# PRACTICAL WIRELESS

JULY 1969

3/0

## AC/DC METER


ALSO INSIDE

integrated circuit AF SIGNAL INJECTOR

# Lasky's Radio

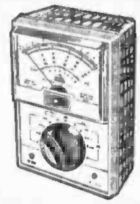
LASKY'S RADIO ESTABLISHED OVER 36 YEARS

## TMK Model PL-436

20,000 O.P.V. Multitester for the amateur or professional. Features mirror scale and wood grain finish front panel. SPEC.: DC/V ranges: 0·6, 3, 12, 30, 120, 600V at 20K/O.P.V. AC/V ranges: 3, 30, 120, 600V at 8K/O.P.V. DC current: 50μA, 0·6, 60, 600mA. Resistance: 10K, 100K, 1M and 10M ohms end scale (65, 650, 6·5K and 65K ohms centre scale). Decibels: −20 to +57dB in four ranges. Operates on 2 × 1·5V U7 type batteries. Size: 5¾ × 4¼ × 2¼in.

**LASKY'S PRICE £7.19.6** Post 5/-

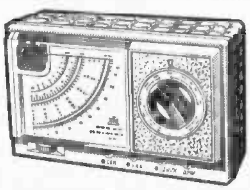
## TTC Model C-1000



A really tiny 1,000 O.P.V. pocket multi-tester with "big" meter performance. Precision 2 jewel meter movement. Hand calibrated to ±3% accuracy on full scale of DC ranges, 4% on AC ranges. 2½in. square meter. SPECIFICATIONS: AC/V ranges: 0–10, 50, 250, 1,000V at 1K/O.P.V. AC/V ranges: 0–10, 50, 250, 100V at 1K/O.P.V. DC current: 0–1–100mA. Resistance: 0–150K/ohms (3,000 ohms centre scale). Decibels: —10 to +22dB. Operated on one penlight cell. Two colour buff/green case—size only 3¼ × 2¼ × 1in. Click stop range selection switch. Ohms zero adjustment. Complete with test leads, battery and instructions with circuit data.

**LASKY'S PRICE 39/6** Post 2/6

## TTC Model C-1051

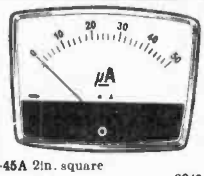


A completely new design 20,000 O.P.V. pocket multimeter with mirror scale and built in thermal protection circuit. Exceptionally large easy to read meter with D'Arsonval movement. Colour coded scales. Single positive click-in, recessed selection switch for all ranges. Ohms zero adjustment. Range spec. AC volts: 0–6–30–300–1200V at 10K/ohms/V. DC volts: 0–3–15–150–300–1·2KV at 20K/ohms/V. Resistance: 0–60K–6megs. DC current: 0–60μA–300mA. Decibels: —20dB to +17dB. Hand calibration gives extremely high standard of accuracy on all ranges. Uses one 1½V penlight battery. Strong impact resistant plastic cabinet—size only 4¾ × 3¼ × 1¼in. Two colour buff/green finish. Complete with test leads and battery. Original list price 5gns.

**LASKY'S PRICE 75/-** Post 2/6

**JUST ARRIVED**
MODEL C-1052 3000 O.P.V. meter. Similar appearance to 10051 PRICE **£5.19.6.** Post Free.

## LASKY'S CLEAR PLASTIC PANEL METERS



Precision made in Japan by HIOKI. Each meter boxed and fully guaranteed with all fixing nuts and washers. Sizes are of front panel. Add 1/6 Post on each. Quotes for quantities.

Type KR-52 3 × 2¼in. (illustrated)

| | | | |
|---|---|---|---|
| 1mA | 33/6 | 50μA | 56/- |
| 5mA | 38/6 | 1mA S meter | 39/6 |
| 100mA | 38/6 | 100μA | 52/6 |
| 300 V | 35/- | 500μA | 45/- |

Type MK-38A 1½in. square

| | |
|---|---|
| 1mA | 29/6 |
| 5mA | 27/6 |
| 100mA | 27/6 |
| 300V | 27/6 |
| 50μA | 37/6 |
| 1mA S meter | 29/6 |
| 100μA | 37/6 |
| 500μA | 29/6 |

Type MK-45A 2in. square

| | |
|---|---|
| 1mA | 29/6 |
| 5mA | 28/6 |
| 100mA | 28/6 |
| 300 V | 28/6 |
| 50μA | 49/6 |
| 1mA S meter | 32/6 |
| 100μA | 42/6 |
| 500μA | 35/- |

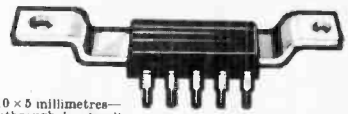
Type MK-65A 3in. square

| | | | |
|---|---|---|---|
| 1mA | 38/6 | 50μA | 59/6 |
| 5mA | 36/- | 1mA S meter | 38/6 |
| 100mA | 38/6 | 100μA | 52/6 |
| 300 V | 36/- | 500μA | 42/- |

Type KR-65 3½ × 3in.

| | | | |
|---|---|---|---|
| 1mA | 38/6 | 50μA | 59/6 |
| 5mA | 37/6 | 1 mA S meter | 42/- |
| 100mA | 38/6 | 100μA | 56/- |
| 300 V | 36/- | 500μA | 46/- |

## ANOTHER EXCLUSIVE FIRST
## PRESENTING THE IC-403
### INTEGRATED CIRCUIT AMPLIFIER MODULE
### AVAILABLE NOW!



These tiny modules—size only 25 × 10 × 5 millimetres—represent the most amazing breakthrough in circuit design since the introduction of the transistor. The actual circuit—no bigger than a pin-head—is encapsulated in solid plastic fused with the heatsink and connecting pins to make an almost indestructible unit. The IC-403 is an integrated power and pre-amplifier requiring only the addition of tone and volume controls, power source and speaker to form a complete audio amplifier of 3W output. Originally developed for computer and space projects—there are many applications for this unique device, wherever high efficiency and ultra compact size is required, i.e. miniature P.A. and audio amplifiers, intercoms, electronic organs, tape recorders etc. etc.

**SPECIFICATION** (ratings at 20°C): Output power typically 3W from 250mV input. Frequency response 20Hz to 80KHz ±3dB. Power amp. distortion 0·3% (at 1W, 400Hz). Pre-amp. gain 24dB. Power amp. gain 26dB. Max. operating voltage 21V. Min. operating load 7·5 ohms. Noise level −75dB. Pre-amp. input imp. 2m/ohms. Now Pre-amp. and power amp. D.C. input current 50μA.

***THE IC-403 IS AVAILABLE FROM STOCK EXCLUSIVELY FROM LASKY'S—COMPLETE WITH INSTRUCTION DATA AND SUGGESTED CIRCUIT APPLICATIONS.***

**LASKY'S PRICE ONLY 52/6** Post 2/6

## NEW FANTAVOX TRC-2
### SOLID STATE COMPACT CASSETTE RECORDER

A new Lasky's STAR BARGAIN this beautifully made compact cassette recorder and play back machine offers tremendous performance and value. BRIEF SPEC: 6 transistor and 1 thermister circuit Constant speed capstan drive system. AC bias recording. PM magnet erase. 2½in. PM Dynamic speaker. Economical operation on 4 × 1·5V (U-2 type) batteries. SPECIAL FEATURES: Absolutely foolproof operation. Piano key controls. Powerful volume with recessed control. Handsome impact resistant cabinet finished in black with satin aluminium and ivory trim. Size 9¼ × 5¾ × 2¾in. Jack sockets for remote control microphone, earpiece and external 6V battery pack (or AC adaptor). COMPLETE WITH Remote control Dynamic microphone, earpiece, removable carrying strap, batteries, full instructions and three C-60SX cassettes.

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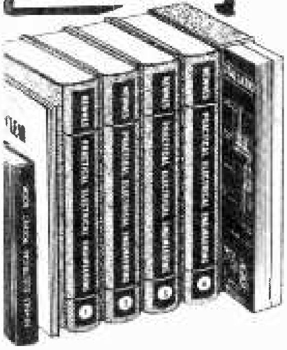

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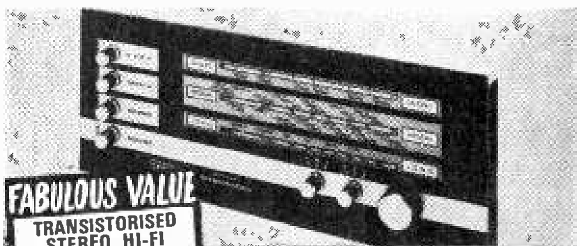

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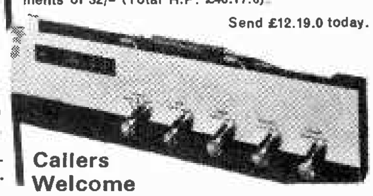

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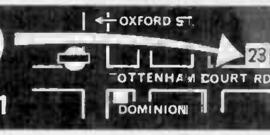


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The Premier Stereo System consists of an all transistor stereo amplifier, Garrard Model 2025 auto/manual record player unit fitted stereo/mono cartridge and mounted in teak finish plinth with perspex cover and two matching teak finish loudspeaker systems. Absolutely complete and supplied ready to plug in and play. The 10 transistor Amplifier has an output of 5 watts per channel with inputs for pick up, tape and tuner also tape output socket. Controls: Bass, Treble, Volume, Selector. Power on/off, stereo/mono switch. Brushed aluminium front panel. Black metal case with teakwood ends: Size 12" x 5½" x 3½" high (Amplifier available separately if required £14.19.6. Carr. 7/6).

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All complete with mounting brackets and instructions
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Removes unwanted deposits from delicate tape heads. Fits all cassette recorders.
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STEREO STETHOSCOPE SET Low imp. 25/- P. & P. 2/-.
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£7.19.6 Carr. 7/6

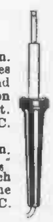
### MULTI TESTERS

MODEL D14. A really versatile instrument that makes a handy pocket size tool. Measures AC or DC voltage in three ranges of 0–15–150–1000 volts. Resistance 0–100,000 ohms. Current 0–150 mA D.C. Size only: 3¾ x 2½ x 1¼in. Complete with battery, test leads and instructions. 49/6 P. & P. 2/6.

POCKET SIZE MODEL. With wide-angle, jewelled meter movement, ceramic long-life, low-loss switching, tough impact resisting case. Sensitivity 20,000 ohms/volt D.C. 10,000 ohms/volt A.C.
19 Ranges: 0-5-25-50-250-500-2500 volts DC. 0-10-50-100-500-1000 volts AC. 0-50 uA-2·5 mA-250 mADC. 0-6000 ohms-6 megohms, 10u uf-0·001 mfd-1 mfd. −20 to +22dB. Complete battery, test lead and instructions. £4.19.6 P. & P. 3/6.

### WELLER SOLDERING TOOLS

"Expert" Solder Gun. Saves time and simplifies soldering in the home and service dept. Two position trigger gives instant dual heat. 100/140 watt. 240 volt A.C. 67/6 P. & P. 2/–.



"Marksman" Soldering Iron. Lightweight, conventional 3/16" pencil bit. Ideal for regular bench use and all those jobs around the home. 25 watts. 240 volt A.C. 31/6 P. & P. 2/-.

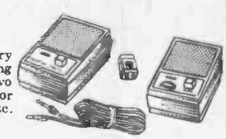
### MONO GRAM AMPLIFIER

2½ watts output. Uses EL84 valve, double wound mains transformer. Ideal for use with any record deck. Volume/on/off and tone controls on flying leads. Output impedance 3 ohms. Size overall 5½"w. x 5½"d x 3"h. A.C. 200/240V. ONLY 49/6. P. & P. 5/–.

### JULIETTE NA.5018 5 BAND 18 TRANSISTOR MAINS/BATTERY RADIO

Covers AM 540–1600Kc/s. Marine 1·6–4·6Mc/s. FM 88–108Mc/s. VHF 108–134Mc/s. PB 148–174Mc/s. Ferrite bar aerial for AM/MB. Telescopic aerial for FM/VHF/PB. 4" P.M. Speaker. Operates on AC 250v. or D.C. by four 1·5v. batteries. Size: 9⅜" x 5½" x 3½".
PREMIER PRICE 33 GNS. P. & P. 10/-.

### TWO STATION TRANSISTOR INTERCOMS.



Complete with battery and 50ft. connecting wire. Compact size, two way call system. Ideal for home, office, factory, etc.
49/6 P. & P. 4/–.

FOUR STATION INTERCOM. Master unit and 3 slaves. Ideal for office and home. Complete with battery and connecting wire £7.19.6 P. & P. 5/6.

## "VERITONE" RECORDING TAPE

SPECIALLY MANUFACTURED IN U.S.A. FROM EXTRA STRONG PRE-STRETCHED MATERIAL. THE QUALITY IS UNEQUALLED.

TENSILISED to ensure the most permanent base. Highly resistant to breakage, moisture, heat, cold or humidity. High polished splice free finish. Smooth output throughout the entire audio range. Double wrapped—attractively boxed.

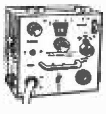
| | | | | |
|---|---|---|---|---|
| LP3 | 3" | 250' | P.V.C. | 5/6 |
| TT3 | 3" | 450' | POLYESTER | 7/6 |
| DT3 | 3½" | 600' | POLYESTER | 11/6 |
| SP5 | 5" | 600' | P.V.C. | 8/6 |
| LP5 | 5" | 900' | P.V.C. | 10/– |
| DT5 | 5" | 1200' | POLYESTER | 15/– |
| LP6 | 5¾" | 1200' | P.V.C. | 12/6 |
| DT6 | 5¾" | 1800' | POLYESTER | 22/6 |
| TT6 | 5¾" | 2400' | POLYESTER | 37/6 |
| SP7 | 7" | 1200' | POLYESTER | 12/6 |
| LP7 | 7" | 1800' | P.V.C. | 15/– |
| DT7 | 7" | 2400' | POLYESTER | 25/– |
| TT7 | 7" | 3600' | POLYESTER | 50/– |

TAPE SPOOLS 3" 1/–, 5", 5¾", 7" 1/9. TAPE CASES 5", 5¾", 7" 2/6.
Post and Packing 3" 1/–, 5", 5¾" 1/6. 7" 2/–. (3 reels and over Post Free).

# RACAL RA-17

**First ministry release of these world famous communication receivers. Frequency range 500 kc/s–30 Mc/s. Available in excellent condition, fully tested and guaranteed. £150. Carr. 40/–.**

## 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.

## CLASS D WAVEMETERS No. 2

Crystal controlled. 1·2–19 Mc/s. Mains or 12V. D.C. operation. Complete with calibration charts. Excellent condition. £12.10.0. Carr. 30/–.

## MARCONI CT/44/TF956

**AF Absorption Wattmeter**

1 μ/watt to 6 watts. £20. Carr. 10/-.

## LELAND MODEL 27 BEAT FREQUENCY OSCILLATORS

Frequency 0–20 Kc/s. on 2 ranges. Output 500 Ω or 5k Ω. Operation 200/250V. A.C. Supplied in perfect order. £12.10.0. Carr. 10/–.

## AVOMETERS

Supplied in excellent condition, fully tested and checked. Complete with prods, leads and instructions. Model 47A £9.19.6. P. & P. 7/6.

## SOLARTRON CD-1016 OSCILLOSCOPE

Double beam. D.C. To 5 Mc/s. Excellent condition. £55 each. Carr. 20/–.

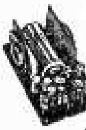
## AM/FM SIGNAL GENERATORS

Oscillator Test No. 2. A high quality precision instrument made for the ministry by Airmec. Frequency coverage 20–80 Mc/s. AM CW/FM. Incorporates precision dial, level meter, precision attenuator 1μV–100mV. Operation from 12 volt D.C. or 0/110/200/250 volt A.C. Size 12 × 8½ × 9in. Supplied in brand new condition complete with all connectors fully tested. £45. Carr. 20/-.

## GEARED MAINS MOTORS

Paralux type SD19 230/250V. A.C. Reversible. 30 r.p.m. 40 lb./ins. Complete with capacitor. Excellent condition. 99/6. Carr. 10/–.

## SINCLAIR EQUIPMENT



Z12 12 watt amplifier, 89/6
PZ4 Power Supply Unit 89/6
Stereo 25 Preamp. £9.19.6
Q14 Speakers £7.19.6
Micromatic Radio Kit. 49/6. Built 59/6.
ALL POST PAID

**SPECIAL OFFER**

Two Z12 Amps., PZ4 Power Supply, Stereo 25 Preamplifier, £22, or with two Q14 speakers, £37.

## NEW SINCLAIR 2000 SYSTEM

35 watt Integrated Amplifier, £29. Carr. 5/-. Self-powered FM Tuner, £25. Carr. 5/-.

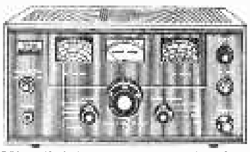
## ECHO HS-606 STEREO HEADPHONES

Wonderfully comfortable. Lightweight adjustable vinyl headband. 6ft. cable and stereo jack plug. 25-17,000 cps. 8 ohm imp. 67/6 P. & P. 2/6.

## 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.**

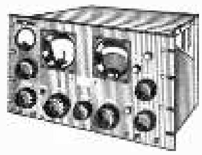
## TRIO COMMUNICATION RECEIVER MODEL 9R-59DE



4 band receiver covering 550 Kc/s to 30 Mc/s. continuous and electrical bandspread on 10, 15, 20, 40 and 80 metres. 8 valve plus 7 diode circuit. 4/8 ohm output and phone jack. SSB-CW ● ANL ● Variable BFO ● S meter ● Sep. bandspread dial ● IF 455 Kc/s ● Audio output 1·5 W. ● Variable RF and AF gain controls. 115/250V. A.C. Mains. Beautifully designed. Size: 7 × 15 × 10in. With instruction manual and service data. £42.10.0, carriage paid. **TRIO COMMUNICATION TYPE HEADPHONES.** Normally £5.19.6. OUR PRICE £3.15.0 if purchased with above receiver.

## TRIO JR-500SE 10–80 METRE AMATEUR COMMUNICATION RECEIVER IN STOCK £69

## HAMMARLUND SP600JX COMMUNICATION RECEIVER

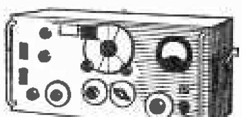


High quality professional dual conversion communication receivers available for the first time in this country at a reasonable price. Frequency range 540 Kc/s–54 Mc/s. in 6 bands variable tuning or 6 channel crystal controlled. 2·5 watt output into 600 ohms. Input 110/230V. A.C. 20 valve circuit incorporating: Xtal filter B.F.O. A.N.L. Xtal calibrator, S meter etc. Size 19 × 12 × 22in. (List £520). Offered in excellent condition, fully tested and checked. £100 each.

## LAFAYETTE LA-224T TRANSISTOR STEREO AMPLIFIER

19 transistors, 8 diodes, IHF music power, 30W at 8Ω. Response 30–20,000 ± 2dB at 1W. Distortion 1% or less. Inputs 3mV and 250mV. Output 3–16Ω. Separate L and R. volume controls. Treble and bass control. Stereo phone jack. Brushed aluminium, gold anodised extruded front panel with complementary metal case. Size 10¼ × 3 9/16 × 7 13/16in. Operation 115/230V. A.C. £28. Carriage 7/6.

## MARCONI TEST EQUIPMENT



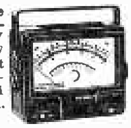
EX-MILITARY RECONDITIONED. TF.144G STANDARD SIGNAL GENERATORS, 85 Kc/s–25 Mc/s, £25. Carr. 30/–. TF.885 VIDEO OSCILLATOR 0–5 Mc/s £45 Carr. 30/–. TF.195M BEAT FREQUENCY OSCILLATOR 0–40 Kc/s. 200/250V. A.C. £20 Carr. 30/–. TF.142E Distortion Factor Meter, £20 Carr. 20/–. All above offered in excellent condition, fully tested and checked. TF.1100 VALVE VOLTMETER, Brand New, £50. TF.1267 TRANSMISSION TEST SET, Brand New, £75. TF.1371 Wide Band Millivolt Meter, Brand New. £50.

## MULTIMETERS *for EVERY purpose!*

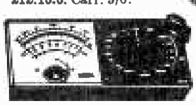
**LAFAYETTE DE-LUXE 100K Ω/VOLT "LAB TESTER"** Giant 6½in. scale. Built-in meter protection 0/·5/2·5/10/50/250/500/1,000V D.C. 0/3/10/50/250/500/1,000V A.C. 0/10/100μA/10/100/500mA/2·5/10A. 0/1K/10K/100K/10M/10MΩ. – 10 to 49·4dB £18.18.0. P. & P. 5/–.

**TE-900 20,000 Ω/VOLT GIANT MULTIMETER mirror scale and overload protection.** 6in. full view meter. 2 colour scale. 0/2·5/10/250/1,000/5,000 v. A.C. 0/25/12·5/10/50/250/1,000/5,000v. D.C.0/50μA/110/100/500 mA/10 amp. D.C-02K/200K/20 MEG. OHM. £15. P. & P. 5/-.

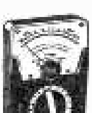
**MODEL AS-100D. 100K Ω/VOLT.** 5in. mirror scale. Built-in meter protection. 0/3/12/60/120/300/600/1,200v. D.C. 0/6/30/120/300/600v. A.C. 0/10μA/6/60/300mA/12 amp. 0/2K/200K/2M/200MΩ. –20 to +17dB. £12.10.0. P. & P. 3/6.



**LAFAYETTE 57 Range Super 50k Ω/volt Multimeter.** D.C. volts 12 mV –1000V. A.C. volts 1·5V –1000V D.C. current 25μA–10 amp Ohms 0–10meg Ω dB –20 to +81 dB. Overload protection. £12.10.0. Carr. 3/6.

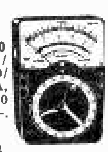


**PROFESSIONAL 20,000 opv LAB. TYPE Multitester.** Automatic overload protection, mirror scale. Ranges: 1/10/50/250/500/1,000 volts. D.C. and A.C. 0–500μA, 10mA, 250mA Current: 0/20K, 200K, 2 megohm. Decibels: –20 to +22dB. £5.19.6. P. & P. 2/6.

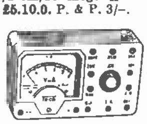


**MODEL TE-90 50,000 O.P.V. mirror scale overload protection** 0/3/12/60/300/600/1200v. D.C. 0/6/30/120/300/1200v. D.C. ·03/6/60/600mA. D.C. 16K/160K/1·6/16meg Ω. –20 to +63dB. £7.10.0. P. & P. 3/-.

**MODEL TE-70.** 30,000 O.P.V. 0/3/15/60/300/600/1,200v. D.C. 0/6/30/120/600/1,200v. A.C. 0/30μA/3/30/300mA. 0/16K/160K/1·6M/16 Meg. Ω £5.10.0. P. & P. 3/–.



**MODEL TE-80.** 20,000 O.P.V. 0/10/50/100/500/1,000v A C 0/5/25/50/250/500/1,000v D C. 0–50μA, 5/50/500mA. 0/6K/60K/600 K/6meg. £4.17.6. P. & P. 3/–.



**MODEL PT-34.** 1,000 O.P.V. 0/10/50/250/500/1,000v. A.C. and D.C. 0/1/100/500/mA. D.C 0/100K Ω. 39/6. P. & P. 1/6.

**MODEL TE-12** 20,000 O.P.V. 0/0·6/6/30/120/600/1,200/3,000/6,000v. D.C. 0/6/30/120/600/1,200v. A.C. 0/60μA/6/60/600mA. 0/6K/600K/6Meg./60 Meg. Ω 50pF. 0·2mFd. £5.19.6. P. & P. 3/6.

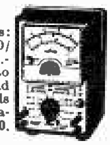
## TO-2 PORTABLE OSCILLOSCOPE

A general purpose low cost economy oscilloscope for everyday use. Y amp. Bandwidth 2 CPS–1 mHz. Input imp 2 meg Ω 25 pF. Illuminated scale. 2in. tube. 115 × 180 × 230mm. Weight 8lb. 220/240V. a.c. Supplied brand new with handbook. £22.10.0. Carr. 10/–.

## FIELD TELEPHONES TYPE L

Generator ringing, metal cases. Operates from two 1·5V batteries (not supplied). Excellent condition. £4.10.0 per pair. Carr. 10/–.

## TE-40 HIGH SENSITIVITY A.C. VOLTMETER



10 meg. input 10 ranges: ·01/·003/·1/·3/1/3/10/30/100/300V. R.N.S. 4cps.-1·2 Mc/s. Decibels – 40 to +50dB. Supplied brand new complete with leads and instructions. Operation 230V. A.C. £17.10.0. Carr. 5/-.

## AUTO TRANSFORMERS

0/115/230V. Step up or step down. Fully shrouded.

| | | |
|---|---|---|
| 150 W. | £1.12.6. | P. & P. 3/6. |
| 300 W. | £2. 7.6. | P. & P. 3/6. |
| 500 W. | £3.10.0. | P. & P. 6/6. |
| 1,000 W. | £5.10.0. | P. & P. 7/6. |
| 1,500 W. | £6.10.0. | P. & P. 8/6. |
| 7,500 W. | £15.10.0. | P. & P. 20/–. |

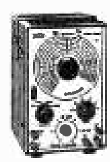
## TE22 SINE SQUARE WAVE AUDIO GENERATORS

Sine: 20c/s to 200 Kc/s on 4 bands. Square: 20c/s to 30Kc/s. Output impedance 5,000 ohms. 200/250V. A.C. Supplied brand new and guaranteed with instruction manual and leads, £16.10.0. Carr. 7/6.

## TE111. DECADE RESISTANCE ATTENUATOR

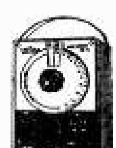
Variable range 0–111dB. Connections, Unbalanced T and Bridge T. Impedance 600 Ω range (0·1dB × 10) + (1dB × 10) + 10 + 20 + 30 + 40dB. Frequency: d.c. to 200kHz (–3dB). Accuracy: 0·05dB. +Indication dB × 0·01. Maximum input less than 4W (50V). Built in 600 Ω load resistance with internal/external switch. Brand new £27.10.0. P. & P. 5/–.

## TE-20D RF SIGNAL GENERATOR



Accurate wide range signal generator covering 120 Kc/s–500 Mc/s on 6 bands. Directly calibrated. Variable R.F. attenuator, audio output. Xtal socket for calibration. 220/240V. A.C. Brand new with instructions. £15. Carr. 7/6. Size 140 × 215 × 170 mm.

## TY75 AUDIO SIGNAL GENERATOR



Sine Wave 20 CPS–200 Kc/s. Square Wave 20 CPS–30 Kc/s. High and low impedance output. Output variable up to 6 volts. 220/240 volts A.C. Brand new with instructions. £16. Carr. 7/6. Size 210 × 150 × 120 mm.

**Full range of all components · valves semiconductors · test equipment receivers · hi-fi equipment · all at discount prices.**

G. W. SMITH & CO (RADIO) LTD.
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# NEW CATALOGUE

Nearly 200 pages giving full details of a comprehensive range of COMPONENTS, TEST EQUIPMENT, COMMUNICATION EQUIPMENT AND HI-FI EQUIPMENT. Each section greatly enlarged and fully illustrated. Thousands of items many at bargain prices.
Free Discount Coupons Value 10/-

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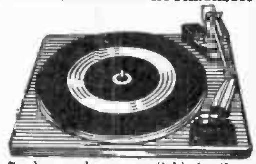
# GARRARD

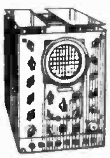
**FULL CURRENT RANGE OFFERED BRAND NEW AND GUARANTEED AT FANTASTIC SAVINGS**



| | | | |
|---|---|---|---|
| SRP22 Mono | £6.10.0 | *SP25 MK II | £11.19.6 |
| SRP22 Stereo | £6.19.6 | *SL55 | £11.19.6 |
| *1025 Mono | £7.10.0 | A70 MK II | £12.10.0 |
| *1025 Stereo | £7.15.0 | *AT60 MK II | £13.10.0 |
| *2025 Stereo | £7.19.6 | *SL65 | £14.14.0 |
| *2025T/C Mono/Stereo | £8.17.6 | AP75 | £19. 0.0 |
| | | 401 | £28. 7.6 |
| | | SL75 | £29. 0.0 |
| *3000 Stereo | £9.19.6 | SL95 | £35. 0.0 |

Carriage/insurance 7/6 extra any model. WB4 Bases £3.19.6. Perspex covers £3.10.0. *Special offer base and cover available for these models at £4.15.0. Carr. 5/-. Full range of Garrard accessories available.

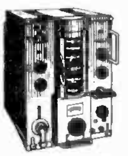
## TYPE 13A DOUBLE BEAM OSCILLOSCOPES



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/-.

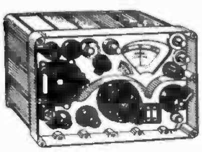
## ADMIRALTY B.40 RECEIVERS

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/P output, etc. Built-in speaker, output for phones. Operation 150/230 volt A.C. Size 19½ × 13¼ × 16in. Weight 114 lbs. Offered in good working condition. £22.10.0. Carr. 30/-. With circuit diagrams. Also available B.41 L.F. version of above. 15 Kc/s–700 Kc/s. £17.10.0. Carr. 30/-.



## R209 MK II COMMUNICATION RECEIVER

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, B.F.O., aerial trimmer, internal speaker and 12v. D.C. internal power supply. Supplied in excellent condition, fully tested and checked £15.0.0. Carr. 20/-.



## ADVANCE TEST EQUIPMENT

Brand new and boxed in original sealed cartons

**VM. 76 VALVE VOLTMETER.** R.F. measurements in excess of 100 Mc/s and D.C. measurements up to 100V with accuracy of +2% D.C. range 300 MV to 1 KV. A.C. range 300 MV to 300 V RMS. Resistance ·02-500 MΩ. Price £72.

**VM.78 A.C. MILLIVOLT METER.** Transistorised 1 MV-300 V. Frequency 1 c/s to 1 Mc/s. Price £55.

**VM.79 UHF MILLIVOLT METER.** Transistorised. A.C. range 10 MV-3 V. D.C. current range ·01µA–3 MA. Resistance 1 ohm-10 megohms. Price £125.

**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.

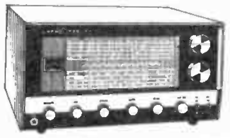
**J2B AUDIO SIGNAL GENERATOR.** As per J1B except fitted with output meter. Price £35.

**TT18 TRANSISTOR TESTER.** £37.10.0. Carriage 10/- per item.

## SOLARTRON MONITOR OSCILLOSCOPE TYPE 101

An extremely high quality oscilloscope with time base of 10µ/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/-.

