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# Lasky's Radio

LASKY'S RADIO ESTABLISHED OVER 36 YEARS

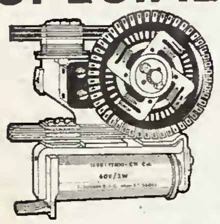
## TCC G-1120

### HEADPHONE/BOOM MICROPHONE SET

This lightweight headphone and boom microphone assembly is especially suitable for TV camera crews, communications equipment, language labs., recording studios, etc. The fully adjustable headset is extremely comfortable to wear for long periods. Low impedance microphone allows long cables to be used without any signal loss. Used with a Tape Recorder this assembly will provide constant monitoring. High quality specification and superb finish at a price you can afford.
Headset spec.: Dynamic, impedance 16 ohms. Frequency res. 20-14-1000Hz. Input 200mW. Cord length 59in with jack plug fitted. Mic. spec:. Dynamic, impedance 200 ohms. Frequency res. 200-8000Hz, sensitivity 75dB. Cord length 69in complete with jack plug.

**LASKY'S PRICE £6.5.0** Post 2/6

## SPECIALIST RELAYS

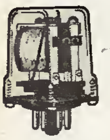


### SCHRACK 4 POLE 12 WAY

This stepping relay inches one step per pulse of the coil, contacts are provided for continuous stepping and 2 pole changeover at position "6" Uses include programming Christmas tree lights, selection of stations on multiway intercom systems (using standard 2 way intercoms), Servo steering of radio control models. Automatic operation of model railways, etc.

Type RT 319600 60V - 2W coil **OR** Type RT 319120 12V - 2W coil

**LASKY'S PRICE 59/6 each** Post 2/6



### THORN PYGMY PLUG-IN RELAY

A miniature 8 pin plug-in relay with 10A double changeover configuration. Mains operated coil switched for internal powered remote mains switching, using one contact as a latch to hold the relay in until the external circuit is broken. Coil resistance 82K/ohms, 200-240V AC/DC operation.

**LASKY'S PRICE 12/6** Post 2/6

### AEI MINIATURE RELAY

A miniature shrouded 3 pole "make" relay of the chassis mounting type. DC coil resistance 900 Ω 24V operation. Useful for remote Audio switching circuits, control systems, using low voltage and current, controlling small D.C. motors and pilot lights, etc., and any application switching three circuits from one switch.

**LASKY'S PRICE 8/6** Post 1/6

### AD-76K MOVING MAGNET CARTRIDGE

New high compliance moving magnet stereo cartridge that really breaks the quality/price barrier. SPECIFICATION: Diamond Stereo LP stylus. Compliance $10 \times 10^{-6}$cm/dyne. Frequency response 20-20,000c/s. Channel separation 20dB. Output 5mV. Tracking pressure 2 grammes. Standard ½in mounting. Replacement Diamond stylus available. Fully guaranteed.

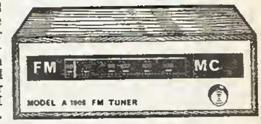
**LASKY'S PRICE 90/-** Post 2/-

## FANTAVOX 500 12W STEREO AMPLIFIER

This outstanding amplifier incorporates all the features expected of an expensive unit but at a budget price. The amplifier has separate tone and volume controls for both channels plus stero mono switch and tuner output socket. Finished in an attractive walnut grained metal cabinet with anodised pale gold metal front panel. Brief spec: 12 transistors, 2 silicon diodes. Output, Peak power 12 watts (6 watts per channel). Freq. Response: 40-20,000 Hz, Output impedance 4-16 ohms. Input sensitivity. Phono/Tuner 250mV. Size: 9½ × 3¼ × 5¾in.

**LASKY'S PRICE £12.10.0** Post 5/-

## NEW TTC Model A-1008 BUDGET FM TUNER



For size, quality and price we feel sure the Model A-1008 FM Tuner is unbeatable. Probably the world's most compact FM tuner with 6 transistor and 3 diode printed circuit, self powered—operating from any 9V D.C. source. Slow motion tuning drive. Housed in beautifully finished walnut cabinet with classic silver trim. Clear horizontal tuning scale covering the entire FM band 88-108 Mc/s. Complete with FM aerial. Brief Spec.: aerial imp. 75 ohms. Sensitivity better than 10uV (at 100% modulation for 20dB S/W). Size 7½ × 5 × 3¼in.

**LASKY'S PRICE £9.19.6** Post 3/6

### ADD MULTIPLEX TO THE MODEL A-1008

You can enjoy stereo sound with the Model A-1008 FM Tuner above by adding the TTC Model A-1005M Multiplex Adaptor. Brief Specification: MPX input sensitivity 100mv. Output 150mV. Self powered by a 9V battery. 4 transistor and 6 diode circuit. Size 5¼ × 2 × ¾in. Also suitable for use with other FM tuners with MPX input.

**LASKY'S PRICE 99/6** Post 3/6

### NEW INTERNATIONAL TAPE

FAMOUS AMERICAN MADE BRAND TAPE at RECORD LOW PRICES

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|---|---|---|---|
| 3in. Message tape, 150ft. | 2 6 | 5¾in. Standard play, 850ft. PVC | 11 6 |
| 3in. Message tape, 225ft. | 3 9 | 5¾in. Long play, 1200ft. Mylar | 15 0 |
| 3in. Message tape, 300ft. | 7 6 | 5¾in. Triple play, 2400ft. Mylar | 45 0 |
| 3¼in. Triple play, 600ft. Mylar | 10 0 | 7in. Standard play, 1200ft. Acetate | 12 6 |
| 4in. Triple play, 900ft. Mylar | 17 6 | 7in. Standard play, 1200ft. Mylar | 12 6 |
| 5in. Double play, 1200ft. Mylar | 15 0 | 7in. Long play, 1800ft. Mylar | 19 6 |
| 5in. Long play, 900ft. Acetate | 10 0 | 7in. Double play, 2400ft. Mylar | 25 0 |
| 5in. Standard play, 600ft. PVC | 8 6 | 7in. Long play, 1800ft. Acetate | 15 0 |
| 5in. Triple play, 1800ft. Mylar | 35 0 | 7in. Triple play, 3600ft. Mylar | 50 0 |
| 5¾in. Double play, 1800ft Mylar | 22 6 | | |
| 5¾in. Long play, 1200ft. Acetate | 12 6 | | |

P. & P. 1/- extra per reel. 4 reels and over Post Free. Special quotes for quantities.

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The Dulci range of tuners and amplifiers offer exceptional quality at a sensible price.
**Amplifiers:** 207 and 207M. **Tuners:** FMT7 and FMT7s.
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**Sonotone** 9TA and 9TA/HC. Diamond Cartridge brand new, boxed in manufacturers' carton **49/6** plus 2/6 p/p. **Acos** GP 91-1 and GP 91-3 stereo compatible cartridges, new in sealed manufacturers' cartons **22/6** plus 2/6 p/p.

**TRIO Stereo Moving Magnet Cartridge Model AD76K.** Diamond Stereo LP Stylus. Frequency response 20-20,000c/s output. 7mV tracking pressure 2 grammes ± 0·5 grm. Fully guaranteed. Price 85/- p/p free.

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| 5in | 600ft. **14/-** | 900ft. **19/-** | 1200ft. **30/-** |
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● **Bargain—Changer decks at lowest prices ever**

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|---|---|---|
| Beautiful teak plinth and | 1025 | **£8.0.0** |
| perspex | 2025 | **£8.10.6** |
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| 2N687 | 300 | 16 | 25/6 |
| 2N688 | 400 | 16 | 32/6 |
| 2N689 | 500 | 16 | 47/6 |
| 2N690 | 600 | 16 | 50/- |
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| 2N692 | 800 | 16 | 62/- |

**1/- each TESTED TRANSISTORS 1/- each**
**ONE PRICE ONLY PNP. NPN. SILICON PLANAR 1/- EACH**

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| BC108 | 2N696 | 2N1132 | 2N2220 | 2S733 |
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| BFY50 | 2N706 | 2N1711 | 2N3711 | TIS44 |
| BFY51 | 2N708 | 2N2904 | 2S102 | 2N2906 |
| BFX84 | 2N929 | 2N2905 | 2S103 | 2N2907 |
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| AC127 | ACY28 | NKT142 | NKT773 | 2G301 | 2G399A |
| AC128 | ACY29 | NKT212 | OC44 | 2G302 | |
| AC130 | ACY30 | NKT213 | OC45 | 2G303 | |
| ACY19 | ACY31 | NKT214 | OC71 | 2G308 | 1/6 |
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**Sub-Min. Plastic 1 Amp Sil. Rect.**

| Type No. | PIV | Each |
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| 1N4004 | 400 | 2/9 |
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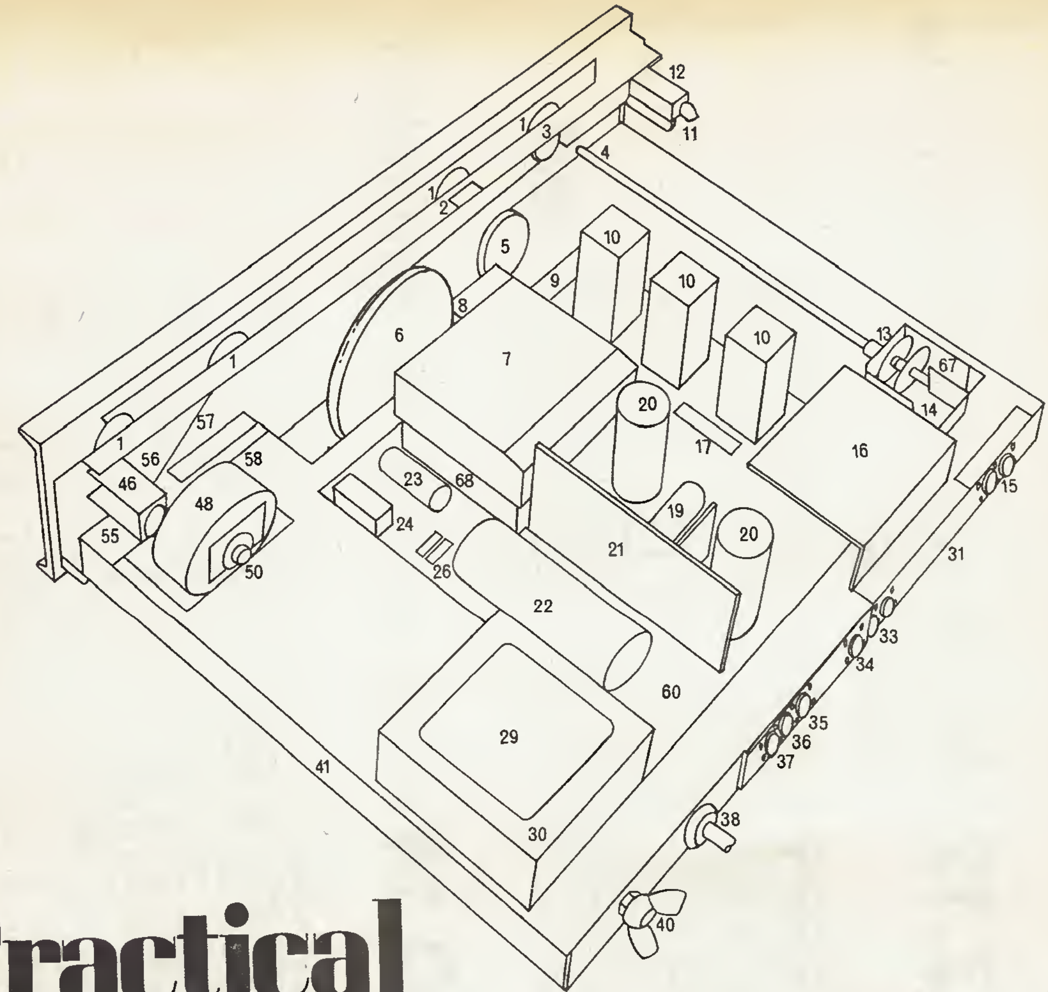
**Vast mixed lot of subminiature glass diodes. Comprising of Silicon, Germ., Point Contact and Gold Bonded types plus some Zeners.** 500,000 available at Lowest of Low Price. 1,000 pieces **£3.0.0.** 5,000 pieces **£13.10.0.** 10,000 pieces **£23.**

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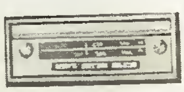
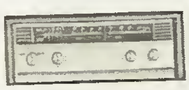


**CR-1** Car Radio



**AR-27** FM Monophonic Receiver

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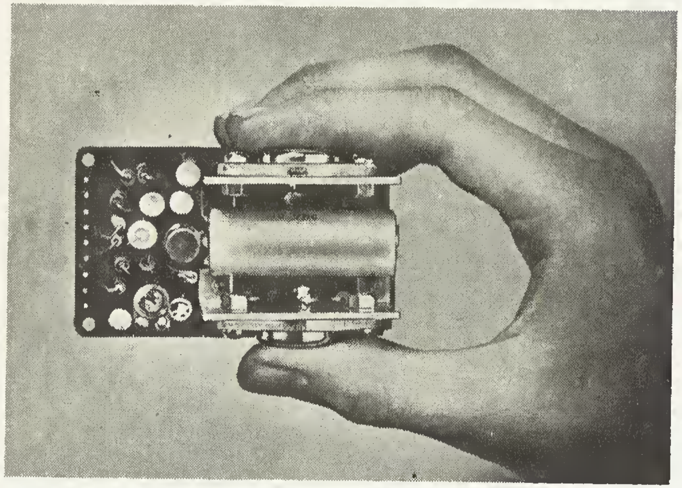
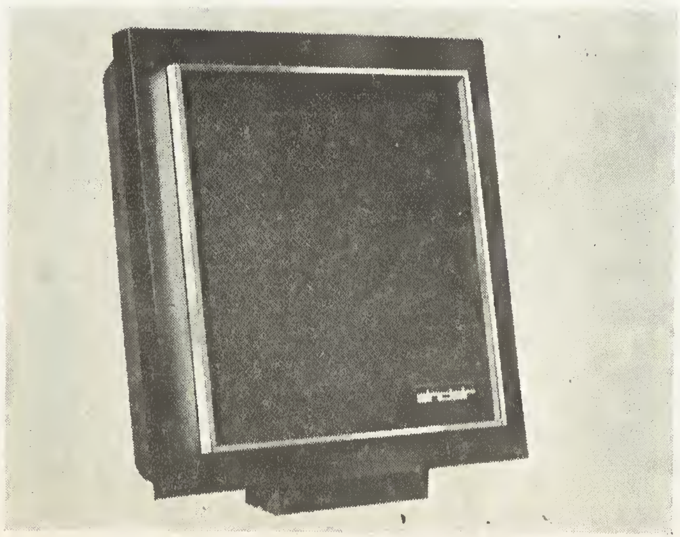


# Z.12 - for all you want from any amplifier

The Z.12 is a most versatile integrated amplifier and pre-amp in which power, compactness and true high-fidelity standards are combined within a unit of very modest price. The most widely used unit of its kind in the world, the Z.12 has an output of 12W R.M.S. continuous sine wave (24W peak) or 15W music power (30W speak). It has Class B ultralinear output which can be fed into any loudspeaker from 3 to 15 ohms. (Two 3 ohm speakers can be used in parallel.) Frequency response—15 to 50,000Hz ± 1dB; input sensitivity—2mV into 2 K/ohms. The Z.12 will operate from any power source between 6 and 20V d.c. As such, a car battery or the PZ.4 are eminently suitable, giving much wider than usual scope in the applications to which the Z.12 may be put. As well as hi-fi, these include systems for P.A. electronic guitars, organs, intercom systems, laboratory, education or industry. You will find the Z.12 in use in such instances again and again. The Sinclair Z.12 is supplied ready built, tested and guaranteed, complete with manual of circuits and instructions for matching it to your precise requirements. Two may be used in stereo when, with the Stereo 25 and PZ.4 together with two Q.14s, you will have an ideal high fidelity assembly.

**89/6**

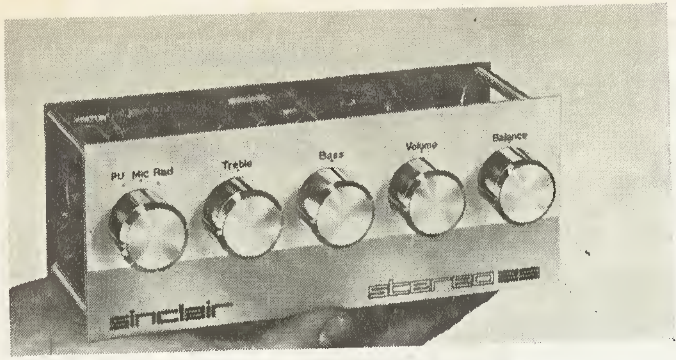



# Q.14 - the unique loudspeaker

New materials and original design techniques have been used to produce speaker of fantastic quality at a most attractive price. Experts and reviewers have enthusiastically endorsed its performance. The shape and size of the Q.14 make it far more adaptable to its environment than is the case with conventionally styled speakers so that it is much easier to position this speaker in the room in which it is to be heard. The Sinclair Q.14 has a substantially flat frequency response from 60 to 16,000Hz and outstandingly good transient response. It will comfortably handle up to 14W loading and is positively brilliant in stereo. Measuring 9¾in square by 4¾in deep, this loudspeaker is finished in matt black with solid aluminium bar trim.

Try the Q.14 in your own home without delay. If you are not delighted with it, your money including cost of return postage to Sinclair will be refunded immediately.

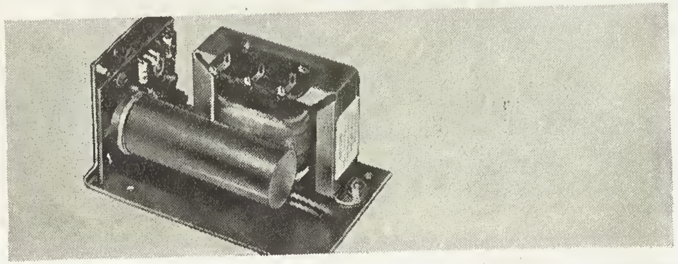
**£7.19.6**




# 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 6½ × 2½ × 2½in plus knobs. Supplied built, tested and guaranteed.

**£9.19.6**



# PZ.4 - stabilised power supply unit

Designed specially to meet the power requirements for an assembly of two Z.12s and the Stereo 25, this heavy duty transistorized power supply unit has stabilised output of 18V d.c. at up to 1·5A. It is for a.c. mains operation 200/250V.

Supplied built, tested and guaranteed.

**99/6**


# SINCLAIR MICROMATIC

Whether you buy your Micromatic in kit form or built ready for use, you must not deny yourself the thrill of owning this fantastically small British receiver. Smaller than a matchbox, it has power, range and selectivity that must be experienced to be believed. The high quality magnetic earpiece supplied with the set ensures excellent reproduction indoors and out. The Micromatic tunes over the medium waveband and has A.G.C. to counteract fading from distant stations. Bandpass tuning makes reception of Radio 1 easier; in fact you will find this set performing in some cases where other sets cannot be heard at all. The Micromatic is housed in a neat black case given an elegantly modern appearance by the attractive aluminium front panel and matching tuning control.

*Kit in fitted pack with magnetic earpiece, instructions and free solder*

**49/6**

*Built, tested and guaranteed, inc. magnetic earpiece*

**59/6**

Mallor Mercury Cell type RM.675 (2 required) 2/9 each

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PE.569

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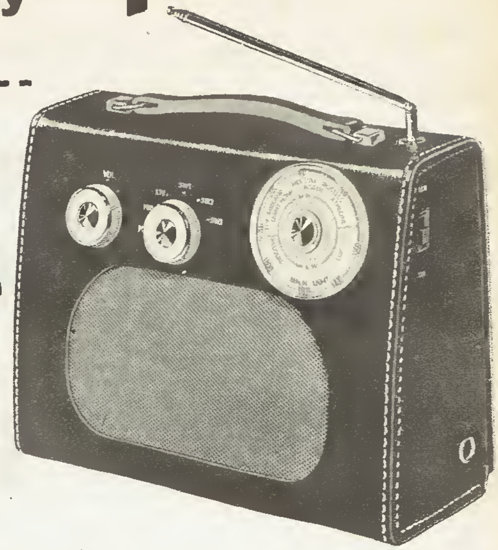
# backed by our after sales service!



## roamer seven mk iv

**SEVEN WAVEBAND PORTABLE**

SEVEN TUNABLE WAVEBANDS—
MW1, MW2, LW, SW1, SW2, SW3 AND TRAWLER BAND.

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

**Total building costs**

**£5.19.6** P. & P. 7/6

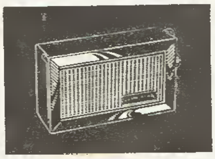
Personal Earpiece with switched socket for private listening 5/- extra.

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

## pocket five

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

Attractive black and gold case. Size 5½ × 1½ × 3¼in. Tunable over both Medium and Long Waves with extended M.W. band for easier tuning of Luxembourg, etc. All first grade components—7 stages—5 transistors and 2 diodes, supersensitive ferrite rod aerial, fine tone moving coil speaker, also Personal Earpiece with switched socket for private listening. Easy build plans and parts price list, 1/6 (FREE with parts).



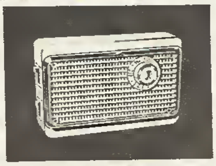
**Total building costs**

**44/6** P. & P. 3/6

## transona five

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

Attractive case with red speaker grille. Size 6½ × 4¾ × 1½in. 7 stages—5 transistors and 2 diodes, ferrite rod aerial, tuning condenser, volume control, fine tone moving coil speaker also Personal Earpiece with switched socket for private listening. All first grade components. Easy build plans and parts price list 1/6 (FREE with parts).



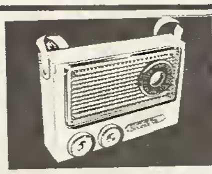
**Total building costs**

**47/6** P. & P. 3/9

## super seven

**THREE WAVEBAND PORTABLE WITH 3in. SPEAKER**

Attractive case size 7½ × 5½ × 1¾in. with gilt fittings. The ideal radio for home, or outdoors. Covers Medium and Long Waves and Trawler Band. Special circuit incorporating 2 R.F. Stages, push pull output, ferrite rod aerial, 7 transistors and 2 diodes, 3in. speaker (will drive larger speaker) and all first grade components. Easy build plans and parts. Price list 2/- (FREE with parts). (Personal Earpiece with switched socket for private listening 5/- extra.)



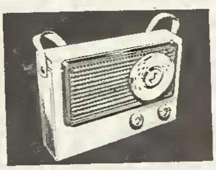
**Total building costs**

**69/6** P. &. P. 4/6

## roamer six

**SIX WAVEBAND PORTABLE WITH 3in. SPEAKER**

Attractive case with gilt fittings, size 7½ × 5½ × 1¾in. Tunable on Medium and Long waves, two short waves, Trawler band plus an extra M.W. band for easier tuning of Luxembourg, etc. Sensitive ferrite rod aerial and telescopic aerial for Short waves. All top grade components. 8 stages—6 transistors and 2 diodes including Micro-Alloy R.F. Transistors, etc. (Carrying strap 1/6 extra.) Easy build plans and parts price list 2/- (FREE with parts). (Personal Earpiece with switch socket for private listening 5/- extra.)



**Total building costs**

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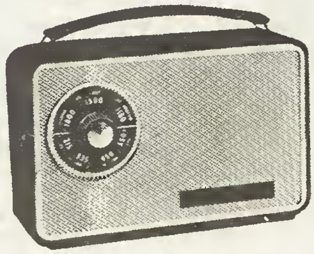

8 stages—6 transistors and 2 diodes. Covers Medium and Long Waves. Top quality 3½in. Loudspeaker for quality output and also with Personal Earpiece with switched socket for private listening. Two R.F. Stages for extra boost. High "Q". Ferrite Rod Aerial. Push-pull output. Handsome pocket size case with gilt fittings. Size 6½ × 4 × 2in. Easy build plans and parts price list 2/- (FREE with parts).

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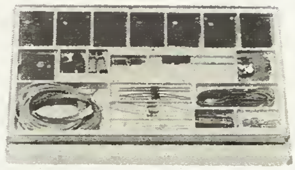

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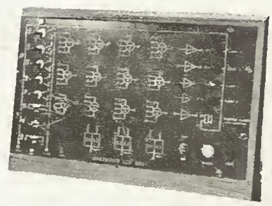

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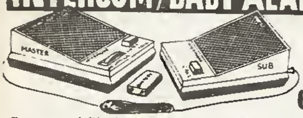


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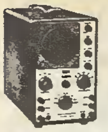

3in. tube. Y amp. Sensitivity ·1v p-p/CM. Bandwidth 1·5 cps–1·5 MHZ. Input imp. 2 meg Ω 25 PF. X amp. sensitivity. ·9v p-p/CM. bandwidth 1·5 cps–800 KHZ. Input imp. 2 meg Ω 20 PF. Time base. 5 ranges 10 cps–300 KHZ. Synchronization. Internal/external. Illuminated scale 140 × 215 × 330 MM. Weight 15½lb. 220/240 V. A.C. Supplied brand new with handbook. £35.0.0. Carr. 10/-.

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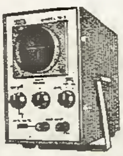

A general purpose low cost economy oscilloscope for everyday use. Y amp. Bandwidth 2 CPS–1 MHZ. Input imp. 2 meg Ω 25 P.F. Illuminated scale. 2in tube. 115 × 180 × 230mm. Weight 8lb. 220/240V a.c. Supplied brand new with handbook £22.10.0. Carr. 10/-.

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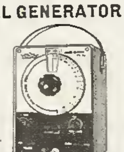

Sine Wave 20c/s to 200kc/s. Square Wave 20c/s to 30kc/s. High and low impedance output. Output variable up to 6 volts. 220/240 volts a.c. Size 210 × 150 × 120mm. Brand new with instructions. £16. Carr. 7/6.

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2pF-2,000 mfd 2 ohms-200 megohms. Also checks impedance, turns ratio, insulation, 200/250V a.c.

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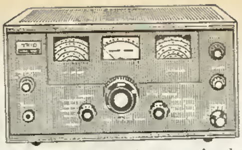

4 band receiver covering 550Kc/s to 30Mc/s. continuous and electrical bandspread on 10, 15, 20, 40 and 80 metres. 8 valve plus 7 diode circuit. 4/8 ohm output and phone jack. SSB-CW ● ANL ● Variable BFO ● S meter ● Sep. bandspread dial ● 1F 445Kc/s ● Audio output 1·5W. ● Variable RF and AF gain controls. 115/250V A.C. Mains. Beautifully designed. Size: 7 × 15 × 10in. With instruction manual and service data. £39.15.0. carriage paid.
**TRIO COMMUNICATION TYPE HEADPHONES.** Normally £5.19.6.
**OUR PRICE £3.15.0** if purchased with above receiver.

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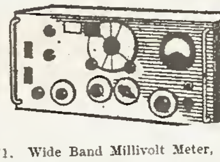

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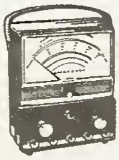

6in. full view meter. 2 colour scale, overload protection. 0/2·5/10/250/1,000/5,000V a.c. 0 / 25 / 12·5 / 10 / 50 / 250 / 1,000 / 5,000V d.c. 0 / 50μA / 110 / 100 / 500mA 10A d.c. 20K / 200K / 20 MΩ. £15. P. & P. 5/-.

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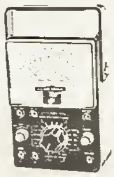
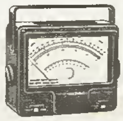


5in. mirror scale. Built-in meter protection. 0 / 3 / 12 / 60 / 120 / 300 / 600 / 1,200V d.c. 0/6/30/120/300/600V a.c. 0/10μA/6/60/300MA/12 Amp. 0/2K / 200K / 2M / 200MΩ. —20 to +17dB. £12.10.0. P. & P. 3 6.

### LAFAYETTE 57 Range Super 50,000 O.P.V. Multimeter.



D.c. Volts 125V-1,000V A.c. Volts 1·5V-1,000V D c. Current 25μA-10 Amp. Ohms. 0·15 Meg Ω dB.—20 to +81dB. Overload Protection. £12.10.0. Carr. 3/6.

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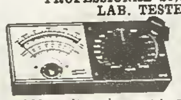
### PROFESSIONAL 20,000 O.P.V. LAB. TESTER



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.

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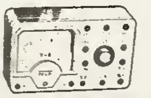

1,000 O.P.V.0/10/50 / 250 / 500 / 1,000V a.c. and d.c. 0/1/100/500 mA d.c. 0/100 KΩ 39/6. P. & P. 1/6.

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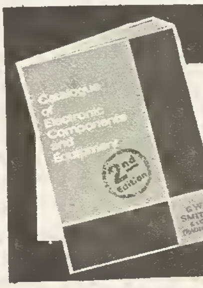


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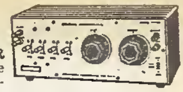

Variable range 0–111dB. Connections. Unbalanced T and Bridge T. Impedance 600Ω range (0·1dB × 10) + (1dB × 10) +10 + 20 + 30 + 40dB. Frequency: d.c. to 200kHz (—3dB). Accuracy: 0·05dB. +indication dB × 0·01. Maximum input less than 4W (50V). Built in 600Ω load resistance with internal/external switch.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

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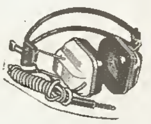

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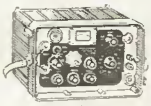

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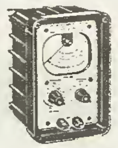

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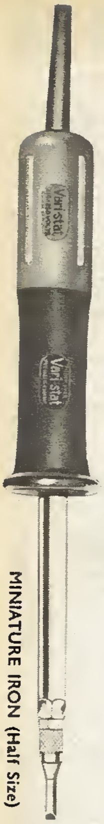

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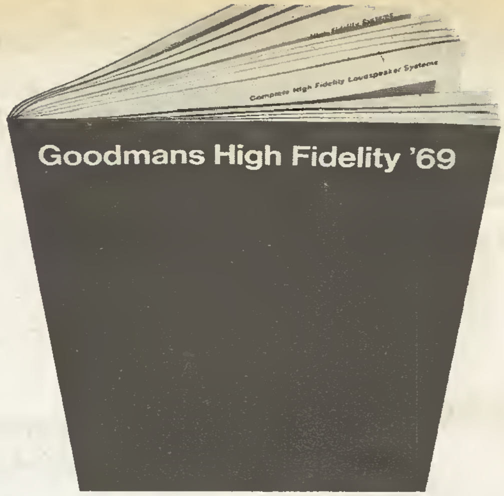


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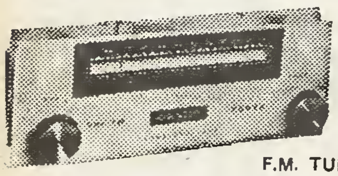

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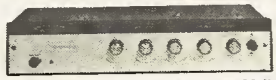

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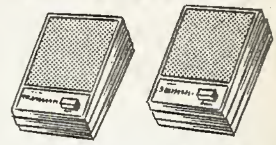

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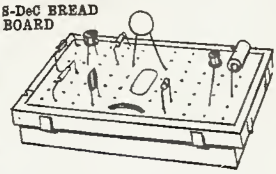

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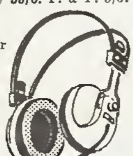

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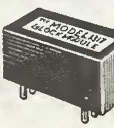

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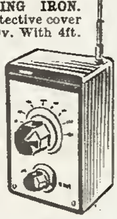

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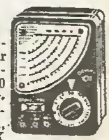

DC voltage: 5-25-50-250-500-2·5K (20,000 ohms per volt). AC Voltage: 10-50-100-500-1000 volts (10,000 ohms per volt). DC Current: 0-50μA, 0-2·5mA, 0-250mA. Resistance: 0-6K, 0-6Mg (300 ohm and 30K at centre scale.) Capacitance: 10pf. to ·001 mfd, ·001μf to ·1μf. Decibels: —20 to +22dB. Size 4½×3¼×1in. Complete with case 77/–. P. & P. 3/6.

