ... | £126 0 0 | £99 0 0 |

## CARTRIDGES

| | Rec. Retail Price | Comet Price |
|---|---|---|
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| SHURE M80E ... | £21 10 0 | £18 7 0 |
| SHURE M5D ... | £17 2 6 | £14 2 0 |
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| SHURE M31E ... | £13 19 2 | £11 14 0 |
| SHURE M32E ... | £12 14 11 | £10 12 0 |
| SHURE M44C ... | £12 14 11 | £10 12 0 |
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| SHURE M75E/95G | £27 6 3 | £23 0 0 |
| SHURE M75/6 ... | £17 2 4 | £14 2 0 |
| SHURE V 15 Mk II... | £40 1 2 | £34 9 0 |
| ORTOFON S15TE cartridge ... | £33 7 6 | £27 19 6 |
| ORTOFON 'M' shell | £1 10 6 | £1 7 6 |
| ORTOFON SL15 cartridge ... | £22 3 0 | £18 19 6 |
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| WHARFEDALE Super Linton ... | £20 13 0 | £17 10 0 |
| WHARFEDALE Melton ... | £29 10 0 | £25 0 0 |
| LEAK Sandwich ... | £43 10 0 | £35 19 6 |
| LEAK Mini-Sandwich | £29 15 0 | £24 10 0 |
| GOODMANS Maxim | £20 0 5 | £16 19 6 |
| GOODMANS Mezzo II ... | £30 18 0 | £25 13 0 |
| GOODMANS Magnum-K ... | £40 2 0 | £32 19 6 |
| DULCI AS3 Speaker | £8 8 0 | £6 19 6 |
| CELESTION Ditton 15 ... | £30 12 4 | £26 5 0 |
| CELESTION Ditton 10 | £20 15 6 | £17 16 0 |
| TELETON SA. 1003 Speaker 5 Watts RMS 8 Ohms. 1 Speaker System 6" x 9" x 5" (Rec. for use with F.2000) | £5 0 0 | £4 8 3 |
| TELETON SB.1002 8 watts RMS 8 Ohms. 2 Speaker System 5½" x 10½" x 7½" | £9 11 0 | £8 0 0 |

## TURNTABLES

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| GARRARD 3500 ... | £11 18 10 | £10 1 10 |
| GARRARD AT.60 Mark II ... | £16 19 8 | £13 19 8 |
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| THORENS TD.150 | £28 16 11 | £25 7 0 |
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| AKAI M-9 4 tr. w/o acc. ... | £195 0 0 | £156 0 0 |
| SHARP RD.707 Stereo Tape Recorder ... | £96 12 0 | £81 0 0 |
| MARCONI 4218 Stereo Tape Recorder ... | £88 0 0 | £77 19 6 |
| MARCONI 4238 4-track Tape Recorder | £58 11 0 | £49 19 6 |
| MARCONI 4216 4-track Tape Recorder | £41 5 0 | £35 19 6 |
| MARCONI 4214 twin-track Tape Recorder ... | £35 16 0 | £31 0 0 |
| AKAI X-360 4 track | £339 0 0 | £284 0 0 |
| AKAI X-360D deck 4 tr. ... | £290 0 0 | £243 0 0 |
| AKAI X-300 2 tr. ... | £263 0 0 | £220 0 0 |
| AKAI X-300 4 tr. ... | £263 0 0 | £220 0 0 |
| AKAI X-V 4 tr. ... | £180 0 0 | £151 0 0 |
| AKAI X-150D deck 4 tr. ... | £130 2 4 | £109 0 0 |
| AKAI 1880SD 4 tr. ... | £199 0 0 | £167 0 0 |
| AKAI 1800 4 tr. ... | £158 0 0 | £133 0 0 |
| FIDELITY HF Playmaster 2 track ... | £26 15 6 | £19 19 6 |
| FIDELITY Braemar 2 track ... | £30 9 0 | £24 17 5 |
| FIDELITY Braemar 4 track ... | £33 12 0 | £27 8 11 |
| SHARP 504 battery/ mains tape recorder, complete with all accessories, guaranteed 5 yrs. | £35 5 3 | £24 19 6 |
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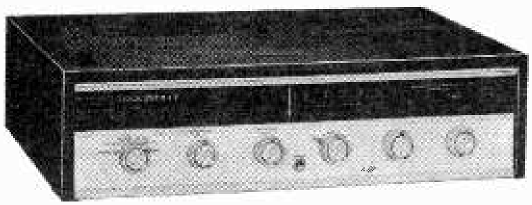

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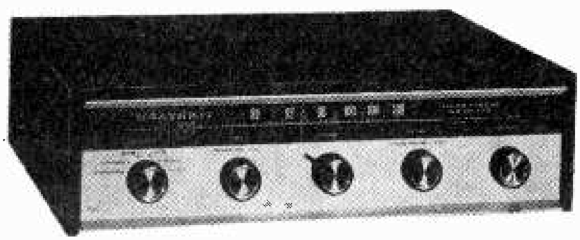

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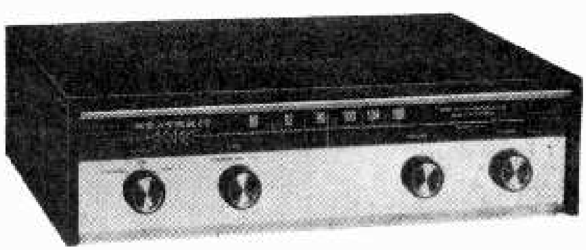

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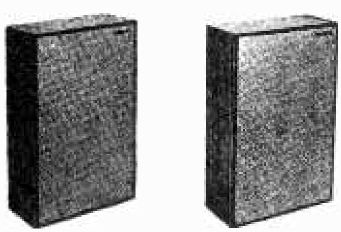

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● 13 transistor, 6 diode circuit for high-fidelity sound reproduction, long life, low heat, freedom from hum, and service-free operation. ● 7 watts music power. ● $\pm$1dB, 25 to 60,000 Hz at 5 watts. ● Input connectors for phonograph and auxiliary signals. ● Complete front panel controls. ● Flywheel tuning. ● Preassembled and prealigned FM tuner, all other critical parts factory aligned. ● Easy, circuit board assembly. ● Compact bookshelf size. ● 3-way installation . . . wall, free standing or in a suitable cabinet. ● 117 v. A.C. or 210/240 v. A.C., 50 Hz operation.

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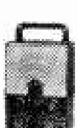

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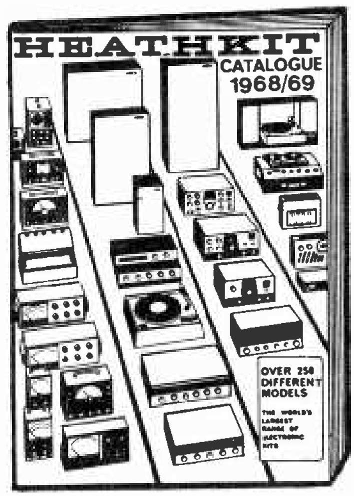


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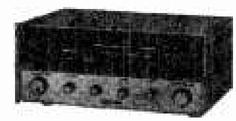

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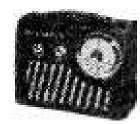

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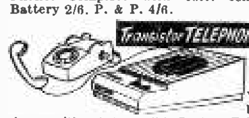

59/6

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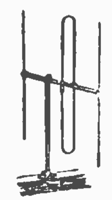

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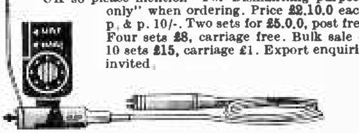

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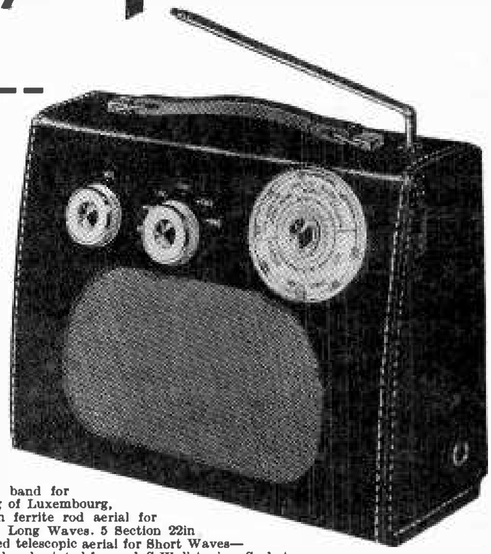

## roamer seven mk IV

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SEVEN TUNABLE WAVEBANDS—
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Extra M.W. band for easier tuning of Luxembourg, etc. Built in ferrite rod aerial for Medium and Long Waves. 5 Section 22in chrome plated telescopic aerial for Short Waves—can be angled and rotated for peak S.W. listening. Socket for Car Aerial. Powerful push pull output. 7 transistors and 2 diodes including Micro-Alloy R.F. Transistors. Famous make 7 x 4in. P.M. speaker for rich-tone volume. Air spaced ganged tuning condenser. Volume on/off control wave change switches and tuning control. Attractive case with carrying handle. Size 9 x 7 x 4in. approx. First grade components. Easy to follow instructions and diagrams make the Roamer 7 a pleasure to build.

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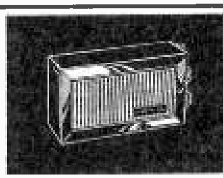
Parts price list and easy build plans 3/- (Free with parts).

## pocket five



MEDIUM WAVE, LONG WAVE AND TRAWLER BAND (to 50 metres approx.) PORTABLE WITH SPEAKER AND EARPIECE

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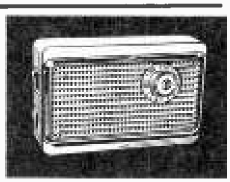

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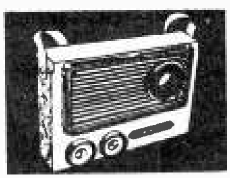

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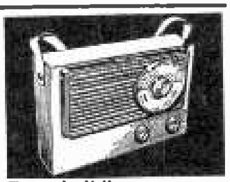
## roamer six



SIX WAVEBAND PORTABLE WITH 3in. SPEAKER

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|---|---|---|---|---|
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| 200 | 1/9 | 4/- | 4/9 | 20/- |
| 300 | 2/3 | 4/6 | 6/6 | 22/- |
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|---|---|---|---|---|
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| 100 | 8/6 | 10/- | 15/- | 45/- |
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Contains 10 ft. coil of 18 s.w.g. Ersin Multicore Savbit Alloy. 2/6 each.

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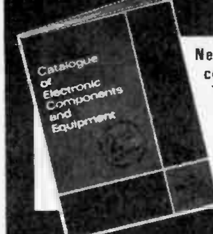


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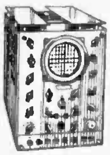

An excellent general purpose D/B oscilloscope. T.B. 2 cps-750 Kc/s. Bandwidth 5·5 Mc/s. Sensitivity 33mV/CM. Operating voltage 0/110/200/250V. A.C. Supplied in excellent working condition. £22.10.0. Or complete with all accessories, probe, leads, lid, etc. £25. Carriage 30/-.

## AVOMETERS

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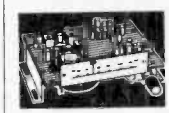
An extremely high quality oscilloscope with time base of 10 μ/sec to 20m/sec. Internal Y amplifier. Separate mains power supply 200/250v. Supplied in excellent condition with cables, probe, etc., as received from Ministry. £8.19.6, carriage 30/-.

## ★ TRANSISTORISED FM TUNER ★



6 TRANSISTOR HIGH QUALITY TUNER, SIZE ONLY 6 × 4 × 2½in. 3 I.F. stages. Double tuned discriminator. Ample output to feed most amplifiers. Operates on 9V battery. Coverage 88–108Mc/s. Ready built ready for use. Fantastic value for money. £6.7.6. P. & P. 2/6. Stereo multiplex adaptors 99/6.

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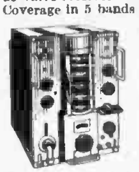
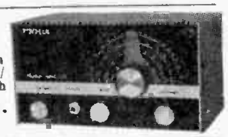
Released by the Ministry. High quality 10 valve receiver manufactured by Murphy. Coverage in 5 bands 650 Kc/s–30 Mc/s. I.F. 500 Kc/s. Incorporates 2 R.F. and 3 I.F. stages, band-pass filter, noise limiter, crystal controlled B.F.O., calibrator. O/F output, etc. Built-in speaker. output for phones. Operation 150/230 volt A.C. Size 19¼ × 13¼ × 16in. Weight 114 lbs. Offered in good working condition. £22.10.0. Carr. 30/-. With circuit diagrams. A few Brand New £35. Carr. 30/-. Also available B.41 L.F. version of above. 15 Kc/s–700 Kc/s. £17.10.0. Carr. 30/-.



## UNR-30 4-BAND COMMUNICATION RECEIVER



Covering 550 Kc/s–30 Mc/s. Incorporates BFO. Built in speaker and phone jack. Metal cabinet. Operation 220/240V. A.C. Supplied brand new, guaranteed with instructions. Carr. 7/6 **13 gns.**

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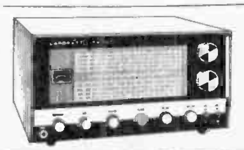
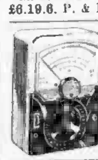
## LAFAYETTE SOLID STATE HA600 RECEIVER



**5 BAND AM/CW/SSB AMATEUR AND SHORT WAVE 150 Kc/s–400 Kc/s and 550 Kc/s–30 Mc/s** F E T front end ● 2 mechanical filters ● Huge dial ● Product detector ● Crystal calibrator ● Variable BFO ● Noise limiter ● S meter ● 24in Bandspread ● 230V. A.C./12V. D.C. neg. earth operation ● RF gain control. Size 15in. × 9¼in. × 8¼in. Weight 18 lbs. EXCEPTIONAL VALUE. 45£. Carr. 10/-. S.A.E. for full details.

## NEW MODEL 500 30,000 O.P.V.



NEW MODEL 500 30,000 O.P.V. with overload protection, mirror scale 0/·5/2·5/10/25/100/250/500/1,000v. D.C. 0/2·5/10/25/100/250/500/1,000v. A.C. 0/50μA/5/50/500mA. 12 amp. D.C. 0/60K/6 Meg./60 MegΩ. £8.17.6. Post paid.

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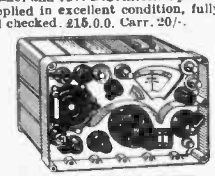
11 valve high grade communication receiver suitable for tropical use. 1·20 Mc/s on 4 bands. AM/CW/FM operation. Incorporates precision vernier driver, BFO. Aerial trimmer, internal speaker and 12v. D.C. internal power supply. Supplied in excellent condition, fully tested and checked. £15.0.0. Carr. 20/-.



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High quality construction. Input 230V. 50–60 cycles.
Output full variable from 0·260 volts. Bulk quantities available.
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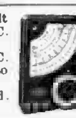
8 amp.—£14.10.0; 10 amp.—£18.10.0; 12 amp.—£21.0.0;
20 amp.—£37.0.0.

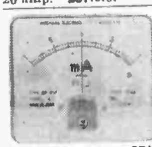
## MODEL TE-10A



MODEL TE-10A. 20kΩ Volt 5/25/50/250/500/2,500v. D.C. 10/50/100/500/1,000v. A.C. 0/50μA/2·5 mA/250 mA D.C. 0/6K/6 meg. ohm. −20 to +22dB. 10·0, 100mFd. 0·100–0·1mFd. 69/6. P. & P. 2/6.

## CLEAR PLASTIC PANEL METERS

First grade quality Moving Coil panel meters available ex-stock. S.A.E. for illustrated leaflet. Discounts for quantity. Type MR 38P. $1^{21}/_{32}$in. square fronts.



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| 500μA | 37/6 | 10mA | 25/- | 500mA | 25/- | 50V. A.C. | 25/- |
| | | 750mA | 25/- | 3V. D.C. | 25/- | 150V. A.C. | 25/- |
| | | 1 amp | 25/- | 10V. D.C. | 25/- | 300V. A.C. | 25/- |
| | | 2 amp | 25/- | 20V. D.C. | 25/- | 500V. A.C. | 25/- |
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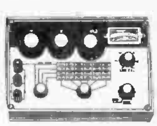
- **H1B AUDIO SIGNAL GENERATOR** 15 c/s–50 Kc/s. sine or square wave. Price £30.
- **J1B AUDIO SIGNAL GENERATOR** 15 c/s–50 Kc/s. Price £30.
- **J2B AUDIO SIGNAL GENERATOR** As per J1B except fitted with output meter. Price £35.
- **TT1S TRANSISTOR TESTER** £37.10.0

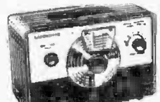
Carriage 10/- per item.

## TRANSISTORISED L.C.R. A.C. MEASURING BRIDGE



A new portable bridge offering excellent range and accuracy at low cost. Ranges: R. 1Ω–11·1 megΩ 6 Ranges ±1%. L.1 μH – 111 HENRYS 6 Ranges –2%. C. 10pF ± 1110mFd. 6 Ranges ±2%. TURNS RATIO 1:1/1000–1:11100. 6 Ranges ±1%. Bridge voltage at 1,000 cps. Operated from 9 volts. 100μA. Meter indication. Attractive 2 tone metal case. Size 7¾ × 5 × 2in. £20. P. & P. 5/-.

## TE-20RF SIGNAL GENERATOR



Accurate wide range signal generator covering 120 Kc/s–260 Mc/s on 6 bands. Directly calibrated Variable R.F. attenuator. Operation 200/240v. A.C. Brand new with instruction. £15.0.0. P. & P. 7/6, S.A.E. for details.

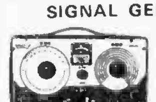
## MODEL ZQM TRANSISTOR CHECKER

It has the fullest capacity for checking on A, B and Ico. Equally adaptable for checking diodes, etc. Spec.: A: 0·7–0·9967. B: 5–200. Ico: 0–50 microamps 0–5mA. Resistance for diode 200Ω–1MΩ. Supplied complete with instructions, battery and lead. £5.19.6. P. & P. 2/6

## CLASS D WAVEMETERS

A crystal controlled heterodyne frequency meter covering 1·7–8 Mc/s. Operation on 6 volts D.C. Ideal for amateur use. Available in good used condition. £5.19.6. Carr. 7/6. Or brand new with accessories. £7.19.6. Carr. 7/6.

## ARF-100 COMBINED AF-RD SIGNAL GENERATOR



A.F. SINE WAVE 20–200,000 c/s. Square wave 20–30,000 c/s. O/P. HIGH IMP. 21V. P/P600Ω 3·8V. P/P. TF 100 Kc/s–300 Mc/s. Variable R.F. attenuation int/ext. modulation. Incorporates dual purpose meter to monitor AF output and % mod. on R.F. 220/240V. A.C. £30.0.0. Carr. 7/6.

## LAFAYETTE LA-224T TRANSISTOR STEREO AMPLIFIER

19 transistors, 8 diodes. IHF music power 30W at 8 ohms. Res. 30–20,000 ±2dB at 1W. Distortion 1% or less. Inputs: 3 MV and 250 MV. Output: 3–16 ohms. Separate L. and R. volume controls. Treble and bass control. Stereo phone jack. Brushed aluminium, gold-anodised extruded front panel with metal case. 10¼ × $3^{9}/_{16}$ × $7^{13}/_{16}$in. 115/230v. A.C. £28. Carr. 7/6.

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★ Moderate size, only 25 x 14 x 10in. Complete Kit **19 Gns.**
★ Response 30-20,000 c.p.s. Impedance 15 ohms. Carr. 12/6
★ Performance comparable with units costing considerably more. Consists of (1) 12in. 15 watt Bass unit with cast chassis, Roll rubber cone surround for ultra low resonance, and ceramic magnet. (2) 3-way quarter section series cross-over system. (3) 8 x 5in. high flux middle range 'speaker. (4) High efficiency tweeter. (5) Measured weight of woollen acoustic damping material. (6) Teak veneered cabinet. (7) Circuit and full instructions.

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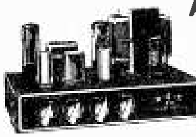
## R.S.C. STEREO/20 HI-FI AMPLIFIER PROVIDING 10/14 WATT

ULTRA LINEAR PEAK PUSH-PULL OUTPUT ON EACH CHANNEL. SUITABLE FOR "MIKE", GRAM, RADIO OR TAPE. (7) valves ECC83, (2) ECL86, (4) EZ81. Frequency Response: ±2dB 30-20,000 c.p.s. Hum Level: 65dB down. Sensitivity: 30 millivolts max. Harmonic Distortion: 0·2% ★Four-position tone compensation and Input Selector Switch. ★Stereo/Mono switch. ★Neon panel indicator. ★Handsome Perspex Frontplate. ★Separate Bass and Treble controls. Output transformers are high quality sectionally wound. Outputs for 3 and 15 ohms speakers. Complete set of parts, point-to-point wiring diagrams and instructions. Or factory assembled with our usual 12 mths' gntee 19gns. Or Dep. £4.10.0 and 9 monthly payments £2 (Total £22.10.0). *Send S.A.E. for leaflet.*

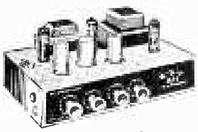
**15 Gns.** Carr. 12/6

## R.S.C. A10 30 WATT ULTRA LINEAR HI-FI AMPLIFIER



Highly sensitive. Push-Pull high output, with Pre-amp./Tone Control Stages. Performance figures of factory built units: Hum level —70dB. Frequency response ±3dB 30-20,000c/s. Sectionally wound output transformer. All high grade components. Valves EF86, EF86, ECC83, 807, 807, GZ34. Separate Bass and Treble Controls. Sensitivity 36 mV so that almost any kind of Microphone or Pick-up is suitable. Designed for Clubs, Schools, Theatres, Dance Halls or Outdoor Functions, etc. For use with Electronic Organ, Guitar, String Bass, etc. Gram, Radio or Tape. Reserve L.T. and H.T. for Radio Tuner. Two inputs with associated volume controls so that two separate inputs such as Gram and "Mike" can be mixed. 200-250v. 50c/s A.C. mains. For 3 and 15 ohm speakers. Complete kit of parts with point-to-point wiring diagrams and instructions. Carr. 12/6 **14 Gns.** Twin-handled perforated cover 27/6. Supplied factory built with EL34 output valves. 12 months' guarantee for 17 gns. TERMS: Deposit £5.14.0 and 9 monthly payments of 31/3 (Total £19.15.3). Send S.A.E. for leaflet.

## R.S.C. A11 HIGH FIDELITY 12-14 WATT AMPLIFIER



PUSH-PULL ULTRA LINEAR OUTPUT "BUILT-IN" TONE CONTROL PRE-AMP. Two input sockets with associated controls allowing mixing of "mike" and gram, etc. etc. High sensitivity. 5 valves—ECC83 (2), EL84 (2), EZ81. High quality sectionally wound output transformer. IND. BASS AND TREBLE CONTROLS. Frequency response ±3dB 30-20,000 c/s. Hum level —60dB. SENSITIVITY 40 millivolts. Suitable for Crystal or Ceramic PUs, all types "mikes". For Musical Instruments such as String Bass, Electronic Guitars etc. Size approx. 12 x 9 x 7in. For AC mains 200-250v. 50 cps Output for 3 and 15 ohm spkrs. SAE for leaflet. Complete kit. **9 Gns.** Full instructions and point-to-point wiring diagrams. Carr 11/6 (or factory built 12 Gns.) Twin handled metal cover 27/6. TERMS ON ASSEMBLED UNITS. Deposit 87/6 and 9 monthly payments of 22/-. (Total £14.5.6).

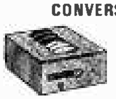
RSC A11T TRANSISTORISED VERSION of above complete kit 9 Gns (Assembled 13 Gns)

## R.S.C. BASS-REGENT 50 WATT AMPLIFIER

An exceptionally powerful high quality all-purpose unit for lead, rhythm, bass guitar, vocalists, gram, radio, tape. Peak O/P rating.
★ Two extra heavy duty 12in. Loudspeakers.
★ Four Jack inputs and two Volume Controls for simultaneous use of up to four pick-ups or "mikes". Bass and Treble controls.

**52 Gns.** Carr. 30/- or dep. £10.1.9 and 9 monthly payments of £5.11.9. (Total 57¼ gns.). Send S.A.E. for leaflet.
Also B20 Bass inc. 15in. 25w Spkr. 29¼ gns. G15 inc. 12in. 20w Spkr. 19¼ gns.

## R.S.C. BATTERY/MAINS CONVERSION UNITS



Type BM1 An all-dry battery eliminator. Size 5¼x4¼x 2in. approx. Completely replaces batteries supplying 1·5v. and 90v. where A.C. mains 200/250v. 50c/s is available. Complete kit with diagram 49/11 or assembled 59/11.

## SELENIUM RECTIFIERS | F.W. (Bridged)

All 6/12v. D.C. output. Max. A.C. input 18v. 1a. 3/11. 2a. 6/11. 3a. 9/9. 4a. 12/9. 6a. 15/9.

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FULLY GUARANTEED. Interleaved and Impregnated. Primaries 200-250v. 50c/s. Screened

**MIDGET CLAMPED TYPE 2¾ × 2¾ × 2¼in.**

| | |
|---|---|
| 250v., 60mA, 6·3v. 2a. | 15/11 |
| 250-0-250v., 60mA 6·3v. 2a. | 16/11 |

**FULLY SHROUDED UPRIGHT MOUNTING**

| | |
|---|---|
| 250-0-250v. 60mA, 6·3v. 2a., 0-5-6·3v. 2a. | 21/9 |
| 250-0-250v. 100mA, 6·3v. 4a., 0-5-6·3v. 3a. | 37/9 |
| 300-0-300v. 100mA, 6·3v. 4a., 0-5-6·3v. 3a. | 37/9 |
| 300-0-300v. 130mA, 6·3v. 4a., c.t., 6·3v. 1a. For Mullard 510 Amplifier | 45/9 |
| 350-0-350v. 100mA, 6·3v. 4a., 0-5-6·3v. 3a. | 37/9 |
| 350-0-350v. 150mA, 6·3v. 4a., 0-5-6·3v. 3a. | 47/9 |
| 425-0-425v. 200mA, 6·3v. 4a., c.t., 5v. 3a. | 69/9 |
| 425-0-425v. 200mA, 6·3v. 4a., 6·3v. 3a., 5v. 3a. | 75/- |
| 450-0-450v. 250mA, 6·3v. 4a., c.t., 5v. 3a. | 87/9 |

**TOP SHROUDED DROP-THROUGH TYPE**

| | |
|---|---|
| 250-0-250v. 70mA, 6·3v. 2a., 0-5-6·3v. 2a. | 21/9 |
| 250-0-250v. 100mA, 6·3v. 3·5a. | 25/9 |
| 250-0-250v. 100mA, 6·3v. 2a, 6·3v. 1a. | 26/9 |
| 350-0-350v. 80mA, 6·3v. 2a., 0-5-6·3v. 2a. | 27/9 |
| 250-0-250v. 100mA, 6·3v. 4a., 0-5-6·3v. 3a. | 37/9 |
| 300-0-300v. 100mA, 6·3v. 4a., 0-5-6·3v. 3a. | 37/9 |
| 300-0-300v. 130mA, 6·3v. 4a., 0-5-6·3v. 1a. Suitable for Mullard 510 Amplifier | 44/9 |
| 350-0-350v. 100mA, 6·3v. 4a., 0-5-6·3v. 3a. | 37/9 |
| 350-0-350v. 150mA, 6·3v. 4a., 0-5-6·3v. 3a. | 45/11 |

**FILAMENT or TRANSISTOR POWER PACK Types** 6·3v. 1·5a. 7/9; 6·3v. 2a. 8/9; 6·3v. 3a. 10/9; 6·3v. 6a. 21/9; 12v. 1a. 8/9; 12v. 3a. or 24v. 1·5a. 21/9; 0-9-18v. 1½a. 17/9; 0-12-25-42v. 2a. 29/9.

**CHARGER TRANSFORMERS** 0-9-15v. 1½a. 14/11; 2½a. 17/9; 3a. 19/11; 5a. 23/9; 6a. 27/9; 8a. 33/9.

**AUTO (Step UP/step DOWN) TRANSFORMERS**
0-110/120v. 200-230-250v. ......50-80 watts 15/9
150 watts, 29/11; 250 watts 49/9; 500 watts 99/9

**OUTPUT TRANSFORMERS**

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| Standard Pentode 5,000Ω or 7,000Ω to 3Ω | 8/9 |
| Push-Pull 8 watts EL84 to 3Ω or 15Ω | 12/9 |
| Push-Pull 10 watts 6V6 ECL86 to 3, 5, 8 or 15Ω | 22/9 |
| Push-Pull EL84 to 3 or 15Ω 10-12 watts | 21/9 |
| Push-Pull Ultra Linear for Mullard 510, etc. | 39/9 |
| Push-Pull 15-18 watts, sectionally wound 6L6, KT66, etc., for 3 or 15Ω | 35/9 |
| Push-Pull 20 watt high quality sectionally wound EL34, 6L6, KT66 etc. to 3 or 15Ω | 59/9 |

**SMOOTHING CHOKES**
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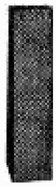
## R.S.C. COLUMN SPEAKERS



Covered in two-tone Rexine/Vynair, ideal for vocalists and Public Address. 15 ohm matching. C57 15 watts inc. five 7 x 4in. speakers £7.19.11.
Type C48S, 30 watts. Fitted four 8in. high flux 8 watt speakers. Overall size approx. 42 x 10 x 5in. Or deposit 65/- and 9 mthly pmts 34/9 (Total £18.17.9) Carr. 10/-. **16 Gns.**
Type C412S, 50 watts. Fitted four 12in. 11,000 line 15 watt speakers. Overall size 56 x 14 x 9in. approx. Carr. 15/-. **24 Gns.**
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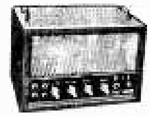

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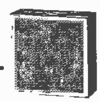

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## FANE 'POP' 100 LOUDSPEAKER

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5 watts high quality output on each channel. Sensitivity 50 millivolts. Suitable all crystal or ceramic stereo cartridges. Ganged Bass and Treble Controls. Valves ECC83 (2), EL84 (2), EZ81. Output rating is peak. For 2-3 ohm speakers. Assembled with 12 months' guarantee Carr. 11/6 **£11.19.6**

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Complete kit of parts incl. Ammeter and Circuit.
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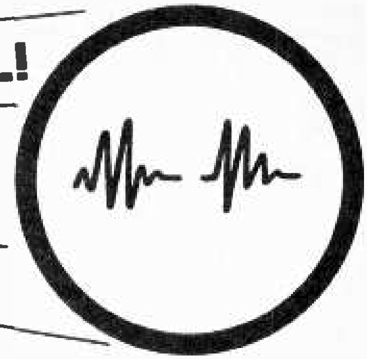

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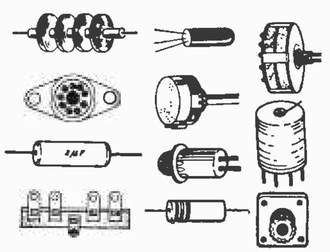

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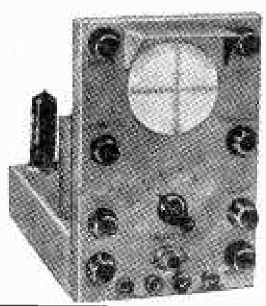

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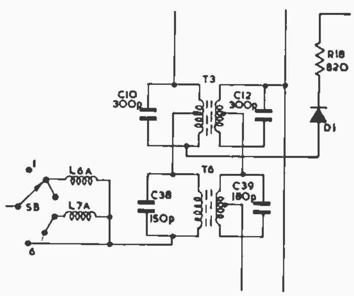


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# PRACTICAL WIRELESS

VOL 45 No 1

*Issue 747*

MAY 1969


## TOPIC OF THE MONTH

### Seven Ages (so far)

ACCORDING to what we hear, there are seven ages of man. If this is true, it doesn't apply to readers of P.W. who—to our knowledge—range from seven to seventy, or thereabouts. But if it is impossible to split readers into seven ages, an attempt could be made with the subject itself.

There are still a few readers who can remember Age 1, the dawn period when you had to *make* most, if not all, of the components before wiring could begin. The next generation of enthusiasts was luckily able to buy most of the bits and pieces and was no doubt considered rather effete by the old guard!

Later on, in Age 3, the purists were even more affronted because complete units, including communications receivers, could be obtained. The rot had set in. For Age 4 let us nominate the immediate post-war years when the flood of surplus equipment swamped the stores and found its way into thousands of radio dens.

The next generation (Age 5) grew up in the kit era. There had been kits before, but now they proliferated and if you could solder a joint you could become a member of the fraternity. The pace accelerates to Age 6 when printed circuits and transistors burst on the scene simplifying construction and bringing in real miniaturisation for the first time. The present generation (Age 7) sees modules and ICs beginning to make an impact.

At each of these stages in the evolution of the radio hobby, it was perfectly understandable for the preceding generation to shake its collective head and remark that "things are not like they used to be" and "Today everything's far too easy". Yet, the hobby continues to flourish!

One strong reason why this should be so is that radio fans are usually very adaptable and fired with curiosity. Thus, even today there is room for experiment and ingenuity, and this cannot be better exemplified than by a new series of articles we have commissioned under the generic heading of *TAKE 20*. Each part will describe a constructional project using 20 or less components and costing 20 or less shillings to build. Turn to page 49 for the first instalment.