## LAFAYETTE SOLID STATE HA600 RECEIVER



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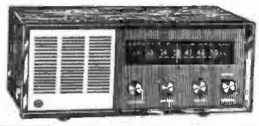

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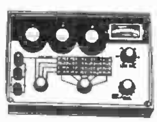

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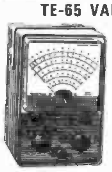

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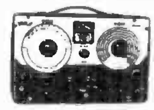

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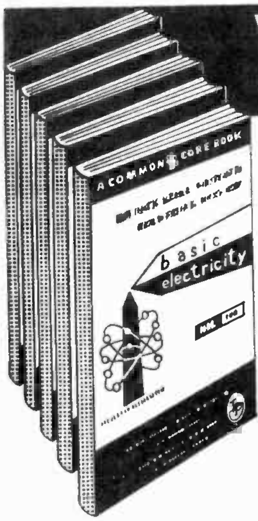


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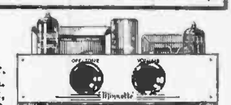


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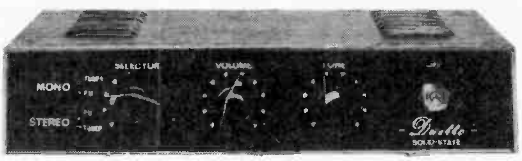


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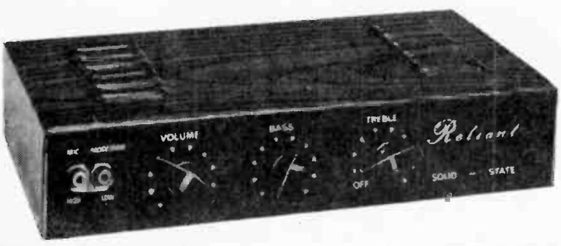


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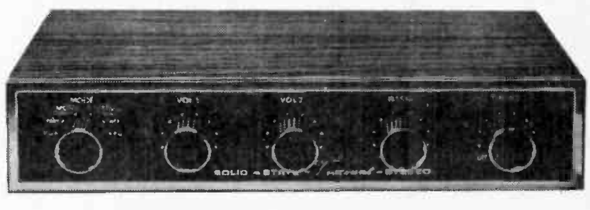

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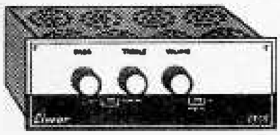

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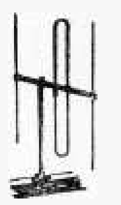

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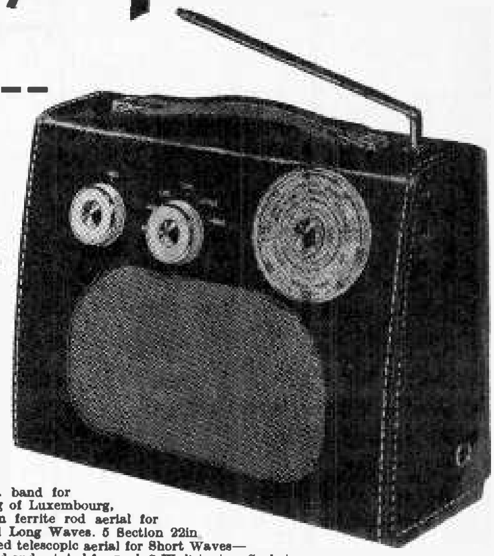

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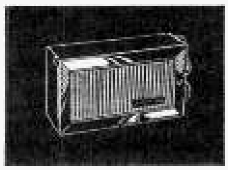

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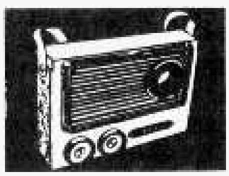

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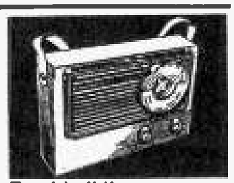

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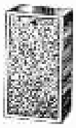
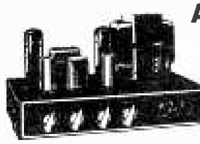


## R.S.C. STEREO/20 HI-FI AMPLIFIER

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. Suitable for high impedance microphones, Crystal or Ceramic P.U's. 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 £6** and 9 monthly payments of 32/- (Total £20.8.0). 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. For Crystal or Ceramic PUs, High Impedance "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 97/6 and 9 monthly payments of 22/-. (Total £14.15.6).

**RSC A11T TRANSISTORISED VERSION** of above complete kit 9 Gns (Assembled 11 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 57½ gns.). Send S.A.E. for leaflet.
**G100 100 watt peak output with Pr. speaker columns and a Bass Unit (Six 12" and Two 15" Spkrs). 99 gns**

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

Type BM1 An all-dry battery eliminator. Size 5½x4½x2in. 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. 4/3. 1½a. 5/6. 2a. 6/11. 3a. 9/9. 4a. 12/9. 6a. 15/9.

## R.S.C. MAINS TRANSFORMERS

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

**MIDGET CLAMPED TYPE 2½ × 2½ × 2½in.**

| | |
|---|---|
| 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. 10a. 55/11.

**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**

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

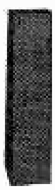
**SMOOTHING CHOKES**
150mA, 7-10H, 250 Ω 12/9; 100mA, 10H, 200 Ω 10/9; 80mA, 10H, 350 Ω 8/9; 60mA, 10H, 400 Ω 4/11.

# BLACKPOOL

AGENT APPOINTED O. & C. ELECTRONICS 227 CHURCH ST.

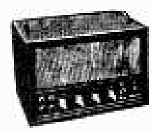
R·S·C HI-FI CENTRES LTD.

## R.S.C. COLUMN SPEAKERS



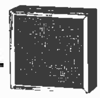
Covered in two-tone Rexine/Vynair, ideal for vocalists and Public Address, 15 ohm matching. C57 15 watts inc. five 7 x 4in. speakers £7.19.11.
TYPE C48S 30 WATTS. Fitted four 8in. high flux 8 watt speakers. Overall size approx. 42 x 10 x 5in. Or deposit 67/- and 9 mthly pmts 34/9 (Total £18.19.9) Carr. 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.** Or Deposit £4.13.3 and 9 monthly payments of 52/6 (Total £28.5.0).

## 30 WATT HI-FI AMPLIFIER



for Guitar, Vocal or Instrumental Group
A 2 or 4 input, 2 vol. control Hi-Fi unit with Separate Bass and Treble controls. Current valves. Peak output rating. Strong Rexine covered cabinet with handles. Attractive black/gold perspex facia. Neon indicator. For 200-250v. A.C. mains. For 3 or 15 ohm speakers. Send S.A.E. for leaflet. Deposit 4 gns. and 9 mthly payments of 39/8 (Total 21 gns). **18 Gns.** Carr. 12/6

## 12in. HIGH QUALITY LOUDSPEAKERS



In Teak or Afrormosia veneered Cabinets
15 Watt 11,000 lines 3 or 15 ohms. Carr 7/6 **£5.15.0**
20 Watt 10,000 lines 15 ohms. Carr 8/9 **£8.19.9**

## FANE ULTRA HIGH POWER LOUDSPEAKERS

All power ratings are R.M.S. continuous. 2 year guarantee. High Flux 14,000 line ceramic magnets. Heavy cast chassis.

| 'POP' 100 | 'POP' 60 | 'POP' 50 |
|---|---|---|
| 18" 100 Watt | 15" 60 Watt | 12" 50 Watt |
| **19** GNS. Carr. 15/- | **12** GNS. Carr. free | **10** GNS. Carr. free |

## POWER PACK KIT

Consisting of Mains transformer, Metal Rectifier, Electrolytics, smoothing choke, chassis and circuit. 200/250v. A.C. mains. Output 250v. 60mA 6·3v. 2a. Supplied with case in lieu of chassis 29/11. Or assembled 39/11. **25/11**

## CLEARANCE LINES

**HIGH QUALITY 8" x 3" LOUDSPEAKERS** 10000 Gauss 3 ohm only **11/9** Post 2/-

**15" 40 WATT LOUDSPEAKERS IN CABINET 14 Gns**
Heavy construction. Covering Rexine and Vynair

**14 WATT HI-FI AMPLIFIERS** High sensitivity. Two separate inputs. Two vol. controls for mixing purposes. Separate Bass and Treble Controls. Valves ECC83, ECL86, ECL86, EZ80. Output for 15 ohm Loudspeaker. 200-250v 50 c.p.s. A.C. mains operation. Size approx. 8 x 8 x 6in. Factory built and fully guaranteed. Limited number to clear at **£7-19-11** Carr. 10/-

**E.M.I. HIGH FIDELITY LOUDSPEAKERS** 13" x 8" 15 ohms **5½ Gns**
Gauss 13,000 lines. Formed flexible P.B.C. cone surround for very low fundamental resonance. Range 30-15,000 c.p.s. Rating 10 watts.

**EXTENSION 'SPEAKERS 29/9**
Cabinet size 12 x 8 x 5in. approx. attractive grey lizard skin finish. Fitted high flux 5 watt 3 ohm speaker.

**EMI PLAYER TURNTABLES**
with P.U. 4 speed. Turnover cartridge. Limited number.
Mono **59/9** Stereo **69/9**

**PHONE AMPLIFIERS** Speak and listen with both hands free. Standard dry battery operated. Attractive black moulded case. **59/9**

**1 WATT TRANSISTOR AMPLIFIERS** for 3-5 ohm loudspeakers. Miniature size. Brand new boxed. Post free **37/9**

**PRINTED CIRCUIT KITS** for making printed circuits. Complete with 72 square ins. laminated board and necessary fluids. **12/9** Post 2/9

**J.B. VHF/FM DIAL & DRIVE ASSEMBLIES** ONLY **9/9**
Complete with escutcheon. Size 7" × 4½". Escutcheon 7½" × 2½". Post 2/9

**TAPE RECORD/PLAYBACK AMPLIFIERS** 4 watts output. Magic Eye Recording level indicator. For 3 ohm L/S. All normal facilities. Less Facia plate. For 200/250 A.C. mains. Carr 8/6. **£8.15.0**

**ARMSTRONG UNITS CLEARANCE** Our Price
Stereo Amplifier 222 Our Price **£25** Carr. 10/6
AM/FM Tuner Amplifier 227M **£35** Carr. 10/6

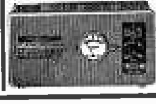
**MINI-8 HI-FI LOUDSPEAKER UNITS**
Teak or Afrormosia veneered cabinet, size approx. 10½ x 6½ x 7½in. Peak power handling 8 watts 3 ohms. Carr. 5/-. Clearance Price **59/11**

**JASON VHF/FM TUNER DESIGNS**
Total cost of parts FMT1 **5 Gns.** FMT2 **£6.19.11.** JTV2 **9½ Gns.** Please state channel

**STEREO/TEN HIGH QUALITY AMPLIFIER**

5 watts high quality peak 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. For 2-3 ohm speakers. Assembled with 12 months' guarantee Carr. 7/9 **£11.19.6**

**6/12V CAR BATTERY CHARGERS**



Complete kit of parts with Ammeter and Circuit. Both models with variable charge rate selector.
**4 amp 49/9** **6 amp 69/9**
All types 200-250v. A.C. Mains. Built 10/- extra.

# R.S.C. SENSATIONAL HIGH FIDELITY STEREO PACKAGE OFFERS

**"PACKAGE 3" 30 WATT OUTPUT**
★ Goldring Transcription Turntable on Plinth
★ Shure or Goldring Magnetic Pick-up Cartridge
★ Super 30 Amplifier in veneered housing **86 Gns.**
★ Pair of Stanton Loudspeaker Units
Special total price. Four fully wired units ready to "plug-in". Carr. 25/-.
**TERMS AVAILABLE ALL PACKAGE OFFERS**

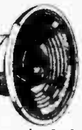
**Matching as recommended for optimum performance. Send for coloured brochure showing other money saving offers.**

Illustrated with TFMI Mk II Tuner fitted

**"PACKAGE 2" 30 WATT OUTPUT**
★ Garrard SP25 Mk II Turntable on Plinth
★ Goldring CS90 Ceramic P.U. Cartridge
★ Super 30 Amplifier in veneered housing
★ Pair Stanton Speaker Units **76 Gns.** Carr. 25/-
Special total price. Four fully wired units ready to "plug-in"

**"PACKAGE 1" 13 WATT OUTPUT**
★ Garrard SP25 Mk II 4 sp player unit on plinth
★ Goldring CS90 Ceramic P.U. Cartridge
★ TA12 Amplifier in cabinet
★ Pair of Dorchester L'speaker Units. Special total price. **51 GNS.**
Or Dep. £10 and 9 monthly payments £5.11.0. (Total £59.19.0.) Perspex cover 3gns. extra.

## AUDIOTRINE HIGH FIDELITY LOUDSPEAKERS

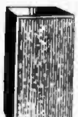


Heavy construction. Latest high efficiency ceramic magnets. Treated Cone surround giving low fundamental resonance. "D" indicates Tweeter Cone providing extended frequency range 40–15,000 c.p.s. Impedance 3 or 15 ohms. **Please state choice.** Exceptional performance at low cost. Prices include carriage.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| HF510L | 5" | 10W | 57/9 | HF100D | 10" | 15W | £5.15.0 |
| HF801D | 8" | 8W | 58/9 | HF120 | 12" | 15W | 69/9 |
| HF811D | 8" | 10W | 4 gns. | HF120D | 12" | 15W | 79/9 |
| HF102D | 10" | 8W | 59/9 | HF126 | 12" | 15W | 89/9 |
| | | | | HF126D | 12" | 15W | 5 gns. |

### HIGH FIDELITY LOUDSPEAKER UNITS

**Cabinets latest style Satin Teak or Afromosia veneer. Acoustically lined or filled woollen damping. Ported where appropriate Credit terms available**

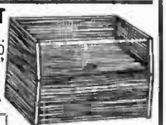


**DORCHESTER** Size 16 x 11 x 9in. Appr. Range 45–15,000 c.p.s. Rating 8–10 watts. Fitted High flux 13 x 8in. Dual Cone spkr. Imp. 3 or 15 ohms **£8.19.9** Carr. 7/6

**STANTON IIIS** Size 18x11x10in. Rating 10 watts. Incorporating Fane 803b speaker with roll rubber cone surround and 15,000 line magnet. High flux tweeter. Handsome Scandinavian design cabinet. Range 30–20,000 c.p.s. Impedance 15 ohms. Gives smooth realistic sound output. **16 Gns.** Carr. 7/6

**GLOUCESTER** Size 25 x 16 x 10in. 12in. High flux 12,000 line speaker. Cross-over unit and Tweeter. Rating 10 watts. Frequency range 40–20,000 c.p.s. Impedance 15 ohms. **12½ Gns.**

### E2 EQUIPMENT CABINET



Size 17" wide 14½" deep 11½" high. Cut for TA12, Super 15, Super 30 and other amplifiers. 'Roll over' perspex cover. Satin Teak or Afrormosia veneer finish. Price inc. carr. **8 Gns.**

**MOTOR BOARDS** cut for Garrard Turntables and many other units. Price **12/9**

### EXTREMELY ATTRACTIVE AND VERSATILE PLINTHS

finished in Teak or Afrormosia veneer. Tinted Perspex "roll over" cover with satin chrome handle.

### RECORD PLAYING UNITS

Money saving units. Ready to plug into Amplifier or Tape Recorder.

**RP2** Consisting of Garrard SP25 Mk II (with heavy turntable) fitted Goldring CS90 high compliance ceramic Stereo/Mono cartridge with diamond stylus. Mounted on Plinth. Inc. Perspex cover. Carr. 15/-. **22 Gns.**

**RP3** As above but with Goldring Lenco GL68 Transcription unit and CS90 Cartridge. Supplied with Perspex Cover. **£28** Carr. 21/-

### R.S.C. PLINTHS

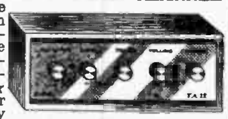
for Record Playing units. Teak finish cut for Garrard 1000, 2000, 3000, AT6, AT60, SP25 etc., etc. **59/9** Available with clear Perspex cover as ill. Inc. Carr. **6 Gns.** Perspex cover sold separately at 3 Gns. Limited number of covers slightly damaged but repaired by makers. **39/9**

### 10 W HIGH FIDELITY AMPLIFIERS

**LINEAR L10** Separate Pre-amp and Main Amp. Matched to Magnetic P.U. To clear **10 GNS.**

## R·S·C·TA12 13 WATT STEREO AMPLIFIER

**FULLY TRANSISTORISED, SOLID STATE CONSTRUCTION HIGH FIDELITY OUTPUT OF 6·5 WATTS PER CHANNEL**



Designed for optimum performance with any crystal or ceramic Gram P.U. cartridge, Radio tuner, Tape recorder, 'Mike' etc. ★ 3 separate switched input sockets on each channel ★ Separate Bass and Treble controls ★ Slide Switch for mono use ★ Speaker Output 3–15 ohms ★ For 200–250v A.C. mains ★ Frequency Response 30–20,000 c.p.s. —2dB ★ Harmonic Distortion 0·3% at 1000 c.p.s. Hum and Noise —70dB ★ Sensitivities (1) 300mV (2) 50mV (3) 100mV (4) 2mV Output rating I.H.F.M. ★ Handsome brushed silver finish Facia and Knobs. Complete kit of parts with full wiring diagrams & instructions. Factory built with 12 mth gntee 16 GNS or Deposit £5.2.6 and 9 mthly pymts 31/6 (Total £19.6.0) Or in Teak or Afrormosia veneer housing 19½ Gns. Dep. £5.10.6 and 9 mthly pymts 39/-. (Total £23.1.6). **12½ GNS.** Carr. 7/9

### AUDIOTRINE HI-FI SPEAKER SYSTEMS

Consisting of matched 12in. 12,000 line 10 watt 15 ohm high quality speaker, cross-over unit and tweeter. Smooth response and extended frequency range ensure surprisingly realistic reproduction. **5 Gns.** Or **Senior 15 watt** inc. HF 126 15,000 line Speaker **6 Gns.** Carr. 6/6 Carr. 5/9

### HI-FI SPEAKER ENCLOSURES

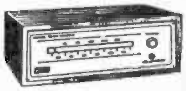
Teak or Afrormosia veneer finish. Modern design. Acoustically lined and ported. Inc. carr.
**JE8** Size 16 x 11 x 9in. Pressurised. Gives pleasing results with any 8in. Hi-Fi 'speaker. **4 Gns.**
**SE8** For optimum performance with any 8in. Hi-Fi 'speaker. Size 22 x 15 x 9in. **5 Gns.**
**SE10** For outstanding results with 10in Hi-Fi 'spkr Size 24 x 15x10in. **£5.10.0**
**SE12** For exclnt prfmnce with 12in Hi-Fi speaker and Tweeter. Size 25 x 16 x 10½in. **6 Gns.**

### INTEREST CHARGES REFUNDED on Credit Sales settled in 3 months.

### R.S.C. TA6 6 Watt HIGH FIDELITY SOLID STATE AMPLIFIER

**200-250v. AC mains operated** Frequency Response 30–20,000 c.p.s. —2dB. Harmonic Distortion 0·3% at 1,000 c.p.s. Separate Bass and Treble 'lift' and 'cut' controls. 3 input sockets for Mike, Gram, Radio or Tape. Input selector switch. Output for 3–15 ohm spkrs. Max. sensitivity 5mV. Output rating I.H.F.M. Fully enclosed enamelled case, 9½ x 2½ x 5½in. Attractive brushed silver finish facia plate 10½ x 3½in. and matching knobs. Complete kit of parts with full wiring diagrams and instructions. Carr. 7/6 **£6.19.9**
Or factory built with 12 months guarantee. £8.19.9

### R.S.C. TFM1 SOLID STATE VHF/FM RADIO TUNER

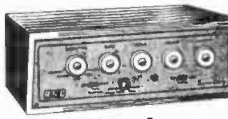


Total cost of parts with detailed wiring diagrams & instructions. Inc. Carr. **14 Gns.** Or factory built 16½ gns. Or in Teak finished cabinet as illustrated 19½ gns. Terms: Deposit £5 and 9 monthly payments £2. Total £23.

★ **High-sensitivity** ★ **200-250v. A.C. Mains operation.** ★ **Sharp A.M. Rejection.** ★ **Drift-free reception.** ★ **Output ample for any amplifier (approx. 500 m.v.).** ★ **Simple alignment instructions.** ★ **Output available for feeding tuning meter.** ★ **Output for feeding Stereo Multiplexer.** ★ **Tuner head using silicon Planar Transistors.** ★ **Designed for standard 80 ohm co-axial input.** Visually matching our Super 15 and 30 amplifiers and of the same high standard of performance and reliability. The pre-wired tuning head facilitates speed and simplicity of construction. Printed circuitry. Only high grade transistors and components used. A quality product at considerably less than the cost of comparable units. Stereo version, all parts 20 gns. Inc. carr. Assembled 22½ gns. inc. carr.

## R.S.C. SUPER 15 HI-FI AMPLIFIER — SOLID STATE CONSTRUCTION — R.S.C. SUPER 30 STEREO AMPLIFIER

**SPECIFICATIONS COMPARABLE WITH UNITS COSTING CONSIDERABLY MORE**



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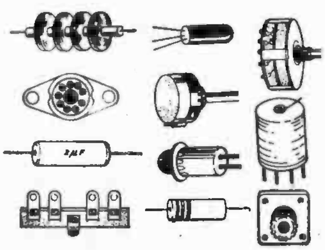

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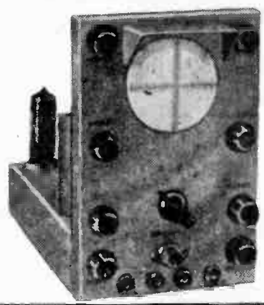

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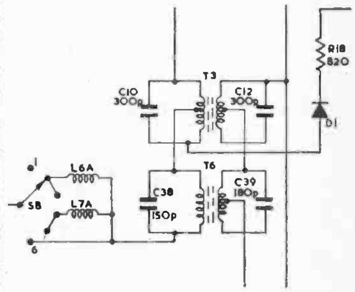


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# PRACTICAL WIRELESS

VOL 45 No 3

*Issue 749*

JULY 1969

TOPIC OF THE MONTH

## Self-satisfaction

WHY do we do it? Now, there's a leading question if ever there was one. With the keenly competitive market of today, and the resultant multiplicity of receivers, units, test equipment, and the like, often at prices impossible to match by the lone enthusiast, it would seem to the outsider to be difficult to account for the continued popularity of our hobby.

Yet, despite all logical attempts to understand the reasons why the home constructor should still spend his leisure hours making something he could probably buy cheaper, the ranks increase in number. Certain projects, of course, *are* much cheaper to build oneself, especially if the proverbial spares box has any pretensions. But it is necessary to dig a little deeper to discover why more and more people are actively engaged in connecting R1 to C4. For it is obvious that the mere saving of money is not the primary motive.

Man is a curious animal (in at least two definitions of the phrase!). In the first place he is blessed with an intuitive inquisitiveness which may manifest itself in anything from wanting to go to the moon to wondering if it is possible to build a portable radio that not only looks good but sounds good. Perhaps this is the main driving force.

Another well-established characteristic of many specimens of *homo sapiens* (though not in all, by a long way!) is an inherent seeking for the pride that comes from a sense of achievement. In the past, very many people could attain this mental condition at their workbenches but the days of individual craftsmen are fast disappearing. With mass production and modern manufacturing techniques, many erstwhile craft jobs have given way to those offering little in the way of personal satisfaction. This seems to have created a void and is no doubt a strong reason for the astonishing boom in all kinds of do-it-yourself activities.

Many of these frustrated artisans take up radio and electronics. And it is paradoxical that one of the reasons for the de-humanising of industry is the increasingly widespread use of electronics!

W. N. STEVENS—*Editor.*

## NEWS AND COMMENT



## CONSTRUCTIONAL



## OTHER FEATURES



**AUGUST ISSUE WILL BE PUBLISHED ON JULY 4th**

### *QUERY COUPON*

This coupon is available until 4th July, 1969 and must accompany all queries in accordance with the rules of our Query Service. An s.a.e. must be included.

PRACTICAL WIRELESS, JULY 1969

# NEWS AND COMMENT...

## RADIO AND TV SERVICING FOR THE YOUNG

The Department of Employment and Productivity has produced a *Choice of Careers* booklet (No. 66) on careers in radio and television servicing. The booklet states that most homes now contain at least a radio and television and in many cases a record player and tape recorder as well. It says that it is therefore essential that adequate repair facilities are available and that there are excellent prospects for the "keen young man who has the aptitude for the job, applies himself wholeheartedly to learning it thoroughly and is prepared to keep abreast of current developments".

The book says that prospects are not limited solely to servicing and those with the ability to extend their knowledge through further study and training may qualify for executive and administrative posts.

Radio mechanics and technicians are responsible for the maintenance of radio receivers and transmitters, weather radar sets, direction and position finding equipment and a wide range of electronic safety and navigational aids. There are also jobs with independent and multiple retailers, with the service organisations, with manufacturers' servicing departments, rental and relay companies, the radio and television organisations and government departments.

There are openings for girls—on production, sometimes with servicing, and some jobs doing semi-skilled work.

The booklet is amply illustrated with photographs showing the branches of the work.

The price of the booklet is 1s. 6d. and is obtainable from H.M. Stationery Office.

## THE "WATERCHECK"


**Automents Ltd., New Street, Oadby, Leicester, LE2 4LB, specialise in designing, developing and manufacturing car instruments and accessories and their latest design is called the "Watercheck". It consists basically of a Darlington pair and is a water-level indicator. Whenever the water level falls to the level of the probe, fitted into the header tank at a predetermined level, a signal is passed to the Watercheck instrument on the dashboard flashing an amber light, so warning the driver to take action before engine damage occurs. The makers claim the unit can be fitted by the average driver in 20 minutes and there are only three electrical connections to make. Two models are available—12V positive and 12V negative earth. The cost is £3. 15s including postage.**

**Automents Ltd. state that they will be launching, within the next few months, a windscreen wiper control and a unit called the "Speedset"—an audible speed computer which sounds an alarm as soon as a predetermined speed has been exceeded.**

## 15 + 15W STEREO AMPLIFIER


*Futuristic Aids Ltd., 106 Henconner Lane, Leeds, announce their "Phase Thirty-Two" solid state stereo amplifier. Sensitivites are: Magnetic p.u., 3·5mV, Ceramic, 30mV, Radio, 100mV, Tape, 500mV, Microphone, 5mV and Tape Head, 2mV. Frequency response is 10–40,000 c.p.s. —3dB; hum level, —80dB and signal-to-noise, —60dB. Harmonic distortion is 0·1% at 10W r.m.s. 1,000 c.p.s.*

*The unit is housed in a satin teak veneered cabinet and the fascia plate is Perspex with black background and silver lettering. There is a 5-position input selector—disc, radio, tape, mic., tape head. The price is 35 guineas.*

## CODAR MOVE

Codar Radio Co. (Inc. Codar Electronics Co.), Bank House, Southwick Square, Southwick, Sussex, have moved into their new factory.

Now all correspondence and goods must be addressed to: *Codar Radio Company, *Codar Electronics (*as applicable) Thesiger Close, Meadow Road Industrial Estate, East Worthing, Sussex. Telephone: Worthing 37315.

## NEW MULLARD PUBLICATION

*Consumer Electronics* is the title of a new Mullard quarterly which concentrates entirely on the existing and future applications of electronics in consumer goods.

Among topics dealt with in the 18-page March issue are: the control of domestic appliances by thyristors, an electronic controller for electric blankets, rental for domestic appliances, colour TV picture tubes, microminiaturisation and hearing aids, and a quartz-controlled wristwatch.

*Consumer Electronics* is free to all interested in the design and manufacture of consumer goods in which electronic devices are or could be used. It is not, however, intended for retailers or consumers. Requests for issues should be addressed, on company headed notepaper, to C.I.H./C.M.S. Dept., Mullard Ltd., Mullard House, Torrington Place, London, W.C.1.

## CABLE & WIRELESS APPOINTMENT

Mr. Robert F. Forrest, is the new secretary of Cable and Wireless Ltd.

During the Second World War he saw service on one of the famous Blue Trains—mobile radio stations which provided frontline communications for Allied troops.

Mr. Forrest, in fact, travelled with his Blue Train from Algiers to Vienna, visiting Naples, Rome, Frankfurt and other war-torn cities on the way.

# NEWS AND COMMENT...

### NEW MULLARD PHOTO-CELL

A new cadmium sulphide cell announced by Mullard has a larger photo-sensitive element than the well-established ORP60, but is the same size externally (6mm in diameter and 16·5mm long excluding leads). Hence, the new cell, type ORP69, is more sensitive and has a higher dark resistance.

The ORP69 will dissipate 100mW and withstand voltages up to 350V d.c. Its initial dark resistance is greater than 100MΩ; in an illumination of 50 lux from a lamp with a colour temperature of 2700°K, the cell resistance is typically 30kΩ. It has a sensitivity of approximately 17μA/lux.

### PERIOD STYLE SEPARATES

*In Queen Anne style, the Dynatron Hambledon Model HFC13, illustrated on the right, incorporates the SRX25 tuner-amplifier with the Garrard 3500 auto-changer with stereo cartridge and diamond stylus.*

*Recommended retail price including purchase tax £139 15s.*

*Matching Queen Anne style loudspeaker enclosures—Model LS250—are available for this model at the recommended retail price including purchase tax of £30.*

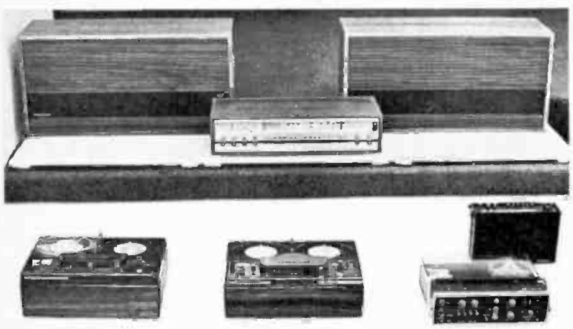
## ELECTRONICS at the Norway Trade Centre

Mr. S. Walter Rostoft, the Norwegian Minister of Industry, recently opened the first exhibition at the new Norway Trade Centre at 20 Pall Mall, London, S.W.1.

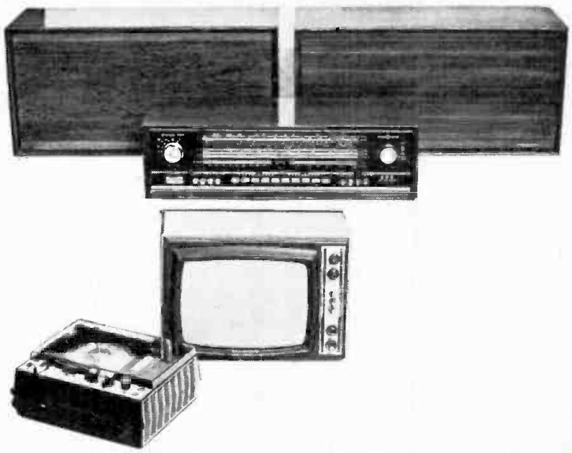
Called "Design for Export", the exhibition showed a wide range of Norwegian export products. Many of the exhibits were design articles for the home, including glass, china, cutlery, furniture etc. but another section of the exhibition featured a number of electronic articles including tape recorders, radio receivers and television.

Tandbergs Radiofabrikk A/S Oslo, represented in the United Kingdom by Elstone Electronics Ltd., Leeds, were the major exhibitor at the exhibition. Tandbergs export 50% of production to the UK, Sweden and the USA.

Norway's oldest radio manufacturer, A/S Radionette, established in 1927, was showing its Multirecorder f.m. tape recorder, its Kurer u.h.f./v.h.f. portable TV working from mains or battery and housed in a wooden cabinet, and its new Soundmaster HiFi stereo radio which employs pressure chamber speakers. This set cover 6 wavebands: Long, Medium, Short 1 (60-24m), Short 2 (24-10m), f.m. and Marine Band. In the UK Radionette is represented by Denham & Morley Ltd., London, W.1.



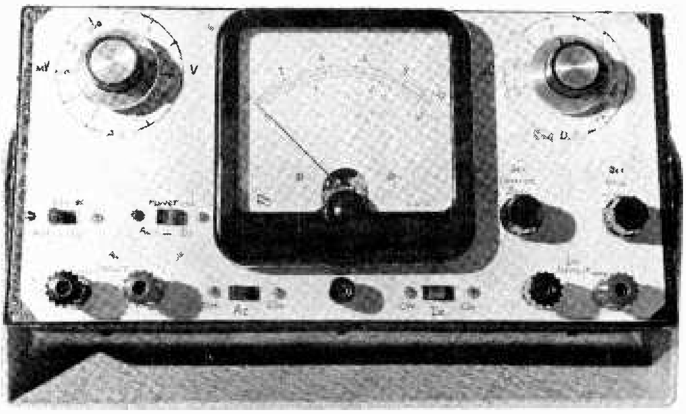
*From Tandbergs Radiofabrikk A/S, radio "Huldra" in palisander with two loudspeakers also in palisander. On the left, tape recorder 1200X, the series 15 and the tape recorder 11 which is battery driven. The TP 3-3 portable radio is on the right.*



*From A/S Radionette, the Soundmaster Hi-Fi Stereo with pressure-chamber speakers, the "Kurer" 11in. TV and the Multi-recorder—FM—a one-spool portable tape recorder with built-in f.m. radio.*

# AC-DC METER

H. T. KITCHEN



THE further the enthusiast ventures along the electronics path, the more he realises the limitations of the ubiquitous test meter. For many applications the test meter is adequate, often indispensable, and it is only when he begins to delve into the regions of millivolts, or begins to soar into the kilohertz region that the limitations of the ordinary test meter become obvious. In order to explore these regions successfully, more sophisticated equipment is necessary. It was to fulfil such a requirement that the test set to be described was evolved.