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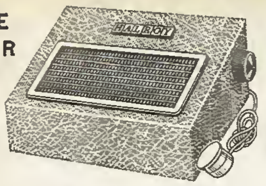

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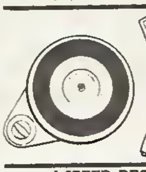
Circuit diagram, construction details and parts list (free with kit) 1/6. (S.A.E.).



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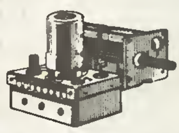

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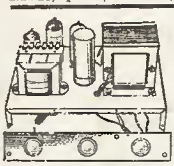

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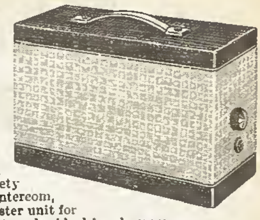

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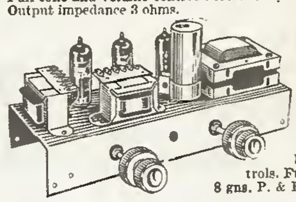

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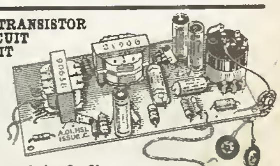
**HIGH GAIN 4 TRANSISTOR PRINTED CIRCUIT AMPLIFIER KIT**
Type TA1



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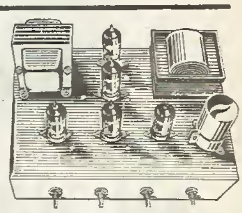

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VOL. 5 No. 5
May 1969

# PRACTICAL ELECTRONICS

## SOUND ECONOMICS

THANKS to advances in audio engineering and the availability of quality sound reproduction systems, listening to music has become a popular but highly civilised form of home entertainment. With this widespread appreciation of good music it is not surprising that many non-musicians feel the urge to become music makers themselves and thus extract the ultimate of pleasure this art can offer. In looking for the ideal instrument many turn to the electric organ. Certainly this offers a source of limitless pleasure to performer and listener alike with its flexibility in tonal expression and wide dynamic range.

Electronic organs of musical compass to satisfy the most fastidious of organists, while sufficiently compact in physical form to be compatible with the average home, can be purchased. There is a healthy business in this market, yet because the price of these instruments is comparable with the cost of a family car, such organs are a luxury beyond the reach of countless would-be music makers.

Realisation of this hard ecomonic fact has spurred on many intrepid enthusiasts to the formidable task of designing and building an organ for themselves. It is also abundantly clear that there exists an even greater number of music lovers who would like to build an organ, but who do not wish (or perhaps are not able) to indulge in protracted experiments with circuits and systems.

An organ is a far from standardised instrument. The musical compass can be wide or limited, the voices can be arranged to suit classical works or lighter romantic music, and various musical effects may be included or excluded, according to individual preference. When considering a design for publication, many aspects had to be taken into account in order to satisfy the widest number of potential constructors. Investigations made by the designer of the Practical Electronics Organ showed that the romantic sound characteristic of the theatre organ would be the more generally preferred sound amongst amateur organists: so this kind of voicing has been adopted.

This decision almost automatically solved another major question which always has to be faced when drawing up an organ design, i.e. the type of tone generators to be employed. Divergent views are heard on this subject. There are, for example, those who claim that only the free phase oscillator is satisfactory; this is undoubtedly true if the intention is to synthesise closely the characteristic sound of a pipe organ. For technical and economic reasons, the frequency divider method has much to commend it, although it produces an "electronic" sound which some purists amongst organists might object to. But this method lends itself admirably to the romantic type of organ, so it is used in this present design.

F. E. Bennett—*Editor*

## THIS MONTH

### CONSTRUCTIONAL PROJECTS



### SPECIAL SERIES



### GENERAL FEATURES



### NEWS AND COMMENT



***Our June issue will be published on Thursday, May 15***

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# INFRA-RED

By D. BOLLEN

PERHAPS the most efficient and versatile method of detecting the presence of a burglar is by means of an invisible beam of light, positioned in such a way that the intruder must interrupt the beam to gain entry.

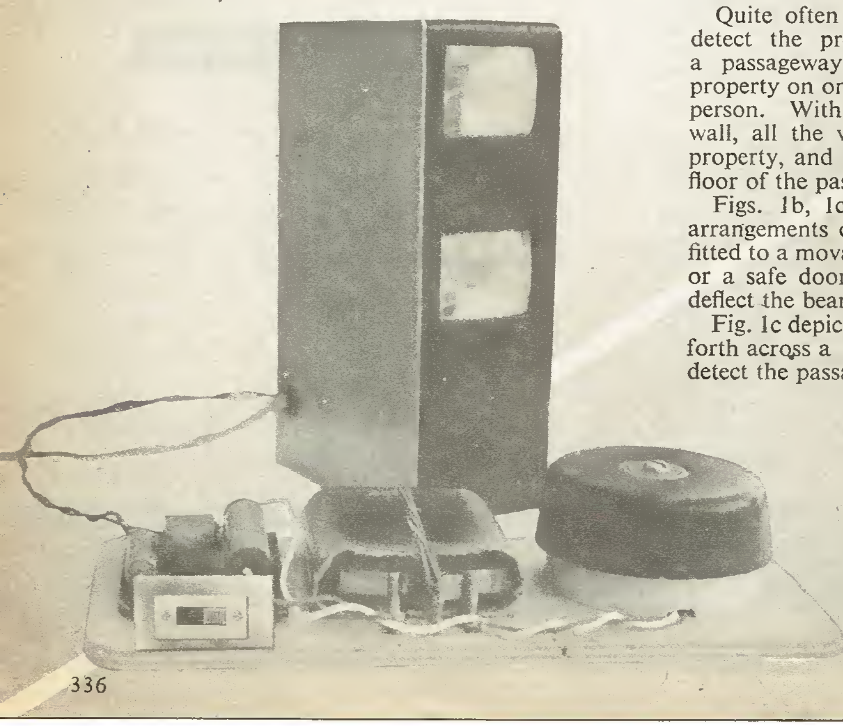
Unfortunately, the modern criminal comes equipped with tools and considerable know-how. He may be able to nullify the alarm before it can give a warning. To be completely effective, an infra-red alarm system must be fail-safe, and proof against knowledgeable tampering. The equipment described here has several novel features, and is designed to combat the efforts of an astute burglar.

## DESIGN PRINCIPLES

A light bulb is powered from a 50Hz supply giving rise to modulated light at a frequency of 100Hz, because the bulb is switched off twice per cycle and will glow on both negative and positive waveform peaks. When the light bulb is small, and its filament has a short thermal delay, the modulated light output at 100Hz will have a useful amplitude.

Conventional a.c. methods can be employed to detect and amplify the light signal from the bulb at a distance somewhat greater than can be achieved using d.c. amplification of a steady light signal.

With modulated light, a long beam path is obtainable; typically 150 feet.



A tungsten filament bulb will radiate about 75 per cent of its input energy in the infra-red region of the frequency spectrum; only some 6 per cent will appear as visible light. If a gelatine filter, with good infra-red acceptance properties, is used to block the visible light output from the bulb, there will be very little attenuation of the effective infra-red output.

The same applies when a germanium photo-detector—such as the OCP71, which has a peak response at 1·55 microns—well inside the infra-red region—is arranged to pick up the filtered light from the bulb. The effect of removing the visible light from the beam will be insignificant and there will be virtually no loss of efficiency.

It is usual to employ three units in an infra-red alarm system; a bulb and lens unit to project a narrow beam of light, a photo-detector and amplifier head mounted opposite the projector, and a remote electric bell.

This design, however, combines projector and amplifier into one unit, the beam of light being reflected back to the detector by a small mirror, or collection of mirrors (see Fig. 1a). Note that the beam length is doubled when a mirror is used, and this is where the high sensitivity of a modulated light beam system comes in useful.

## PRACTICAL DETAILS

Quite often an infra-red alarm unit is required to detect the presence of an intruder passing along a passageway between two buildings, where the property on one side of the passage belongs to another person. With a small mirror mounted on the opposite wall, all the wiring can be confined to the owner's property, and there is no need to run wires under the floor of the passageway.

Figs. 1b, 1c, and 1d show how alternative mirror arrangements can operate. In Fig. 1b the mirror is fitted to a movable object, which could be a money box or a safe door. The slightest mirror movement will deflect the beam and sound the alarm.

Fig. 1c depicts a method of lacing the beam back and forth across a doorway, for added protection and to detect the passage of small objects.

# BURGLAR ALARM

In Fig. 1d an area is enclosed by the beam, for instance a room with several doors and windows. Entry of an intruder through any door or window would interrupt the beam and trigger the alarm.

The lamp and amplifier must be mains powered if they are to operate continuously for long periods, but provision should be made for sounding the alarm in the event of a supply failure. The bell is therefore furnished with its own battery, and the latching relay is mounted close to the bell.

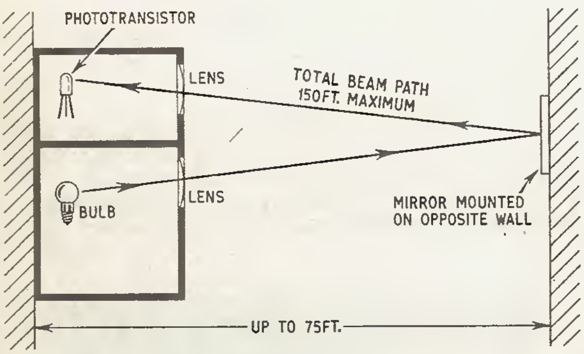



*Fig. 1a. Principle of operation of the infra-red alarm*

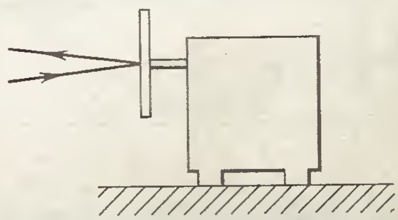


*Fig. 1b. Mirror mounted on moveable object*

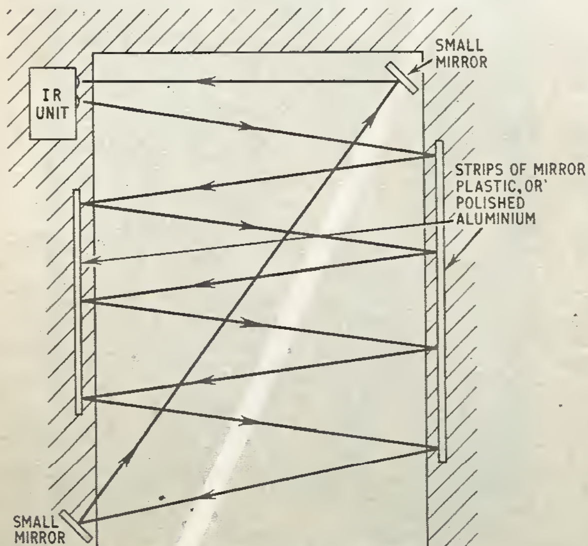



*Fig. 1c. Method of lacing beam across doorway*

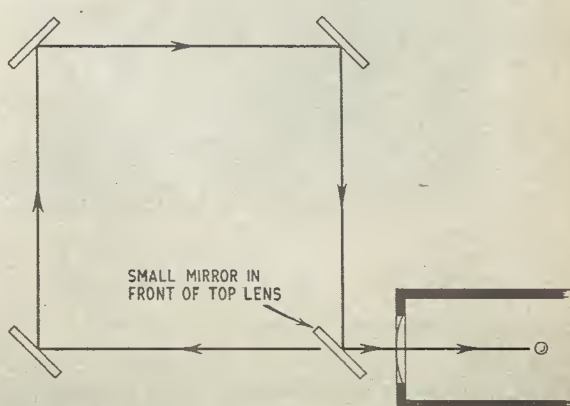



*Fig. 1d. Mirrors arranged to enclose an area*

## DETECTOR AND AMPLIFIER

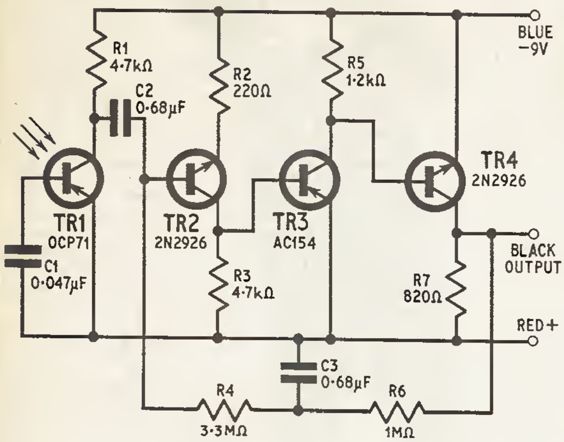



*Fig. 2. Circuit diagram of the detector and amplifier stages*

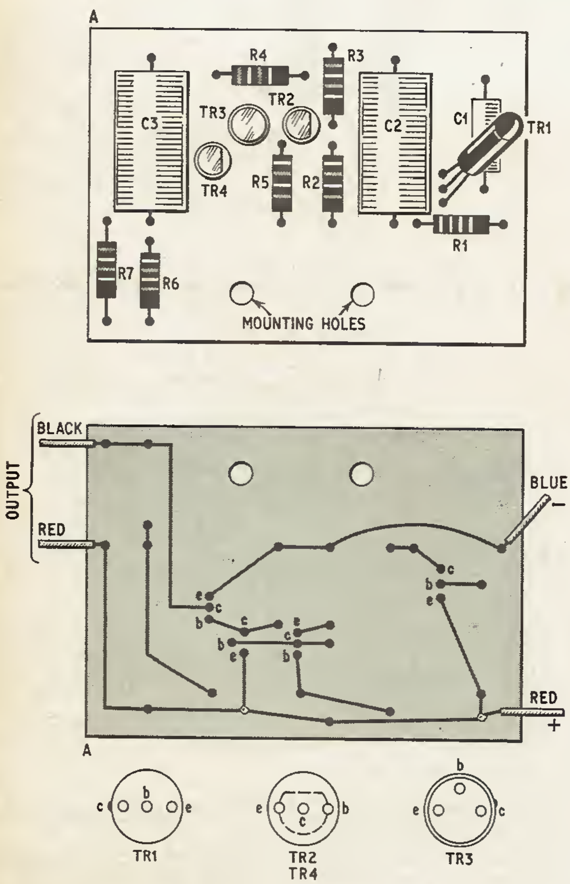



*Fig. 3. Component layout and wiring for the amplifier board*

If the mains supply is cut off, the relay will close and the bell will ring. In normal operation, the 100Hz signal from the beam projector holds the relay contacts open. If wires leading to the relay are cut or shorted, the relay contacts will close, and remain closed even if the 100Hz signal is restored later.

### PHOTO-DETECTOR AND AMPLIFIER CIRCUIT

Fig. 2 shows the photo-detector and amplifier circuit. Phototransistor TR1 is coupled to the amplifier by C2. C1 is included across the normally open-circuit base of TR1 to prevent high frequency instability.

Light falling on the collector-base junction of TR1 will cause an increase of collector current, and an a.c. signal will appear at the collector when the light is modulated.

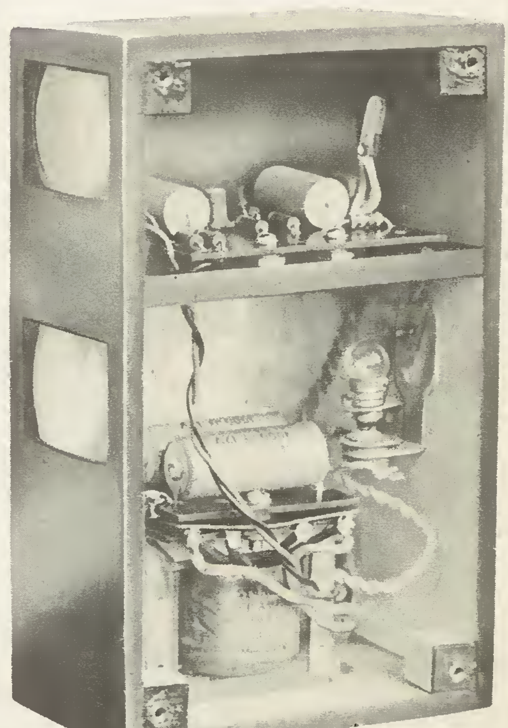
To eliminate bulky electrolytic capacitors, keep components to a minimum, and ensure a uniform low frequency response. The amplifier, composed of TR2, TR3, and TR4, is d.c. coupled.

Voltage gain is better than 200, and d.c. negative feedback is applied via resistors R4 and R6, to stabilise the amplifier against temperature drift. Capacitor C3 decouples the feedback network to a.c. and thus prevents attenuation of the signal.

### AMPLIFIER CONSTRUCTION

Colour coded wiring is included in the diagrams to simplify connections to the circuit panels. The amplifier circuit panel layout and underside wiring appears in Fig. 3.

It is important to note carefully the connections to the *npn* and *pnp* transistors when wiring them into circuit. The panel is drilled and components wired up underneath, using tinned copper wire where the component leads are too short to make a direct connection.



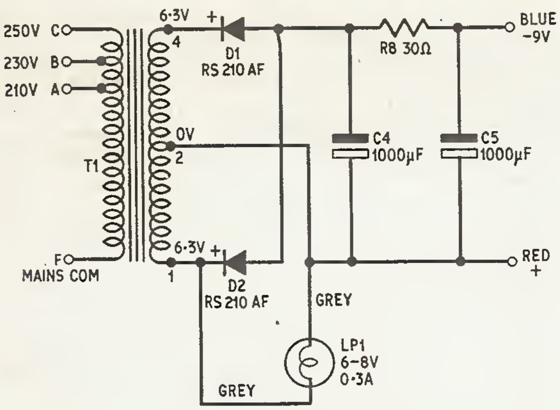



*Fig. 4. Circuit diagram of the power supply*

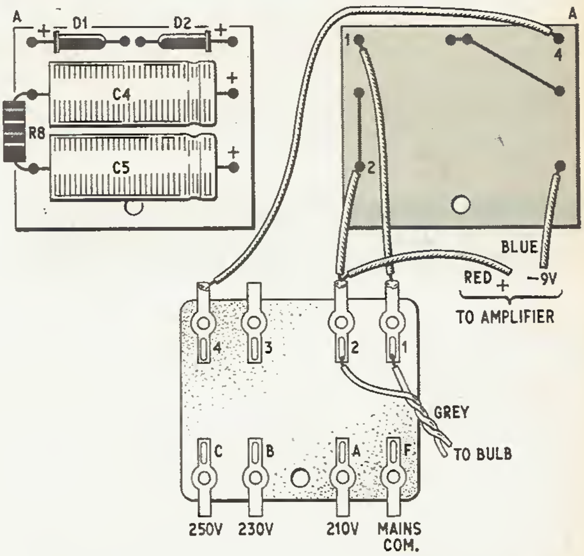



*Fig. 5. Component layout and wiring of the power supply*

## POWER SUPPLY

A standard 6·3V—0—6·3V filament transformer (T1 in Fig. 4) is used. After full-wave rectification (D1 and D2) and smoothing (C4 and C5) a d.c. voltage of approximately 9V is available to feed the amplifier. The bulb is wired to one half of the transformer secondary.

Although RS210AF silicon rectifiers are specified for D1 and D2, almost any silicon diode with a p.i.v. of 100 volts and a maximum current of 500mA or more could be used instead.

## POWER SUPPLY CONSTRUCTION

Rectifiers D1 and D2, resistor R8, and smoothing capacitors C4 and C5 are positioned on a small s.r.b.p. panel which bolts to the transformer tag panel, forming a compact assembly. Panel layout and underside wiring, together with numbering details of the transformer tag panel, are given in Fig. 5.

# COMPONENTS . . .

**Resistors**
- R1 4·7kΩ
- R2 220Ω
- R3 4·7kΩ
- R4 3·3MΩ
- R5 1·2kΩ
- R6 1MΩ
- R7 820Ω
- R8 30Ω 3W wirewound

All 10%, $\frac{1}{4}$W carbon, except R8

**Capacitors**
- C1 0·047µF polyester 250V
- C2 0·68µF polyester 250V
- C3 0·68µF polyester 250V
- C4 1,000µF elect. 12V
- C5 1,000µF elect. 12V
- C6 100µF elect. 9V
- C7 2µF elect. 9V

**Transistors**
- TR1 OCP71 or equivalent phototransistor
- TR2 2N2926 (orange spot)
- TR3 AC154 *or* OC71
- TR4 2N2926 (orange spot)

**Diodes**
- D1, D2 RS210AF (STC, see text)
- D3, D4 OA81

**Transformer**
- T1 6·3V—0—6·3V, 0·5A mains centre tapped heater transformer

**Relay**
- RLA reed switch (Radiospares type 7RSR) and 800Ω reed operating coil

**Miscellaneous**
- LP1 6V–8V, 0·5A m.e.s. bulb
- BY1 4·5V battery (type 1289)
- S1 single pole on-off switch
- "L" shaped signal lampholder
- S.r.b.p. panels, 2in × 2$\frac{3}{4}$in, 1$\frac{3}{4}$in × 2in, 1$\frac{1}{3}$in × 3in (1 off each)
- Lenses 3in focal length—see text (2 off)
- Infra-red filter No. 87, 2in square gelatine sheet (Kodak)
- Electric bell, 4$\frac{1}{2}$V
- Magnet (see text)
- $\frac{1}{4}$in plywood, two off 3$\frac{3}{4}$in × 2in, two off 7in × 2in, one off 8$\frac{1}{2}$in × 4in
- Aluminium 7in × 4$\frac{1}{4}$in, 16 or 18 s.w.g. (2 off)
- 4B.A. and 6B.A. fixings

## A.C. LATCHING RELAY AND ALARM BELL CIRCUIT

It will be remembered that the relay must respond to a low level a.c. signal, and latch on permanently when the signal is cut off. There are a number of ways of achieving a.c. operation with latching, but in this instance a twin coil reed relay is employed, and is magnetically biased.

The circuit shown in Fig. 6 operates in the following manner. The low level signal from the amplifier output (black lead) is rectified by D3 and D4, and is partially smoothed by C7. About 2 to 3 volts d.c. is developed, under normal long beam path conditions, across the relay coils, not enough to close the reed switch contacts.

If now a permanent magnet is brought close to the reed coils, and orientated in such a way that its field opposes the field induced by the signal voltage, cancellation will occur. Then, when the magnet is brought closer still, the magnetic field will begin to increase in the opposite direction, but will now consist of the permanent magnet field minus the signal induced field.

Therefore, with the magnet positioned just at the point where the reed switch contacts are on the point of closing, removal of the signal will increase the field and the contacts will close.

If the signal reappears it will not be able to re-open the contacts, due to inherent backlash in the reed switch mechanism. The reed relay can be re-set in two ways: either by placing a small sheet of ferrous metal between the magnet and the reed coil—which acts as a magnetic shunt—or by counteracting the effects of the bias magnet with another magnet.

After triggering the reed relay will remain closed and needs no power to keep it in that condition; the bell will ring until its battery is exhausted or until the relay is re-set or switch S1 is turned off.

**RELAY AND ALARM BELL**

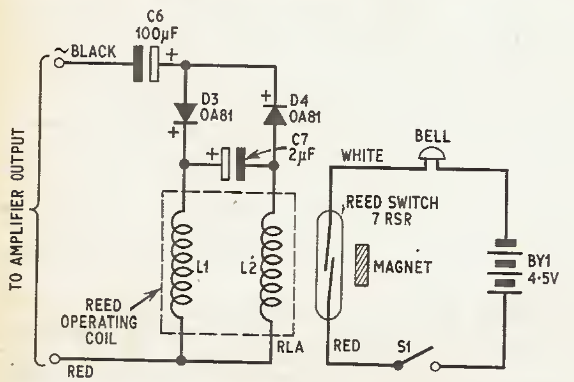



*Fig. 6. Circuit diagram for the a.c. latching relay and alarm bell*

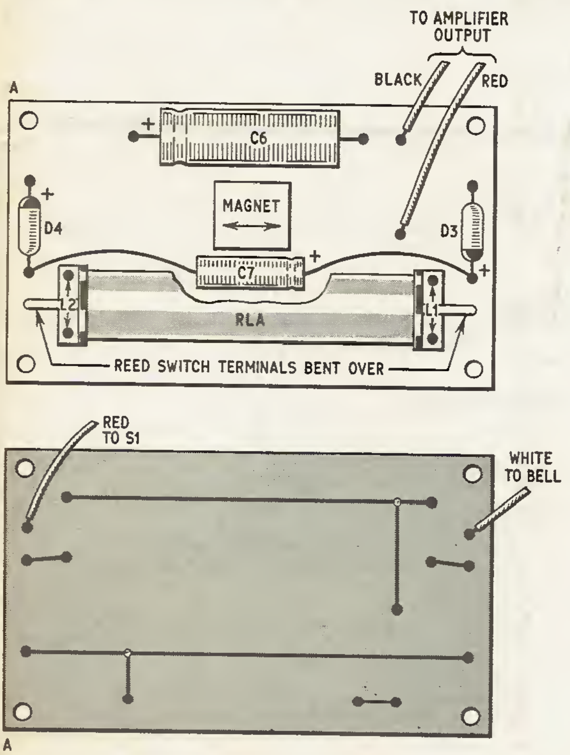



*Fig. 7. Component layout and wiring for the relay board*

## A.C. LATCHING RELAY CONSTRUCTION

The layout of the latching relay is shown in Fig. 7. Once again, a simple s.r.b.p. panel form of construction is employed, although etched circuits could be used if considered worthwhile. The only points to watch are the capacitor and diode polarities.

The magnet can be taken from an old moving armature headphone. In the original construction, two such magnets were glued together, to increase the magnetic field so that the magnet could be conveniently positioned about $\frac{1}{4}$in from the exterior of the reed coil. A range of magnets are available from technical suppliers and a $\frac{1}{4}$in square by 2in long bar magnet would be suitable for biasing the reed switch.

## OPTICS

A pair of lenses with a focal length close to 3in are needed. The approximate focal length can be checked by focusing a sharp image of a window on to the wall of a room and measuring the distance of the lens from the wall. Fortunately, the lenses need not be of good quality in this particular application. Plastic lenses taken from two postage stamp magnifiers, were used for the prototype system.

It is false economy to fit very small lenses, as this would tend to reduce the overall sensitivity. Something of the order of $1\frac{1}{2}$in diameter, or diagonal in the case of rectangular lenses, can be taken as a reasonable size to use.

## LENS BOX

The box can be made up from four pieces of $\frac{1}{4}$in plywood; two off $3\frac{3}{4}$in × 2in, and two off 7in × 2in. Holes are cut for the lenses in the front panel using a fretsaw, and the joints are glued with epoxy resin.

The box sides are 16 s.w.g. or 18 s.w.g. aluminium sheet; one side is permanently glued to the box, while the other side should be detachable, to give access to circuit panels and wiring. Box details, giving positions of amplifier, bulb, and power unit, are shown in Fig. 8.

The amplifier circuit panel is bolted to the s.r.b.p. partition using stand-off spacers. Holes must be drilled in the partition to take amplifier supply and

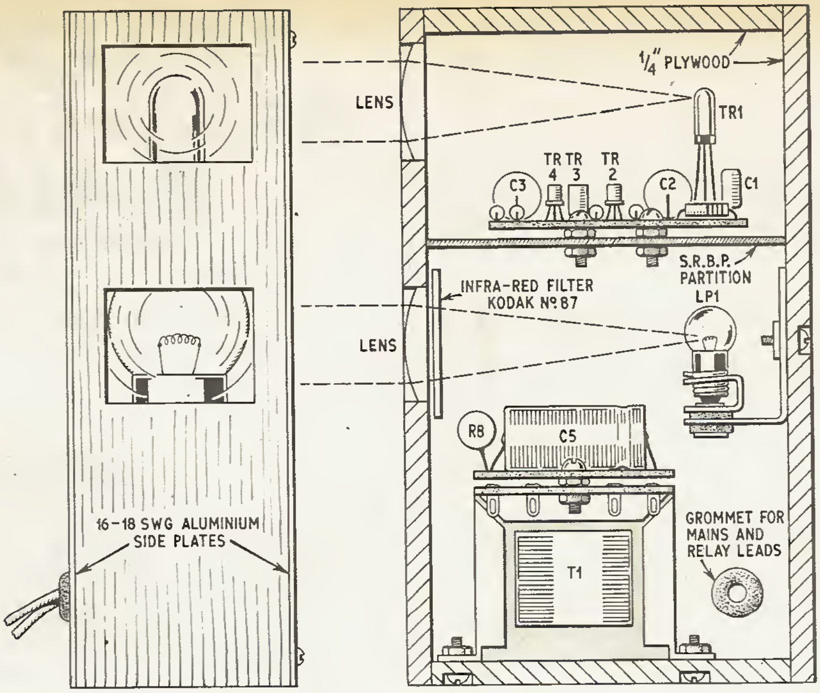



*Fig. 8. Positioning of components inside the lens housing case*

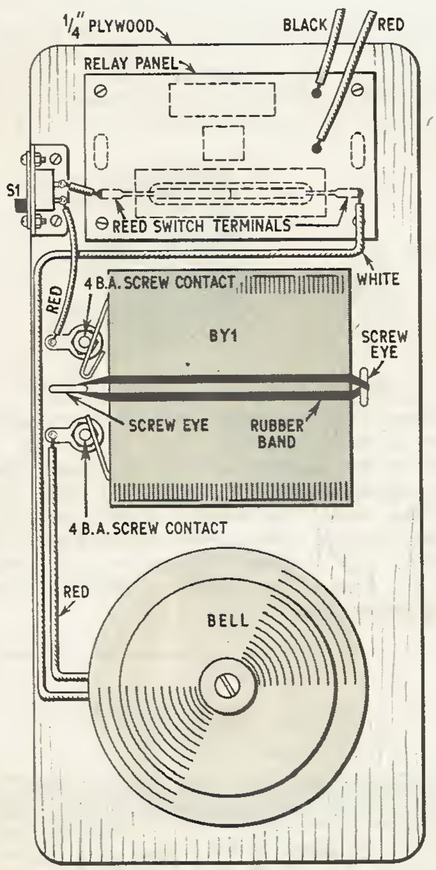



*Fig. 9. Details of relay and alarm bell unit*

output leads. Phototransistor TR1 is roughly positioned at the focal point of the lens, and can be precisely aligned afterwards by bending its leads.

It is important to ensure that the partition between the amplifier compartment and the bulb compartment is completely light-proof.

Black insulation tape can be glued to the edges of the partition panel to mask off the joint between panel and box. The inside of the amplifier compartment can also be painted matt black, to cut down reflections. Equally important is the elimination of stray light from chinks in the lens box, which could be visible to the burglar in the dark. Painting all joints with matt black paint should stop most of the stray light, and the removable aluminium side can be fitted with a soft plastics or rubber gasket.

The bulb holder is an "L" shaped signal lampholder, and provides a range of adjustment to deflect the beam at an angle to the axis of the lens box.

The inexpensive gelatine filter (No. 87) is 2in square and can be ordered from any supplier of Kodak photographic equipment. A small card frame can be made up to take the filter, so that it can be quickly removed to facilitate initial beam alignment with visible light.

## RELAY AND BELL MOUNT

The bell mounting can take the simple form depicted in Fig. 9. Latching relay panel, battery, switch S1, and bell are fixed to an $8\frac{1}{2}$in $\times$ 4in $\times$ $\frac{1}{4}$in piece of plywood.

A plastics cover may be placed over the relay panel to protect it from dust. Two 4B.A. screws serve as battery contacts, and the battery is held in position by a rubber band. Switch S1 is mounted on a small angle bracket and can be any single pole on-off type switch.

## SETTING UP

It is advisable to pre-set the infra-red alarm before installing it in its permanent position. After completing all wiring, check that the amplifier consumes approximately 10mA.

If there is a serious departure from predicted consumption, this might be caused by a fault or by spreads in the gain characteristic of the transistors used. If necessary, the amplifier working point, and consumption, can be adjusted by altering the value of R4 (Fig. 2).