W. N. STEVENS—*Editor*.

## NEWS AND COMMENT



## CONSTRUCTIONAL



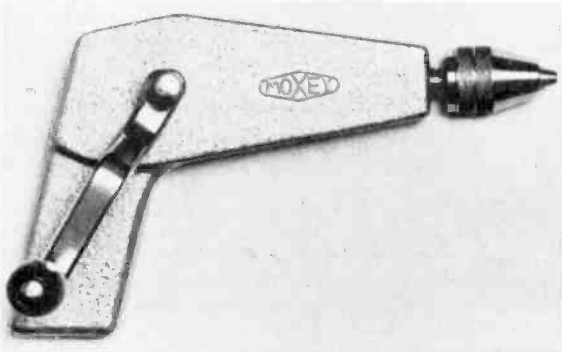
## OTHER FEATURES



**JUNE ISSUE WILL BE PUBLISHED ON MAY 9th**

# NEWS AND COMMENT...

### "MOXEY" PISTOL-GRIP HAND DRILL




*Main feature of the new pistol-grip hand drill made by the Moxey Manufacturing Co., is the enclosed gear mechanism. This eliminates the chance of pinching your fingers on the open cogwheel which is a disadvantage of so many hand drills on sale today. The gears of the Moxey drill are hidden in the aluminium casing and the 3⅜in. driving handle is made to come off for easy storage.*

*The drill is named after Bernard A. Moxey, aged 39, a Herts. toolmaker who set up on his own in 1953. Now, after having made millions of parts for other firms he has embarked upon manufacture of a finished product of his own design.*

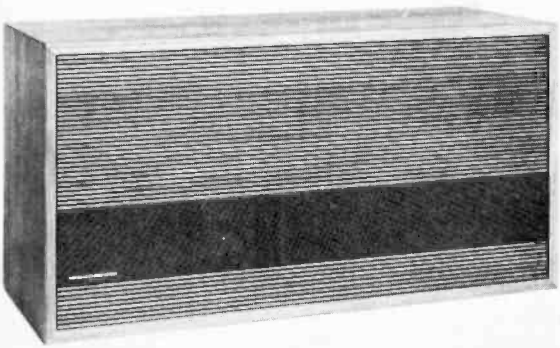
*The drill measures 8¾in. from the chuck tip to the handle extremity and weighs 18oz. The casing may be opened for lubricating the moving parts but the makers claim they are not likely to require lubrication for some years.*

*The Moxey drill is available at ironmongers stores and departmental stores and costs 32s. 6d.*

### THANET MOBILE RALLY

**On 18th May the Thanet Radio Society Mobile Rally will be held at Ramsgate, Kent. An added attraction this year is the SRN-4 hovercraft at nearby Pegwell Bay. Further details, send s.a.e. to Dick Trull, G3RAD, Hon. Treasurer and P.R.O., 1 Approach Road, Broadstairs, Kent.**

### TANDBERG HI-FI SYSTEM 15



*The Hi-Fi System 15 comprises a 12in. woofer, a 5in. midrange and a 2·5in. tweeter. The impedance is 4Ω and the handling capacity is 30W. The speaker is available in teak and a rosewood version will be available shortly. Price (teak) is £40 19s.*

### MULLARD FILMSTRIP ON INTEGRATED CIRCUITS

New from the Mullard Educational Service is a 36-frame, 35mm. colour filmstrip called "Integrated Circuits". It acts as an introduction to the subject for students of semiconductor technology and for those with a wider interest in electronics. Although an elementary knowledge of semiconductors is desirable, it is not essential and the notes provided with the filmstrip can easily be edited to suit varying audience levels.

Also available as a set of slides mounted in 35mm. frames, the film is obtainable from The Slide Centre Ltd., Portman House, 17 Broderick Road, London, S.W.17. The cost is £2 for the filmstrip and £2 10s. for the slides. Good value as a club investment.

### DRY JOINT LOCATOR


Techmation Ltd. announce their dry-joint locator. It is manufactured in the UK by Davian Instruments Ltd. and is basically a linear-scaled ohmmeter of variable sensitivity which is normally preset. By using a high current to measure low resistances, any dry joints show up as the current tends to accentuate the resistance of the joint. On any resistance greater than 4 times f.s.d. (including o/c) an active protection circuit reduces the current from its preset value to about 10–15mA total. In order to protect both meter and circuitry under test, the maximum applied voltage is limited to less than 1V.

A good soldered joint should have a resistance of less than 50mΩ and dry joints normally have a resistance greater than 0·5Ω. Any joint of greater resistance than 0·1Ω is a potential source of trouble and should be re-soldered.

Other possible applications of the unit are: investigation of earth loops and return paths, relay contacts, measurement of contact resistance, determination of wire lengths etc.

The price of the battery-powered version is £17 excluding batteries. The mains version is £19 10s. and post and packing are 7s. 6d. extra. Techmation Ltd., 58 Edgware Way, Edgware, Middlesex.

# NEWS AND COMMENT...

### OFF-THE-SHELF "MINIS"


A new off-the-shelf range of miniature power transformers has recently been introduced by The Belclere Co. Ltd. Outputs range from 3-0-3V to 20-0-20V and each transformer delivers up to 600mW. Standard construction is p/c pin mounting, varnish impregnated, but clamped versions with or without electrostatic screen are also available.

Prices start at less than 10s. each for quantity, and "specials" using the same frame size can also be designed and supplied.

Full details are available from The Belclere Company Ltd., 385/387 Cowley Road, Oxford. Tel.: Oxford 77266.

### KNIGHT-KIT REDUCTIONS

**The Electroniques new list of Knight-Kit prices shows a reduction—in many cases up to or exceeding 20%. Electroniques say that they have been able to do this because of their record 1968 sales figures.**

### RADIO AMATEUR LEADS AFRICA EXPEDITION

*David Dunn, GW3XRM, aged 25 and a senior design draughtsman with Hydraulic Machinery (G.B.), is off on an 8-month trans-Africa safari. He and his team will study the reliability of low-powered short wave radio communications and carry out geological investigations of the Rift Valley area of East Africa.*

*David (pictured) will make daily QSOs en route with a radio operator based at Cardiff University. Both the university and Students' Union have provided grants for the provision of the radio gear which is installed on the ex-Army Commer cross-country truck the team purchased for £100 to take them on their 12,000 mile journey. He has also applied for licences to transmit from each country the team visits.*

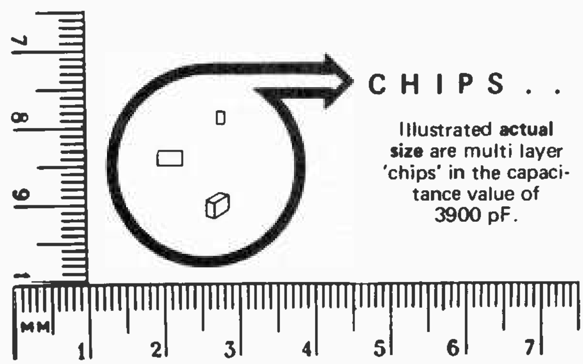
### ANNUAL DINNER FOR SUTTON & CHEAM

**The Sutton & Cheam Radio Society announce their 21st Annual Dinner and Ladies' Festival to be held at The Crown Inn, Morden, Surrey, (just by Morden station at end of Northern Line Underground) on Saturday, 12th April 1969. Reception at 6.30p.m.**

**The President of the RSGB, Mr. J. W. Swinnerton, G2YS, has kindly accepted their invitation to attend as guest of honour, and it is expected that a number of other well-known personalities in the field of Amateur Radio will be present.**

**A really first-class evening, including cabaret, is planned and a heavy demand for tickets is anticipated. Please contact Roy Scott, G2CZH, 140 Seymour Avenue, Morden, Surrey, as soon as possible for bookings, at 35s. per person, and further information.**

### "CHIP" CAPACITORS




*From The Radio Resistor Company Limited comes a new range of multi-layer capacitor "chips" for incorporation into integrated circuits. Available in a wide range of capacitance values to order these new capacitors can be supplied with or without tin-plated electrodes.*

*In addition, the range is also available as complete components with radial terminations and synthetic-coated finish in a capacitance range of from 470pF to 47,000pF.*

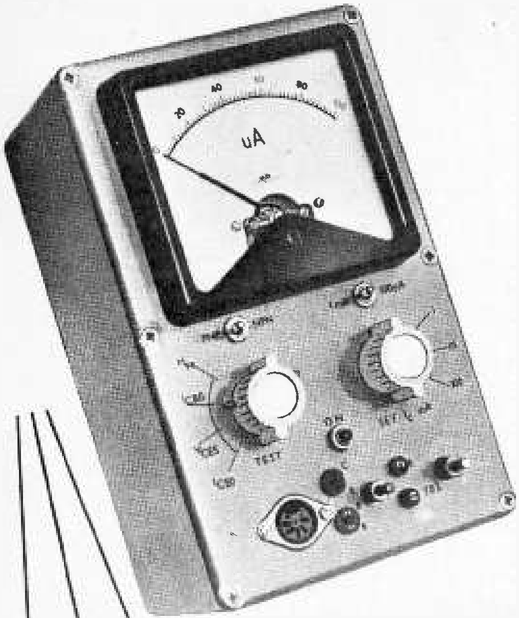
*Tolerance on capacitance on both types is $\pm 20\%$ and $\pm 10\%$; Working voltage is 63V d.c.; Loss factor is equal to or less than $25 \times 10^{-3}$.*

*These multi-layer capacitors are manufactured by Rosenthal Isolatoren G.m.b.H. for whom The Radio Resistor Company Limited, 9-11 Palmerston Road, Wealdstone, Harrow, Middlesex, are the sole UK representatives.*

### MULLARD DATA HANDBOOK 1969

**The *1969 Mullard Data Handbook* gives abridged data on the extensive range of Mullard valves, picture tubes, semiconductors and components used in the consumer electronics industry.**

**Each product has been printed on different coloured pages to facilitate quick reference, and although some of the earier devices are not listed due to lack of space the handbook will prove invaluable to the serviceman or the amateur constructor. The cost of the handbook is 3s. 6d.**



# a comprehensive transistor tester

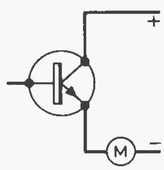
J. A. JEBB

THE specification sheet of a particular transistor may, at first sight, seem a little forbidding, and perhaps give the impression that the evaluation of a transistor is a difficult task. The important parameters are, Ic for a certain Ib, the bottoming voltage, and the serviceability of the junctions. These quantities are related to β (also known as Hfe), Vce (sat) and Iceo.

## Basic Tests

The transistors considered will all be n-p-n types, for the sake of argument, that is, wired with collector to positive.

**Test for Iceo.** This is essentially an insulation test of both the junctions, see Fig. 1. A good silicon transistor will have Iceo $<0{\cdot}1\mu A$. A good germanium transistor has Iceo about 0·1mA, but this varies from device to device, and also depends on the temperature (Iceo doubles for every 10°C. rise, and even on the intensity of light illumination at the time of testing.)

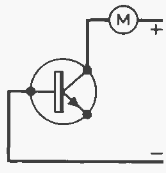



Iceo

*Fig. 1: Test for Iceo.*

**Test for Icbo.** Again an insulation test, but this time over only one junction. Icbo is always $<20\mu A$, even for germanium transistors, see Fig. 2.

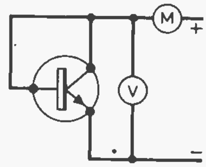
**Test for Vce (sat.).** This is a measure of the turn-on voltage of the transistor. It will be about 0·7V for silicon and 0·2V for germanium. A meter is included in the collector circuit shown in Fig. 3, in order to ascertain that the Ic is not too great. This is an indication of the construction of the device under test, i.e., whether it is silicon or germanium. (The Iceo value is also a guide, but this can be confused if the device is faulty). This test also applies to diodes.




Icbo

*Fig. 2: Test for Icbo.*

**Establishing β.** This parameter enables us to set up a reasonable Ic when the device is in use, and is consequently of great importance. The circuit in Fig. 4 will evaluate β, and can be set up on the bench. The variable resistors are used to set Ic and Ib to a reasonable level. β is given by $\frac{\Delta Ic}{\Delta Ib}$ by definition. If β is linear in Ic, then $\beta = \frac{Ic + Iceo.}{Ib}$ Since Iceo is usually $< 1/10$ Ic, then $\beta \simeq \frac{Ic.}{Ib}$




Vce (sat) .

*Fig. 3: Test for Vce (sat).*

The tests described so far give a fairly good indication of the nature of the device, its gain, and whether it is in working order. In order to perform these tests quickly, a small unit has been constructed, which simplifies testing, and embodies several desirable features. Many commercial, and the majority of home-designed testers employ a technique which, though very simple, has one main draw-back. This technique is described in the circuit shown in Fig. 5.

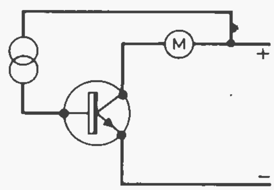



*Fig. 4: Circuit for establishing β.*

The base of the transistor under test is fed from a constant current source, usually a high-value resistor. Depending on β a current is set up in the collector, which is then measured. This is unfortunate, as the value of β at a specified Ic is normally required, not β at a certain Ib, as this test gives.

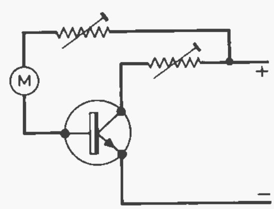



*Fig. 5: A common method of transistor testing which has disadvantages described in the text.*

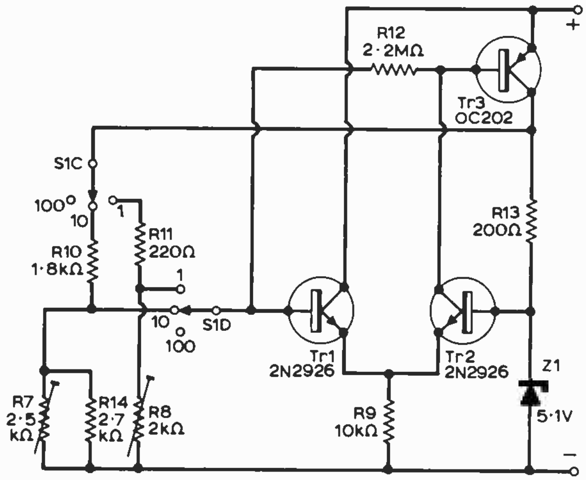



*Fig. 6: The circuit for the 1mA and 10mA constant current source.*

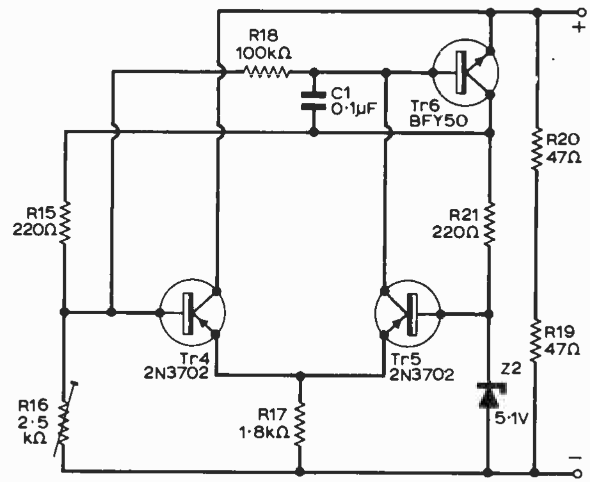



*Fig. 7: The circuit for the 100mA constant current source.*

## The Circuit

The unit described in this article has a constant current source in the collector circuit, and a meter in the base circuit. The constant current source is switchable to 1mA, 10mA, and 100mA, and the meter is shunted from 100$\mu$A to 1mA by independent switch, and 10mA by switch ganged to the 100mA range.

There are two separate constant current sources used in the instrument, one providing 1mA and 10mA, the other 100mA: Fig. 6.

The differential amplifier formed by Tr1 and 2 drives a series transistor Tr3, which is of opposite polarity to Tr1 and 2. In the 1mA and 10mA circuits, the series transistor is an OC203, an obsolete p-n-p junction type. The differential pair are 2N 2926 green (the green refers to the gain grouping), with a gain of approximately 250. The OC203 was chosen because of its low leakage current and its gain, which is substantially constant over 1mA–10mA. A germanium OC81D was tried and worked, but the specimen used was a glass-encapsulated one, and its Iceo was greatly affected by changes in temperature and ambient light conditions, resulting in poor stability. There is a fair amount of switching to be done to change 1mA to 10mA, but stability considerations made this essential.

The 100mA range was designed round a BFY 50, n-p-n transistor, with a maximum dissipation of 800mW. A heat flag was originally fitted but this proved unnecessary. P-N-P transistors are required in the differential pair, and 2N 3702's were used for reasons of availability and price. One disadvantage

### Common transistor symbols and abbreviations

| | | | |
|---|---|---|---|
| $BV_{CBO}$ | Collector-base breakdown voltage | $I_{CBO}$(max) | Maximum collector-base cut-off current with emitter open-circuit |
| $CB$ | Common-base circuit | $I_{CM}$(max) | Maximum peak collector current |
| $Ccb$ | Collector-base capacitance | $I_E$ | Emitter current |
| $CC$ | Common-collector circuit | $I_{EBO}$ | Emitter-base leakage current, collector open-circuit |
| $CE$ | Common-emitter circuit | $I_F$ | Forward current |
| $c_{ob}$ | Maximum common-base output capacitance | $I_R$ | Reverse current |
| $c_{tc}$ | Collector depletion capacitance | $P_C$(max) | Maximum collector dissipation |
| $f_T$ | Transition frequency | $P_{tot}$(max) | Maximum total dissipation |
| $h_{fe}$ | Small signal common-emitter signal current gain with output short-circuited to a.c. | $T_{amb}$ | Ambient temperature |
| $h_{FE}$ | Large signal common-emitter signal current gain with output short-circuited to a.c. | $T_c$ | Case temperature |
| $h_{FEL}$ | Large signal current amplification factor | $T_j$ | Junction temperature |
| $I_B$ | Base current | $T_j$(max) | Maximum junction temperature |
| $I_C$ | Collector current | $V_{BE}$ | Base-emitter voltage |
| $I_{C(AV)max}$ | Maximum mean collector current | $V_{CB}$ | Collector-base voltage |
| $I_{CBO}$ | Common-base collector-base current with emitter open-circuit (leakage current) | $V_{CBM}$(max) | Maximum peak collector-base voltage |
| | | $V_{CB}$(max) | Maximum collector-base voltage |
| | | $V_{CE}$, etc. | Collector-emitter voltage, etc., as for collector-base voltages |
| | | $V_{CE}$(sat) | Collector-emitter voltage for saturated (fully conducting) operation |
| | | $V_F$ | Forward voltage |
| | | $V_R$ | Reverse voltage |

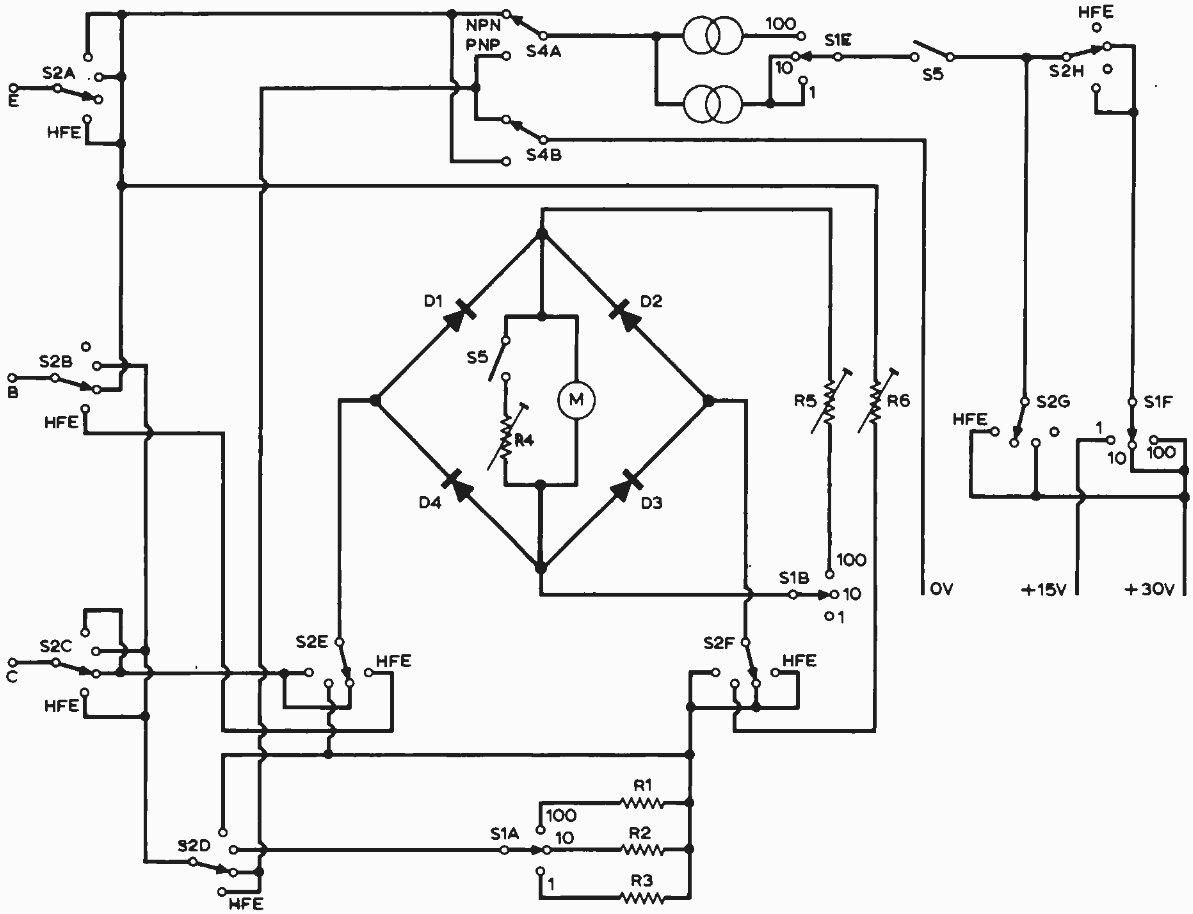



*Fig. 8: The complete circuit of the transistor tester. The constant current sources are shown as two interlocking circles.*

of these is that the gain varies from between approximately 10 ,at 100μA to 60 at 10mA, however, the stability of the circuit is quite adequate.

The switch used to change the constant current circuit (Sw1) is ganged to others which alter the meter shunts. Most transistors which will take 100mA Ic have a gain of between 10–100, so a meter shunted to 10mA gives a useful scale. This only applies to this range, and an independently switched 1mA shunt is employed on other ranges. Transistors with a gain of 10–1000 may be tested at 1mA or 10mA.

After some weeks of usage, it was noticed that the tester often showed a transistor to be excessively leaky, even when it worked satisfactorily in practical circuit. This was traced to the rather high value of battery voltage used. Since the leakage currents are quite small, the constant current supplies will not operate and the full 30V will be placed across the device under test. Accordingly, the circuit was modified so that, when Sw2 was set to Iceo or Icbo, the setting of Sw1 determines the battery voltage applied. Setting Sw1 to 1mA gives a voltage of 15V, setting to 10mA or 100mA gives 30V. For the Vce (sat) and Hfe tests, voltage is always 30V.

The switch Sw1 selects the test required, also the type of metering required (current or voltage).

To obviate the need for extra poles on the polarity switch, a bridge rectifier was placed around the meter. This was most convenient, and introduced no non-linearity on the current ranges, but on the Vce (sat) range, it was found that no useful reading was obtained. This was attributed to the non-linear current/voltage characteristic of the diodes. The solution to the problem lies in the introduction of an off-set voltage of just enough strength to turn on the diodes. This is effected by the insertion of a resistor in series with the transistor under test, having such a value that the meter just begins to register a reading when the appropriate current from the constant current source is passed with collector and emitter terminals shorted.

When a transistor is inserted, Vce (sat) is added to the off-set voltage and can be measured on the meter. Three resistors are required, one for each Ic range, and these are switched by the current switch Sw2. Owing to variations in diode characteristics, the value of resistor cannot be predicted accurately, but for the 1mA it is a good start to try 1KΩ and then 4·7K, 3·9K, 3·3K and 2·7K in turn, in parallel with this, with collector and emitter shorted. The other current ranges decrease the resistor value by 1/10 each time.

This test does not give a very accurate voltage check (within about 10%), but it is good enough to distinguish 0·2V from 0·7V, and hence decide on the structure of an unknown transistor.

The Hfe test connects collector and emitter to the constant current source, and base to the metering system. At 1 and 10mA, current ranges of 100μA and

1mA are satisfactory for Hfe up to 500 and down to about 2. However, at 100mA, the problem is different, owing to the relatively small range of Hfe encountered in transistors that will take this current without damage. Most fall within the range 10–100, i.e., a 1mA or 100μA meter system is not satisfactory.

It was decided that 10mA would be an appropriate sensitivity, and that a pole on the current range switch could be ultilised to bring in the appropriate resistor. This has the advantage that it is now more difficult to grossly overload the meter through using the high-current range. Overloading is possible, of course, on the 10mA range, if the meter is set at 100μA.

**Next Month the article will be concluded with full constructional and comprehensive operating details.**

## ★ components list

**Resistors:**

| | | | |
|---|---|---|---|
| R1 | see text | R12 | 2·2MΩ |
| R2 | see text | R13 | 220Ω |
| R3 | see text | R14 | 2·7kΩ |
| R4 | 150Ω preset pot. | R15 | 220Ω |
| R5 | 15Ω preset pot. | R16 | 2·5kΩ preset pot. |
| R6 | 10kΩ preset pot. | R17 | 1·8kΩ |
| R7 | 2·5kΩ preset pot. | R18 | 100kΩ |
| R8 | 2kΩ preset pot. | R19 | 47Ω |
| R9 | 10kΩ | R20 | 47Ω |
| R10 | 1·8kΩ | R21 | 220Ω |
| R11 | 220Ω | | |

**Semiconductors:**

| | | | |
|---|---|---|---|
| Tr1 and 2 | 2N2926G | Z1 and 2 | BZY88 |
| Tr3 | OC202 | D1, 2, 3 and 4 | OA47 |
| Tr4 and 5 | 2N3702 | | |
| Tr6 | BFY50 | | |

**Miscellaneous:**

C1 0·1μF; Meter, 100μA movement, 1kΩ coil resistance; SW1 Six pole, three way switch; SW2 Seven pole, four way; Batteries to give 30 Volts, 100mA; Veroboard; Eddystone diecast box type 6827P; two miniature toggle switches; transistor sockets as discussed in text.

# RECENT PROPOSALS FOR COMMERCIAL RADIO

**Two days before last month's publication date Paul Bryan M.P., the Opposition spokesman on broadcasting made a speech which was very much in line with our last leader. As the consequences of this may alter broadcasting in this country greatly we are publishing the main proposals made in the speech without comment.**

THE "pirate" radio stations showed that people want commercial radio in addition to the B.B.C. programmes. The Government are determined to stop us having it. A Socialist Government will always prefer the B.B.C. monopoly, over which it has some measure of control. The Post Office conveniently asserts that the technical problems of establishing many more radio stations are very great. No independent experts agree with them.

The next Conservative Government will set up 100 or more local commercial radio stations. These will come under the general supervision of the I.T.A., which is already highly skilled and experienced in the control of broadcasting programmes and of advertising. The Independent Television Authority would become the Independent Broadcasting Authority and would be responsible, in co-operation with Local Authorities, for the selection of programme contractors and for the transmission of programmes.

There would be a limit to the number of stations available to any one contractor. The levy money paid by the station contractors could profitably be put to use locally on all the social and cultural activities which are, at present, starved for funds, such as the repertory theatre, playing fields, swimming baths, etc. Local newspapers should be allowed to take a financial interest, but not a controlling financial interest, in local radio. This would not only compensate for the advertising revenue they may lose, but their news-gathering facilities would be a great help to the radio station.

The Government's local radio experiment has been a completely irresponsible venture. These stations were certain to have some programme success, for they are well run and have no competition and who is to say if a programme is a success when only a quarter of the homes can hear it?

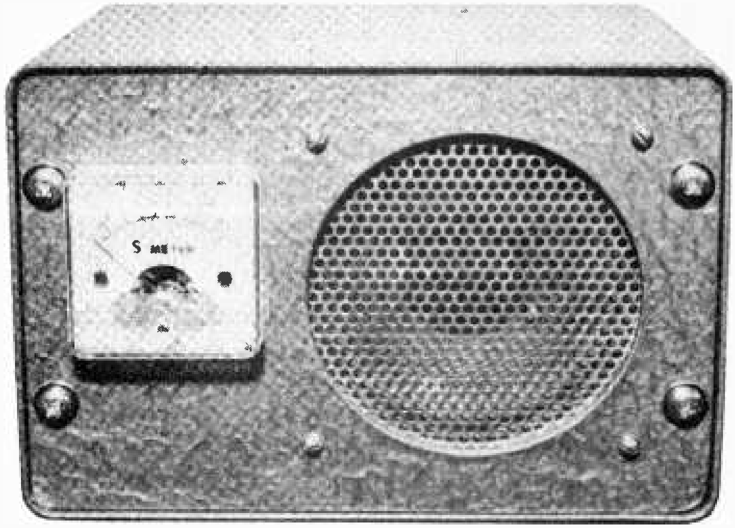
But typically, the Labour Government never faced the problem of who would pay for local radio. The last P.M.G. but two, Mr Short, told us that the money for the stations would be raised "locally but not through the rates", and that it would be wrong for the B.B.C. to pay, except in the experimental stages, and then only the cost of actually setting up the stations. In any event, and precisely as we Conservatives warned the Government, practically no money has been raised locally except through the rates and the B.B.C. has had to pay much more than was intended.

Local Authorities will not go on paying for the stations and it would be wrong if they did. I do not favour a system of finance which smacks of sponsorship. What does a Local Authority do when the station it subsidises is over-critical of its doings?

As Lord Hill has rejected raising funds by advertisement and the Postmaster General has said that the B.B.C. ought not to pay for local radio from its general licence revenue, and sufficient money is not forthcoming locally, the experiment is heading for a totally foreseeable financial collapse. ■

# combined loudspeaker and S-meter

F. G. RAYER




MANY commercial communications receivers have no internal speaker or S-meter, and most users find that they have to provide these themselves. They can easily be combined in a neat and compact unit, and with receivers such as the Eddystone 640, 740, 750 and 888A, the S-meter connection can simply be made via an octal plug in the rear socket provided. With other receivers however, such as the CR100, an internal connection will have to be made.

A ready-calibrated S-meter was fitted in the unit shown, this simply being a 1mA moving coil meter, with an appropriate scale. It is therefore possible to use an ordinary 1mA meter, or a 500μA, 250μA, or 100μA instrument. The latter can provide increased sensitivity, if required, but means that the scale will have to be calibrated by the constructor.

The speaker fitted was a 3½in. moving coil unit, and this allowed everything to fit in a 6×4×4 "Dinkicase". There is, of course, no reason why this size speaker has to be used, and it might be possible merely to fit the S-meter in an existing speaker cabinet.

Figure 1 is the circuit used, but Fig. 2 may be more convenient with some receivers. Both employ a bridge arrangement in which the meter reads zero for minimum signal strength, the reading rising as signal strength increases.

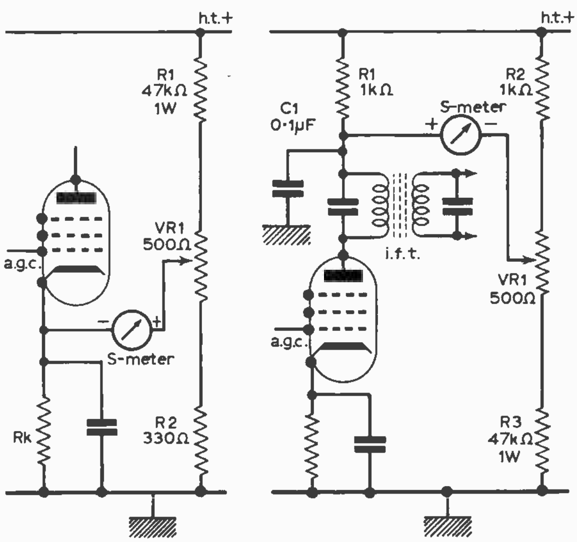



*Fig. 1: (Left), An S-meter operated from the cathode circuit of the last i.f. amplifier*
*Fig. 2: (Right). An S-meter connected to the anode circuit.*

## Cathode Circuit

The meter is connected to the cathode of a valve which receives automatic gain control bias (generally an i.f. stage). R1 and R2 form a potential divider, with VR1 for zero adjustment. With no signal present, VR1 is adjusted so that the voltage drop across the cathode resistor $R_k$ equals that in the lower part of the resistor network, so no voltage is present across the S-meter.

When a signal is present, a.g.c. bias reduces cathode current. Current through $R_k$ falls, resulting in a smaller voltage drop in $R_k$. The meter negative terminal thus moves negative, giving a reading. Movement of the meter pointer depends on the a.g.c. voltage, and thus on the strength of the received signal.

R2 needs to be similar to $R_k$ in value, and can be 330Ω for many valves of the 6K7 and similar type, but should be 68Ω for the 6BA6. R2 can be omitted if VR1 is adjusted carefully, a portion of VR1 then substituting for R2.

## Anode Operated

In Fig. 2, C1 and R1 may be present. If not, these or similar values can be fitted. When anode current falls (with increased signal strength) reduced voltage drop in R1 results in the application of a positive voltage to the meter.