The cost of such an instrument, even if home made, is relatively high when one considers the multitude of cheap and usually good test meters available to the enthusiast.

In the "good old days" of vacuum state equipment, test meters having input resistances of one or two kΩ/V were quite adequate. A 10kΩ/V meter was occasionally necessary; a 20kΩ/V meter was really something. Nowadays, silicon transistors drawing only a few hundred micro-amps collector current are not uncommon, with base currents in the nA (nA=nanoamp=0·001 μA) or a few μA region. In such an instance, even a 20kΩ/V meter can impose an intolerable drain on the circuit, giving readings well below the true value, or even no reading at all. Quite clearly, a much higher input resistance meter is required, and since the major requirements, such as sensitivity, and robustness and resistance against damage due to mechanical shock, conflict, there is a limit to the degree of sensitivity attainable in the meter movement itself. Recourse has to be made to "active" voltmeters containing amplifiers that can increase the minute voltages to the extent that relatively insensitive, and therefore mechanically robust, meter movements can be used. These amplifiers constitute what are in effect, impedance transformers that allow the low resistance high current consumption meter movement to be connected into a high resistance low current consumption circuit without affecting it adversely.

One other limitation of the ordinary test meter is its restricted measuring range. Few test meters are intended for measuring voltages below a few volts a.c. and d.c., so that the very limited a.c. output voltages from tape leads, moving coil pickups and microphones are virtually undetectable, let alone measureable. As far as d.c. in concerned, voltage differences of a few hundred mV are not uncommon—and are difficult to measure accurately on the average test meter.

A further limitation is that of frequency response, or rather the lack of it. Most of the older test meters employed selenium rectifier for the a.c. ranges, and the response of these rarely exceeded several kHz. The response of the germanium or silicon rectifiers, however, in current use, is much better.

Having proved, I hope, the necessity of parting with more hard earned (?) cash, we can now get to grips with the article itself.

The design to be described consists of two entirely separate amplifiers, one for a.c. and one for d.c., the outputs of which may be selected, to feed a moving coil meter. Two separate meter amplifiers are used for maximum efficiency; one meter movement for maximum economy. In practice, where it matters most, the compromise works well, since the inputs of the amplifiers can be connected into the parts of the circuit under examination, and the meter switched into the output of either meter amplifier as required. This method therefore resulting in the minimum of circuit disturbance.

## DC Amplifier

The d.c. amplifier is the simpler of the two, and will accordingly be described first. The circuit shown in Fig. 1 contains five transistors of which the first four Tr1-Tr4 function as a long tailed quartet, and form the amplifier proper. The fifth transistor operates as a constant current source serving two different, and very useful functions.

Without the amplifier, the d.c. meter would have an input resistance of only 20kΩ/V at a f.s.d. (full scale deflection) current consumption of 50μA. With the amplifier added, the meter has an effective input resistance of 3MΩ/V and an f.s.d. current consumption of 333nA. The amplifier therefore, has a current gain of ×150. Even higher gains are possible, but as will be explained later, are not a practical proposition.

An explanation of the action of the d.c. amplifier is perhaps best effected by temporarily ignoring Tr5 and its associated components R19 and D1 and by connecting the slider of VR2 to the negative line. Tr1 to Tr4 will then be seen to comprise a very high gain push-pull amplifier, with input voltage applied between the bases of Tr1 and Tr4 with the output voltage developed by Tr2 Tr3 across R13 R16 applied to the meter. The amplifier is therefore a differential amplifier.

Assuming component equality "either side" of the meter movement, the bases of Tr1 and Tr4 will be at the same potential as each other, as will the collectors of Tr2 and Tr3. There will therefore be no current flow through the meter. If a d.c. voltage is now applied between the bases of Tr1 and Tr4, the balance will be disturbed and the current flowing through one pair of transistors, (Tr1 Tr2) will increase, the current through the other pair will decrease, and a current will therefore flow through the meter. Due to the amplification afforded by the transistors, a minute current into the bases, in this instance 330nA, will cause the meter to pass 50$\mu$A and so read full scale.

Due to manufacturing tolerances, component equality cannot be assured, and so other means have to be sought to bring the meter pointer initially to zero. This is achieved by VR1 and VR2, the former equalising the base voltages, the latter the emitter. Base bias is by R11 R12 VR1 for Tr1 Tr2, and by R17 R18 and VR1 for Tr3 Tr4.

The reason for requiring two equalising controls is quite simple. It is quite possible to effect meter zero by equalising the emitter voltages only by means of VR2, even if the base voltages are dissimilar. However, the transistors will amplify the *difference in the base voltage as well as the wanted voltage.* Considerable errors are therefore possible, the error being a function of the difference in polarity and magnitude of the "difference" and "wanted" voltages.

An unfortunate aspect of high gain d.c. amplifiers is that the zero once set, tends to drift, the tendency to drifting increasing with increased amplifier gain. Unless this drift can be curtailed, meter readings will be subject to error.

## SPECIFICATION

### D.C. METER

Ranges:
100mV, 300mV, 1V, 3V, 10V, 30V, 100V, 300V.
Input Resistance:
3MΩ/V–10V constant at 30MΩ thereafter.
Input Current:
330nA for f.s.d. to 10V thereafter 1$\mu$A for 30V, 3·3$\mu$A for 100V, 10$\mu$A for 300V.
Accuracy: 3% or better.

### A.C. METER

Ranges:
3mV, 10mV, 30mV, 100mV, 300mV, 1V, 3V, 10V, 30V, 100V, 300V.
Input Resistance:
3MΩ+35pF 3mV–1V.
10MΩ+15pF 3V–300V.
Frequency Response:
±0·5dB 20Hz–200kHz
±3dB 10Hz–400kHz.
Noise:
10$\mu$V on 3mV range, input short circuited.
Accuracy: 3% or better.

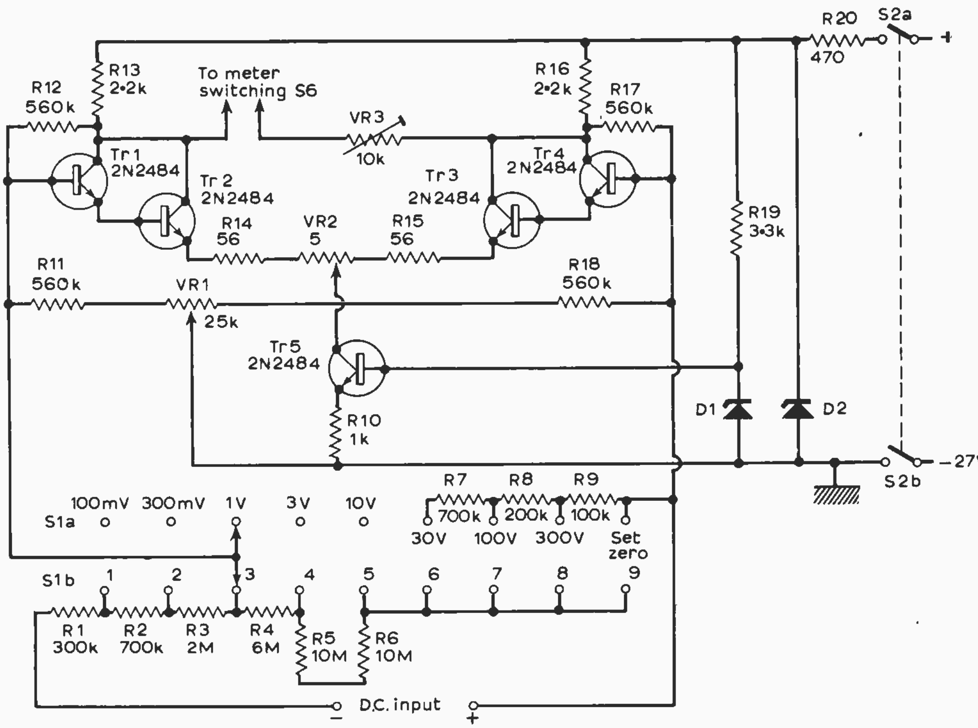



*Fig. 1: Complete circuit of the d.c. differential amplifier.*

Assuming the zero is initially correct, drift is caused by a component altering its characteristics. The adoption of high stability close tolerance resistors assists in the maintenance of good zero stability, and also by the use of silicon transistors. The biggest enemy of good zero stability is a temperature differential existing between components, principally the transistors on "opposite" sides of the meter. This can be easily demonstrated on the completed instrument by lightly resting a finger—nothing warmer is required—on one of the input transistors, when the zero will be seen to rapidly drift. Even the output transistors will cause a change in the zero setting, though this is usually less severe than the drift due to the input transistors. On removing the finger, or by placing another finger on the "opposite" transistor, the zero setting will be restored, assuming equality of finger temperature of course! The temperature differential can be minimised by placing the opposite pairs of transistors in close proximity or by enclosing them in a common heatsink, though normally a heatsink is quite unnecessary due to the minute power dissipation in each transistor.

Heavy negative feedback is developed in the circuit in two ways. Firstly, by means of R12 and R17 which are returned to the collectors, and thus passes back any variation in collector voltage to the base. Secondly, by means of R14 VR2 and R15, as variations in emitter voltage take place through the common load Tr5, and are therefore once again in opposition. The effect of this feedback is threefold. It stabilises amplifier gain, reduces zero drift, and improves linearity.

Equalisation of the emitter and base voltages is effected, as already explained, by VR1 and VR2. As both affect the collector voltages, it is necessary to adjust VR2 first by temporarily short-circuiting the bases of Tr1 and Tr4 together. The s-c is then removed and the bases are equalised by VR1. As there is a degree of mutual interdependence, several attempts are necessary before correct zero is obtained.

We come at last to the purpose of Tr5, which serves two purposes. Firstly, it improves the common mode rejection ratio, which is the ability of the amplifier to amplify the wanted signal applied to the bases of Tr1 and Tr2 differentially, and to reject any unwanted signal that may reach both bases simultaneously. This purpose is fulfilled by Tr5 in a most acceptable manner. The other purpose of Tr5 is almost incidental. It improves the stability of the amplifier gain most markedly, so that whilst the zero shifts with changing supply voltage (temporarily disregarding D2) the gain remains constant.

When the amplifier was first built, a sensitivity exceeding 20MΩ/V was obtained. Zero stability was however unacceptably poor, drifting (in time) to the extent of $\pm 10\mu$A, and it was necessary to improve matters. As feedback was at a maximum, it was decided to reduce the sensitivity of the meter movement. This was done by means of VR3 and the zero drift dropped to about $\pm 1\mu$A, the input resistance dropping to 3MΩ/V.

Another reason for reducing the sensitivity was the virtually impossible task of obtaining economically the very high value resistors necessary. Assuming one would tolerate a slow drift of $\pm 10\mu$A, where would one obtain a resistor of 6,000MΩ in order to provide a 300V range? Even with the sensitivity reduced to the level of 3MΩ/V, a series of shunt resistors (R7 R8 R9) are required to keep within the range of easily obtained resistor values.

Range switching is effected by S1a and S1b. S1b switches in the series resistors R1-R6. After R6, the contacts are connected together and S1b is used to bring the series of shunt resistors into circuit, so reducing the sensitivity and allowing a maximum voltage of 300V to be measured. In the final position, position 9, S1a and S1b are arranged to s-c the bases of Tr1 Tr4 together, so allowing emitter zero to be set. This end of the scale was deliberately chosen so that, having set zero, one started at 300V and worked way down the scale, so obviating the possibility of setting zero and then absentmindedly (it has been done) trying to measure 300V on the 300mV switch position.

The power supply of 27V is provided by three 9V batteries in series. This is dropped to, and stabilised at 20V by R20 and D2. The current consumption is very modest and the batteries should have a long and useful life. On/off switching is effected by S2a-b, a miniature slide two-pole two-way switch.

## AC Amplifier

As far as the a.c. amplifier is concerned, at least two bipolar transistors, in the Darlington configuration, would be required to provide the requisite high input resistance and the use of an f.e.t. in this position was considered to be a viable proposition. The a.c. amplifier, Fig. 2, is basically quite simple. The a.c. input is applied to a coarse attenuator comprising S3a-b, R21 TC1 and R22 C1. The output from the slider of S3a is applied via C2 to the gate of the f.e.t Tr6. Bias to this stage is by means of the gate resistors R26-R32 in the source circuit, the source current being 450$\mu$A. Bootstrapping of Tr1 is by means of C3 which feeds back the a.c. signal at the source to the junction of the gate resistors R23 R24 and R25. The input resistance of Tr6 stage is in the region of 5MΩ in parallel with 3·5pF.

From the wiper of S3b, the a.c. signal is passed via C6 to the base of Tr7, which is the input transistor of the amplifier proper comprising Tr7 Tr8 and Tr9. These three transistors are d.c. coupled throughout. The coupling, from Tr9 collector to Tr7 base forms a d.c. feedback loop that very effectively stabilises the collector currents of all three transistors. Since only d.c. feedback is wanted along this route, a.c. decoupling is necessary and is effected by C7. Originally, R37 and R38 were used for feedback purposes, being 270kΩ each. However, due most probably to the variation in the d.c. leakage resistance of C7, the d.c. conditions tended to be somewhat unstable. No sooner were R37 and R38 selected for the requisite collector current in Tr9, than they had to be changed again. Reducing R37 and R38 and introducing R41, small in comparison to the leakage resistance of C7, has improved matters and the d.c. characteristics are now stable.

Negative feedback with all its advantages is via meter rectifier diodes D3-D6 and C10 to the emitter circuit of Tr8. Variation of feedback and hence of the amplifier gain, is effected by VR4 and C9. When the slider of VR4 is at the earthy end of its travel, feedback is at minimum, the emitter is short-circuited (to a.c.) by VR4 and the amplifier gain is at a maximum. With VR4 slider at the emitter end of its travel, C9 is undecoupled, feedback is at a maximum and the amplifier gain is at minimum. Variation of VR4 allows the gain to be set at any intermediate figure. The meter deflection for any given input can therefore be set within quite wide limits, thereby allowing for the variation in hfe between individual transistors.

So much for the "active" side of the circuit. We come now to the "passive" side, the attenuator

Briefly then, the primary attenuator passes all voltages below 1,000mV or 1V to the gate of Tr6, the secondary attenuator which is of course coupled to the primary attentuator, tapping off the sequence 1-3-10-30 etc., so that the input to Tr7 never exceeds 3mV. The "attentuation" factor of the primary attenuator is, at this stage, zero, i.e. the a.c. input is fed directly to the gate of Tr6 via the d.c. blocking capacitor C2.

Voltages exceeding 1V are still fed to the gate of Tr6 via C2, but have now to pass through the primary attenuator which now offers an attenua-

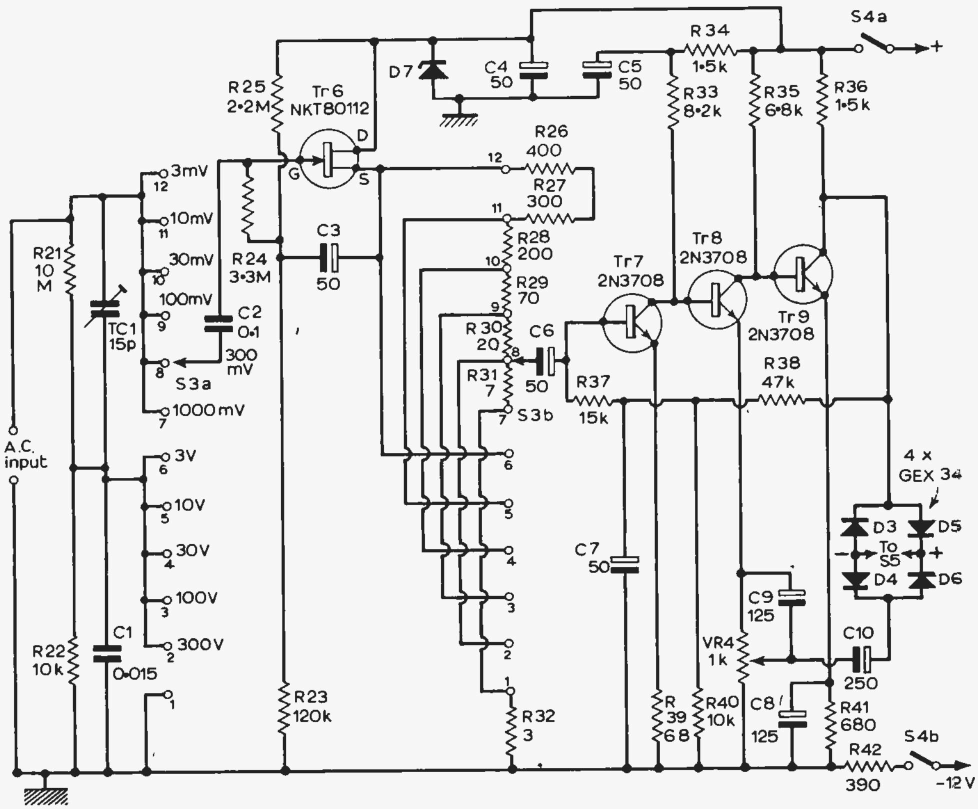



*Fig. 2: The a.c. amplifier—note the use of an f.e.t. in the input.*

comprising S3a-b together with other sundry components. The "split" attenuator used is a time-honoured design intended to overcome a number of problems involving input resistances and voltage, and frequency compensation. The sensitivity of the main amplifier Tr7-Tr9 is 3mV for f.s.d. on the meter. Inputs exceeding 3mV will cause the meter to exceed f.s.d and if excessively high, could damage the transistors and/or the meter. In the source circuit of Tr6 is a six position (essentially) attenuator that limits the input to Tr7 to 3mV on each of its ranges. The total resistance of this chain of resistors comprising R26 to R32 is 1,000Ω, low enough not to require frequency compensation at the frequencies involved.

The input stage Tr6 will accept voltages up to 1,000mV without undue stress. Since we will wish to measure voltages greatly exceeding this figure, the primary of the split attenuator is arranged to feed the gate of Tr6 limiting the input to 1,000mV or less.

tion of ×1,000. The inputs to the base of Tr7 are still only millivolts, i.e. 3V is reduced to 3mV, 10V to 10mV and so on. The last five positions of the secondary attenuator are connected to the first six, i.e. 1 to 7, 2 to 8, and so on, so that the 1-3-10 sequence established for millivolts is still retained for volts, and the main amplifier still receives its requisite 3mV for meter f.s.d.

Frequency compensation of the primary attenuator is eased by having only two attenuation factors, of ×0 and ×1,000. Since the ×0 is straight through, only the ×1,000 requires compensation, and this is effected by TC1, which is set so that the time constant of TC1 × R21 is equal to the time constant of C1 × R22, the frequency response then being, in theory anyway, to infinity.

The primary and secondary attenuators are built on two separate single-pole twelve-way wafers mounted on a common spindle, thus transference of the primary attentuator from volts to millivolts, and

# ★ components list

**Resistors:**

| | | | |
|---|---|---|---|
| R1 | 300kΩ 1% 1W | R23 | 120kΩ |
| R2 | 700kΩ 1% 1W | R24 | 3·3MΩ |
| R3 | 2MΩ 1% 1W | R25 | 2·2MΩ |
| R4 | 6MΩ 1% 1W | R26 | 400Ω 1% 1W |
| R5 | 10MΩ* 1% 1W | R27 | 300Ω 1% 1W |
| R6 | 10MΩ* 1% 1W | R28 | 200Ω 1% 1W |
| R7 | 700kΩ 1% 1W | R29 | 70Ω 1% 1W |
| R8 | 200kΩ 1% 1W | R30 | 20Ω 1% 1W |
| R9 | 100kΩ 1% 1W | R31 | 7Ω† |
| R10 | 1KΩ | R32 | 3Ω† |
| R11 | 560kΩ | R33 | 8·2kΩ |
| R12 | 560kΩ | R34 | 1·5kΩ |
| R13 | 2·2kΩ | R35 | 6·8kΩ |
| R14 | 56Ω | R36 | 1·5kΩ |
| R15 | 56Ω | R37 | 15kΩ |
| R16 | 2·2kΩ | R38 | 47kΩ |
| R17 | 560kΩ | R39 | 68Ω |
| R18 | 560kΩ | R40 | 10kΩ |
| R19 | 3·3kΩ | R41 | 680Ω |
| R20 | 470Ω | R42 | 390Ω |
| R21 | 10MΩ 1% 1W | R43 | 2·2kΩ |
| R22 | 10kΩ 1% 1W | R44 | 2·2kΩ |

All resistors 5% ½W hi-stabs except where shown as 1% 1W. * R5 R6 may be replaced by single 20MΩ 1% if available. † R31 R32 may be selected from 10% range or wound from 36 s.w.g. Eureka wire. 42·5cm and 18·5cm for 7Ω and 3Ω respectively.

**Switches:**

S1a, b, S3a, b R.S. "Maka-switch" shafting (2 off) Four single pole twelve-way wafers.
S2 Two-pole two-way slide switch
S4 Two-pole two-way slide switch
S5 Two-pole two-way slide switch
S6 Two-pole two-way slide switch

**Meter:**

50μA f.s.d. Sifam type M404. 4½in. square. Scaled 0–3 and 0–10 (internal resistance 1250Ω) or similar.

**Capacitors:**

C1 0·015μF silver mica or paper
C2 0·1μF paper 250V wkg. p.c. mounting (see note below)
C3 50μF 15V wkg. p.c. mounting
C4 50μF 15V wkg. p.c. mounting
C5 50μF 15V wkg. p.c. mounting
C6 50μF 15V wkg. p.c. mounting
C7 50μF 15V wkg. p.c. mounting
C8 125μF 6V wkg. p.c. mounting
C9 125μF 6V wkg. p.c. mounting
C10 250μF 6V wkg. p.c. mounting
C11 1000μF 6V wkg. p.c. mounting
TC1 15pF trimmer

*Note:* D.C. working voltage of C2 depends on magnitude of d.c. it is likely to be connected across. For example, when measuring a.c. ripple on a high potential d.c. supply, the difference could easily be 300V d.c. to 100mV a.c. or even greater.

**Semiconductors:**

Tr1 to Tr4 2N2484
Tr5 BC109
Tr6 NKT80112
Tr7 to Tr9 2N3708
D1 3·9V 5% 400mW zener
D2 20V 5% 400mW zener
D3 to D6 GEX34
D7 7·5V 5% 400mW zener
D8 and D9 1S940

**Potentiometers:**

VR1 25kΩ w.w. or carbon linear
VR2 5Ω w.w. linear or up to 25Ω w.w.
VR3 10kΩ linear, skeleton p.c. mounting
VR4 1kΩ linear, skeleton p.c. mounting

**Miscellaneous:**

Knobs; ¼in. r.h. chromed 6BA screws with nuts; ¼in. self-tapping screws; insulated wire assorted colours; terminals, two red, two black, one black earthing type.

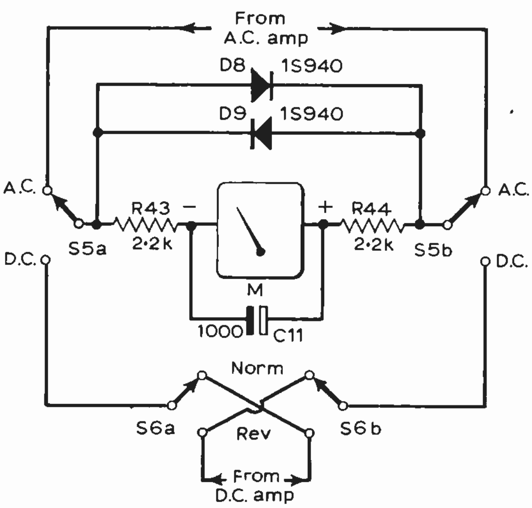



*Fig 3: Switching circuitry, relevant to the moving coil meter and amplifiers.*

of the two "separate" sections of the secondary attenuator, are completely automatic. The synchronisation of the primary and secondary attenuators on to a common switch means only one switch has to be manipulated in order to measure any voltage from 3mV to 300V.

The power supply is again by means of batteries, two of 6V each being employed to give a 12V supply. This is then dropped to, and held at the required 7·5V by R42 and the zener diode D7. The current consumption is quite modest and the batteries should have a usefully long life. On/off switching is effected by a miniature two-pole two-way slide switch, S4.

In the interests of economy, which is of more interest to the average amateur than the slight increase in operating time, a single meter is used, switched into the output of either amplifier as required by S5. On a.c. the meter connects straight into the output of the a.c. amplifier; but for d.c. a polarity reversing switch S6 is interposed between the meter movement and the d.c. amplifier.

TO BE CONTINUED

READY CALIBRATED

# SIGNAL GENERATOR

F. G. RAYER

A SIGNAL generator giving an audio output, c.w. or modulated output in the range about 150kc/s to 35Mc/s is extremely useful for stage-by-stage checks of audio and intermediate frequency stages, the alignment of i.f. and aerial circuits, and similar purposes. When such an instrument is constructed, its calibration can be something of a problem unless other accurately calibrated equipment or means of calibration are available.

To overcome this difficulty the signal generator described here has ready-made fixed-inductance coils L1, L2, L3, L4 and L5, see Fig. 1, tuned by a particular specified variable capacitor VC1. As these coils are manufactured to high accuracy and other items have very little influence on frequency, it is possible to adopt ready-made scales.

Five bands are covered, as follows:
(1) 35-10Mc/s (2) 10-3·2Mc/s (3) 4-1·2Mc/s
(4) 1500-425kc/s (5) 450-150kc/s

This covers all bands from about 9-2000 metres and includes those frequencies generally needed for i.f. circuit alignment. Tuning is by means of a reduction drive which has a 0-100 logging scale so frequencies can be written directly on the dial.

In Fig. 1, V1a is the r.f. oscillator, each coil L1 to L5 having its own feedback winding selected by SW1b. R.F. is taken through R3 and C3 to VR1, which allows adjustment of output; C5 isolates external circuits. Space was left for a buffer/amplifier between V1a and the output circuit, but with r.f. taken from the feedback windings in the way shown, such a stage was found unnecessary.

V1b is the audio oscillator, with transformer T1; the audio tone can be provided as output through C4 or used to modulate V1a. With SW2 at "c.w." an unmodulated radio frequency signal is obtained, with this switch at "Mod." the r.f. signal is modulated and thus audible on an ordinary receiver. When the switch is at "a.f." an audio frequency output is obtained for a.f. circuit tests.

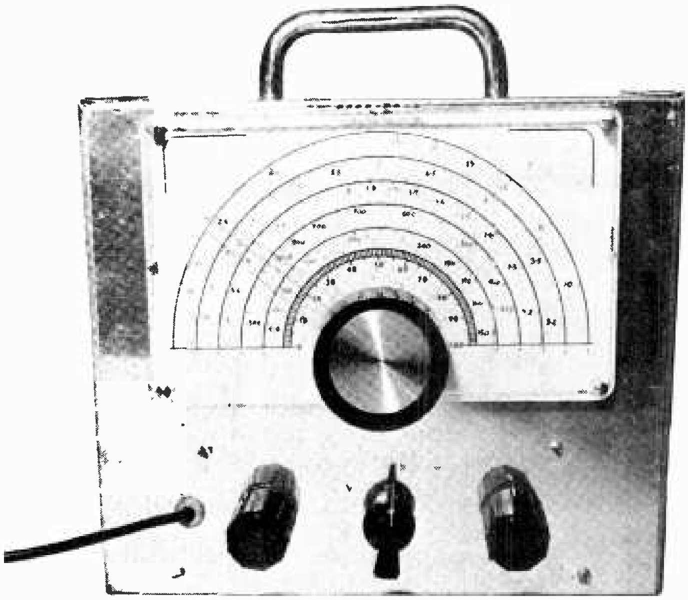
## Cabinet and chassis

A strong and inexpensive case is made from "Universal Chassis" members, the case top, chassis, and case bottom are 8 x 3in. and flanged. Cut away ½in. from the ends of the long flanges on one 8 x 3in. member so that it will fit inside the side members which are 7 x 3in. This 8 x 3in. item forms the chassis and it is bolted to the 8 x 7in. plate (panel) 2⅜in. from the bottom, see Fig. 2.

L3, L5 and T2 are fixed to the panel before fitting the dial using countersunk bolts. Wiring is completed and the signal generator is tested before adding the bottom and right-hand side (viewed from the rear). The box is closed with perforated zinc, or with a second 8 x 7in. plate in which holes have been punched. Self-tapping screws have to be used here.

## Layout from behind

Figure 2 shows the positions of most components; the drive listed has a paper template as a guide to



drilling. An insulated lead is soldered to the lower fixed tag of VC1, before mounting this item and passes down through a hole to SW1a.

C6/C7 is a dual capacitor and its common negative tag is connected to the chassis. The contact-cooled rectifier D1 is held by means of bolts.

The positions for other items can be seen from Fig. 3. T1 should have a ratio of about 3:1, and a primary suitable for the combined anode currents of both sections of the ECC81; transformers intended for use with transistors are not suitable. Connections in Fig. 3 are for the specified transformer. If another transformer is used and no audio tone is obtained, reverse the connections to one winding.

A three core flexible cord is required for the mains lead, and the earth conductor is secured to the case by a bolt holding the chassis and side together. Output was arranged with a co-axial lead, the inner conductor going to C5 and the outer brading to chassis. A co-axial socket may be preferred as shown in Figs. 2 and 3.

## Coils and switching

The coils are placed to allow short connections for the h.f. ranges, and to prevent absorption by windings not in circuit. Red tags go to SW1a. For ranges 2, 3, 4 and 5 the next tag clockwise goes to SW1b. The next tag on all coils is wired to chassis, and the remaining tag of coils for ranges 2, 3, 4 and 5 go to the h.t. circuit at C2. For range 1, tag 2 goes to R2, and tag 4 to SW1b (anode), Fig. 3. The following details should be helpful.

**Range 1.** Solder a ¾in. wire from red tag to adjacent tag of SW1a. Take a wire 1¾in. long from

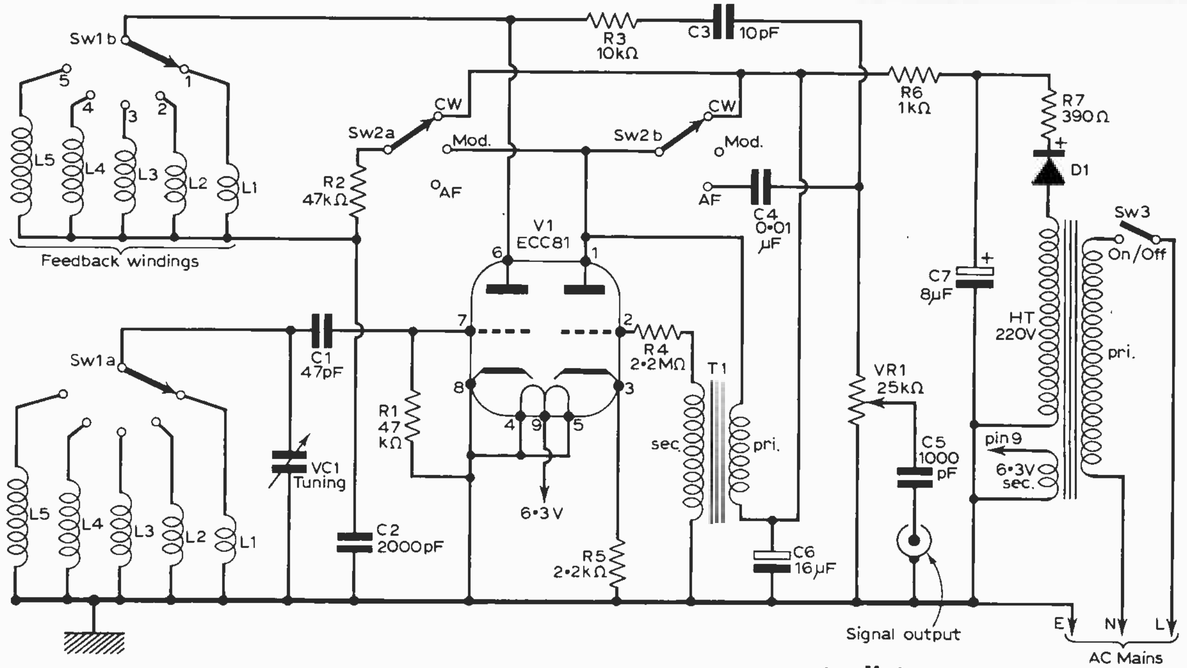



*Fig. 1. The circuit of the ready calibrated signal generator.*

tag 3, directly to chassis near the valve, Fig. 3. Join C2 immediately between this chassis tag and tag 2 of L1. Connect tag 4 to SW1b.