All tests should be conducted away from the light of mains powered lamps when the lens box side cover is removed.

Place the lens box on a flat surface, switch on, and set the lampholder to throw a level beam, and a well defined image of the glowing filament on a wall about 20ft away from the unit. If the image is out of focus, bend the lampholder to move the filament to the focal point of the lens.

The next step is to place a mirror where the image occurs on the wall, and deflect the beam back to the photo-detector lens. With a small piece of white card held near the phototransistor, pick up the returned image and find the true focal point (where the image is smallest and brightest), then bend the phototransistor leads until the collector-base junction is at the focal point and is receiving the image.

If all is well, connect an a.c. volt meter to the amplifier output; a signal of about 2·5V r.m.s. should be indicated. This can be reduced by placing a hand across the light beam.

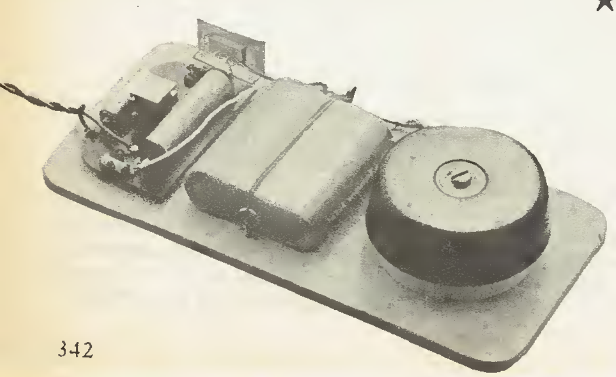
A high residual voltage will indicate that hum is occurring in the amplifier, and can usually be reduced by earthing tag 2 on the transformer (Fig. 5). A residual voltage of up to about 0·5V r.m.s. is acceptable for optimum performance.

## FINAL ADJUSTMENTS

The lens box can be mounted in its permanent location, on a wall bracket, and mirror adjustments made in dull light, or after dark. When satisfied that the beam is correctly aligned, the infra-red filter can be slipped into place, behind the projector lens, and the lens box side screwed on.

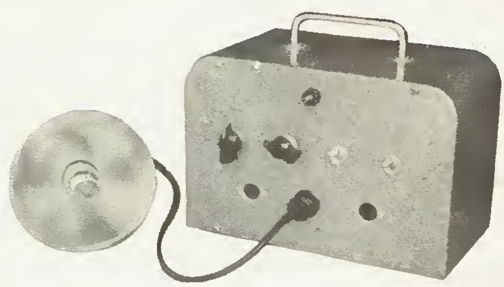
It only remains to find a siting for the latching relay and bell unit, and to fix it in place. This part of the unit should be "behind the beam" so that it is protected from the burglar by the beam. The bell must of course be audible to the householder and/or others. The correct position for the bias magnet is then found and the magnet is glued in place.

The unit is then ready for use and can be tested by breaking the light beam. As soon as the beam is broken the bell should ring and continue to ring after the beam has been restored. The relay can then be reset as described earlier. ★

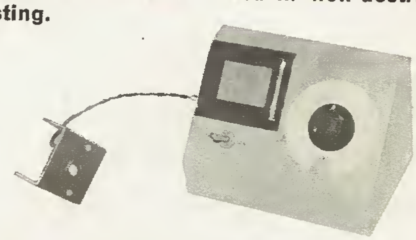












# COLD CATHODE TUBES

## By J. B. Dance M.Sc.

*Cold cathode gas filled tubes are widely used in industrial electronic equipment for automation, control, and for other purposes involving switching. Although larger than transistors, simpler and more economical circuits can often be designed using gas filled tubes than is possible with transistors. In the form of numeral character display devices, they are as yet unchallenged by solid state counterparts.*

Most cold cathode tubes have a failure rate which is much lower than that of thermionic valves, but they do have the disadvantage that they cannot be used to carry out very high speed switching operations.

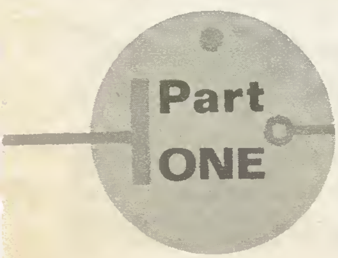
Gas filled tubes are not much used by amateur enthusiasts interested in radio as a hobby. Neither are these tubes normally found in commercially manufactured radio and television equipment produced for the domestic market. There are two main reasons for this.

Gas filled tubes are on/off devices which, unlike thermionic valves and transistors, are always fully conducting or completely non-conducting. Such devices which do not have states of partial conduction cannot be used to amplify the sine waves or signals of random waveforms that are found in domestic radio and television equipment.

In addition the positively charged ions in gas move much more slowly than do the electrons in a high vacuum thermionic valve, precluding the use of most types of cold cathode tube at frequencies much above the audio range. Nevertheless the simplicity of many cold cathode tube circuits is an attractive feature for the average amateur experimenter.

Cold cathode tubes are especially useful as function indicators; for example, they may be used for indicating when the potential between two points exceeds a certain value or for indicating the number of electrical pulses counted by a circuit. They can be used for operating relays, generating waveforms (other than sine waveforms) and timing circuits (for example, photographic timers).

Various types of voltage stabiliser circuit have been developed using these tubes. Special types have been produced for counting electrical pulses.




The basic principles of gas discharge ionisation will be discussed in this, the first part; subsequent parts will look into the more important types of cold cathode tube in detail, with practical circuits for their use.

### FUNDAMENTALS

If a potential is applied between two electrodes in a gas, no current will flow if the applied voltage is fairly small, since a gas is an almost perfect insulator. As soon as some charged particles (ions) are formed in the gas, however, these ions will be attracted to the electrodes. Their movement to the electrodes constitutes the flow of an electric current, since a current is the movement of charged particles.

Therefore, two conditions must be satisfied before conduction occurs in a gas: a voltage must be applied between the electrodes present in the gas, and ions must be present in the gas at the time the voltage is applied.

Ions can be formed in a gas in a number of ways. All materials contain a very small quantity of radioactive atoms.

If the radiation emitted by a radioisotope passes through matter, ions will be created as the radiation gives up its energy. In some types of cold cathode tube a small amount of a radioisotope is incorporated into the tube during manufacture to provide the ions required to initiate a discharge.

In addition to the radiation emitted by radioactive materials, cosmic rays pass through all materials and also form ions. Therefore, even if no ions are artificially introduced into the gas in a tube, the ions formed by cosmic rays and naturally occurring radioisotopes will enable a discharge to take place when a suitable potential is applied.

However, natural sources of ionising radiation do not provide a continuous source of ions and some method of creating ions artificially in a tube which must conduct promptly is required. These methods will be discussed later.

### STRIKING AND MAINTAINING VOLTAGES

Cold cathode tubes must be used in series with a resistor in the type of circuit shown in Fig. 1.1. The resistor imposes a limit on the maximum current which can flow. At low applied potentials the current flowing through a gas discharge tube is very small (less than a

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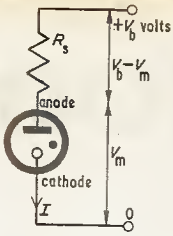



*Fig. 1.1. Basic circuit for operating a cold cathode tube*


*Fig. 1.3. Tubes operating in the normal glow region have a space charge surrounding the cathode*

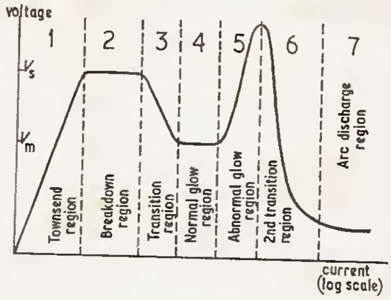
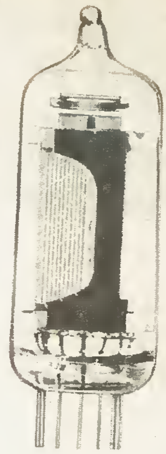



*Fig. 1.2. Regions of typical gas discharge*



micro-microamp), but when the applied voltage reaches a certain value known as the ignition or striking voltage, the current suddenly increases (typically to some milliamps if the series resistor is of a suitable value). Simultaneously the potential across the tube falls.

This process is known as striking or ignition. The voltage across the conducting tube in the circuit of Fig. 1.1 is known as the maintaining or running voltage, $V_m$. If the voltage across the tube is reduced below $V_m$, the discharge will cease and the gas will become an insulator again.

It must be emphasised, however, that striking can only occur when ions (or, more precisely, electrons) are present in the gas.

## CHARACTERISTIC CURVE

The general form of the relationship between the current flowing in a gas filled cold cathode tube and the potential difference across the tube is shown in Fig. 1.2. It is assumed that a small number of ions are present in the tube at all times whilst this curve is being plotted. The current is plotted on a logarithmic scale so that a very wide range of current can be accommodated on a single graph.

As the applied potential is gradually increased from zero, a very small current flows through the tube. This current increases with the applied voltage and with the number of ions being introduced into the gas.

If the applied voltage is increased, the electrons present in the gas discharge can give rise to more ions by a process known as gas amplification or gas multiplication. Electrons are accelerated by the applied electric field towards the anode and gain enough energy to knock further electrons out of atoms of the gas, thereby forming positive ions.

The electrons removed from gas atoms by this process can, after further acceleration, knock other electrons out of other molecules of the gas. This multiplication of the number of electrons present in the tube enables a much greater current to flow than would otherwise be possible. The type of discharge which occurs in region 1 of Fig. 1.2 is known as the Townsend discharge after the English physicist who worked on it.

## FORMATION OF GLOW DISCHARGE

When the potential applied to the tube reaches the striking voltage, $V_s$, a new phenomenon becomes important. Positive ions are accelerated in the region surrounding the cathode of the tube and strike the cathode with such force that they knock electrons from its surface.

These electrons will undergo gas amplification, thus forming further ions. These in turn bombard the cathode and cause more electrons to be emitted. Thus once the normal glow discharge has occurred, the discharge is self-sustaining and no further ions need be created in the gas for the discharge to continue. The process is one of positive feedback.

The current flowing through the tube is no longer limited by the number of ions introduced into the gas, but is determined only by the value of the series resistor and the value of the applied potential, $V_b$ (see Fig. 1.1).

Once the applied potential reaches the striking voltage of the tube, breakdown is said to occur and the discharge quickly passes through regions 2 and 3 of the curve (Fig. 1.2) to the normal glow region marked 4. In region 3 the discharge shows a negative resistance effect. That is, the current flowing through the tube decreases with an increase of the applied voltage.

If the discharge reaches this region, any random increase in the potential difference across the tube will reduce the current flowing. The voltage drop across the series resistor (Fig. 1.1) therefore falls and this results in a further increase in the potential across the tube. Thus the negative resistance region is unstable and the discharge quickly passes to the normal glow region (region 4) of the characteristic.

In the normal glow region the voltage across the tube is almost independent of the current flowing through it. Tubes operating in this region can therefore be used for voltage stabilisation, but this subject will be discussed in more detail in a later article.

## SPACE CHARGE

The properties of tubes operating in the normal glow region of the characteristic are largely due to the formation of a positive space charge around the

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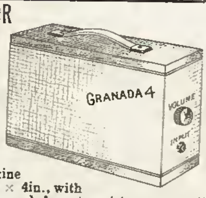


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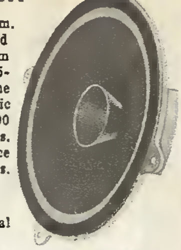

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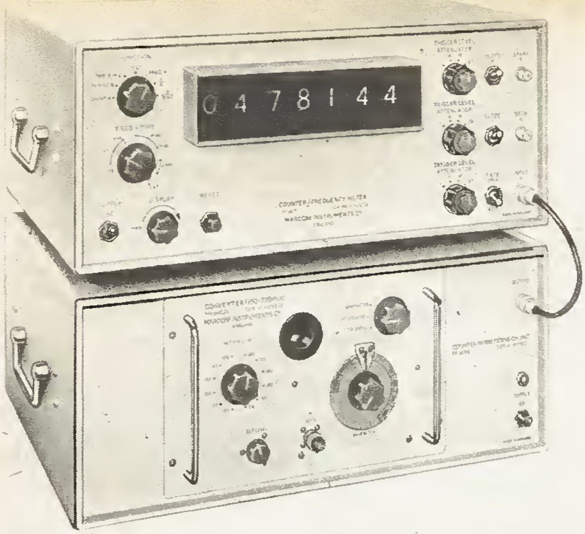



*The Marconi TF1417 counter/frequency meter which employs cold cathode tubes to provide a display of the count in digits*

cathode. At the low currents which occur in the Townsend discharge the number of ions which are present in the gas at any time is relatively small and the electric field strength is uniform at all points in the tube. (This is strictly true only for the case of plane and parallel electrodes.)

In the normal glow region, however, large numbers of positive ions are formed. These ions are relatively heavy and therefore move comparatively slowly towards the cathode. This results in a net charge of positive ions being formed around the cathode (Fig. 1.3).

The positive space charge acts somewhat like an anode and is therefore often called a "virtual" anode. The effect on the performance of the tube is similar to that which one might expect if one used an anode close to the cathode. The electric field strength in the neighbourhood of the cathode is considerably increased by the presence of the space charge and is greater than that in other parts of the tube.

The high field strength around the cathode enables a high gas amplification factor to be obtained and as a result of this the maintaining voltage of the tube is considerably less than the striking voltage. However, a high gas amplification factor alone is not sufficient to render the discharge self-sustaining; electron emission from the cathode by ionic bombardment must also occur.

In the normal glow region of the characteristic of Fig. 1.2, the area of the cathode covered by the discharge automatically adjusts itself so that the ionisation efficiency is a maximum. The area of the cathode covered by the glow is thus proportional to the current flowing through the tube.

In the circuit in Fig. 1.1, the voltage across the tube remains almost constant at the maintaining voltage, $V_m$, as the current passing through it is altered. Thus if the supply voltage is $V_b$, the voltage across the series resistor is $(V_b - V_m)$ and, applying Ohm's Law to this resistor,

$$V_b - V_m = IR_s$$

Thus the current $I$ can be changed by altering either $V_b$ or $R_s$ or both.

## ABNORMAL GLOW

If the resistor $R_s$ is gradually decreased in value, the current flowing through the tube will increase until the discharge covers the whole of the surface of the cathode. A further increase in current will then cause the discharge to move into the so-called "abnormal glow" region of the characteristic; this is marked 5 in Fig. 1.2. In the abnormal glow region the voltage across the tube increases with the current flowing.

## ARC DISCHARGE

A further increase in current results in the discharge passing through a second negative resistance region (marked 6 in Fig. 1.2) to the arc discharge region (marked 7 in Fig. 1.2).

The arc discharge region is characterised by very high current densities (amps/sq cm of the cathode surface covered by the glow) and by a low potential across the tube (typically 20 volts).

There are believed to be two kinds of arc discharge. If the cathode is made of a material with very high boiling point (for example, carbon), it becomes so hot under intense bombardment of positive ions that electrons are emitted from it and they sustain the discharge. The emission is like the thermionic emission of electrons in a thermionic valve.

If the cathode is made of a material of relatively low boiling point (for example, mercury), the electrons are believed to be drawn out of the cathode by the very intense electric field which can be formed in these circumstances.

## TUBE OPERATING REGIONS

A few cold cathode tubes (such as nuclear radiation detector tubes) operate in the Townsend region where the discharge is not self-sustaining. Such tubes pass a current only when a particle of radiation creates ions in the tube.

Most cold cathode tubes operate in the normal glow region. Such tubes include miniature neon indicators, ordinary trigger tubes, decade stepping tubes, most voltage stabiliser tubes, and numerical and character indicating tubes. Some voltage reference tubes operate in the abnormal glow region.

Some types of high current tube operate in the arc discharge region, but most of them are designed for pulse operation only. That is, they are not capable of passing a large continuous current without being damaged. Such tubes include flash tubes for photographic and stroboscopic work and various types of tube for protecting high voltage power lines; the latter types of tube conduct when the voltage surge across them exceeds a certain value.

## CONSTRUCTION OF COLD CATHODE TUBES

The composition of the gas employed in cold cathode tubes greatly affects the characteristics of the tubes. Most types are filled with a mixture of inert gases at a low pressure (neon/argon/helium, etc.), but decade stepping tubes are normally filled with pure neon.

Under certain conditions the use of a small amount of hydrogen in the gas mixture enables a tube to operate at a higher speed. Some types of arc discharge tube are filled with gas at a pressure exceeding atmospheric, but these tubes are not very common.

The reasons which determine the choice of a gas mixture for a certain type of tube lie beyond the scope of this article, since they are connected with the ionisation potentials and metastable energy levels of the gases concerned. Further information on this subject can be obtained from reference books.

## CATHODE MATERIALS

The properties of cold cathode tubes are particularly sensitive to the materials elected for the cathode, but the composition of the other electrodes hardly affects the behaviour of the tubes. The reason for this is that the processes which sustain the discharge (ion bombardment and gas multiplication) occur mainly in the region of the cathode surface. Some types of cathode material lose electrons easily (that is, they have a low work function). Such cathodes will emit electrons readily under positive ion bombardment and tubes employing them can therefore operate at a relatively low voltage.

The type of cathodes that emit electrons easily normally consist of a metal surface covered with an oxide coating (similar to that used to coat the cathodes of thermionic valves) or with a metal of low work function such as potassium.

The other type of cathode used in cold cathode tubes has a higher work function and does not emit electrons so readily. Such cathodes normally consist of a pure metal (usually molybdenum or nickel). Although tubes employing these cathodes must necessarily work at a higher voltage than those employing coated cathodes, they are much more reliable and have a longer life than coated cathode tubes. They also have closer tolerance characteristics, but may be rather more expensive.

## SPUTTERING

The positive ion bombardment of the cathode results not only in electrons being emitted, but also in atoms of the cathode material being ejected from the cathode surface. This phenomenon is known as "sputtering". It results in a deposit of the cathode material being formed on surfaces near to the cathode; this may result in failure of the tube by the shorting of two of the electrodes.

Sputtering can also result in premature tube failure if it causes the surface of the cathode to be damaged; this is especially liable to occur with tubes employing coated cathodes. However, sputtering is used to good effect in the manufacture of tubes with pure metal cathodes. Heavy sputtering is allowed to occur during the manufacture of these tubes. This not only leaves the cathode surface very clean, but the sputtered material on the glass envelope of the tube retains foreign gas impurities very effectively. Such impurities can affect the characteristics of the tubes.

The rate at which sputtering occurs increases considerably with an increase of the cathode current. In many types of tube the maximum cathode current is set by the need to prevent excessive sputtering from shortening the life of the tube.

## PRIMING

Although a limited number of ions are formed intermittently in any gas by natural radiation, if no other ions are artificially introduced, there may be a delay of up to a minute or so between the application of a potential exceeding the striking voltage and the establishment of a discharge. The greater the applied voltage, the smaller this delay.

There are various ways in which the required ions can be introduced into the gas. The introduction of such ions is known as "priming".

## PHOTOPRIMING

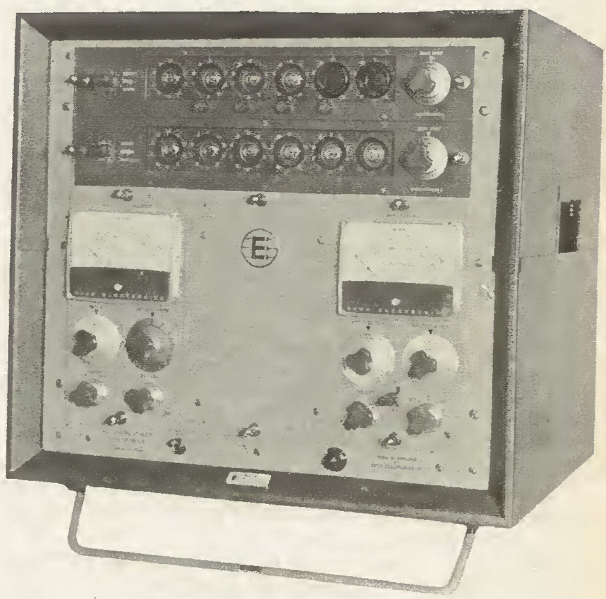
Coated cathodes will emit electrons very readily when ordinary light falls onto the cathode surface. Such tubes often rely on light for priming. For this reason one may often read in a data sheet, for a tube employing a coated cathode, that the ambient illumination should not be less than a certain value (for example, 20 lux).

If the illumination is low or if the tubes are operated inside a dark instrument case, there may be a delay in the firing of the tubes when a potential exceeding the striking potential is applied to them. In addition it is important that tubes employing coated cathodes should not be operated in bright direct sunlight, or the number of electrons emitted from the cathode may be so great that the striking voltage falls almost to the maintaining voltage of the tube.

Some tubes employing coated cathodes contain a little radioactive gas, usually tritium (hydrogen of atomic weight 3), or another radioactive material such as nickel-63, to provide the priming electrons. Such tubes can be operated in complete darkness but should not be used in very bright direct sunlight. The radiation cannot penetrate the walls of the tube, but even if the tube is fractured, the amount of the radioactive material employed is so small that it is relatively harmless.

Visible light will not cause photoemission from tubes employing pure metal cathodes. Although ultraviolet light can cause the emission of electrons from such cathodes, ultra-violet radiation cannot pass through the glass walls of a normal cold cathode tube. Some other method of priming must therefore be employed if a tube with a pure metal cathode is required to strike within about a millisecond of the application of a potential exceeding the striking potential of the tube.

The use of a radioisotope is not a particularly satisfactory method of priming in tubes which are to be used



*The Echo N610A Automatic Scaler. This nucleonic counter employs decade stepping tubes for counting, but the two tubes on the upper right are point indicators. The lower group of decade stepping tubes are used for timing and for stopping the count after a preset time*

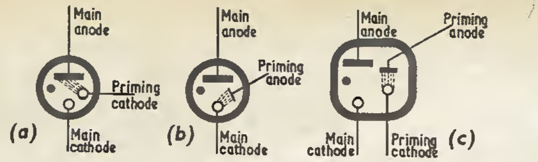



*Fig. 1.4. Methods of priming using an auxiliary discharge*

at very high speeds. One of the most common methods of priming involves the use of an auxiliary priming discharge. The latter generates ions which diffuse to all parts of the tube.

Commonly used forms of priming electrodes are shown in Fig. 1.4. An additional cathode known as the priming cathode is used in the system in Fig. 4a. A small priming discharge takes place to this electrode whenever the equipment is switched on, no matter whether the main cathode is conducting or not. This type of tube is not really suitable for use in circuits in which the anode voltage is liable to fall considerably, since the priming discharge would then be extinguished.

A somewhat similar system in which an additional priming anode is employed is shown in Fig. 1.4b. Although this type of tube can be used in circuits in which the main anode potential is liable to fall suddenly, it is not really satisfactory for use in circuits in which the main cathode potential is liable to rise suddenly, since this could result in the discharge being extinguished.

A third type of tube employs two auxiliary priming electrodes (see Fig. 1.4c); this may be used when the potentials of the main anode and cathode change by any reasonable amounts. The priming currents are normally a few microamps.

In one type of tube with two separate priming electrodes, a mica screen is placed between the priming electrodes and the main gap electrodes; ultra-violet photons generated in the priming discharge can then pass into the region of the main gap where they cause ionisation.

### CARE OF COLD CATHODE TUBES

Cold cathode tubes are extremely reliable components when they are used in correctly designed circuits. They can, however, be permanently damaged by incorrect use just as easily as transistors. All users should therefore check that the conditions under which they use cold cathode tubes do not violate the recommendations in the tube manufacturers' data sheets.

In particular it should be noted that most cold cathode tubes should not be allowed to pass a reverse current from cathode to anode. If any electrode which has not been designed as a cathode is allowed to act as a cathode, the electrode will probably be permanently damaged by positive ion bombardment and the characteristics of the tube affected. Any reverse voltage applied to a cold cathode tube should therefore be kept below about 90% of the voltage at which striking will occur.

However, a few types of tube (mainly miniature neon diodes) are designed so that they will not be damaged if a reverse current passes through them. Indeed, in some miniature neon diodes the anode and cathode are identical and such tubes can be operated from an alternating supply voltage.

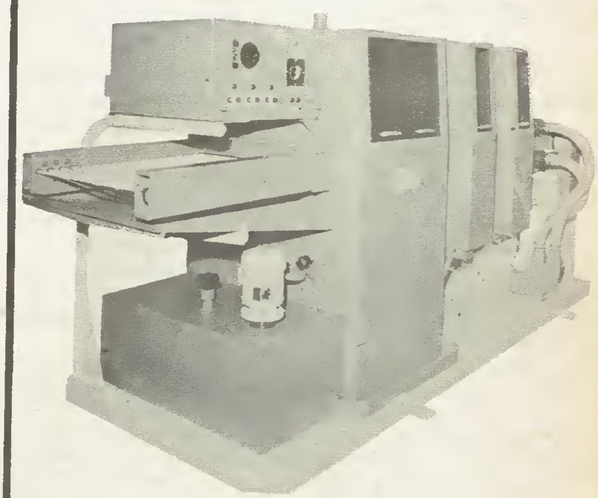
**Next month: Gas filled diodes—their properties and applications.**

# NEWS BRIEFS

## Printed Circuit Production Increased

BY USING a new spray-etching plant—developed by APV-Kestner Ltd., of Greenhithe, Kent, for mass production of rigid or flexible printed circuits and small electrical components—a manufacturer of television sets is currently obtaining 110 square metres of finished circuit boards per hour and will be able to increase this output at will to meet future demands.

The installation shown below, consists of separate p.v.c. cabinets which are linked by a variable-speed conveyor and can be assembled in whatever order or number is required for different applications.



## Displacement Measurement by Laser

USING an interferometer in conjunction with a specially modulated laser beam, members of the Philips Research Laboratories at Eindhoven have obtained an extreme degree of accuracy in measuring displacements. This facility is required for automatically controlling high-precision metal-working machines or for making integrated circuits.

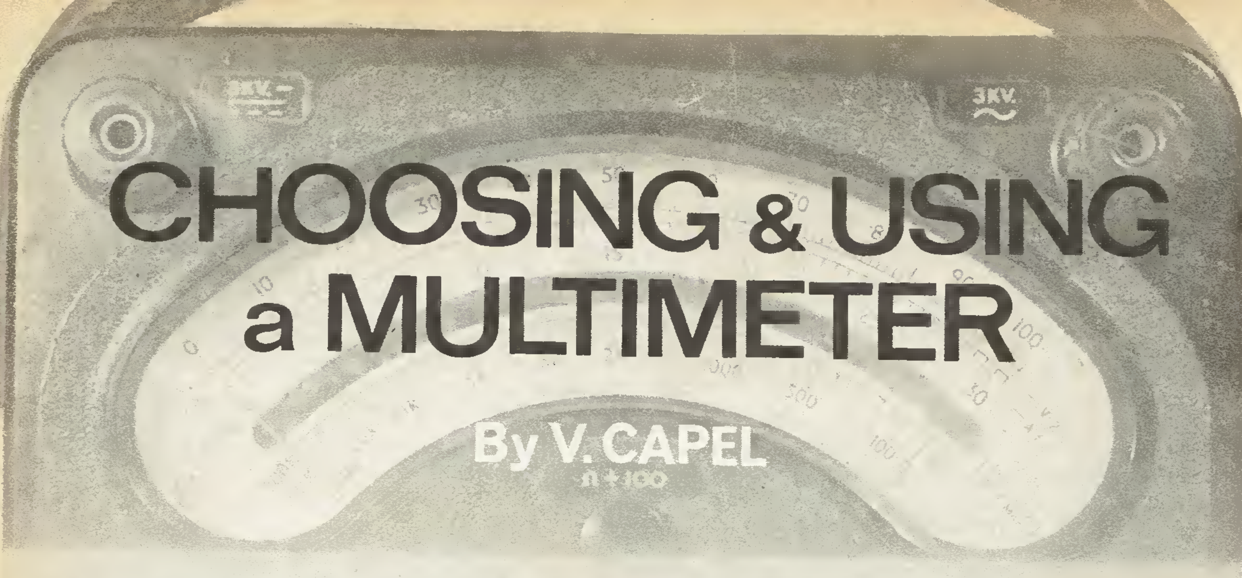
The apparatus will make it possible to achieve even higher precision in automated machining techniques than was previously possible.

## Gun Sound Ranging System

FOLLOWING three years of development work under a contract awarded by the British Government, and extensive users' trials overseas, the Plessey Electronics Group has received an order from the Ministry of Technology for a Gun Sound Ranging System which incorporates radio links.

This equipment represents the most advanced method of locating hostile artillery, known to be the cause of some 80 per cent of battlefield casualties.

The principal of sound ranging is based on the assumption that sound travels uniformly at a known velocity. Thus if a line of microphones, each at a known location, is placed across the line of fire, the intervals between the time of arrival of the gun sound at each can be transmitted to a central "command post" to be converted to bearings whose intersections will give the source location.



# CHOOSING & USING a MULTIMETER

By V. CAPEL

TODAY, the would-be purchaser of a multi-range testmeter has a considerable range of instruments to choose from. There are models to suit almost every purpose and pocket.

As good an instrument as can be afforded should be obtained, as it is considered to be the engineer's best friend. The meter should be accurate and have a fairly wide range of facilities. The robustness of the service engineer's instrument may not always be necessary, and so some saving in cost can be achieved in this direction, although the ranges may be more limited.

A second test meter can be very useful where it is often necessary to take two voltage readings simultaneously or a voltage and current reading at the same time. Also a second instrument is a valuable asset as a standby in case of accident or breakdown with the first.

The meter needs to be reliable otherwise the whole point of having a measuring device is lost. Economy should be along the lines of restricting the ranges rather than choosing an instrument that offered many facilities but with a poor basic meter movement.

When comparing the specifications of various multi-range meters it may be noticed that some of the cheaper ones offer nearly as much as more expensive ones, and it is tempting to question the necessity of paying so much.

Sometimes users of meters of doubtful worth, when faced with an unexpected or unexplained reading, will say: "Perhaps it is the meter playing up again." This should never be; the test meter should always be above suspicion; if it is in any way unreliable, it is defeating its purpose. With test equipment as with so many other things, you get what you pay for.

## METER RESISTANCE

The most important feature in the manufacturer's specification is the meter resistance. Two figures are usually quoted, one for the d.c. ranges and one for a.c. The d.c. resistance is the highest and the most important. It is quoted as so many ohms-per-volt and is related to the range being used, thus a 10,000 ohms-per-volt meter will have a resistance of 1 megohm on the 100 volt range and 10 megohms on the 1,000 volt range.

Beginners often ask what difference the meter resistance makes; if the meter is accurate it will surely read the correct voltage whatever its resistance. This would apply when the impedance of the voltage source, such as a battery or h.t. supply, is very low relative to that of the meter.

Consider the case though, where there are, say, two 1 megohm resistors in series across a voltage supply (Fig. 1); the voltage at their junction will be half that of the supply.

If we now connect the meter, set to 100V range, across the lower resistor R2, we are putting another 1 megohm in parallel across it. Hence the combined resistance of R2 and the meter will be ½ megohm. The voltage ratio now between R1 and the meter +R2 combination will be 2 : 1 so the actual voltage registered on the meter will be one third of the total supply voltage.

When measuring a voltage through a resistor, there is bound to be an additional voltage drop due to the current drawn by the meter. When the value of the resistor is small relative to that of the meter, the voltage drop is so small that there is little effect on the reading, but when the value is of a similar order, then quite large errors will occur.

It follows from this that a very high resistance instrument should be chosen to obtain the highest accuracy; 10,000 ohms/volt is about the minimum for best results, but 20,000 ohms/volt is regarded as the better standard for most applications except high impedance signal voltages (see later).

While it may seem that higher values are better, there are mechanical limitations to consider. The meter movement has to be made more delicate to overcome friction, since less power is available to move the pointer and return spring.

A meter will only indicate r.m.s. values on a.c. ranges, so only pure sine waveforms can be measured accurately in these circumstances.