In both circuits VR1 need not be 500Ω. VR1 should be wire-wound, and preferably not over about 2kΩ, or its adjustment becomes critical.

Should values in a receiver be such that VR1 does not allow the meter to read zero, with no signal input, this can be corrected by changing R1 or R2 in Fig. 1, or R2 and R3 in Fig. 2. Actual values are not too important, provided the circuit can be balanced for no voltage across the meter, with no signal.

The sensitivity of either circuit may be reduced by placing a resistor in series with the meter. A pre-set will allow adjustable sensitivity.

## Construction

The few components can be fitted in any suitable case, similar to Fig. 3. The speaker circuit is quite separate to that for the S-meter, and it is wise therefore to colour code the flexible leads for the latter: red for h.t. positive, green for cathode (or C1, Fig. 2) and black for chassis return.

For the Eddystone receivers mentioned, connections can be to an octal plug or the base of an old octal valve. Viewing this plug from the pins, and counting clockwise from the key-way, take red to pin 1, green to pin 2, and black to pin 8. As a series diode is present, set the meter pointer mechanically a little below zero. Short receiver aerial to earth, and adjust VR1 for zero on the meter.

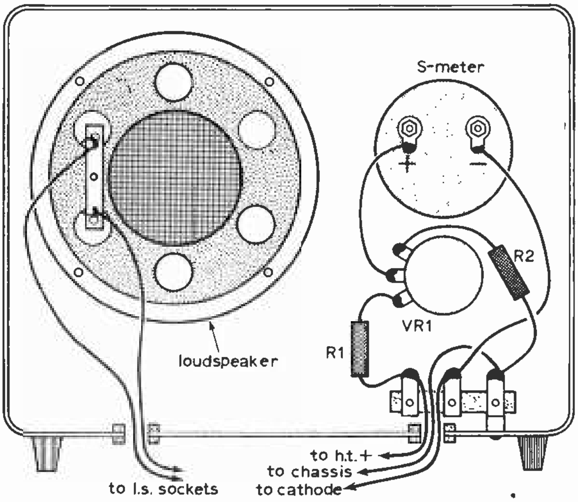



*Fig. 3: The wiring in the box used by the author.*

With other receivers, locate the cathode or h.t. side of an i.f.t. in a stage controlled by a.g.c. bias, and connect as in Fig. 1 or Fig. 2. If the unit needs to be readily detached, any convenient means could be used, such as a valve base, B7G miniature plug or 3-pin plug, and socket to match. ■

## CQ! CQ! CQ! CQ! CQ! CQ!

**APPARATUS REQUIRED**

. . . pressure roller for a Walter 101 tape recorder.—D. Burke, 51 Carna Drive, Glasgow, S.4.

. . . an X79 radio vaive. All the normal sources have been tried with no success.—E. Pennington, 4 Northdown Road, Longfield, Kent.

**CORRESPONDENTS WANTED**

. . . anyone using an Eddystone S640 with an interest in s.s.b.—H. Bolwell, Ivanhoe, Lodge Lane, Wraxall, Nr. Bristol.

. . . someone of about my own age (15½) who simply adores physics.—M. Mcnally, 17 Crosslees Park, Thornliebank, Glasgow, Scotland.

. . . any female (16–18) who is interested in any form of radio, electronics, organic chemistry or any other science.—W. Gunn, 9 Brannen Terrace, Dornoch, Sutherlandshire, Scotland.

. . . anyone of my own age (15) who shares my interests in semiconductor circuitry and amateur radio in general.—D. Hogon, 4 Priors Croft, Walthamstow, London, E.17.

**TAPESPONDENTS WANTED**

. . . any English-speaking female of my own age (15). My tape recorder is a Philips four-track with speeds of 1⅞ and 3¾ i.p.s. Maximum reel size is 7in. My interests are radio, tape recording, electronics, and pop records.—S. Isherwood, 3 York, Nr. Langho, Blackburn, Lancashire.

. . . any female about my own age (15). I have a HMV recorder with four tracks, and a speed of 3¾ i.p.s. Spool size is up to 5¾in. I am interested in electronics, music and photography.—M. McClushey, 23 Woodley Grove, Ormesby, Teesside.

# THE MW COLUMN

WHEN the writer expressed the hope earlier in the season that a fall in sunspot activity might lead to improved conditions on the medium waves he was hardly prepared for what followed. December and January brought the finest North American DX for several years. Joe Stephenson of Hull reports: "On New Year's Eve CBA (1070) was interfering with Paris at 2100hrs GMT—at midnight on the 3rd January WOWO (1190) in Fort Wayne, Indiana was a fantastic S8-S9." Other items from Joe's log include CFCY (630) Charlottetown, Prince Edward Island; WJR (760) Detroit; WHAS (840) Louisville, Kentucky; WABI (910) Bangor, Maine; WCFL (1000) Chicago; WTIC (1080) Hartford, Connecticut; KMOX (1120) St. Louis; WWVA (1170) Wheeling, West Virginia; WGAR (1220) Cleveland; CKCW (1220) Moncton, New Brunswick; ZBM1 (1235) Hamilton, Bermuda; CKBL (1250) Matane, Quebec; CKOY (1310) Ottawa; WEGP (1390) Presque Isle, Maine; WENE (1430) Endicott, N.Y.; WPTR (1540) Albany, N.Y.; WQXR (1560) New York City. Joe uses a Hammarlund SP600, a TV aerial and an aerial tuning unit.

The writer's best catch came from the Caribbean when he heard St. Vincent (705) in the Windward Islands close down at 0218hrs GMT on December 19th. This station is only 500 watts and it verified with a quite specific but rather unattractive QSL card. Although the good conditions of mid-winter ended with a fadeout in February the indications are that we are 'over the hump' and we can look forward to some good DX as sunspot activity continues to decrease.

Traditionally, medium wave DXing is a winter occupation to be abandoned as the days lengthen, though in actual fact the hobby can be pursued throughout the year. North American stations are often audible in midsummer for about an hour before sunrise. Static from local thunderstorms can be troublesome but QRM from Eastern Europe is much less severe than in winter since this area is in daylight. DX from East and South Africa is often possible in May and June. South Africa has been heard on 782 and 1286 between 0200 and 0300hrs.; Mozambique on 917; Dar es Salaam, Tanzania on 638.

It is from South America though that the bulk of summertime DX is obtained. This continent is, of course, having its winter during this period. From June to September for about 2 hours before sunrise is the time to look for YVKS (750) *Radio Caracas,* Venezuela; HJKC (850) Bogota, Colombia; CX16 (850) *R. Carve,* Montevideo; PRA3 (860) Rio de Janeiro; CX20 (930) *R. Montecarlo,* Montevideo; PRF4 (940) *R. Journal,* Rio; LR3 (950) *R. Belgrano,* Buenos Aires; OAX4U (1010) *R. America* Lima, Peru; LS10 (1030) *R. Libertad,* Buenos Aires. When conditions are favourable some remarkably strong signals can be heard.

**CHARLES MOLLOY**

# ON THE SHORT WAVES

## MONTHLY NEWS FOR DX LISTENERS

Times GMT
Frequencies in kc/s

## THE BROADCAST BANDS by CHRISTOPHER DANPURE

HERE we are in the month of April, with the good DX conditions which come with spring. But the only problem I find is that directly the h.f. bands of 25, 21 and 17Mc/s stay open later at night, we get swamped by *R. Free Europe* in Lisbon with 250RW blotting out all we have gained with better conditions. Still that's the way the conditions play, it all comes back to the need for frequency control by an international committee to halt the chaos before it goes too far.

Next on the list comes the month's propagation conditions as prepared by Cable and Wireless of London.

**South Africa:** 0800-1400 25, 21 and 17Mc/s; 1400-1700 25, 21, 17 and 15Mc/s; 1700-1800 25, 21, 17, 15 and 11Mc/s; 1800-2000 21, 17, 15, 11 and 9Mc/s; 2000-2200 17, 15, 11, 9, 7, 6 and 5Mc/s; 2200-0200 15, 11, 9, 7, 6 and 5Mc/s; 0200-0400 9, 7, 6, 5 and 4Mc/s; 0400-0600 11, 9 and 7Mc/s; 0600-0800 21, 17 and 15Mc/s.

**South Asia:** 0800-1200 21, 17 and 15Mc/s; 1200-1400 21, 17, 15 and 11Mc/s; 1400-1600 21, 17, 15, 11 and 9Mc/s; 1600-1800 15, 11, 9, 7 and 6Mc/s; 1800-2000 15, 11, 9, 7, 6 and 5Mc/s; 2000-2200 11, 9, 7, 6, 5 and 4Mc/s; 2200-2400 11, 9, 7, 6, 5, 4 and 3Mc/s; 2400-0200 9, 7, 6 and 5Mc/s; 0200-0400 11 and 9Mc/s; 0400-0600 15 and 11Mc/s; 0600-0800 17 and 15Mc/s.

**South East Asia:** 0800-1200 21 and 17Mc/s; 1200-1400 21, 17 and 15Mc/s; 1400-1600 21, 17, 15, 11 and 9Mc/s; 1600-1800 17, 15, 11, 9 and 7Mc/s; 1800-2000 15, 11, 9, 7, 6 and 5Mc/s; 2000-2200 11, 9, 7, 6 and 5Mc/s; 2200-2400 11, 9 and 7Mc/s; 2400-0200 9Mc/s only; 0200-0400 11Mc/s only; 0400-0600 15Mc/s only; 0600-0800 17Mc/s only.

**North East Asia:** 0800-1400 17 and 15Mc/s; 1400-1800 11Mc/s only; 1800-2000 11 and 9Mc/s; 2000-2200 11 and 9Mc/s; 2200-0200 circuit closed; 0200-0400 11Mc/s only; 0400-0600 circuit closed; 0600-0800 15Mc/s only.

**E. Australia via Asia:** 0800-1000 21Mc/s only; 1000-1200 17Mc/s only; 1200-1400 15Mc/s only; 1400-1600 15 and 11Mc/s; 1600-1800 11 and 9Mc/s; 1800-2000 11, 9 and 7Mc/s; 2000-2200 11 and 9Mc/s; 2200-2400 11Mc/s only; 2400-0800 circuit closed.

**West Coast of South America (North of Chile):** 1200-1600 21 and 17Mc/s; 1600-2000 21, 17 and 15Mc/s; 2000-2200 17, 15 and 11Mc/s; 2200-2400 15, 11, 9 and 6Mc/s; 2400-0600 11, 9, 6, 5, 4 and 3Mc/s; 0600-0800 15, 11, 9 and 6Mc/s; 0800-1000 11 and 9Mc/s; 1000-1200 15 and 11Mc/s.

Now what information have we next for the DX-tips? Firstly, *Radio Nederland* has a very useful DX Information Catalogue listing all the free publications which interest DX-ers that *R. Nederland* publish. The address is R. Nederland, English Section, P.O. Box 222, Hilversum, Holland. *R. Nederland* have also issued a special Red, White and Blue QSL card for the full operation and opening on their relay base at "Bonaire Noord". Reports on the new transmissions from Bonaire in May will be QSL'd by the new card first, before the Lopik reports receive the new card, if any are left. So now down to those DX-tips.

### AFRICA

**Ethiopia:** *Radio Voice of the Gospel*, station ETLF, is now on the following schedule: 0300-0425 11,730; 0330-0425 9,680; 0430-0555 15,400; 0445-0525 15,180; 0530-0555 11,890; 1230-1300 17,760 or 17,815; 1300-1510 15,315; 1330-1625 15,400; 1515-1555 15,315; 1600-1710 6,065; 1630-1655 11,770 or 11,735; 1700-1755 9,695; 1715-2015 11,910; 1800-1900 9,705; 1900-1945 15,410.

**South Africa:** There have been last minute alterations to *Radio R.S.A.* transmissions, the last published details are correct except for these transmissions: 0956-1050 now 21,535, 17,825 and 15,220, and 1156-1250 now 17,825, 15,220 and 11,900.

### PACIFIC AREA

**Australia:** *R. Australia*'s booster station at Darwin is now on the following test transmissions with reduced power of 100kW on beam 300° directed to Central S.E. Asia. 0030-1000 Sundays only on 15,355 in English, Mon.-Sat. from 0830-1000 only in English on 15,355, daily from 1000-1130 in Indonesian on 6,050 and 1130-1330 in Mandarin and Vietnamese on 9,650. The other alterations to Shepperton and Lyndhurst transmissions, is now the 1000-1212 service on 9,580 to N.E. Asia stops at 1100 and the East Coast N. American service from 1212-1315 now starts at 1112-1215 on 11,710 and 9,580. And the Mid-Pacific service from 0830-1212 now runs on 7,205 instead of 7,190.

### EUROPE

**Fed. Rep. Germany:** The *Deutche Welle* at Cologne has had a complete shuffle of all its transmissions from the Jüilich transmitters. In brief, the German transmissions are now only 2 hours 10 minutes' duration instead of 2 hours 55 minutes. There is now a daily Japanese service and the Chinese and English broadcasts have been extended. The English transmissions are now: 0120-0200 on 11,965 and 9,545; 0130-0250 on 9,735, 6,185 and 6,130; 0345-0405 on 9,545 and 7,290; 0435-0555 on 11,945, 9,545 and 6,145; 0600-0630 on 17,845, 15,275 and 11,785; 0920-1020 on 21,560, 17,845, 17,740 and 11,795; 1045-1055 on 15,315, 11,905 and 9,605; 1700-1735 on 17,875 and 15,275; 1900-1910 on 17,790, 15,405 and 11,795 and then 2100-2200 on 15,275, 9,765 and 7,290. The new Japanese service is transmitted from 1120-1220 on 21,580, 17,705 and 15,275.

Well that's all the space we have, so remember those DX-tips to be in by 18th April, good DX-ing and 73s.

MIXED conditions seem to be the verdict for this past month on the amateur bands, but on the whole very satisfying for those who persisted. Twenty metres has become almost a 24-hour band although there were times when one seemed ear-deep in EU stations all calling CQ DX.

Fifteen has really come into its own and provided some juicy prefixes. It hasn't stayed open as long as 20 and at the time of writing it opens around 0700 and fades at 2100. Its stable-mate, 10 metres, has been a bit of a disappointment. The first part of the month saw 10 as a very slow starter but it did make the effort later. It opened about the same time as 15 but seemed to close an hour or so earlier.

A very excellent month for the l.f. sections, and there was quite a lot of activity on 40, 80 and 160. A number of W stations have been prominent on 160, while on 80 and 40 some sleuths have detected some very nice DX.

A good tip for all bands is to listen during that twilight time when the band is just starting to close. Very often one can catch some very good DX about this time although it is admittedly usually weak, and certainly c.w. offers the best bet for hooking something really good.

Reports tell tales that the infamous Citizens' Band is peaking very well. Tune from 27 to 28Mc/s for interesting dialogue and quite startling revelations. Rumours that ZL stations are peaking on 80 at 0730 but my receiver just won't confirm this.

A number of letters query how to send in reports. Just for the record here's the basic requirements: date, time (GMT), frequency, call-sign, mode (c.w./s.s.b./a.m.), gear in use, aerial and last but most important—call-signs in alphabetical order please; it makes it so much easier.

## LF LINGERINGS

A 5RV aerial entwined around the rhubarb and the loan of an AR88LF add up to a log from **David Pick** (Leicester). He confesses to passing R.A.E. (welcome to the club OM) and to great concentrations on c.w., meanwhile his s.s.b. log for 160 reads —EI4AN, GC3UJE, GD6IA, GI6TK, GM3YCB, GW3UCB, HB9CM, HB9T.

**P. Tomes** (Dorset) has a B40 and a quarter-wave aerial for 160. His efforts to read c.w. resulted in sigs from—DL9KRA, HB9CM, K1LMO, K2GNC, K4WUY, KV4FZ, OK1AES, OK1ATP, OK1FAB, OK2BOB, OK3BU, OL6AKP, W2CRS, W2EQS, W2FJ, W3DPJ, W3EOP, W3FE, W3IN, W3TV, W8AH, WA3EPT, WA8EMJ.

"Why are 80 metre logs so sparse in your columns?" **W. Wright** (Staffs) writes this query and promptly furnishes a log to prove what's about. He claims that there's plenty of DX on the band and he's logged—CO2DC, CT2AP, CT2AS, EL8J, F9UC/FC, HI7VDC, HK3AIS, HP1JC, K1CEC, K2DPA, K3NPV, K3UZE, K8HZU, KP4CL, KZ5WH, KZ5JQ, LA2PH/MM, OD5BA, OHØNC, PJ7JC, SL7AY/MM, UH8AE, UI8LM, VE1ARY, VE2AFM, VE3BSU, VO1FX, VP7NH, VP9BK, W1BL, W1BGD/2, W2LV, W3MSK, W4IHK, WA8LEO, XE1ZB, XE3EB, YV5ANF, ZD8Z, ZL4AK, 4X4UF, 6Y5CC, 6Y5DW, 9E3USA, 9H1BL. The receiver is an RG-1 and the aerial a 180ft. end fed.

**N. Thornley** (Northampton) plans to be 14 years old in one year's time. He is passing the time with an R107 plus 80ft. end fed. Rewards for his labours on 80 metres include—CM2DC, CT1LN, F9UC/FC, HV3SJ, K3UZE, KZ5RP, KZ5WH, VE1AMJ, VE3DJE, VE8RCS (Ellesmere Island), VO1FX, W5IOU, XE1KB, XE3EB, ZL2BCG, 4X4GV. Cor, wish I was 13 and had an R107.

Mock GCEs and Christmas are said to have seduced **D. Henbry** from proper care and listening on his HA500. Still, the 7ft. rod aerial at 30ft. is still standing faithfully to attention and during a weak moment David confesses to hearing—CR6GA, K6AHE, KR6JD, PY1CAD, OD5EJ, PY2PA, PY7VKZ, W6KG, W6QV, ZD8Z, ZL1ATS, ZL3LE, 4X4VL, 6W8DY, 9J2VX.

## HF HAPPENINGS

After reading David Henbry's log for 40 I thought I stood a good chance with my 20 metre bests. However, I can't even boast of these coz **S. Mummery** presented me with this basket of goodies all on 20 s.s.b.—CR6LF, EP3AM, HI8LA, JA5HB, OY7S, PJ2PJ, PZ1BG, VK3AKP, VK6MN, VK9BJ, XE3AT, XE1EA, YV5ANF, ZF1GC, ZL1KN, ZL3JO, ZP5KN, ZS1YF, ZS5KAL, ZS6BJ, 5A5TS, 5R8AS, 6Y5GB, 8P6CV. I'd just sipped my gripe water when I saw his log for 15—JA1KXY, OD5AT, OHØNI, PY2CYT, SVØWN, TF5TP, VK2EK, VK2XT, VK5BB, WA5EQN/MM (China Seas), YV1EL, YV5CMQ, ZC4HS, ZL2KD, 4X4RW. The mode was s.s.b. and the receiver a **B34**.

**L. Bousher** (near Swansea), has been reported as "at it" on 20 s.s.b. Thirty feet of wire and an R1155 is all that stood between him and—CN8GE, CN8MJ, CR6IV, EA6BI, EL8J, ET3REL, JA2BTV, MP4TCF, OA8RT, OX5BA, OY7Z, PY7ASQ, PZ1BG, SU1IM, TF2WLM, VE1KG, VE3BZK, VE7IL, VE8RCS, VK2AVA, VK6XW, VP8KD, VS6DR, YA5RG, ZB2AY, ZC4TK, ZD9BE, ZE1BP, ZL1AXB, ZL4BX, ZS3HF, ZS6OY, 3A2CO, 5A4TF, 5H3KJ, 6W8DY, 9G1GD, 9H1M, 9K2CF, 9L1HT, 9X5AA.

**D. Honeywood** (Surrey) CR300/1, dipole, 20—JA1JBB, TF2WLM, VK2AVA, VK2XQ, VK3MO, VK4HR, ZL1AHT, ZL5VK, 3A2CL, 5N2ABG.

**J. Moore** (Leicester) CR100/2, 60ft. end fed, claims that the following are only radiating one sideband on 15—CO8RA, CP5DM, CR8AH, EA6AR, HC2HM, HI3AGS, HR1KS, K6SHA, MP4MBB, TF2WLM, VE6AAV, VK2FA, VK3VK, VK5GF, XE1LLS, YA1HD, ZD3D, 9Y4EH.

## HERE AND THERE

Quite a few happenings in April. On the 6th is the ARMS mobile meeting at Lydd Airport in Kent; 12th-13th, 4 metre contest; 20th, North Midlands mobile rally at Drayton Manor Park in Staffs; 26th, VHF/UHF convention at the Winning Post Hotel, Whitton, near Twickenham; 27th, The Belle Vue Convention at Manchester. May 3rd-4th, 2 metre portable contest. That's all for now, and bcnu all again next month.

# BASIC SEMICONDUCTOR TECHNOLOGY

PART ONE

by M. F. DOCKER, M.Sc.

EVERY material is composed of submicroscopic particles called atoms. Some materials contain only a single type of atom, these substances being called elements. Other materials, called compounds, contain several types of atom combined to form molecules. No matter how much a compound is chemically refined it will still contain the same ratio of atoms of the different elements of which it is composed. The molecule thus contains a certain fixed number of each type of atom; for example a water molecule contains two hydrogen atoms and one oxygen atom.

The atom has been shown to contain various elementary particles—electrons, protons, neutrons and others which will not be of concern to us in these articles. The electron has a very small mass, $9 \times 10^{-28}$ gram, and a negative charge of $1{\cdot}6 \times 10^{-12}$ e.s.u.; the proton has a mass 1,840 times that of the electron and a charge equal to that of the electron but of opposite sign. The neutron has a mass equal to that of the proton but carries no charge.

Figure 1 shows a model of an atom of helium which has two electrons encircling a nucleus composed of two protons and two neutrons. The nucleus

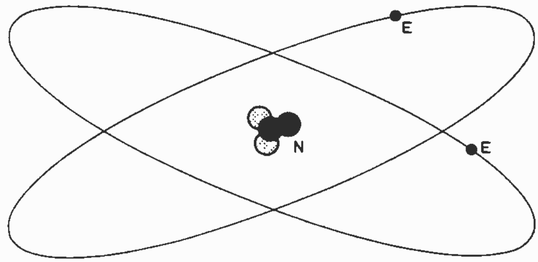



*Fig. 1: Representation of a helium atom, showing the electrons E in orbit around the nucleus.*

thus has a charge of plus two which is precisely balanced by the negative charge on the electrons, leaving the whole atom electrically neutral. The mass of one helium atom is equal to four times that of the proton, neglecting the masses of the electrons.

Many atoms can be shown to have masses which differ although they are chemically the same. These are isotopes of one element, having the same atomic structure as each other except that the number of neutrons is different. Thus hydrogen has three isotopes; hydrogen, deuterium and tritium; having one neutron, two and three neutrons respectively. As the chemical properties of the atom are determined mainly by the electrons, and as *their* number remains unchanged from isotope to isotope, the properties of isotopes of the same element are virtually the same as each other.

The electrons of an atom move in orbits around the nucleus. They are not clearly defined paths, such as planetary orbits, but more regions in which the electrons may be expected to be found. Another finding of modern atomic theory is that the electrons are arranged into certain groups called shells. Those atoms that have just sufficient electrons to completely fill a shell are particularly stable. Examples of these are helium, neon and argon. These substances do not form compounds easily.

## *Electrovalent Bonding*

In atoms not containing the "magic" numbers of electrons it is the electrons which are not in a full shell that account for most of the properties of the atom. Thus sodium with one excess electron combines with chlorine which has seven excess electrons to form sodium chloride. In this case the sodium donates its excess electron to the chlorine atom, leaving itself positively charged; the chlorine atom accepts one electron to make up a complete group of eight electrons, the chlorine atom then having a net charge of minus one. Since one electron has changed hands the sodium and chlorine are both said to have valencies of unity. Other atoms have valencies of 2, 3, 4 and 5.

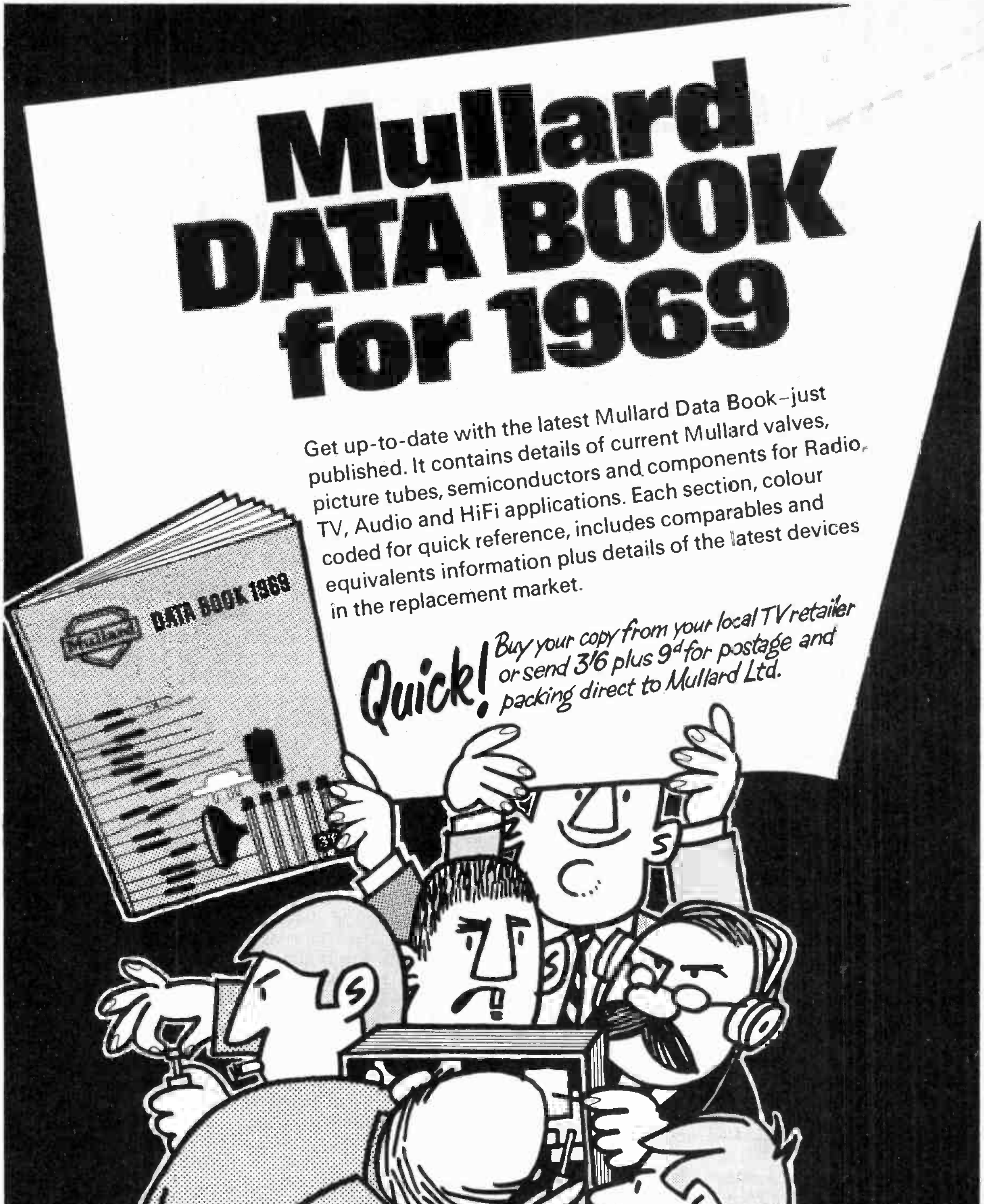
This type of atomic bonding is called electrovalent bonding. Other types of bonding are possible, the most important being covalent bonding where two or more atoms share electrons in order to make up the full shells which give a stable atomic structure. This occurs in hydrogen which has one electron per atom: two atoms combine to form a single hydrogen molecule, the electrons being shared between the two atoms to give a stable structure with the first shell, which contains two electrons, being filled.

## *Crystal Structure*

Most inorganic substances have a crystalline structure. The atoms of which the crystal is composed are bound together by covalent forces. For example carbon which has a valency of four forms a well known crystal, the diamond structure, in which each atom is surrounded by four other atoms. Each carbon atom has four electrons in its outer shell and shares one from each of its neighbours to make up the stable structure with eight electrons in the outer shell. Figure 2 shows the arrangement of the atoms in the diamond structure. Many other elements such as germanium and silicon have similar structures.

The outer shell of electrons is called the valence shell for reasons which should by now be obvious.

—*continued on page 31*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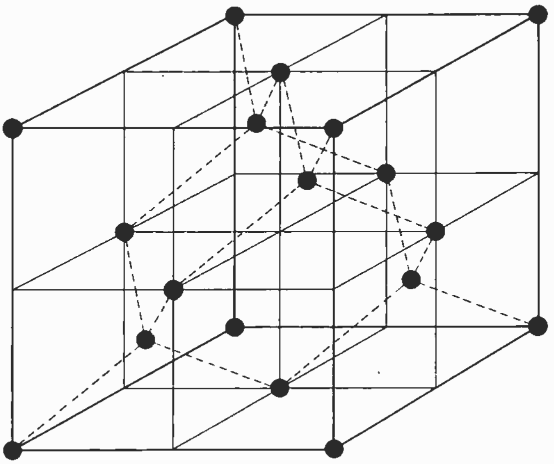

*Fig. 2: Crystal structure of diamond. Each atom has four near neighbours as can be seen for those inside the crystal lattice structure.*

Electrons in this shell are attached to the atom by electrostatic forces. If one of the electrons receives sufficient energy it may be able to reach the next highest band, the conduction energy band. The use of the term energy band calls for some explanation.

## Energy Bands

When two systems having the same energy states, such as two pendula, are brought together they interfere with each other and the energy level is split into two. Thus in a crystal the energy levels which are discrete in the atom are split into millions of levels all close together. These constitute the energy bands of which more will be heard and which are illustrated in Fig. 3.

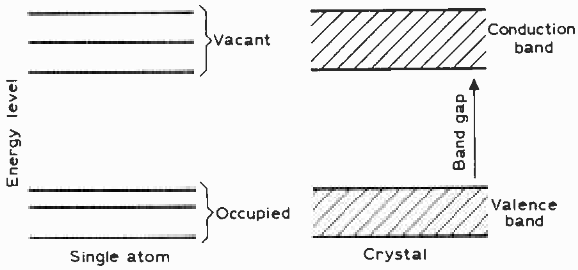


*Fig. 3: Energy levels in a semiconductor atom and in semiconductor crystal.*

These bands are separated in semiconductors and insulators, the difference in energy between the valence and conduction bands being called the energy band gap. In germanium the band gap is 0·67eV. (One electron-volt, or eV, is the energy that an electron gains when it is accelerated by a potential difference of one volt. About $3 \times 10^{+19}$ or three times ten million, million, million electron volts are required to warm one gram of water by one centigrade degree.)

The separation of these bands determines the conducting nature of a given material. In insulators the separation is large, the band gap being several eV wide. In order to lift these electrons from the valence to the conduction band a potential difference of several volts would thus have to exist across each atom. If this situation existed the insulator would break down. In metals either there is no band gap, the valence and conduction bands being in contact, or else the valence band is only half full. A third alternative as seen in copper is that both these conditions are present. These three circumstances each lead to a high conductivity.

In semiconductors the band gap is quite small as mentioned previously for germanium. In this case thermal vibrations in the crystal lattice can lead to the excitation of electrons to the conduction band. This results in a small current flowing through the crystal when a field is applied to the sample. However the number of electrons liberated depends almost entirely on the thermal vibrations and not on the applied field. So when a voltage is applied across the crystal a current flows which does not vary with voltage. However it does depend on the temperature, being called *temperature-saturated current*. The number of electrons increases exponentially with temperature, the saturated current increasing similarly. This accounts for the reverse leakage currents experienced in solid-state diodes and transistors (Icbo).

## n- & p-type Semiconductors

If an atom of phosphorus or another pentavalent element is introduced into a pure or "intrinsic" semiconductor crystal such as germanium there will be one electron which cannot enter into the covalent bonding. This electron will be only weakly bound to the atom since the presence of the surrounding atoms will substantially modify the local electrostatic fields, lowering the attraction by about a factor of ten. This electron thus requires only a small fraction of an electron volt to lift it to the conduction band, and this is easily supplied by heat in the crystal. Such an atom is called a donor atom and gives rise to a local donor state in the crystal. The material so formed is said to be doped with phosphorus and to be an n-type semiconductor.

Conversely if an atom having only three valence electrons such as aluminium is introduced into the lattice there will be a vacancy which can easily be filled by an electron from the valency band. Such an atom is called an acceptor atom. As before, the energy required to fill this acceptor state is very small. However a difference is apparent. Since electrons move from the valence band into these acceptor states these latter states must be near to the valence band rather than to the conduction band. The various states and energy bands are shown in Fig. 4. The vacancies result in electrons

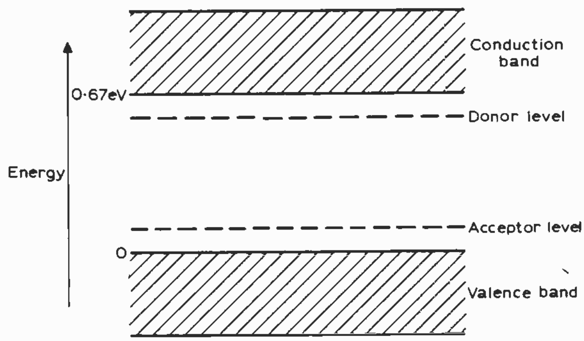


*Fig. 4: Acceptor and donor energy levels.*

moving from the valence band to fill them. These electrons leave behind them holes. The states into which the electrons move are called acceptor states. A material doped with aluminium is said to be a p-type semiconductor.