**Range 2.** This coil mounts on the case side, Figs. 2 and 3. The wire from SW1a to tag 1 is ½in. long, and the chassis return from tag 3 is 1¾in. long. Tag 4 is wired directly to C2 and tag 2 on L1.

**Range 3.** This is mounted on the panel in the position shown in Fig. 2. Leads pass down through the chassis, and their exact length has no significant effect on frequency coverage.

**Range 4.** This is secured to the chassis, Fig. 2. As with other coils, it is a little over the coil-diameter away from metal parts.

**Range 5.** This is mounted above L3, leads passing down to the switch.

Coil connections are shown in Fig. 3. Referring to Fig. 1 and Fig. 3, switching must be so arranged that each tuned winding L1 to L5 is selected by SW1a and the appropriate anode winding is in circuit (via SW1b) at the same time. Feedback windings must also be in correct phase or no r.f. output will be obtained.

## Function switch

In the "c.w." position, SW2a applies h.t. to the r.f. oscillator, and SW2b shorts the primary of T1. With this switch in the "Mod." position, SW2a obtains h.t. for V1a from the anode of V1b, for a modulated output. In the "a.f." position, no h.t. reaches V1a, and a.f. from V1b is via C4 to the output circuit.

## Scales

The drive listed has a half-cursor, used temporarily for calibration. Marks made along the straight edge of this cursor will afterwards be under the hair-line of the normal cursor. One scale provided with the

## ★ components list

**Resistors:**

| | |
|---|---|
| R1 47kΩ ½-watt | R5 2·2kΩ ½-watt |
| R2 47kΩ 1-watt | R6 1kΩ ½-watt |
| R3 10kΩ ½-watt | R7 390Ω ½-watt |
| R4 2·2MΩ ½-watt | VR1 25kΩ carbon linear pot |

**Capacitors:**

| | |
|---|---|
| C1 47pF silver mica | C5 1000pF mica |
| C2 2000pF 500V disc ceramic | C6 16µ 350V |
| C3 10pF silver mica | C7 8µF 350V |
| C4 0·01µF 400V | |

VC1 500pF Jackson E1, Home Radio (Mitcham) Cat. No. VC5.

**Fixed Inductance Coils:**

L1 0·5µH Home Radio (Mitcham) Cat. No CO84D
L2 5·5µH " " " " " CO84E
L3 37·5µH " " " " " CO84F
L4 310µH " " " " " CO84G
L5 2200µH " " " " " CO84A

**Miscellaneous:**

T1 3 : 1 12mA Home Radio (Mitcham) Cat. No TIV1
T2 Half-Wave 200/230V 25mA, 6·3V 0·5A or similar
D1 250v contact-cooled rectifier.
Drive and Dial, Electroniques, SMD2
8 x 7 x 3in. Universal Chassis box and extra
8 x 3in. runner
8 x 7in. perforated zinc
Type A, H2, 4in. handle (Home Radio)
Mains toggle switch
2-pole 3-way rotary switch
2-pole 6-way ditto
Three knobs
3-tag strip (2 insulated)
Co-axial socket or cable, 3-core mains cord, etc.
ECC81 valve
B9A valve holder

drive is numbered 0—100 and has five spare ranges. The innermost is used for range 5 and and the outermost for range 1. This agrees with the positioning of the bandswitch knob.

Readings should be taken from the calibration table and written on the spare scales. Set VC1 fully closed and the cursor at 100 before beginning. When markings are finished, fit the usual cursor and dial cover.

If the generator is assembled as shown, with the specified coils and VC1 as listed, accuracy should be similar to that of popular, ready-made signal generators. The coils are doped, and so calibration should not change.

If the necessary equipment is available, there is no reason why the generator should not be individually calibrated from this source. The calibration table will then provide a close guide. The use of an all-wave communications type receiver and 1Mc/s and 100kc/s crystal oscillators will allow most satisfactory and easy calibration. The required 1Mc/s or 100kc/s harmonics are tuned in on the receiver and the signal generator is then tuned to the same frequency and its scale marked. The 500kc/s and 50kc/s markings can be obtained by beating the generator 2nd harmonic against the 1Mc/s or 100kc/s crystal harmonics.

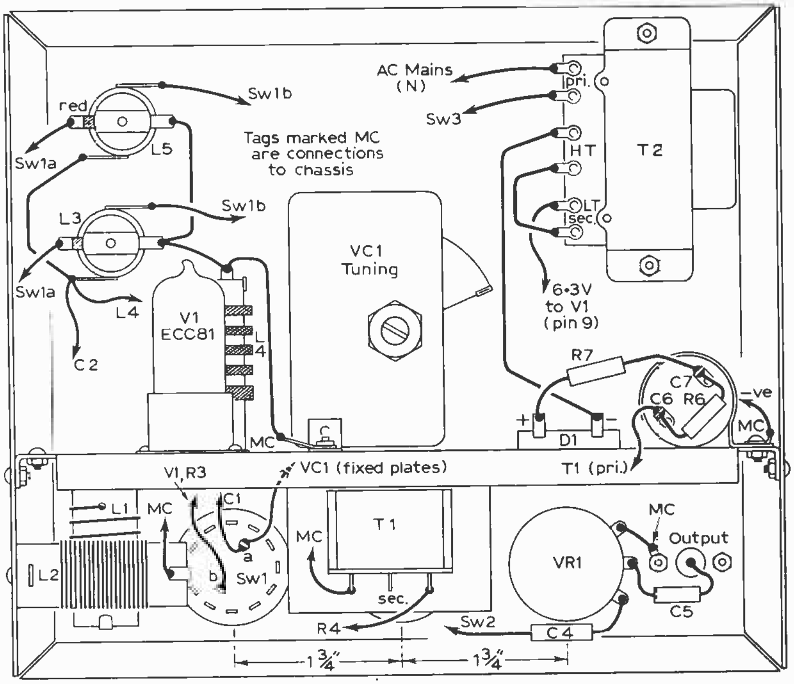



*Fig 2: The component layout viewed from the rear. The added chassis plate is fixed 2⅜in. from the bottom.*

## Generator uses

It is only proposed to give brief notes on these, as more comprehensive details have appeared from time to time.

**AF CIRCUIT CHECKS.** If a receiver or audio amplifier gives no results an audio signal can be injected, working back point by point from the output stage. When the source of the fault has been passed, the audio tone is no longer heard in the speaker. Investigation is then confined to one stage or a few components or connections.

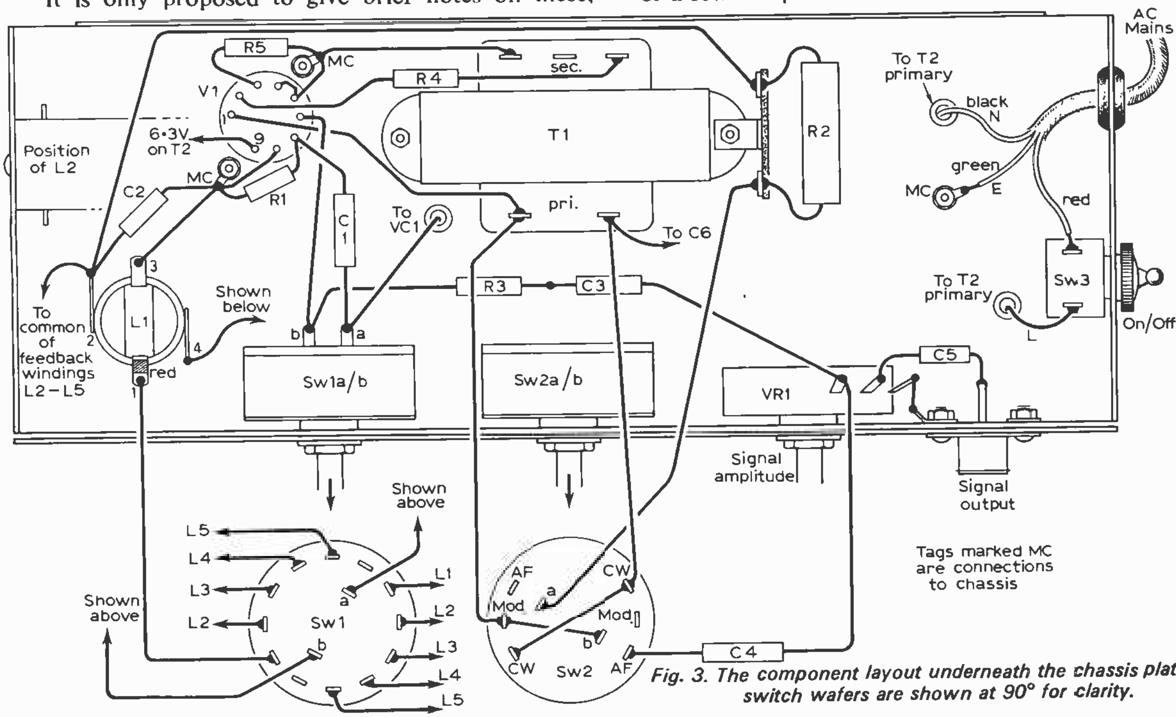



*Fig. 3. The component layout underneath the chassis plate; the switch wafers are shown at 90° for clarity.*

**IF CIRCUIT CHECKS.** A fault in the intermediate frequency section of a receiver, causing lack of reception, can be quickly found by injecting a modulated r.f. signal in at the final i.f. transformer, working backwards from here, stage by stage. Signals stop when the fault has been passed. Thus a single i.f.t., transistor, or valve, and its associated wiring etc., only need be checked in detail. If the intermediate frequency is not known, tune the signal generator until the receiver provides an audible output (probably around 455-470kc/s, for most receivers; or around 1·6Mc/s for s.w. receivers or the first i.f. section of dual-conversion receivers).

**IF CIRCUIT ALIGNMENT.** A signal of the appropriate frequency is injected at various points in the i.f. amplifier and the i.f.t.'s are adjusted for best results.

**RF CIRCUITS.** Wavebands of a receiver can be trimmed and aligned to secure best results or agreement with a calibrated dial on the receiver. A direct connection is usually not needed, the generator output lead inner conductor being placed near the receiver aerial circuit.

## CALIBRATION TABLE

**Range 1**

| Mc/s. | Dial |
|---|---|
| 35 | 9 |
| 30 | 15 |
| 28 | 17 |
| 25 | 22 |
| 20 | 33½ |
| 17 | 44 |
| 15 | 53 |
| 14 | 59 |
| 13 | 65 |
| 12 | 71½ |
| 11 | 80½ |
| 10 | 91 |

**Range 4**

| Kc/s. | Dial |
|---|---|
| 1500 | 5½ |
| 1300 | 11 |
| 1100 | 18½ |
| 1000 | 23 |
| 900 | 28 |
| 800 | 36 |
| 700 | 46½ |
| 600 | 57½ |
| 550 | 65 |
| 500 | 74 |
| 450 | 85½ |
| 425 | 92 |

**Range 2**

| Mc/s. | Dial |
|---|---|
| 10 | 5 |
| 9·5 | 8 |
| 9 | 11 |
| 8 | 17½ |
| 7 | 25½ |
| 6 | 36½ |
| 5 | 50½ |
| 4·5 | 60 |
| 4 | 71 |
| 3·8 | 76 |
| 3·5 | 85 |
| 3·2 | 96½ |

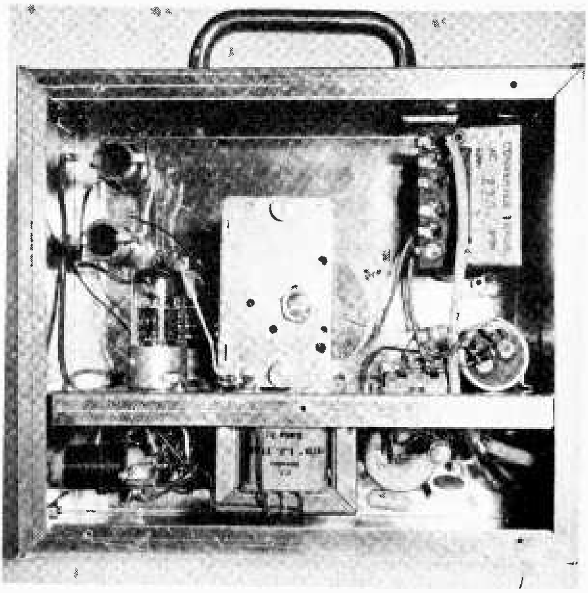
**Range 5**

| Kc/s. | Dial |
|---|---|
| 450 | 5 |
| 400 | 11 |
| 350 | 17½ |
| 300 | 29 |
| 250 | 43½ |
| 220 | 55 |
| 200 | 64 |
| 180 | 74½ |
| 170 | 81 |
| 160 | 88½ |
| 150 | 97 |

**Range 3**

| Mc/s. | Dial |
|---|---|
| 4 | 5½ |
| 3·5 | 11½ |
| 3 | 18 |
| 2·5 | 29 |
| 2 | 45 |
| 1·8 | 53 |
| 1·7 | 57½ |
| 1·6 | 63 |
| 1·5 | 69 |
| 1·4 | 76 |
| 1·3 | 84 |
| 1·2 | 94 |

The positions for intermediate markings can be estimated.



*An interior view of the finished signal generator.*

In all tests signal strength is kept down to avoid overloading stages in the receiver. The c.w. signal will operate a tuning meter or indicator, and is most suitable for some adjustments. For an audible signal with r.f. tests, the switch is placed at "Mod." ■

# CODAR CR.70A

## Communications Receiver 540-10 metres


# 20 gns.

Carriage 7/6 extra

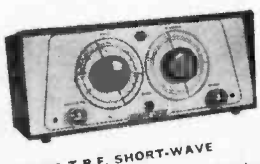
*Ideal for SWLs *5 valves (inc. two twin triodes) giving 7 valve line-up *Excellent on amateur and shipping frequencies *Calibrated signal strength meter (illuminated) *Automatic volume control *Separate B.F. oscillator for morse and S.S.B. signals *Two speed vernier tuning *Separate output for recording etc.

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.

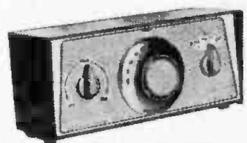
In four stable ranges the receiver covers from 540 metres medium wave, right through the shipping and coastguard frequencies all the short wave and international amateur bands up to and including 10 metres, where the rapidly improving conditions that now prevail allow the regular reception of world-wide 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.

**T28 RECEIVER FOR 160 & 80 METRES AMATEUR BANDS**
9 transistors, bandspread 1.8-2Mc/s and 3.5-4Mc/s 12 volts, only 8" x 4" x 3½". Ideal portable, mobile or home receiver. Efficient BFO, printed circuits. ONLY £15.17.6. Carr. 4/6.



**CR45 MAINS T.R.F. SHORT-WAVE RECEIVER**
World wide reception. *Separate electrical band-spread. *3 slow motion drives. *Output 3 watts for 2/3 ohm speaker. *Valves ECC81, EL84, EZ80. Size 12" x 5½" x 7". CODAR-KIT CR.45K with 3 coils (10-28, 25-75, 60-176 metres). £9.15.0. Carr. 6/-, or ready built CR.45 £11.19.6. Carr. 6/-. Extra coils 5/4 each.



**R.F. PRE-SELECTOR MODEL P.R.30**
1.5-30Mc/s
Provides up to 20dB gain plus substantial image rejection, improved signal/noise ratio and selectivity. Power requirements 180-250 volts 12mA H.T. 6.3 volts, .3 amp L.T. Size 8½" x 5" x 4". Ready built complete with cables, plugs and instructions. £5.19.6. Carr. 4/6. Self-powered P.R.30x £7.19.6. Carr. 4/6.

**MINI-CLIPPER—OUR FAMOUS SHORT-WAVE RECEIVER**
*Can be built in one evening. *Complete with valve, one coil 25-75 metres and 4 page instruction manual. Price £2.4.6. Carr. 3/-. Extra coils 5/4.

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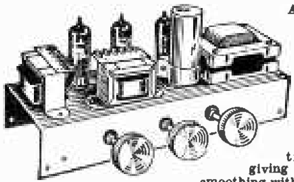

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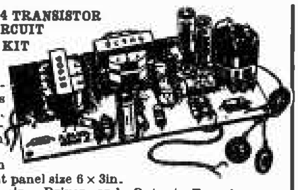
**Type TA1**



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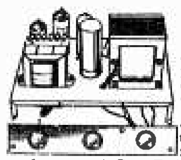

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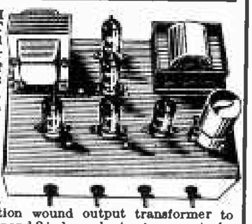

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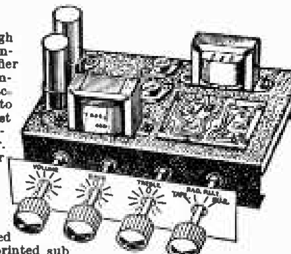

A really high fidelity monaural amplifier with performance characteristics to suit the most discriminating listener. 6 transistor circuit with integrated pre-amplifier assembled on special printed sub panel. AD161-AD162 operating in symmetrical complementary pair. Output transformer coupled to 3 ohm and 15 ohm speaker sockets. Standard phono input sockets. Full wave bridge rectifier power supply for AC mains 200-240v. Controls: Bass, Treble, Volume/on/off. Function selector for PU1, PU2, Tape, Radio. The HSL.700 is strongly constructed on rigid steel chassis bronze hammer enamel finish, size 9½ × 5 × 4½ in. high.
Performance figures:
Sensitivity: PU1-50m/v. 56K input impedance.
PU2-110m/v, 1 meg input impedance.
Tape—110m/v, 1 meg input impedance.
Radio—110m/v, 1 meg input impedance.
Output power measured at 1Kc—6.2 watts RMS into 3 ohms, 5.8 watts RMS into 15 ohm. Overall frequency response 30 c/s-18 Kc/s: Continuously variable tone controls; Bass, + 8 db to − 12 db at 100 c/s. Treble, + 10 db to —10 db at 10 Kc/s.
The HSL.700 has been designed for true high fidelity reproduction from Radio Tuner, Gramophone deck and Tape Recorder pre amp but is also capable of being used in conjunction with a guitar by connecting to PU1 socket and the peak output power will then be in the region of 15 watts. Supplied ready built and tested, complete with knobs, attractive anodised aluminium front escutcheon panel, long spindles (can be cut to suit your housing requirements) full circuit diagram and operating instructions.
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# practically wireless commentary by HENRY

No. 58

## Hard on Hardware

YOU are always going on about computers, Henry: have you seen the latest news?

About the Edinburgh University computer that taught itself to balance a pole on a moving cart for 90 minutes, you mean? That must have been fun for Professor Donald Michie. The best one of his students could do was five seconds flat. I wonder if it was a caber that the Department of Machine Intelligence experimented with. That would have been worth watching at next year's Highland Games.

No, I was not being frivolous. I was referring to the chess matches.

Oh, that's old hat. Computers have been whacking men at chess and noughts and crosses since the abacus was invented by Confucius' nephew.

That is just the point. This was a Russian . . .

Confucius' red nephew then. What's the difference? Moscow has been crowing ever since their M-20 beat an American version some time last year.

You are getting warmer. It was actually the M-20 that was involved in this incident, in a contest sponsored by the *Uralsky Rabochy* and the Soviet Academy of Sciences' Institute of Theoretical and Experimental Physics.

Sounds as if you are making this up!

Do not be sceptical, Henry. I am indebted for my information to *Janus* of *Electronics Weekly*, and the Soviet chess champion, Lev Polugayevsky.

Apparently the contest went on for four months. Playing against the computer were chess fans from 80 towns in the Urals, and this was the first mass competition to involve an electronic computer.

Evidently, you haven't heard about Operation Match.

Frivolity again, I am not concerned with computer selection of dating couples, and, anyway, that was in London. The point I am trying to impress upon you is that the USSR competition was arranged by feeding moves suggested by the majority of fans, via letters to the aforesaid newspaper, to the M-20 computer, which worked under the same programme it had used to beat the Americans in the straight computer match last year. So what! First prize a trip to Siberia; second prize a longer trip. The computer always comes out on top. What's the point of all this?

If you will stop interrupting, I'll tell you. During the play, the computer exhibited some "human" weaknesses. It began by taking an opposing pawn without due caution—and after 19 moves, the computer resigned.

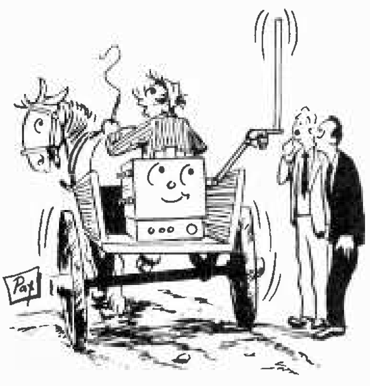
### SAY THAT AGAIN!

After nineteen moves the computer resigned. It could foresee an inevitable mate in three further moves. This would seem to indicate a triumph for the human mind, and some hope for the future of mankind in a world rapidly becoming more and more dominated by—

Shut him up, Mr. Editor. Who let that man in? Surely it is obvious that the computer was completely bemused by the variation in approach, in style of play, by the 80 groups of fans, many of them probably mere enthusiastic amateurs, even in Soviet Russia. We must be careful how we treat our electronic brains. Look at what happened at St. Louis, and again at Harvard, for example. In the first case, an engineer fed a computer with the listed numbers in four local exchanges and the machine gave him back all the non-listed numbers. He then used these to get access to private-leased trunk lines. The *Wall Street Journal* doesn't tell us whether the computer was arrested as an accessory.

In the second case, students at Harvard used a computer, a recorder (the type you blow through), and their native ingenuity to imitate signalling tones and bypass the telephone company's billing computer, getting free calls anywhere. They even obtained access to Defence Department trunk lines—when they were finally caught. There is a thousand dollar fine for this Federal offence, but apparently these lads got away with it, after they had told the Trunks and Telegraphs Company exactly how they performed their anti-social swindle.

After 19 moves the computer resigned



Computer that balanced a pole

# pulse circuits in operation

I. J. KAMPEL

SATURATION switching was dealt with in last month's article. We shall now turn to various switching circuits, a large number of which employ saturation switching. Others avoid this in order to minimise the stored base charge.

The multivibrator is surely the simplest and the most familiar pulse circuit there is, yet the transistors seen in multivibrator designs are all too frequently required to operate in conditions which exceed their maximum ratings. Since most such ratings include a safety factor, operation under such conditions is usually satisfactory, but the practice can hardly be recommended. The multivibrator has an inherently slow rising edge, and it is not always appreciated that with a slight circuit modification, such a fallibility may be overcome.

The term "multivibrator" is frequently used erroneously to describe any two-transistor circuit which has regenerative action and switches between stable or quasi-stable states. The true "multivibrator" has two quasi-stable states, that is to say there are two basic states which the circuit may be in at any moment in time, but without any external stimuli, the circuit oscillates between these two states. The multivibrator may be used to generate an approximately square wave in its most basic form, or, with unequal quasi-stable states, act as a pulse generator. As such, the multivibrator may be the heart of a section of pulse circuitry.

Figure 2.1a shows the simplest form a multivibrator may take, with the two quasi-stable states as follows: Tr1 bottomed, Tr2 cut off; Tr2 bottomed, Tr1 cut off. Operation is as follows. When the circuit is initially switched on random current flows in the circuit, and even though basically a symmetrical circuit, the slightest unbalance, which must exist, will cause one or other of the transistors to take more current than its partner. In consequence, this transistor now turns fully on, the regenerative action to be described switching the other transistor into the OFF state.

Figure 2.1b shows the voltage waveforms at various points in the circuit for a short duration. We shall assume that initially Tr1 switches on. Base current flows through R2 and collector current through R1. The base-emitter voltage ($V_{BE}$) may be regarded as substantially constant at 0·7V for a silicon transistor, and for the rest of this article only silicon transistors will be considered. Since $V_{B1}=0{\cdot}7V$, a current $I_{B1}=\frac{V_{cc}-V_{BE1}}{R2}$ is set. This programmes the current which will flow in the collector of Tr1 with no saturation since this will be the d.c. gain times the base current, i.e., $I_{C1}=h_{FE}.I_B$. The collector load is chosen such that Tr1 is driven *into* saturation with the programmed base current.

Section (a) of Fig. 2.1b shows the collector voltage during the first part of the cycle at $V_{CE}$sat, and part (b) shows the base voltage at $V_{BE1}$. During the initial period before Tr1 switched on, both capacitors have charged through the collector loads. As Tr1 switches on, the charge on capacitor C1 thus takes the base of Tr2

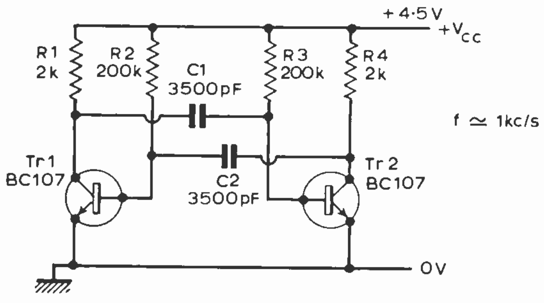



*Fig. 2.1(a): The basic form of multivibrator (n-p-n).*

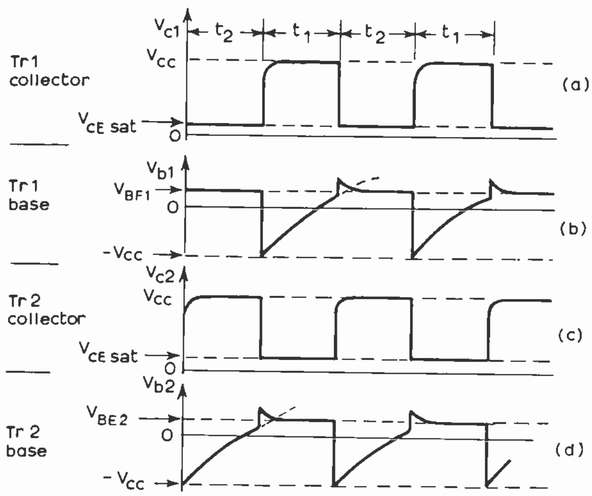



*Fig. 2.1(b): Voltage waveforms of the multivibrator.*

## part two multivibrators

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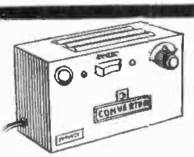

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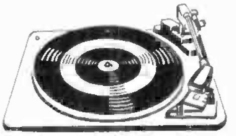

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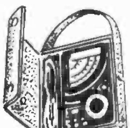

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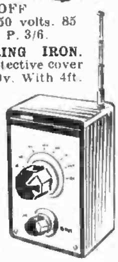

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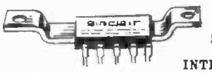

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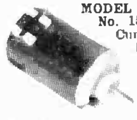

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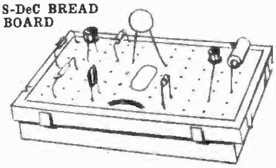

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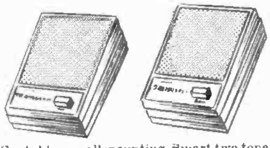

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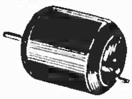

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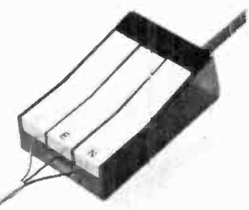

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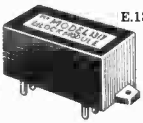

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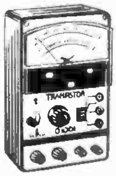

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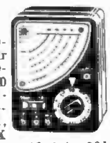

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hard negative. Initially the capacitor will have a voltage at its terminals equal to the line voltage, $V_{cc}$, the collector end of C1 just before switching being $+V_{cc}$. Since the collector goes to near the ground potential and the voltage still remains across the capacitor, $V_{B2}$ goes to $-V_{cc}$, or more exactly, $V_{CE1}sat-V_{cc}$. Thus if the line voltage was 5V, the capacitor has 5V across its terminals initially. Upon switching, $V_{C1}$ drops to 0·1V and $V_{B2}$ is taken to —4·9V.

Tr2 is driven into reverse bias and is thus cut hard off, ensuring that only $I_{CBO}2$ flows through R4 and that $V_{C2}$ is approximately at $+V_{cc}$. In normal operation C2 would not be charged, but at the initial cycle it may well be. If it is not fully charged, it now becomes so, charging from $V_{B1}=0{\cdot}7V$ to $+V_{cc}$. Section (c) of Fig. 2.1b shows the collector of Tr2 at line potential and the positive-going voltage at Tr2 base is seen in section (d).

This latter waveform shows how the voltage at the negative side of C1 is changing. Directly after switching it is at $-V_{cc}$, but it then begins to discharge through the Tr2 base resistance, R3, in an effort to charge its negative end to $+V_{cc}$ through this resistor. The voltage thus reduces across the capacitor until, with the capacitor totally discharged, Tr2 base is taken to +0·1V. The capacitor now begins to charge in the opposite potential as the negative side of the capacitor aims for $+V_{cc}$. It is not allowed to charge to this potential, however, for when it reaches the $V_{BE}$ of Tr2, Tr2 is switched on, and the emitter base holds the negative end of the capacitor from rising any further. By this time capacitor C2 will be fully charged at line potential.

Tr2 switches on, its collector dropping to $V_{CE2}sat$, as shown in Fig. 2.1b. Just as Tr1 caused Tr2 base to drive negative on switch-on, now Tr1 base is driven negative to $-V_{cc}$, and Tr1 is cut off. Now C2 begins to gradually discharge through R2, and C1 begins to charge through R1 since $V_{C1}=V_{cc}$.

It will be appreciated that due to the difference between magnitudes of base and collector currents, the base resistances are very much larger than the collector resistances. It is thus ensured that the time constant for the capacitors to charge through the collector loads is shorter than for the discharge through the base resistances, and thus it is certain that upon switching, the new timing capacitor to come into action will start fully charged. This action is repeated and regenerative switching continues as long as the supply is connected.

Examining the waveforms more closely, at first glance their shapes might seem a little unusual, but when considering the full cycle in detail the shapes are explained. Considering the base waveforms, they are seen to cut off sharply when reverse bias is applied, as might be expected. We then see a normal capacitor discharge into the positive region, followed by the rather unusual "pip". At this point the capacitor is aiming to charge to the line potential through the base resistor, and as the emitter-base diode comes into conduction there is for a short period an interaction as the base current settles down to a steady state value, whilst the voltage at the base attempts to increase above $V_{BE}$. The emitter-base is finally in full conduction and holds constant at 0·7V.