## SCALE MARKINGS

The scale should be as large as the instrument dimensions will allow so that the divisions on the scale are well separated and easily seen. Various means have been used by makers to give maximum scale length.

Some have made the scale cover the whole of the meter width, and put the range selector control and test prod terminals at the side to make room for it. Others have mounted the meter scale diagonally with the pointer pivot in one corner instead of in the centre of the instrument. These aim at giving the largest possible scale within small case dimensions.

Poor scales are not sufficiently numerated and the user must sometimes mentally multiply the scale reading by the range factor. This not only slows down measurements, but increases the possibility of error.

The resistance ranges are not linear on the scale, so check to see how cramped the divisions are at the high resistance end of the scale. Some meters boast a resistance range extending to 10 megohms, but the spacing between 5 and 10 megohms is so small, that interpolation between these values are impossible. Take a look too at the lower end of the scale; it should be possible to read 1 ohm easily and with better instruments lesser values should be interpolated fairly accurately. The resistance range should be at the top of the scale to give maximum scale length.

A well designed scale can be quickly read in conjunction with the range setting without confusion. All range numerators should be inscribed on the scale, so if we have voltage ranges of, say, 0–3, 12, 60, 120, 300, 600, 1,200 volts, the scale should have three numerators scales, 0–3, 0–6, and 0–12.

## PARALLAX ERRORS

One possible source of error when taking meter readings is due to parallax effect. This is when the pointer appears to occupy a slightly different position relative to the scale, due to viewing it at an angle greater or less than 90 degrees to the scale, see Fig. 2. In most cases, error is small because the distance between the pointer and the scale is small, but it can be significant when reading the cramped upper end of the resistance range.

Also when comparing readings of very small voltage or current differences, parallax errors could be important. For this reason high grade meters incorporate an anti-parallax mirror behind the scale. When taking a reading, the scale is viewed so that the pointer appears to be exactly above its own reflection, which then indicates the true reading on the scale.

The pointer should move smoothly over the scale and come to rest without much, if any, oscillation to and fro.

## VOLTAGE RANGES

Now we come to the actual ranges. Even on low priced meters, the d.c. voltage range nowadays is quite extensive and can be as high as 1,000 volts or more. For solid-state electronics though, it is the lower end which is the most applicable, particularly for measurements of less than 1 volt. It should be possible to read a tenth of a volt with a reasonable standard of accuracy.

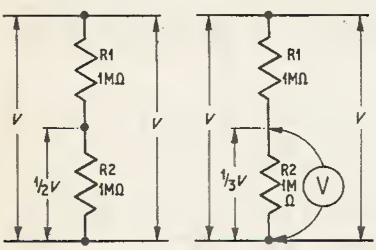



*Fig. 1. False readings can be obtained by a poor meter resistance characteristic. (a) The true reading across R2 is equal to half the supply voltage. (b) The meter resistance presents an additional shunt path reducing the voltage across R2*

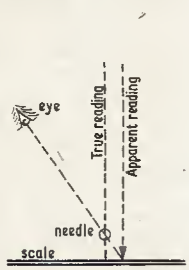



*Fig. 2. Parallax error due to incorrect position of the eye in relation to the meter needle*

If it is intended to measure signal voltages in amplifiers, one or two factors will have to be considered. A low range will be needed for this as signal voltages from low impedance amplifier outputs are also low. A decibel range would be useful here, but it is better to employ a transistor or valve voltmeter, with high input impedance, since the frequency response of a multi-range meter may not be adequate for measuring over the required frequency range.

Of course, if audio measurements are not contemplated it can be assumed that most a.c. measurements will be at mains frequency (50 and 100Hz).

## RESISTANCE RANGES

Next to the d.c. voltage ranges, the most important are the resistance ranges. These should cover a wide range. Values down to 1 ohm and at least up to 5 megohms should be measurable.

Some meters offer extended upper ohms ranges by using external batteries and resistors. Manufacturers' instructions should indicate how this is done.

The majority of instruments incorporate a "set zero" control, which is a variable resistor set to compensate for the falling battery voltage. This setting is usually different for each ohms range, so the zero calibration should be checked when switching from one range to another.

With time and use, the "set zero" potentiometer can become worn and it becomes increasingly difficult to find the zero spot. Some thought has been given to this inconvenience by some makers and there are at least two methods of overcoming this problem. One is to use separate controls for each "ohms" range. Once set up, the ranges can be switched without further adjustment until the next occasion the meter is used.

Another method is to use mercury cells instead of the usual carbon/zinc cells to prolong battery life and reduce the necessity for adjustment at frequent intervals.

Some models can be switched from one "ohms" range to another and used immediately without any adjustment. Any meter that has one of these or a similar arrangement is well worth considering, provided other features are as required.

## CURRENT RANGES

The current ranges are much less used than the others; in several models a.c. current ranges are omitted altogether. The lowest d.c. current range is usually the basic current rating of the meter movement without shunts, i.e. for a 20,000 ohms per volt movement, $50\mu A$.

Although little used, a.c. current ranges can be very useful at times. A transformer with a short-circuited turn, for example, can most easily be checked by measuring primary and secondary currents and comparing (taking into account the turns ratio of course).

## OTHER FACILITIES

A polarity reverse switch is very useful when working on apparatus that has both positive and negative voltages to chassis. This saves reversing the leads and changing over the chassis-clip and test-prod each time an opposite voltage is encountered.

Some meters include a capacitance range, but these usually involve the use of external circuits and are less satisfactory than using a capacitance bridge.

One facility that should be provided is some form of overload protection. This may be a mechanical plunger, which jumps up and disconnects the meter when the pointer exceeds a certain speed, or it may be a fuse, or some electronic overload device. A fuse is perhaps less convenient because it will need to be replaced when it blows, and one may not be readily available. However, make sure that the meter is protected in some way.

## CONNECTIONS TO CIRCUIT COMPONENTS

The correct use and connection of any test meter must be strictly observed or damage may result to either the meter or the circuit under test. Fig. 3 shows the correct methods of connecting the meter to a circuit or component for measuring current, voltage, and resistance. Remember, always start the meter range setting on the highest range before switching on power supplies.

If the polarity is unknown, connect the test leads, switch to the highest range, have your finger on the "polarity reverse" button, then switch on. If the needle kicks backwards, i.e. to the left of zero, press the button quickly to indicate the correct reading.

## GRAVITY INFLUENCE

It should always be remembered that the meter is a delicate instrument. Never leave it in a precarious position where it may topple over. Never leave the test leads dangling over the edge of the workbench as they could easily get caught in clothing and pull the meter off the bench. Mechanical shock can dislodge the movement bearings necessitating repair.

The meter may have an effective overload protection device, but this is no reason to become careless and frequently overload the instrument by selecting the wrong range. Few if any of such devices are 100 per cent fool-proof; they are intended to minimise the risk of damage on the rare occasions a mistake is made.

Inaccuracies may be small when the meter is used in the vertical position, but for the greatest accuracy the meter should be horizontal. When vertical, the needle must overcome its own weight when operating in the first half of the scale; it is in fact moving upward. Readings taken here will be under the true value. In the second half of the scale, the needle is moving back down and so is assisted by gravity, hence readings will be slightly more than they should be.

While the needle is very light in weight, the power available to move it is also very small, especially in high impedance instruments. The degree of error is small, but it should be remembered if highly accurate work is required.

The most accurate part of a meter's range is in the centre portion of the scale. Again, where extreme accuracy is needed, select the range which brings the pointer into this part.

With high-grade instruments very little difference will be noted in accuracy over the whole scale, but the less expensive ones may show a discrepancy when a voltage is measured on two ranges. This is particularly true of the ohms range, where, in addition to the inaccuracy of the meter movement, we have the unavoidable scale cramping at the higher end.

## MEASURING CURRENT

Special care is needed when measuring current; not only may a fault condition exist in the equipment causing a current flow many times higher than expected, but it is possible that a mistake may have been made in connecting the leads.

A crocodile clip may be touching two parts of the circuit and either give an erroneous reading or even damage the meter or circuit. Double check connections and put the meter to its highest range before switching on.

## MEASURING RESISTANCE

Inaccurate results can be obtained by overlooking some influencing feature of the circuit under test. This is frequently the case when taking resistance readings.

It is very easy when checking the resistance of a component in circuit, to overlook some part of the circuit which is effectively in parallel with that being tested. The result is a lower reading than expected.

An example of this type of error is shown in Fig. 4. If we attempt to measure R1 in the base-bias divider, there will be two additional circuits that will affect the reading.

The first will be the base/collector junction in the transistor itself with R3, which will give a high or low resistance reading depending on the meter connection.

Secondly there is a circuit through resistor R2 and the power supply. This latter may consist of leakage paths through electrolytic capacitors and other networks across the supply line or the supply battery itself. Any reading attempted will therefore be much lower than the actual value of the resistor. As a general rule resistance readings should only be made when disconnected from the associated circuitry.

When checking a diode, it is usually sufficient to compare readings taken backwards and forwards, that is, with the meter leads first one way round and then reversed. The reading in the forward direction should

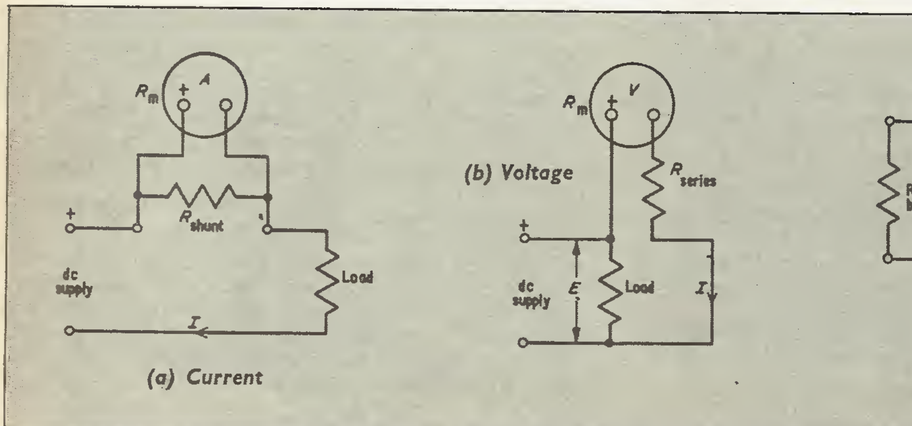



Fig. 3. Correct connections for the meter

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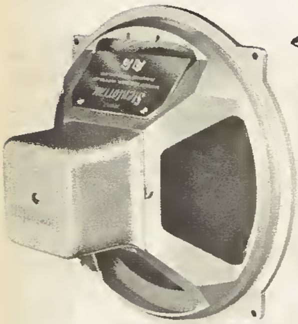

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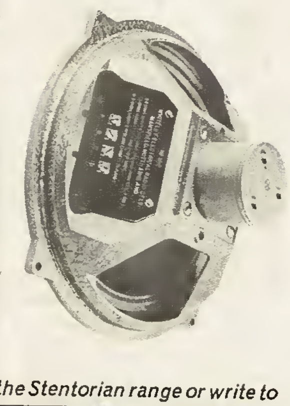

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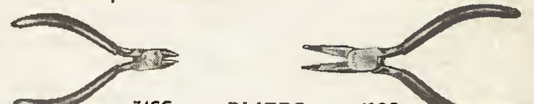


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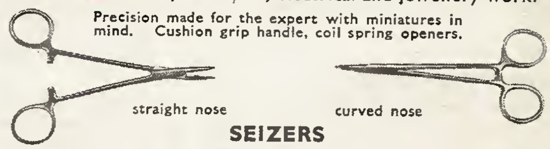


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MIXER UNITS. Type 18. H.F., M.F., L.F. Valve V882. 10/–. P. & P. 2/6.
FLEXIBLE METAL TUBING. Galvanised ⅜in. dia. 35/– 100ft. P. & P. 7/6.
FIELD TELEPHONES TYPE "F". 32/6. P. & P. 7/6.
CHASSIS UNIT. 13 valves. ECC82(5), EB91(6), EF91(2). 60 Resistors, Capacitors, etc. Valve cans and bases. Multicon Plugs. 30/–. P. & P. 6/–.
RESISTORS. Mixed Parcel of 200. 20/–. P. & P. 2/6.
RESISTORS. Variable. Mixed Parcel of 30. 20/–. P. & P. 2/6.

**TRANSFORMERS**

SSTR 894. Pri. 220–230–250V. Sec. 6.3V (2A), 300–350–390V (35mA). 80–90–100V(10mA). 30/–. P. & P. 5/–.
SSTR 073. Pri. 220–230V. Sec. 35V(0.5A). 6.3V(2A). 225-0-225V(27mA). 25/–. P. & P. 5/–.

**S.A.E. FULL LIST**

**STATUS SUPPLIES**

Status House, Wilkinson Avenue, West Park Drive, Blackpool. Tel. 62788 (2 lines)

*ELECTRONIC ORGAN CONSTRUCTORS..........*

*We can supply just about everything you are likely to need for your project:*

MANUALS: 3, 4 and 5-octave
PEDALS: 13, 25, 30 and 32-note
TONE SOURCES: Square-wave, 4-8 octave
Saw-tooth, 6-8 octave
CONTACTS: Blocks and printed circuit assemblies
STOP SWITCHES, FOOT SWELLS, etc., and even COMPLETE ORGAN KITS

*Drop us a line or phone*

Harmonics (Bromley) Ltd Clarion Works, Napier Road, Bromley, Kent. 01-460 2122 be much lower than in reverse. Diodes working as a pair, such as in a discriminator circuit should have closely matched forward resistance and any large discrepancy will produce fault symptoms.

When using the ohms range make sure that there is no current being supplied to the circuit other than that from the meter battery. For this reason, nearly all resistance checks, unless there are special circumstances, should be made with the equipment switched off.

Even so, it may be possible that a voltage with a high current potential may persist. For example, with a power supply unit that has an open-circuit smoothing resistor, the reservoir capacitor will be fully charged with no load to "bleed" the charge away (Fig. 5). Even when switched off for some time it would not be safe to check around this circuit with an ohmmeter.

When in doubt, check with the meter on the voltage range first, then discharge the smoothing capacitors through a low resistance path.

Whenever finishing work, always make a point of leaving the meter switched to the highest voltage range. In a workshop where others are present, there is the possibility that someone else may borrow the meter for a quick test on something else; re-check the range settings before connecting to your circuit.

The meter should never be left switched to one of the ohms ranges. It is possible that with the test leads left connected, one prod may touch the other; this will result in a full scale deflection of the needle and a continuous drain on the battery until the leads are moved. It may not be realised for some while during which time the battery may be considerably depleted, if not run right down, by the time the instrument is used again.

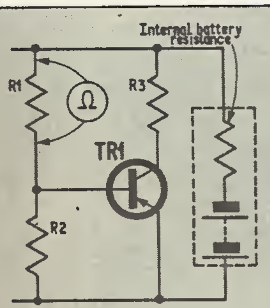



*Fig. 4. Misleading errors occur, when measuring resistance in circuit, due to other resistive paths*

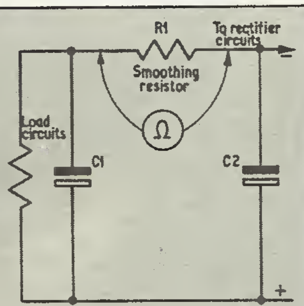



*Fig. 5. The charged capacitors can give incorrect readings when measuring in circuit, even when the supply is switched off*

## BATTERY LIFE

The life of a battery in a meter can be surprisingly long. Even with regular use, life spans of several years are quite common. Really, the conditions of use are ideal for the carbon/zinc cell.

When a battery has finished its useful life, it will be found that it is not possible to obtain a "zero ohms" (full scale) deflection even with the ohms set zero control full out. It may be found that this condition is reached on one ohms range before the others.

Some meters use more than one battery, a single-cell torch unit for the lower ranges and a higher voltage battery for the highest range.

## CAUSE OF ERRORS

If the ohms range should prove erratic, with constant adjustment being needed to the "set zero" control, it could be the leads giving trouble; a poor contact can add quite a few ohms to the circuit. Try shorting out the meter terminals on the ohms range with a piece of bare thick copper wire and see if stability is restored; if it is, then the leads are at fault.

Another source of trouble could be the internal battery contacts; these can also be cleaned up and lightly greased in cases of erratic operation.

The potentiometers themselves can become worn or dirty. If access can be obtained to the track, a few drops of switch cleaner may help. In most cases dirt is the answer, but an instrument that has been in use for many years may be worn and a new control from the makers may be the only satisfactory cure. Of course it will be a long time before a new meter gets to this stage.

Oscillator circuits can be prevented from oscillating by the application of the meter or the frequency of oscillation can be radically changed. As voltages in an oscillating circuit differ considerably from those existing when the circuit is not oscillating, it can be seen that completely false readings can be obtained. To minimise the damping effect of the meter, it is best to take measurements in such circuits on the highest range that will give a readable indication.

R.F. circuits can be made unstable by the application of the test prod. As they are then behaving as an oscillator, it follows that voltages will be abnormal. If measurements are confined to points that are decoupled, this problem will not arise.

## VOLTAGE READINGS

In the case of voltage measurements, one must take into consideration the effect that the meter itself may have on the circuit, which may affect the operation, hence the reading.

When measuring through a high impedance, the meter will draw current and thereby produce a voltage drop. This must be allowed for, but it can be calculated by finding the ratio of the meter impedance (ohms-per-volt multiplied by the voltage range) to the source impedance and then applying the same ratio to the source voltage.

## MAINTENANCE

Apart from replacing the batteries once in a while, there is very little maintenance that is needed. Contacts between the meter terminals and test-lead plugs may need occasional attention. These can be cleaned with methylated spirit and then smeared sparingly with thin grease.

The leads themselves are the most likely cause of trouble because, in spite of being made of special high-flexibility cable with a large number of thin strands of wire, they can go open-circuit with constant flexing. Generally the site of the break is near the ends and sometimes a repair can be made.

Other than the points mentioned, the only maintenance is to keep the case clean. A rub over with a barely damp cloth and a polish with a dry cloth will clean most flat plastic surfaces. To clean rough pimple finish surfaces or grooves use an old toothbrush.

Avoid letting any moisture into any of the apertures in the case or damp may start to cause rust on some parts of the interior.

So then, by carefully selecting the most suitable multimeter, giving it reasonable treatment and making the best use of it as we have discussed, we will have a valuable aid in the testing and repair of electronic equipment, whether for business or pleasure. ★

The **PRACTICAL ELECTRONICS** organ is based on a number of distinctive solo stops or theatre voices, with a flute or tibia chorus of extended pitch range. Provision is made for an accompaniment manual and in this case, the manuals are reversible by means of a separate expression pedal for each; so that, for example, an 8ft solo tibia can be reduced in volume to accompany a 4ft flute on the lower manual. The useful expressiveness is thus much extended, great volume not being required in the average home.

The pedal section provides the ground bass one octave below the manual pitch, but there is also 8ft tone so that the monotony of 16ft can be relieved. This section of the organ has its own amplifier and loudspeaker to reduce intermodulation.

No electronic vibrato is provided, but a Leslie type rotor is applied to the manual loudspeaker, thus achieving both frequency and amplitude modulation, as in a pipe organ.

# THE P.E. ORGAN

By Alan Douglas, Sen. Mem. I.E.E.E.

In presenting a design for a small electronic organ, we must remember that the present day concept of this class of instrument is far removed from the classical instruments which have relied on pipes for hundreds of years. Current tastes in the field of entertainment bear no relation to those of 50 years ago, and we have largely electronics to thank for this; it is only because of electronics that we can enjoy sound and music of all kinds in our own homes.

However, in the electronic organ we have a special case; for it is an adaptation of old tone colours to a new method of producing them. So that if one is not well acquainted with the original sounds and how they were formed and combined, there is little likelihood of obtaining realistic synthesis. The author is fortunate in that he has made and played pipe organs for very many years, and in this way we know the limitations beyond which a simple generator cannot go.

This particular instrument has a generating system of extreme simplicity, since the general use of silicon planar transistors throughout removes the need for circuitry essential to confine germanium transistors to their correct working characteristics.

## FREQUENCY DIVIDER SYSTEM

We can define this organ as being a square wave frequency divider system, generating one single type of waveform from nearly 8kHz to 32Hz, distributed over two manuals and pedal. The use of a single waveform severely limits the tonal synthesis possible, but it does so

## SPECIFICATION . . .

| Solo | | Accompaniment | | Pedal | |
|---|---|---|---|---|---|
| 61 notes, CC to C | | 61 notes, CC to C | | 30 notes, CCC to F | |
| contra tibia | 16ft | flute | 8ft | sub bass | 16ft |
| contra viole | 16ft | viole acute | 8ft | major bass | 16ft |
| double horn | 16ft | clarinet | 8ft | bass flute | 8ft |
| tibia | 8ft | trumpet | 8ft | | |
| viole | 8ft | flute | 4ft | | |
| echo horn | 8ft | violina | 4ft | | |
| oboe | 8ft | | | | |
| tibia | 4ft | Expression pedal | | | |
| violina | 4ft | | | | |
| piccolo | 2ft | | | | |
| Expression pedal | | | | | |

**Circuit**
All transistorised. Square wave frequency divider system

**Output**
Manuals: 15W amplifier driving 10in W.B. unit with Leslie tremulant
Pedal: 7W amplifier driving 12in W.B. unit
Loudspeakers housed in separate two-compartment enclosure

**Dimensions**

| | *Width* | *Depth* | *Height* |
|---|---|---|---|
| Console: | 53in | 20½in | 45in |
| with pedalboard | | 36¼in | |
| Loudspeaker enclosure: | 15⅛in | 24in | 55in |

**Finish**
Arborite Superdec Sapele laminate

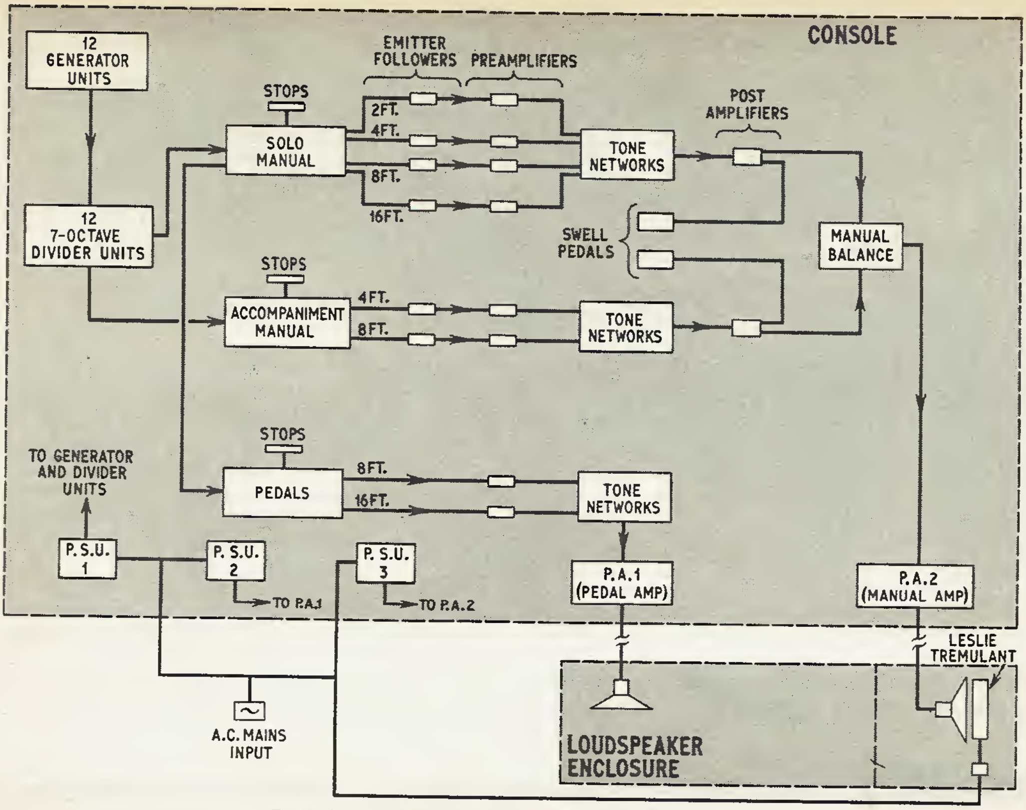



*Fig. 1.1. Block diagram of the complete organ*

happen that all the tone colours or voices required for a romantic entertainment organ can be formed from a square wave. It would not do for a church or concert organ, which would have to have sine and sawtooth waves as well.

Naturally, the high harmonic content of a square wave requires careful handling; a common method being to use such heavy filtering that little is left but fundamental tones. Such instruments, whilst sweet and attractive at first, soon pall as there is no life in the sounds. Another common failing is that the generating system does not go high enough in pitch.

In most small organs, the top octave, or even the top two octaves, double back in pitch so that in fact stops labelled 4ft and 2ft are misleading because they do not cover the compass stated. Such instruments cannot have any brilliance of tone. It seems a pity, when the basic cost is naturally high, that an extra octave or two is not added—it makes such a difference.

## TONAL SPECIFICATION

It is the prevailing custom to divide the small domestic organ into an upper keyboard having predominantly solo voices, and a lower manual really for accompaniment. The pedal section supplies the bass, and we have followed this scheme in the specification shown, but with one very important difference.

Whereas it is customary to have the whole organ on one expression pedal, we use a separate one for each manual and the pedal is not controlled in volume except by the stops. This facility enables us to reverse the organ, as it were, and subdue the upper keyboard voices whilst making the lower ones louder if desired.

In this way, extra solo voices are obtained at negligible cost, and we have added a clarinet and trumpet to the lower keyboard for this reason. Thus, any balance whatever between the two manuals is possible and it is surprising what extra flexibility and tonal range this gives.

One would find this, of course, on a theatre pipe organ as a matter of normal design. It certainly makes the organ a little harder to play, but then any organ has to be carefully studied before the best results can be obtained.

## KEY AND PEDAL COMPASS

Many small organs have a keyboard compass of 3, 3½ or 4 octaves which is admittedly a help for the tone circuits, since it eliminates many technical difficulties. But if we can provide sufficient tone colours to interpret a great deal of organ music, then the legitimate 5 octave keyboard is much more useful.

The same applies to the pedals, and we have fitted a full 30 note pedalboard here which can be pulled out and stood on end; but of course, the short compass boards of 13 notes could quite well be fitted if desired.

## MODIFICATION

In any organ, we can degrade the system much more easily than improve it, therefore we start with a full scale system and this can be simplified in some respects as will be apparent later on. The question of space may be the deciding factor, but it must also be remembered that all electronic tone generators can be modified or enlarged, so that if, at some future date it is decided to extend or revise the tonal scheme, then if all the playing facilities are there in the first place, it will be much easier.

## SIGNAL PATHS

If we look at Fig. 1.1, a block diagram of the complete system, we can trace the path of the signals and see how the sections are co-ordinated. The 12 oscillators are powered by the same unit as the 12, 7-octave dividers. The divided signals reach the manual resistive contact switches and are applied to busbars of the correct pitches by printed circuit wiring.

The signals now pass through an emitter follower for each pitch and through a preamplifier to their respective tone networks. Each manual mixed tone net outlet goes to a post amplifier and so to a balancing network. From this, the expression pedals route the tones to the manual power amplifier.

The pedal signals are derived from the upper manual and have their own tone nets and preamplifiers. There are no post amplifiers and the 8 and 16ft tones pass direct to the pedal power amplifier.

The manual speaker has a Leslie type rotor tremulant; the pedal loudspeaker of course has no vibrato. These units are contained in a separate enclosure.

Three power supplies, all well regulated, serve the different sections. The pedal contacts have provision for sustain, although this is not fitted; similarly a reverberation device can be applied after the balancing network if desired. The tone networks are enclosed in a screening box as are the post amplifiers and the balancing circuit. Otherwise no screening is used beyond that on the signal cables.

## GETTING STARTED

Now the circuitry associated with a transistorised frequency divider organ is quite light in weight, so that the whole system can be fixed to the kneeboard of the instrument and this means that no cumbersome building frame is required.

We can start with the preliminary console details which are nearly all woodwork. A cutting list of materials required is given on page 360. Ultimately the woodwork can be clad with one of the popular imitation wood finish laminates. Our prototype organ is finished with Arborite Superdec Sapele.

For convenience, cheapness, and strength we make the sides from ¾in plywood. After cutting off the corner pieces as shown in Fig. 1.2, the cut-outs for lower frame members should be made.

To provide a secure base for the sides, two hardwood feet as shown in Fig. 1.3 should be fixed. Prior to this a decorative ¼in chamfer is made along the edges. It is essential to countersink fully for the three 2½in No. 12 woodscrews fixing these hardwood strips so that the screw heads cannot catch in a carpet.

Attachment of the lower frame member D, with two 2in No. 12 countersunk wood screws at each of the sides will enable the frame to stand upright. Additional support is provided when the kneeboard support batten E is slid into the cut outs of the side panel and glued as shown in Fig. 1.4.

## KEYFRAME SUPPORTS

It is surprising how much force is sometimes unwittingly applied to a keyboard. Usually the pair of manuals are carried on a heavy wooden plank, but it is easier, and in many ways more convenient, to use a piece of 1in × 1in × ⅛in rolled steel angle with a hardboard rear keyboard support rail. Deformation of the keyframes would certainly lead to contact trouble.

Attachment of the front keyboard support rail F is by means of two 2in lengths of 1in × 1in batten which are first screwed to the sides A with a 1¼in No. 8 woodscrew. Where the steel angle meets these battens, holes should be drilled and countersunk to take single ½in No. 4 woodscrews. The rail can now be affixed.

The rear keyboard support rail C, which is of hardwood, has similar batten mounting pieces, the only difference here being that two fixing screws, 1¼in No. 8, are used for retention as shown in Fig. 1.5.

## OBTAINING THE KEYBOARDS

The next step is to obtain and fit the keyboards. These are of five octaves compass, 61 notes, CC to C, and are obtainable as single units from J. J. Goddard Ltd., or the same but made throughout in plastic and extruded metals from Kimber-Allen Ltd. This is again a single unit set and is made in Sweden; it is much superior to the Italian sets available from some sources.

As we are going to use key switches actuated by their own integral plungers, one might be lucky enough to pick up a second-hand matched two manual set from an organ builder or even from an old harmonium. The small amount of side play cannot affect the kind of key switch proposed, though it might be quite serious with some other forms of contact.

## MOUNTING THE LOWER KEYFRAME

The Goddard keyframe is not very strong and is intended to be mounted on a more substantial material which in our case is the steel support rail F and rear batten C, no further reinforcement being necessary.

Centrally position the lower keyboard on the support members then secure it with four short screws through the steel and four long ones through the batten.

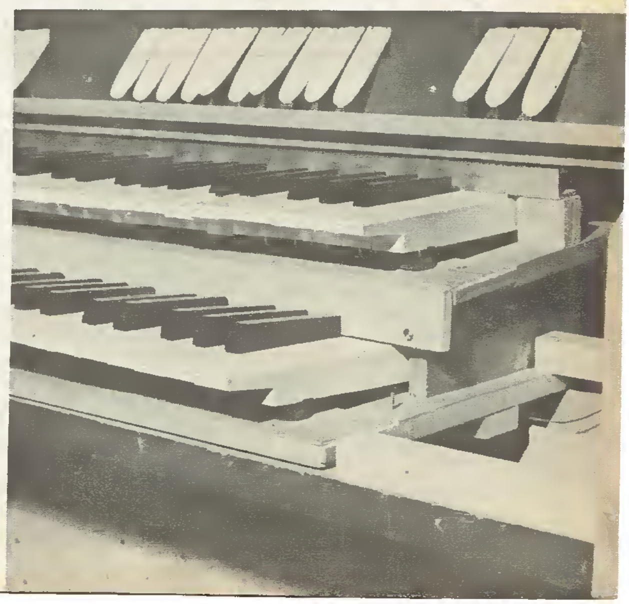
When purchased the Goddard key will not have any springs fitted. These can be obtained from Henry's Radio Limited. If plastic keyboards are purchased it will be found that springs are integral to these assemblies.

Examination of the keys at this stage will show a slight upward tilt. By slightly rotating forward the steel angle and rear batten the keyboard position can be made parallel with the floor.