Hole conduction can be likened to the movement of cars in a circle of parking meter spaces, where the cars represent the valence electrons and the spaces the holes. If there are only a certain number of meter bays and they are all full no movement of cars can occur since no car is allowed to move into a bay which already contains a car. However if one car leaves the circle a bay becomes vacant and the cars can proceed around the circle step by step. It is obvious that the hole or vacant bay seems to move in the opposite direction to that in which the electrons or cars move.

Electrical conduction in a semiconductor can be due to movement of electrons in the conduction band or else to the movement of holes in the valence band. Conduction can occur by both holes and electrons in the same sample of material. When this occurs the current carrier which is in the majority is called the *majority carrier*, the other being called the *minority carrier*.

The simple addition of p- and n-type dopents in equal quantities will not result in an equal part of the conduction being shared by the holes and electrons. Compensation is said to occur, electrons from the donor states filling the vacancies in the acceptor states. This mechanism only occurs efficiently at low levels of doping.

## Measuring Semiconductor Properties

When semiconducting substances are manufactured it is necessary to know certain of their physical properties. Such things as resistivity, type of doping (that is whether the crystal is p- or n-type) and the band gap of the intrinsic material need to be measured.

The resistivity of a sample of a semiconductor is measured by making use of Ohm's law. Two probes, P1 and P2 in Fig. 5, from a source of

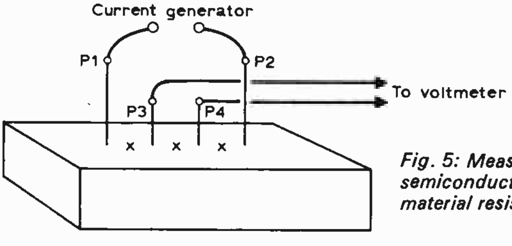

*Fig. 5: Measuring semiconductor material resistivity.*

current are placed on the surface of the sample. Two further probes, P3 and P4, are placed on the suface of the sample and coupled to a valve voltmeter. The resistivity of the sample can be shown to be proportional to the ratio of the measured voltage and current. This method overcomes the difficulties encountered because of contact potentials.

## Hall Effect

The Hall effect is very important in measurements on semiconductors and will be briefly described. As is well known a wire carrying a current is deflected when in a magnetic field. This effect is used in

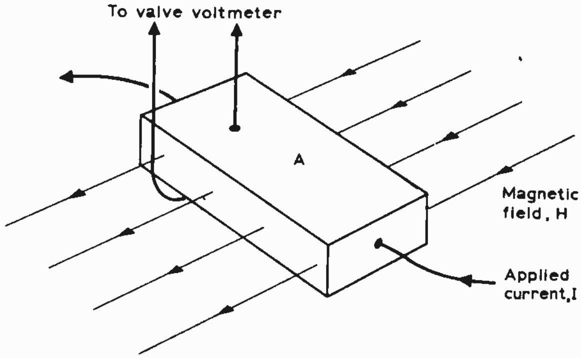

*Fig. 6: Demonstration of the Hall effect.*

moving-coil galvanometers. The same effect occurs when electrons flowing in a semiconductor are subjected to a magnetic field. In Fig. 6 the electrons would be deflected upwards towards face A. The electrons which accumulate near to this face set up an electric field which opposes the electron motion since the top surface becomes negative. An equilibrium situation is thus developed, the Hall voltage being measured with the valve voltmeter.

Holes are deflected in the same way. However as they have a positive charge the Hall voltage is of opposite polarity. Thus by measuring the voltage developed it is possible to determine if the conduction is due to holes or electrons.

The Hall effect has many other applications. Among these are the use for measuring magnetic field strengths and as a multiplying device in computers.

## Other Properties

As mentioned previously the number of carriers excited to the conduction band varies exponentially with temperature. As the conductivity is proportional to the number of carriers this too varies exponentially. By measuring the temperature dependance of the conductivity of the material the band gap can be calculated.

The degree to which a semiconductor needs to be purified can be judged from the fact that at room temperature intrinsic germanium contains only one electron-hole pair per thousand million atoms. So in order to be able to study the intrinsic behaviour of germanium a purity of one part in $10^9$ is required.

In silicon with the wider band gap of 1·1eV a purity of one part in $10^{12}$ is required. This refinement is not possible and other techniques are required to obtain intrinsic behaviour. The methods used in the purification of semiconducting material will be discussed in Part 2.

TO BE CONTINUED

## CORRIGENDA

**January issue—Simple Capacitance Bridge**

In the multivibrator circuit certain component values were inadvertently transposed: R1 and R4 should be 2·2kΩ and R2 and R3 10kΩ.

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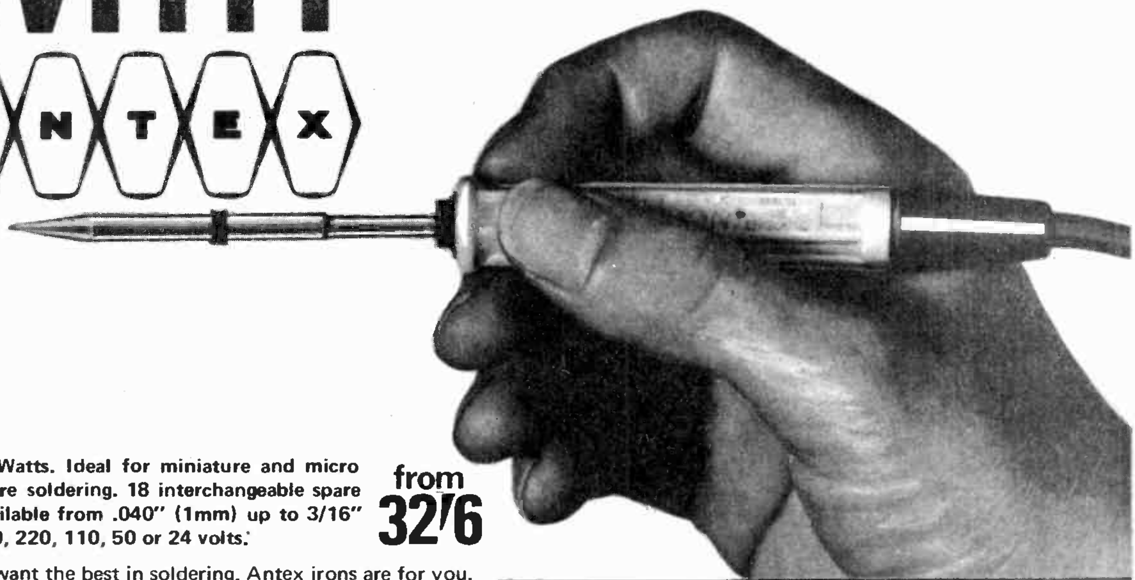

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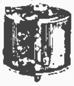
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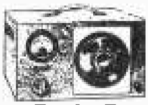
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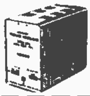

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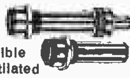

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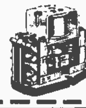

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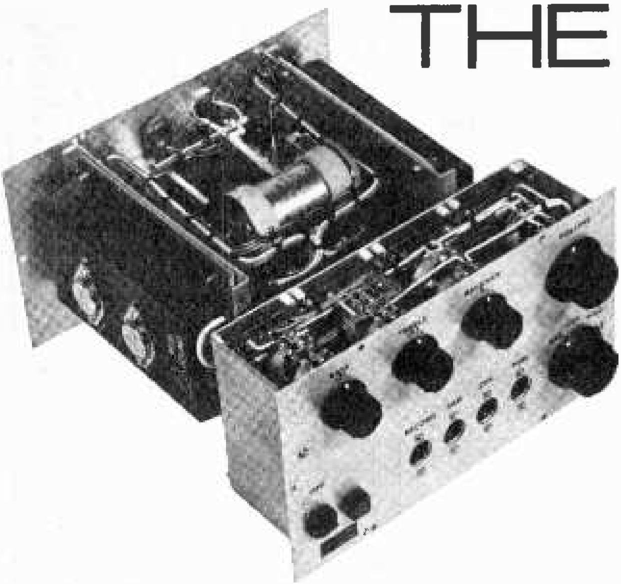


# THE P.W. DOUBLE·12 HI-FI AMPLIFIER


HAL MOORSHEAD


## PART 2

**Last month details were given on the construction of the preamplifier and tone control panels. This month we are dealing with the completion of the preamplifier as a complete unit and the metalwork for the whole unit.**

HAVING built up the preamplifier and tone control panels, these have now to be mounted together with the input sockets and controls into a complete unit. For those wishing to use the preamplifier with an existing power amplifier or one of another design this unit will be all that is required apart from a supply of 20V; this can generally be taken from the main amplifier power supply.

As the photographs of the unit show, all the controls are mounted on the front panel enabling the preamplifier to be permanently fitted into a cabinet. The four panels described last month are fitted vertically behind this front panel, bolted to another panel forming the back of the unit. They are arranged so that the tags on the boards are in close proximity to the variable pots controlling the treble, bass, volume and balance. The other ends of the panels have the contact pins for the selector switch inputs and the power supply.

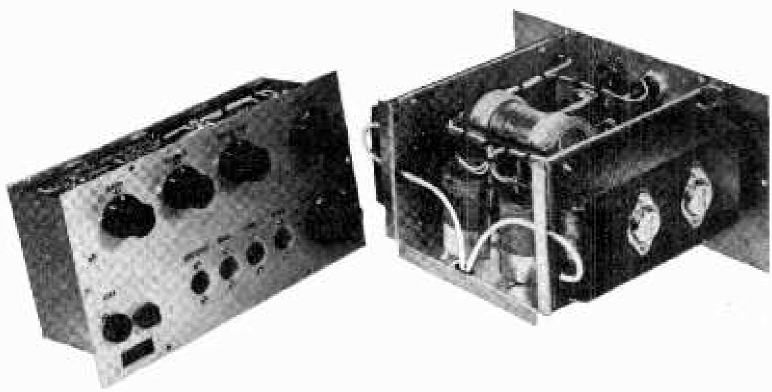
The matching resistors for the input circuit are mounted on the actual input plugs. An additional plug is incorporated with the three inputs; this is a low level output from the preamplifier unit for feeding into a tape recorder or external amplifier, the output to this plug is not controlled by the volume control.

The P.W. Double-12 is not provided with a mono/stereo switch, a feature often provided on stereo amplifiers. This facility is not required as any mono input, such as an a.m. radio tuner or standard record player input will be fed to the preamplifier by means of a DIN plug. Where the input is mono all that is necessary is to fit a jumper wire inside the plug paralleling the inputs. The actual plugs chosen were the Philips 5-pin or DIN type, these having become almost universal for this kind of equipment.

In order to bring all the active controls to the front panel, the on/off switch and the indicator neon are also mounted on the front.

## Layout of the preamplifier unit

Figure 1 shows a block diagram of the connections for the preamplifier as this is fairly involved and mistakes can easily be made. After having made up the metal work for this unit mount the necessary items on it, that is the on/off switch, the input and output sockets, the selector switch and the variable pots. Potentiometers are sold with spindles of varying lengths and it is advisable to cut these to the required length before mounting them as cutting spindles *in situ* can damage the equipment. Clasp the spindle firmly in a vice and cut with a sharp



*The two sections of the completed amplifier before being bolted together.*

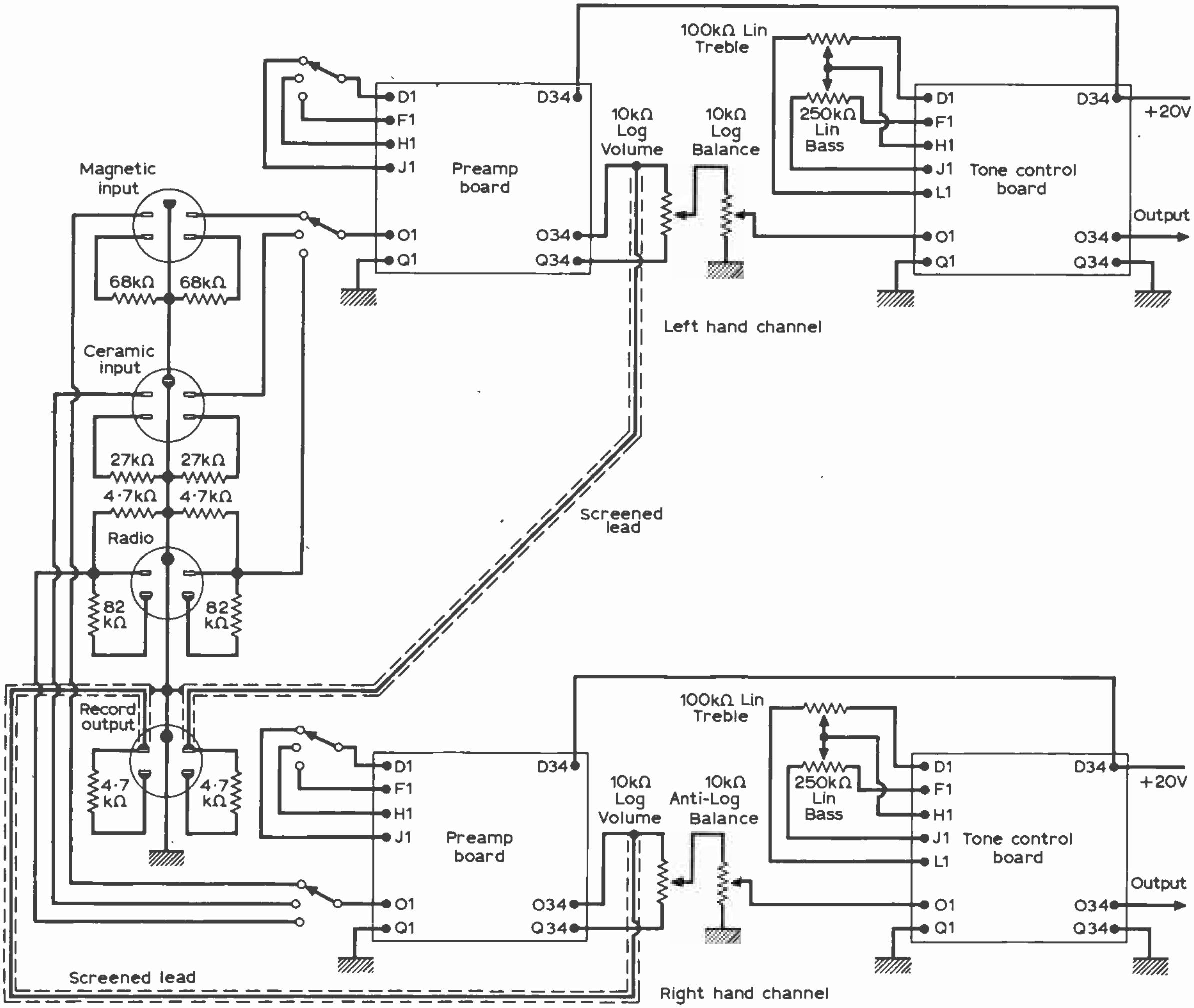
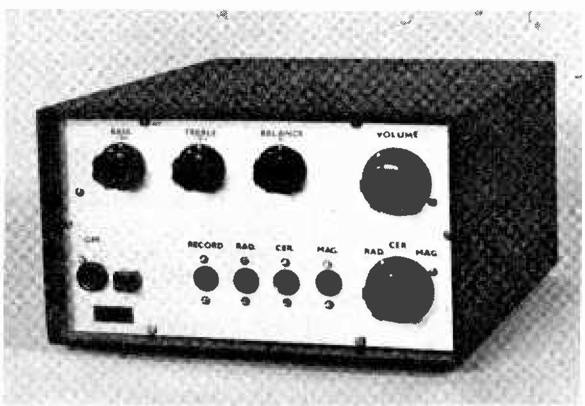



*Fig. 1: Schematic diagram showing the interconnection of the panels. The DIN sockets are viewed from the rear and note that the balance control should be wired so that the chassis connection for one of the sections is fed from the left hand tag (viewed from the front) and in the other case from the right hand tag. It does not matter which section of the balance control is used for which channel.*




*Front view of the completed amplifier.*

## ★ components list

Balance control—10kΩ double gang, one section log., the other anti-log.

Two 4·7kΩ, ¼ watt miniature resistors.

Four DIN input sockets; knobs; Mains switch toggle; indicator neon; Eight way tag strip (if used as a separate unit); 6BA nuts and bolts; screened lead.

Metalwork as shown.

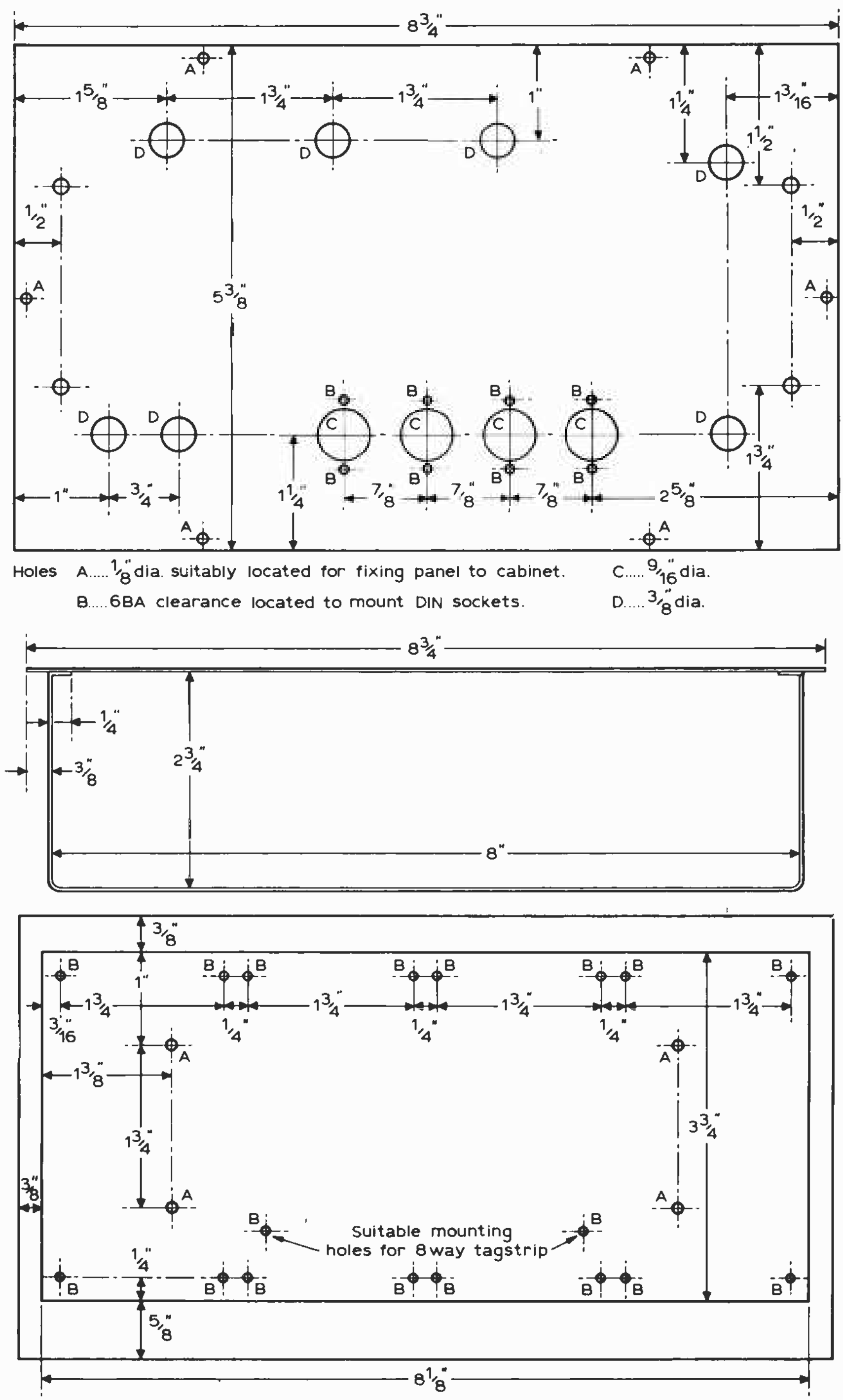



*Fig. 2: The metalwork details for the preamplifier section.*

hacksaw, finally filing off the rough edges. The actual length of spindle will depend upon the knobs chosen, but about ¾in. should be right. Arrange the pots in such a way that the contacts are facing upwards.

A small solder tag should be fitted to one of the bolts holding the DIN plugs and a bus-bar threaded through the pins as shown. The attenuating resistors are mounted on the DIN plugs, their chassis connections being taken to the bus-bar.

The feeds from the input sockets are taken to the selector switch as shown in the diagram. In turn the output from the switch is fed to the preamplifier panels which are mounted behind the selector switch.

It is advisable firstly to do the necessary wiring between those points on the front panel and to also solder the wires which will later lead to the boards, this will save at least fixing both ends of the inter-connecting wires when the unit is assembled.

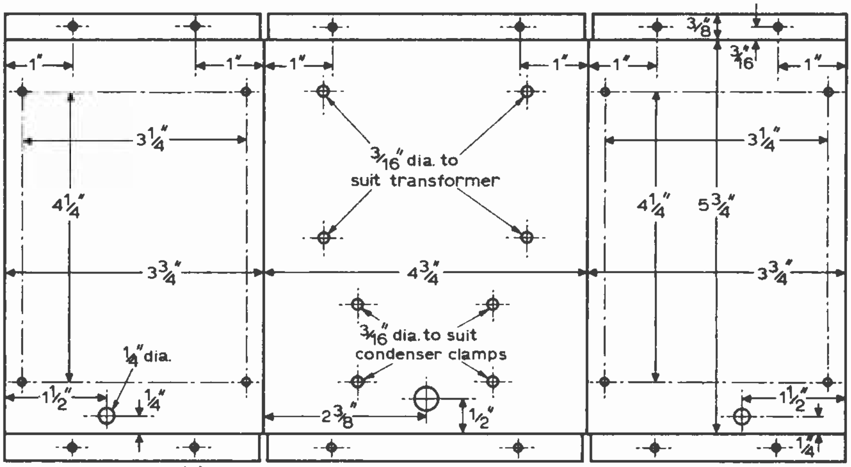
## Mounting the boards

The preamplifier and tone control boards should next be mounted on the back panel. Each of these are held by means of four 6BA screws half an inch long, quarter-inch tubular spacers support the panels themselves and prevent the connecting pins from touching the chassis.

For those wishing to use the preamplifier by itself it is suggested that an eight way tag strip is mounted on the back of the rear panel to which the wires of the mains, supply voltage and outputs may be taken; if the preamplifier is to be used with the main amplifiers and power supply suggested this will not be required as the leads will connect directly to points on the other chassis. Screened leads are only necessary for the final outputs from the tone control panels and on the feeds from the top of the volume control to the low level output. In wiring the unit it is strongly recommended that wire of several different colours is used; this will greatly help in reducing mistakes.

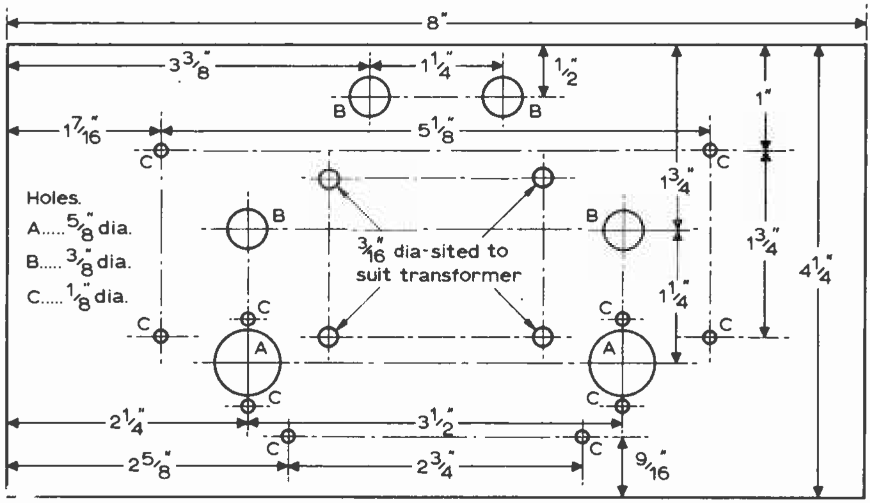
The secret of wiring such a unit is to work logically, starting at the input and working through to the output and once the job is done leave it for a couple of hours and start with a fresh mind and follow through the sequence again.

Fig. 3: The metalwork for the centre section which should be bent as shown in the photograph on page 35. This section will hold the power amplifiers and power supply in the completed unit.



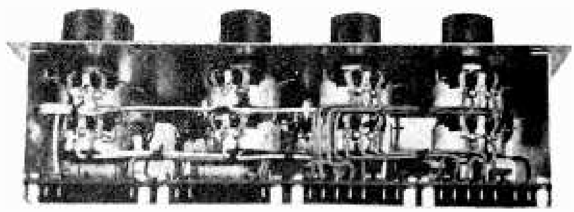

All unmarked holes 1/8" dia.

Fig. 4: Details of the drilling required for the back panel. The loudspeaker sockets fit into the ⅝in. diameter holes. The power amplifier fuses fit into the two centre ⅜in. holes while the top two ⅜in. holes are used for the mains input lead and the mains fuse.




## The metalwork

As mentioned before, the design of the metalwork has been kept as simple as possible. Aluminium sheet, 16 s.w.g., should be used which is available from component suppliers, it can easily be cut using metal shears. All holes should be carefully marked and drilled, the resulting scurf being removed by a countersink bit. Chassis bending can easily be done in a vice although the aluminium should be protected from the jaws by sandwiching between cardboard.



*Top view of the completed preamplifier section.*

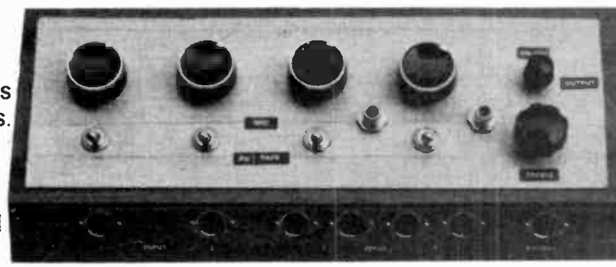
PRACTICAL WIRELESS have made arrangements with H. L. Smith and Co. Ltd. of 287/289 Edgware Road, London W.2, to supply the basic metalwork, as specified complete with the six holes of over ⅜in. diameter already punched for 26/2d plus 4s 6d p. & p. All that is necessary is to drill the smaller holes detailed in the drawings.

**Next month, the final article will deal with the construction of the main amplifiers, the power supply and a suggested design for a cabinet.**

# HERE'S YOUR LINE-UP FOR NEXT MONTH'S PRACTICAL WIRELESS

## A COMPREHENSIVE AUDIO MIXER

Most small audio mixers have very limited applications and the audio enthusiast has to resort to hookups of attenuators, transformers and other devices to match sources to inputs. The P.W. mixer to be described next month provides comprehensive facilities so that almost anything can be plugged into it without alteration. Facilities are also provided for monitoring the composite signal.



## TRANSISTOR POWER OUTPUT STAGES

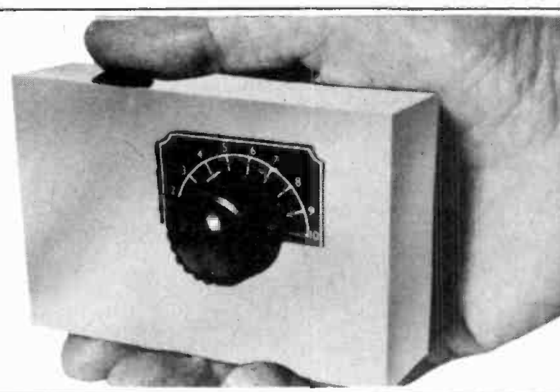
Transistor amplifiers look simple enough, but once you deviate from a published circuit design not only can performance be disappointing but components can be easily damaged. This article explains the peculiarities of various output circuits.

## P.W. DOUBLE-12

The final article in this series deals with the building of the power amplifiers and power supply. Together with the preamplifier (for which you will find completion details in this issue), the unit described next month will build up into a complete hi-fi system *at a considerable saving over ready built units.*

## A SLIMLINE SUPERHET

This simple medium wave superhet receiver using just four transistors and two i.f. transformers is designed to feed a personal earpiece or headphones. Measuring only $4\frac{1}{2}$ x 3 x 1in., it is easy to build and full wiring instructions are given.



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# A NEW SERIES – BY I. J. KAMPEL

THIS is the first in a short series of articles dealing with the theory behind the operation of pulse circuits. All the familiar, and some of the not-so-familiar circuits are discussed in a detailed analysis. The descriptions of how these circuit elements function should be of great assistance to the beginner with a basic knowledge of semiconductors as practical illustrations of how semiconductors work together in switching circuits. These basic building blocks are frequently taken for granted, perhaps not considered worthy of detailed appraisal, but an intimate knowledge of how such circuits operate must lead to improved design techniques in even modest pulse circuitry. Since saturation switching plays such an important role in pulse circuitry, this subject will be dealt with before more practical pulse circuits are discussed.

voltage approaches the line voltage since only minimal voltage is developed across the load by this small leakage current.

To take two examples, a germanium transistor having a leakage current of 5μA at a line voltage of 10V might have an effective saturation resistance of only 4Ω. The impedance in the ON state is thus 4Ω, and in the OFF state it is determined by the leakage current and the line voltage, since $V_{CE}$ sat may be considered negligible compared with $V_{cc}$, the line voltage. The OFF state impedance is $10/(5\times10^{-6})=2\text{M}\Omega$. Therefore,

$$\text{off-to-on ratio}=\frac{10}{4\times5\times10^{-6}}=0{\cdot}5\times10^{6}$$

If we consider a typical silicon transistor, the saturation resistance will be higher, but the leakage current will be lower, and a similar ratio results. Taking a silicon

# pulse circuits in oper

The ultimate aim in switching circuits is to obtain a means of effectively switching between the two states of zero impedance and infinite impedance, upon the application of electrical stimuli. The electromechanical switch, the relay, gives the closest approximation to this as is possible, since it switches between contact resistance, perhaps milliohms, to a true open-circuit. The relay thus has an infinite off-to-on impedance ratio.

Whilst a useful off-to-on impedance ratio is obtainable with a relay, there are many applications where a relay is quite impracticable, due to its severe limitations. As an electromechanical unit with moving parts it is subject to wear and has a limited lifetime. The mechanical parts limit its speed of operation, the unit is bulky, and it is also expensive. The transistor on the other hand provides an inexpensive form of switching which is silent, fast, reliable, with almost infinite lifetime, and it is also very small. It is true that a transistor cannot have an infinite off-to-on impedance ratio, but more than adequate ratios are obtainable.

When a transistor is overdriven in terms of base current, and made to bottom, the collector voltage drops to $V_{CE}$ sat, usually of the order of one or two hundred millivolts for a typical silicon transistor. The normal emitter-base voltage for a silicon transistor is six to seven hundred millivolts, indicating that when a transistor is saturated the collector voltage is *below* the base voltage, i.e. the transistor is driven into a state where the normally reverse-biased collector-base junction is now forward-biased.

When a transistor is cut off, only the leakage current $I_{CBO}$ flows through the collector load, and the collector

transistor with a leakage current of 100nA at $V_{cc}=10\text{V}$, and a saturation resistance of 200Ω,

$$\text{off-to-on ratio}=\frac{10}{0{\cdot}1\times10^{-6}\times200}=0{\cdot}5\times10^{6}$$

Similar ratios are thus possible with silicon and germanium transistors. Power transistors have lower saturation resistances but higher leakage currents.

From the above considerations it is seen that transistors make useful switches, and switching speeds may be over a thousand times better than with high speed relays. The mode of switching will normally be common emitter, for in the common base mode, a current almost as large as the current to be controlled in the collector must be applied to switch. In common emitter the necessary switching current is reduced by the factor of the transistor's current gain, $h_{FE}$, and a small current in the base can control a much larger current in the emitter-collector circuit.

Figure 1.1 shows the output characteristics of a typical silicon transistor, and a load line is drawn for a line voltage of 20V, not exceeding the maximum power rating, while another load line passes through the region where the power rating is exceeded. We shall consider the former initially, $R_{L1}$. Point A represents the upper limit for the transistor to be in the OFF state, where $I_B=0$. If a small negative bias is applied to the base of an n-p-n transistor (or positive bias for a p-n-p transistor), this will cause a negative current $I_B=I_{CO}$ to flow, and the transistor is switched into a more definite OFF state.

Point B on load line $R_{L1}$ represents a point in the ON state where the transistor is non-saturated since the effective collector-emitter voltage is seen to be 6V, and in fact the transistor in this state, with a base current drive of 250µA, dissipates a power of $50 \times 10^{-3} \times 6 =$ 300mW. Point C on the load line represents the transistor in saturation, and it will be seen that here the power dissipation is very small since the collector-emitter voltage is very small. With this particular load resistance, any base current in excess of about 400µA will drive the transistor hard into saturation.

The maximum power dissipation curve plotted on the diagram indicates the area on the graph which should not be exceeded by the load line in normal operation. In the case of a fast switching operation, there are situations where it is quite acceptable to exceed this power curve, however. First of all consider point E on this new load line, $R_{L2}$. This point represents the transistor operating with a base current drive of 350µA at a collector current of nearly 70mA, i.e. the power dissipation is in excess of the maximum rating throughout the period of the ON state. Point E must never be used therefore. Point F, however, is slightly different.