Considering the collector waveforms, a fast falling edge is observed. When a transistor goes into the ON state it is switched on sharply and wastes little time in dropping to $V_{CE}sat$. When the transistor switches off however, the situation is a little different. The capacitor attached to the collector is charged a little in the opposite polarity, and it now has to recharge in its normal polarity through the collector resistance. With a small voltage across the terminals in the reverse polarity, it tends to pull down on the collector as it tries to rise to line potential, and hence we see the slow rising edge of the basic multivibrator.

The switching periods of the multivibrator may be determined as follows. Taking the situation where Tr2 has just switched on, and Tr1 base has just been driven to $-V_{cc}$, the base end of C2 begins to charge to an aiming potential of $+V_{cc}$, i.e. an effective $2.V_{cc}$ volts. It does not reach this potential since when it reaches an effective $V_{cc}$ volts (i.e., really approximate potential of the earth line), switching occurs.

The basic expression for the instantaneous voltage of a capacitor C, charging through a resistor R, to a potential V, is given by:

$$\text{instantaneous voltage, } v=(V/R)\, e^{-t/CR}$$

Applying this to the case in question,

$$V_{b1}=2.V_{cc}\,(1-e^{-t1/R2.C2})-V_{cc}$$

This simplifies to

$$V_{b1}=2.V_{cc}-2.V_{cc}.e^{-t1/R2.C2}-V_{cc}$$
$$=V_{cc}\,(1-2.e^{-t1/R2.C2}).$$

To simplify the expression, assume the emitter-base voltage is negligible, i.e. assume $V_{b1}=0$.

Then,

$$0=V_{cc}\,(1-2.e^{-t1/R2.C2}).$$

Therefore,

$$1-2.e^{-t1/R2.C2}=0 \text{ since } V_{cc} \text{ is not zero.}$$

Simplifying,

$$2.e^{-t1/R2.C2}=1.$$

Taking logarithms to base e,

$$\log_e 2+(-t_1/R_2.C_2)\log_e e=\log_e 1.$$

Therefore,

$$\log_e 2-t_1/R_2.C_2=0.$$

Rearranging,

$$t_1/R_2.C_2=\log_e 2.$$

Therefore,

$$t_1=\log_e 2.R_2.C_2=0.693.R_2.C_2.$$

This thus explains the approximation frequently used for such circuits of t=0·7C.R.

If the capacitors and base resistors are identical, and with the usual circuit only the capacitors might differ, the ON and OFF states for both transistors will be equal. If one capacitor is larger than another, it will take longer to discharge, and will hold the transistor in the OFF state for a longer period of time. Unequal quasi-stable states will result, and one collector will provide short positive-going pulses, the other collector long positive-going pulses. Output may be taken from either collector, most simply by capacitive coupling. It is possible to d.c. couple, however, if this is desired.

The frequency is given approximately by:

$$f=\frac{1}{t_1+t_2}.$$

In these articles n-p-n transistors will be dealt with for consistency, and since they are the more common types with modern silicon planar transistors. A p-n-p version of any of the n-p-n circuits would simply have a reversed rail polarity, and reversed capacitor and diode polarities.

Figure 2.2 has been included to illustrate this point, being the p-n-p version of Fig. 2.1a.

To now consider the practicalities of calculating component values, some very simple mathematics show the requirements.

Assuming $V_{CE}sat \simeq V_{EB} \simeq 0$

Then, where $R_B$ is the base bias resistor and $R_C$ the collector load,

$$R_B \simeq \frac{V_{cc}}{I_B} \text{ and similarly, } R_C \simeq \frac{V_{cc}}{I_C}.$$

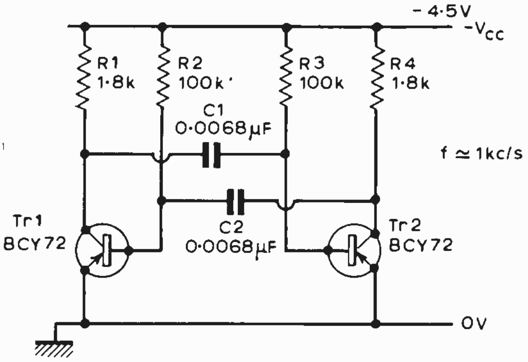


*Fig. 2.2: A p-n-p multivibrator of similar design to Fig. 2.1(a).*

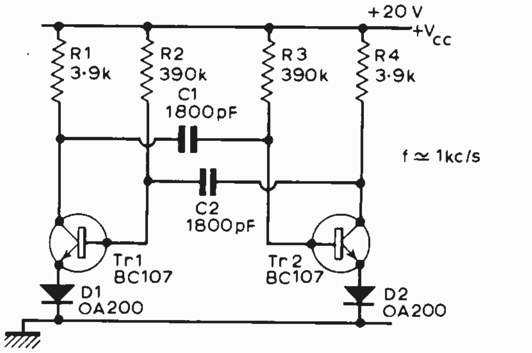


*Fig. 2.3: Emitter diodes protect the transistors against excess reverse emitter-base voltage.*

Now, $I_C \simeq h_{FE}.I_B$. Therefore,

$$\frac{V_{cc}}{R_C} \simeq h_{FE}.\frac{V_{cc}}{R_B}.$$

Simplifying,

$$\frac{1}{R_C} \simeq \frac{h_{FE}}{R_B}.$$

Therefore,

$$R_B = h_{FE}.R_C.$$

i.e., the base resistance will be approximately larger than the collector load by the factor of the d.c. gain for saturation switching. Thus if the required collector current is 1mA into a collector load of 4·7kΩ, the base resistance should be 4·7kΩ × $h_{FE}$. For a high gain silicon transistor $h_{FE}$ might be 200, giving a base resistance of 940kΩ, say 820kΩ as the nearest lower preferred value. We see that $V_{cc}$ is set at $I_C.R_C = 4·7V$, and have only to substitute $R_B$ into the 0·7CR formula to design for a particular frequency.

Out of interest, and to conclude the mathematics, let us calculate the minimum value of $h_{FE}$ for reasonable operation. To simplify the maths, let us select a suitable voltage for $V_C$ to reach. If we allow $V_C$ to reach $0·99V_{cc}$ we are assured of the collector voltage making its full excursion.

We may express the requirement in terms of an unknown, X for the moment.

Let $t_1 = 0·7.C_2.R_2$ be greater than $x.C_1.R_1$
and thus $(1 - e^x) = 0·99$

Therefore, $e^{-x} = 0·01$.

Thus, $x = 4·6$.

Now if C1=C2

$$0·7.R_2\,(\text{min}) = 4·6.R_1.$$

Therefore,

$$R_2\text{min} = 6·6.R_1.$$

Or in more general terms,

$$R_B = 6·6.R_C.$$

Therefore,

$$h_{FE}\text{min} = 6·6.$$

With the gains of modern silicon transistors it is seen that we should do far better than $V_C = 0·99V_{cc}$. Higher gain, that is, of the order of one or two hundred, allows smaller capacitors to be used and consequent saving in space, and possibly cost.

It was stated at the beginning of this article that transistors in multivibrator circuits are sometimes seen in circuits where the maximum ratings are exceeded. The rating referred to is the maximum emitter-base reverse bias. With typical silicon transistors, this is usually of the order of 5V. A 5V line will thus take the transistors to this limit when the capacitor takes the base to 5V *below* the earth rail. It is not always appreciated that this is in fact what happens, and if the supply voltage for the multivibrator exceeds the maximum reverse bias of the emitter-base junctions of the transistors, special precautions *should* be taken in a correctly designed circuit.

Figure 2.3 shows one method of overcoming this problem. Here diodes have been placed in the emitter lines of the two transistors, and if the bases of the transistors are now taken more negative than the maximum rating for the transistor's reverse $V_{EB}$, even a modest diode will not break down at normal line voltages, and the reverse-biased diode will protect the transistor.

## Speeding-up the Rising Edge

For some applications it may be desirable to improve the rather slow rising edge which is a characteristic of the basic multivibrator. This may be achieved by the addition of two further resistors, and two diodes, as shown in Fig. 2.4. Operation of the multivibrator is now as follows.

Assuming Tr1 is initially on, and Tr2 cut off, C1 is discharging from $-V_{cc}$ at the base of Tr2, and C2 is now charging chiefly through R5. With $V_{C2} = V_{cc}$, diode D2 is reverse biased as far as the charging capacitor is concerned, and it charges through the resistor indicated. C2 will be fully charged by the time that the potential at Tr2 base rises to +0·7V. When Tr2 switches on its collector goes negative, taking with it Tr1 base. Tr1 collector now suddenly rises toward the $+V_{cc}$ rail, and it is here that the capacitor C1 would normally exert its influence in slowing down the collector's rise towards the rail.

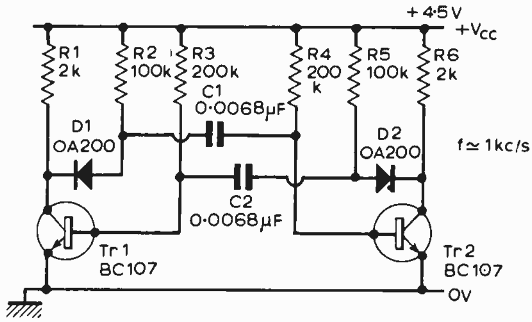


*Fig. 2.4: A low voltage multivibrator with fast switching times*

Initially, with about 0·7V reverse bias on it, the anode of D1 is at about earth potential, and when Tr1 cuts-off and the collector rises, the diode is cut off into reverse bias. This acts as a gate, a block between C1 and Tr1 collector, and the collector is free to rise sharply up to the positive rail. Capacitor C1 may now recharge in normal polarity through resistor R2.

It should now be possible to obtain fast rise and fall times from either collector, provided that the value of R2 is suitably chosen. When a transistor is in saturation, the diode connected to its collector will be forward biased and conducting, and if the diode coupled resistor is small, it will shunt the true collector load resistance, and may cause the transistor to come out of saturation. It was pointed out before that since the collector load is usually much smaller than base bias resistors, this ensured that the capacitors could recharge fully before switching took place due to the discharging capacitor. It is therefore necessary to make the diode coupled resistor significantly smaller than the base bias resistor.

For normal silicon transistors, a useful rule of thumb is to make the diode coupled resistor about one-half the value of base bias resistor. It will be seen that for a transistor with a gain of say 100, with a 1kΩ collector load, and a 100kΩ base resistance, this would give a diode coupled resistance value of about 50kΩ. Such a value will not appreciably shunt 1kΩ, and will provide a much shorter time constant for the charging capacitor than it will see on discharge.

Low gain transistors should be avoided in this type of circuit. Rise and fall times of the order of 100nS are possible to achieve with this type of circuitry and high frequency transistors. For high speed operation, the diodes should also be fast types.

The method of placing emitter diodes in circuit to protect transistors against excessive reverse $V_{BE}$'s may not be desirable in certain circumstances. One disadvantage of this is that when the transistor is driven into saturation, its collector voltage will be $V_{CE}sat+V_F$ where $V_F$ is the forward voltage of the diode, which will be of the same order as a $V_{BE}$. With silicon components, the collector voltage in saturation might therefore be slightly larger than 0·8V. A voltage dropping right to the earth rail (effectively) might be desired, and if so, a diode cannot be placed in the emitter.

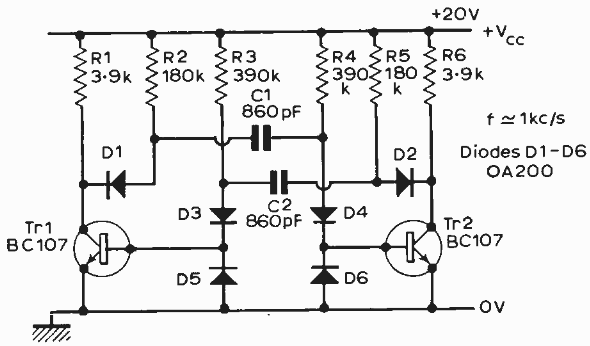


*Fig. 2.5: A high voltage multivibrator with fast attack and decay.*

A method of protecting the emitter-base for higher line voltages without using emitter diodes is shown in Fig. 2.5. If we assume Tr1 has just switched on, the negative-going collector will have just taken the anode of D4 negative to $-V_{cc}$. Diode D1 comes into conduction when Tr1 drives into saturation, so the potenttial at the anode of D1 will be $V_{CE}sat+V_F$. Now with the anode of D4 taken below the earth rail, it is reversed biased, cutting off the base current supply to Tr2, and hence cutting off Tr2. The base of Tr2 cannot be taken more negative than the forward voltage of diode D6 since this comes into forward conduction when $V_{B2}$ is taken down to approximately $-0{\cdot}7$V.

If we consider D4 short-circuited for the moment, Tr2 emitter-base would still be protected, and would still cut off, but the restraining voltage of the diode D6 would prevent the capacitor from going as far negative as it wishes to, and reflects back to the collector of Tr1. With D4 in circuit, since reverse-voltages may be anything under the breakdown, the capacitor is free to go to full $-V_{cc}$.

As in normal operation, C1 will rise towards the positive rail through R4 eventually, Tr2 will come back into conduction, at a slightly later point, when D4 anode voltage is $V_F+V_{EB}$, and regenerative switching takes place.

Without diodes D3 and D4 the circuit will operate in that it will oscillate, but, another point to bear in mind, apart from the resulting degraded waveform, is that diodes D5 and D6 will then present a low impedance discharge path, and the frequency of operation will also be affected.

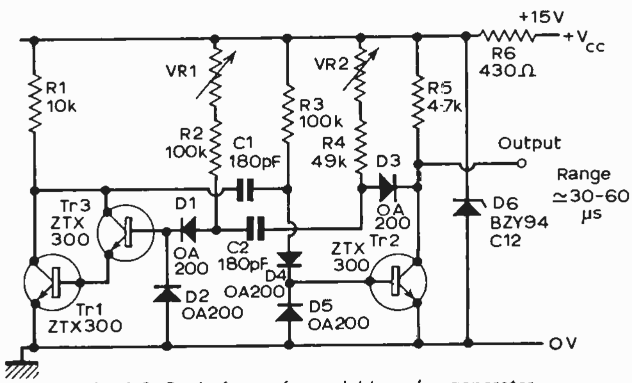


*Fig. 2.6: Basic form of a variable pulse generator.*

Figure 2.6 shows the basic form a pulse generator might take, the heart of which is a high speed multivibrator. Since an output will only be required from one side, it is not necessary to achieve a fast rising edge at the collector side which will not be used. A diode coupled resistor is thus only used on the output side, D3. Now in a pulse generator, we shall wish to vary the repetition rate and pulse length, and have a constant amplitude output with good fast edges. For low repetition rates, excessively large capacitors might be required, leading to stability problems. In the figure, the left-hand components will determine the repetition rate, whilst the transistor Tr2 will determine pulse length with its associated components.

A Darlington Pair, Tr1 and Tr3 give the repetition rate transistors a high gain, which enables us to use very high resistances in the base bias, and consequently reduced capacitance values to still obtain a long repetition rate. VR1 in series with a fixed resistor to ensure that the base bias resistance can never be zero, enables the repetition rate to be adjusted over a given range, related to C2, and TR2 similarly allows an adjustment of pulse length. For a wide range instrument since the resistance range is limited for reasonable bias conditions and assurance of transistor saturation, capacitors C1 and C2 will simply be selected capacitors in switched ranges, the variable resistors allowing variation between the limits set by these ranges.

In this circuit, a zener diode D4 sets a fixed and stable $V_{cc}$ and hence pulse height, and Tr2 should drive into saturation for a stable bottom level of the pulse. Diode protection has been afforded to allow a large voltage output in a similar manner to that described in Fig. 2.5.

There is thus more to the simple multivibrator than might at first be thought. A single article on it alone proves this point.

**In next month's article, the family of monostable circuits will be discussed.**

# integrated circuit audio signal injector

**This pocket signal injector takes full advantage of the size and cheapness of the more available I.C.s and will provide an excellent introduction for the beginner to these new components.**

S. ELLIOTT

MOST cigar tube type a.f. signal injectors tend to be rather large and cumbersome to use and a small but reliable injector was needed. The outside diameter should not exceed $\frac{3}{4}$in. for easy handling, for over this size it cannot be held like a pen, which is the natural way to hold the instrument. Four inches (excluding the probe) is about the maximum length, but if it were light in weight a much longer casing could be used; the length of the probe is up to the user. The injector described here falls well within these limits, with an outside diameter of $\frac{5}{8}$in. and an overall length (excluding probe) of only 3in.

It was decided to use an integrated circuit to save space and the one chosen was the Fairchild μL914, a digital I.C. which is readily available. This I.C. contains ten components six of which are used in the injector. There are five discrete components. It is not recommended that beginners and those that have no previous experience of semiconductors build this project as it requires that some of the soldering takes place almost on the component bodies themselves and prolonged heating could ruin them.

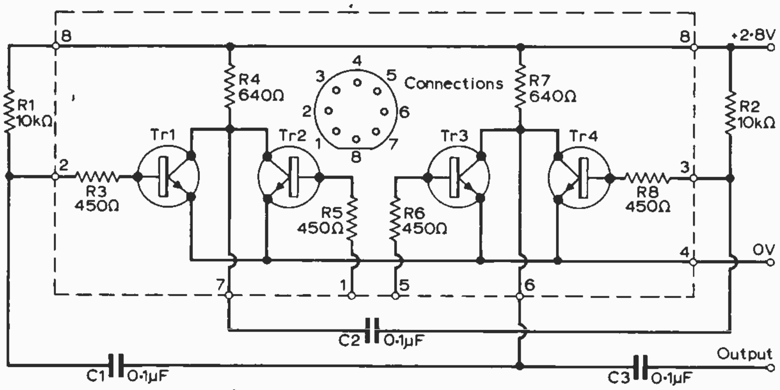


*Fig. 1: The circuit of the I.C. audio signal injector.*

## The circuit

The circuit of the injector shown in Fig. 1 is a straightforward multivibrator (astable) with no frills. Suppose Tr1 is off and Tr4 is on; therefore as the collector of Tr4 is more or less at earth C1 charges through Tr4 and R1. This causes the base of Tr1 to become more positive and so it begins to conduct. A regenerative action occurs and Tr1 switches on quickly. The negative-going pulse at Tr1 collector is transferred via C2 to Tr4 base and causes it to turn off, which in turn sends a positive-going pulse via C1 to Tr1 base which makes Tr1 conduct even more. Now Tr4 is off and Tr1 is on. C2 charges through R2 and Tr1, and so the cycle repeats.

The output is taken from Tr4 collector via C3 to the injector probe.

The period of oscillation is determined by:

$$T = 0{\cdot}69\,(R1, C1 + R2, C2)$$

but $R1 = R2 = R$

and $C1 = C2 = C$

where T is the time constant.

$$\therefore\ T = 1{\cdot}38RC$$

$$f = \frac{1}{T}$$

$$f = \frac{1}{1{\cdot}38RC}$$

In this particular case:

$$f = \frac{1}{1{\cdot}38 \times 104 \times 10^7}$$

$$= \frac{10^3}{1{\cdot}38}$$

$$= 725 \text{ c/s.}$$

This is slightly modified by transistor impedances in the final circuit.

## ★ components list

R1 and R2 10kΩ, 0·1 watt subminiature type.
C1, C2 and C3 0·1μF 3V subminiature type.
Integrated circuit: Fairchild μL914 (Henry's Radio).
Miniature press button switch (G. W. Smith).
2in. × $\frac{1}{2}$in. diameter copper tube. Coax plug.
Crocodile clip. Araldite. Batteries: two RM675H (Ever Ready).

## Construction

To start, leads 1 and 5 are cut off as near to the I.C. as possible, lead 4 is cut off about $\frac{3}{16}$in. from the I.C. and a lead soldered on, this is the negative supply to the oscillator. Next R2 is connected up by positioning it inside the lead configuration, the lower end being taken

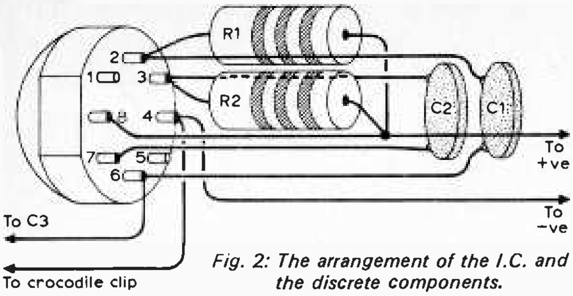

*Fig. 2: The arrangement of the I.C. and the discrete components.*

to lead 3 and the upper to lead 8, the positive supply line. R1 is positioned beside this, the top of it connected to the top of R2 and the bottom to lead 2. Lead 8 is cut off above the join of R1 and R2 and is soldered to a length of wire, this is the positive supply line. The two capacitors C1 and C2 are miniature disc ceramic types and are roughly the same diameter as the I.C. They are positioned above R1 and R2 and directly over the I.C. The leads are bent and soldered as in Fig. 2. A lead is soldered to lead 6, this will eventually go to C3 and the output probe.

## Testing

The oscillator should be checked at this stage to see if it is functioning correctly. The two power leads are connected to a 3V battery or the two mercury cells that will be used in the final injector. The output is taken via a 0·1μF capacitor to an amplifier and loudspeaker; upon connecting the battery a note should be heard. If it is not, disconnect immediately and check the wiring against the circuit diagram. If all is well the whole circuit is wrapped in p.v.c. tape to insulate it from the case, care being taken that none of the leads are likely to come into contact with each other. Now the next stage of construction, the case, can be started.

## The case

The main body of the case is a piece of half-inch inside diameter copper tubing (the type used in small bore central heating). A piece is cut 2in. long and its ends are filed smooth. A coax plug is used for the ends. The end through which the cable should go is of sufficient size to incorporate a push-button switch sold by G. W. Smith Ltd., at 1s. 6d.

The switch is put into place and the nut tightened up. This piece of the plug has striations down its side. A plug should be chosen that has not got these striations down its whole length; if the unstriated part is filed down it should be a tight fit into the end of the copper tube. It may be found that the end of the tube has to be expanded by pushing a pair of long nosed pliers down it and twisting them round so forcing the sides of the tube outwards slightly.

The probe end of the injector is formed by the other pieces of the coax plug. The pin is removed from the nylon insulator by heating with a soldering iron and withdrawing it when the nylon is just melting around the pin. The shoulder is then cut off the nylon with a razor blade so that it will go right to the end of the remaining part of the plug as shown in Fig. 3. This remaining part of the plug is then cut in half just below where the threads finish. This should now fit into the end of the copper tube loosely.

The probe is then heated and fitted into the nylon so that it barely comes out the other side. C3 is then soldered to this end. The nylon is glued with Araldite or a similar resin glue to the piece of coax plug. The hollow in which C3 is fitted is completely filled with Araldite, care being taken that the leads do not touch the case. A piece of wire is soldered to the other side of C3 and the whole assembly is glued to the copper tube. It will probably be found that the assembly will have to be clamped in place while the glue is setting so that it is not glued in at an angle to the copper tube. A hole is drilled in the copper tube near the prod end for the earth wire (—ve). This wire is soldered to pin 4 of the I.C.

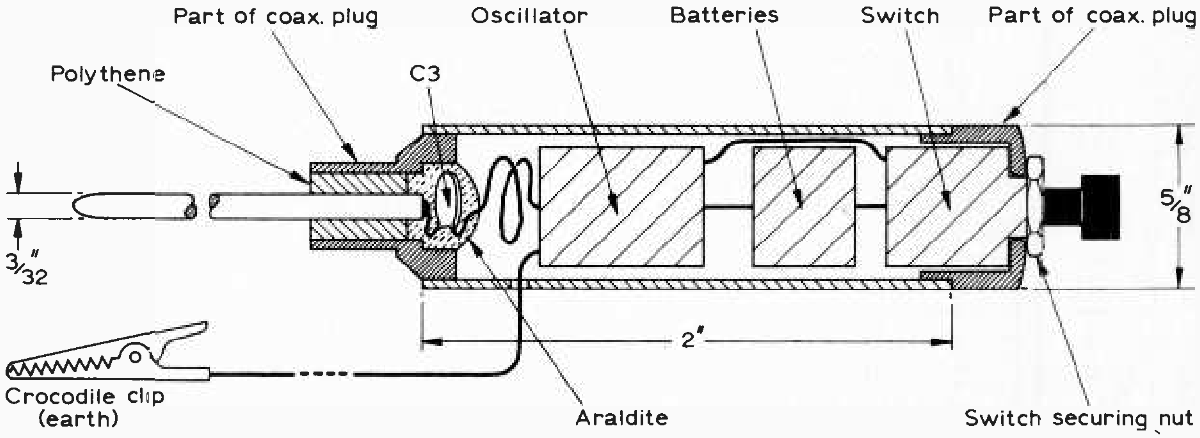

*Fig. 3: The assembly of the completed signal injector.*

The mercury batteries are soldered together—care being taken so that they are not overheated. It doesn't matter whether the positive or negative lead is switched; in the prototype the negative was switched. One side of the switch goes to pin 4 of the I.C. and the other is more or less soldered directly to the negative button of the battery. The other side of the battery is taken to pin 8 of the I.C. The batteries are wrapped in p.v.c. tape and the whole electronics assembly is slid into the tube. The injector is now ready for use.

The output waveform is not good enough for measurements and assessing the frequency response of an amplifier but it provides a portable audio source that can be used in many ways for tracing circuit faults. In conjunction with an audio amplifier it could be used as morse oscillator but in this case it need not be built into such a small housing. ■

# AERIALS

## A. J. WHITTAKER

## PART 4—TRANSMISSION LINES

THE fourth part of this series on aerials will primarily concern transmission lines, or feeders, but to introduce the subject we will describe an amateur bands transmitting aerial which uses transmission lines in rather a special way to enable it to function over a wide band of frequencies. The aerial is the G5RV dipole, 102ft. long, designed to cover the 1·8, 3·5, 7, 14, 21 and 28MHz amateur bands.

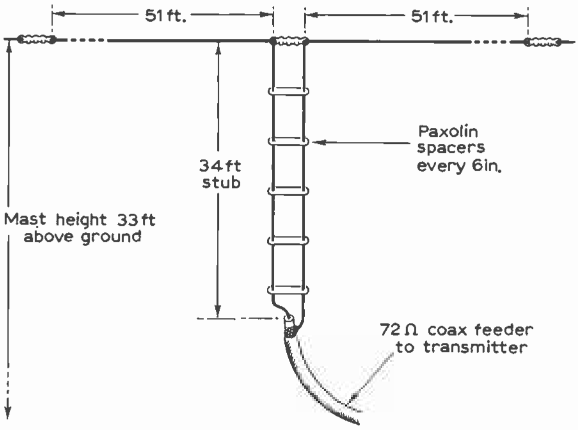


*Fig. 4.1: The G5RV multiband dipole aerial.*

The aerial is shown in Fig. 4.1. It is made from two lengths of covered wire, each 51ft. long, and coupled in the centre by a suitable strong insulator. From this centre point is taken a 34ft. open wire feeder, which acts as a matching stub, and to this is connected any convenient length of 75Ω coaxial cable. The whole aerial should be suspended above ground $\frac{1}{2}\lambda$ at 14MHz, i.e., 33ft., which will ensure a good match to the 75Ω feeder. On 1·8MHz, the two feeder wires at the transmitter end should be joined and fed via a series tuned coupling network. On 3·5MHz, the electrical centre of the aerial appears to be some 15ft. down the feeder, meaning that 30ft. of the aerial are folded into the open wire line. At 7MHz, the aerial is two half-waves in phase, also with a section "folded" in the line in the centre. On 14MHz, the aerial is three half-wavelengths long, and the stub acts simply as a 1 : 1 transformer. On 21MHz, it is a slightly lengthened two-wavelength aerial, and on 28MHz, it consists of two $1\frac{1}{2}\lambda$ aerials fed in phase.

The important part of this aerial which enables it to function over such a wide frequency range is the matching stub. The theory behind this stub comes under the general category of transmission lines, which is a very complicated and lengthy subject to explain. In the rest of this article, however, we will attempt to provide a simple explanation of the fundamentals, and if you find that after reading it you are sufficiently interested in studying the subject, some suitable references will be provided for further reading.

### Transmission Lines

Generally speaking, there are two types of aerial feeder: (i) the parallel or open wire feeder, and (ii) the concentric feeder, i.e., coaxial cable.

Dealing with (i) first, this consists of two wires running parallel and supported at least 6ft. above the ground. Spacers are provided at regular intervals to support and keep the wires an equal distance apart. Twin feeders are essentially balanced devices and are suitable only for feeding balanced aerial systems such as dipoles or an array of dipoles.

At any point along the twin-wire feeders the currents in the two wires are equal in magnitude and opposite in sign, so as the wires are close together the possible radiation is cancelled. The characteristic impedance for a twin wire feeder is given by

$$276 \log \frac{2D}{d}$$

where $D$ is the distance from the centre to centre of feeder wires and $d$ is the diameter of the feed wires (Fig. 4.2a). This formula gives a typical impedance of between 400 and 800Ω.


*Fig. 4.2: Conductor identification for open wire and coaxial feeders.*

Concentric feeder has one conductor completely enclosed by the other, as in the construction of coaxial cable. The characteristic impedance for a concentric feeder is given by

$$138 \log \frac{b}{a}$$

where $a$ is the diameter of the inner conductor and $b$ is the inside diameter of the outer conductor or screen. Fig. 4.2b. The usual characteristic impedance for this type of feeder is 75Ω, although 50Ω is quite common for transmitters. Losses are higher than with twin-wire feeder, for a low loss coaxial cable described as having an impedance of 75Ω and a shunt capacitance of 18pF per foot, exhibits losses of 0·68dB at 10MHz and 2·7dB at 200MHz.

### Transmission line theory

A transmission line made up of two parallel wires has distributed inductance (L) and capacitance (C) per unit length. Fig. 4.3.

If the end of the line is short-circuited, standing waves are set up along the wires, i.e., the current waves which have travelled along in one direction will return along the other wire and produce a standing wave pattern on the feeder. Fig. 4.4.

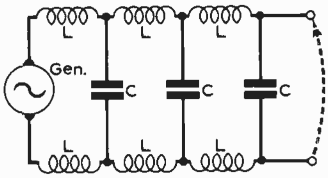


*Fig. 4.3: The equivalent circuit of a transmission line without resistive loss.*

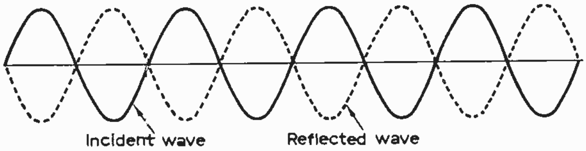


*Fig. 4.4: How standing waves are represented. In this case 100% reflection occurs.*

In this condition the receiving end becomes a point of low impedance (volts low, current high). Similar conditions occur if the receiving end is open-circuited. In either case the relative impedance will vary along the wires with the distance from the generator or source. If no energy is reflected no standing waves will be present on the feeder wires and these will only carry travelling waves and behave as if the lines were of infinite length. It can be shown that such a line possessing distributed inductance (L) and capacitance (C) has the property of a resistance given by

$R = \sqrt{L/C}$ called characteristic impedance.

If a resistance of this value be fixed across the ends of a feeder it will behave as if it were infinitely long and waves will travel along it without reflection (i.e. travelling waves). The only losses are due to the high frequency resistance of the wires which is higher than the ohmic resistance due to the phenomenon of skin effect. (i.e. h.f. currents induce a voltage into the current carrying conductors in opposite direction to the currents producing them, so forcing the initial currents to travel along the surface, or skin, and so effectively increasing the resistance.)