## KEYBOARD THUMPER BARS

The upper keyboard rests on two end pieces as in Fig. 1.6. Here again we must tilt the keys forward with a 10 degree slope, which facilitates certain types of playing.

*Arrangement of upper and lower manuals. Full details and measurements appear on next two pages*



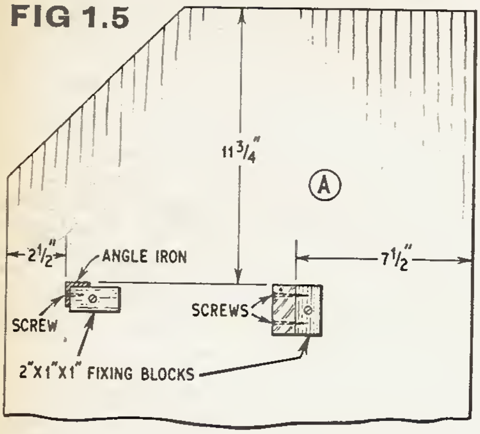
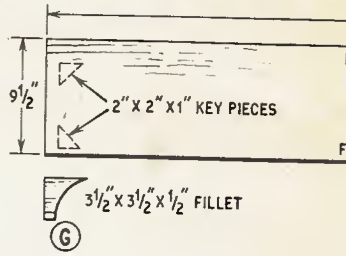



FIG 1.5



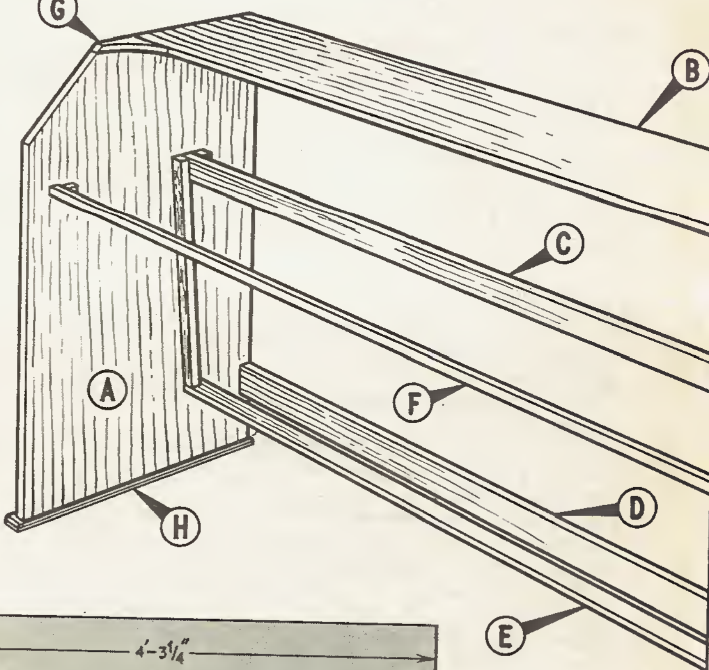




FIG 1.4

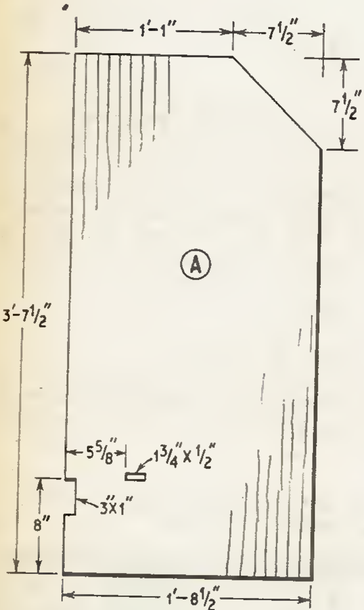



FIG 1.2

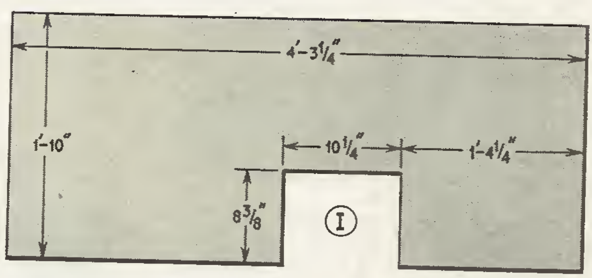



FIG 1.11

## CONSOLE CUTTING LIST

| | |
|---|---|
| Sides (A) (2 off) | 1ft 8½in × 3ft 7½in × ⅞in ply |
| Top (B) | 4ft 5in × 9½in × ½in ply |
| Rear keyboard support rail (C) | 4ft 3¼in × 2in × 1in hardwood |
| Lower frame member (D) | 4ft 5in × 3in × 1in hardwood |
| Support batten for kneeboard (E) | 4ft 5in × 1¾in × ½in wood |
| Front keyboard support rail (F) | 4ft 3¼in—1in × 1in × ⅛in steel angle |
| Top fillet (G) (2 off) | 3½in × 3½in × ½in ply |
| Feet (H) (2 off) | 1ft 9in × 1¾in × ⅝in hardwood |
| Kneeboard (I) | 4ft 3¼in × 1ft 10in × ⅜in ply |
| End cheeks (J) (2 off) | 10¾in × 4½in × 1½in wood |
| Upper keyboard supports (2 off) | 7in × 3⅜in × ¾in wood |
| Lower thumper bar | 2ft 11¾in × 1¼in × ⅜in wood |
| Upper thumper bar | 2ft 11¾in × ¾in × ¾in duralumin |

Quantity of 1in × 1in batten as required

**Keyboards**

61 note keyboards (2 required)
J. J. Goddard Limited,
37 Union Street, London, S.E.1.

The same but made throughout in plastic
Kimber-Allen Limited,
London Road,
Swanley, Kent.

Key springs (not required for plastic keyboard)
Henry's Radio Limited,
303 Edgware Road, London, W.2.

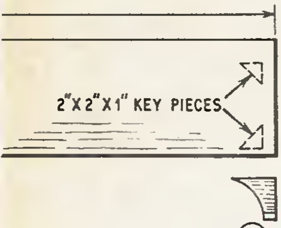
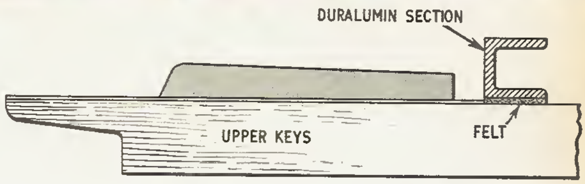



FIG 1.10



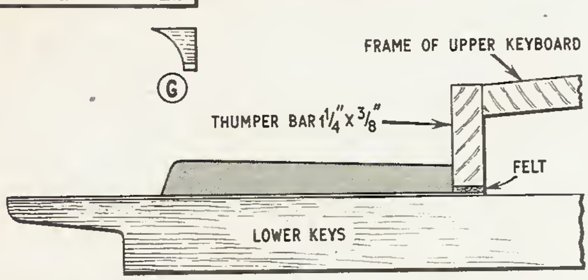




FIG 1.7

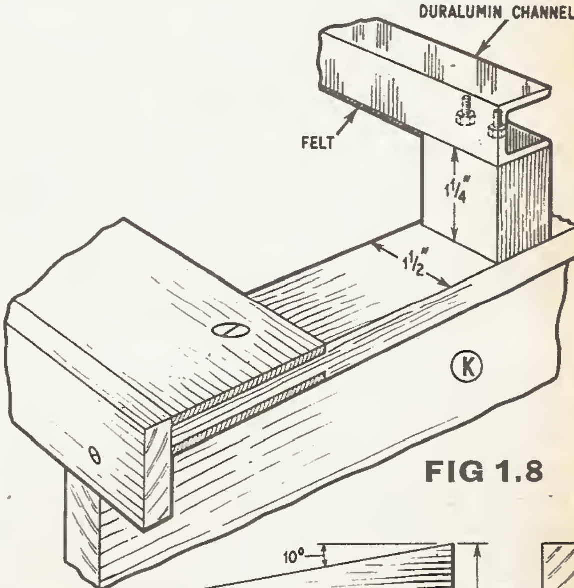



FIG 1.8

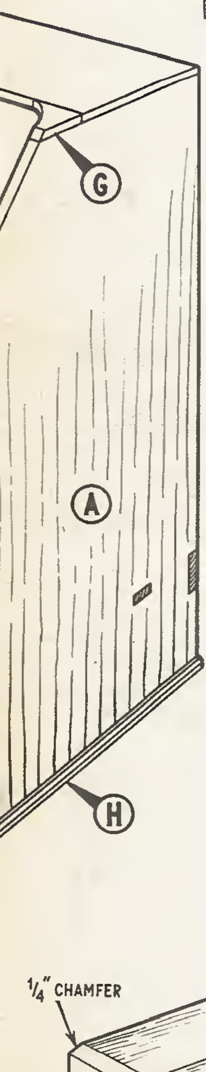



*Fig. 1.2.* *Case sides*

*Fig. 1.3.* *Hardwood feet*

*Fig. 1.4.* *Sides positioned by frame and keyboard supports*

*Fig. 1.5.* *Fixing method for keyboard supports*

*Fig. 1.6.* *Upper keyboard supports*

*Fig. 1.7.* *Lower keyboard thumper bar in position on keys*

*Fig. 1.8.* *Upper keyboard thumper-bar shown bolted to lower keyframe via woodblock*

*Fig. 1.9.* *Ornamental end cheeks*

*Fig. 1.10.* *Panel for case top*

*Fig. 1.11.* *Kneeboard*

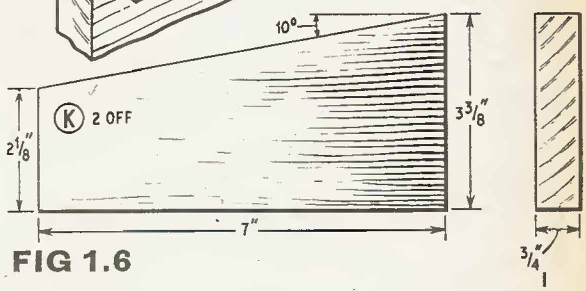



FIG 1.6

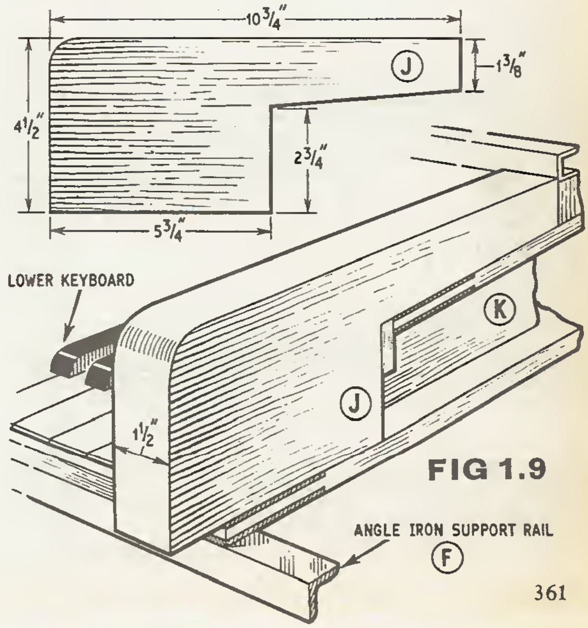



FIG 1.9

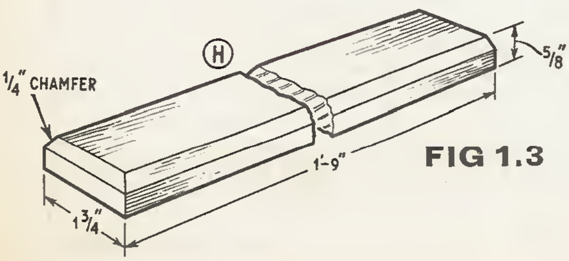



FIG 1.3

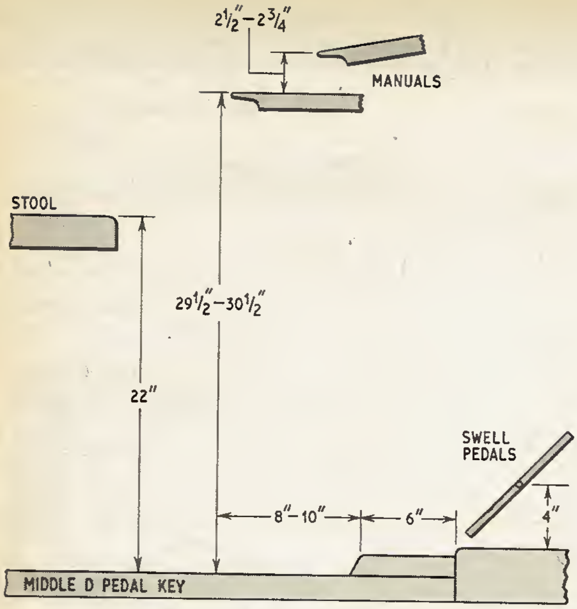


*Fig. 1.12. Preferred console dimensions*

When the springs are attached to the keys, these latter will rise at the front, as will those of the lower keyboard.

To check the lower keys a strip of wood called a thumper bar is fixed across the side members as in Fig. 1.7. The height of this is adjusted until the depth of touch, the distance a key will depress, is about $\frac{5}{16}$in. In time, this will fractionally increase due to compression of the felt.

Now we can try the touch resistance of the lower keys and if need be, stretch the springs slightly if too strong.

For the upper keyboard we need a stronger thumper bar and this is made from a piece of duralumin channel section $\frac{3}{4}$in × $\frac{3}{4}$in × $\frac{1}{8}$in wall thickness.

A two point anchorage is required at each end as shown in Fig. 1.8 using 4B.A. nuts and bolts, the bolt length being 2¼in. Again the height is adjusted to give a touch of $\frac{5}{16}$in. To prevent mechanical clicks, the underside of both bars is covered with a strip of red or green felt $\frac{3}{4}$in wide by $\frac{1}{16}$in thick which is obtainable from Goddard Ltd.

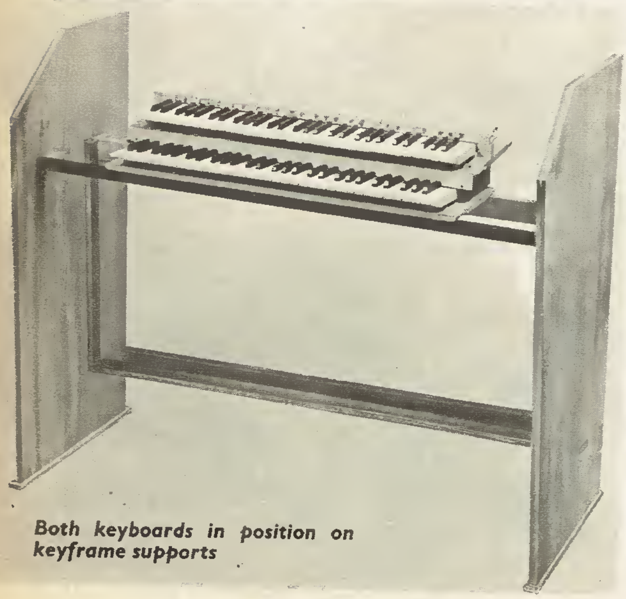
When the top keyboard is in position, a wood screw can be passed through the lower thumper bar into the frame of the upper keyboard, which will stiffen this assembly.

Plastic keys have limit stops moulded in, so require no bars, but ornamental strips of wood may be attached to conceal the metal frame. .

The complete assembly can be seen in the photograph.

Finally make two ornamental end cheeks as in Fig. 1.9 from 1½in thick wood such as oak or mahogany. The illustration shows how they are fitted and they can be seen in the introductory photograph of the organ.

All the foregoing requires great care, but should be persevered with, since if there is any uncertainty about the keys, the organ will never be a pleasure to play.


*Both keyboards in position on keyframe supports*

## TOP AND KNEEBOARD

The last two major items of woodwork that complete the console will now be described. Both are essentially rectangular so the carpentry is simple.

First, the top B which is of ½in ply is shown in detail in Fig. 1.10.

For reasons of easy access to electronic subassemblies it was decided not to make this a fixture. A simple method of locating the top to the sides is by the use of triangular key pieces shown dotted.

The actual glueing of these pieces should be delayed until the organ is complete. This will ensure a more precise keying of the top.

The two fillets G are an optional decorative extra.

Fig. 1.11 gives the dimensioning of the $\frac{3}{4}$in ply kneeboard I which will take the bulk of the electronic assemblies.

To fix this, first cut two lengths of 1in × 1in batten. These should now be attached as shown in Fig. 1.4, one at either end of the cross members E and C.

Fixing should be at the sides A and forward of the rear support rail C using 1½in No. 8 woodscrews.

The kneeboard can now be retained by the battens using six 1in No. 8 woodscrews.

## INTERNATIONAL STANDARDS

Whilst the case geometry could be modified to conform with different tastes, one thing is essential, that the keys and stops should be properly related to the pedalboard. We give the preferred measurements in Fig. 1.12 which conform closely to the agreed international standard.

Comfort is essential when playing especially with a full size pedalboard. One can see that the whole physical design is related to the pedalboard, and this also refers to the extent to which the sharps on the pedals are set back from the front of the manual keys.

This in turn determines the position of the expression pedals. So that, if no pedals were fitted, or in the case of a 13 note pedalboard, the dimensions of Fig. 1.12 will still prove to be the most suitable.

Therefore in the console design, we have allowed for the use of the proper full scale parts, and if the pedals are not fitted at once, one can be confident that they will mate with the console at a later date.

Next month we will start on the attachment of the key contact system and some of the electronic sub-assemblies.

*To be continued*


**By M. A. Colwell**

WHAT is the true definition of stereo (in the domestic hi fi world)? A strange question one may think, but this was recently brought home to me by recent comments in an article in a Sunday newspaper.

It seems to be a not uncommon practice for some recording companies to cut discs and label them stereo, when really the recording has been made by judicious juggling of faders, to control the relative sound levels of each instrument and feed them into two independent channels. The result can be quite pleasing and the unsuspecting listener is probably unaware of how his recording was produced.

## TWO-AND-A-HALF DIMENSIONAL

"So what!" you might say—"the effect is three-dimensional, it sounds like stereo, so what does it matter!" But is it really three-dimensional or only two-and-a-half dimensional? Does it seem to have depth as well as width.

This is an all important aspect of stereo, but it can become a cheap and easy means for any Tom, Dick, or Harry to set himself up to record music, that is not a true facsimile of the original performance in terms of instrumental positioning. But is this important? Well, conductors and composers think it is important in order to put over the message they are trying to recreate.

The only genuine method is for recording companies to use (as many do) the very simple arrangement of twin microphones in the centre of the proceedings.

But it is claimed that there is a serious risk of "hole-in-the-middle" effects, i.e. the balance of the two channels is such that what goes on in the centre is reproduced in equal magnitude by both channels, leaving a certain air of uncertainty as to its precise location. This problem can and is being overcome in some circles, but is only "small-fry" in comparison with deceiving the customer.

## MISLEADING SPECIFICATIONS

On the same topic is the publication of a specification for so-called hi fi equipment, worded in such a way that the customer, who is perhaps only moderately acquainted with the jargon, sees no reason to suspect that the equipment is anything but hi fi. But on comparison with much better gear he finds that the "fi" is not as "hi" as he was led to believe.

So he looks again at the specification. Perhaps he cannot understand what is wrong. Usually it is the phrasing of the specification that is not acceptable.

For instance, a frequency response of, say, "30Hz to 20kHz" means absolutely nothing. If it was termed frequency range then this quotation could be correct, but it says nothing about the sound levels at the ends of this spectrum in relation to the mid-frequency range (1kHz). True, the level at 10 or more kilohertz could be audible, but only just.

Similarly a power rating of so many watts means very little unless some indication of distortion is given with the correct loading. The importance of an accurate description is as important as diagnosing an illness correctly before applying suitable treatment.

If you are not absolutely sure you understand every word in a specification consult an acknowledged expert in high fidelity audio before committing yourself to a purchase.

But you may think: How do I tell where low fidelity ends and high fidelity begins? Experience will tell, but in the meantime, go along to some of the several hi fi showrooms up and down the country and ask for a demonstration of several combinations of equipment. The dealer will either be very willing to do this for your own sense of satisfaction, or will blush at being behind the times.

## SOUND REINFORCEMENT

In addition to the hi fi fraternity, another body, the Association of Public Address Engineers, is equally concerned with moral ethics and standards in specifications, and are always willing to help potential clients of their members in obtaining satisfactory equipment and facilities for the purpose for which it is required.

Sound reinforcement is the preferred term these days and modern equipment has been designed to assist the audience with the absolute minimum of unnatural electronic phenomena imposing on aural comfort. Some of this equipment and talks were held at the annual exhibition at the King's Head Hotel on the Hill at Harrow from March 11 to 13.

## ON SHOW?—NOT YET!

The rather different appearance of this article this month, with no news of new equipment, is partly deliberate, partly accidental. The fact is that in the few months prior to the Annual Audio Festival and Fair (Olympia, London, October 16 to 21), manufacturers put on "cloak and dagger" and are very reluctant to release details of new developments too soon, for fear of being too helpful to competitors.

Last year, the Fair showed some interesting advances; this year we hope we shall be equally surprised. Nonetheless, the main interest will be to see if the new venue proves acceptable (audibly) and successful (commercially).

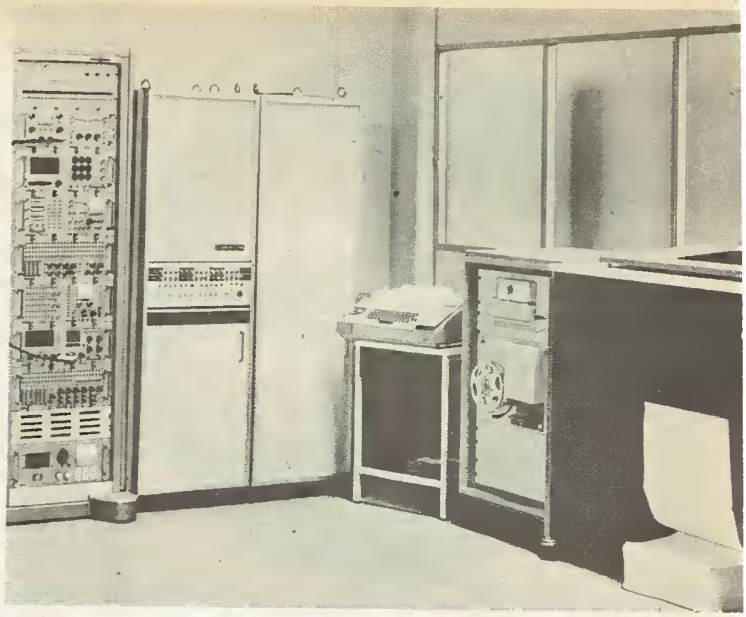
It is expected that P.E. will be represented there after another hair-raising stint at the R.S.G.B. exhibition. What are we going to show? Wait and see—we can be just as secretive as the manufacturers, but it will all be worth while.

## British Computers Help Europe's Satellite

THE European Space Research Organisation's HEOS-A satellite successfully lifted off the launch pad at Cape Kennedy after being thoroughly checked out by two British computers. These systems, a Honeywell DDP 516 and DDP 116 (shown right), have been closely involved in the "Highly Eccentric Orbit Satellite" project from first test to final countdown and launch.

The computers provided two complete and identical check-out systems which, via telemetry equipment, were responsible for all communications with the HEOS-A spacecraft. Messages transmitted under keyboard control included up to 200 variable commands for switching experiments on or off, and for changing experimental modes.

Among the experiments being conducted by HEOS-A are investigations of the earth's magnetic and electrical fields, interplanetary magnetic fields, high energy cosmic ray protons, and low energy solar protons, the flux and spectrum of cosmic ray particles and the so-called solar wind.



# ELECTRONORAMA

## Water Pollution Study

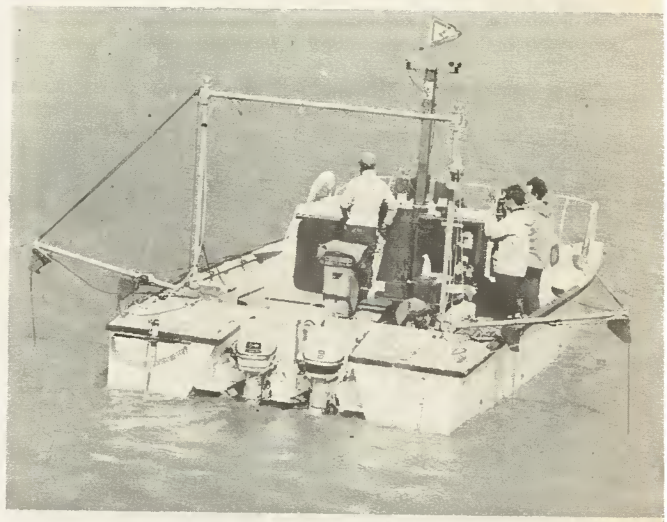
POLLUTION of beaches around our coast is a subject of public concern. The Water Pollution Research Laboratory at Stevenage, a department of the Ministry of Technology, have been carrying out experiments to examine the effects of environmental factors on the dispersion of sewage from sea outfalls.

A radioactive tracer (Bromine 82) is added either to the sewage as it enters the sea or directly to the sea at the site of an existing or hypothetical outfall. The dispersal of the tracer is then determined by a number of radiation counters towed at constant speeds and different depths by the survey vessel shown right.

The output from the counters is fed to a recorder housed in the vessel (see photograph below). The recorder, which is battery powered, has five tracks for recording counter output and three other tracks for a recorded controlled-frequency pilot tone, an audio "notebook" containing readings of the position of the vessel, and an event marker channel for pinpointing the audio position "fixes".

On completion of the sea survey the recorded tape is replayed in the laboratory on a similar instrument feeding a timer-counter, a paper tape punch and, if required, a decimal printer.

The recorded controlled-frequency pilot tone is used as the time base for the timer-counter to allow for differences in the speeds of the two tape transport systems. The event marker signals corresponding to shore "fixes" appear on the punched tape as serially numbered identification characters.



(Crown Copyright, Water Pollution Research Laboratory)

(Crown Copyright, Water Pollution Research Laboratory)

## Electronic Sorting

As a major step towards establishing fully automated postal sorting offices in Britain, The Plessey Company has completed its first production test of electronic coding desks and translators. This equipment substitutes the written postal code/address on letters with a code that can be understood by machines used for mail handling in an automated post office.

After being sorted for size and then letter faced, the mail is presented to an operator on a coding desk who copytypes the six character code on the electronic keyboard, similar to a typewriter. Information is then fed as an electronic signal to the translator which changes the data into two 12 bit binary code patterns, one representing the "post town" of the address and the other the street or road in which the recipient lives.

The binary code patterns are printed on the envelope as two rows of luminescent dots which are almost indiscernible to the human eye. All mail sorting machines are designed to read these dots thus enabling a letter to be processed completely automatically.

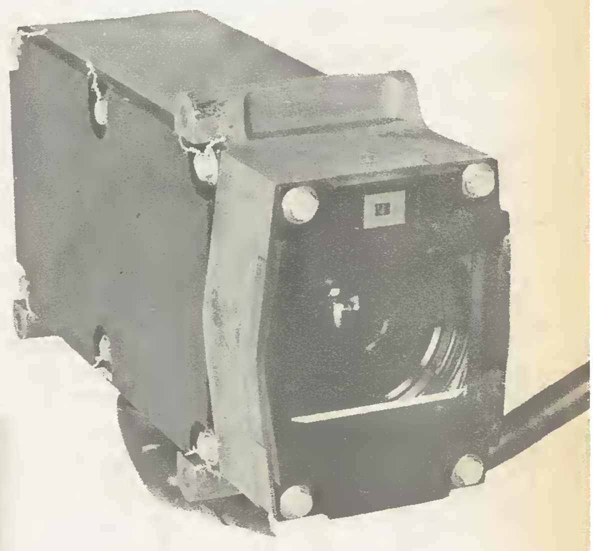
*Mr. N. C. C. De Jong, Director of Postal Mechanisation for the GPO, accompanied by Mr. J. Piggot, Deputy Director of Design and Development and Mr. J. H. Nicoll, General Divisional Manager of Plessey Automation Divisions at Poole, examines mail being processed through the electronic code translator*

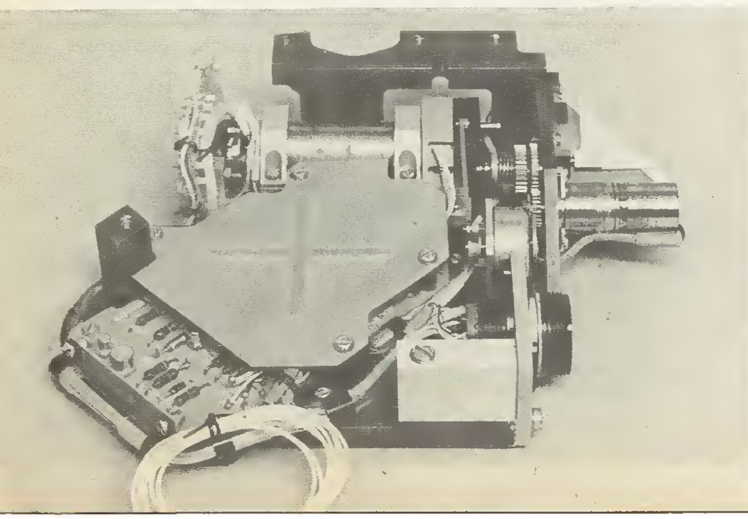
## CCTV for Concorde

Closed circuit television equipment has been installed in Concorde prototypes 001 and 002. Pictures from any of the cameras can be selected for viewing on two monitors and can also be recorded on a video tape recorder.

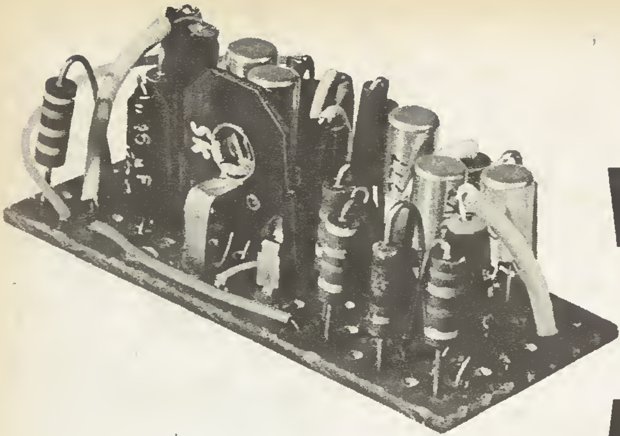
This very rugged camera head, specially designed for aircraft use, is completely sealed in a strong aluminium alloy casting. The lens, housed internally, looks out through a sealed window which incorporates an electrical heater. The camera incorporates a sun shutter and when used with the EMI Camera Control Unit type CC1106 provides a fully automatic camera system. The rugged EMI 26mm (1 inch) Vidicon Tube type 9730 and printed circuit scanning coils are used in this unit.

Two of these cameras, one facing aft and one facing forward, are used on each Concorde aircraft for taxiing and landing aid applications.





Three of these cameras have been fitted within various small spaces available in engine nacelles to enable possible in-flight icing conditions to be observed and recorded. Special optical devices have been engineered to give the necessary viewing angles required in the confined spaces available.



# VERY HIGH IMPEDANCE AMPLIFIER

BEFORE delving into the technicalities of this particular circuit, it is necessary to explain just how important a very high input impedance is in certain applications, and just what is meant by the expression "high impedance".

The terms "high" and "very high" impedance are, of course, relative terms. In valve circuits, for example, impedances in the range of several hundred kilohms are normal, whereas, in transistor circuits, impedances in the range of a few kilohms are considered to be common. Generally, in transistor circuits, impedances in the range of several tens of kilohms are considered to be "high", while impedances of greater than a few megohms are regarded as "very high".

## INPUT IMPEDANCE

The higher the input impedance of a unit, such as a voltmeter, valve voltmeter or oscilloscope, etc., the lower will be the power that it takes from any circuit under test and thus the lower will be any error in the readings that are obtained due to loading effects.