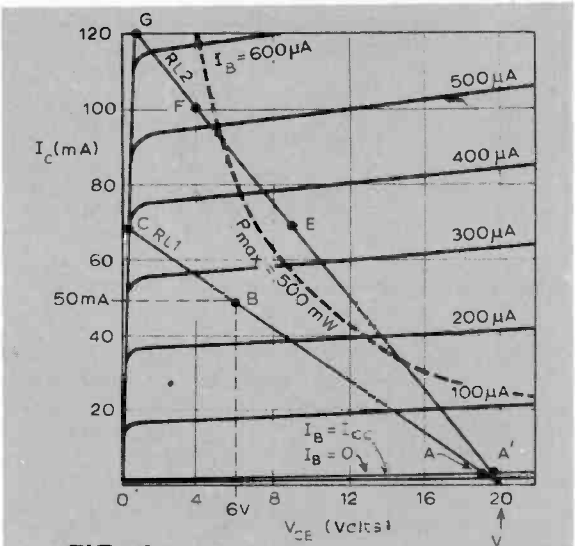



FIG. 1.1

tion part one

# saturation switching

Although the load line intersects the limiting power curve, the operating point is within the power limit. It is possible to operate a switching transistor in this mode, but careful design is necessary, since the switching time is critical—the transistor must not spend any great time in the region of the load line where the power rating curve is exceeded. Where switching from point A to point F occurs rapidly, this is acceptable.

Point G indicates another saturated point for the transistor on $R_{L2}$, and provided that switching occurs rapidly, although the load line exceeds the maximum power rating, the transistor should not dissipate excessive power, since most power is dissipated during the switching operation. A base current greater than about 800µA would be required to switch the example transistor into definite saturation with load $R_{L2}$. In the design of such circuits, the duty cycle of the pulse must be carefully considered.

## Switching Speed

The switching speed of a transistor is considered when an ideal square wave, or step function is applied to the base, in Figure 1.2. The voltage applied to the base is shown in (a). For a transistor to repeat this step function precisely it would have to have an infinite bandwidth, since a perfect step function with a vertically rising edge is made up from the harmonics of an infinite number of frequencies. To switch the transistor on fast, the base current is overdriven, that is to say, referring to the saturated position of point C in Figure 1.1, instead of

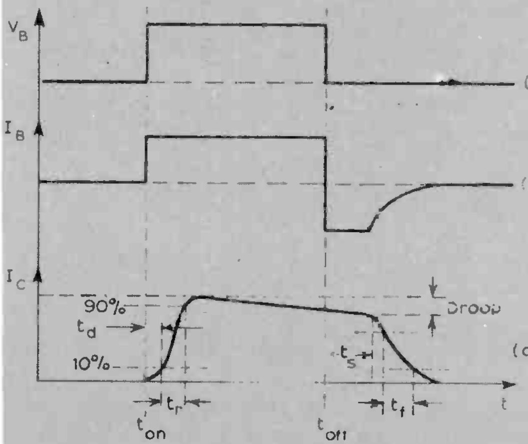



FIG. 1.2

applying minimum base current for saturation, namely 350µA, 500µA or more are driven into the base. The base current resulting from a given emitter-base voltage will vary with transistor spreads, and to take up this spread it is usual to use a constant current source to switch the base current. The transistor cannot have infinite bandwidth, and hence follow the step function exactly since it takes a finite time for the transit of carriers, and minority carriers have to be swept out of the base region before switch-off is complete.

Figure 1.2 shows how a transistor will respond to a step function input. As the base voltage rises at $t_{on}$ so the base current immediately responds, rising to the programmed constant current level. Since carriers must travel across the base region before a collector current can flow, a turn-on delay results, and collector current does not immediately respond. Electrons travelling to the collector all have their own individual paths through the lattice structure, some short paths, some long, some undergoing many collisions, others few. There is thus a delay in the rise time before anything like a constant and maximum current can flow. (The rise time is defined as the time taken for the current to rise from 10% to 90% of its maximum value). The delay time is measured from the beginning of the input pulse to the 10% point of rise, and is denoted $t_d$ in the figure.

Since the transistor is driven into saturation, the collector now will emit electrons into the base region, just as the emitter does normally. This has the effect of flooding the base region with minority carriers, and before the transistor can be turned off, all these excess carriers, the *stored base charge*, have to be removed. When the step function reaches its falling edge, for a finite delay time, the *storage time*, the base region rich in minority carriers supports the original collector current and there is no instantaneous response to the switch-off at the base. Again the time interval over which the last carriers leave the collector is drawn out as they follow dissimilar paths, and the *fall time* results (90 to 10%). The stored charge due to the minority carriers in the base region causes the base to go negative at the switch-off point until the minority carrier storage has ceased. This is shown in (b). By driving a reverse current into the emitter-base, in fact overdriving in the reverse direction, the switch-off time may be improved, just as overdriving speeded up the switch-on time.

Overdriving to turn a transistor sharply on may, in certain circumstances, dissipate too much power in the transistor if excessive overdrive is employed for too long a period. To get over this problem and yet still maintain a high overdrive current, the ideal input to the emitter-base is shown in Figure 1.3a. The forward current is seen to be a step function, driving initially up to the overdrive value, remaining at this level until the transistor is in the ON state, then dropping to $I_B$sat(min) to maintain the saturation, but at reduced power dissipation.

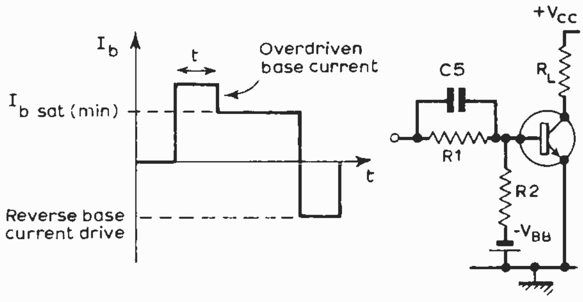



*Fig. 1.3* *(a)* *(b)*

Such a waveform can be approached by the use of a speed-up capacitor, and in Figure 1.3b a speed-up capacitor is shown shunting the resistor R1. The speed-up capacitor $C_5$ is chosen such that the current through it takes up the difference between the required overdrive current, and the minimum base current for saturation, $I_B$sat(min). The battery $V_{bb}$ in Figure 1.3b holds the transistor cut off when no pulse is supplied at the input, thus ensuring that only $I_{CBO}$ flows through $R_L$ and that switching is substantially between $V_{cc}$ and $V_{CE}$sat at the collector.

If the input voltage is sufficiently large in order that the voltage dropped across R1 is large compared to $V_{BE}$, substantially constant current will be driven into the emitter-base circuit.

In Part Two of this series, the multivibrator family will be considered. The precise operation of various forms of multivibrator will be explained, and a method of speeding up the inherently slow rising edge will be discussed.

**TO BE CONTINUED**

# practically wireless commentary by HENRY

## No. 56

## Too Clever By Half

MY mate Bob is a practical man. He says. Not for him the involved calculations on a bench-side jotting pad to prove the profundities of some designer's quirk. He does not waste his time with deep diagnosis, conjuring the whys and wherefores of a burned-out resistor.

Bob is a practical man: he belongs to the "suck-it-and-see" brigade. And, like many another hardworking technician, he achieves a very fair proportion of successes.

Before I get a heap of textbooks heaved at my head, let me state that this measure of success is not merely because the empirical method is superior to logical progression in fault-finding. Nor that I believe experiment to be a good idea when equipment breaks down for no obvious reason. In these days of direct-coupled transistor amplifiers, where a faulty component sets up a domino-effect chain of disasters, guesswork can have catastrophic results. One does not even connect the test-meter without offering up a silent invocation.

In his first few months with us, Bob made some overeager bloomers that looked too much like guesswork. At odd moments we could see him racking his brains for possible solutions, and it was as well that he did not have too much pride to ask for guidance. Only in that way can experience be built up—and too often a failure in the workshop happens because some engineer has become "bogged down" in a mess of dead-ends.

*A heap of textbooks at my head.*

Of course, here and there we come across the old hand whose experience, like moss on a boulder, has so encrusted the basic man that he is incapable of taking in anything new. This is the type of chap who derides transistors because—he avers—they are noisy, untrustworthy, too vulnerable, cannot be replaced without major surgery, and are as likely to be swept under the bench with the rubbish as put back neatly into store. He says: "You know where you are with valves." What he really means is that he simply cannot grasp the concept of holes and barriers.

There is a danger nowadays that the new men will take the opposite view, forgetting that there are still many fields where valved equipment can do a better job. Worse still, the characteristics of the later devices are being taken for granted. "Suck-it-and-see" is a dangerous philosophy when a complicated piece of electronic gear is on the bench.

And as technology scoots along breathlessly we can rely much less often on experience. Almost daily, the engineer is confronted (confounded?) with a circuit that incorporates some new technique.

Sceptics may think Henry unduly alarmist. Some of my colleagues in the Society of Service Managers have already seen the red light. They are pressing ever more vehemently for increased industrial training. We cannot, they say, allow the technician to gravitate into a dead-end groove. The more science becomes the province of the specialist, the more is there a need for the chap in the workshop to learn his groundwork thoroughly. And be better supervised.

*An élite of engineers*

Readers in the radio repair trade will have seen the change that colour TV has brought. An *élite* of engineers is growing up, trained by the manufacturer, flushed with the novelty of it all, keen as can be. Despite all the foolproofing that a designer can dream up, there will always be room for the technical man with a diagnostic flair and a good solid grounding in the fundamentals. There is less time today to gather that moss of experience.

Despite all, there will always be room for blokes like Bob, who have a keen nose for the possible fault and a good memory for symptoms. We could do with a few more in the editorial office, answering readers' queries. Although I sometimes feel an inspired omniscience would be more useful, with letters that begin: *"My receiver went dead last Saturday. What do you think can be wrong?"*

# P.W. GUIDE TO COMPONENTS

## PART 5

M.K.TITMAN, B.Sc.(Eng)

TRANSISTORS are used extensively as amplifying components in electronic circuits and have almost displaced thermionic valves in this role. Only in the specialist fields of high frequency power circuits and high voltage circuits are transistors unable to meet the circuit requirements. Nevertheless it is entirely possible that solid state circuits will in time replace the valve even in these fields.

Transistors are three terminal amplifying devices of semiconductor material. Semiconductor material with the required electrical characteristics is obtained by adding impurities to pure silicon or germanium crystal structures. By suitable choice of the chemical element used as the impurity an excess of positive charges or negative charges is established in the material. This results in the two basic forms known as p-type or n-type material respectively (p-type with an excess of positive charges—holes, and n-type with an excess of negative charges—electrons).

When a single junction is formed between a p-type and an n-type semiconductor the resulting structure is known as a p-n junction, and has the properties of a diode. A two junction structure as shown in Fig. 1 has amplifying properties—providing the centre or base region is very thin. Two basic forms of amplifier are possible, the p-n-p transistor or n-p-n transistor. The structure and circuit symbols for each type are shown in Figs. 1 and 2 respectively.

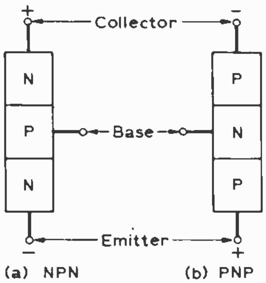
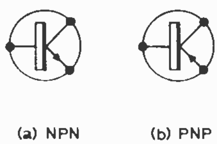



*Fig. 1 (left): Basic transistor construction*

*Fig. 2 (below): Standard transistor symbols.*




In order to understand the reason for the methods used in transistor construction let us examine further the mechanism by which amplification is achieved. Figure 3 illustrates the diode properties of each junction individually and clearly the transistor appears as a back-to-back diode combination as shown in Fig. 3(c). When a voltage is connected between the collector and emitter no conduction can take place. However if the base region is very thin then conduction across the base-emitter junction obtained by biasing the base with respect to the emitter results in current flow between collector and emitter. This can be regarded in the n-p-n configuration shown as due to electrons flowing into the base region and thereby establishing a conduction path between collector and emitter. In order to make the base-emitter junction conduct it must be forward biased and this is achieved by applying bias to overcome the natural junction barrier potential of 0·2-0·3V for germanium transistors and 0·6-0·75V for silicon.

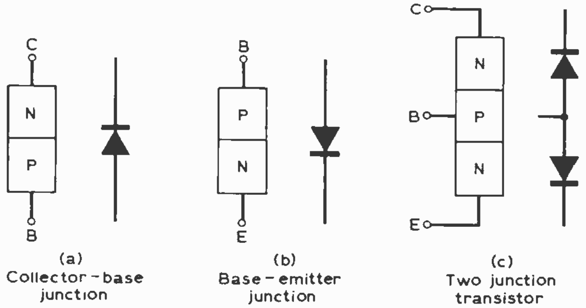



*Fig. 3: N-P-N transistor junction characteristics.*

Once this barrier voltage has been overcome a small increase in the voltage between the base and emitter will drastically increase the collector-emitter current flow. The relationship between base-emitter voltage and collector current for a germanium transistor is shown in Fig. 4 and it can be seen that a change of 25mV results in an emitter current change of 4mA giving an effective gm of 160mA/V. Therefore a very small base-emitter voltage change—once the barrier voltage is overcome—gives a change in collector current which when passing through a suitable load resistor results in a large voltage change. Hence the transistor has voltage amplification properties due to its capacity for current or power gain.

The mechanism of operation depends on current gain because current flow into the base produces current flow from collector to emitter and this is the reason for

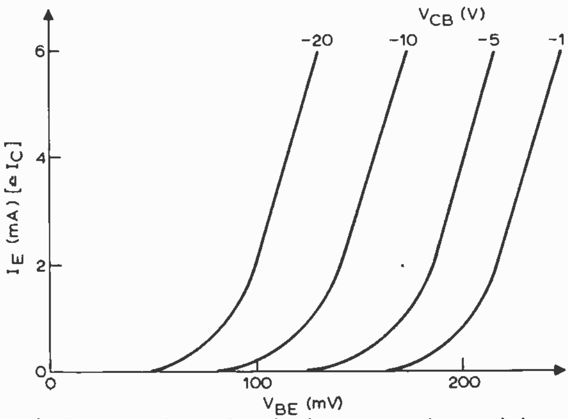
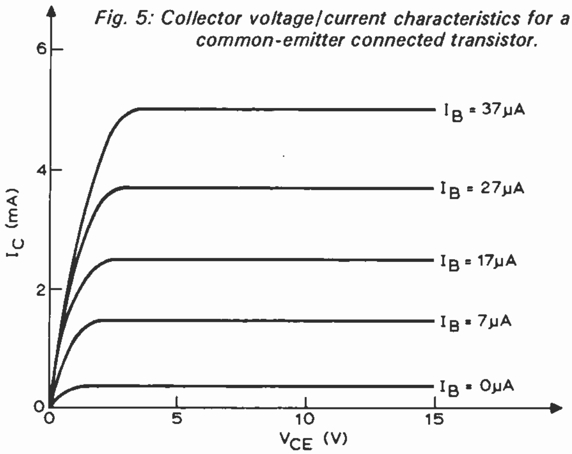



*Fig. 4: Base-emitter voltage/emitter current characteristics.*

Fig. 5: Collector voltage/current characteristics for a common-emitter connected transistor.




the designation of transistors as current-operated devices. However as we have seen from Fig. 4 the transistor can equally be regarded as voltage-operated.

The relationship between collector current and collector-emitter voltage is shown in Fig. 5 and it will be noticed that the general shape of the curves of constant base current resembles very closely those of pentode valve characteristics. This feature of base current operation further explains the term "current-operated" for transistors though this expression has tended to produce a psychological barrier for those more familiar with valve operation. In fact amplification is achieved in the same way and the transistor and valve amplifiers shown in Fig. 6 are analogous.

A small positive increase at the base (in the case of an n-p-n transistor) or grid results in an increase in collector or anode current and produces a change in collector or anode voltage. Polarities, phasing and operation of the amplifiers shown is identical—it is only the voltage levels and impedances that differ.

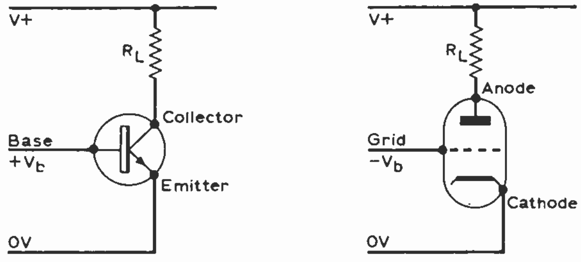
As transistor characteristics are basically given in terms of current it is usual for the current gain, which is change in collector current for change in base current, to be quoted. The current gain approximates to the values given for $h_{fe}$, α′ or β in transistor characteristics. The gm can however be determined and is defined as the change in base-emitter voltage for a given change in collector current. This corresponds to the slope of the characteristic shown in Fig. 4.

Having briefly covered the method of operation of transistors of the basic p-n-p or n-p-n two-junction structure, let us now examine how this structure is manufactured in practice and the advantages and limitations of different forms of construction.

## Alloy Junction Transistors

Transistors first became commercially available with the alloy junction form of construction and well-known examples of this type are the OC70 series. Initially germanium was used as the base material as its melting point of 950°C is lower than silicon (1,400°C) and it is therefore easier to work with.

The transistors from 1950 were germanium p-n-p types made from n-type material formed by purifying germanium to an impurity concentration of 1 part in $10^6$ and then adding arsenic or antimony to give the n-type characteristic. The single crystal material was cut and diced into chips 0·1in. square and 0·005in. thick. The two junctions were then formed by alloying beads of p-type impurity—normally indium—to both sides of the chip as shown in Fig. 7.




(a) NPN transistor amplifier (b) Triode amplifier

Fig. 6: Comparison of simple transistor and valve amplifiers.

Alloying was achieved by heating the indium pellets to their melting point at which stage a solid bond was obtained and some of the indium diffused into the n-type slice to give p-type material. The depth of penetration was determined by the time and temperature and thus the base thickness was controlled.

The transistor characteristics of all transistors are determined by base thickness, material, impurity concentrations, resistivity etc., and by using the alloying technique fairly wide tolerances occurred. As a result useful transistors of like characteristics are obtained by individual selection within acceptable limits. Thus each production line produces a range of transistors such as the OC70, OC71 and OC72, and the yield of each type differs. The cost of each type of transistor therefore is largely determined by the numbers required and the production yield.

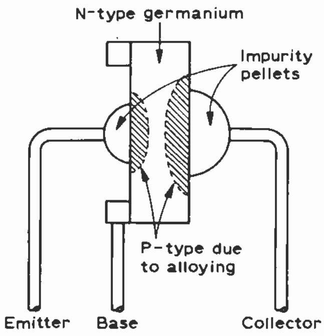



Fig. 7: Alloy junction transistor construction.

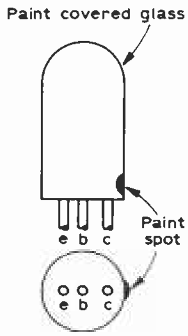



Fig. 8: Glass encapsulation.

Silicon alloy junction transistors, which are still produced in fairly large quantities, utilise aluminium as the p-type impurity to alloy with the silicon slice. N-P-N transistors were more difficult to produce and like silicon more expensive than the p-n-p germanium transistor. With n-p-n transistors this was due to the use of arsenic or antimony as the n-type impurity which had to be alloyed to lead to make the pellets.

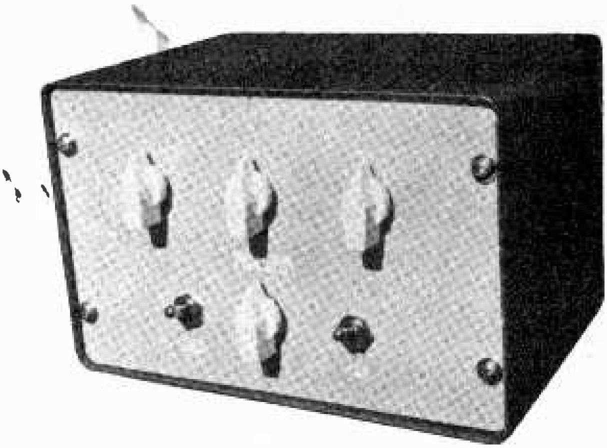
The finished transistor slices of the early transistors were encapsulated in glass, as shown in Fig. 8, after soldering the lead-out wires to the centre slice and the two pellets. The glass formed an efficient hermetic seal and was coated with paint to prevent light penetration to the junction. The device was marked with its designation and the collector lead indicated by a coloured paint spot.

Glass encapsulations however are not efficient for heat dissipation, although grease is inserted to give additional conduction between the chip and the glass, and later devices used metal containers of the same basic shape.

—continued on page 54

# CALIBRATION OSCILLATOR

R. F. GRAHAM



A CALIBRATION oscillator of this type provides calibration signals at a large number of fixed frequencies, so that the tuning scales of receivers and other equipment can be marked. The actual frequencies available fall into three ranges, as follows:

5Mc/s and its multiples 10, 15, 20, 25 and 30Mc/s, to provide signals at 5 megacycle intervals from 60 to 10 metres.

1Mc/s and multiples to give signals at 1, 2, 3, 4, 5, 6, 7Mc/s etc., permitting calibration at 1 megacycle intervals from 300 to 10 metres.

100kc/s and multiples for calibration of medium waves from 500 kilocycles to 1,500 kilocycles (600 to 200 metres) and for short wave bands where required. A typical use is calibrating at 1,800, 1,900 and 2,000kc/s for the 160M amateur band, or 3,500, 3,600, 3,700 and 3,800kc/s for the 80M band.

In such equipment, crystals are generally employed. In view of the cost of these, inductors are used instead, with a combination of fixed and pre-set capacitance in parallel. These circuits are set on frequency with the aid of the 200kc/s BBC Radio 2 (1,500M) transmission, and the National Physical Laboratory 5Mc/s signals. There is no great difficulty in obtaining an accuracy far higher than that which can be observed on the tuning scales of any general coverage communications type or other receiver.

Figure 1 is the calibration oscillator circuit. The pentode section of the ECF80 has cathode feedback from the taps on coils L1, L2 and L3, with electron coupling to the anode output circuit. This gives isolation of the tuned circuits, and quite a large r.f. output.

The ECF80 triode section is an audio oscillator, allowing tone modulation when required. This gives ready identification of the calibration oscillator output.

Power can generally be borrowed from the receiver. If not, a small power pack, giving 6·3V at 0·43A, and about 10mA at 220V, will be required.

## Harmonic Output

Figure 2 shows some of the outputs available from the calibration oscillator, and will help to clarify the way in which it is used. The fundamental outputs 5Mc/s, 1Mc/s and 100kc/s (0·1Mc/s) and multiples of them will be heard on a receiver. The multiples grow progressively weaker, the upper frequency limit depending either on the coverage of the receiver, or its sensitivity. The outputs of 5Mc/s, 1Mc/s, 100kc/s and their multiples, are selected by the calibration oscillator bandswitch. With a typical communications receiver, all can be heard up to 30Mc/s.

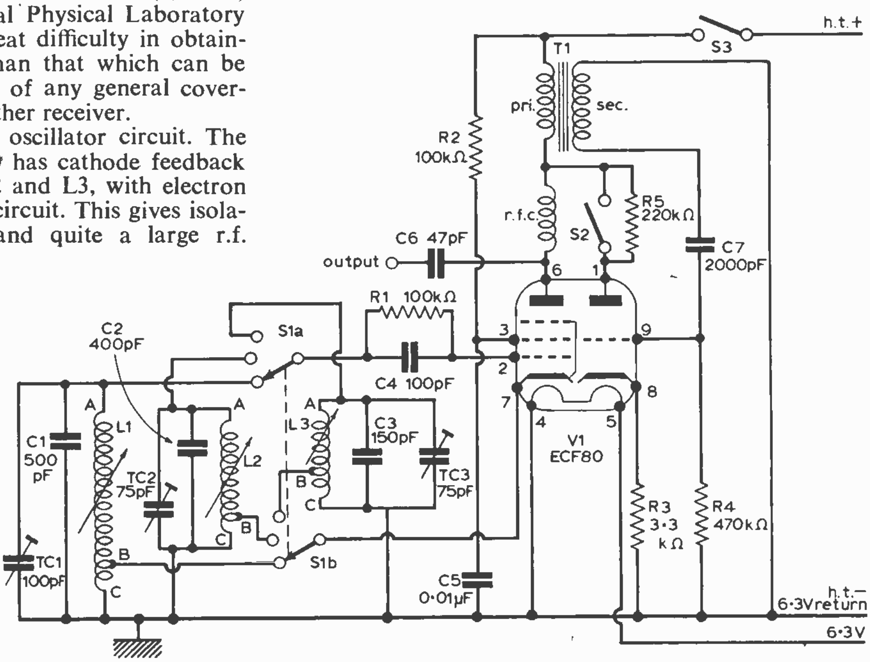



*Fig. 1: Complete circuit of the calibration oscillator.*

The harmonics may be used for trimming and aligning purposes, or to correct errors in dial readings of a ready-made receiver. When dealing with the h.f. bands, first check at 10, 15, 20, 25 and 30Mc/s, for positive identification of these frequencies by the 5Mc/s oscillator harmonics. Appropriate 1Mc/s points can then be located by tuning up and down from the 5Mc/s multiples, as required.

With a completely uncalibrated receiver, a similar method is used. First mark the receiver scales at 5Mc/s intervals, omitting the numbering if not known. The 1Mc/s coil is then switched in, and lighter marks made at 1Mc/s intervals. This gives a scale similar to a portion of Fig. 2, but without numbers. It is now necessary to identify *one* frequency on each receiver band, and to count up and down from this, to fill in all marks on that band. This is generally easy, but the following notes may be useful.

The National Physical Laboratory signals on 2·5Mc/s and 5Mc/s identify these frequencies. Amateurs will be heard on the low frequency side of the 2Mc/s mark in the 1·8-2·0Mc/s band. Amateurs also use 3·5-3·8Mc/s, so will be heard a little l.f. of a 4M/cs mark, and this and other bands can be calibrated by counting the 100kc/s signals between 1Mc/s markings already put on the receiver scale.

For higher frequency ranges, identification can if wished be from amateur bands. Since one 5Mc/s mark will be 15Mc/s, a 1Mc/s harmonic l.f. of this will be 14Mc/s, and the 20M amateur band is 14-14·35Mc/s. Another 5Mc/s harmonic is 20Mc/s, and a mark 1Mc/s h.f. of this will be 21Mc/s, or the l.f. end of the 15M or 21-21·45Mc/s amateur band.

For medium waves, mark the dial at 100kc/s intervals throughout the tuning range. Identify one mark by noting its relationship to a BBC transmission or any other station. Then count up and down from this, writing in the frequencies, as for the short wave bands.

## Construction

This should be rigid. Figure 4 is under the chassis, and Fig. 5 above the chassis. Each coil has a parallel fixed capacitor, and smaller pre-set or variable control for narrow frequency adjustment around the wanted spot frequency. If coils and capacitors are as shown, the correct frequencies can easily be found. Except for this, there is no need that capacitor values are exactly as shown, so it might be possible to utilise trimming and other capacitors already to hand.

Various intervalve coupling transformers and tapped output transformers will produce an audio tone. A single tapped winding, such as available on an output transformer, can be used by taking the tapping to h.t. positive (switch). One outer tag then goes to the triode anode (via modulation switch) and the other outer tag to C7. Transistor type transformers are unsuitable. If no oscillation is obtained by using a transformer having two windings, reverse connections to one winding.

## Inductors

These are wound on ½in. diameter formers having adjustable cores. The smallest coil L3 has 20 turns of 24 s.w.g. enamelled wire, side by side. Begin at A, Fig. 3, the start of all coils being as near the tagged ends of the former as possible. Bare and tin the wire, thread it through the pin A, and solder at the tip. Tapping B is a loop, and C is the end of the winding. For L3, tapping B is five turns from earthed end C. All turns are in the same direction. Pressure should not be exerted on the pins while they are hot.

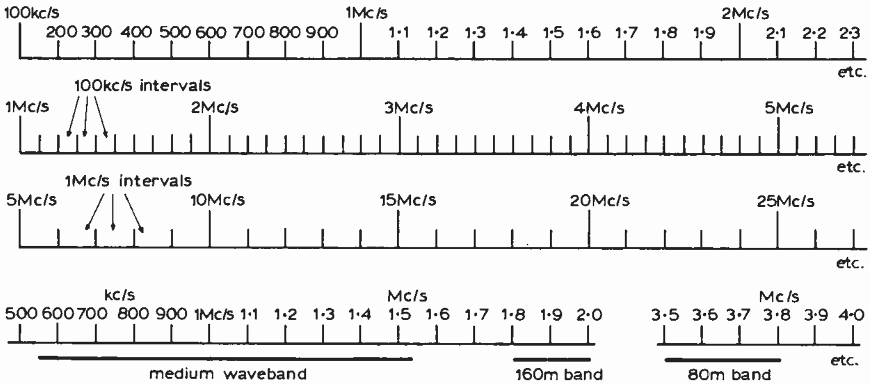



*Fig. 2: Chart showing output frequencies of calibration oscillator.*

L2 has 58 turns of 34 s.w.g. enamelled wire side by side, tapped at eight turns from C.

The large coil L1 has 500 turns of 36 s.w.g. enamelled wire, tapped at 50 turns from C. Cut two discs about 1in. in diameter from paxolin or hardboard. Punch or make ½in. diameter holes so these discs are a push fit on the former. They are cemented as in Fig. 3, with ¼in. winding space between them.

End A passes through a small hole in the upper disc, near the former. Wind on 450 turns, then make a loop and place sleeving on it. The loop goes through pin B, and is soldered. A further 50 turns are then wound on, in the same direction, and the coil finished at C.

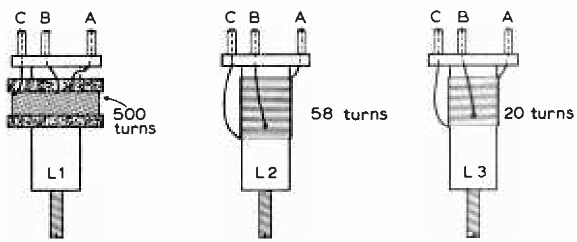



*Fig. 3: Coil winding details.*

Windings are lightly cemented in place. The coils are held by 6BA nuts, which are tightened after adjusting the cores.

An insulated socket is provided for the output lead. Enough coupling can be obtained on some frequencies by placing the output lead near the aerial socket of the receiver, or near a short insulated wire connected to the aerial socket. With portables, place the lead near the receiver.

## Oscillator Calibration

The 100kc/s signal should first be checked by tuning in Radio 2 on 200kc/s on any available receiver, and rotating the coil core of L1 so that the calibration oscillator harmonic falls on the same frequency, with VC1 about half closed. Then lock the core.

Short wave conditions vary, but listening on one or two occasions should enable the "tick" of the NPL signal to be located on 5Mc/s. If necessary, first identify 1Mc/s or 300M in the medium wave band by using the 100kc/s harmonic, and tune the 1Mc/s circuit L2 to this. A 1Mc/s harmonic will then be 5Mc/s, and will show where to tune for the NPL signal.

When the 5Mc/s NPL signal is found, both the 1Mc/s and 5Mc/s circuits L2 and L3 are tuned to zero beat with this. The 100kc/s circuit L1 may also be checked on this frequency, but *after* tuning to Radio 2 as described.

Check that four 1Mc/s marker signals are obtained between each 5Mc/s marker signal and the next, every fifth 1Mc/s harmonic naturally falling on the 5Mc/s harmonics. In the same way, nine 100kc/s marker signals will be found between each 1Mc/s signal and the next, the tenth 100kc/s harmonic falling on 1Mc/s, and so on (Fig. 2).

Put dots on the panel to show tuning positions for the calibration oscillator controls. The equipment should be placed in a cabinet. Before accurate and permanent calibration of a receiver, switch on the oscillator in advance, and correct its circuits against the NPL signal on 5Mc/s, if necessary.

## Receiver Calibration

When the calibration oscillator unmodulated harmonic falls near a radio transmission (e.g., Radio 2) a heterodyne note is heard. This falls in frequency as the difference between the two signals is reduced. With modulation off, tune for "zero beat".

A heterodyne is best heard when the two signals are reasonably similar in strength. For example, tight coupling on 200kc/s can swamp the receiver so that the Radio 2 signal is scarcely audible.