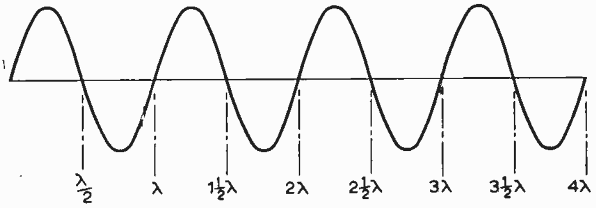


*Fig. 4.5: The theoretical appearance of waves travelling along a feeder (Fig. 4.3).*

Figure 4.5 is a sketch of travelling waves along a feeder, where each successive $\frac{1}{2}\lambda$ may be considered as a tuned circuit (series or acceptor circuit). The peak value of the current is given by,

$$I = \frac{V}{\omega L} \qquad (\omega = 2\pi \times \text{Frequency})$$

As the circuit is tuned

$$\omega = \frac{I}{\sqrt{LC}}$$

By substitution

$$I = V\sqrt{\frac{L}{C}}$$

As the wave travels along the feeder towards the receiving end it will carry its stored energy with it. If the receiving end is terminated with an impedance $Z_r$ the peak value of current flowing through it will be

$$I = \frac{V}{Z_r}$$

and if there is no reflection

$$I = \frac{V}{Z_r} = V\sqrt{\frac{L}{C}}$$

That is $Z_r = \sqrt{L/C}$

## The $\frac{1}{4}$ Wave Matching Line

If a transmission line is $\frac{1}{2}\lambda$ the impedance at each end will be the same: $Z_s = Z_r$ (I)

It therefore follows that the $\frac{1}{2}\lambda$ line behaves as a 1/1 transformer. The ratio of the impedances at each end depends upon $\sqrt{L/C}$ and from transmission line theory we have $Z_s\ Z_r = Z_0^2$ (2).

This relationship is true when there is no reflection and $Z_s = Z_r = Z_0 = \sqrt{L/C}$. Equation 2 means that a $\frac{1}{4}\lambda$ line acts like a step up or down transformer, and this led to the $\frac{1}{4}\lambda$ matching line. For example, if a 600 ohm line is to be matched to an 80 ohm dipole the matching line would have a characteristic impedance of $\sqrt{600 \times 80} =$ 220 ohms approx.

The process of matching consists of adjustment of the $\frac{1}{4}\lambda$ matching line spacing "$Z_0$" until no reflection occurs in the transmission lines. A $\frac{1}{4}\lambda$ matching line is also known as a "Q" bar (Fig. 4.6).

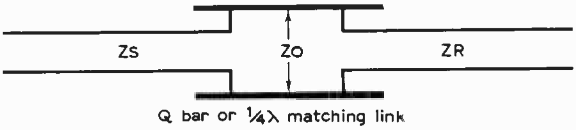


*Fig. 4.6: An impedance matching device known as a Q-bar.*

## The Balun Transformer

The name balun is derived from BALanced to UNbalanced and this device is used when an aerial requires a balanced feed with respect to ground. The balun converts the unbalanced co-ax feeder to the balanced output required by the aerial system, an example being matching an unbalanced feeder to a dipole.

Figure 4.7 below is a sketch of $\frac{1}{4}\lambda$ OPEN Balun or "Pawsey Stub".

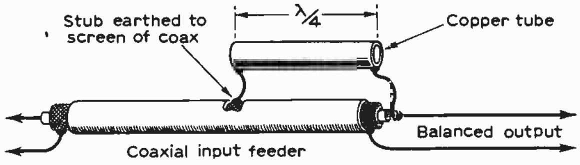


*Fig. 4.7: An open Balun made from coaxial cable.*

Point A presents a high impedance preventing the wave from travelling over the surface and spilling over the end and tending to travel back along the braiding of the co-ax. If this occurs the re-radiated wave on the surface of the braiding modifies the aerial polar diagram and the outer surface of the feeder is found to have a r.f. voltage on it. This may be detected by placing your hand around the co-ax. If r.f. is present it will affect a received signal.

A Balun may be made using a $\lambda/4$ piece of coaxial cable and connected as above.

To complete these notes on feeders a word or two about audio-frequency lines would not be out of place. Here then are a few empirical rules.

## Short high impedance A.F. lines

Main factors affecting short line (about 100ft. long) working are,

1 Series inductance;
2 Series resistance;
3 Shunt capacitance.

Series inductance offers a variable impedance to the line current which varies with frequency. Typical values for series $L=20\mu H$ per 100ft.

Series resistance provides a uniform resistance at all frequencies, typical values for single and double core cables ranging from 1 ohm to 1·5 ohms per 100ft.

Shunt capacitance provides a by-pass to the line current which varies inversely with frequency (i.e., falls in value with increasing frequency). Typical values for single core cable are 6,000 pF and for double core cable 4,000 pF per 100ft. The maximum effect of these impedances will depend on the relative value of the generator and load impedances. The series R and L will have little effect if the generator or load impedances are high in comparison (i.e. so that the line current will be low). In general, the generator or load impedances should be at least twice the value of the impedance of L and R at the highest frequency it is desired to transmit down the lines.

Shunt capacitance—here the impedances offered by the generator or load should be less than half the impedance offered by the shunt capacity at the highest frequency it is desired to transmit down the line. Typical examples of shunt capacities are, 26kΩ at 8kHz for 30ft, ¼ mile, shunt capacitance 500Ω at 8kHz.

**References:**
1 *Short Wave Radio Communication* (Ladner & Stoner).
2 *Admiralty Handbook Wireless Telegraphy.*
3 *Amateur Radio Handbook.*

TO BE CONTINUED

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

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# DIRECTIONAL MICROPHONE

C. R. BRADLEY

THE directional microphone to be described was built for outdoor tape recording in connection with amateur movie sound-tracks. It effectively reduced offstage noises e.g. wind noise, traffic roar, camera sounds.

A directional microphone has many other applications. Public address systems can be operated at higher levels before feedback howl is produced. The acoustic characteristics of a "noisy" (reflective walled) room, such as a tiled bathroom, can be reduced or exaggerated for recording purposes. If the microphone is pointed at a speaker in such a room his voice will sound "flat" and echoless. If the microphone is directed away from the speaker it will pick-up his voice by reflection from the walls, giving the voice an echo-chamber effect. Another advantage of a directional microphone is that distant sound sources which cannot be approached easily (birds, animal, trains, aeroplanes) can be recorded with less background noise.

The heart of the microphone is a magnetic microphone cartridge. This is mounted at one end of a cylindrical case made of plaster of Paris. The heavy case shields the cartridge from sound sources behind and to the side. Ordinary carpet felt is used to deaden reflections inside the case (Fig. 2a). The cartridge "sees" only a small angle of the outside world and the microphone is sensitive in this direction. It is very directional but rather insensitive. This is remedied by a low-noise self-powered preamplifier.

The directional microphone can be built quite cheaply.

The microphone casing is cast in plaster of Paris in a simple mould made of card or heavy paper. There should be no difficulty in doing this if the mould is waxed (by rubbing with a candle) before the plaster is poured in. This should be mixed with plenty of water and poured in immediately. The cast will get quite warm as the plaster hardens. Small air-bubbles in the cast do not matter. The outer surface can be left plain, painted, or covered with material as desired. A coat of glossy paint will help protect it against chipping.

The microphone cartridge chosen[1] has a metal case and a tiny gauze-covered round "window". It is not very directional as the case is very thin. The first step is to encapsulate the cartridge in Araldite epoxy cement leaving only the "window" exposed. Successive layers of cement are applied until the cartridge is deeply embedded. Use plenty of cement (about half a 6s. two-tube pack) to give the encapsulation plenty of weight. Three cotton threads are

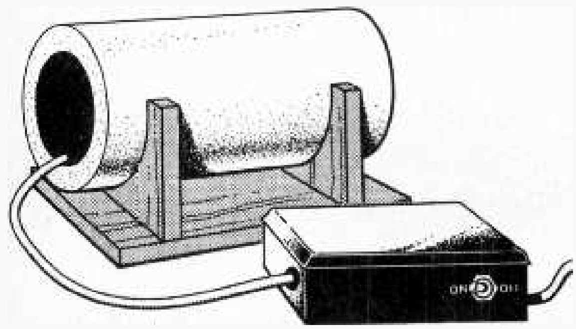


*Fig. 1: Directional microphone and preamplifier, with microphone table stand.*

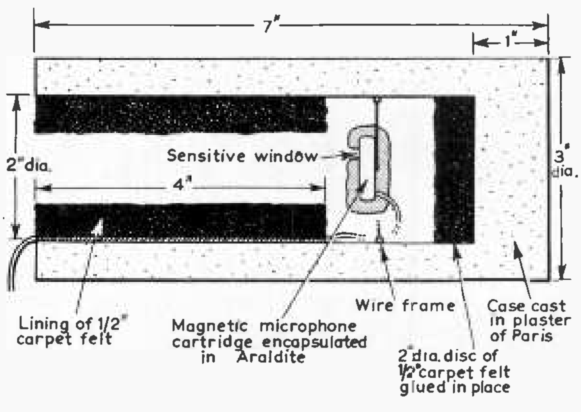



*Fig. 2 (a): Cross-section of the microphone.*

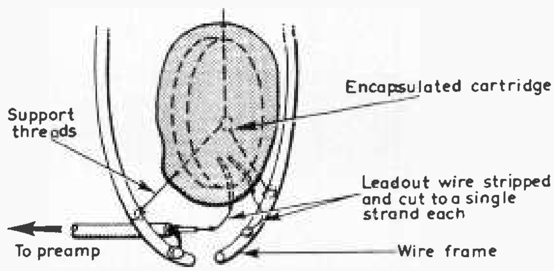



*Fig. 2 (b): Cartridge connections. Leave sufficient slack in the leadout wires to allow for cartridge movement.*

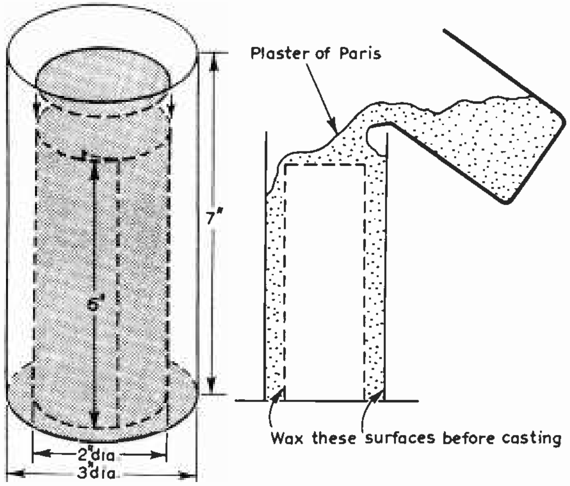



*Fig. 3: Paper mould for casting the microphone case.*

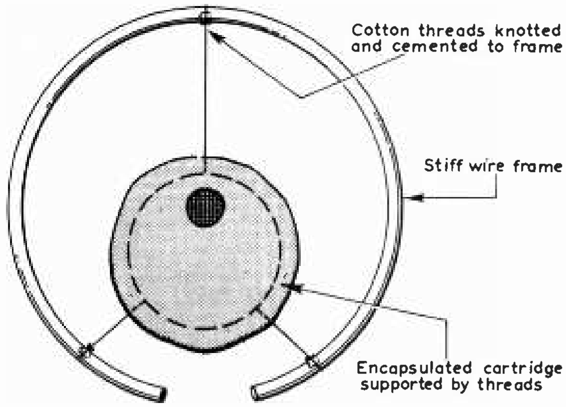



*Fig. 5: Cartridge mounting. Sensitive window must be in centre of frame, and the frame a push fit in the plaster microphone case.*

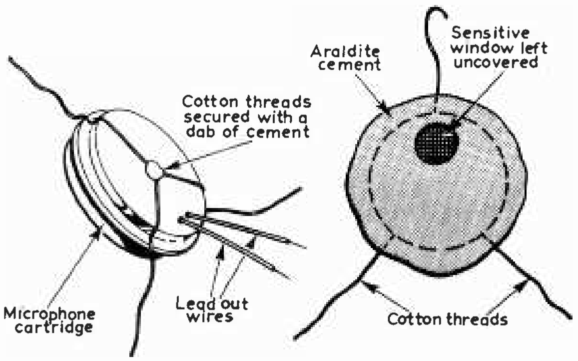



*Fig. 4: Microphone cartridge encapsulation.*

embedded with the cartridge as shown in Fig. 4 and the lead-out wires are brought out at the back. The cartridge will now be found to be less sensitive but much more directional. The weight of Araldite used also makes it less sensitive to handling noises. i.e. sounds picked up by mechanical contact.

About six inches of stiff wire is bent into a round frame about two inches in diameter. This should be a tight push fit into the plaster case. The encapsulated cartridge is now mounted in the frame by tying and cementing the support threads to it. In this way the cartridge is mechanically isolated as far as possible. It is mounted eccentrically with the sensitive "window" at the centre of the frame. It must not touch the frame and some Araldite should be filed away it this occurs.

The stranded lead-out wires are stripped and cut down to a single strand each. They are soldered to a screened cable as shown in Fig. 2b. Note that the strands are left slack to allow for movement of the cartridge. The cable screen is connected to the wire frame.

Two pieces of ordinary carpet felt are used. Felt about ½in. thick is suitable. A 2in. diameter disc of felt is cut and glued inside the plaster case. The frame carrying the cartridge is now pushed into the case until the cartridge almost touches the felt. Another piece of felt is now rolled into a 4in. long cylinder and pushed into the case, not far enough to touch the cartridge. The microphone cable is brought out under the felt to the front (or through a small hole drilled in the plaster) and the microphone is complete. The cartridge "window" should just be visible at the back of the case and the encapsulated cartridge should not touch the wire frame, the felt or the case.

To compensate for the low sensitivity of the microphone a two-transistor preamp is used. This is wired inside a small (tobacco) tin and is self-powered. The input cable from the microphone should be as short as possible.

Two silicon n-p-n transistors are used. The microphone signal is coupled by C1 to the base of Tr1 which is operated at low collector current for low noise. The divider R1/R2 furnishes base bias. Part of the emitter resistance (R4) is not decoupled by C2 and therefore provides negative feedback, reducing noise further. The amplified signal is taken from Tr1 collector to the base of Tr2 by C3. Tr2 is connected as an emitter follower with the output

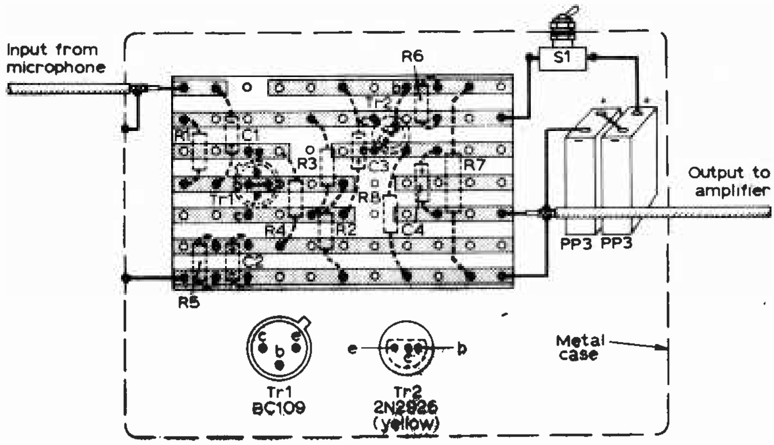



*Fig. 6: The preamplifier can be conveniently wired on Veroboard.*

## ★ components list

**Resistors:**

| | | | |
|---|---|---|---|
| R1 | 39kΩ | R5 | 4·7kΩ |
| R2 | 6·8kΩ | R6 | 22kΩ |
| R3 | 22kΩ | R7 | 22kΩ |
| R4 | 470Ω | R8 | 1·8kΩ |
| | | All ¼W | 10% |

**Capacitors:**

C1 50μF 6V electrolytic
C2 50μF 6V electrolytic
C3 50μF 6V electrolytic
C4 100μF 10V electrolytic

**Semiconductors:**

Tr1 BC109 (Mullard)
Tr2 2N2926 (yellow)

**Miscellaneous:**

'Norman' magnetic microphone cartridge; 1 pack Araldite epoxy cement; cotton thread; 6in. heavy gauge wire; plaster of Paris; ½in. carpet felt; S1 SPST on/off switch; B1 2 x PP3 batteries; battery clips; Veroboard; metal box; screened cable, etc.

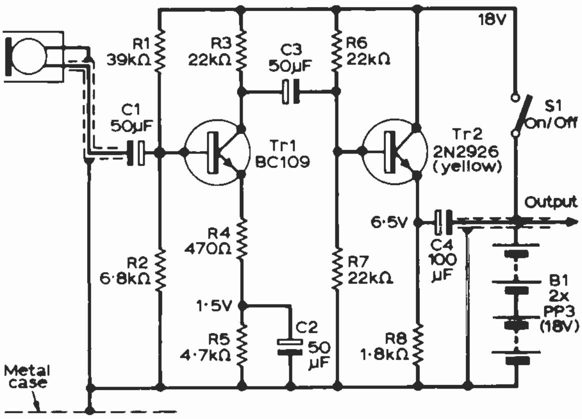



*Fig. 7: Low-noise preamplifier circuit.*

signal appearing across R8. The output here is of low impedance and may therefore be run through several yards of screened cable without hum pickup problems. It can be fed to an amplifier or tape recorder.

The circuit can be wired on a small piece of Veroboard as shown in Fig. 6. The components are closely packed, so check that they will fit on the board before wiring. After cutting the copper strips as shown in Fig. 6 the components are wired, leaving the transistors until last. No excessive precautions need be taken with these but *do not* shorten their leads and *do* solder as quickly as possible. Note the different wire arrangements of the two transistors.

The circuit is connected via S1 to two PP3 9-volt batteries in series and mounted inside the tin. The tin is connected to the input and output cable screens. The output lead is fitted with a suitable plug and the microphone is ready for use. The way in which it is mounted will depend on the application; a suitable table stand is shown in Fig. 1. ■

# THE MW COLUMN

IT is unlikely that the MW DXer will be content merely to log a distant station. Much of the pleasure of DXing in this band comes from writing to stations, telling them they have been heard and hoping they will reply with a "verification" which can be preserved as a memento and shown to other DXers.

Obtaining a QSL from medium wave stations requires a rather different approach than when writing to those on the short waves. The latter operate international services aimed at listeners abroad and these stations are usually very pleased to make contact with their audience and to provide them with QSL cards, programme schedules etc. The MW DXer however is located well outside the service area of the stations he listens to and he should remember that they are doing him a favour when they reply as he is really an eavesdropper. Many MW stations are genuinely surprised and pleased to have been heard at a great distance and will verify a correct report with pleasure, sometimes publicising it over the air or in the local press.

A reception report to a MW station should contain sufficient evidence in the form of programme details to enable the station to check that they were really heard by the DXer. It should be sent off as soon as possible after the logging and must always be accompanied by return postage. Unused foreign postage stamps can be obtained from stamp dealers but an International Reply Coupon is more convenient and can be purchased at main post offices.

North American stations are good verifiers. Many issue QSL cards and nearly all will reply to an accurate reception report. These should be sent to the Chief Engineer while the address should include the station call letters (e.g. Radio Station WINS) followed by the name of the city or town and the state (or province if in Canada). Mention the frequency, call letters, date and time of reception (preferably in the local time of the station) and details of the programmes heard must always be given. A common error made by beginners is to compile a list of records or the titles of tunes played over the air. Unfortunately, stations seldom retain this information. In the United States a station log is kept of all announcements made. Station identification comes on the hour and generally on the half-hour too. Commercials, names of announcers, weather reports, public service announcements, station slogans, provide the "meat" from which the DXer can compile a report which the station staff can check against the station log. Reporting codes such as SINPO or RST should be avoided, so should the use of International Q Code abbreviations such as "QRM" as it is unlikely these will be understood. Just give a simple verbal description such as "the signal was strong (or weak)". Conclude the report with a brief description of the receiver and aerial in use and then *request* a verification. Finally, do not forget to thank the Chief Engineer for taking the time and trouble to reply—he is probably a busy man.

**CHARLES MOLLOY**

# TRANSISTOR OUTPUT STAGES

## PART 2

I. R. SINCLAIR

*Continued from June*

## Transformer Input

This type of input is shown in Fig. 7. The input transformer has three windings, the two primaries usually being wound bifilar, meaning that two wires are wound as one so that the windings are as near as possible identical. The ratio is not very important and is usually about 3 : 1+1, meaning three primary turns to one turn on each secondary.

The use of a transformer means that single-ended stage can be used for driving, and that the driving transistor need not supply the full current required for the bases of the output transistors. This is important in a high power stage where the bases may take peak currents of 0·5A, requiring a lower power output stage to drive them. For amplifiers with outputs of 10W or more, this is an economical and reliable circuit, and the transformer imposes very little restriction on the band-width. A suitable transformer design is shown in Table 2.

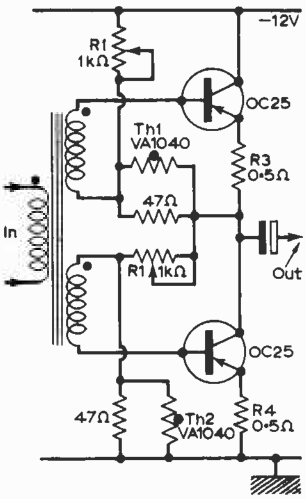



*Fig. 7: A transformerless-output amplifier with a driver transformer enables the amplifier to be driven by a single-ended stage.*

## Paraphase Transistor Input

A long-tailed pair circuit driving through CR coupling can be used just as in valve practice, provided that the bias is suitable for each transistor of the totem pair, but the most common transistor driving circuit is the complementary pair shown in Fig. 8, which is directly coupled to the output pair.

The bias on the output pair now depends on the current in the complementary pair, which in turn is regulated by the voltage between their bases; the voltage at the output (which should be midway between — and + lines) is regulated by the voltage level at the collector of the driver. In most circuits the driver bias is used to adjust the voltage level of the output and the small load resistor between base connections to the complementary pair is used to adjust output current. This small load resistor usually consists of a resistor in parallel with a thermistor so that there is some compensation for temperature effects. Note that each transistor of the complementary pair must be able to supply the maximum base current demanded by each output transistor, so that load resistors must be small and bias current fairly high.

## Complementary Pair Output

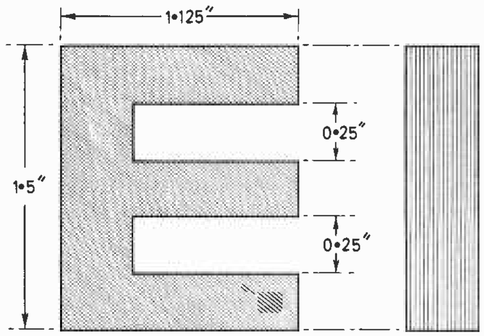
If, in the previous circuit, the complementary pair can provide sufficient power, we can remove the final pair and use the complementary pair as the output. This is an admirably simple arrangement provided suitable pairs of transistors can be found. Such pairs are now available in the lower powers (for example AC128/AC176 for about 2½W, AD161/AD162 for about 6W) although not so easily found in the higher power range among transistors manufactured in this country. A typical circuit is shown in Fig. 9.

## Load Coupling and Drive Impedance

A totem-pole output pair can be coupled directly to a load, provided that the other terminal of the load can be biased to the same voltage as the no-signal voltage at the output. This normally requires a tapped power supply, which is no difficulty if the amplifier is designed to operate from two 12V batteries, as are many public address amplifiers, but there is always a difficulty in ensuring that no direct current flows through the load; particularly important when this load is a loudspeaker, as a steady current causes the cone to be displaced from rest position.

In a mains operated circuit it is more normal to

**Table II**




CORE: Laminations should be approximately of the size shown, and can be obtained from an old transformer provided that it has not been a blocking oscillator transformer.

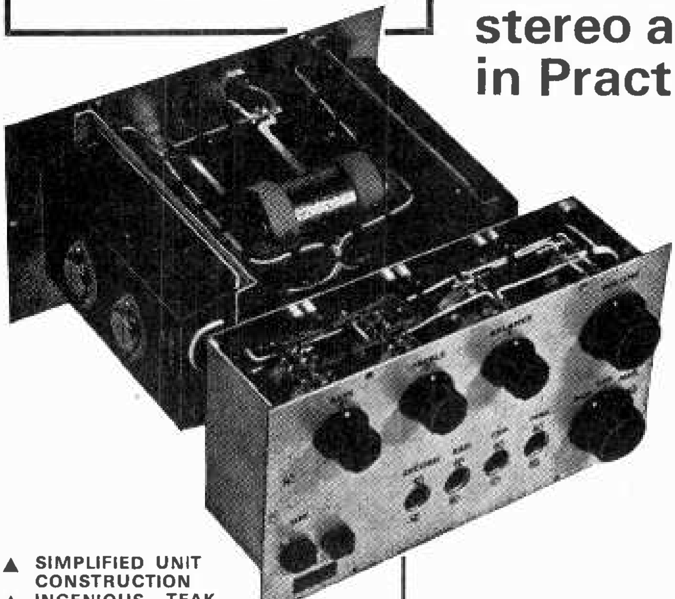
PRIMARY: 700 turns of 36-38 gauge wire, enamelled, wound in about six layers with a layer of transformer paper between each layer. Insulate primary from secondary with two layers of paper.

SECONDARY: Two wires of 30-32 gauge enamelled copper are wound for 200 turns, with a layer of paper between each layer.

*The design that's based on Peak Sound Cir-Kit*

# P.W. DOUBLE 12

## Integrated high-fidelity stereo amplifier as described in Practical Wireless



Peak Sound are justifiably proud to be associated with this outstandingly successful P.W. design and that so much of it has been made possible because of Peak Sound products and design techniques. Basically, the design of the "P.W. Double 12" demonstrates the value of using "Cir-Kit" in modern circuit board units whether for single or prototype examples. In this instance, however, Peak Sound have contributed more besides to the success of this project. This includes the remarkable power amplifiers, the power pack and the ingeniously styled cabinet which almost assembles itself, it is so simple to build. The "P.W. Double 12" has already been fully described in Practical Wireless for April, May and June, so that you can go right ahead now and build this exciting new design with authentic, exact-to-specification Peak Sound kits as described. With this unit you will be able to enjoy standards of reproduction of the highest order for very modest outlay.

- ▲ SIMPLIFIED UNIT CONSTRUCTION
- ▲ INGENIOUS TEAK CABINET DESIGN
- ▲ PROFESSIONAL IN EVERY WAY AND MONEY SAVING TOO!

## *This is your "P. W. Double 12" shopping list*

These are the Peak Sound units with which you can build this excellent design. They are exact to specification. Transistors included.

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| 5 Controls as specified | 2 | 0 | 0 |
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Metal work (make or buy), knobs, plugs and sockets, fuses etc. allow £3.0.0. From your local dealer.

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for your authentic Peak Sound Kits. In case of difficulty, please send direct, giving the name and address of your usual supplier where possible and add 11/- postage for complete assembly, or 5/6 if without power pack.

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### ▲ P.W. Double 12 abridged specification

**Formation**—Two pre-amp panels, two tone control panels, two power amplifier modules, power supply unit on chassis, housed within teak finished cabinet.
**Controls**—Bass and treble cut and lift based on Baxandall circuitry/Volume/Balance/Rotary selector.
**Input Sensitivity**—Magnetic P.U. (per channel) 2·5mV into 68kΩ. Ceramic P.U.—25mV into 27K. equalised for flat response. Radio/Aux. 60mV. HIGH OVERLOAD FACTOR ON ALL INPUTS.
**Frequency Response**—20Hz to 30KHz ± 1dB overall,
**Output**—12 watts per channel into 15Ω (8Ω speakers may be used).
**Negative Feedback**—43dB over each section.
**Power required**—45V D.C. (supplied by built-in power unit).
**Cabinet**—Afrormosia teak finish, pack-flat, easy to build kit. Size 9½ x 5½in. high x 9½in. deep.
**Transistors**—Ultra low noise in pre-amp and tone control stages.
PERFORMANCE CHARACTERISTICS, PARTS REQUIRED, ETC., SEE P.W. FOR APRIL, MAY AND JUNE.

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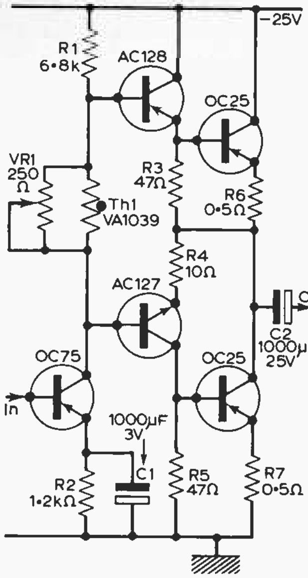


*Fig. 8: A transformerless-output amplifier driven by a complementary pair.*

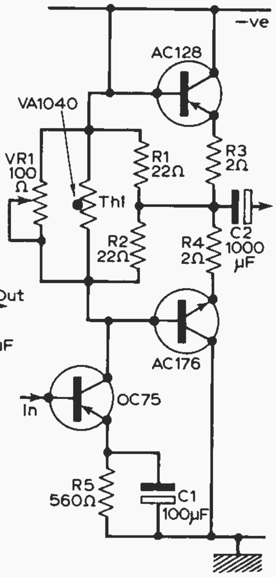


*Fig. 9: A simplification of Fig. 8 which can be adopted if the complementary pair can be made to provide sufficient power.*

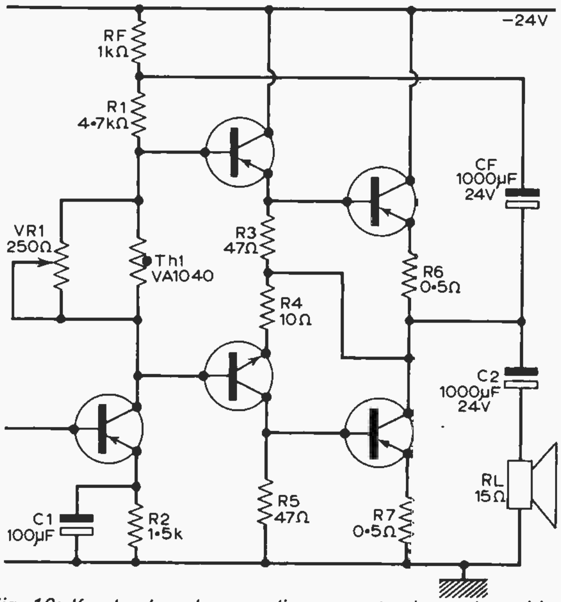


*Fig. 10: If a loudspeaker coupling capacitor is used, positive feedback can be used to compensate for a lack of bass response.*

couple the loudspeaker through a large capacitor (typically 1,000µF, 6V), and earth. This inevitably causes attenuation at low frequencies, but this can be compensated for by positive feedback (bootstrapping) back to the driver stage. An example of this is shown in Fig. 10. For this to be effective the feedback time constant ($C_F \times R_F$) should be considerably greater than the load time constant ($C_L \times R_L$), and fortunately this is usually easy to arrange.

In class B stages where the driver is CR coupled to the output transistors, the low input impedance is made worse by the low resistance of the bias network; necessarily low to prevent thermal runaway. This causes a restriction on low frequency amplification which can be dealt with by isolating the base from the bias network during the "on" time of the transistor. This is most easily arranged by connecting the bias through a diode which is back-biased during drive (Fig. 5).

## Thermal Calculations

The power which can be dissipated in an output stage depends much more on the efficiency with which heat can be removed from the collector junction than on the type of transistor used. Several American manufacturers publish dissipations calculated for the case where all the heat generated in the case of the transistor could be removed with 100% efficiency (infinite heatsink); the practically obtainable dissipations are much less. British manufacturers usually quote more realistic ratings; for example, the dissipation of the OC28 is given as 30W provided the case temperature is less than 45°C. The actual dissipation which can be used depends on (1) the maximum collector junction temperature which can be tolerated (usually 90°C for germanium transistors and 200°C for silicon types) and (2) the resistance to the removal of heat caused by the connection to the case, heatsink etc.

For every transistor, the *thermal resistance* (which is the heat equivalent of electrical resistance) of the collector junction is quoted. But before heat can be totally removed, it has to flow through mica washers, if used, to a heatsink and from there to the air around whose temperature must also be taken into account. Since all these resistances are in series, they have to be added together, and the power dissipation permissible is given by $P = \frac{T}{\theta}$ where T is the difference between the maximum junction temperature and the maximum air temperature and $\theta$ is the total thermal resistance in °C per watt.