## CRYSTAL MICROPHONE

When a crystal microphone or pick-up is to be fed to an amplifier, it is very important that the amplifier should have a very high input impedance, if low frequency attenuation is not to take place. The effective circuit of the crystal microphone feeding into the amplifier input is shown in Fig. 1. The equivalent circuit of the crystal microphone is shown dotted in Fig. 1, a voltage generator in series with a capacitance, usually in the order of 1,000pF. This capacitance is in series with the input of the amplifier.

Since *C* and *R* are in series, they act as a potential divider network, the attenuation of the circuit depending on frequency. When the reactance of *C* equals *R*, the signal appearing at their junction will be half that at the generator terminals (or 6dB down). Thus, for a good low frequency response, *R* should be as large as possible.

## HIGH IMPEDANCE TRANSISTOR CIRCUITS

One transistor circuit which will give a high input impedance is the emitter follower or common collector amplifier, shown in its basic form in Fig. 2a. Another method is to use the Darlington or super-alpha pair, shown in Fig. 2b. Here, TR2 is connected as a normal emitter follower, as in Fig. 2a, but an additional transistor, TR1 is interposed between the input and TR2. The additional transistor has its emitter directly coupled to the base of TR2; this way the effective gain of the circuit as a whole is equal to the product of the two individual transistor gains.

## BOOTSTRAPPING

In Figs. 2a and 2b the base-bias is shown as being current derived via a single resistor R2; this method of base-bias results in poor temperature stability. For good stability, a voltage-divider base-bias network

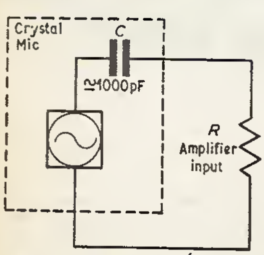



*Fig. 1. Effective circuit of a crystal microphone connected to the amplifier input*

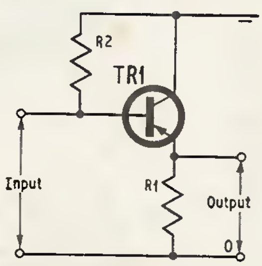



*Fig. 2a. Basic emitter follower or common collector circuit*

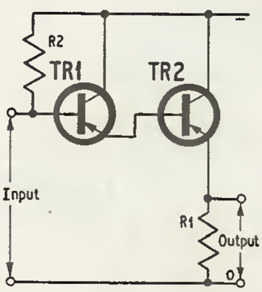



*Fig. 2b. Basic Darlington pair connected emitter follower*

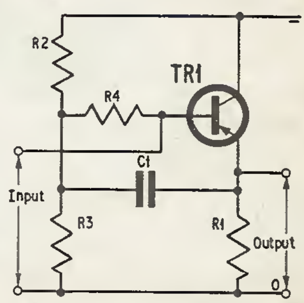



*Fig. 2c. Basic bootstrapped emitter follower*

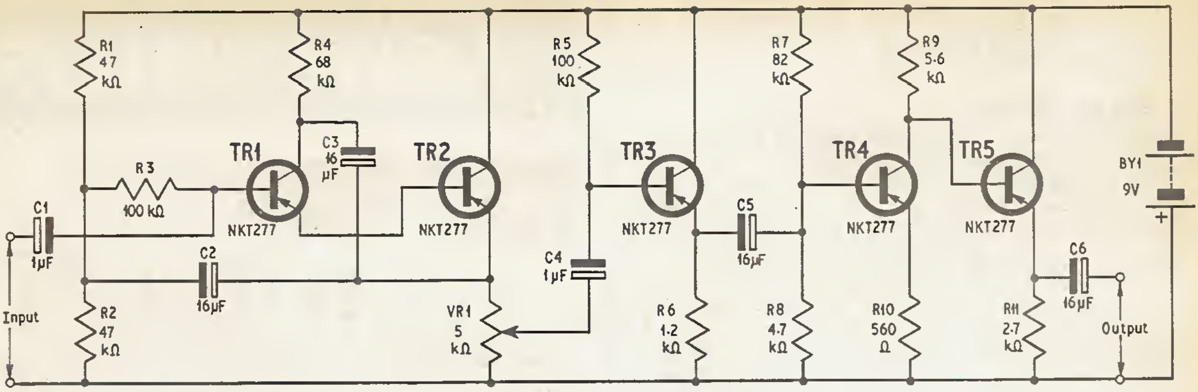



*Fig. 3. Circuit diagram of the very high impedance amplifier*

should be used. Such a network would shunt the input circuit even more and so reduce the input impedance further.

This difficulty can be overcome by employing the technique known as "bootstrapping", as shown in Fig. 2c. Here, the voltage-divider base-bias network comprises R2 and R3. The input signal is fed directly to TR1 base.

The voltage gain of an emitter follower is nearly 1, and virtually the same signal injected at the base will be reflected at the emitter, both signals being in phase.

The a.c. emitter signal is coupled back to the junction of R2, R3, and R4 via C1; thus, the same a.c. signal is present at each end of R4 and no a.c. current flows in this resistor. It follows that the resistor acts as an extremely high impedance to a.c. (but not to d.c.) and thus eliminates the shunting effect of the base-bias network.

The final circuit of the very high impedance amplifier has an input impedance of approximately 5 megohms and the output impedance is one hundred ohms.

## PRACTICAL CIRCUIT

Referring to the full circuit diagram shown in Fig. 3, the input is connected via C1 to the base of TR1. TR1 and TR2 are connected as a super-alpha pair in the emitter follower configuration, the emitter load being VR1. The base-bias network, R1 and R2, is coupled to TR1 base via R3. Capacitor C2 feeds the bootstrap voltage from TR2 emitter to the potential divider junction. The effective leakage impedance of TR1 is also bootstrapped, via R4 and C3.

To prevent the emitter load of TR2 from being effectively shunted by the input impedance of TR4, an additional emitter follower stage, TR3, is inserted in the circuit. The base biasing of TR3 is controlled by resistor R5.

Resistor R10 is the emitter load for TR4 which is connected as a common emitter amplifier. As R10 has no decoupling, negative feedback is applied to this stage, and TR4 produces a voltage gain of approximately $8\frac{1}{2}$ times.

Finally, another emitter follower, TR5, has its base

## COMPONENTS . . .

**Resistors**

| | | | |
|---|---|---|---|
| R1 | 47kΩ | R7 | 82kΩ |
| R2 | 47kΩ | R8 | 4·7kΩ |
| R3 | 100kΩ | R9 | 5·6kΩ |
| R4 | 68kΩ | R10 | 560Ω |
| R5 | 100kΩ | R11 | 2·7kΩ |
| R6 | 1·2kΩ | | |

All ±10%, ¼ watt carbon

**Potentiometer**

VR1 5kΩ miniature skeleton preset

**Capacitors**

| | | | |
|---|---|---|---|
| C1 | 1μF elect. 15V | C4 | 1μF elect. 15V |
| C2 | 16μF elect. 15V | C5 | 16μF elect. 15V |
| C3 | 16μF elect. 15V | C6 | 16μF elect. 15V |

**Transistors**

TR1, 2, 3, 4, 5 NKT277 (Newmarket) (5 off)

**Miscellaneous**

BY1 9 volts, type PP7 or PP9

Veroboard, battery connectors, p.v.c. covered wire, screened input lead, metal case and coaxial plug and socket (if required)

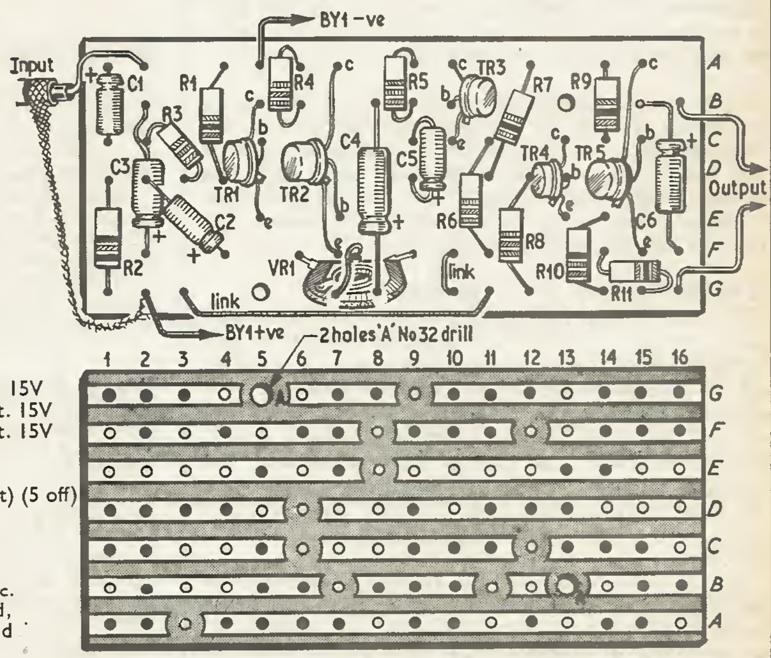



*Fig. 4. Layout of components on the board and underside view showing the breaks in the copper strips*

directly coupled to TR4 collector and gives a final output impedance of approximately 100 ohms, via C6.

The emitter load of TR2 is the volume control VR1.

### CONSTRUCTION

Start by cutting the Veroboard to size and breaking the copper strips as indicated in Fig. 4.

Wire up the first two stages of the unit—TR1 and TR2. With a voltmeter, check that the voltage on the base of TR1 and the emitter of TR2 is about 4½ volts. Carry out a simple function check on this stage.

Wire up the rest of the unit, one stage at a time, checking carefully the wiring and carrying out a functional check on each stage.

When used in high impedance applications, it is essential that a screened input lead be used, and that the completed circuit board be enclosed in a metal case.

Two 6B.A. mounting holes are shown in Fig. 4; the board should be mounted on insulating spacers with two 6B.A. screws. Clear away surplus copper around the screws to avoid the risk of short circuits. A coaxial socket can be mounted on the case if desired or the screened lead can pass through a hole in the case directly to the board at points *2A* and *2G*. If the input lead is passed through a hole in the case, a rubber grommet should be fixed in the hole to protect the lead from chafing.

### VARIATIONS OF THE CIRCUIT

If the unit is required to act as a straight forward impedance transformer, without amplification, then TR4 and TR5 stages can be eliminated from the circuit, the output being taken from C5 positive.

If greater voltage gain is required in the audio frequency band, connect a 50$\mu$F decoupling capacitor in parallel with R10. If a voltage gain in the order of approximately 8½ to 25 is required, with maximum possible bandwidth, insert the decoupling capacitor as above and also break the connection between R7 and the negative line and re-connect the top end of R7 to TR4 collector. Adjust the values of R7 and R8 until the required value of gain is obtained, consistent with a no-signal voltage of approximately 4½ volts at TR4 collector.

It may be necessary, in both of these cases, to insert a decoupling network in the negative supply line between the TR3 and TR4 stages, to prevent instability. This would be a 470Ω resistor in series with the negative supply line between R7–R9 and TR3 collector. A 100$\mu$F capacitor is then connected between TR3 collector and the common positive line.

### APPLICATIONS OF THE UNIT

The unit is ideal for use as a buffer stage between a high impedance crystal microphone and the low impedance input to a transistor amplifier. If the TR4 and TR5 stages are eliminated from the unit and VR1 is replaced with a fixed 4·7 kilohm resistor, the resulting unit will be small enough to be built into a crystal microphone case. The crystal microphone unit will then have an effective output impedance of 100 ohms and thus overcome the hum troubles that normally occur when these have long connecting leads to amplifiers.

Because of the very low value of input capacitance of the circuit, input impedances some 10 to 15 times greater than are possible with normal test equipment, are available at frequencies above about 100KHz. The voltage rating of C1 will, generally, have to be increased to suit the application. ★



# NEWS BRIEFS

## Rapier Anti-Aircraft System to get Radar Eyes

The Ministry of Technology has placed a contract with the British Aircraft Corporation and Elliott Space and Weapon Automation Limited to develop and manufacture equipment to extend the capability of the BAC "Rapier" anti-aircraft missile system. About 70 per cent of the value of this contract will go to Elliotts who will manufacture the Elliott-designed tracking radar units.

The "Rapier" system, using optical guidance, has been successful during its trials and has been ordered for both the Royal Air Force and the British Army. Substantial overseas sales have also been made. The new radar tracking system will permit engagement of targets during the hours of darkness and in poor visibility.

## Pocket Paging for Stock Exchange

Pocket paging receivers, measuring only 1$\frac{9}{16}$in wide by 5¼in high by ¾in deep, are to be used at the London Stock Exchange to call dealers immediately they are required by their offices. Initially 1,200 pocket receivers will be installed but the system can be expanded up to 4,000 units.

The paging receiver uses copper-clad Bakelite laminate, supplied by BXL, for the circuit board.

## Fifteenth VHF Convention

The fifteen VHF/UHF Convention will take place on Saturday, April 26 at the Winning Post Hotel, Whitton, near Twickenham in Middlesex. Tickets for the Convention can be obtained from Mr F. Green at 48 Borough Way, Potters Bar, Herts. Tickets for the whole day are priced at 32s 6d, for the afternoon 5s, and for the banquet only 27s 6d.

## Central Training Council Report

The third report of the Central Training Council, under the chairmanship of the Rt. Hon. Frank Cousins, was published on March 3. The report deals with many aspects of Industrial training and gives recommendations for the training of computer staff.

A second Committee was set up to look more closely at the problem of computer staff training, its recommendations for the training of systems analysts (commercial) has now been published and work is in hand on the process and scientific areas of training. Both the "Central Training Council" report and "The Training of Systems Analysts" are available from HMSO at 4s and 5s respectively.

## Cricket by Computer

People in South Africa are reading ball-by-ball accounts of the test series with England that never took place. The games are being played by an ICL 1900 computer which has been programmed with the records of batsmen over their past 50 first class games and for bowlers 25 matches have been used.

Even the small variables have not been left out; the computer is programmed for such items as the new ball and the state of the pitch. Team tactics are governed by a captain who programmes the computer on team positions and play tactics.

At the start of the first match John Edrich, the England opener, was clean bowled by the first ball—proving even a computer can keep the surprises in the game.

# electronic SPIROGRAPH patterns

By W. W. McLEAN, B.Sc.

OF THE many methods of comparing frequencies and phase difference, the phase splitter circuit provides all the visual advantages of the Lissajous figures, but provides a clearer display of phase difference and allows a wide range of measurements of even numbered frequency ratios (as high as 50 : 1) and a very precise determination of odd-numbered frequency ratios. The simple circuit consists only of resistors and capacitors.

This article describes a development of the ideas behind the circuit in four stages. The cycloid patterns are produced, in effect, as if the spot of the c.r.o. were on the tip of a vector rotating on the tip of another rotating vector. The shape of the patterns depends on (a) the frequencies of the rotating vectors, (b) the amplitudes of the alternating voltages, and (c) on whether the vectors are rotating in the same or opposite directions.

## STAGE 1

At the mention of frequency comparison, the familiar display of Lissajous figures immediately springs to mind. The two frequencies are connected, as in Fig. 1, to the X and Y plates of the c.r.o. One member of each pair of plates is common to both deflecting circuits.

For two sources of the same frequency (and the same amplitude), the c.r.o. spot traces out a straight line, an ellipse or a circle depending on the phase difference between the sources. If the two sources have slightly different frequencies, the phase of one will gradually overtake that of the other and the pattern will slowly change through the complete sequence 0–360 degrees. This is shown in Fig. 2.

## STAGE 2

One pattern which we will follow up is for the 1 : 1 ratio with a phase difference of 90 degrees (Fig. 3).

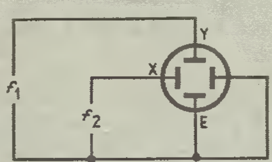



*Fig. 1. Simple method of displaying Lissajous figures on an oscilloscope connecting to the X and Y plates*

*Fig. 3. Vector diagram indicating phase difference of 90°*

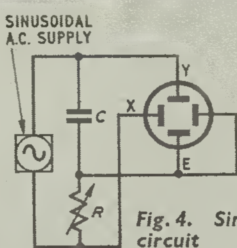



*Fig. 4. Simple phase splitting circuit*

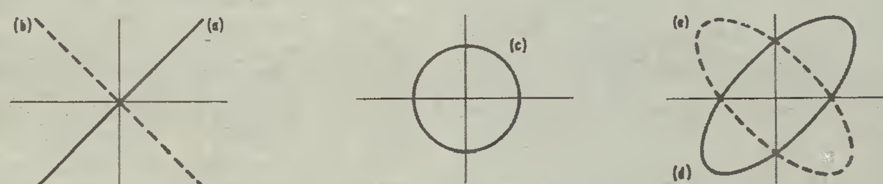
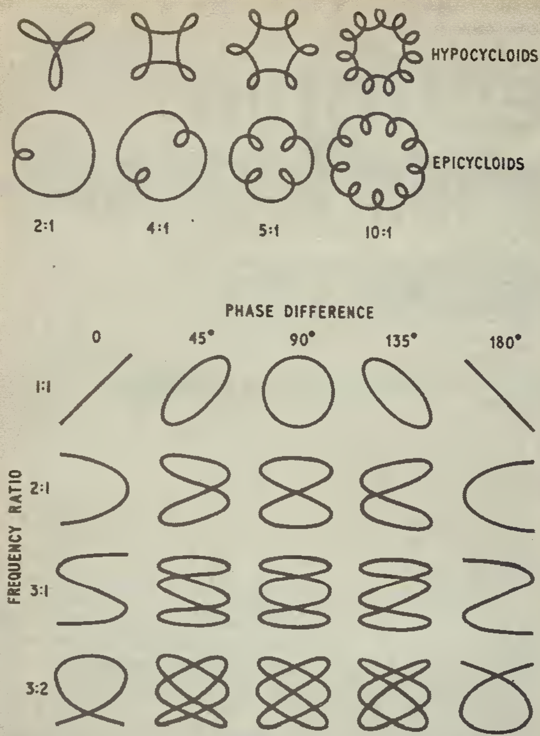



*Fig. 2. Basic Lissajous patterns indicating phase differences (a) 0° (360°), (b) 180°, (c) 90° or 270°, (d) 45° or 225°, (e) 135° or 315°*

# OSCILLOGRAPHS

**Selection of spirograph patterns as displayed on an oscilloscope**




*Comparison of cycloid patterns with Lissajous figures for certain frequency ratios. Note that the shapes of both forms of figure depends on the phases of the input voltages, frequency and magnitude*

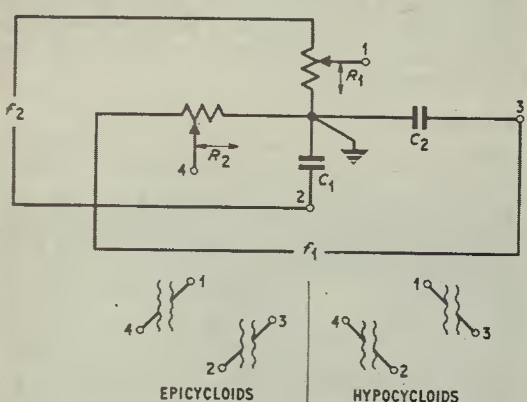



*Fig. 5. Basic circuit for cycloid frequency measurement. Here the numbered outputs refer to the oscilloscope connections for horizontal and vertical amplifiers*

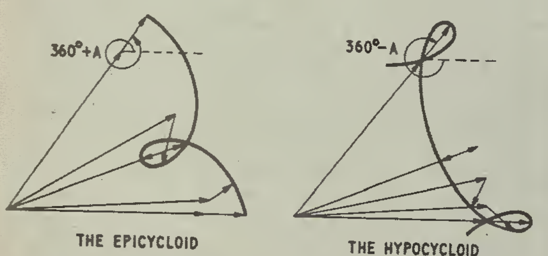
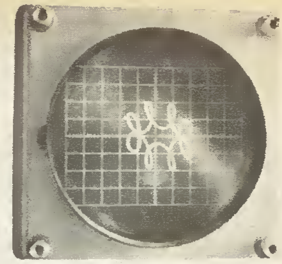
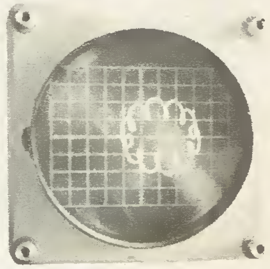


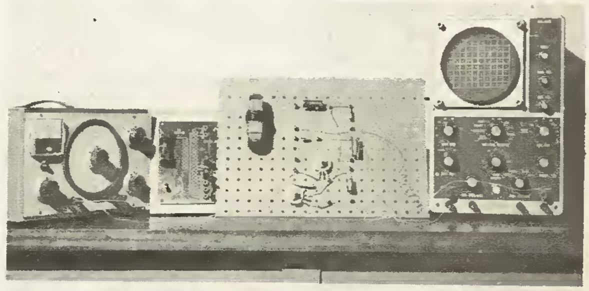

*Fig. 6. One segment of a polar oscillograph or spirograph*



***Hypocycloid with full loops***



***Epicycloids***



***The oscilloscope is set up with an a.f. signal generator and phase splitting circuit for displaying cycloids***

Assuming that when the voltage source is positive, the spot is deflected as indicated by the arrows for the appropriate sources, and further that the voltages have the same amplitude and the c.r. tube the same deflection sensitivity on both of its axes, the application of the mains (sinusoidal) voltage for $f_2$ will produce a circle with $f_1$ if their phase difference is 90 or 270 degrees.

## STAGE 3

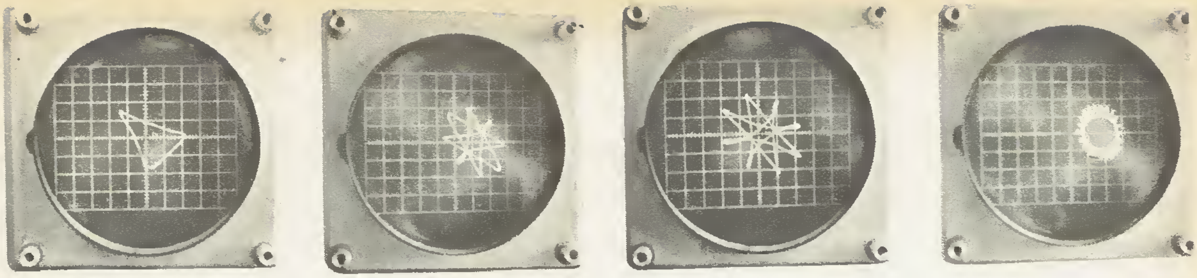
With only one frequency source, the same pattern is obtained with the circuit of Fig. 4, which serves as a simple phase splitting circuit. The voltage across C (taken to the Y plates) being 90 degrees out of phase with that across R (taken to the X plates).

If the value of R is equal to the reactance of C and if the X and Y gain controls (sensitivity. of deflection) have been adjusted to equality, the spot traverses a circle at the frequency of the supply source. The angular displacement (rotation) of the spot is proportional to the time ($1/f$) and the radius of the circle is proportional to the peak value of the voltage across C and that of the voltage across R.

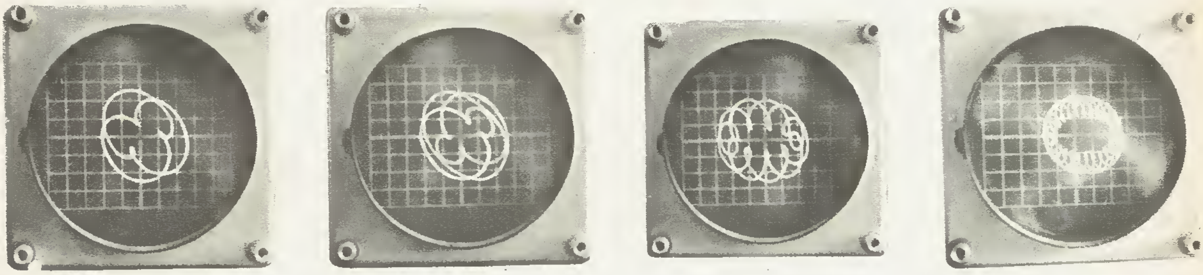
If C = $0{\cdot}1\mu$F, then its reactance at mains frequency of 50Hz is $1/(2\pi fC)$ = 31,840 ohms. The voltages across C and R are equal. Otherwise a circular trace would be obtained if $V_c \times Y_{gain} = V_R \times X_{gain}$.

## STAGE 4

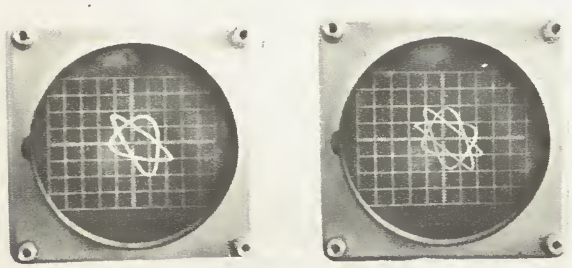
The basic circuit for frequency comparison with cycloids is shown in Fig. 5. The 50Hz reference



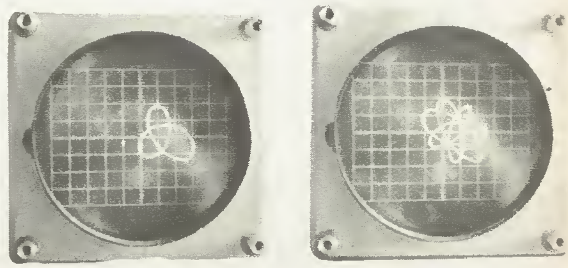
*Epicycloids, loops now peaked*



*Epicycloids*



*Epicycloids, loops now peaked*



*Outside loop patterns showing ratios of less than 1*

frequency is $f_2$ and $R_2$ is adjusted to the reactance of $C_2$.

$R_1$ may be adjusted to be equal to the reactance of $C_1$ for the unknown frequency $f_1$. If the voltages across R and C are applied to the c.r.o. the spot should trace out a circle in each case.

If the pairs of voltages are applied simultaneously, the spot traces out the cycloids. The epicycloid is for the vectors rotating in the same direction; the hypocycloid for the vectors rotating in opposite directions.

## INTERPRETING THE CYCLOID PATTERNS

Fig. 6 shows part of a polar-oscillograph or spirograph. For one complete loop-the-loop cycle, the reference vector rotates through an angle $\omega$ while the added vector rotates in the same time through an angle $360 + \omega$ (for the epicycloid) or $360 - \omega$ (for the hypocycloid). The frequency ratio $m = f_1/f_2$ is proportional to the ratio of these angles;

$$m = \frac{360 + \omega}{\omega} = \frac{360}{\omega} + 1 \text{ (epicycloid),}$$

and

$$m = \frac{360 - \omega}{\omega} = \frac{360}{\omega} - 1 \text{ (hypocycloid).}$$

If the ratio

$$\frac{360}{\omega} = \frac{s}{p}, \quad \text{then} \quad m = \frac{s}{p} + 1 \text{ (epicycloid)}$$

and

$$m = \frac{s}{p} - 1 \text{ (hypocycloid)}$$

where $s$ is the number of loops or cusps in the pattern, and $p$ is the number of complete revolutions of the spot for a complete pattern. This can be found by counting the number of intersections along a radius from the centre of the figure. If the radius goes through a cross over point, count 2. Cross-over points are easily distinguished from peaks or sharp loops.

## PRACTICAL CIRCUITS

The basic circuit in Fig. 7 is practical, of course, and is easily set up on a circuit board of perforated hardboard, size 10in × 8in, using spring connectors.

If the whole audio frequency range has to be coped with, capacitors of value 0·1, 0·05, 0·025, 0·010, 0·005$\mu$F can be inserted at C2. If a reference frequency other than 50Hz is to be used, a similar set of capacitors can be used at C1 (Fig. 7).

Whether you will get an epicycloid or a hypocycloid depends on the phase of the voltages arriving at the oscilloscope. By throwing the reversing switch S1 you can change from one kind of cycloid to the other.

A 0–20V a.c. supply is suitable for the reference frequency. It is possible by switches (not shown in the diagram) to switch off either of the signals and adjust the circles individually and then to switch over to both frequencies to produce the combined pattern.

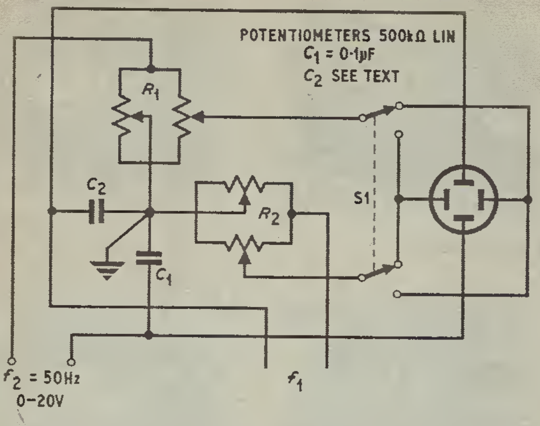



*Fig. 7. Circuit for showing epicycloids and hypocycloids*

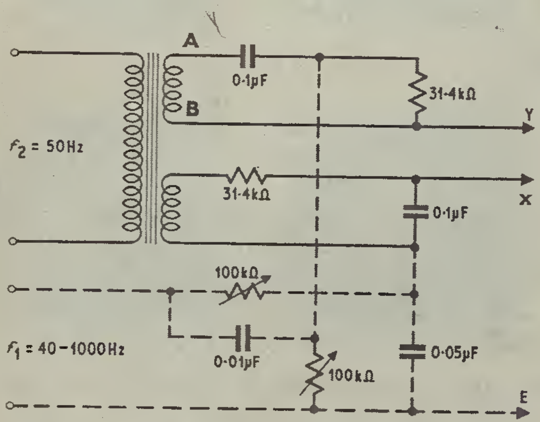



*Fig. 8. Alternative circuit to that shown in Fig. 7*

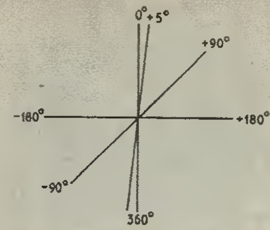



*Fig. 9. Vector diagram showing phase angle accuracy*

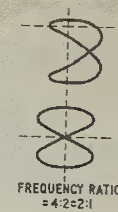



*Fig. 10. The determination of frequency ratio by counting intersections of the trace on an imaginary axis*

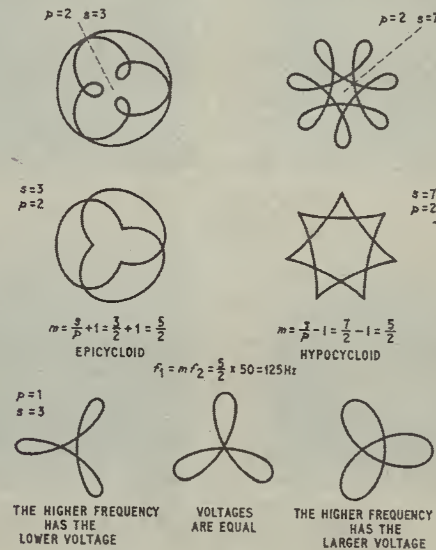



*Fig. 11. Cycloid patterns of various frequency ratios.*

In an alternative circuit, Fig. 8, the R–C components are duplicated again for convenience in superimposing the unknown frequency on the reference frequency to produce epicycloids. The components can be rearranged on the circuit board to produce the hypocycloids.

For sources of equal frequency and equal amplitude, in the case of hypocycloids, there will be a stationary straight line trace which will show an angle of rotation with the vertical. The phase angle is twice the angle of rotation of the trace and is accurate to within 5 degrees (see Fig. 9).

## INFLUENCE OF SIGNAL CIRCUITS

The loops at first on the screen can be made into peaks by reducing the amplitude of the voltage with the higher frequency.

If the patterns are not stationary, the frequency difference corresponding to the nearest frequency ratio represented by the pattern, can be determined from the number of peaks (or loops or cusps) per second passing a given point. An extremely accurate determination of frequency ratio can be made in this way. Some typical examples of these patterns are shown in Fig. 11.