When heterodyning the calibration oscillator with a transmission or with a signal generator or v.f.o. for calibration purposes, the receiver is merely to

*—continued on page 54*

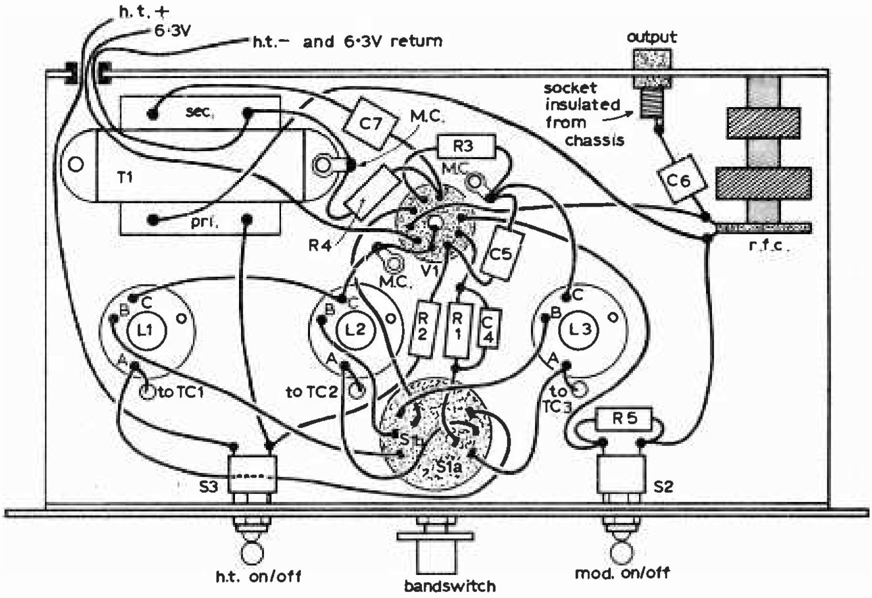



*Fig. 4: Under-chassis wiring details.*

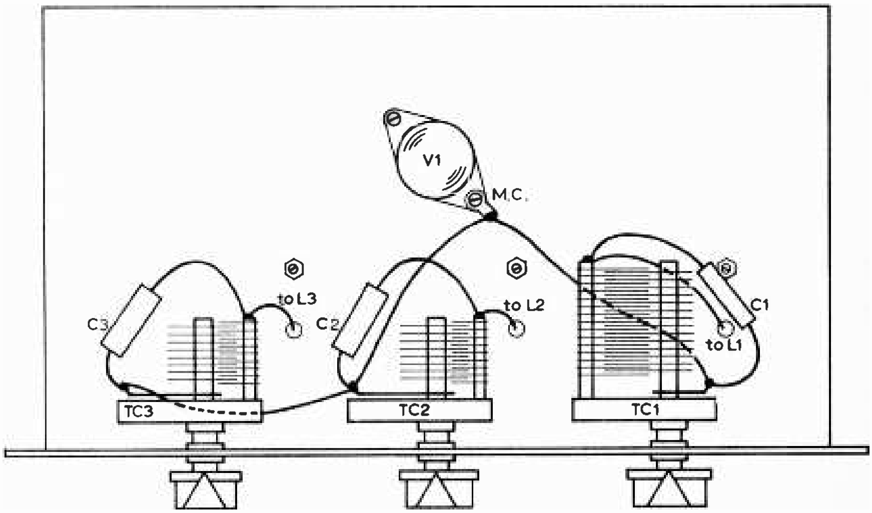



*Fig. 5: Above-chassis view.*

# TAKE 20

JULIAN ANDERSON

## A SERIES OF SIMPLE TRANSISTOR PROJECTS, EACH USING LESS THAN TWENTY COMPONENTS AND COSTING UNDER TWENTY SHILLINGS TO BUILD.

NEARLY all the amplifiers described for the constructor are for a specific purpose, either for a record player radio or tape-recorder. Again nearly all of them amplify the input to at least 350 milliwatts and do their best to faithfully reproduce the signal but these amplifiers are relatively complicated (at least compared to the design about to be described) and not inexpensive, especially as several use transformers.

The two-transistor amplifier described in this article could hardly be simpler, it certainly isn't Hi-Fi (even using that term in its present adulterated term) and it hasn't much of an output, nevertheless it has plenty of uses. Being very simple and also being capable of being made very small it is ideal for adding to miniature radios and other equipment. With no modifications it is ideal as an audio signal tracer and by adding a detector diode and smoothing capacitor it may also be used as an r.f. signal tracer.

## THE CIRCUIT

The signal is fed to the base of Tr1 via C1, this ensures that whatever the input, the d.c. working conditions of the first transistor are unaffected. The output from Tr1 appears across R2 and is coupled directly to the base of Tr2 and in turn the output appears across the loudspeaker coil. R1 is connected between the collector and base of Tr1 and not only provides the correct working voltage but applies both a.c. and d.c. feedback. To provide the correct working voltage at the emitter of Tr2 a resistor is inserted in the emitter circuit of this transistor as it is conducting all the time a voltage is developed across R3. However the conductivity of Tr2 varies with the signal and so will the voltage, making it necessary to "iron out" the fluctuations, this is done by C2.

By using a speaker of 75Ω impedance an output transformer is unnecessary. Speakers of this impedance are very common in the smaller diameters (2in. etc.).

## CONSTRUCTION

The construction is absolutely straightforward and layout is not at all important, a suggested arrangement is shown in Fig. 2. A volume control is not shown on the board but this could easily be included as could the diode and smoothing capacitor when required as an r.f. signal tracer. The transistors used are an OC71 and an OC81 but almost all germanium P-N-P transistors could be substituted—and have been by the author. An output transistor should be used in place of the OC81 as small signal types can get a bit hot and fail. Only a very small signal is needed at the input to provide an audible output and so by inserting a high value resistor (about 1MΩ) it can be used to trace fairly high impedance signals. ■

## No.1 a two transistor amplifier

### ★ components list

**Resistors:**
R1 120kΩ
R2 4·7kΩ
R3 330Ω
VR1 5kΩ with switch.

**Capacitors:**
C1 5μF
C2 32μF
C3 100μF

Tr1 OC71, Tr2 OC81—see text.
Loudspeaker, 75Ω impedance. Veroboard 1¾ x 1⅜in.
9 volt battery, PP3 etc.

Extra components for r.f. signal tracer, C1, 1,000pF, C2 0·01μF, Diode OA79 etc.

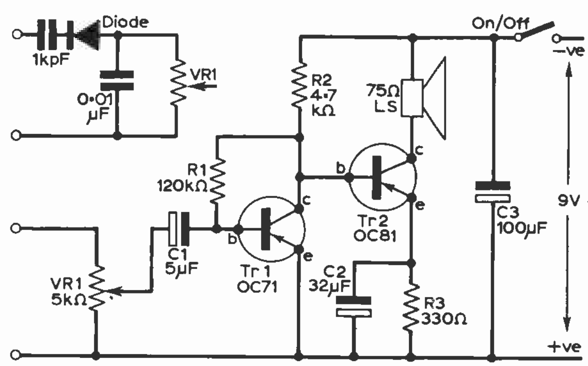



*Fig. 1: The circuit of the two transistor amplifier.*

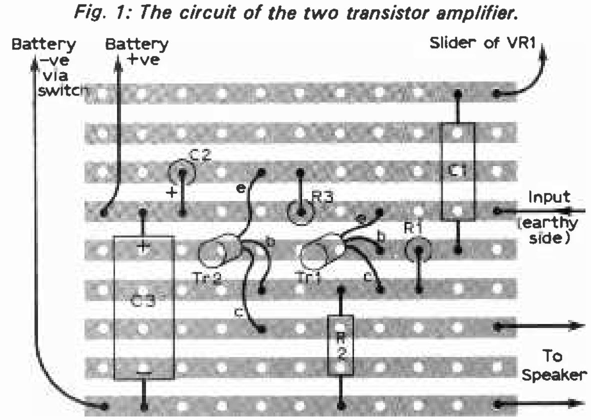



*Fig. 2: The component layout; note that none of the copper strips need be broken.*

# AERIALS

## A. J. WHITTAKER

## PART 2—TRANSMITTER AERIALS *(CONTINUED)*

LAST month we discussed some of the basic principles of the radiation of radio waves from a dipole aerial. In this article we shall continue our investigation by examining the simple dipole and the Marconi quarter-wave aerials.

### Radiation Height

Radiation height depends upon the current distribution in the aerial. It may be approximately linear, or sinusoidal. See Fig. 2.1 below.

The effect is to make the aerial effectively shorter because the amount of power radiated is reduced. In practice the power radiated is indicated by "metre amperes" which is equal to the radiation height multiplied by the r.m.s. current flowing in the aerial wire= $L_r$. I.

The power radiated from a dipole, using $L_r$ in the equation, is given by,

$$P=\frac{320\pi^2 L_r^2 I^2}{\lambda^2} \qquad R_r=\frac{320\pi^2 L_r^2}{\lambda^2}$$

Where,

$L_r$=radiation height=K × physical height

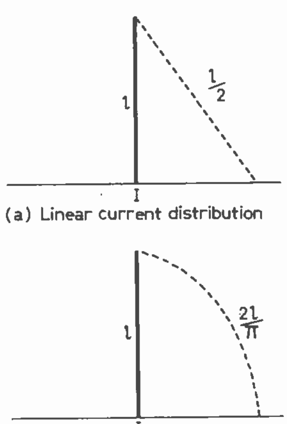
K=aerial form factor (see below)

$\lambda$ is the wavelength in metres.

The radiation resistance of a dipole, $R_r$, may be derived by expressing the physical height in terms of the wavelength $\lambda$ in use. If the dipole height is $\lambda/2$, putting $\lambda=4L$ and $L_r=2L/\pi$ (form factor) we have,

$$R_r=\frac{320\pi^2 4L^2}{16L^2\pi^2}=80 \text{ ohms.}$$

This value is typical for all half wave aerials erected above the ground and provides an empirical rule for estimating radiated power.



(a) Linear current distribution

(b) Sinusoidal current distribution

Fig. 2.1

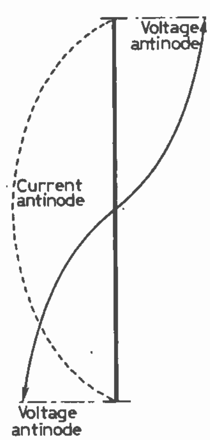


Fig. 2.2

Figure 2.2 below illustrates the voltage and current patterns in a simple dipole aerial. Nodes of voltage or current are points of minimum amplitude. Anti-nodes are points of maximum voltage or current.

The aerial impedance (Z) is the ratio of r.m.s. volts/r.m.s. current at any point and is thus a minimum in the centre, being typically 80 ohms. The aerial system, equivalent to a series resonant circuit, is current fed at the centre, and is said to be excited at its natural or fundamental frequency.

### Marconi Quarter-wave Aerial

The fundamental frequency of the aerial in Fig. 2.3, is four times its physical length. This may be compared with an organ pipe with the top closed, producing a note of four times the length of the pipe.

As there is a current antinode at the base of the aerial, this is a convenient point to fix a current meter. This is usually of the thermocouple type, its purpose being to monitor the aerial current when tuning the system. The aerial is in tune when the meter shows maximum reading.

Figure 2.4 shows the voltage and current wave patterns on a quarter-wave Marconi aerial with a current meter fixed at the current anti-node point.

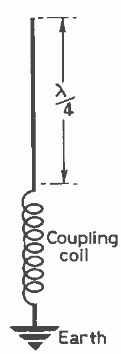


Fig. 2.3

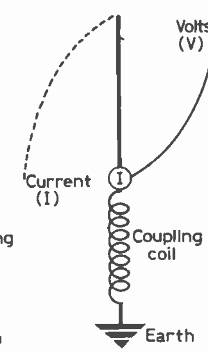


Fig. 2.4

Figure 2.5 shows the radiation pattern from a Marconi quarter-wave aerial. P O $P_1$ represents the earth line and as this is not a perfect conductor, it absorbs energy from the passing wave front causing a forward tilt. This assists the wave to follow the earth's curvature (l.f. waves only, 30–300kc/s).

The power radiated from a Marconi quarter-wave aerial is given by,

$$P=\frac{160\pi L_r I}{\lambda}$$

Again putting $\lambda=4L$ and $L_r=2L/\pi$ (form factor) we have

$$\text{Radiation resistance } R_r=\frac{160\pi^2 4L^2}{16\, L^2\pi^2}$$
$$=40 \text{ ohms.}$$

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# P.W. DOUBLE 12

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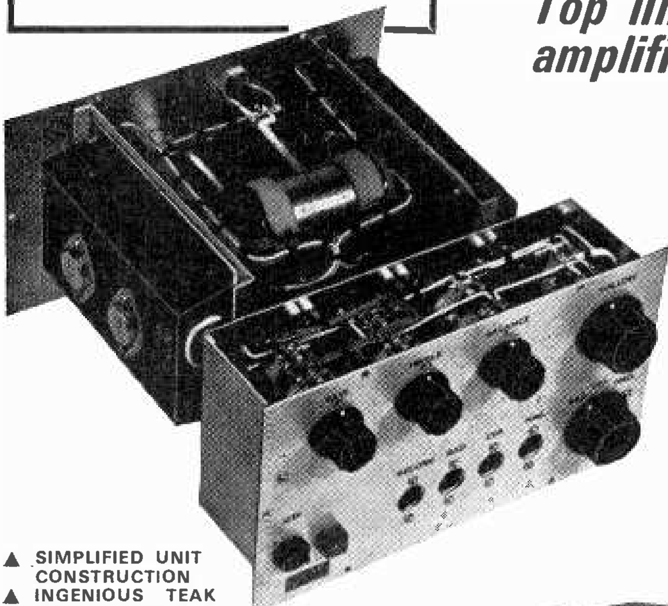

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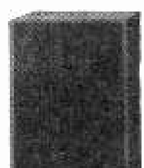

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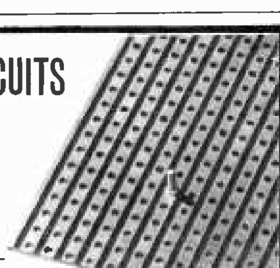

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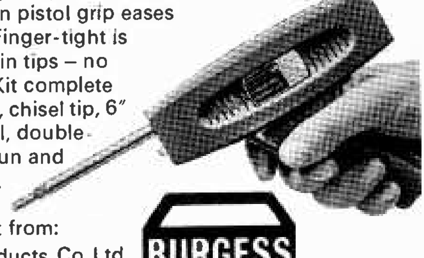

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Where
$L_r$=radiation height=K×physical height (K=form factor).
$R_r$=radiation resistance.

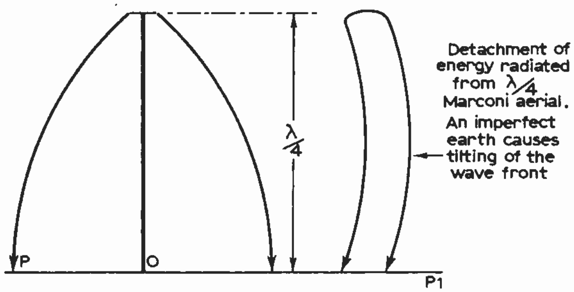


Fig. 2.5

## Image Aerials

Figure 2.6 shows the image of a dipole aerial suspended above the ground on a mast. As in the case of optical reflection from a mirror the effect of the ground in the neighbourhood of the aerial system may be assessed by replacing the ground by an image of the aerial, from which half of the total energy is radiated. The total radiation field is then calculated by assessing the joint field so produced by the aerial and its image.

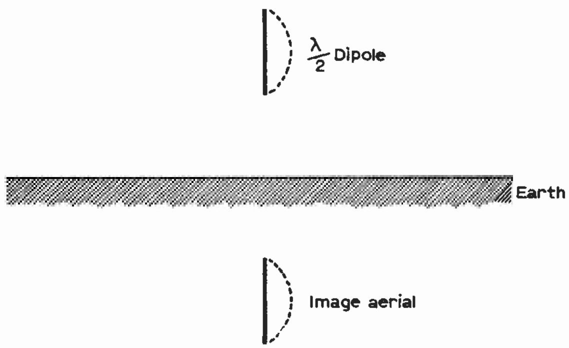


Fig. 2.6

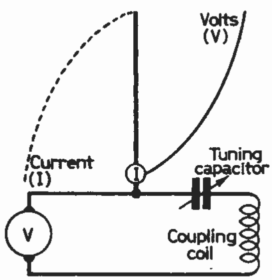


Fig. 2.7

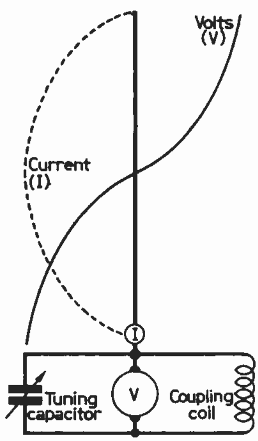


Fig. 2.8

## Aerial Impedance and Tuning Arrangements

The measurement and tuning of a Marconi quarter-wave aerial may be done by fixing volt and ammeters at appropriate points in the circuit. Figure 2.7 shows the general arrangement. The aerial is in tune when the ratio V/I is a minimum. The value of this ratio gives the aerial impedance ($Z_1$) and is typically 40 ohms.

In the case of the half-wave aerial, end fed, the circuit at the feed point is tuned for maximum V/I ratio. This gives the aerial base resistance which is typically 3500 ohms. Figure 2.8 shows the circuit with the voltage and current meters in place.

## Aerial Capacitance

If we add an extension to our quarter-wave aerial and bend this over so as to form an inverted L shape, we will increase the capacitance of the aerial. The parallel or top part of the wire forms an additional capacitor plate. The effect of this is to increase the current flowing in the vertical wire and so increase the effective height. The form of the voltage and current distribution in such an aerial system is given below, Figs. 2.9a and b.

The "T" aerial gives much the same results but is a slightly better radiator and has slight directional properties. Its form is given below, Fig. 2.10b.

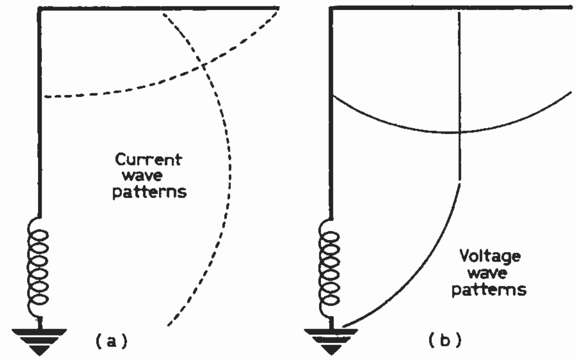


Fig. 2.9

## Aerial Form Factor

Aerial form factor (AFF) refers to T and L shaped aerials where the current distribution in the vertical part is no longer sinusoidal and it is impossible to arrive at an estimate of the power radiated. However, it is possible to arrive at a factor by which the actual height may be multiplied in order to obtain the *effective or radiation height*. This is the AFF given in the tables, which give a good approximation for the effective height for fixed ground stations.

The symbol used for effective or radiation height is $L_r$, and in the case of the dipole, it refers to the mean value of current flowing in the length of the aerial system concerned.

The AFF of the inverted "L" aerial, when the vertical and horizontal members are equal in length, gives a ratio of L/l=1, whence the AFF=0·904 (see table below).

For the "T" aerial the horizontal or top part is twice the length of the vertical part. Figure 2.10 (a and b) shows the general arrangement of the two aerial systems.

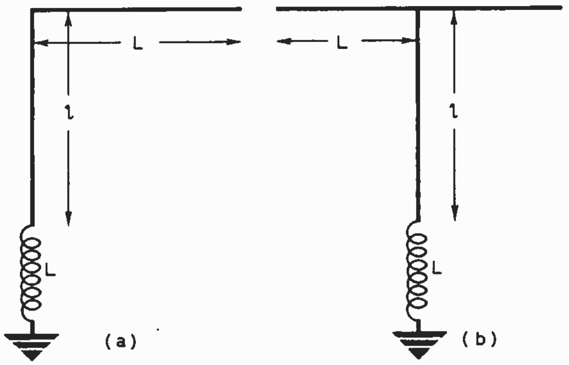


Fig. 2.10

### Table of Aerial Form Factors

| $\frac{L}{l}$ | AFF | $\frac{L}{l}$ | AFF |
|---|---|---|---|
| 0·0 | 0·639 | 1·5 | 0·940 |
| 0·1 | 0·696 | 2·0 | 0·958 |
| 0·2 | 0·741 | 3·0 | 0·979 |
| 0·3 | 0·777 | 4·0 | 0·987 |
| 0·4 | 0·806 | 5·0 | 0·993 |
| 0·5 | 0·830 | 6·0 | 0·996 |
| 0·6 | 0·850 | 7·0 | 0·998 |
| 0·7 | 0·867 | 8·0 | 0·999 |
| 0·8 | 0·881 | 9·0 | 0·999 |
| 0·9 | 0·893 | 10·0 | 1·0 |
| 1·0 | 0·904 | — | — |

### Aerial Capacity

All l.f. (30kc/s–3000kc/s) aerials are of necessity of the large capacity type and they are either of "L" or "T" form or earthed quarter-wave types. This is because (a) radiation resistance ($R_r$) is proportional to the square of the effective height. This is made large by erecting the aerial system as high as possible and by attaching a horizontal member, forming either an "L" or "T" shape, thereby increasing the capacity ($\sigma$) which makes the effective height nearly equal to the actual height. (b) The greater the capacity of the aerial the less inductance will be required to tune the aerial thus lowering the oscillatory potential and the less likely to brush discharge.

To increase the aerial capacity, a number of parallel wires are added in the horizontal plane well separated, usually about 3ft. apart.

The simple Hertzian dipole aerial system and variations thereof are generally used for v.h.f. communication, the range being little more than optical distance depending upon a number of factors, such as aerial height, nature of terrain between transmitter and receiver.

### References

Admiralty Handbook *Wireless Telegraphy*.
*Short Wave Wireless Communication.*

**TO BE CONTINUED**

**PART 3 WILL DESCRIBE DIPOLE AERIALS AND THE CONSTRUCTION OF A V.H.F. F.M. AERIAL**

## CALIBRATION OSCILLATOR

*—continued from page 48*

compare signals from the two sources, and exact tuning of the receiver has no bearing on calibration.

Exact alignment of circuits, or calibration, is best obtained with the modulation off. In these circumstances, the harmonic will be heard as an unmodulated carrier, with the receiver b.f.o. switched on.

With the modulation switch S2 closed, the audio tone will be heard accompanying all harmonics, and this is occasionally useful.

## ★ components list

**Resistors:**

| | | | |
|---|---|---|---|
| R1 | 100kΩ½W | R3 | 3·3kΩ½W |
| R2 | 100kΩ1W | R4 | 470kΩ½W |
| | | R5 | 220kΩ½W |

**Capacitors:**

C1 500pF silver mica
C2 400pF silver mica
C3 150pF silver mica
C4 100pF silver mica
C5 0·01μF 250V
C6 47pF mica
C7 2000pF paper, mica or ceramic
TC1 100pF air spaced variable
TC2 75pF air spaced variable
TC3 75pF air spaced variable

**Miscellaneous:**

R.F.C. Osmor QC1 all-wave r.f. choke; three Type CR22 ½in. dia. formers and cores (Home Radio, Mitcham); T1 Type TIV3 1:3 transformer (Home Radio, Mitcham); ECF80; B9A valveholder; Chassis 4in. x 6½in. x 2in; 5in. x 8in. x 5in. Dinkicase (Electroniques); two-pole three-way rotary switch S1a, b; Four small pointer knobs; Two toggle on/off switches S1, S2; Tagstrip, wire, etc.

When dealing with a superhet whose design or frequency coverage results in strong second channel indications, these can be identified in the usual manner. Avoid swamping or overloading the receiver with the lower order harmonics, as this may give confusing results. To calibrate a v.f.o. or signal generator, tune in the wanted calibration oscillator harmonics on a receiver, tune the v.f.o. or signal generator to zero beat, and mark its scale. ■

## P.W. GUIDE TO COMPONENTS

*—continued from page 45*

Alloy transistors suffer one major drawback and this is due to the alloy process. In the process the base thickness cannot be controlled accurately enough to give very thin base regions. As the frequency response depends largely on this thickness alloy transistors are limited to operation below approximately 10Mc/s.

As a result of this limitation and with the improvement of diffusion techniques the drift transistor was subsequently introduced. This uses the mesa form of construction.

**TO BE CONTINUED**

# CODAR CR.70A

## Communications Receiver 540-10 metres


The Codar CR.70A is an excellent general coverage communications receiver for the keen short wave listener. Very reasonably priced at just £21 the CR.70A is outstanding value for money. In four stable ranges, the receiver covers from 540 metres medium wave, right through the shipping and coastguard frequencies all the short wave and international amateur bands up to and including 10 metres, where the rapidly improving conditions that now prevail allow the regular reception of world-wide call-signs! The CR.70A has a high 'Q' aerial input stage using exclusive CODAR COIL air space inductor. Double tuned, iron cored I.F. transformers produce high selectivity. Ready to plug into 200-250 volt AC mains, the CR.70A needs only your aerial and a 2-3 ohm loudspeaker. The cabinet measures only 13" x 5¾" x 7¾" and the control panel is finished in black and white with chrome trim knobs. Fully guaranteed for 12 months! New model has separate direct output socket for feeding tape recorder, Hi-Fi equipment, etc.

# 20 gns.

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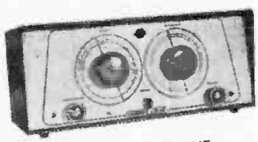

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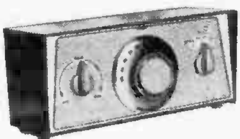

**R.F. PRE-SELECTOR MODEL P.R.30**
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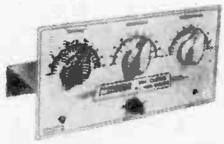

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### PART 2

**GOONHILLY 2—TECHNICAL CHARACTERISTICS**

A brief summary of the general technical characteristics of Goonhilly 2 operating to Intelsat III—F2 is as follows:

**Aerial Gain:** Gain at 4165MHz (TV receive) 60dB; Gain at 6390MHz (TV transmit) 63dB; Beamwidth at 4GHz approximately 11 min. arc; Side lobe level at 6GHz is greater than 33dB lower than main lobe level with 1 degree arc away from main lobe.

**Aerial G/T:** Noise Temperature at 4165MHz and 30° elevation 55 deg. k; G/T at 4165MHz and 30° elevation 42·6dB/deg. k.

**Aerial Tracking:** Aerial steerability (a) Azimuth: 96 deg. 53 min. to 295 deg. 18 min. E. of N. Tracking rate is up to 5 deg./min. (b) Elevation: 0 deg. 14 min. to 43 deg. 55 min. Tracking rate is up to 2·5 deg./min.

Tracking modes: Autotrack, manual velocity, manual position, tape control.

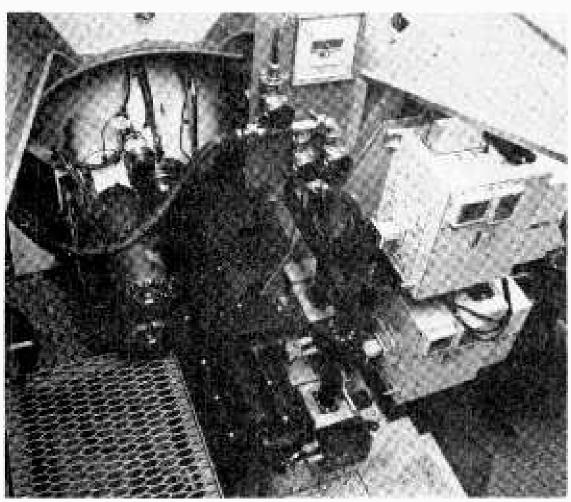
**System Bandwidth:** Nominally 500MHz. (a) Transmit: 5900MHz to 6437MHz; (b) Receive: 3685MHz to 4225MHz.

**Polarisation:** Circular.

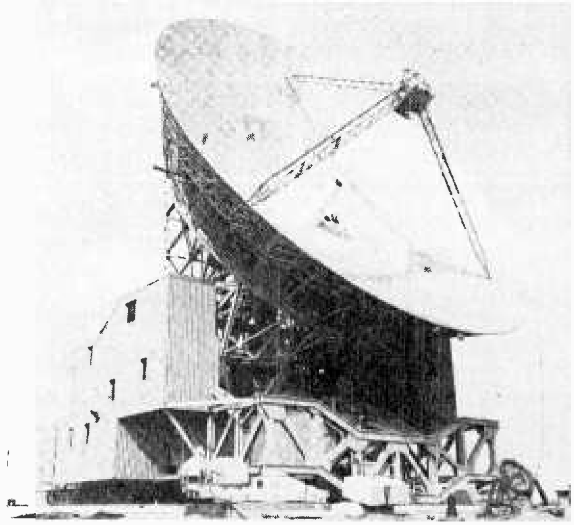
**Equivalent Isotropically Radiated Power:** Up to 93dBW at 6390MHz (TV transmit). This is equivalent to 1kW transmitter output power. Power stability is better than ±0·1dB. Frequency accuracy is generally within 40kHz of nominal at 6GHz.

**Modulation:** Frequency modulation is used throughout. The deviations used are: (a) Television 23MHz peak–peak; (b) Telephony 630kHz rms test tone for 132 channels, 410kHz rms test tone for 60 channels, 250kHz rms test tone for 24 channels.

Normal CCIR pre-emphasis is used for both TV and Telephony.



*First stages of the receiving system, housed in a cabin directly behind the centre of the aerial dish. The two cryogenic enclosures can be seen as white boxes with waveguide network leading to them from aerial horn feed at dish vertex.*



*The No. 2 aerial.*

## *Microwave Link*

A microwave radio link from Goonhilly extends the satellite circuits to the International Telephone Services Centre in London. In the central building at Goonhilly the circuits are rearranged at baseband frequencies into units of 24, 60 or 132 channels as dictated by traffic requirements. Each baseband unit then modulates an intermediate frequency of 70MHz in the modulator section of the equipment provided by GEC-AEI (Electronics) Ltd. Also injected into the circuit at this point are a 60Hz continuity pilot, an energy dispersal signal to restrict the level of intermodulation products during light traffic loading and engineering service channels at sub-baseband frequencies. Intersite coaxial cables transmit the modulated i.f. carriers to the equipment on the aerial, where they are converted individually to their assigned frequencies on the GHz band. All carriers are then combined at low power level before amplification, in two stages, by common wideband travelling-wave-tube amplifiers. The output stage has a maximum capability of 8-10W but in order to restrict the power of unwanted intermodulation products it will not normally be loaded above 1·5W. A second transmitter which serves as a reserve for the telephony system can be used alternatively for television transmissions.

## *Parametric Amplifier*

The very weak signals from the satellite in the 4GHz band are amplified by a three-stage parametric amplifier, cooled in a closed-circuit, gaseous-helium refrigeration system followed by a tunnel-diode amplifier. The four stages have an overall gain of 40dB over the 500MHz band assigned for the down path from the satellite. At the output of the common amplifier the individual carriers are separated by a selective branching network converted in frequency to 70MHz and extended individually by coaxial cables to the feedback demodulators in the main building. Here supervision is effected by monitoring the synchronising pulses.

The main and standby parametric amplifiers are mounted in separate containers inside the low-noise receiver cabin. This cabin has a movable floor which remains horizontal at any aerial altitude and is readily accessible for maintenance. Each container is completely removable for servicing without affecting the other.

## Wideband TWTs

The transmitter uses wideband travelling wave tubes to provide a final peak saturation power output of 10kW, but in normal operation this power is limited to about 1kW to ensure that intermodulation between carriers is virtually eliminated and to avoid overloading the satellite.

The gain of each of the TWT stages is of the order of 30dB throughout the entire civil satellite communications band of 5,952MHz to 6,425MHz.

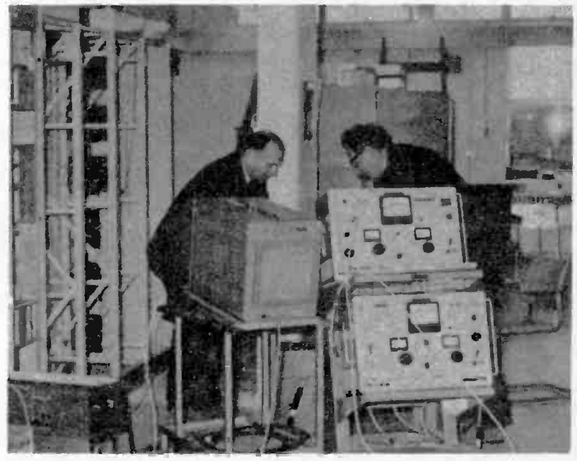
Two TWT amplifier stages are employed in series to provide a high power output capable of transmitting three separate telephony carriers, giving the capacity for up to 400 telephone channels. The standby transmitter can be used simultaneously to provide a television videocarrier and separate sound channels in addition to the telephony channel on the main transmitter.

Extensive provision of switched redundant equipment in the system and the comprehensive control facilities will ensure a high standard of reliability and enable maximum economy of operational manpower to be achieved.

*A logic board—old style and new. 156 of the old ones are equal to the unit held in the technician's right hand. Here the "i.c." comes into its own again.*

*This is the logic equipment for the steering of Aerial No. 2. Technician John Austin is seen here inspecting one of the logic board modules.*

*The consul in the control tower for Aerial No. 1 which can be seen through the window in the background. Visibility is normally better than this but our reporter chose the one day Cornwall had snow for his visit to Goonhilly.*



*Here some of the Station engineers are repairing logic faults on the changeover equipment on the microwave link gear.*

## Satellite tracking

The satellite is tracked using a beacon signal which it transmits itself. The signal from this beacon is separated from the communication carrier signals in the waveguide branching network and fed into the tracking receiver.

The tracking signal itself is derived from the rotation of the horn feed at the vertex of the dish to produce a conical scanning motion of the beam at the beacon frequency only. This conical motion, only 0·4 minutes of arc off centre, produces a modulation of the received beacon signal which reduces to zero when the beam is pointing directly at the satellite.

## Key position

The Goonhilly Downs Post Office Radio Station has played an important part in the experimental and operational phases of satellite communications. With the completion of No. 2 aerial and the further modifications to the No. 1 aerial, it occupies a key position in the world-wide satellite communication network.