For example, if the maximum junction temperature is 90°C, the maximum air temperature is 30°C and the thermal resistance is 4·5°C/W, the maximum dissipated power is $\frac{90-30}{4\cdot5} = \frac{60}{4\cdot5} = 13\cdot3$W.

As a guide, the maximum air temperature for use in industrial atmosphere and in car radios is taken as 45°C; for indoor use in living rooms (for example, hi-fi equipment) 25°C is more realistic as the maximum *provided* the transistors are not in the path of heat from a radiator, fire or TV set. A thermal resistance of 4·0-4·5°C/W is also reasonable for most power transistors well bolted down to a *blackened* heatsink of aluminium at least 7in. square. If extruded alloy heatsinks are used, the thermal resistance should be known and should be added to that for the transistor (usually 1-2°C/W) plus an allowance of 0·5°C/W extra if a mica washer is used or 0·2°C/W if the transistor is bolted directly to the heatsink. In every case silicone grease should be used between transistor, mica and heatsink to ensure good thermal conductivity.

For most applications, it is preferable to mount transistors on separate heatsinks which are insulated from the chassis; this avoid the use of mica washers. The heatsink should be blackened before use by using matt black paint (obtainable from photographic suppliers) or printer's ink. The difference in thermal resistance between a polished metal surface and a matt black one is enough to mean the loss or use of two good transistors! ■

# LETTERS...

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

## All a question of holes

Mr. Green is perfectly correct when he says that we have no difficulty in discussing a hole in our bank balance as an overdraft but this does not make it a tangible reality. You cannot withdraw an overdraft in the bank and pay it into another bank. You must first get an overdraft in another bank by withdrawing money from it and then you can satisfy the overdraft at the first bank.

In the same way a "hole" in a semiconductor cannot move without an equal and opposite movement of electrons. It is impossible to move a "hole" without moving electrons because it is not a tangible reality—it has no mass, no existence in its own right. The fact that we have to use the idea of holes in explaining transistor action would seem to point to an error in physical theory. In reality we have not explained transistor action but have "explained it away". Surely this is unscientific. **D. H. Ross** (*Edinburgh*).

## A little therapy

I have to thank Mr. Green (Letters P.W. May 1969) both for taking the trouble to write and also for supplying a splendid example of incomprehensible thought—the characteristic symptom found in those of our unfortunate friends afflicted with Hiatitis Pungens.—A little therapy might help.

I have always understood, and the massive Oxford Dictionary convinces me, that the English language is the richest in the world fully capable of supplying the needs of anyone for any purpose. Certainly I have seldom been at a loss for words.

It would also give me much pleasure to be present at any time when Mr. Green found it necessary to explain to a man that the severe electric shock he had just received was an abstract idea quite incapable of description in the English language. No, Sir, it just will not do.

It is not the English language which is inadequate, it is the ideas which are wrong. For too long have the "blinders with Science" had it all their own way and the time has come to call their bluff. I maintain that there is nothing at all complicated or difficult about transistor operation and, when I wrote my (March 1969 P.W.) letter I was under the impression that I was alone in denouncing "hole theory" in print. Since then one of my students has lent me a book which gives me powerful support. It is written by Dr. M. G. Suffern who, among other achievements before and since, ended the war—1945—as Deputy Director of Electronics, Ordnance Dept., US Forces.

Referring to n-p-n he writes:

"... Note the arrow on the emitter points away from the base, because of the same unfortunate compromise found in other devices in which the supposed current flows in an opposite direction to that of electrons. Conservative thinking cannot break away from old ideas and tend to complicate rather than simplify.

For our purposes, rather than to surrender to outmoded ideas, we shall continue to observe the (−ve) direction of current flow as is proper."

Again, later, referring to p-n-p, he writes:

"... In fact, some individuals call such positive charges 'holes', (atoms lacking an electron and bearing a positive charge). For our purposes, however, the actual electron flow comprises the electric current and the direction of such current is that of electron flow."

I like that "some individuals" bit. It puts the "holier than thou" theorist firmly in his place.

English is inadequate indeed! I am having to forcibly restrain myself to avoid writing sufficient to fill an issue of P.W.

A mathematician myself, I cannot see that directed numbers have any bearing on our discussion and Mr. Green has himself answered the only point he made, i.e., if the accident of history had been reversed and electrons were called positive instead of negative, he (not I) would have been talking about −ve "holes" so what difference does that make?

Even so, I still seem to be the only person with an alternative electron theory of p-n-p. The textbooks now appearing are adopting the crafty habit of describing n-p-n in detail and giving only a casual unexplained reference to p-n-p.

I do not know if my ideas are 100% correct but I do know that I am happy to go on record as stating categorically that "hole" theory is 100% nonsense.

I am in no predicament. I am simply heartily sick of teaching nonsense at the insistence of authors and examiners who should be setting an example of clear thought and not simply redrafting the same ideas in this uncritical manner. I am very grateful for the opportunity which P.W. has given me of making this firm protest. As I had already said in another place before this opportunity arose, I believe that "hole theory" is a great mistake and sooner or later it will have to be discarded. When that happens, all the "hole theorists" will jump on the wagon and will happily talk about things as they really are and hope that nobody will remember that they previously said something quite different. If anything I have said hastens this day, I shall be more satisfied. I repeat—there is nothing unimaginable about transistor theory as long as the imagination stays firmly with electrons. It is the incorrectness of the whole idea of "holes" which makes THAT theory unimaginable.—**B. R. Meredith, G2CYV** (*London*).

## A fair swop

Which British reader of PRACTICAL WIRELESS would like to exchange his already-read monthly edition with the Dutch radio-magazine *Radio-Bulletin*.

*Radio-Bulletin* is a monthly with a contents identical to that of P.W., but in the Dutch language. This, however, will not give many difficulties, because schemes, sketches and symbols are international.

You will also find lots of advertisements in it, just as in P.W.

Please write to me.—**B.W.C. van Albeslo** (*Bumerweg 8 Winterswijk—Holland*).

We should like to thank readers for correspondence received on the subject of Commercial Radio. We shall shortly be publishing a selection of these letters.

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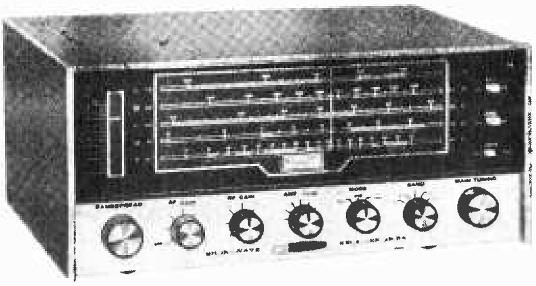

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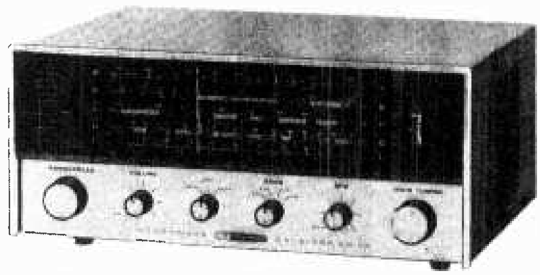

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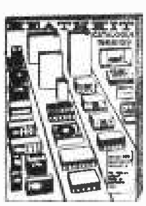

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# TAKE 20

JULIAN ANDERSON

## No. 3 A MINI METRONOME

**A series of simple transistor projects, each using less than twenty components and costing less than twenty shillings to build.**

THIS month we have a really simple project—a unit that simulates beautifully the sound of a time bomb ticking away! For those more attracted to gentler pastimes it may also serve as a metronome, that is it gives a loud click at regular intervals, the actual interval being varied by a potentiometer in the circuit. It's very simplicity also makes it highly suitable for use as an audio warning device, inserting the alarm switch in the supply line.

## THE CIRCUIT

The actual working of the circuit is fairly simple; on applying a voltage across R1, VR1, C1 and the loudspeaker, the capacitor C1 charges up till a point is reached when Tr1 switches on, this in turn switches Tr1 to a conducting state meaning that a voltage is applied across the loudspeaker causing it to "plop". As these little electrons charge up the emitter lead and out through the collector a few get diverted and pass out through the base and neutralise the charge on C1 and soon the voltage on the base will reach the stage where the transistor is turned off; thus the cycle starts all over again. The rate at which C1 charges depends upon VR1 and thus by altering this the interval between each cycle can be varied.

## SURPLUS TRANSISTORS

The actual transistors used are unimportant, I have tried a large variety and all have worked successfully. One of the transistors is a p-n-p, the other n-p-n and several advertisers are offering 60 or more germanium transistors and 30 or more silicon types at 10s. for each pack. The germanium ones are similar to the OC71, OC44 etc. and the silicon ones are like the BC108, BC109, 2N2926 etc; not all the transistors in these packs work, you will probably get about 10% duds (even many of these can be used as diodes) but those you have left work out at only pennies each and are ideal for projects such as this. In the near future I will be describing many projects using these unmarked transistors and for those who are following *Take 20* a pack of each will be an investment.

## CONSTRUCTION

The components are mounted on a small piece of Veroboard, one end is drilled to take the potentiometer (⅜in. spindles are virtually standard) and the other components are mounted and soldered at the other end. The project is so simple that very little can go wrong and immediately you switch on regular "plops" will be heard. By altering VR1 a wide range of intervals should be covered but if you want slower ones—that is with several seconds' interval, increase the value of C1, if you want faster ones lower its value.

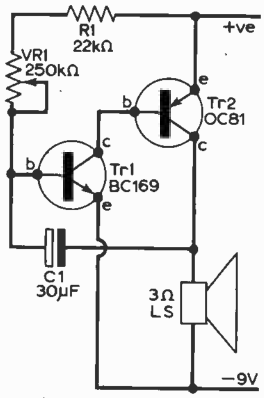


*Fig. 1: The circuit*

## USES

The circuit described is certainly the cheapest method of getting a sound from a loudspeaker and thus it makes an ideal warning device, the plops themselves are loud and the unit could be used as a burglar alarm arranging the supply voltage to be switched on when a window is opened etc; even if the plopping isn't heard by anyone you can bet it'll get your unwelcome visitor worried. The time intervals are regular and the unit will serve well for its intended use as a metronome providing the beat for music lessons etc.

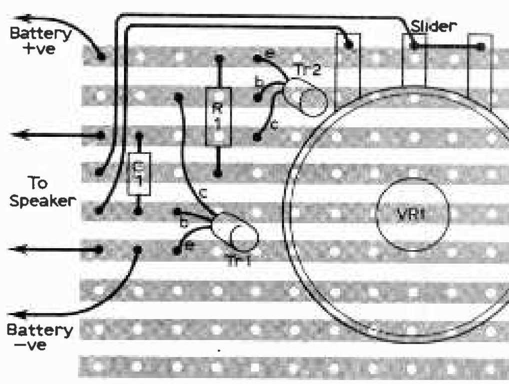


*Fig. 2: The component layout on the Veroboard*

## ★ components list

R1 22kΩ, 10%, ¼W
C1 30μF 12V
VR1 250kΩ lin pot
Tr1 BC169, see text
Tr2 OC81, see text
Loudspeaker any 3Ω or 8Ω type
Veroboard 1¾ × 1⅜ in. 0·15 in. matrix
9V battery

Next month our project will be an electronic organ using a unijunction transistor. For those wanting to build it a 2N2646 or equivalent is needed; this should cost between 7/6 and 10/-. ■

# P.W. GUIDE TO COMPONENTS

PART 7

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

ELECTROMAGNETIC devices are components which use the magnetic field derived from an energised coil to provide a force to actuate a mechanical movement. The most important components in this group are: relays, solenoids, loudspeakers, microphones and meters. As the principle of electromagnetic force has been understood for a considerable time all the devices in this group have been available in some form for many years. Therefore little discussion will be spent on operating principles but attention given to constructional features, design restrictions, availability, price and reliability.

## Relays

Relays have been used since the days of the earliest "electric telegraph". Since then improved materials and methods of construction have increased their reliability and decreased their size. Figure 1 shows the essential

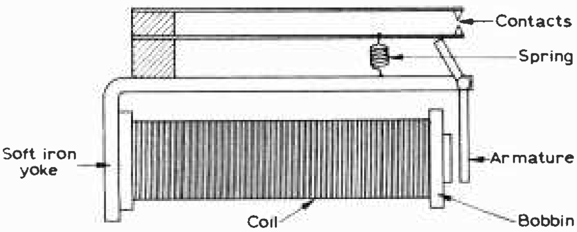


*Fig. 1: Basic construction of a relay.*

construction of a relay. It consists of a coil wound on a bobbin and soft iron core. The armature piece is fixed by means of a pivot and spring loaded away from the core pole. In this position the contacts are open. When the coil is energised the armature is attracted to the pole against the spring force and closes the contacts. The spring returns the armature to the contact open position when the coil is de-energised.

The action of a relay is that of a switch controlled by an electrical circuit. As the coil power is low a considerable power gain is inherent. Ideally therefore a relay should have a control coil which uses a minimum of power whilst the contacts should be capable of switching a maximum power. Also the mechanical construction should be such as to give the fastest speed of switching and greatest reliability.

The coil is constructed as a solenoid wound on a plastic bobbin with a soft iron or similar magnetic material core. The coil is designed for a specific operating voltage and the resistance determined by the magnetic force (ampere-turns (AT)) necessary to close the contacts. The coil power also has to overcome frictional forces and usually a power of 1–5W is used to give the required characteristics, such as speed of switching, reliability etc. By semiconductor standards this power requirement is high and as a result usually necessitates a driver transistor in order to operate the relay. Because the relay coil is inductive, several limitations result in surge voltages due to the inductance which would break down the transistor. As a result a protection diode as shown in Fig. 2 is incorporated in

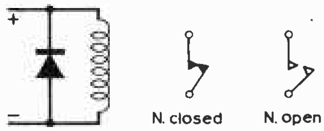


*Fig. 2: Relay symbols.*

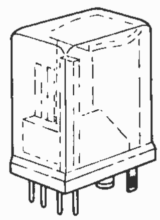

*Fig. 3: Plug-in relay.*

the circuit and allows a circulation path for the inductively maintained current. However this has the effect of maintaining the ampere-turns and consequently delays the contact release by 10–20msecs. The inductance and inertia also reduce the switch-on time which is also of the order of 10–20msecs.

The other essential component of a relay is the contacts. Usually the armature operates a bank of changeover contacts and from one to four such contacts are usual. The actual contact face is welded to a link and often the link is of spring steel and itself provides the return force for the armature. Contacts are made of palladium, silver-gold-plated silver, or gold, in order to have a low surface resistivity. The contact resistance determines the maximum current which the contacts can pass. However this is usually considerably greater than the maximum current which can be switched.

The relay contacts are perhaps the most unreliable component in the relay, especially in relays working near the maximum contact rating. The faults associated with contacts are: dirt on the contact surface which increases contact resistance; pitting and corrosion of the surface due to arcing; and welding of the contacts. For these reasons the contacts are manufactured from pure, inert metals and for greatest reliability should be operated well below the rated power levels. Modern relays are also often enclosed in a plastic casing in order to minimise the effect of dust and other surface corrosive elements. Plug-in relays are also commonly employed in modern circuits and Fig. 3 shows a typical plug-in, plastic enclosed relay. It is worth noting that for reliable operation it is essential to use a retaining clip to prevent movement of the relay.

Relays are commonly specified in terms of coil

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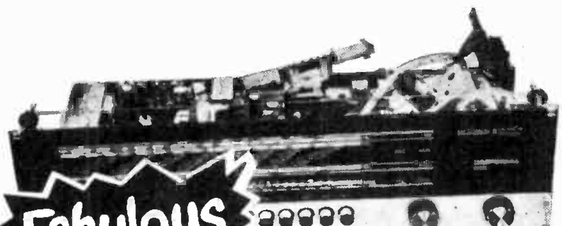

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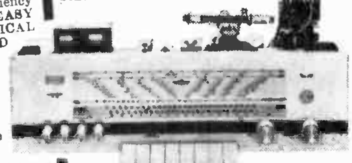

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voltage ratings and contact current and voltage ratings. The coil resistance is also included especially for low voltage coils intended for transistor circuits. Standard coil voltages are 6, 12, and 24V d.c. with coil resistances of 100Ω–1000Ω. A.C. operated coils are usually for 115, 240, and 440V r.m.s. circuits. Coil power is generally 1W–5W for most electronic relays but is considerably more for power relays and contactors.

Coils are normally rated for continuous operation and for this reason a maximum coil voltage is stated together with a minimum coil voltage for the just-operate condition. It is preferable to operate relays at their rated voltages since the mechanical characteristics are designed for these conditions. Working at low voltages gives low speed switching and increases the danger of arcing or welding of the contacts. High voltage working decreases the reliability of the coil whilst the mechanical shock of the contacts through faster switching causes switch bounce and vibration and a consequent reduction in mechanical life.

Contact ratings are often ambiguous since commonly they are rated for maximum voltage and current. Whilst these are true for the steady state closed or open conditions, they do not apply to the transient opening and closing periods during which arcing may occur. The transient condition is usually limited by the power rating of the contacts which is considerably lower than the value indicated by the maximum voltage and current ratings. Thus contacts with maximum ratings of 250V a.c. and 3A a.c. steady state ratings usually have a power rating of 200VA or 80W.

Relays are inherently unreliable components since they have a definite mechanical life. However due to the use of modern materials the reliability has increased and a life of $10^6$–$10^8$ operations is often quoted. Reliability is very high for relays employed in low power switching applications but falls with high power levels.

Relays are common circuit elements particularly in control circuits and they are consequently readily available. Average prices for the smaller devices used in electronic circuits vary from 15s. to £5 depending on quality and standardisation. It should be remembered that the cheaper relays unless bulk produced are of poorer quality and as a result tend to be less reliable. With relays the familiar quotation "You get what you pay for" is particularly true.

## Reed relays

Reed relays are essentially a development of the relay to increase the reliability and speed of operation. The reed consists of two leads of sprung magnetic material encapsulated in a glass envelope as shown in Fig. 4. The leads have contact faces, usually of diffused gold, which are brought together by the action of an external magnetic field. The reed therefore is simply an encapsulated contact, and the contact operation is illustrated in Fig. 5.

Reed switches can be purchased as contacts for use with permanent or electromagnet systems. For example reeds are commonly employed for proximity applica-


*Fig. 4: Reed relay contacts.*

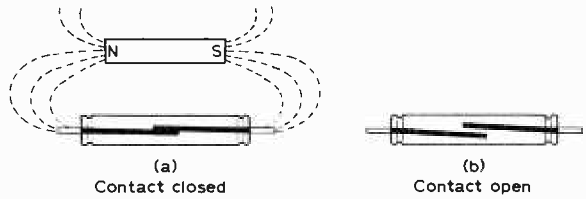


*Fig. 5: Reed relay operation.*

tions in conjunction with permanent magnets. Generally however they are used in conjunction with separate coils which are for printed circuit mounting or in complete encapsulations. One or more coils are employed to switch the relay and by changing the coil polarities logic functions can be achieved. One or more reeds are employed and changeover configurations are available. Thus a complex system of reeds and coils can be built up.

The design of reed relay assemblies is easily achieved since reed parameters always quote the minimum or just-operate ampere-turns (AT) required to switch the contacts. Average values of AT are from 20–50 for small reeds 1·5in. long to 70–150AT for 3in. power reeds. Thus a 100AT reed requires a coil of 100mA current and 1,000 turns to just operate the switch. Wound coils on printed circuit bobbins are also available suitable for 12V circuits and have resistance values from 500Ω to 2kΩ.

Reed contacts are rated for maximum current and voltage but the maximum power for reliable operation is considerably lower than conventional relays. Typical maximum power ratings are 3–10W for small reeds and 10–20W for the larger types. Again, operation well below the rated power level gives a considerable increase in life expectancy. Generally breakdown voltages are in excess of 400V and the maximum current ratings are 0·25–1A.

The principal advantages of reed relays are their long switching life of $10^8$ operations and the speed of switching. Typical turn-on time is from 1–2msecs with turn-off times of the same order. Reed switches can therefore be used for switching at up to 2kHz rates. Another important advantage, particularly in logic circuits, is the lack of switch bounce.

Reeds and relay assemblies are now readily available. Individual reeds vary in price from 4s. to £1 whilst coil assemblies vary in price from 6s. to £1. Complete encapsulations including a magnetic shield range from £1 to £4.

## Mercury wetted relays

Mercury wetted relays are designed for extremely reliable systems where the characteristics of high speed switching and lack of switch bounce are required. Lifetimes in excess of $10^9$–$10^{10}$ operations can be achieved and this is due to the construction which continually "wets" the contact surfaces with mercury by capillary action. These devices are available for operation between 6V and 50V supply voltages and cost from £3 to £5. A disadvantage results from the limitations in mounting, since for the capillary action to operate they must be mounted vertically.

## Meters

Meters are devices which convert electrical power into a mechanical force which is counterbalanced by a

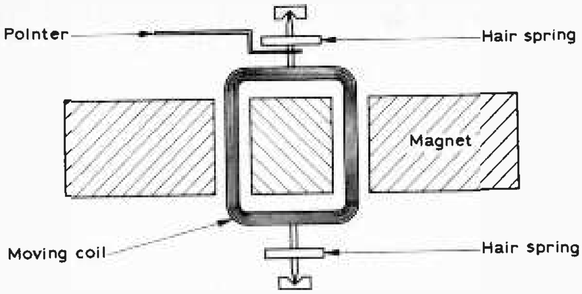


*Fig. 6: Basic moving-coil meter construction.*

spring movement. The physical movement of the coil is used to give an indication on a dial. As moving-coil meters are by far the most widely used type only these will be considered here.

Figure 6 illustrates the essential components of a moving-coil meter. A coil is suspended in a strong magnetic field produced by a permanent magnet. The bearings are often jewelled and movement of the coil is prevented by a coil spring. When the coil is energised by a direct current flowing through it, a rotational force is exerted on the coil due to the interaction of the permanent and electromagnetic fields. This force is opposed by the torque characteristics of the spring and in consequence the accuracy of reading depends upon the linearity of the force-displacement characteristics of the spring. As springs generally have a linear relationship between force and displacement moving-coil meters have a linear scale reading. It can be seen therefore that moving-coil meters are direct current meters since it is direct current which is linearly related to the mechanical force exerted upon the spring.

The ideal moving-coil meter should have an absolute linearity between coil current and scale reading and the range of current measured should be as large as possible. Also the time taken for the meter to arrive at a stable reading should be a minimum. In order to achieve the ideal meter the suspension system of the coil would have to be frictionless and the permanent magnetic field should be uniform and radial. The reading accuracy and range of an instrument are largely determined by the physical size of the scale over which the pointer moves. This is physically limited by the size of the meter and the pivot and suspension system. But in any event as the scale is linear, accuracy at the low end of the scale is essentially less than at the top end.

The speed in which a reading is obtained is also important especially since a force instantly applied to a coil inherently results in an oscillation of the spring

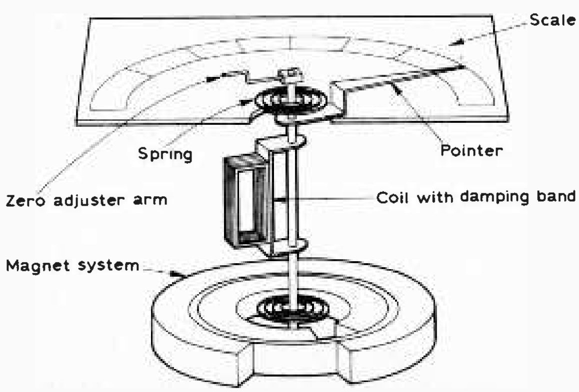


*Fig. 7: Exploded view of moving-coil meter.*

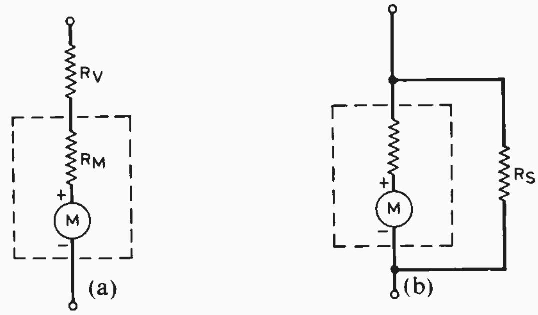


*Fig. 8: Meter modifications to measure (a) d.c. voltage and (b) direct current.*

system. Thus practical meters have damping systems which are designed to give critical damping. This is an oscillatory condition in which stability is achieved in a minimum time. If the movement is overdamped then the pointer moves slowly and creeps up to the final reading, whilst underdamping results in the pointer swinging about the final reading.

Most of these limitations have been reduced to minute proportions by the practical meter design shown in the exploded view of Fig. 7. The magnet has a strong radial field and is generally of Al Ni Co, whilst the spring and coil system is light with little inertia or friction. Damping is by air vanes, magnet systems or oil dash-pots. Scales are physically limited in size and 2 to 5in. is general but 10 to 20in. can be achieved. To improve reading accuracy mirrored scales are used. However the basic limitation due to linearity remains, and a reading accuracy of 1% of the full scale value is only possible with high quality meters.

All moving-coil meters are basically direct current operated and the current required by the coil to give full-scale deflection varies from 10μA to 10mA for average meters. Most however are within the range 50μA to 1mA. This basic current determines the quality of the meter since moving-coil meters can be used for the measurement of most electrical quantities providing a direct current in the above range is present. By using resistors as shown in Fig. 8 the meter can be used to measure d.c. voltage and current, whilst the addition of a rectifier enables the meter to read a.c. voltage and with a transformer alternating current.

The resistors $R_v$ and $R_s$ for d.c. measurements can be calculated from the following formulae:

$$R_v = \frac{V_{d.c.}}{I_m} - R_m$$

where $V_{d.c.}$ is the full scale voltage reading in volts,
$I_m$ the basic meter current in amps and
$R_m$ the meter coil resistance.

$$R_s = \frac{I_m R_m}{(I_{d.c.} - I_m)}$$

where $I_{d.c.}$ is the full-scale current reading in amperes.

The quality of a meter is dependent upon the current for full-scale deflection and the figure of merit quoted on most universal meters is derived from the series resistance required to measure d.c. volts; and is stated in ohms/volt. Thus from the formula a 50μA meter requires $1/50 \times 10^{-6}$ or 20,000Ω/V total series resistance, whilst a 1mA meter requires $1/1 \times 10^{-3}$ or 1,000Ω/V series resistance. Inherent meter resistance ($R_m$) reduces with figure of merit and is of the order of 100Ω for 1mA meters to 1kΩ for 50μA meters.

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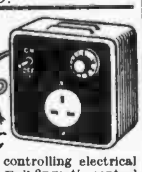

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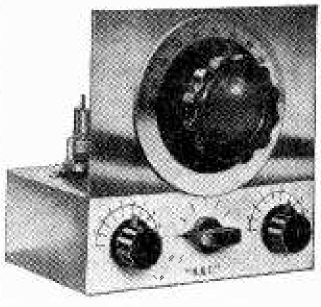

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# ON THE SHORT WAVES

## MONTHLY NEWS FOR DX LISTENERS

THE days seem to fly by and we are now in the summer season here in the Northern Hemisphere. With summer conditions the best DX is found during night hours and early morning. So set your alarm clocks for 0400 and you may get some good DX on 11, 9, 7, 6, 5, 4 and 3MHz. But during the day you'll find 25, 21, 17, 15 and 11MHz swamped by *R. Liberty*, *R. Free Europe* plus the whole Russian and Iron Curtain jamming network working overtime, together with *R. Moscow*, *The Voice of America* and all the high power stations. So sleep at day and DX at night. Now on to the propagation predictions for the summer months.

**West Africa:** 0800-1600 21, 17 and 15MHz; 1600-1800 21, 17, 15 and 11MHz; 1800-2000 21, 17, 15, 11, 9, 7 and 6MHz; 2000-2200 17, 15, 11, 9, 7, 6, 5, 4 and 3MHz; 2200-0200 15, 11, 9, 7, 6, 5 and 4MHz; 0200-0400 11, 9, 7, 6, 5, 4 and 3MHz; 0400-0600 15, 11, 9, 7, 6,5 and 4MHz; 0600-0800 17, 15, 11 and 9MHz.

**South Africa:** 0800-1600 21 and 17MHz; 1600-1800 21, 17 and 15MHz, 1800-2000 21, 17, 15, 11, 9 and 7MHz; 2000-2200 17, 15, 11, 9, 7, 6, 5 and 4MHz; 2200-2400 15, 11, 9, 7, 6 and 5MHz; 2400-0200 11, 9, 7, 6 and 5MHz; 0200-0400 9, 7, 6 and 5MHz; 0400-0600 11, 9 and 7MHz; 0600-0800 21, 17 and 15 MHz.

**East Africa:** 0600-1600 21, 17 and 15MHz; 1600-1800 21, 17, 15, 11 and 9MHz; 1800-2000 17, 15, 11, 9 ,7 and 6MHz; 2000-2200 15, 11, 9, 7, 6, 5 and 4MHz; 2200-2400 11, 9, 7, 6 and 5MHz; 2400-0200 11, 9, 7 and 6MHz; 0200-0400 11, 9 and 7MHz; 0400-0600 17, 15, 11 and 9MHz.

**South Asia:** 0600-1400 17 and 15MHz; 1400-1600 17, 15 and 11MHz; 1600-1800 17, 15, 11, 9 and 7MHz; 1800-2000 15, 11, 9, 7, 6, 5 and 4MHz, 2000-2200 15, 11, 9, 7, 6, 5, 4, and 3MHz; 2200-2400 11, 9, 7, 6, 5 and 4MHz; 2400-0200 11, 9, 7 and 6MHz; 0200-0400 11 and 9MHz; 0400-0600 15 and 11MHz.

**South East Asia:** 0600-1200 17MHz only; 1200-1400 15MHz only; 1400-1600 17, 15 and 11MHz; 1600-1800 17, 15, 11 and 9MHz; 1800-2000 15, 11, 9, 7, 6 and 5MHz; 2000-2200 11, 9, 7, 6 and 5MHz; 2200-2400 11 and 9MHz; 2400-0400 11MHz only; 0400-0600 15MHz only.

**East Australia via Asia:** This circuit is rather unpredictable in results, the official forecast reads as follows: 1600-1800 on 11MHz only; 1800-2000 9MHz only; 2000-2200 11 and 9MHz; 2200-2400 15 and 11 MHz. But signals have been logged via this route round about 0700 on 21MHz and 0900 on 15MHz.

**West Coast South America (South of Peru):** 1200-1800 17MHz only; 1800-2000 21, 17 and 15MHz; 2000-2200 21, 17, 15 and 11 MHz; 2200-2400 17, 15, 11 and 9MHz; 2400-0200 15, 11, 9, 6, 5 and 4MHz; 0200-0400 11, 9, 6, 5, 4 and 3MHz; 0400-0600 11, 9, 6 and 5MHz; 0600-0800 9MHz only.

Those were the propagation predictions as supplied be Cable and Wireless, London.

Times in GMT • Frequences in kHz

## THE BROADCAST BANDS

Christopher Danpure

The other day I received a very nice letter from Mr. P. J. McNamara concerning a new Shortwave Listeners' Club which has just opened. The name of the club is the "Limerick City Short Wave Radio Club". They publish a very well produced monthly bulletin which as well as giving DX tips also has tips on such things as how to report correctly to a station for a QSL card. The cost to receive the club bulletin for 1 year is 7s. 6d. and membership is open to all SWL's anywhere in the world. The address to write to for further information is Limerick City Short Wave Radio Club, 7 Colbert Park, Janesboro, Limerick City, Ireland.

Now on to this month's DX and SWL's tips.

### ASIA

**North Vietnam:** *R. Hanoi* has been heard closing at 1700 on 15,018 in Vietnamese irregularly. This station does QSL and sends out schedules and information about N. Vietnam, I believe, and according to loggings this station is not using directional aerials for this frequency.

### AFRICA

**Ghana:** External Services, *R. Ghana*, Accra is now beaming its English service to Europe from 2045-2215 on 15,285 according to Limerick City S.W. Club Bulletin.