As the frequency of one source is increased, the rate at which the pattern changes is increased, but at certain frequency ratios, stationary patterns appear. These patterns are known as Lissajous figures, from which the frequency ratio can be obtained.

In general, if vertical and horizontal lines are drawn (in imagination) on the pattern and the number of intersections counted, the ratio of these numbers gives the frequency ratio of the two sources. If the line is drawn where the trace crosses itself, two intersections on that line are counted (see Fig. 10).

If the frequencies are not in the exact ratios above, the pattern goes through a complete precession of figures. The frequency of repetition is equal to the difference between the frequencies of the two sources.

The determination of larger frequency ratios such as 14 : 3 is not easy because of the difficulty of separating and counting the number of loops in the complex trace produced; phase comparison is almost impossible.

The transformer in the practical circuit has three separate windings, each of 100 turns of 38 s.w.g. enamelled copper wire, on two C-cores. By reversing the connections A and B the epicycloids can be changed to hypocycloids. ★

# MARKET PLACE

**Items mentioned in this feature are usually available from electronic equipment and component retailers advertising in this magazine. However, where a full address is given, enquiries and orders should then be made direct to the firm concerned.**

## PRINTED CIRCUIT BOARDS

Many of our readers showed great interest in our *Rhythm Generator* published in the November and December 1968 issues, but seemed to have been deterred in some cases by the complex wiring appearance of the prototype.

It should be of interest to many, therefore, that a printed circuit board has been developed to make easier, neater and quicker construction. Designed and supplied by **Almary Designs,** 12 Lattimore Road, Wheathampstead, Herts., the printed board is supplied undrilled with a circuit layout plan and costs 29s 6d including postage.

The board measures $14\frac{3}{4}$in × $5\frac{1}{4}$in which is approximately the area of the four Letrokit panels used in the original design. With all the components mounted on one side of the board, all parts of the circuit are easily accessible for testing and fault finding.

**S.D.C. Products (Electronics) Ltd.,** have extended their range of modular solderless breadboarding systems to include two new boards, intended primarily for integrated circuits and discrete components.

The μ-DeCs can accommodate two 16-lead digital integrated logic (DIL) modules or four 10-lead TO5 modules. The T-DeCs, intended primarily for discrete components, can also accommodate one DIL module or two 10-lead TO5 modules.

Spring contacts are of heavy gauge phosphor bronze either silver plated or gold over nickel plated finish. The layout of the parallel contact strips are arranged on two panels, the rows being 5mm apart. This spacing enables short lead devices to be easily inserted directly into the boards.

All DeCs may be interlocked to give a greater working area; full details of the new boards can be obtained from S.D.C. Products (Electronics) Ltd., The Corn Exchange, Chelmsford, Essex.

## WIRING BOARD CASE

Two new width sizes have been added to the Chilworth range of portable module cases manufactured by **Vero Electronics Ltd.** Making six new sizes in all, these cases are designed for use in conjunction with standard modules from the Vero modular rack system 1A. Guides are located in the cases on special trays, and fitted to allow either single or multiple combinations. A detachable rear panel is supplied as standard.

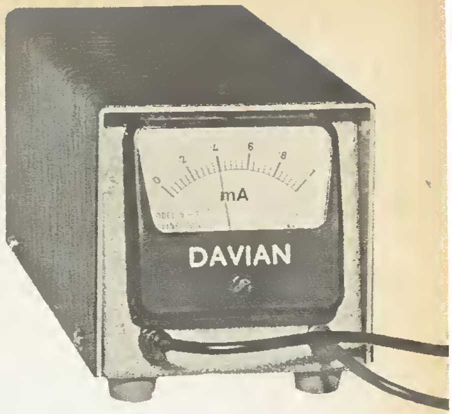
## DRY JOINT LOCATOR

To counter the problem of solder joint failure (i.e. "dry" connections), **Davian Instruments** are now manufacturing a continuity measuring device to detect dry joints.

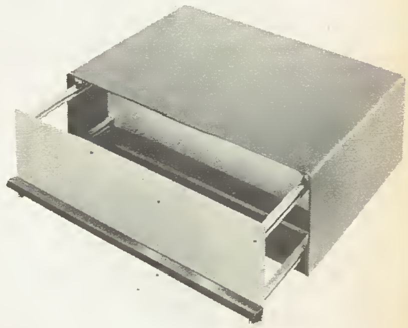
The unit is basically a linear-scaled ohmmeter of variable (normally preset) sensitivity, and either mains or battery powered. The meter uses low voltage and high current to measure low resistances. By using the high current to measure low resistances any dry joints will be shown by the high joint resistance.

A good soldered joint should have a resistance of less than 50 milliohms and dry joints normally have a resistance greater than 0·5 ohm. Other possible applications are: investigating earth loops and return paths; testing coils for shorted turns and measuring relay contact resistances.

Sensitivity is continuously adjustable with a minimum accuracy of 5 per cent f.s.d. The meter has an adjustable full scale deflection of




*Davian dry joint meter from Techmation*

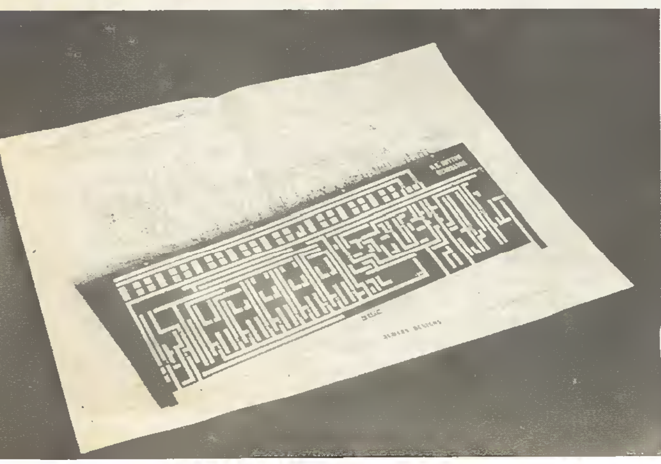


*Wiring board case manufactured by Vero Electronics*

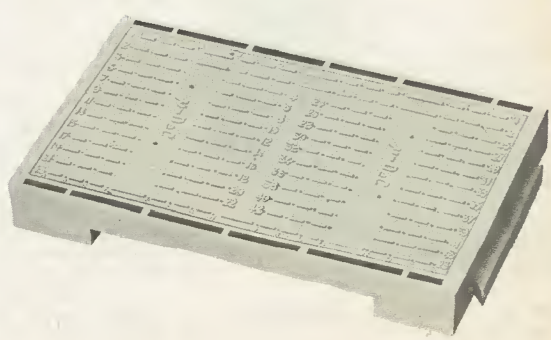
0·5 ohm minimum and 5 ohms maximum. In order to protect the meter and circuit under test, the maximum applied voltage is limited to less than 1 volt. The applied current is 250mA on the minimum range and 25mA on the maximum. Resolution at 1 per cent f.s.d. is 5 milliohms at minimum and 0·05 ohm at maximum reading.

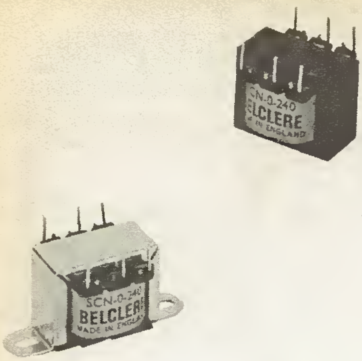
The Davian Dry Joint Locator costs £17 for the battery version and £19 10s for the mains version; postage and packing is extra. The meters and further information are available from **Techmation Ltd.,** 58 Edgware Way, Edgware, Middlesex.

*P.E. Rhythm Generator printed circuit board and circuit sheet supplied by Almary Designs*

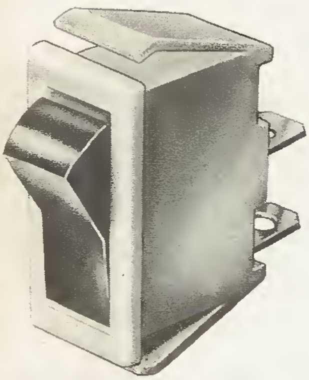


*μ-DeC experimental circuit board marketed by S.D.C. Products (Electronics) Ltd.*

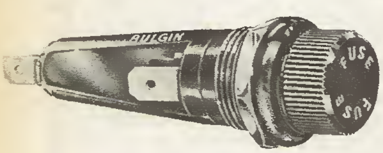




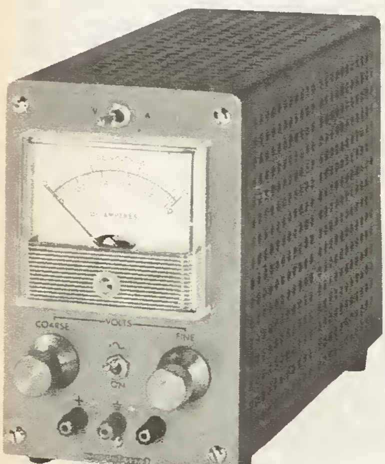
*Miniature mains transformers from Belclere*



*Carr Fastener press-fit switch*




*Panel mounting fuseholder produced by A. F. Bulgin*




*Coutant series LM stabilised power supply*

## MINIATURE TRANSFORMERS

A new "off-the-shelf" range of miniature mains transformers has recently been introduced by the **Belclere Co. Ltd.,** 385/7 Cowley Road, Oxford.

Outputs range from 3–0–3 volts to 20–0–20 volts and each transformer delivers up to 600mW. The current output ratings vary from 30mA to 200mA. By not using the centre tap you can obtain 6V at 100mA, 12V at 50mA, 18V at 33mA, 24V at 25mA or 40V at 15mA.

These transformers are varnish inpregnated and supplied with printed circuit pin mounting terminals, or can be obtained with clamp mounting fixing with or without an electrostatic screen.

Belclere also run a special sub-miniature transformer design service to order and experimenters are recommended to write to them for further details.

## SWITCH

A new type of rocker switch is now being manufactured by **Carr Fastener Co. Ltd.,** Stapleford, Nottingham.

The switch press-fits into a rectangular hole and is rated at 13 amp 250 volts a.c. A useful feature of the switch is that a number of these switches can be ganged together in one hole, a self-retaining push-on linking bar can be supplied when it is required to link any switches electrically.

## FUSEHOLDERS

The incorporation of fuses in electronic apparatus is always a recommended safety precaution, particularly for experimental work.

The best type of equipment fuse holder is probably that intended for panel mounting.

A new range is being produced by **A. F. Bulgin & Co. Ltd.,** Bye Pass Road, Barking, Essex, that follows this style. When the screw cap is withdrawn with the fuse, the circuit is automatically disconnected; it is virtually impossible to short out the contacts accidentally.

These new moulded construction fuseholders carry ¼in diameter fuses and are rated at 15A at 250 volts or 20A at 32 volts. Heavy overload tests carried out with a 20A fuse under direct "short circuit" conditions resulted in no damage to fuseholder or fuse cartridge ferrules.

## POWER SUPPLY

A new additional range of stabilised power supplies have been added to the **Coutant** electronic products. Known as the LM series of power supplies, these units use cascade connected voltage amplifiers to provide the high gain necessary for maximum stability and minimum noise. A fast acting current limiting circuit protects the power supply from damage in the event of an overload or short circuit.

There are two models in the series: the LM 50/30 is a 0 to 30V d.c. at 0·5A model and the LM 100/15 which is a 0 to 15V d.c. at 1A model. Each model includes both coarse and fine panel-mounted potentiometers for accurate adjustment of the output voltage. A built-in meter can be switched to read either the output voltage or current. The output terminals are completely isolated or "floating" and either terminal may be earthed.

The output impedance is less than 5 milliohms at d.c. and less than 500 milliohms at 500kHz. The ripple voltage is less than 1 millivolt peak-to-peak.

Complete details and specification of the LM series can be obtained from Coutant Electronics Ltd., 3 Trafford Road, Reading.

## FILM FOR EDUCATION

A new, 36-frame, 35mm colour film entitled "Integrated Circuits" is now available to schools, colleges, evening institutes, clubs and training establishments from the **Mullard Educational Service,** Mullard House, Torrington Place, London, W.C.1.

The film is intended as an introduction to the subject for students of semiconductor technology and for those with a wider interest in electronics. Although an elementary knowledge of semiconductors is desirable, it is not essential. The notes accompanying the film can easily be edited to suit a wide range of academic levels.

The filmstrip commences with a brief introduction to integrated circuits and illustrates the great reduction in size that the integration technique has made possible. Then follows a step-by-step description of the manufacturing processes; preparing the silicon slice, oxidisation, photo-etching, diffusion of the *n*- or *p*-type materials, cutting the windows, etc. and finally a description of the testing and encapsulation of integrated circuits is given.

The filmstrip costs £2 from Mullard Ltd., and a set of slides can be purchased for £2 10s, including postage, from The Slide Centre Ltd., Portman House, 17 Brodrick Road, London, S.W.17.

## AGENT

The West German firm of Richard Hirschmann have appointed **Electroustic Ltd.,** 73b North Street, Guildford, Surrey, their sole U.K. agents.

Amongst the wide range of components are terminals, panel mounting and spade types; single-pole sockets, insulated and non-insulated; banana plugs and sockets; five styles of test prods; crocodile clips, insulated and non-insulated; and continental plugs and sockets.

Catalogues and full information is available from Electroustic Ltd.

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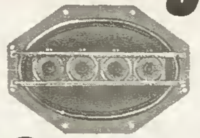

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A selection of readers' suggested circuits. It should be emphasised that these designs have not been proven by us. They will at any rate stimulate further thought.
This is YOUR page and any idea published will be awarded payment according to its merit.

## TRANSISTOR CHECKOUT

THE circuit shown in Fig. 1 has proved very useful for checking gains of "surplus" type transistors. The battery BY1 is connected by a switch S2 for *pnp* or *npn* types. The middle position is off.

To set up the tester, the 5 kilohm potentiometer VR3 is adjusted so that an external voltmeter, connected across points (a) and (b), will read 6 volts. A known good transistor is then connected to the test socket or test leads, and a multimeter switched to its 50$\mu$A range connected across point (a) and position 2 of switch S1. With switch S1 in position 1, VR2 is adjusted for a reading of 25$\mu$A. Then the test lead on position 2 is transferred to position 3 and VR1 adjusted for a reading of 50$\mu$A.

Operation is now fairly simple; a sample transistor is connected into the circuit and *pnp* or *npn* selected by S2. When S1 is in position 1, $I_{CEO}$ is measured. When the switch is in position 2, d.c. $\beta$ or $h_{FE}$ can be measured, assuming f.s.d. on the meter is 100. For a.c. $\beta$ or $h_{fe}$, with the switch in the same position, the reading in milliamps is taken. Call this $I_1$. Then the reading in milliamps is taken with the switch in position 3. This is $I_2$. Then, $h_{fe}$ is calculated from:

$$h_{fe} = \frac{I_2 - I_1 \text{ (mA)}}{0{\cdot}025 \text{ (change in } I_b)}$$

C. Woods,
Oadby,
Leicestershire.

## MORE PLAYERS FOR "STOCKMARKET"?

I HAVE just built the *Electronic Stockmarket* shown in your December 1968 issue. In doing so I have found it possible to accommodate several players at low cost. The "bank" and "current" account capacitors can be connected to a two-pole multiway switch. By this means only one set of push buttons and one detector circuit are required and the number of players is only limited by the number of positions on the switch. In practice I have used a three-pole six-way switch, the other pole being used to light low powered indicator lights to show which player is "dealing". The switch must of course be a break-before-make type.

Added interest is achieved by using 100$\mu$F, 200$\mu$F and 300$\mu$F capacitors in the commodity bank, introducing three types of shares: (1) "guilt edged"—with small gains and losses; (2) "normal"—with average gains and losses; (3) "high risk"—with large gains and losses.

These are easily marked by using different coloured lettering.

E. B. Eves,
East Grinstead,
Sussex.

## INTEGRATED CIRCUIT HOLDER

I HAVE noticed that many of your contributors who use integrated circuits have warned constructors to be absolutely sure of the circuit's correct position before soldering. I have an idea that might save integrated circuits from destruction during desoldering of a faulty circuit.

If the integrated circuit is soldered into a 5-pin continental plug (as used on many tape recorders), five of the eight leads are accommodated. The earth shield can be used as another connection, leaving two more leads. If needed these can be soldered to flexible leads and taken out of the top of the plug

The socket can be soldered onto a circuit board. The metal inner case can also be used as a heatsink if desired.

L. M. Newell,
Woodbridge,
Suffolk.

*A B9A valveholder and plug would provide the required number of connections.—Ed.*

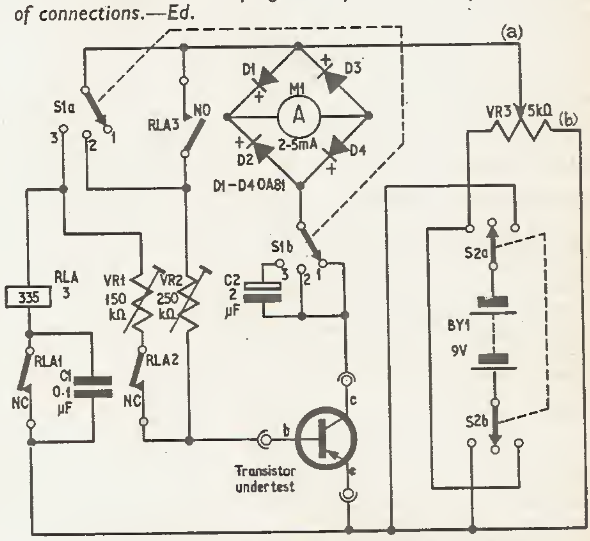


*Fig. 1. Circuit diagram of the transistor checker*

# SPACEWATCH

**By Frank W. Hyde**

## THREE MILE RADIOTELESCOPE

Sanction has been given by the Science Research Council for the new telescope requested by Professor Sir Martin Ryle for the Mullard Radio Astronomy Observatory of Cambridge University. The cost is expected to be of the order of £2·1 million and the work will take about two years to complete.

The old proverb that "It's an ill wind that blows nobody good" is exemplified here. The ideal site for the aerial array is one of the Beeching redundant sections of the Cambridge-Bedford railway track which runs in a straight line almost due east and west at Lord's Bridge. Named after this station, the Observatory site and the railway is on the northern boundary of the site. The straight stretch of track is about three miles long.

Lord's Bridge station which has stood derelict and is roughly in the centre of the three mile stretch will be used as a control room. It is indeed fortuitous that this was available, for had it not been so there would have arisen much controversy over any negotiations if more farmland had to be taken over.

## RECEIVERS

The new telescope will consist of eight dish aerials each 42ft in diameter. These aerials, to be supplied by the Marconi Company, are the direct descendents of the 40ft dishes built for a military programme. Each dish is made up of aluminium sheets mounted on a quasi-paraboloid steel structure. They are to be of the Cassigrain type where the ray path is from the source to the dish then to a secondary reflector, which is quasi-hyperboloidal, and from there the ray passes through the main dish to the two detachable receiver horns.

One receiver will operate at 2·7GHz, the other at 5GHz and will be mounted on the hub structure. These receivers will be provided by Professor Ryle's own group. The front end of the receiver, consisting of a parametric amplifier and mixer will be mounted at the telescope. The i.f. signals will then be fed to the control room for combinations determined by the programme of work.

## COMPUTER CONTROL

In the control room there will be a Marconi Myriad II time sharing computer. This will, besides calculating the linear and angular positions of the movable aerials, combine the incoming signals in each of the 16 possible pairings of the dishes in a simultaneous interferometer arrangement.

The output of the computer drives an X–Y plotter which provides a map of the radio sources in equal energy contours. The result is a map looking somewhat like a contour relief map where sources are easily located.

The computer will also control a complex network of delay lines which are necessary for equalising phase delays which arise as a result of the displacement of individual aerials along the baseline.

## TRACKING SYSTEM

Each aerial is mounted on a tripod system which is fully steerable, and are grouped on a fixed and moving pairing plan. Four of the dishes on the western side of the system will be fixed in positions on concrete platforms 1·13km apart. On the eastern side the other four dishes will be fitted with bogies and travel on an 8·5 metre wide railway track which will be 1·17km long (see Fig. 1).

These four will be used to make up the combinations of interferometers together with the four fixed dishes. Altogether there are 32 specific positions which will be available to an accuracy of less than one millimetre. The railway track itself will be held to a level of accuracy of one millimetre. The resolving power of the telescope will be of the order of one to two seconds of arc.

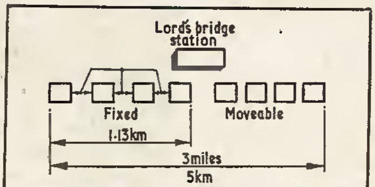


*Fig. 1. Layout of the three mile telescope*

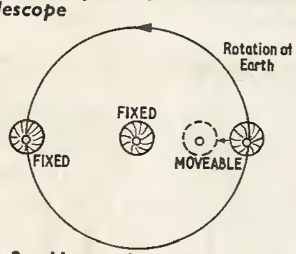


*Fig. 2. How the aperture is "filled" by the rotation of the earth and the change of position of the moveable aerial on successive scans of the sky*

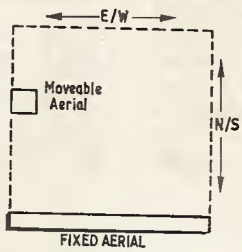


*Fig. 3. An example of aperture synthesis such as was used in early Cambridge work*

The new telescope will operate in the same manner as the present one mile telescope and works on the principle of aperture synthesis, which has been the special technique pioneered by Professor Ryle and his group.

Aperture synthesis is based on the covering of large areas using two or more individual aerials. If one aerial is fixed and another moved in specific relation to it, and a plot over 24 hours is made of the sky in each position (see Fig. 2), then the results in digitised form can be fed into a computer. The result is a map of all the sources seen. If the maximum distances so used are, for example, one kilometre in extent east to west and north to south, this is equivalent to an aerial one kilometre square (see Fig. 3).

## RESEARCH NEEDS

The one mile telescope which has already shown its value in the resolving of small sources (or very distant sources) made the need for an ever larger telescope desirable. The resolving power of this telescope is about 20 seconds of arc but it has shown that there are more sources which require the higher resolution of the new telescope. The need to understand the mechanism of quasars and galaxies is of great importance to cosmologists and astrophysicists so that this new venture is another important step in the understanding of the Universe.

The advent of the new telescope does not reduce the work of the one mile telescope, for this will continue with source counting when the three mile unit comes into operation.

Now that the intention of the Science Research Council to support only two schools of radio astronomy has been announced, there will be an end to delay on the Mark 5 telescope for Jodrell Bank. This is to be a 400ft diameter dish with full facilities.

The 250ft dish is to be overhauled and modified. The modification will be the upgrading of the reflecting surface to make it suitable for wavelengths as short as 3cm. This will be accomplished by resurfacing of the central area to a diameter of 100ft.

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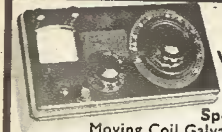

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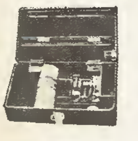

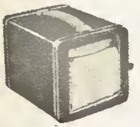

**Specification. Type:** Moving Coil, D.C. **Range:** 0–500 milliamps. **Chart Width:** 100mm. **Scale Length:** 127mm. **Chart Speeds:** 20, 60, 180, 600, 1800 & 5400mm/hr. **Precision:** 1.5%. **Shunts:** 75mV (Internal). **Operating temperature:** +5 to +50°C. **Dimensions:** 180h × 163w × 245mm. **Weight:** 5.5kg. **Complete with:** 10 chart rolls, gears, inks, pipette, scale template and component case. List price £65. **Our price £35**

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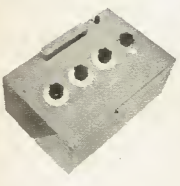

**Specification. Range:** 0–11.110mH in 0.002mH divisions. **Accuracy:** $\pm\left(0.3 \times \frac{0.012}{M}\right)\%$ where M = value of mutual inductance in mH set on the box. **Frequency range** 0–2.5 Kc/s for all decades except X1 = 0–1.5 Kc/s. **Maximum current** 0.5A for decades 1A for variometer (both primary and secondary windings). **Case:** Polished teak. List price £65. **Our price £26.10.0**

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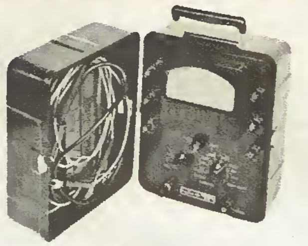

**Specification.**

**Ranges:** 0-60 & 0-300$\mu$A D.C. 0-3, 0-30 & 0-120mA D.C. 1.2 & 12 amps D.C. 0.6-3 & 6-30mA A.C. 24-120mA A.C. 0.24-1.2A A.C. 3-12-30-300-600-1,200 & 6,000 V, D.C. 0.6-3, 2.4-12, 6-30, 60-300, 120-600, 240-1,200 & 1,200-6,000 V, A.C. 3-333 ohms, 0.3-30 Kohms, 0.03-3 megohms D.C. Resistance −12 to +78 Decibels. **Frequency:** 50 c.p.s. **Input Resistance D.C.:** 20,000 ohms/volt. **Input Resistance AC.:** 2,000 ohms/volt. **Temperature Range:** −10 to +50°C. **Dimensions:** 255 × 215 × 170mm. **Weight:** 8kg. **Supplied with:** 2 voltage dividers, H.V. leads, spare rectifiers, 1.5 & 22.5V battery. List price £25. **Our price £12.19.6**

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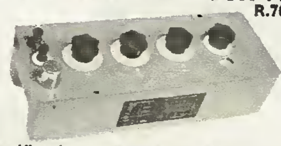

**Specification. Range:** 0.00002$\mu$F-1$\mu$F in 0.00002$\mu$F steps. **Accuracy:** 0.05%. **Frequency Range:** 40c/s–10 Kc/s for all decades except X1 = 40c/s–5Kc/s. **Case:** Hammer finished stove enamel.
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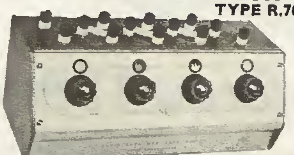

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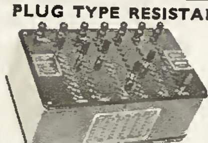

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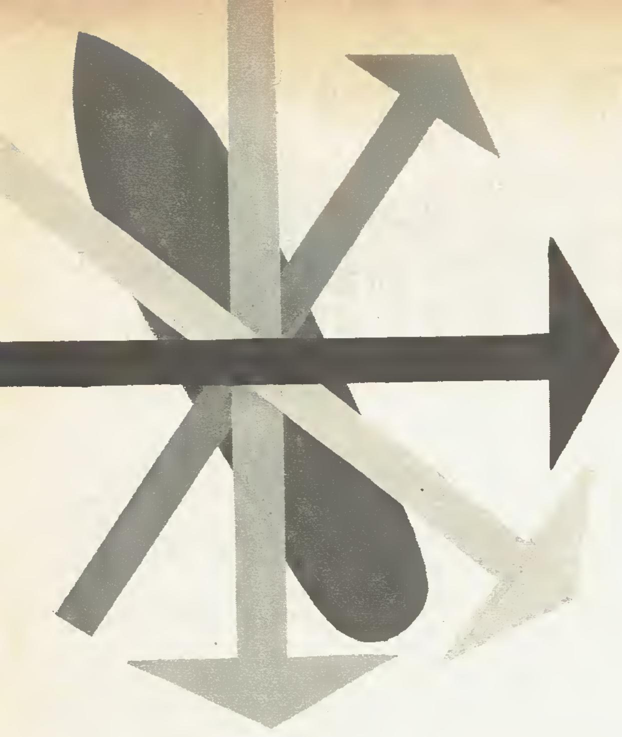

# TONE FILTER for RADIO CONTROL

By J.J.A. TENNANT

THE simplest radio control system uses an unmodulated carrier, and can control only one relay in the model; the addition of a modulator stage in the transmitter and filters in the receiver not only improves selectivity, particularly with super-regenerative receivers, but allows the control of a number of relays.

The modulation "tone" is normally detected, amplified and either applied to a reed bank (mechanical resonant switches) or is electrically filtered and operates switching transistors. Thus, a three tone transmitter (three channels) can independently control three operations in turn, or can control more than three if they are linked (sequential).

## PROPORTIONAL CONTROL

If the transmitter has multiple modulators then simultaneous modulation by different tones allows simultaneous control of two or more operations; a further development of this is the "proportional" system in which the receiver output is directly applied to a servo motor which develops a torque or displacement proportional to the change in frequency of the modulated tone.

A filter is necessary for each channel of the system; the filter module illustrated consists of four sections which may be connected in series, tandem, or separately as four filters. Banks of filters may be made up as desired, the module being designed to be divided on either axis for packing, each filter weighing less than a half-ounce.

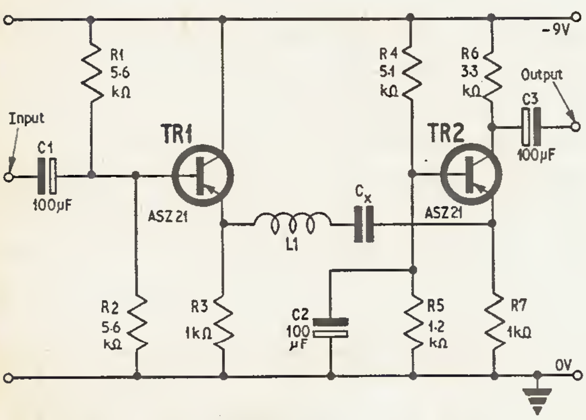


*Fig. 1. Circuit diagram of the basic tone filter*

## CIRCUIT DESIGN

The circuit of the tone filter (Fig. 1) is relatively simple but many factors affect its design and should be considered when "tailoring" the unit to meet individual needs.

The resonant frequency of a tuned circuit is given by $f = 1/2\pi\sqrt{(LC)}$ and will be the same provided the product of $L$ and $C$ is maintained constant; there is, however, an optimum value for the $L$ to $C$ ratio. The frequency range considered is from 1 to 7kHz and for values of $L$ less than 100mH, capacitors greater than 0·5μF would be required. Since electrolytic capacitors may not be used, the size of the capacitor needed would be excessive for radio control applications.

A reasonable compromise for minimum size and weight of both inductor and capacitor is obtained over the range 0·3 to 1·0H and 0·0001 to 0·05μF. Series tuned circuits only are considered due to the ease with which the necessary low impedance matching is obtained and the fact that there is no d.c. component in the inductor; there is no need to use a larger core with an air gap to off-set the effects of saturation.

## Q-FACTOR

The $Q$ of the circuit is the most important factor and for a single stage filter is determined by $Q = f/B$ where $f$ is the filter frequency and $B$ is the bandwidth (acceptance range) for the low frequency "proportional" signal.

For a tone frequency of say 3kHz and a bandwidth of 100Hz, the $Q$-factor will be 3,000/100 = 30.

## BANDWIDTH

The performance of such a circuit is shown in Fig. 2, the bandwidth being measured at the 3dB down point (at approximately 70 per cent of the peak signal level).

For a large bandwidth and good adjacent channel rejection, only two channels can be accommodated in the range 1 to 6kHz (the approximate range of a receiver). To improve upon this two stages are used. If both are tuned to exactly the same frequency the effective $Q$ is greater than that of the individual stages, but if one stage is detuned the effect is to give a wider bandwidth with better rejection of adjacent frequencies. It is therefore possible to use five "proportional" channels or more simple "reed" tones having a narrow bandwidth.

The frequency range available is limited by the cut-off frequency of the receiver—say 7kHz for a good superhet receiver—and by approximately 10 times the channel bandwidth, for example, 1kHz for a bandwidth of 100Hz, allowing a minimum factor of 10 to 1 (carrier to modulation) for detection purposes.