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Complete kit inc. cabinet/power pack DIN plugs and socket.
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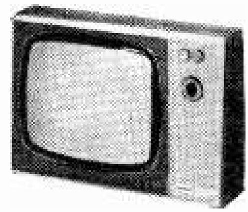

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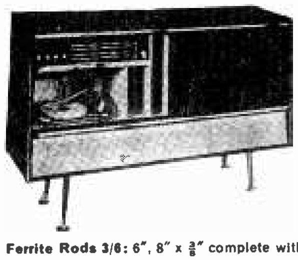

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| 6AT6 | 4/- | 30P19 | 12/- | ECC85 | 5/9 | ME1400 | 15/- | PY33 | 10/- | UY85 | 5/9 |
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| 6BA6 | 4/6 | 30PL13 | 14/6 | ECF80 | 7/- | PABC80 | 7/- | PY82 | 5/3 | VP1321 | 21/- |
| 6BE6 | 4/3 | 30PL14 | 15/- | ECF82 | 6/9 | PC86 | 10/3 | PY83 | 5/9 | Z77 | 3/6 |
| 6BJ6 | 7/- | 35L6GT | 8/- | ECH35 | 6/- | PC88 | 10/3 | PY88 | 6/3 | **Transistors** | |
| 6BW6 | 13/- | 35W4 | 4/6 | ECH42 | 10/6 | PC96 | 8/6 | PY800 | 7/6 | AC107 | 3/6 |
| 6F13 | 3/6 | 35Z4GT | 5/- | ECH81 | 5/9 | PC97 | 8/6 | PY801 | 6/9 | AC127 | 2/- |
| 6F14 | 9/- | 6063 | 12/6 | ECH84 | 7/6 | PC900 | 8/3 | R19 | 6/6 | AD140 | 7/6 |
| 6F23 | 13/6 | AC/VP2 | 10/- | ECL80 | 7/6 | PCC84 | 6/6 | R20 | 12/6 | AF102 | 18/- |
| 6K7G | 2/6 | AZ31 | 9/- | ECL82 | 6/9 | PCC85 | 6/6 | TH21C | 9/9 | AF115 | 3/- |
| 6K8G | 4/3 | B729 | 12/6 | ECL83 | 9/- | PCC88 | 9/9 | U25 | 13/- | AF116 | 3/- |
| 6L18 | 6/- | CCH35 | 10/- | ECL86 | 8/3 | PCC89 | 10/6 | U26 | 12/- | AF117 | 3/3 |
| 6V6GT | 6/6 | CL33 | 18/6 | EF39 | 3/9 | PCC189 | 11/6 | U47 | 13/6 | AF124 | 7/6 |
| 6X4 | 3/6 | CY31 | 6/9 | EF41 | 9/6 | PCF80 | 6/9 | U49 | 13/6 | AF125 | 3/6 |
| 6X5GT | 5/9 | DAC32 | 7/3 | EF80 | 4/9 | PCF82 | 6/- | U52 | 4/6 | AF126 | 7/- |
| 7B6 | 10/9 | DAF91 | 4/3 | EF85 | 5/6 | PCF86 | 9/6 | U78 | 3/6 | AF127 | 3/6 |
| 7B7 | 7/- | DAF96 | 6/6 | EF86 | 6/3 | PCF800 | 13/6 | U191 | 12/6 | OC26 | 5/9 |
| 7C6 | 6/9 | DF33 | 7/9 | EF89 | 5/3 | PCF801 | 7/- | U301 | 13/6 | OC44 | 2/3 |
| 7Y4 | 6/6 | DF91 | 2/9 | EF91 | 3/6 | PCF802 | 9/6 | U801 | 18/- | OC45 | 2/3 |
| 10F1 | 15/- | DF96 | 6/- | EF94 | 4/9 | PCF805 | 9/- | UABC80 | 6/3 | OC71 | 2/6 |
| 10P13 | 15/6 | DH77 | 4/- | EF183 | 6/- | PCF806 | 11/6 | UAF42 | 9/6 | OC72 | 2/6 |
| 12AT7 | 3/9 | DH81 | 10/9 | EF184 | 5/9 | PCF808 | 10/6 | UB41 | 6/6 | OC75 | 2/6 |
| 12AU6 | 4/9 | DK32 | 7/6 | EH90 | 6/9 | PCL82 | 7/- | UBC41 | 8/6 | OC81 | 2/3 |
| 12AU7 | 4/9 | DK91 | 5/6 | EL33 | 8/9 | PCL83 | 9/- | UBC81 | 7/- | OC81D | 2/3 |
| 12AX7 | 4/9 | DK92 | 9/3 | EL34 | 9/6 | PCL84 | 7/6 | UBF80 | 6/- | OC82 | 2/3 |
| 12K8GT | 7/- | DK96 | 7/- | EL41 | 10/6 | PCL85 | 9/- | UBF89 | 6/9 | OC82D | 2/6 |
| 19BG6G | 17/6 | DL35 | 5/- | EL84 | 4/9 | PCL86 | 8/6 | UC92 | 5/- | OC170 | 2/6 |

# READERS RADIO

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# EXPERIMENTERS CORNER

## AN INTEGRATED CIRCUIT STEREO AMPLIFIER

L. McNAMARA B.Sc.

THE G.E. (USA) audio amplifier I.C. type PA 222 was introduced to readers of this magazine in the article by A. J. McEvoy in the August 1968 issue, page 260. On that occasion the writer centred his attention on the circuitry of the unit, describing in detail the technical design features. It is now proposed to report on a fully developed practical application of this interesting component, a stereo amplifier with one PA222 in each channel.

The amplifier is intended for use on batteries (e.g. two PP9s in series, giving 18V) and to accept the signal from a crystal type gram pickup. That application implies a high-impedance input to the amplifier, and therefore a special preamp. stage before each PA222. (If the earlier article is consulted, it will be noted that the PA222 alone was found perfectly adequate for use from a medium-impedance source, or with a radio tuner; however, a matching stage is essential with a high-impedance source.)

In the prototype it was decided to employ an integrated circuit in the preamp. stage also, so that the complete project would be as up to date as possible, a true reflection of the state of the art as available to the amateur constructor in 1969.

A suitable I.C. for this application was found in the R.C.A. CA3036, which observant readers will identify as a development of the four transistor CA3018, introduced in the June 1968 issue of PRACTICAL WIRELESS.

### The theory in brief

Since the theory of operation of each of the types of I.C. incorporated in this project has been dealt with in detail recently, only a brief résumé will be given for the benefit of new readers. First, the CA 3036. Assembled, like all monolithic I.C.s to date, on a silicon substratum, this unit is a variant of the CA3018 in that the four transistors are employed as two "super alpha pairs". It is common knowledge that this configuration implies a very high input impedance. Better still, the lower output impedance of the unit matches closely the requirements of the common emitter stage which forms the input element of the PA222.

It is worth noting an advantage of the CA3036 in this particular application (see Fig. 1) since both transistor pairs are formed simultaneously by the same process in the same crystal of silicon, it follows that they must be perfectly matched, to an accuracy much higher than is easily obtained with discrete transistors. The advantage in a stereo preamplifier, where one pair acts for each channel, is obvious. Similarly, the PA222s are manufactured under closely controlled conditions, so that as long as similar loudspeakers are used in the audio system, a balance control may be omitted.

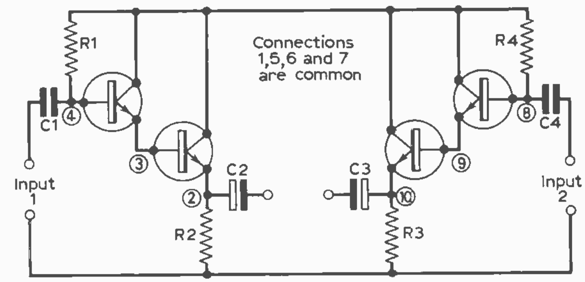



*Fig. 1: The circuit associated with the pre-amplifier. The four transistors are in the I.C. CA3036.*

The PA222 is a 1-watt audio amplifier housed in an 8-lead dual in-line epoxy package, and fitted to a heatsink tab to increase the permissible dissipation of the output transistors. For a full understanding of the operation of the unit it is advisable to consult the previous article, but the basic outline is quite simple.

In Fig. 2 it can be seen that Tr1 is a conventional common emitter amplifier, directly coupled to the phase splitter Tr2. Careful examination of the transistor pairs Tr4 and Tr5, and Tr3 and Tr6 will reveal the essential symmetry in their operation. Receiving opposite phases of the audio signal from the phase splitter, they amplify in class B as super alpha pairs in series connected single ended push-pull. There is then a high power, low impedance signal appearing at the emitter of Tr5, matching into a 25Ω loudspeaker. The diode serves to limit crossover distortion, and a.c. and d.c. feedback systems are provided.

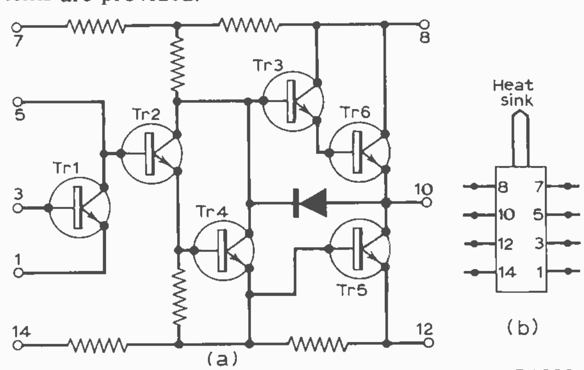



*Fig. 2: (a) The internal circuit of the output stage PA222. (b) The connections to the I.C. package.*

A complete stereo system requires not only high gain with matching to signal source and loudspeaker with symmetry between the two channels, but also tone and volume controls to match the characteristics of the system to the tastes of the listener. All these elements are incorporated in the block diagram of the system, Fig. 3. It will be observed that the CA3036 preamplifier stage, which requires a power supply of 9V, is connected to the battery through a voltage dropper resistor.

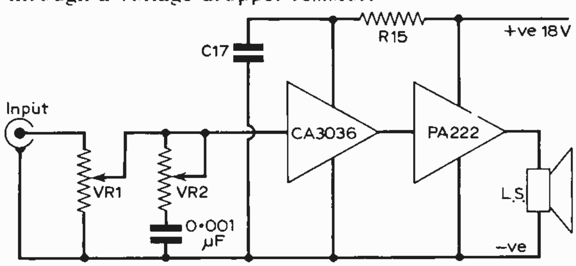



*Fig. 3: Block diagram of each channel.*

This component, with the associated capacitor C17, also serves to decouple the preamplifier from any variation in the voltage supply or audio leakage on the h.t. line; these effects could be quite marked otherwise, as there will be a considerable dependence of current consumption on volume level due to the class B mode of operation of the amplifier. Mention has already been made of the possible omission of a balance control on this amplifier, due to the high degree of symmetry between the two channels. Only one component may differ between the two, and that is the resistor in the collector circuit of the first transistor in each PA222, between pins 5 and 7 on the package.

This component is specified by the manufacturer on the basis of tests during manufacture, to choose the optimum operating conditions for the individual component. Since all the transistors in a PA222 are direct coupled, this resistor sets the currents drawn by each of them, and hence the whole operating conditions of the amplifier channel. Use of the appropriate value will ensure equal performance from each channel. The resistor will be 68kΩ, 100kΩ or 150kΩ, the value recommended is stamped on the epoxy shell.

Nonetheless it would be better if two PA222s could be obtained for which the same value is specified. In that case the channels will be completely identical from pick up cartridge to loudspeaker, so that a balance control to equalise the outputs should be unnecessary. Should one be

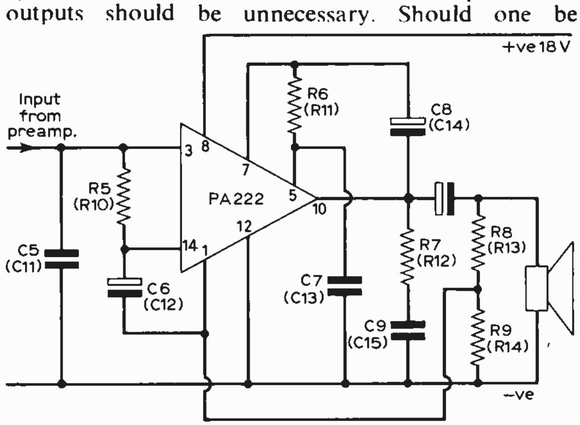



*Fig. 4: The circuitry associated with each output stage. The component numbers in brackets refer to the other channel. The unmarked capacitor between Pin 10 and the loudspeaker is C10 (16).*

desired, though, it may take the form of a 5kΩ linear potentiometer, preferably wirewound, replacing R2 and R3 in the preamp. section. The slider should be earthed, while the other two are joined to the emitters of the transistors of the super alpha pair through 1.5kΩ resistors. Since the output of the preamp. is developed across these emitter resistors, a variation in the ratio of the two emitter resistors implies a variation in the relative amplitudes of the signals developed across them, and hence a "balance control" effect.

Since the completed unit can be made very small, mounting in a record player or other system should pose no difficulties; however, in view of the high input impedance, the same precautions as are employed with valve amplifiers are advisable to minimise hum pickup. Whereas a low impedance transistor amplifier can be used with quite long runs of unscreened cable without difficulty, it is advisable in this case to use screened leads from volume and tone controls if the amplifier is to be more than a few inches from the controls.

The constructor who completes this project can be satisfied that it is one of the most up-to-date devices available in terms of the components used; and further he will notice one of the chief advantages of the integrated circuit, that it permits the assembly of quite complex systems with the maximum assurance of success, since all active elements are carefully matched by the manufacturer, with close adherence to specifications. The variations, with resultant openings for malfunctions, which are associated with a similar project using discrete components, are all but eliminated. In short, commercial standards of quality control are assured, yet the constructor can still say: "I built it myself." ■

## ★ components list

**Resistors:**

| | |
|---|---|
| R1 2·2MΩ | R9 10Ω |
| R2 4·7kΩ | R10 10Ω |
| R3 4·7kΩ | R11 See text |
| R4 2·2MΩ | R12 22Ω |
| R5 22kΩ | R13 180Ω |
| R6 See text | R14 10Ω |
| R7 22Ω | R15 8·2kΩ |
| R8 180Ω | |

VR1 3MΩ log. twin gang. VR2 1MΩ lin. twin gang. (See text for balance control; R2 and R3 are 1·5kΩ with a 5kΩ linear wirewound potentiometer.)

**Capacitors:**

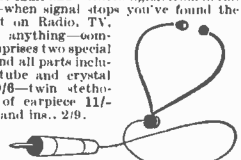
| | |
|---|---|
| C1 0·04μF | C10 125μF |
| C2 10μF | C11 0·001μF |
| C3 10μF | C12 10μF |
| C4 0·04μF | C13 0·001μF |
| C5 0·001μF | C14 10μF |
| C6 10μF | C15 0·001μF |
| C7 0·001μF | C16 125μF |
| C8 10μF | C17 1000μF |
| C9 0·001μF | |

**Miscellaneous:**

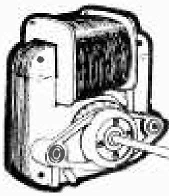
IC 1 CA3036, R.C.A. } Available from
IC 2 and 3 PA222, G.E.(USA) } Henry's Radio
Loudspeakers, two identical, 25Ω impedance. On/off switch, printed circuit board, wire, etc.

## RADIO STETHOSCOPE

**Easiest way to fault find**—traces signal from aerial to speaker—when signal stops you've found the fault. Use it on Radio, TV, amplifier, anything—complete kit comprises two special transistors and all parts including probe tube and crystal earpiece. **29/6**—twin stethoset instead of earpiece **11/-** extra—post and ins., 2/9.



## MAINS MOTOR

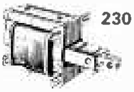


Precision made — as used in record decks and tape recorders—ideal also for extractor fans, blower, heater, etc. New and perfect. **Snip at 9/6.** Postage 3/- for first one then 1/- for each one ordered. 12 and over post free.

## ROTISSERIE MOTOR

Very powerful 7 r.p.m., operates from standard A.C. mains. **29/6.** plus 3/6 P. & P.

## 230 VOLT SOLENOID

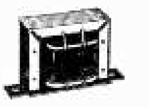


$\frac{3}{4}$in. stroke. Size $2\frac{3}{4}$in. × 2in. × $1\frac{3}{4}$in. **14/6.** postage 2/9.

## SNIPERSCOPE


Famous war-time "cat's eye" used for seeing in the dark. This is an infra-red image converter cell with a silver caesium screen which lights up (like a cathode ray tube) when the electrons released by the infra-red strike it. A golden opportunity for some interesting experiments. **7/6** each, post 2/6. Data will be supplied with cells, if requested.

## MAINS TRANSFORMER SNIP



Making a power pack for amplifier or other equipment? These transformers have normal mains primaries (230/40 v.) and isolated secondaries two types (1) 12 v. 500 mA. at **8/6**; (2) 15 v. 500 mA. at **8/6.**

## SPRING COIL LEADS

as fitted to telephones, 4 core **2/6** each, 3 core **2/-** each.

**PP3 ELIMINATOR.** Play your pocket radio from the mains! save £s. Complete component kit comprises 4 rectifiers—mains dropper resistances, smoothing condenser and instructions, only **6/6** plus 1/- post.

## AC FAN

Small but very powerful mains motor with $6\frac{1}{2}$in. blades. Ideal for cooling equipment or as extractor. Silent but very efficient. **17/6.** post 4/6. Mounts from back or front with 4BA screws.

## TRANSISTOR SET CASE

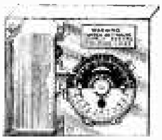
Very modern cream cabinet, size $5\frac{1}{4} \times 3 \times 1\frac{1}{2}$in. with chrome handle, tuning knob and scale. Price **4/6** plus 2/- postage. Printed circuit board for this case **2/6.**

**SOIL WARMING ELEMENT.** 30 yards, heavy PVC covering. **12/6.**

### MAINS TRANSISTOR POWER PACK

Designed to operate transistor sets and amplifiers. Adjustable output 6v., 9v., 12 volts for up to 500mA (class B working). Takes the place of any of the following batteries: PP1, PP3, PP4, PP6, PP7, PP9, and others. Kit comprises: mains transformer rectifier, smoothing and load resistor, condensers and instructions. Real snip at only **16/6.** plus 3/6 postage.

## ELECTRIC TIME SWITCH



Made by Smiths these are AC mains operated, NOT CLOCKWORK ideal for mounting on rack or shelf or can be built into box with 13A socket. 2 completely adjustable time periods per 24 hours, 5 amp changeover contacts will switch circuit on or off during these periods. **59/6.** post and ins. 4/6. Additional time contacts 10/- pair.

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Will dim fluorescent or incandescent lighting up to 600 watts from full brilliance to out. Fitted on M.K. flush plate, same size and fixing as standard wall switch so may be fitted in place of this, or mount on surface. Price complete in heavy plastic box with control knob **£3.19.6.**

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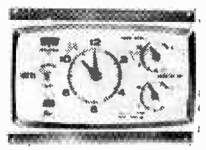
3·6V 500mA size $1\frac{1}{2} \times 1\frac{1}{4}$in. dia. type ref. DKZ500 really powerful will deliver 1 amp for $\frac{1}{2}$ hour. Regular price 32/6 our price **16/6** each. New and guaranteed. Other voltages available, single cell 1·2V **6/6.** 5 cell 6V **29/6.**

## ELECTRIC CLOCK WITH 20 AMP SWITCH



Made by Smith's these units are as fitted to many top quality cookers to control the oven. The clock is mains driven and frequency controlled so it is extremely accurate. The two small dials enable switch on and off times to be accurately set—also on the left is another timer or alarm—this may be set in minutes up to 4 hours. At the end of the period a bell will sound. Ideal for switching on tape recorders. Offered at only a fraction of the regular price—new and unused only **45/-**, less than the value of the clock alone—post and insurance 2/9.

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### Recording Tape

Quadruple tape on 3in. spool giving 600ft. Of the finest quality by very famous maker. Especially suitable for message tapes and portable equipment. Regular price 30/- per spool. Our price **7/6** plus 2/9 p. & p. or 3 for **22/6** post paid.

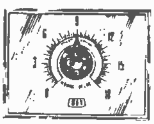
## HI FI BARGAIN

**FULL FI 12 INCH LOUDSPEAKER.** This is undoubtedly one of the finest loudspeakers that we have ever offered, produced by one of the country's most famous makers. It has a die-cast metal frame and is strongly recommended for Hi-Fi load and Rhythm Guitar and public address.
Flux Density 11,000 gauss—Total Flux 44,000 Maxwells—Power Handling 15 watts R.M.S. Cone Moulded fibre—Freq. response 30-10,000 c.p.s.—specify 3 or 15 ohms—Main resonance 60 c.p.s.—Chassis Diam. 12in.—$12\frac{3}{8}$in. over mounting lugs—Baffle hole 11in. Diam.—Mounting holes 4, holes—$\frac{1}{4}$in. diam. on pitch circle $11\frac{5}{8}$in. diam.—Overall height $5\frac{1}{8}$in. A £6 speaker offered for only **£3.9.6** plus 7/6 p. & p. Don't miss this offer. **15in. 30 watt £7.19.6.**

## DRILL CONTROLLER


Electronically changes speed from approximately 10 revs. to maximum. Full power at all speeds by finger-tip control. Kit includes all parts, case, everything and full instructions. **19/6** plus 2/6 post and insurance. Or available made up **29/6.** plus 2/6 post.

## PROCESS TIME CONTROLLER



Made by Smiths, motorised and mains driven, enables 15A circuit to be started up to 18 hours in advance and to stay on for a period from 15 minutes to 3 hours. Totally enclosed in metal box with glass front and chrome surround. **49/6** plus 4/6 post and ins.

## MAINS TRANSISTOR POWER PACK

Designed to operate transistor sets and amplifiers. Adjustable output 6v., 9v., 12 volts for up to 500mA (class B working). Takes the place of any of the following batteries: PP1, PP3, PP4, PP6, PP7, PP9, and others. Kit comprises mains transformer rectifier, smoothing and load resistor, condensers and instructions. Real snip at only **16/6.** plus 3/6 postage.

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Suitable for dozens of different applications, such as burglar alarms, conveyor belt switching. These are simply glass encased switches which can be operated by a passing permanent magnet coil. A special buy enables us to offer these at **2/6** each, or **24/-** a dozen. Suitable magnets are **1/-** each.

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**Multi Purpose Neon Test Unit.** Robust, useful and instructive, tests insulation, capacity, continuity, resistor, volume controls, also acts as signal injector and L.T. fault finder, kit comprises neon indicator, 4-way wafer switch, ebonite tubes, resistors-condensers, terminals etc., with diagram, only **9/6.** plus 2/- post and insurance.

**Tuning Condenser.** solid di-electric ·0005mfd. variable **2/6** each, **24/-** dozen.

**A.E.I. Fractional H.P. Motor.** 200/250 v. 50/60 c.p.s. enclosed, continuous rating 1/40 h.p., ex. equip. Perfect order, **19/6.** plus 4/6.

**Experimenting with ultra violet?** Philips U.V. lamp, **16/6**; holder and control gear **19/6.**

**G.E.C. Black Light Tube** for experiments and special lighting effects—40 watt 2ft. tubes only. **14/6** each; holders and control gear, **19/6.** plus 4/6 post.

**Clock Motor.** 230v. 50 c.p.s. synchronous—self starting. **6/6.**

**Pentode Output Transformer.** Standard size, 40-1, ex-equipment but OK, **4/3** each. **48/-** doz. Post paid.

**E.H.T. Condenser.** 0·1 mfd. 5 kV. **8/6** each.

**Neon Mains Tester. 1/3** each. **12/-** doz.

**Flood Lamp Control.** Our dim and full switch is ideal for controlling photo flood lamps; it gives two lamps in series, two lamps full brilliance and lamps off. Similar control of other appliances can be arranged where used in pair or where circuit can be split exactly in half. Technically the switch is known as a double-pole change over with off. Our price **4/6.**

**Sub-Miniature Silicon Diodes.** General purpose type with gold-plated leads. **1/-** each or **7/6** per dozen.

**Message Tapes.** 225ft. Tape on 3in. spools normally 4.6 each, we offer 4 tapes for **12/6.**

**White Circular Flex.** Ideal for lighting drops, twin made by BICC. Usually 8d. yd., 100 yd. coil for **30/-**, plus 6/- postage.

**Edgewise Control.** Morganite, as fitted many transistor radios. 2K or 5K with switch, **2/6** each or **24/-** per dozen.

**12V Inverter.** Full transistorised for operating a 20-watt fluorescent tube, size 6in. long × $1\frac{1}{2}$ × $1\frac{1}{2}$. **£3.10.0.** Post and insurance 3/-.

**Silicon Rectifier.** Equiv. BY100 750mA 400V., 10 for **20/-.**

**Miniature Pickup** for 7in. records made by Cosmocode, crystal cartridge with sapphire stylus only **3/9** or 36/- dozen.

**Headphones.** Ex W.D. unused and perfect, low resistance. Single with headband **4/6.** Double with headband **8/6.**

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**Compression Trimmers.** Twin 100pF, **1/-** each; 9/- per dozen

**3in. PM Loudspeakers.** 3 ohm, **12/6**; 80 ohm, **13/6.**

**Rotary Cam Operated Switch.** 12 positions each of which close a separate pair of contacts except the last which leaves them all open. Contacts rated at 250V 16 amps. **15/-** each.

**Rotary Cam Operated Switch.** 4 positions: 1st position all contacts open; 2nd contact 1 closed; 3rd contacts 1 and 2 closed; 4th contacts 1, 2 and 3 closed. Contact rated 250V 16 amps, **8/6** each.

**Pocket Test Meter,** measures AC volts (3 ranges), DC Volts (3 ranges), ohms, milli amps, ideal to carry around. Complete with instructions and test prods. **39/6** plus 2/6 p. & p.

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**50 ohm 50 watt Wire Wound Pot-meters. 8/6** each.

**1 Meg Miniature.** Pot-meter Morganite standard $\frac{1}{4}$in. spindle **1/-** each; **9/-** per dozen.

**1 Meg Miniature.** Pot-meter Morganite preset screwdriver control. **9d.** each; **8/-** per dozen.

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# LETTERS...

*The Editor does not necessarily endorse the views expressed by correspondents.*

## My mistake

I was very surprised that my letter was so badly taken, but I realise that this was due to my being very ambiguous. I apologise to Mr. Parkinson, Mr. Thompson and Mr. Kojminihi for misleading them, but I must thank Mr. K. Smith for his obvious understanding of the matter.

I have every intention of getting a full licence, but unfortunately I did not take the wise course used by G3XJB, that of getting his Ticket before taking his "O" Levels (may I wish him and all the rest of us who may be concerned the very best of luck in the exams), but I sincerely hope to alter this soon, and hope to take the RAE next summer. If I pass I sincerely hope he will NOT remove his PA valve as he threatens.

As Mr. Smith so accurately puts it (ESP?) our headmaster has a strong tendency to put school studies "next to God" (several of my friends had been "advised" to discontinue their extra curricular studies, lest it interfere with their work, and lessen their chances of success in the summer), and our Physics teachers weren't over-enthusiastic about the idea of starting an Amateur Radio Club, although they are willing to give us whatever help they can. It is at such places that I consider the Novices' Licence would be of very great use, as the club can be operated during the lunch hour and after school, and as such is a perennial project.

Pupils who would not otherwise have the opportunity of experiencing Amateur Radio at its best can do so, and by adding a few suitable rules, e.g. make the Morse test compulsory for all people wanting to transmit, it should be possible to sort the "weeds from the flowers". Also, as the RAE is basically a cross between the "O" and "A" levels in Physics, I see no reason why the pupils should not get their Ticket gradually. It is also my firm belief that the one subject complements the other, which is why I consider Amateur Radio to be a hobby with many useful "side-effects".

I am therefore wholly in favour of the Novices' licence, or anything similar, if it is used in this way. I do NOT think that it should be run on the same lines as the "great" American Citizens Band.—**C. Williams A5376** (*Staffordshire*).

## "AA" licence

I note that the argument(s) about the once proposed "Beginner's" Licence still goes on. I have once put it to you that a return to the pre-war "Artificial Aerial" Licence would be a good thing and you were kind enough to reply saying that you had already approached the then PMG on this subject with little avail. May I now suggest that a "Beginner's" Licence could take the same form as that as for a Driving Licence? If an enthusiast who, although capable of constructing a Tx but is not yet ready for the RAE could enroll the aid (either through his club or otherwise) of a licensed "Ham" to watch over him whilst working the rig then the problem would become easier. I have personally constructed a 40 watt rig and three friends with current licences are all prepared to work it "Stroke A". This means that when (or IF) I get a ticket I shall have all the "gen" at my finger tips. The "L" driver, if he fails his first test goes on until he does pass. Why not in radio?

I should make it quite clear that although I have built a Tx it is not ready to go on the air—this contravenes GPO regulations, or so I believe.—**H. W. Boyett, BRS 30526** (*Sussex*)

## Nothing false about this

Reading through previous copies of PRACTICAL WIRELESS I came across, in the Amateur Bands column, a note about false logs. Mr. Gibson also mentioned a report received on something like an OC71 into three OC72s being impossible.

I obtain good reception of the Amateurs with my receiver which is a crystal set into a one-transistor amplifier stage into a four-stage amplifier. To crown it, I use a Band III television aerial and the central heating system as an earth.—**B. Beord** (*Hampshire*).

## An appeal

I would like to appeal for copies (no matter how old) of PRACTICAL WIRELESS, *Practical Electronics* and any other radio magazines for use by children in the Nunthorpe County Modern School, Middlesbrough.

I am sure that many readers will be pleased to encourage this interest and hope the children will receive as much enjoyment from reading the old magazines as their original owners did when they were new.—**G. M. Bartram,** Head of Science Department (*Nunthorpe County Modern School, Middlesbrough*).

## From the Opposition Benches

I am heartily sick of reading letters from people who want transmitting licences without the trouble of taking a Morse test, and would like to express an opinion from the Opposition Benches.

Far from abolishing this test, the required speed should be raised to 20 w.p.m. for, as you are well aware, the issue of a licence is not only for one's pleasure but also to enable one to train oneself to become a radio operator in the service of his country should a national emergency arise.

The crowd of "Big Jessies" who natter on for hours on the mike and never touch a key once they have got their ticket are doing nothing at all towards this end for if "telephonists" are ever required in a hurry, female voices are far more suitable for this purpose and furthermore, women could be trained to do the job in a matter of hours.

I would like to see telephony of all kinds totally abolished from 15, 20, 40 and 80m and restricted to 70cms, 2m, 10 and 160m only. This would not only leave the DX bands clear for the *real* radio operators but might also solve the problem of non-activity on 70cms and 2m and prevent these being taken from us for that reason.—**W. Morris, G4HU** (*Cheshire*).

## An old friend

I was looking through some old pre-war radio magazines and QSLs the other day, when I came across a photograph of BRS 1724 and his short wave outfit. I guess the picture was taken between 1932 and 1934. It has the name F. C. Holwill, Dartmouth, impressed on the bottom of it (I expect this is the name of the photographer).

I should like to locate BRS 1724 if possible and send the photograph to him as he might be interested in it.—**F. G. Sadler** (19 *Kithurst Crescent, Goring-by-Sea, Sussex*).

# LETTERS...

The Editor does not necessarily endorse the views expressed by correspondents.

## The fictitious "hole"

While I thoroughly appreciate B. R. Meredith's predicament concerning the fictitious "hole", (P.W. March 1969), might I suggest that it stems from our inability to sufficiently express abstract ideas in our all-too-concrete language. To start with, the concept of energy moving and expressing mass is impossible to conceive in anything but mathematical reasoning. So we build up a theory of particles we can hold in our imagination. It is easy to think of orbits each capable of maintaining fixed energy levels, which when filled constitute a perfect electrical balance. (Where our "concrete" particle is, three dimensionally, during its transit from one orbit to another when it radiates or absorbs its quantum of energy is just as hard to understand as our "hole". Does it momentarily cease to exist in our space, or is it a fault inherent in the picture.) It is when this balance of charges is disturbed that we experience electrical phenomena. The presence of extra electrons we choose to call a negative charge. Extra gaps appearing in an orbit we call positive.

We find no difficulty discussing a hole in our bank balance as an overdraft, making it a tangible reality. Negative figures in everyday life are added together or moved from one record to another with such ease that no one needs to explain the movement of these deficiencies.

When the particle has been classified as a negative though, by reasoning, its deficiency, a minus negative, can only become positive. The fault of reasoning is therefore one of nomenclature. Were electrons classified as positive, their deficiencies, or "holes" would be negative and no one need ever make the mistake of imagining they are "nothings which are current carriers".—**L. G. A. Green** (*Peterborough*).

## Ouch!

I am writing to ask whether or not it is possible to publish articles of a more intellectual nature in both your PRACTICAL WIRELESS and *Practical Electronics* magazines. Do you have to treat all your readers like blithering idiots, because I am sure a child with an IQ of minus 2 could understand your magazine in its present form.

I am sorry to be so blunt, but it seems to me that all your articles are of a descriptive nature, why? I can only conclude by saying that I think that one of your authors in a recent issue has just guessed the values of the components used in his *simple* circuit.

I appreciate the fact that these magazines are for the Practical application of electronics as the names suggest, but this does not mean "spoon-feeding" the readers.—**M. Floyd** (*Berks.*)

[*Really, Mr. Floyd! Fancy associating with* −2 *IQ morons by reading* P.W. *If you want the intellectual stuff try* The New Statesman.—*Editor.*]

## Hello, hello, hello!

Reference G3WVR and his echo effects on the air.

It seems to me that the average Amateur of today forgets two things as quickly as possible once he has obtained his licence. First, Licence Conditions, and secondly c.w. The latter is understandable the former unforgivable.