**Liberia:** *R. Station ELWA* has been heard closing at 2200 in English on new frequency of 9,760 according to Limerick City S.W. Club Bulletin.

### NORTH AMERICA

USA: *R Station WNYW* is now on the following schedule. To Europe from 1600-1830 on 21,525; 1600-1820 on 15,440; 1830-2130 on 17,760; 1900-2140 on 15,440. To Africa from 1600-1850 on 21,580; 1850-2140 on 21,525. To Caribbean and the Americas 1600-2145 on 17,845; 2140-2145 on 21,525, 15,215 and 15,130; 2145-2150 21,525, 17,760, 15,215 and 15,130; 2150-0020 on 21,525, 17,835, 17,760, 15,215 and 15,130. Many thanks for this tip to Mr. C. M. Pearson in Epsom, Surrey. A good fresh item.

### EUROPE

**Switzerland:** The Swiss Shortwave Service, Berne is now on the following schedule until September 7 for its English programmes. 0700-0800 (daily) on 11,775 and 9,590; 0700-0800 (weekdays only) on 9,535 and 6,165; 1000-1100 on 21,520, 17,795 and 15,305; 1130-1230 on 11,865 and 9,665; 1315-1415 on 21,520, 17,845 and 15,135; 1500-1600 on 17,830 and 15,305; 1815-1915 on 17,795 and 15,180; 1930-2030 on 11,865 and 9,665; 0130-0230 on 15,305, 11,715 and 9,535; finally 0445-0545 on 11,715 and 9,720. Well that's about it for this time. Deadline for all those DX-logs is May 20th. So until next time good listening and 73s.

EVEN those with a piece of wet string and a cat's whisker must have heard DX this month on the amateur bands. It was uncle David's month for draping the ageing eardrums around 10 metres, and cor, wasn't it lively up there? Must have been purgatory for the owners of beams, wondering which way to point the darned things for fear of missing something good in the other direction. Using just one vertical in the loft raised all five continents at the same time. The citizens band, too, was really humming with a collection of the most amazing call-signs and conversations you could think of. Incidentally, if "Big fat mumma" somewhere in Brooklyn reads this, you owe me thirty bob for a new front end and I strongly disagree with your remarks concerning women in the summer.

The other end of the spectrum didn't fare too well with me, but logs received indicate that the DX was there, so it must be me. Certainly one could log quite a large number of W stations in the 3·8 to 4MHz segment, but apart from this there didn't seem much about, discounting EUs.

**Nigel Thornley** (Northamptonshire), tells tales of a strange noise which blanketed 20 metres but no remarks from any other sleuths. (It's like that most evenings on 160 anyway). Only a very small number of logs for the l.f. bands but a large number cashed in on the 10 metre openings.

## LOGS LOW

Successful ingredients for an r.f. topband cake coming up. Take one B40 receiver, 175ft. of wire and poke in the terminal marked "antenna". Oh yes, put the head of one **R. Moore** (Dorset) between the headphones and you get—GC3ULZ/P, GD3VMQ, GM3FXM, GW3WBU/P, OE3KIW, OK1TH, OK1VC, OK1KVW, OK2BFI, OK2PCN, OK3CJV, OK3YBE, OL1AKG, OL2AIO, OL5ALY, PAØCC, TA2E, ZB2AY. Most of these on c.w.

Rumours that a GM station has been known to "drop in" for a chat on the Verulam 160-metre club net. Cynics should QRX Saturday nights around 2230 BST on 1980 or thereabouts.

**Christopher Lamb** (Dorset) sends me hieroglyphics which turn out to be the best of his "heard on 80 metres" log—KP4S, K2ISM, K2VOE, VE1AFY, W1ABC, W2BGG, ZL2GJ, ZL4II, ZL4JW. Wish I could hieroglyph like that.

**Bill Wright** (Staffs) has an RG-1 and a 180ft. long wire. A fantastic log for 3·5MHz (that's the posh way to write 80 metres) all s.s.b.—CN8AW, CO2DC, CO2FA, CR4BB, EA8EX, EP2BQ, FG7XX, FG7TI/FS7 (French St. Martin), HI8OSA, K1THQ, K2BZT, K4JN, KP4AST, KZ5WH, MP4TAF, MP4TCU, OD5BA, PJ7JC, PY7ASQ, PY7GV, TF3BV, TI2ES, VE1OW, VE2AYA, VE3AGW, VO1FG, VP2AA, VP9L, W1AP, W2AC, W5LHO, W8GZ, W9BV, WA3LFN, XE1CE, XE3AF, YV1SA, YV3RP, YV4DN, YV5BPG, ZB2BS, ZC4GM, ZL4LM, 3AØCU, 4X4AS, 5A1TN, 5R8AO (Malagasy), 6Y5CC, 9E3USA, 9H1BL, 9Y4LP, 9Y4MM.

## LOGS HIGH

Congrats to **Jim Baker** who now wears a shiny new badge engraved G3YHB. Jim is now working them instead of just listening, although he confesses to a spot of TVI teething troubles. On 20, he managed—CR6TP, CT2AK, 4X4AS, 7X2AL, 9K2BV; while 15 brought—OD5CX, TJ1AI. All with a PCR3 and a Panda Explorer tx.

**O. Shaw** (Yorks.), AR88D, 180ft. end fed went s.s.b.-ing on 20 for—EA8RCS, HC1SJ, HS1HS, HKØPKS, HK7UL, HZ1AB, IS1LIO, KG6AKR, TF3AP.

**D. Isaac** (S. Wales) is 13 and has a homebrew (good lad) 4-valve (what are they?) superhet. Sixty feet of wire and 20 metres produced—CR61V, EL2E, FR7ZG, HI5PW, HK3VO, KH6AFN, KP4CL, VK2AO, VK3TG, VK5MQ, VK7AZ, VK3RX, VK2AO, VK3TG, VK5MQ, VK7AZ, VK7RX, VO1CX, ZL1AGO, ZL2RC, ZL3QN, ZP5JB, ZS5JY, 3AØCU, 4X4IX, 5Z4KO.

**Robert Dinning** (Ayrshire) sends a 15-metre log plus a photograph of himself and his station (he's got more hair than me!). The line-up is HA350 plus PR3OX plus RQ1OX and a 380ft. long long wire with a Z-match on the end. All s.s.b.—CR6GA, CR7BO, HR1WSG, JX1OM, KZ5BU, MP4TCE, OHØNI, PX1JQ, VK2FU, VK2FA, VQ9GA, ZC4HS, ZD5R, ZE5JU, 9J2GJ, 9M2DQ, W1—WØ, VE1—8.

## TEN METRES

**J. Moore** (Leicestershire) reports great happenings on 10. The log to prove it reads—CR6CA, CR6IS, CR7IC, EP2JP, ET3REL, FG7XX, HK3VA, HK4AZX, HS3DR, JA1NVF, JA1OYT, JA2BVZ, JA3GFO, JA6BEE, K5CNZ/P/YV5, KR6EL, KR6JT, PY2EOQ, TL8GL, VK6KM, VK6NM, VK9BB (New Guinea territory), VS6AA, WA6GZZ/AM, ZS1JC, ZS4AA, 4X4CY, 5A1TA, 5N2AAF, 5N2ABG, 7Z3AB (Saudi Arabia), 9X5AA.

**G. Lawlor** (Ireland) R1155 plus RF24B, 10-metre dipole logged—CR6CA, EP2CF, ET3USA, FG7XT, HS3AL, MP4BHL, OA4OS, PY6WG, SVØWJJ, UH8UU, ZD8JW, ZS5KS, 5A3TX, 5Z4DW, 6W8DY, 7Q7WW, 9H1BN.

**P. Cavill** (Gloucestershire), CR45 plus 65ft. end fed eavesdropped on—CE7DW, CP5ED, CR6CA, EL2BE, HS3DR, KV4AD, OD5AP, PY7EC, SV1AL, VE5CK, W4NMK/MM, YV5CPA, ZD3D, 5A1TK, 5A3TX, 6W8DY, 9H1BG, 9J2DT which is pretty good for a t.r.f.

**R. Pusey** (London, N.2), KW201 and 20ft. whip at 30ft logged this bunch on s.s.b.—CE3RR, CR6CA, HK3VA, HS3DR, JA3JAZ, JA6DCE, KH6GRW/P, KV4AD, KZ5JW, TU2BC, VK4HR, VK6KN, VP2BQ, VP8KD, VQ8CG, VS6AD, VU2DK, VU2OLK, YBØAAC, 8P6AH, 9G1BS, 9J2RV.

## NEWS

Happenings for the month of June include: June 5th—7th, special station from Edinburgh, callsign unknown; 7th—8th, National Field Day (start brushing up on your c.w. now); 22nd, 4-metre portable contest; 29th, Mobile rally at Longleat, near Warminster in Wilts; July 5th—6th, topband contest; 5th—6th, 2-metre contest; 6th, South Shields mobile rally.

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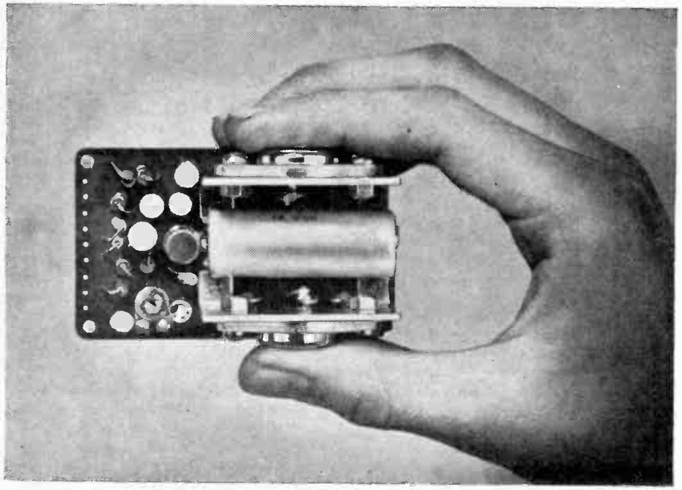

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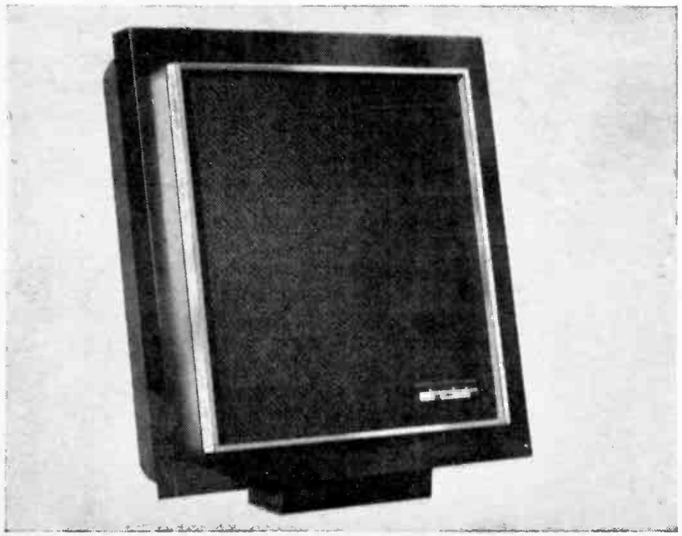
**89/6**



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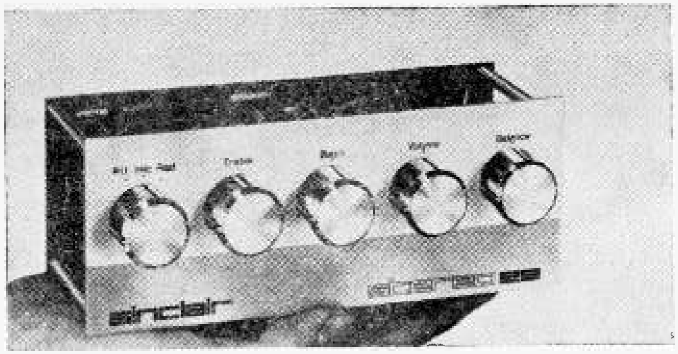

# **Stereo 25** de-luxe pre-amp/control unit

This is a very elegantly styled unit, which, although designed basically for use with the Z.12, is readily adaptable for use with any high quality power amplifier system. The switched input selector allows for Pick-up, Radio and Auxiliary and there are controls for bass cut and lift, treble cut and lift, volume and stereo balance. P.U. input is equalised to R.I.A.A. curve from 50 to 20,000Hz ± 1dB and the instructions manual provided gives matching details for pick-ups, shows how to connect up, etc. The front panel of the Stereo 25 is finished in brushed and polished aluminium embellished in black. The control knobs are in solid aluminium to match. Size $6\frac{1}{2} \times 2\frac{1}{2} \times 2\frac{1}{2}$in. plus knobs. Supplied built, tested and guaranteed.

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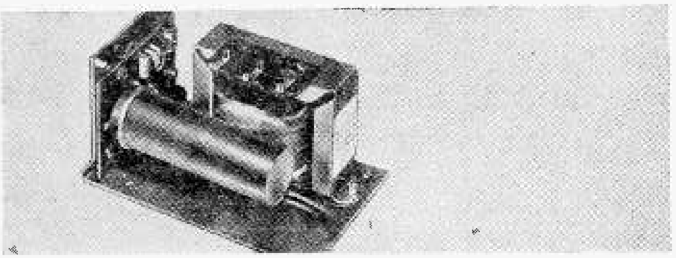

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|---|---|---|---|---|---|---|---|
| 0·25μF | 3 volt | 4μF | 4 volt | 10μF | 25 volt | 64μF | 9 volt |
| 1μF | 6 volt | 4μF | 12 volt | 20μF | 6 volt | 100μF | 9 volt |
| 1μF | 20 volt | 4μF | 25 volt | 25μF | 6 volt | 320μF | 4 volt |
| 1·25μF | 16 volt | 5μF | 6 volt | 25μF | 12 volt | 320μF | 10 volt |
| 2μF | 3 volt | 6μF | 6 volt | 25μF | 25 volt | 400μF | 6·4 volt |
| 2μF | 350 volt | 8μF | 3 volt | 30μF | 6 volt | All at 1/- each. | |
| 2·5μF | 16 volt | 8μF | 12 volt | 30μF | 10 volt | 20 assorted | |
| 3μF | 25 volt | 8μF | 50 volt | 50μF | 6 volt | (our selection) | |
| 3·2μF | 64 volt | 10μF | 6 volt | 64μF | 2·5 volt | 10/- | |

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High stability, carbon film, low noise. Capless construction, molecular termination bonding.

Dimensions (mm.): Body: ¼W; 8 × 2·8
½W; 10 × 4·3
Leads: 35

10% ranges; 10 Ohms to 10 Megohms (E12 Renard Series).
5% ranges; 4·7 Ohms to 1 Megohm (E24 Renard Series).

Prices—per Ohmic value.

| | | each | 10 off | 25 off | 100 off |
|---|---|---|---|---|---|
| ¼W | 10% | 2d. | 1/6 | 3/3 | 10/4 |
| ¼W | 5% | 2½d. | 1/9 | 3/8 | 11/8 |
| ½W | 10% | 2½d. | 1/9 | 3/8 | 11/7 |
| ½W | 5% | 3d. | 2/- | 4/- | 12/10 |

**CAPACITORS**

Subminiature Polyester film, Modular for P.C. mounting. Hard epoxy resin encapsulation. Radial leads.
±10% tolerance. 100 Volt Working.
Prices—per Capacitance value (μF)

| 0·001, 0·002, 0·005, | each | 10 off | 25 off | 100 off |
|---|---|---|---|---|
| 0·01, 0·02 | 6d. | 4/3 | 8/4 | 30/- |
| 0·05 | 8d. | 6/- | 12/6 | 41/8 |
| 0·1 | 10d. | 7/1 | 15/6 | 51/- |
| 0·2 | 1/2 | 10/- | 20/10 | 68/6 |
| 0·5 | 2/- | 17/6 | 37/6 | 125/- |

Polystyrene film, Tubular, Axial leads. Unencapsulated. ±5% or ±1pf tolerance. 160 Volt Working.
Prices—per Capacitance value (μμF)

| 10, 12, 15, 18, 22, 27, 33, | each | 10 off | 25 off | 100 off |
|---|---|---|---|---|
| 39, 47, 56, 68, 82, 100, 120, 180, 220, 270, 330, 390 .. | 5d. | 3/7 | 7/9 | 24/- |
| 470, 560, 680, 820, 1,000, 1,500 .. .. .. .. | 6d. | 4/- | 8/8 | 26/8 |
| 2,200, 3,300, 4,700, 5,600 | 7d. | 5/- | 10/10 | 33/4 |
| 6,800, 8,200, 10,000, 15,000 | 8d. | 6/- | 13/- | 40/- |
| 22,000 .. .. .. .. | 9d. | 6/9 | 18/- | 45/4 |

Polystyrene film, Tubular, Axial leads. Professional Grade. Hard Epoxy Resin encapsulation.
± 1% tolerance. 100 Volt Working.
Prices—per Capacitance value (μμF—except where stated).

| | each | 10 off | 25 off | 100 off |
|---|---|---|---|---|
| 100, 120, 150, 180 .. | 1/3 | 10/2 | 21/2 | 64/6 |
| 220, 270, 330, 390, 470, 560, 680, 820 .. .. | 1/3 | 10/8 | 23/1 | 71/- |
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| 6,800, 8,200, 10,000, 12,000 | 1/9 | 15/2 | 32/10 | 101/- |
| 15,000, 18,000 .. .. | 2/- | 15/11 | 34/9 | 107/4 |
| 22,000, 27,000 .. .. | 2/3 | 17/3 | 37/10 | 115/- |
| 33,000, 39,000 .. .. | 2/6 | 20/1 | 43/6 | 133/9 |
| 47,000, 56,000 .. .. | 2/9 | 22/1 | 47/10 | 147/4 |
| 68,000 .. .. .. | 3/- | 24/9 | 53/8 | 165/4 |
| 82,000 .. .. .. | 3/3 | 26/1 | 56/6 | 173/9 |
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| 0·12 μF .. .. .. | 3/9 | 30/3 | 65/10 | 202/- |
| 0·15 μF .. .. .. | 4/3 | 34/2 | 73/7 | 228/- |
| 0·18 μF .. .. .. | 5/- | 37/10 | 81/11 | 252/3 |
| 0·22 μF .. .. .. | 6/- | 47/- | 101/10 | 313/4 |
| 0·27 μF .. .. .. | 6/9 | 53/9 | 116/8 | 358/4 |
| 0·33 μF .. .. .. | 7/3 | 58/10 | 126/11 | 390/- |
| 0·39 μF .. .. .. | 7/9 | 65/- | 140/10 | 433/4 |
| 0·47 μF, 0·5 μF .. .. | 9/9 | 75/2 | 137/7 | 500/- |

**POTENTIOMETERS (Carbon)**

Superior grade enclosed controls. Low rotational noise. Body Dia. 1 in., Spindle 2in. × ¼in. Tolerance 20%. Linear: 1K to 2M. (¼W. at 40°C.). Logarithmic: 5K to 2M. (⅛W. at 40°C.).

| Prices—per ohmic value | each | 10 off | 25 off | 100 off |
|---|---|---|---|---|
| | 2/- | 16/8 | 37/6 | 133/4 |

**GANGED STEREO POTENTIOMETERS (Carbon)**

¼W at 70°C. Long Spindle.
Logarithmic and Linear: 5k + 5k to 1M + 1M.

| Prices per ohmic value | each | 10 off | 25 off | 100 off |
|---|---|---|---|---|
| | 8/- | 70/- | 162/6 | 575/- |

**SKELETON PRE-SET POTENTIOMETERS (Carbon)**

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.

| Prices—per ohmic value | each | 10 off | 25 off | 100 off |
|---|---|---|---|---|
| Miniature (0·3W) .. .. | 1/- | 8/9 | 18/9 | 66/8 |
| Subminiature (0·1W) .. | 10d. | 7/1 | 14/7 | 46/8 |

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¼in. Type P1. Standard. Screened. Heavily chromed.
¼in. Type SE/P1. Side-entry version of Type P1.
¼in. Type P2. Standard. Unscreened. Unbreakable moulded cover.
¼in. Type P3. Tip-Ring-Sleeve Stereo version of Type P1.
¼in. Type P4. Tip-Ring-Sleeve Stereo version of Type P2.
3·5mm. Type P5. Standard. Screened. Aluminium cover.
3·5mm. Type P6. Standard. Unscreened. Unbreakable moulded cover.

| Prices | each | 10 off | 25 off | 100 off |
|---|---|---|---|---|
| P1 | 3/- | 26/8 | 62/6 | 233/4 |
| SE/P1 | 3/6 | 30/10 | 66/8 | 280/- |
| P2 | 2/6 | 23/4 | 54/2 | 200/- |
| P3 | 6/6 | 60/- | 137/6 | 500/- |
| P4 | 6/2 | 59/6 | 127/6 | 455/- |
| P5 | 2/2 | 19/2 | 43/9 | 158/4 |
| P6 | 1/8 | 15/- | 33/4 | 116/8 |

**JACK SOCKETS**

¼in. Type S3. Stereo version for use with P3 or P4 plugs.
¼in. Type S5. Standard. Moulded body. Chrome insert.
3·5 mm. Type S6. Standard. Moulded body. Chrome insert.
Available with make or break contacts on Tip, Ring and Sleeve.

| Prices | each | 10 off | 25 off | 100 off |
|---|---|---|---|---|
| S3 | 3/3 | 30/- | 68/9 | 250/- |
| S5 | 2/9 | 25/- | 56/8 | 216/8 |
| S6 | 1/6 | 13/4 | 33/4 | 100/- |

**ELECTROLYTIC CAPACITORS (Mullard).** −10% to +50%.

Subminiature (all values in μF)

| | | | | | | |
|---|---|---|---|---|---|---|
| 4V .. .. .. | 8 | 32 | 64 | 125 | 250 | 400 |
| 6·4V .. .. .. | 6·4 | 25 | 50 | 100 | 200 | 320 |
| 10V .. .. .. | 4 | 16 | 32 | 64 | 125 | 200 |
| 16V .. .. .. | 2·5 | 10 | 20 | 40 | 80 | 125 |
| 25V .. .. .. | 1·6 | 6·4 | 12·5 | 25 | 50 | 80 |
| 40V .. .. .. | 1 | 4 | 8 | 16 | 32 | 50 |
| 64V .. .. .. | 0·64 | 2·5 | 5 | 10 | 20 | 32 |
| Price .. .. .. | 1/4 | 1/3 | 1/2 | 1/- | 1/1 | 1/2 |

Small (all values in μF)

| | | | | |
|---|---|---|---|---|
| 4V .. .. .. | 800 | 1,250 | 2,000 | 3,200 |
| 6·4V .. .. .. | 640 | 1,000 | 1,600 | 2,500 |
| 10V .. .. .. | 400 | 640 | 1,000 | 1,600 |
| 16V .. .. .. | 250 | 400 | 640 | 1,000 |
| 25V .. .. .. | 160 | 250 | 400 | 640 |
| 40V .. .. .. | 100 | 160 | 250 | 400 |
| 64V .. .. .. | 64 | 100 | 160 | 250 |
| Price .. .. .. | 1/6 | 2/- | 2/6 | 3/- |

**POLYESTER CAPACITORS (Mullard)**

Tubular 10%, 160V: 0·01, 0·015, 0·022 μF, 7d. 0·033, 0·047 μF, 8d. 0·068, 0·1 μF, 9d. 0·15 μF, 11d. 0·22 μF, 1/-. 0·33 μF, 1/3. 0·47 μF, 1/6. 0·68 μF, 2/3. 1 μF, 2/8.
400V: 1,000, 1,500, 2,200, 3,300, 4,700pF, 6d. 6,800pF, 0·01, 0·015, 0·022 μF, 7d. 0·033 μF, 8d. 0·047 μF, 9d. 0·068, 0·1 μF, 11d. 0·15 μF, 1/2. 0·22 μF, 1/6. 0·33 μF, 2/3. 0·47 μF, 2/8.
Modular, metalised, P.C. mounting, 20%, 250V: 0·01, 0·015, 0·022 μF, 7d. 0·033, 0·047 μF, 8d. 0·068, 0·1 μF, 9d. 0·15 μF, 11d. 0·22 μF, 1/-. 0·33 μF, 1/5. 0·47 μF, 1/8. 0·68 μF, 2/3. 1 μF, 2/9.

**SEMICONDUCTORS:** OA5, OA81, 1/9. OC44, OC45, OC71, OC81, OC81D, OC82D, 2/-. OC70, OC72, 2/3. AC107, OC75, OC170, OC171, 2/6. AF115, AF116, AF117, ACY19, ACY21, 3/3. OC140, 4/3. OC200, 5/-. OC139, 5/3. OC25, 7/-. OC35, 8/-. OC23, OC28, 8/3.

**SILICON RECTIFIERS** (0·5A): 170 P.I.V., 2/9. 400 P.I.V., 3/-. 800 P.I.V., 3/3. 1,250 P.I.V., 3/9. 1,500 P.I.V., 4/-. (0.75A): 200 P.I.V., 1/6. 400 P.I.V., 2/-. 800 P.I.V., 3/3. (6A): 200 P.I.V., 3/-. 400 P.I.V., 4/-. 600 P.I.V., 5/-. 800 P.I.V., 6/-.

**THYRISTORS** (5A): 100 P.I.V., 8/-. 200 P.I.V., 10/-. 400 P.I.V., 15/-

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High quality. Rear tags. Long spindle, ¼in. dia.
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|---|---|---|---|---|
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0·1 Matrix: 3¾in. × 2½in., 4/-. 5in. × 2½in., 4/6. 3¾in. × 3¾in., 4/6. 5in. × 3¾in., 5/3.

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| U11 | 30 | PNP Silicon Planar Transistors TO-5 sim. 2N1132 | 10/- |
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| U17 | 30 | Germanium PNP AF Transistors TO-5 like ACY 17-22 | 10/- |
| U18 | 8 | 6-Amp Silicon Rectifiers BYZ13 Type up to 600 PIV | 10/- |
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| U21 | 30 | A.F. Germanium alloy Transistors 2G300 Series & OC71 | 10/- |
| U22 | 10 | 1-Amp Glass Min. Silicon Rectifiers High Volts | 10/- |
| U23 | 30 | Madt's like MAT Series PNP Transistors | 10/- |
| U24 | 20 | Germanium 1-Amp Rectifiers GJM up to 300 PIV | 10/- |
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| U26 | 30 | Fast Switching Silicon Diodes like IN914 Micro-min | 10/- |
| U28 | | Experimenters' Assortment of Integrated Circuits, untested. Gates, Flip-Flops, Registers, etc. 8 Assorted Pieces | 20/- |
| U29 | 10 | 1 Amp SCR's TO-5 can up to 600 PIV CRS1/25-600 | 20/- |
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| U31 | 20 | Sil. Planar NPN trans. low noise 2N3707 | 10/- |
| U32 | 25 | Zener diodes 400mW DO-7 case mixed Vlts. 3-18 | 10/- |
| U33 | 15 | Plastic case 1 Amp silicon rectifiers W4000 series | 10/- |

Code Nos. mentioned above are given as a guide to the type of device in the Pak. The devices themselves are normally unmarked

## FULLY TESTED

| | |
|---|---|
| AC107 | 3/6 |
| AC126-7-8 | 2/6 |
| AF116-117 | 3/6 |
| AF139 | 10/- |
| AL102 | 15/- |
| BC107-8-9 | 5/- |
| BFY50-51-52 | 7/6 |
| BSY26-7 | 3/6 |
| BSY28-9 | 4/6 |
| BSY95-95A | 4/6 |
| OC22-25 | 5/- |
| OC26-35 | 5/- |
| OC28-29 | 7/6 |
| OC44-45 | 1/9 |
| OC71-81 | 1/6 |
| OC72-75 | 2/6 |
| OC81D-82D | 2/3 |
| OC82 | 2/6 |
| OC140 | 5/- |
| OC170 | 2/6 |
| OC171 | 3/6 |
| OC201 | 7/6 |
| ORP12-60 | 8/6 |
| OCP71 | 8/6 |
| OA5-10 | 1/9 |
| OA47 | 2/- |
| OA70 | 1/3 |
| OA79 | 1/9 |
| OA81-85 | 1/6 |
| OA91 | 1/3 |
| OA95 | 1/9 |
| OA200 | 3/- |
| OA202 | 3/6 |
| 2N696-7 | 5/- |
| 2N706 | 3/6 |
| 2N708 | 5/- |
| 2N2160 | 15/- |
| 2N2646 | 15/- |
| 2N2712 | 5/6 |
| 2N2926 | 2/6 |
| MAT100-101 | 3/- |
| MAT120-121 | 3/6 |
| ST140 | 3/- |
| ST141 | 4/- |

## SIL. RECTS TESTED

| PIV | 750mA | 3A | 10A | 30A |
|---|---|---|---|---|
| 50 | 1/- | 2/9 | 4/3 | 9/6 |
| 100 | 1/3 | 3/3 | 4/6 | 15/- |
| 200 | 1/9 | 4/- | 4/9 | 20/- |
| 300 | 2/3 | 4/6 | 6/6 | 22/- |
| 400 | 2/6 | 5/6 | 7/6 | 25/- |
| 500 | 3/- | 6/- | 8/6 | 30/- |
| 600 | 3/3 | 6/9 | 9/- | 37/- |
| 800 | 3/6 | 7/6 | 11/- | 40/- |
| 1000 | 5/- | 9/3 | 12/6 | 50/- |
| 1200 | 6/6 | 11/6 | 15/- | — |

## TESTED SCR's

| PIV | 1 AMP | 7A | 16A | 30A |
|---|---|---|---|---|
| 25 | — | 7/6 | — | 30/- |
| 50 | 7/6 | 8/6 | 10/6 | 35/- |
| 100 | 8/6 | 10/- | 15/- | 45/- |
| 200 | 12/6 | 15/- | 20/- | 55/- |
| 300 | 15/- | 20/- | 25/- | — |
| 400 | 17/6 | 25/- | 35/- | 80/- |
| 500 | 30/- | 40/- | 45/- | 95/- |
| 600 | — | 40/- | 50/- | — |

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|---|---|
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28O34 ........ 15/- ea.

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Mullard I.C. Amplifiers

| | |
|---|---|
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| TAA293 G.P. Amp | 26/- |
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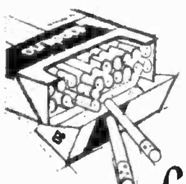

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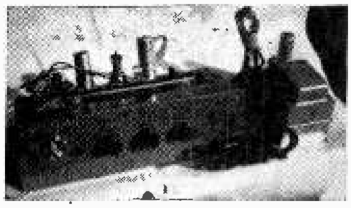

Chassis 12½ x 5½ x 4½in. high. Front panel alum and black—12½ x 4½in. 200–250 A.C. Mains Trans. Off/On-Tone; Vol./Mic.; Vol./Gram.; Mic. Input; Gram. Input; Monitor; Valves 6BR7, ECC83, EM84, EL84 and Rect. 2 Track £10.10.0; 4 Track £12 (12/6 p. & p.). Ready for bolting direct to Magnavox deck.

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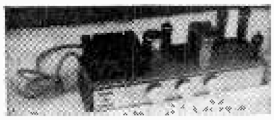
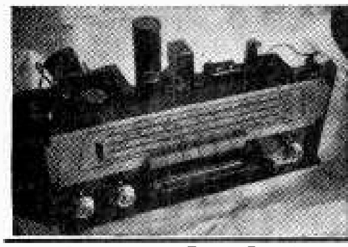


## 6 PUSH-BUTTON STEREOGRAM CHASSIS



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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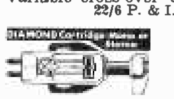

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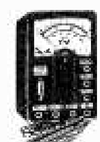

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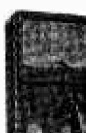

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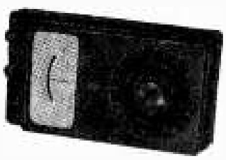

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