If this "Wet behind the ears" Amateur requires to experiment in this manner I suggest that he gives up the idea of ever becoming an Amateur, throws away that B.Sc., lets his hair grow, takes drugs, and joins one of those ill-mannered "groups", who, I feel sure, will appreciate his efforts to produce peculiar sounds. Those of us who can still carry out experiments in the true sense, and have long and enjoyable QSOs (both on the key and mic.) have no time for this type in our ranks.—**B. J. Clark, G3BEC** (*Hon. President, Yeovil Amateur Radio Club*).

## All you need is willpower

Having followed with interest the "battle" in your columns between those advocating a "Beginner's Licence" and their critics, I feel I should offer my opinion. I am one of the many schools' pupils who are about to sit "O" Level Examinations: consequently it is necessary that I revise as much as five years' work. Nevertheless I have found adequate time to pass the RAE and the GPO Morse test—with which I might add that I am all in favour—and take out an Amateur Sound Licence (A), while keeping up a fairly reasonable standard both at school, and at various out-of-school activities. Living in "the wilds" as I do, I have been unable to join a radio club and benefit from its advice and guidance. My studies for the RAE were therefore with the aid of the usual text-books, and also occasional visits to an experienced and very helpful Amateur.

Armed with a licence, then, I began hesitantly to operate—and ran into most of the well-known problems—TVI, aerial loading, shortage of cash, to mention but a few, and above all, inexperience. However, having solved some of these, I made my first contacts on c.w. I believe that were it not for the compulsory Morse test, many people would ignore c.w. as a mode of transmission, and in doing so completely sacrifice an efficient, simple, interesting, and—most important—cheap means of communication.

In my experience, limited though it may be, there should be no reason why someone with sufficient will power and enthusiasm should not pass with relative ease the RAE and the GPO Morse test, even when bound by inevitable commitments and examinations.

I think Amateur Radio is a marvellous hobby. It is one of the few pastimes which is enjoyable, relaxing and yet educational in so many ways.—**D. M. Holburn—15 G3XZP** (*Wolsingham, Co. Durham*)

[*We must now close the subject of the Beginner's Licence, so no more letters on that subject please.—Editor*]

## Stop press

The author of the article "A Six Transistor F.M. Tuner," part 2 of which appeared in the March issue, has asked us to publish this additional note on alignment:

In isolated cases the tolerance of the capacitors in the oscillator tuned circuit may be such that some difficulty may be found in tuning the l.f. end (Radio 2) owing to insufficient capacitance. The simple way to overcome this is to increase the inductance of L4 by screwing in a dust iron core. The core should be made vibration proof by using either a core locking compound, or a thin piece of rubber band screwed in with the core.

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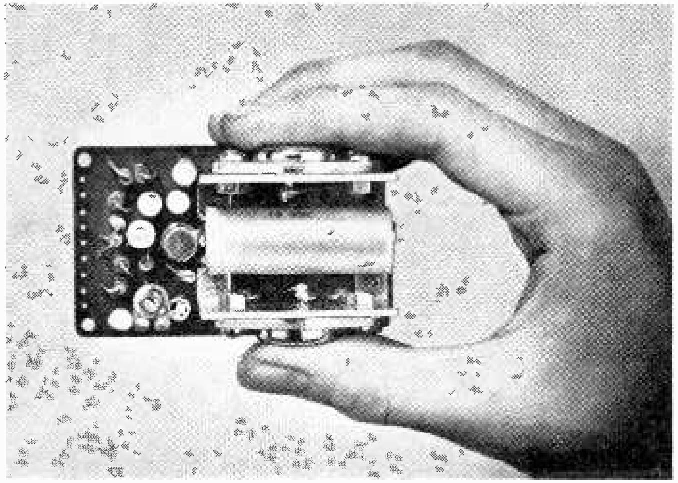

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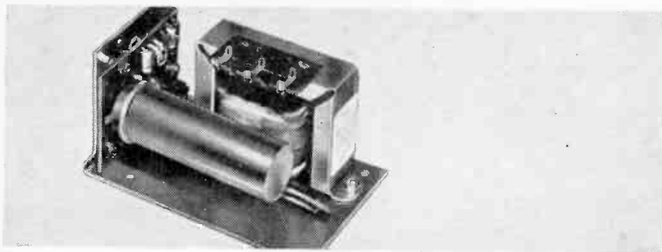

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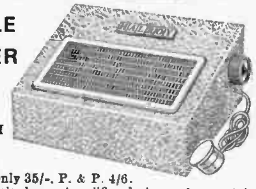

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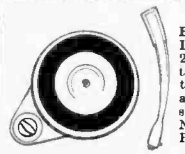

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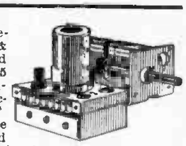

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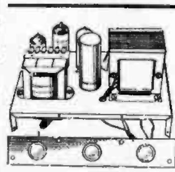

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Set of Mullard 6 transistors OC44, 2—OC45, AC128D, matched pair AC128 25/-; Mullard LFH3 Audio Transistor Pack AC128D and matched pair AC128 12/6; ORP12 Cadmium Sulphide Cells 10/6. All post free.

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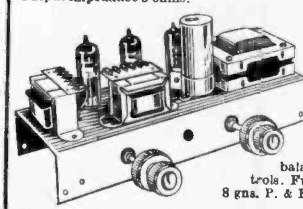
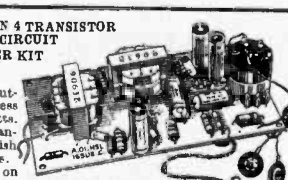
## STEREO AMPLIFIER

Incorporating 2 ECL86s and 1 EZ80, heavy duty, double wound mains transformer. Output 4 watts per channel. Full tone and volume controls. Absolutely complete. Output impedance 3 ohms.



ONLY **£5.9.6**
P. & P. 8/-.
Super Deluxe version with ECL86 valves, sep. bass, treble and balance controls. Full feedback. 8 gns. P. & P. 8/-.

**HIGH GAIN 4 TRANSISTOR PRINTED CIRCUIT AMPLIFIER KIT**
**Type TA1**



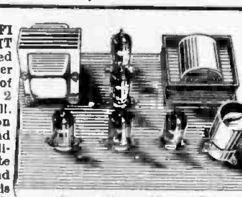
● Peak output in excess of 1½ watts. ● All standard British components. ● Built on printed circuit panel size 6 × 3in. ● Generous size Driver and Output Transformers. ● Output transformer tapped for 3 ohm and 15 ohm speakers. ● Transistors (GET114 or 81 Mullard AC128D and matched pair of AC128 o/p). ● 9 volt operation. ● Everything supplied, wire, battery clips, solder, etc. ● Comprehensive easy to follow instructions and circuit diagram 2/6 (Free with Kit). All parts sold separately. **SPECIAL PRICE 45/-**. P. & P. 3/-. Also ready built and tested, 52/6. P. & P. 3/-.

## HARVERSON'S SUPER MONO AMPLIFIER

A super quality gram amplifier using a double wound mains transformer, EZ80 rectifier and ECL82 triode pentode valve as audio amplifier and power output stage. Impedance 3 ohms. Output approx. 3·5 watts. Volume and tone controls. Chassis size only 7" wide × 3" deep × 6" high overall. AC mains 200/240v. Supplied absolutely Brand New completely wired and tested with valves and good quality output transformer. LIMITED NUMBER ONLY.

OUR ROCK BOTTOM BARGAIN PRICE **49/6** P. & P. 6/-

**10/14 WATT HI-FI AMPLIFIER KIT**



A stylishly finished monaural amplifier with an output of 14 watts from 2 EL84s in push-pull. Super reproduction of both music and speech, with negligible hum. Separate inputs for mike and gram allow records and announcements to follow each other. Fully shrouded section wound output transformer to match 3–15 Ω speaker and 2 independent volume controls, and separate bass and treble controls are provided giving good lift and cut. Valve line-up 2EL84s, ECC83, EF86 and EZ80 rectifier. Simple instruction booklet 2/6 (Free with parts). All parts sold separately. ONLY £7.9.6. P. & P. 8/6. Also available ready built and tested complete with std. input sockets, £9.5.0. P. & P. 8/6.

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**Controls:** Selector switch Tape speed equalisation switch (3¾ and 7½ i.p.s.). Volume. Treble. Bass. 2 position scratch filter and 2 position rumble filter.

**Specification:** Sensitivities for 10 watt output at 1KHz. *Tape head:* 3mV (at 3¾ i.p.s.). *Mag. P.U.:* 2mV. *Cer. P.U.:* 80mV. *Radio:* 100mV. *Aux.:* 100mV. *Tape/Rec. output:* 100mV. Equalisation for each input is correct to within ± 2dB (R.I.A.A.) from 20Hz to 20KHz. *Tone control range:* Bass ± 13dB at 60 Hz. Treble ± 14dB at 15KHz. *Total distortion:* (for 10 watt output) <1·5%. *Signal noise:* <—60dB. A.C. mains 200–250v.
Size 12½in. long, 4½in. deep, 2¾in. high. Teak finished case. **Price 8½ gns.** + 7/6 p. & p.
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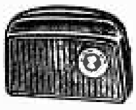
### THE DORSET (600mW output)



7-transistor fully tunable M.W.–L.W. superhet portable —with baby alarm facility. Set of parts. The latest modulised and pre-alignment techniques makes this simple to build. Sizes: 12 x 8 x 3in.

MAINS POWER PACK KIT: 9/6 extra.

PRICE £5.5.0 plus 7/6 p. & p. Circuit 2/6 FREE WITH PARTS.

### THE ELEGANT SEVEN MK. III (350mW output)

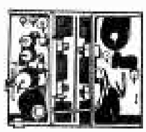
7-transistor fully tunable M.W.–L.W. portable. Set of parts. Complete with all components, including ready etched and drilled printed circuit board—back printed for foolproof construction.

MAINS POWER PACK KIT: **9/6** extra.

**Price £4.9.6** plus 7/6 p. & p.

Circuit 2/6 FREE WITH PARTS.

### X101 10W SOLID-STATE HI-FI AMP WITH INTEGRAL PRE-AMP



**Specifications:** *Power Output* (into 3 ohms speaker) 10 watts. *Sensitivity* (for rated output): 1mV into 3K ohms (0·33 microamp). *Total Distortion at* 1KHz. at 5 watts 0·35%, at rated output 1·5%. *Frequency Response:* Minus 3dB points 20Hz and 40KHz. *Speaker:* 3–4 ohms (3–15 ohms may be used). *Supply voltage:* 24V d.c. at 800mA (6–24V may be used).

**Control assembly:** including resistors and capacitors.
1. Volume: PRICE **5/-**.
2. Treble: PRICE **5/-**.
3. Comprehensive bass and treble: PRICE **10/-**.
The above 3 items can be purchased for use with the X101.

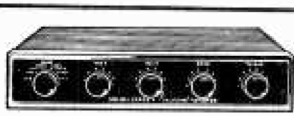
**Price 49/6**
plus 2/6 p. & p.

**Power Supplies for the X101:**
P101 M (for mono) **35/-** plus 4/6 p. & p. P101 S (for stereo) **42/6** plus 4/6 p. & p.

## THE RELIANT MK II
### 10W SOLID-STATE HIGH QUALITY AMPLIFIER

**SPECIFICATIONS**
Output—10 watts
Output Impedance—3 to 4 ohms
Inputs—1. -xtal mic 10mV
2. -gram/radio 250mV
Tone Controls—Treble control range ± 12dB at 10KH2
Bass control range ± 13dB at 100H2
Frequency Response—(with tone controls central) Minus 3dB points are 20H2 and 40KH2. Signal to Noise Ratio—better than —60dB. Transistors—4 silicon Planar type and 3 Germanium type. Mains input— —220 —250V. A.C. Size of chassis—10½" × 4¾" × 2½". A.C. Mains, 200-250V. For use with Std. or L.P. records, musical instruments, all makes of pick-ups and mikes. Separate bass and treble lift control. Two inputs with control for gram. and mike. Built and tested. 8" × 5" speaker to suit price **14/6** plus 1/6 P. & P. Crystal mike to suit **12/6** plus 1/6 P. & P.

**Reliant Mark II. 6½ gns.** plus 7/6 p. & p.
In teak finished case.



## THE VISCOUNT

**Integrated High Fidelity Transistor Stereo Amplifier**

**SPECIFICATIONS:** Output: 10 watts per channel into 3 to 4 ohms speakers (20 watts monoral). Input: 6 position rotary selector switch (3 pos. mono and 3 pos. stereo), P.U., Tuner, Tape and Tape Rec. Sensitivities: All inputs 100mV into 1·8M ohm. Frequency response: 40Hz–20KHz + 2db. Tone controls: (Baxandall type), separate bass and treble controls. Treble 13db lift and cut at 15KHz. Bass 15db lift and 25db cut at 60Hz. Volume controls: Separate for each channel. AC Mains input: 200-240v. 50-60Hz. Size 12¼ × 6 × 2¾in. In teak-finished case. Built and tested

**PRICE 13½ Gns.** Postage & Packing 7/6 extra.

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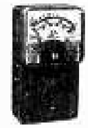


## POCKET MULTI-METER

Size 3¾ x 2½ x 1¾in. Meter size 2½ x 1¾in. Sensitivity 1000 O.P.V. on both A.C. and D.C. volts. 0–15, 0–150, 0–1000 D.C. current 0–150mA. Resistance 0–100kΩ. Complete with test prods, battery and full instructions, **42/6**. P. & P. 3/6. **FREE GIFT** for limited period only. 30 watt Electric Soldering Iron value **15/-** to every purchaser of the Pocket Multi-Meter.

### CYLDON 4 TRANSISTOR U.H.F. TUNER

Brand new. Complete with circuit diagram.

**£2.10.0** plus 1/- p. & p.

### THREE-IN-ONE HI-FI 10 WATT SPEAKER

A complete Loud Speaker system on one frame, combining three matched ceramic magnet speakers with a low loss cross over network. Peak handling power 10 watts. Impedance 15 ohms. Flux density 11,000 gauss. Resonance 40–60 c/s. Frequency range 50c/s to 20kc/s. Size 13¼ x 8¹/₁₆ x 4½ inches. By famous manufacturer. List Price £7. Our price **74/6** plus 5/- P. & P.
Similar speaker to the above without tweeters in 3 and 15 ohm **44/6** plus 5/- P. & P.

### B.S.R. TD-2 TAPE DECK

This tape deck takes 5¾in. spools complete with two-track heads. Size 13½in. long by 8¾in. wide. **£8.19.6** plus 7/6 p. & p.

## 2½ watt ALL TRANSISTOR AMPLIFIER

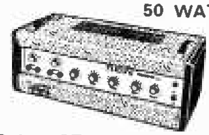
AC mains 240V. Size 7" x 4½" x 1¾". Frequency response 100 c/s—10 Kc/s Semi conductors, two OC 75's two AC 128's and two stabilizers AA129. Tone and volume controls on fly.ng leads. **£2.10.0** plus P. & P. 3/6. Suitable 8" x 5" 10,000 line high flux speaker, **18/6** plus 2/- P. & P.


### FIRST QUALITY P.V.C. TAPE

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 5¾" | Std. | 850ft. | ....**11/6** | 5" | L.P. | 850ft. | ....**12/–** |
| 7" | Std. | 1200ft. | ....**13/–** | 3" | T.P. | 600ft. | ....**12/–** |
| 3" | L.P. | 240ft. | .... **5/6** | 5" | T.P. | 1800ft. | ....**27/–** |
| 5¾" | L.P. | 1200ft. | ....**13/–** | 5¾" | T.P. | 2400ft. | ....**34/–** |
| 7" | L.P. | 1800ft. | ....**20/–** | 7" | T.P. | 3600ft. | ....**44/–** |
| 5¾" | D.P. | 1800ft. | ....**20/–** | 4" | T.P. | 900ft. | ....**16/6** |

P. & P. on each 1/6.

### 50 WATT AMPLIFIER A.C. MAINS 200–250V



An extremely reliable general purpose valve amplifier—with six electronically mixed inputs. Suitable for use with: mics, guitars, gram, tuner, organs, etc. Separate bass and treble controls. Output impedance 3, 8 and 15 ohms.

**Price 27 gns.** Plus 20/- p. & p.

## RECORD PLAYER SNIP A.C. MAINS 240V

The "Princess" 4-speed automatic record changer and player engineered with the utmost precision for beauty, long life, and trouble free service. Will take up to ten records which may be mixed 7" to 10" or 12". Patent stylus brush cleans stylus after each playing and at shut off, the pick-up locks itself into its recess, a most useful feature with portable equipment—other features include pick-up height adjustment and stylus pressure adjustment. This truly is a fine instrument which you can purchase this month at only **£5.19.6** complete with cartridge and ready to play. Post and insurance 7/6 extra.

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(by famous manufacturer)
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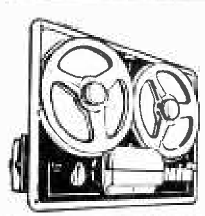
### 3 + 3 watt STEREO AMPLIFIER

Available shortly. A.C. mains 240 volt in teak finished case. Size 10½" long × 4¾" wide × 2½" deep. Price **9 gns.** plus 7/6 p. & p.



## MOTEK

3 Speed 2 track Tape Deck complete with heads, takes 7in. spool.

Incorporating 3 motors.

A.C. mains, 240 volts, listed at £21.0.0.

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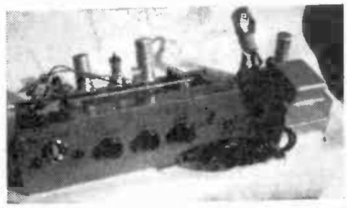
## TAPE AMPLIFIER FOR MAGNAVOX TAPE DECKS — 2 or 4 TRACK

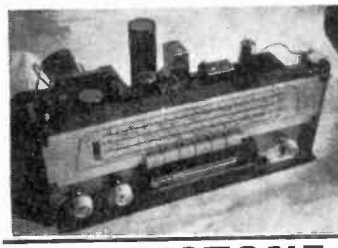


Chassis 12½ x 5¼ x 4½in. high. Front panel alum and black—12¼ x 4¼in. 200–250 A.C. Mains Trans. Off/On-Tone; Vol./Mic.; Vol./Gram.; Mic. Input; Gram. Input; Monitor: Valves 6BR7, ECC83, EM84, EL84 and Rect. 2 Track £10.10.0; 4 Track £12 (12/6 p. & p.). Ready for bolting direct to Magnavox deck. 3 speed Magnavox 4 Track tape deck, Type 363. £16.10.0 carr. paid. 2 × 2 Stereo deck £20.

**FULLY BUILT STEREO AMPLIFIER.** 2 × 3 watts, mains trans., metal rect., 2 × UCL82, 2 o.p. trans. for 3 ohm, vol/on-off, tone, balance, chassis type with 3 controls on front. 11 × 3¼ × 4in. high. £6 (8/- p. & p.).

**8W. PEAK PUSH-PULL OUTPUT AMPLIFIER, 200-250V A.C.** EZ80, ECC83, 2 EL84, Bass, treble, vol/on-off, £7.17.6 (post paid). Size 12 x 3½ x 5in. high. For Record Player, Radio Tuner, etc.
**Mains Trans.** o.p. trans. for 3 ohm.

## 6 PUSH-BUTTON STEREOGRAM CHASSIS



M.W.; S.W.1; S.W.2; V.H.F.; Gram; Stereo Gram; Vol; Tone; Mains Trans; 200-250 Volts; 2 o.p. for 3 ohm. Also operates with two speakers on Radio. Chassis size: 15 x 7 x 6½in. high. Dial silver and black 15 x 3in. 190-550M; 18–51M; 60–187M; VHF 86–100 Mc/s. Valves: ECC85, ECH81, EF89, 2x ECL86, EM84 and Rect. Price £19.19.0, carr. paid. With Stereo Decoder fitted £7,10.0 extra.

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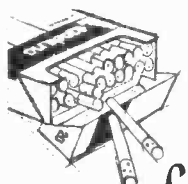

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| ½W | 10% | 2½d. | 1/9 | 3/8 | 11/7 |
| ½W | 5% | 3d. | 2/- | 4/- | 12/10 |

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Polystyrene film, Tubular, Axial leads. Unencapsulated. ±5% or ±1pf tolerance. 160 Volt Working.
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Polystyrene film, Tubular, Axial leads. Professional Grade. Hard Epoxy Resin encapsulation.
± 1% tolerance. 100 Volt Working.
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| 220, 270, 330, 390, 470, 560, 680, 820 .. .. | 1/3 | 10/8 | 23/1 | 71/- |
| 1,000, 1,200, 1,500, 2,200, 2,700 .. .. | 1/6 | 13/10 | 29/11 | 92/- |
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Miniature, fully enclosed, rear tags, carbon brush wiper. Long life, low noise. Body dia., ⅝in. Spindle, 1in. × ¼in. ¼W at 70°C. ±20% below ½M, ±30% over ½M. Lin. 100 ohms to 10 Megohms. Log. 5 Kohms to 5 Megohms.

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|---|---|---|---|---|
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High quality pre-sets suitable for printed circuit boards of 0·1in. P.C.M. 100 ohms to 5 Megohms (Linear only). Miniature: 0·3W at 70°C. ±20% below ½M, ±30% above ½M. Horizontal (0·7in. + 0·4in. P.C.M.) or Vertical (0·4in. × 0·2in. P.C.M.). Subminiature: 0·1W at 70°C. ±20% below 2·5M, ±30% above.

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|---|---|---|---|---|
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| Subminiature (0·1W) .. | 10d. | 7/1 | 14/7 | 46/8 |

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¼in. Type SE/P1. Side-entry version of P1 plug.
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|---|---|---|---|---|
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| P5 .. .. .. .. .. | 2/2 | 19/2 | 43/9 | 158/4 |
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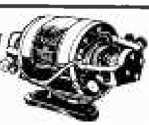

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| PF86 | 10/- |
| PF818 | 14/- |
| PFL200 | 13/- |
| PL33 | 8/- |
| PL36 | 10/- |
| PL81 | 7/6 |
| PL82 | 8/- |
| PL83 | 7/- |
| PL84 | 6/6 |
| PL500 | 13/6 |
| PL504 | 15/- |
| PY31 | 5/- |
| PY32 | 10/- |
| PY33 | 12/6 |
| PY80 | 5/6 |
| PY81 | 5/6 |
| PY82 | 5/- |
| PY83 | 6/6 |
| PY88 | 7/6 |
| PY800 | 9/- |
| PY801 | 9/- |
| QU37 | 27/- |
| SP41 | 5/6 |
| SP61 | 5/- |
| TP22 | 10/- |
| TT21 | 35/- |
| U19 | 40/- |
| U20 | 12/- |
| U22 | 8/- |

| | |
|---|---|
| U25 | 14/6 |
| U26 | 14/6 |
| U31 | 8/- |
| U33 | 30/- |
| U76 | 4/- |
| U191 | 10/- |
| U281 | 8/- |
| U282 | 8/- |
| U403 | 8/- |
| U404 | 5/- |
| UABC80 | 6/- |
| UAF42 | 9/6 |
| UBC41 | 8/6 |
| UBC81 | 8/6 |
| UBF80 | 6/6 |
| UBF89 | 7/- |
| UBL1 | 8/6 |
| UC92 | 6/- |
| UCC85 | 7/- |
| UCF80 | 9/6 |
| UCH21 | 9/6 |
| UCH42 | 9/6 |
| UCH81 | 6/6 |
| UCL81 | 10/- |
| UCL82 | 7/- |
| UCL83 | 9/6 |
| UF9 | 10/- |
| UF41 | 9/9 |
| UF42 | 10/- |
| UF43 | 10/- |
| UF80 | 7/- |
| UF85 | 7/3 |
| UF89 | 7/- |
| UL41 | 9/6 |
| UL84 | 6/6 |
| UM4 | 10/- |
| UM84 | 7/- |
| UU8 | 7/- |
| UU9 | 7/6 |
| UY21 | 9/6 |
| UY41 | 7/- |
| UY82 | 9/6 |
| UY85 | 6/- |
| VU39 | 9/- |
| VU111 | 8/6 |
| VU133 | 8/- |
| W76 | 7/- |
| W107 | 7/- |
| W729 | 10/- |
| X65 | 9/- |
| Z759 | 25/- |
| Z700U | 8/- |
| Z803U | 15/- |

## INTEGRATED CIRCUIT AMPLIFIERS

**RCA Type CA3020**
Integrated Circuit Audio Amplifier in TO5 encapsulation (size of a small transistor), equivalent to seven n-p-n silicon transistors, 3 diodes and 11 resistors. Power output 550mW. Total harmonic distortion 1%. Will operate on voltage from 3 to 9 volts. **30/-** plus 2/- p.p.

**GENERAL ELECTRIC Type PA222**
Epoxy moulded in-line package equivalent to six n-p-n transistors, one diode and six resistors. It will provide output of up to 1-2 watts into 15 ohms. Battery operation 22 volts. **40/-** plus 2/- p.p.

The construction of amplifier using the above integrated circuits had been described in March and August issues of P.W. Please note that we only supply the IC's and no other parts are supplied by us.

**GENERAL ELECTRIC TYPE PA234**
1-watt Audio Amplifier suitable for supply voltage of 9 to 25V and for output loads of 8, 16 or 22 ohms. Only 3 capacitors and 3 resistors are required for making up a complete amplifier delivering 1 watt for an input voltage of 600mW. Epoxy moulded double four-in-line package. **27/6** each, plus 2/- P. & P.

**SILICON WIRE ENDED DIODES**
**Max. frequency 20mc/s**

| | |
|---|---|
| D223, 50 p.i.v., 50mA | 2/- |
| D233A, 100 p.i.v., 50mA | 2/3 |
| D223B, 150 p.i.v., 50mA | 2/6 |

**SILICON POWER RECTIFIERS**
**(Half Wave)**

**'TOP HAT' type, wire ended:**

| | |
|---|---|
| D226B, 400 p.i.v., 300mA | 2/9 |
| D226V, 300 p.i.v., 300mA | 2/6 |

**STUD MOUNTED, KD202 series**

| | | | |
|---|---|---|---|
| 50 p.i.v., 1A | 3/- | 200 p.i.v., 1A | 3/6 |
| 50 p.i.v., 3A | 5/- | 200 p.i.v., 3A | 6/- |
| 100 p.i.v., 1A | 3/3 | 300 p.i.v., 1A | 3/8 |
| 100 p.i.v., 3A | 5/- | | |

**SILICON AVALANCHE RECTIFIERS**
**(Half Wave)**

| | |
|---|---|
| RAS 310 AF, Top Hat type, 1·5A, 1200 p.i.v. | 7/6 |
| RAS 508 AF, Stud Mounted, 6A, 960 p.i.v. | 10/6 |

## DRY REED INSERTS

Glass dry reed inserts approx. ⅛in. dia. x 1in. long with axial leads. One "make" contact of 100mA capacity at 50V. Can be operated by permanent magnet or 30–50 Amp-turns relay coils. PRICE **18/-** per doz. post free.

## CURRENT PRODUCTION CATHODE RAY TUBES

**2AP1**—2in. screen. EHT 500 to 1000V. Typical sensitivity at 500V. X—·220mm/V; Y—·260mm/V. USM11 Base. Overall length 7⅜in. **40/-**
**3BP1**—3in. screen. EHT 1500V. Typical sensitivity X—·150mm/V; Y—·200mm/V. B14A Base. Overall length 10⅛in. **55/-**

## MULTIMETERS

**TYPE MF16**

D.C. voltage range: 0-0·5-10-50-250-500V.
A.C. voltage range: 0-10-50-250-500V.
D.C. current range: 500μ-10-100mA.
Resistance ranges: 100MΩ-1MΩ.
The meter is also calibrated, capacity (1000pF to 0·03μF) and output level measurements. Sensitivity 2000Ω V. Accuracy ±2·5% for D.C. and ±4% for A.C. measurements. Dimensions: 4¼" x 3¼" x 1⅛". Price £4.5.0.

**Type 108-IT:** 24 range precision portable meter. 5000 o.p.v. D.C. Volts: 2·5-10-50-250-500-2500V. A.C. Volts: 10-50-100-250-500-2500V; D.C. current 0·5-5-50-500mA Resistance 2000–20,000 ohms; 2–20 megohms. Power output calibration in A.C. for 600 ohms line. Complete with prods and batteries, £6.5.0. P. & P. 5/-.

## OUR NEW 1968/1969 CATALOGUE IS NOW READY

**THE TECHNICAL INFORMATION SECTION HAS BEEN FURTHER EXPANDED TO INCLUDE MORE DETAILS OF SEMICONDUCTORS. PLEASE SEND S.A.E. (Quarto Size) FOR FREE CATALOGUE.**

## HIGH POWER STUD MOUNTED

**10% Tol. Zener Diodes**
**SERIES D815, 8 watts dissipation:**
4·7, 5·6, 6·8, 8·2, 10·0, 12·0, 15·0, 18·0V.
**SERIES D816, 5 watts dissipation:**
22, 27, 33, 39, 47, 56, 68, 82, 100V.
All at **7/6** each.
Orders for ten or more, may be mixed, **6/9** each.

**TRIACS TYPE 40432**
Gated bi-directional Silicon Thyristors with integral trigger. The triac will control up to 1440 watts at 240V mains frequency. Supplied complete with heat sink, data sheet and application sheets for motor control and dimmer circuits. **37/6** each.

## THYRISTORS

**Low current:**

| | |
|---|---|
| Blue spot; 200 p.i.v., 5 Amps. Gate voltage 3·25V at 120mA | 12/6 |

**High current:**

| | |
|---|---|
| CR 80-021A, 80 Amps. 25 p.i.v. | 25/- |
| CR 100-151A | 30/- |
| CR 100-201A, 100 Amps. 200 p.i.v. | 35/- |
| CR 100-215A, 100 Amps. 250 p.i.v. | 40/- |
| CR 100-301A, 100 Amps. 300 p.i.v. | 45/- |
| CR 100-351A, 100 Amps. 350 p.i.v. | 50/- |
| CR 100-401A, 100 Amps. 400 p.i.v. | 60/- |
| CR 100-501A, 100 Amps, 500 p.i.v. | 70/- |

For all CR series Minimum gate firing voltage is 3V at 150mA.

**UNIJUNCTION TRANSISTORS 2N2646**
Power dissipation 300mW R.M.S. Base-to-Base voltage 35V max. Peak emitter current 2·0A. Suitable for triggering of thyristors. **12/6**

## TRANSISTORS

Apart from the types listed in our Catalogue the following types are added to our stocks:

| | | | | | |
|---|---|---|---|---|---|
| 2N930 | 6/8 | 2N2477 | 12/6 | ASY27 | 6/6 |
| 2N1306 | 6/- | 2N3055 | 20/- | BC118 | 8/6 |
| 2N2217 | 6/6 | 2N3704 | 5/6 | BFX88 | 5/4 |
| 2N2218 | 7/9 | AD161 | 9/- | P346A | 5/- |
| 2N2219 | 8/6 | AD162 | 9/- | | |

# PRACTICAL WIRELESS blueprints

*The following blueprints are available from stock.* **Descriptive text is not available** *but the date of issue is shown for each blueprint. Send, preferably, a postal order to cover cost of the blueprint (stamps over 6d. unacceptable) to Blueprint Department, Practical Wireless, I.P.C. Magazines, Tower House, Southampton Street, London, W.C.2.*

| | | |
|---|---|---|
| The Strand Amplifier / The PW Signal Generator | (Oct. 1962) | 5/- |
| The Berkeley Loudspeaker Enclosure / The Luxembourg Tuner | (Dec. 1962) | 5/- |
| The PW Britannic Two / The PW Mercury Six | (May 1962) | 6/- |
| Beginner's Short Wave Two / S.W. Listener's Guide | (Nov. 1963) | 5/- |
| The Celeste 7-transistor Portable Radio / The Spinette Record Player | (June 1963) | 5/- |
| Transistor Radio Mains Unit / 7 Mc/s Transceiver | (June 1964) | 5/- |
| The Citizen | (December 1961) | 5/- |
| The Mini-amp | (November 1961) | 5/- |
| The Beginner's Short Wave Superhet | (Dec. 1964) | 5/- |
| The Empire 7 Three-band Receiver | (May 1965) | 5/- |
| Electronic Hawaiian Guitar | (June 1965) | 5/- |
| Progressive SW Superhet | (February 1966) | 5/- |
| Beginner's 5-Band Receiver / Home Intercom Unit | (Dec. 1966) | 5/- |

★ PLEASE NOTE THAT WE CAN SUPPLY NO BLUEPRINTS OTHER THAN THOSE SHOWN IN THE ABOVE LIST. NOR ARE WE ABLE TO SUPPLY SERVICE SHEETS FOR COMMERCIAL RADIO, TV OR AUDIO EQUIPMENT. ★

# PRACTICAL WIRELESS query service

**Before using the query service it is important to read the following notes:**

The PW Query Service is designed primarily to answer queries on articles published in the magazine and to deal with problems which cannot easily be solved by reference to standard text books. In order to prevent unnecessary disappointment, prospective users of the service should note that:

*(a)* We cannot undertake to design equipment or to supply wiring diagrams or circuits, to individual requirements.

*(b)* We cannot undertake to supply detailed information for converting war surplus equipment, or to supply circuitry.

*(c)* It is usually impossible to supply information on imported domestic equipment owing to the lack of details available.

*(d)* We regret we are unable to answer technical queries over the telephone.

*(e)* It helps us if queries are clear and concise.

*(f)* **We cannot guarantee to answer any query not accompanied by the current query coupon and a stamped addressed envelope.**

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This coupon is available until 9th May, 1969 and must accompany all queries in accordance with the rules of our Query Service.

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