## DESIGN CALCULATIONS

The $Q$ of a coil is defined as $\omega L/R_l$ or $2\pi fL/R_l$. Where $R_l$ is the effective resistance of the coil—largely the d.c. resistance at low frequency. A fixed length of wire wound on different magnetic formers will produce values of $Q$ related to the inductance produced at the frequency used: the $Q$ will also be proportional to the frequency provided that the core material is suitable. As an example, the table in Fig. 2 shows the $Q$-factor for 710 turns of 44 s.w.g. wire on two types of core (d.c. resistance is 66 ohms).

The core material chosen (FX2236) has a $Q$ range of approximately 2 : 1 (Fig. 3) for the frequency range 1 to 6kHz. The stage $Q$ is determined by the total effective series resistance $R_{tot}$, i.e. the sum of the coil resistance $R_l$, the source impedance $R_s$ and the load resistance $R_L$. The driver output impedance ($Z_o$) is approximately

$$Z_o \simeq r_e + \frac{R_s + r_{bb}}{h_{fe}}$$

and is in parallel with the emitter swamp resistor R3. The emitter resistance is

$$r_e \simeq \frac{(26)}{I_e} + R_s + r_{bb}$$

where $I_e$ is the emitter current in milliamps, $R_s$ is the signal source resistance and $r_{bb}$ the intrinsic base resistance.

*continued on page 385*

TABLE 1

| Frequency | Q for LA2708 l.f. inductance 130mH | Q for FX2236 l.f. inductance 940mH |
|---|---|---|
| 1kHz | 10 | 38·5 |
| 6kHz | 56 | 75 |

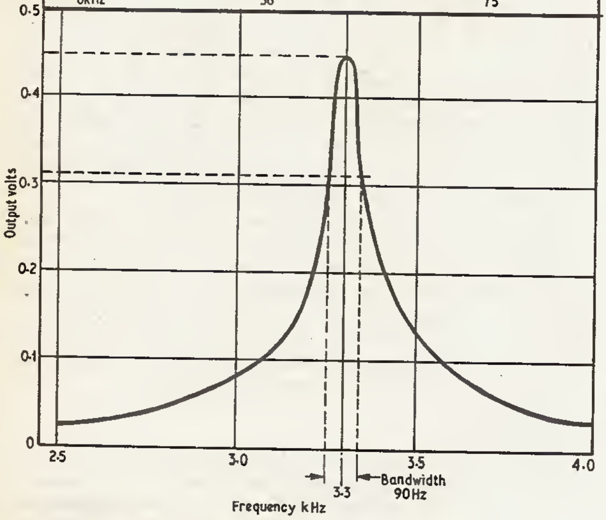


***Fig. 2.** Frequency response curve of the basic tone filter circuit. Bandwidth, measured at the 3dB down point, is 90Hz at a frequency of 3·3kHz*

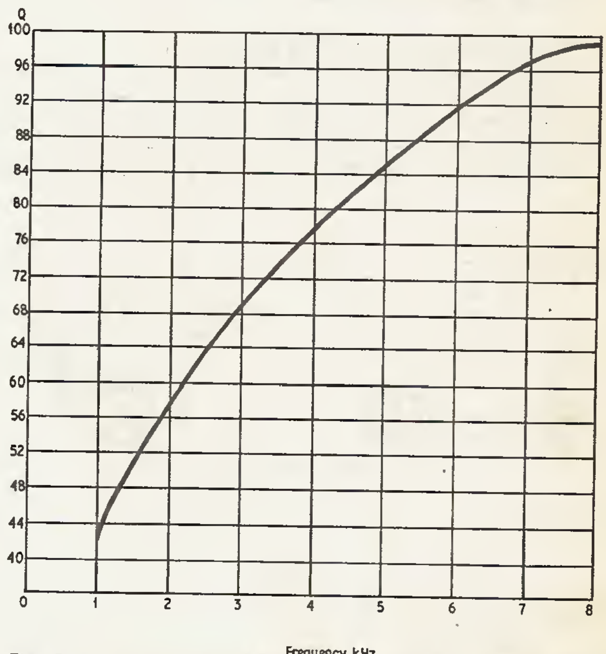


***Fig. 3.** Graph of Q against frequency for a coil of 510 turns of 40 s.w.g. wound on an FX 2236 ferrox core*

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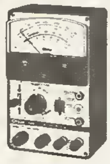

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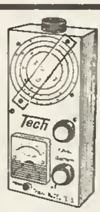

All transistor grid dip meter, absorption wavemeter and osc. detector. Frequency range 440kc/s to 280Mc/s in 6 coils. Uses 3 transistors plus diode with 500μA meter. Internal battery. **TE15, Price £11.10.0.**

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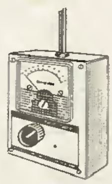
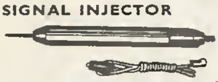


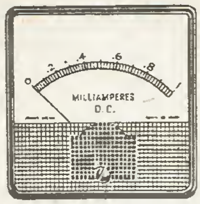
Covers 1–250Mc/s. Switches for model control and any application requiring peaking of transmitters and oscillators. 100μA meter. Complete with aerial. **FS1, Price 45/–.**

### ★ SIGNAL INJECTOR



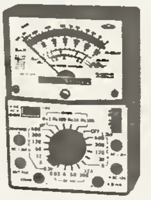
New model for checking all audio and RF up to VHF. Simple to use. Battery operated. Output approx. 1kc/s, 1·4V pp. Harmonics up to VHF. **SE250B, Price 35/–.**

### ★ QUALITY PANEL METERS (D.C. RANGES)

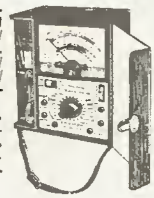



**38 Series.** Face size 42 × 42mm (1⅝in × 1⅝in). 50μA, **37/6**; 100μA, **35/–**; 200μA, **32/6**; 500μA, **27/6**; 1mA, 5mA, 10mA, 50mA, 100mA, 500mA, **25/–** each; 10V, 20V, 50V, 100V, 300V and 500V, **25/–** each; 1A and 5A, **25/–** each. "S" meter, 1mA, **29/6**. VAm meter, **37/6**.
**65 Series.** Face size 86 × 78mm (3⅜ × 3⅛in). 50μA, **62/6**; 100μA, **52/6**; 200μA, **47/6**; 500μA, **45/–**; 1mA, 5mA, 10mA, 500mA, **37/6** each. "S" meter, 1mA, **42/6**. Other ranges and sizes available—state requirements.

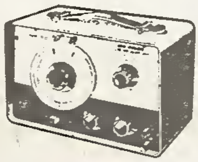
### ★ 50,000 OHMS PER VOLT MULTIMETER



Recommended quality instrument with mirror scale and overload protection. 0/0·3/3/12/60/120/300/600/1200V d.c. 50kΩ/V; 0/6/30/120/300/600/1200V a.c. 10kΩ/V; 0/30μA/6/60/300mA, 0/12A; resistance 0/10kΩ/1/10/100MΩ. Meter movement 20μA. Polarity reversing switch. Complete with batteries, leads and instructions. **AF105, Price £8.10.0**, p.p. 2/6; **Leather case 28/6.**

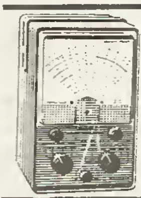


### ★ SINE/SQUARE WAVE AUDIO GENERATOR



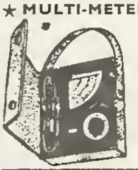
Provides audio output on 4 bands. Sine wave 20c/s to 200kc/s, output up to 7V; square wave 60c/s to 30kc/s, 7V p-p. Distortion under 2%. Output impedance 1kΩ. Variable output amplitude control. Supplied with leads and instructions. A.C. mains operated. **TE22, Price £16.10.0**, carriage, etc., 10/–.

### ★ VACUUM TUBE VOLT METER

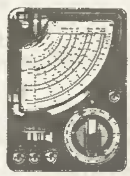


Features low price for such an instrument. Large 6in full view scaled meter. 28 ranges. **D.C. volts:** 0/1½/5/15/50/150/500/1500. **A.C. volts:** 0/1½/5/15/50/150/500/1500 r.m.s.; 0/1·4/4/14/40/140/400/1400/4000 p-p. **Resistance:** R × 10–100–1k–10k–100k–1m–10m. Range 0·2 ohm to 1000MΩ. **dB scales:** –10 to +65dB. Complete with instructions and leads. **Model TE65, Price £17.10.0**, p.p. 7/6. H.V. Probe, 50/–. R.F. Probe, **42/6.**

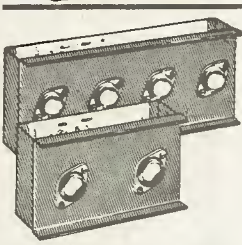
### ★ MULTI-METER 20kΩ/V



Popular model but with extra scale. Range 20,000 ohms per volt. 0/5/25/50/250/500/2500V d.c., 0/10/50/100/500/1000V a.c., 0/50μA, 0/2½/250mA. Resistance 0–6kΩ and 6MΩ. Also dB scales or capacitance. **200H, Price 77/6.** Leather case, Price 15/–.



### ★ TRANSISTOR POWER AMPLIFIERS



12W, 3 ohm, 100mV input, 24V supply. **Model MPA12/3, £4.10.0**, p.p. 3/–.
12W, 12–16 ohm, 100mV input, 40V supply. **Model MPA12/15, £5.5.0**, p.p. 3/–.
25W, 8–16 ohm, 180mV input, 50/60V supply. **Model MPA25, £7.10.0**, p.p. 4/6. **Power supplies:** 24–40V, **90/–**, p.p. 3/6; 50–60V, **97/6.**
**Model PA7** 7W amplifier, 3 ohms O/P, 7mV input, operates 12–18V. **Price 72/6.**

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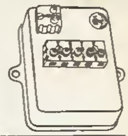
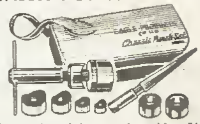
### ★ EXPERIMENTER'S MODULE



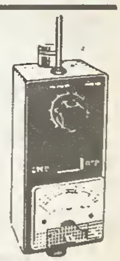
Terrific offer of brand new STC time delay electronic units. Adjustable 3–15 recs. 9–12V operated. Supplied complete with suggested used circuits. **STC Module Price 35/–.**

### ★ CHASSIS PUNCH KIT



Complete kit with punches ⅝in, ¾in, ⅞in, 1in, 1⅛in for metal, plastics, etc., up to 16 gauge. **Price 55/–**, p.p. 4/6.

### ★ SWR ALIGNMENT METER



Ideal for all transmitter alignment. Built-in field strength meter 100μA. Complete. Ready to use. SWR 1:1 to 1:3.

**SWR-3, Price 69/6**, p.p. 2/6.

### ★ TRANSISTORISED INTERCOMMS

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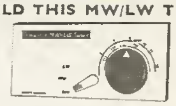

Complete high quality superhet tuner. Built-in ferrite rod. Battery operated. Printed circuit construction, 3 transistors plus diode. **To Build, 79/6**, p.p. 2/6.

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- R2 5·6kΩ
- R3 1kΩ
- R4 5·1kΩ
- R5 1·2kΩ
- R6 3·3kΩ
- R7 1kΩ
- All ±10%, $\frac{1}{8}$W carbon

**Capacitors**
- C1 100μF elect. 12V
- C2 100μF elect. 12V
- C3 100μF elect. 12V
- Cx see text

**Transistors**
- TR1, TR2 ASZ21 (2 off)

**Inductor**
- FX2236 Ferrox pot core—see text for coil details

**Miscellaneous**
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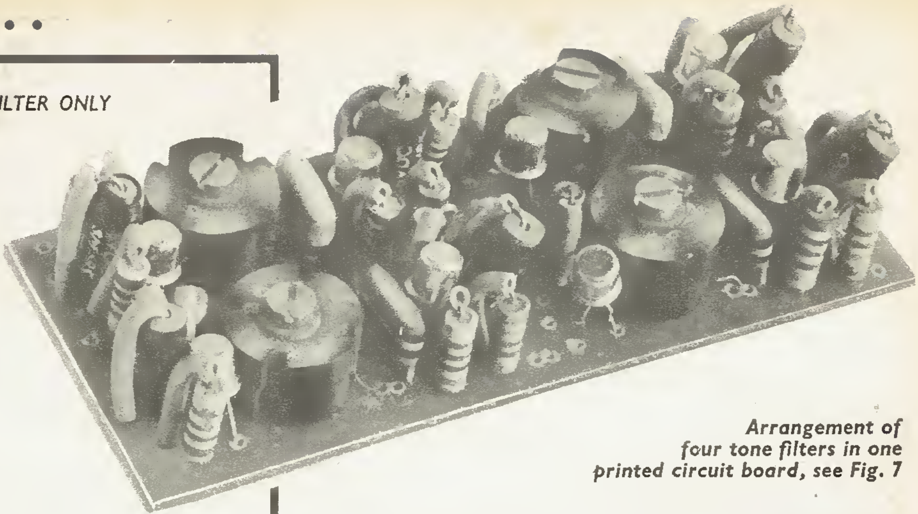
- Plastic covered wire
- 6B.A. fixings (for pot core)



*Arrangement of four tone filters in one printed circuit board, see Fig. 7*

Choosing a high gain ASZ21 ($h_{fe}$ = 70), standing at a current of about 3mA ($I_e$) and with a source impedance of less than 300 ohms, gives an output impedance of 1 kilohm in parallel with 25 ohms.

Similarly with the grounded base stage (TR2) where $R_s$ is kept low by C2 (100μF) in order not to attenuate the low frequency component.

### CALCULATION OF Q

The effective $Q$ of a stage can now be calculated. Assume a winding of 510 turns of 40 s.w.g. wire: from

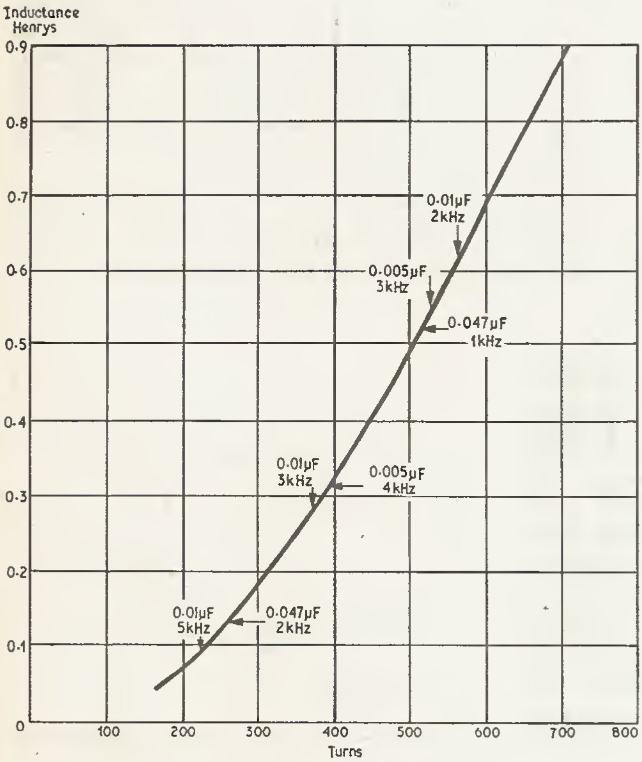



***Fig. 4.** Graph for determining inductance of coil and value of capacitor $C_x$, for various frequencies*

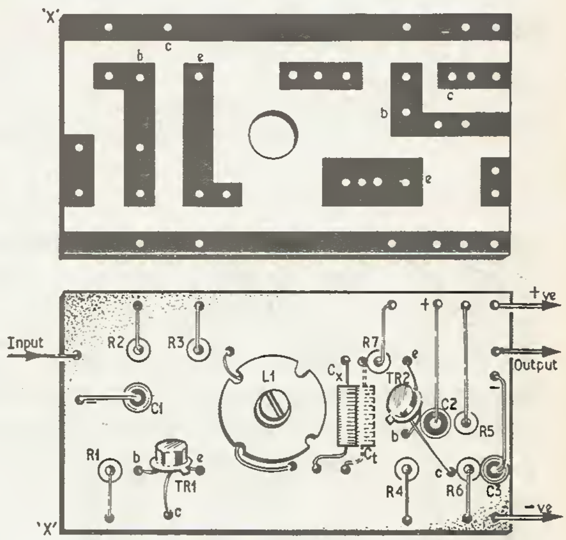



***Fig. 5.** Layout and wiring diagram of the printed circuit board for one complete tone filter capacitor. Capacitor $C_t$ may be needed if two units are used in series—see text*

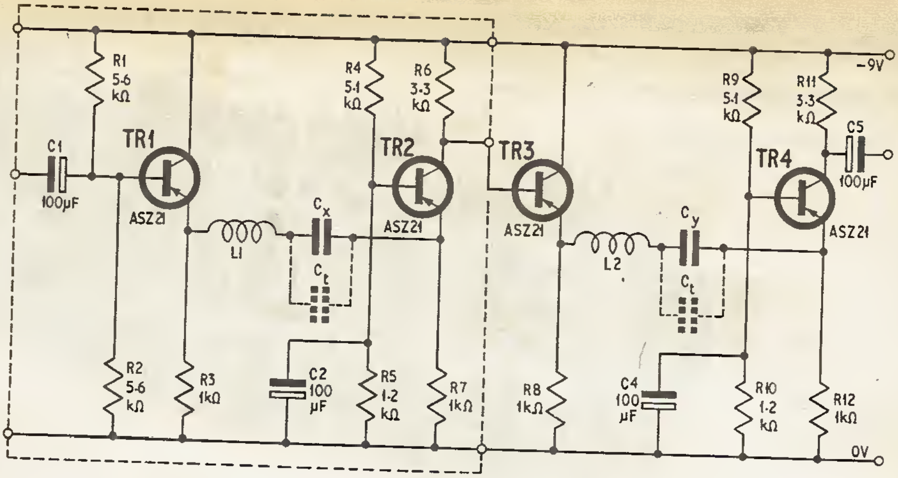



*Fig. 6. Circuit diagram of a two stage unit. Area enclosed by the broken line indicates one stage*

Fig. 4, inductance = 0·5H; from Fig. 3, $Q$ at 3kHz = 69. As $Q = \omega L/R_l$, then

$$R_l = \frac{\omega L}{Q} = \frac{2\pi \times 3{,}000 \times 0{\cdot}5}{69} \simeq 128 \text{ ohms.}$$

Assuming the use of high gain transistors as above, we know that $R_l \simeq 128$ ohms, $R_s \simeq 25$ ohms, and $R_L \simeq 20$ ohms. Therefore, the total series resistance $R_{tot} = 128 + 25 + 20 = 173$ ohms. The effective $Q = \omega L/R_{tot}$

$$Q = \frac{2\pi \times 3{,}000 \times 0{\cdot}5}{173} = 53$$

The bandwidth at 3kHz is given by $B = f/Q$. Therefore

$$B = \frac{3{,}000}{53} \simeq 60\text{Hz}$$

## CONSTRUCTION

The printed circuit board shown in Fig. 5 is laid out for one stage.

When two stages are used the output from the first stage forms the bias for the emitter follower of the second stage, Fig. 6. D.C. coupling is used, omitting C3 from the first stage, R1, R2, and C1 from the second stage, and linking between TR2 collector and TR3 base.

Fig. 7 shows the board layout for four units, and may be used for two channels if divided vertically, or one or two double stage units if divided horizontally.

The gain of the double stage unit is approximately 34dB but this can be reduced, if necessary, by approximately 6dB by using the alternative grounded base stage (Fig. 8). This avoids clipping if the input signal is greater than 0·4 volts peak-to-peak and gives a lower output impedance for coupling into the discriminator.

C1, C3 and C5 (Figs. 1 and 6) are electrolytic coupling capacitors and should be wired to suit input and output circuit d.c. levels. The bandwidth required is set by detuning one stage of the two stage unit. In practice the tolerance of cheap polyester or similar capacitors is sufficient to achieve this directly but the use of a small value capacitor Ct as shown in Fig. 6 gives accurate alignment.

Temperature stability is principally dependent on the temperature coefficient of $C_x$ and $C_y$; optimum results are obtained by using a parallel combination of positive and negative temperature coefficient capacitors. ★

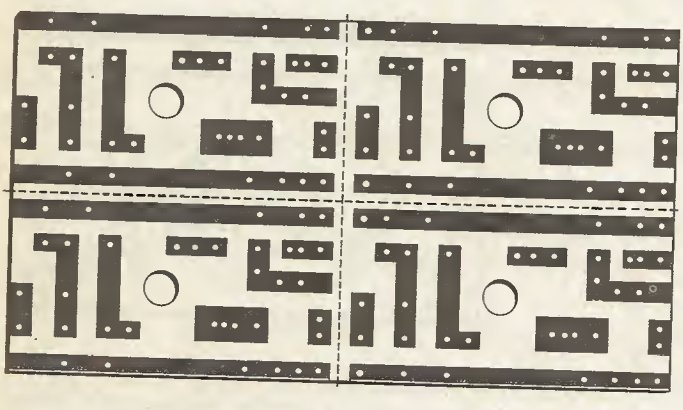


*Fig. 7. Printed circuit board layout for four tone filter circuits*

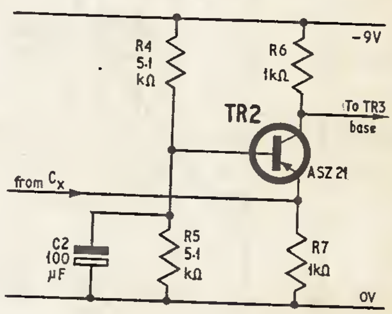
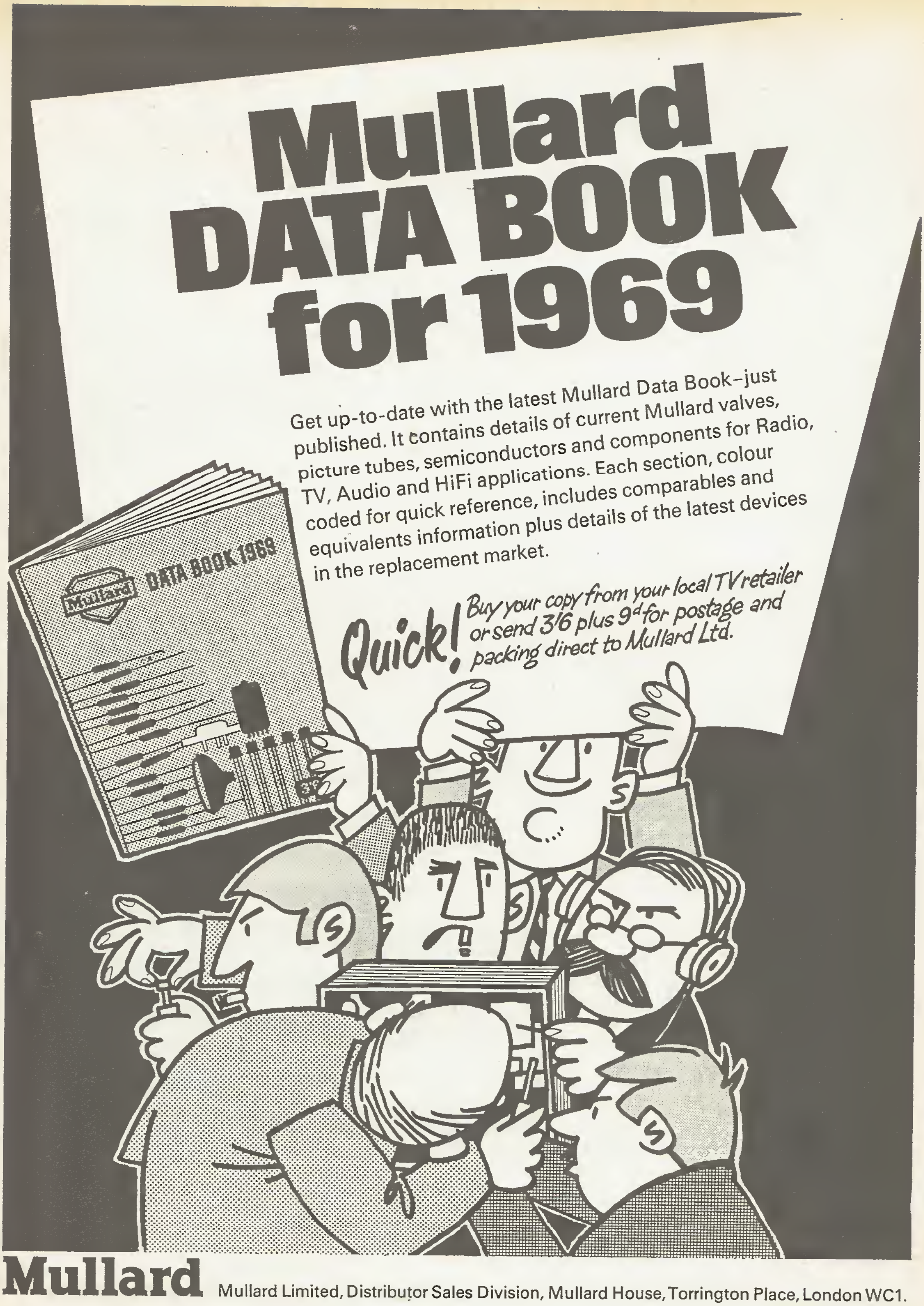



*Fig. 8. Alternative grounded base stage used to reduce gain in the two stage unit*



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# Readout—

## A SELECTION FROM OUR POSTBAG

### Battle of the waves

Sir—We had to reply to the comment in *Report from America*—bedlam (see February issue). Of course we agree that it is ridiculous to allow anyone to use up to 100mW without a licence, but how about showing the other side of the coin for a change.

It is equally as stupid to allow the importation of CB gear over a long period of time and the sale of tens of thousands of 27MHz transceivers. Later the dealer could still sell them but had to tell the buyer "GPO licence required" but not that it was unobtainable, then they have to state "not licenseable in the U.K." but they can still sell them, then the import is banned (theoretically) but dealers are still allowed to sell off their vast stocks.

With a bit of forethought we could have a Citizens Radio Service over here and use the experience of others to our advantage. Let's face it, anything would be an improvement on the state of anarchy that we have today one can hardly be a pirate when there is no legal means of conforming.

Ken Kates (G3 PHS),
U.K. Citizen Band Society,
Caterham,
Surrey.

*Obviously there are a number of points one could debate on in this connection. I will confine myself to just one point, that the 27MHz band in this country is the prerogative of radio control modellers. I do not agree with your statement that these people would welcome a Citizens Band Service. Communications we have received from radio control enthusiasts indicate quite the opposite.—Ed.*

### Bank on memory

Sir—I should like to reply to one point raised by Ken Greenberg concerning the Electronic Stockmarket (Readout, March issue).

The bank level can be observed throughout the game every time the player banks cash, if he is also pressing his CHECK CASH button. He will notice the meter level fall as charge is transferred into his bank, and its final resting-level represents his bank level at the time. It is surely part of the game for him to try to remember this level, so that next time he can gauge whether to transact or to bank his cash. I feel that provision of a separate button would lead to abuse, and also might lower the skill level of the game as a whole, not to mention a reduction in the surprise element.

Incidentally, to those who consider a battery-level button is necessary, I should mention that TAX provides a useful guide to battery state. Simply set rotary switch to TAX and press the CHECK SHARES button. A half-scale reading should be obtained, which could be marked on the meter dial for quick checking.

Brian H. Baily.

### Who's for dice

Sir—I must commend Mr Baily on his design of the Electronic Stockmarket (Dec. 1968). I have one suggestion: could not some sort of electronic dice be designed to take the place of the ordinary throw dice? This would make the game entirely electronic and more interesting.

Brian R. Dellow,
Wellington,
New Zealand.

### No i.c.'s please!

Sir—I look forward to the PRACTICAL ELECTRONICS *Organ* very much, though my constructional activities are of necessity confined to repair, tuning and servicing a few organs as an offering to some Northumberland churches.

But please inform Mr Alan Douglas that I will boycott the reading of his articles if he has used i.c.'s in his design. The integrated circuit seemed to start in the computer field, and as I see some not remote resemblance between binary counters and organ dividers, there is just a danger that the i.c. figures in this organ. If it does I hope that there is a transistor alternative, but my "down" on i.c.'s will have to be the subject of another letter. Suffice it to say that I feel they are not for the public at large!

Meanwhile thanks for an interesting magazine, and keep up the good work!

James W. Robson,
Newcastle upon Tyne.

### PEAC discussion

Sir—Although I am still only considering building PEAC, I do not anticipate having any serious technical difficulty in its construction. Your articles on the subject appears to cover the subject adequately.

However, not having had any experience in the operation of computers, I envisage having some difficulty in putting it to proper use. It is for this reason that I would like to discuss PEAC with someone who has had some practical experience in using it.

D. Grime,
St. Mary Cray,
Kent.

### "I.C." a problem

Sir—I have recently had cause to wonder if, in fact, it is going to be worth the trouble to accept a modern type of transistor radio for servicing. With the one repaired this week, the total goes up to five, all of which had developed faults in an i.f. module.

Over the years spanning the increasing popularity of the transistor radio, I have been able to offer a reasonable repair, but at the fantastic cost of replacing modules it is small wonder that my customer today has gone away believing that I am trying to get rich quick—I think that the boffins who dream up such things should guarantee them for life.

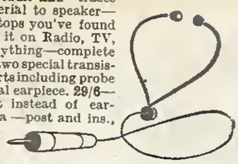
I know that this is regarded as progress by the fact that it speeds servicing, and initial assembly at the factory, but it is also fact that I could replace a component and be fair with the customer regarding cost. As things are now, with the natural swing over from conventional to modules, the customer faces the possibility of having to find pounds instead of shillings just for the replacement module, and before the engineer makes his charge. So the days of the transistor radio being a fair proposition are drawing to a close.

To those who think that it is possible to service one of these modules I say good luck, and trust their curses are not as numerous as were mine.

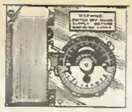
R. W. Craig (Tin Box Rebel),
Bexley,
Kent.

*Your tale of woe is certainly revealing and I wonder if any other readers have been victims of the widespread use of integrated modules in present day equipment. Obviously many other service engineers and general public will feel the impact and you certainly have my sympathies.*
*—Ed.*

## RADIO STETHOSCOPE



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



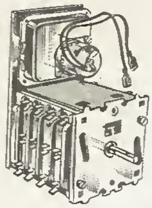
## ELECTRIC TIME SWITCH

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

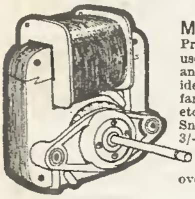
## See in the Dark INFRA-RED BINOCULARS

These infra-red binoculars when fed from a high voltage source will enable objects to be seen in the dark, provided the objects are in the rays of an infra-red beam. Each eye tube contains a complete optical lens system as well as the infra-red cell. These optical systems can be used as lenses for TV cameras—light cells, etc. (details supplied). The binoculars form part of the Army night driving (Tabby) equipment. They are unused and believed to be in good working order but sold without a guarantee. Price **£3.17.6**, plus 10/- carr. and ins. Handbook 2/6.

## MOTORISED CAM SWITCH



Made by the famous meter company Chamberlain and Hookham, these have a normal mains 200-240v motor which drives a ratchet mechanism so geared to give one ratchet action per minute on a wheel with 60 teeth; thus a complete revolution of the cam takes place in one hour. The cam operates 8 switches (6 changeover and 2 on/off thus 480 circuit changes per hour are possible). Contacts, rated at 15 amps, have been set for certain switch combinations but can, no doubt, be altered to suit a special job. Also other switch wafers or devices can be attached to the shaft which extends approximately one inch. **47/6**, post and ins. 4/6.



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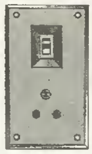

## 5A, 3 PIN SWITCH SOCKETS

An excellent opportunity to make that bench dis board you have needed or to stock up for future jobs. This month we offer 6 British made (Hicraft) bakelite flush mounting shuttered 5A switch sockets for only **10/-** plus 3/6 post and insurance. (20 boxes post free.)

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Panel mounting, consists of neon lamp in red plastic lens with resistor in lead for mains operation **2/6** each, **24/-** doz.

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Ex-W.D. unused and perfect, single with headband **4/6**. Double with headband **8/6**.

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$\frac{3}{8}$in. stroke, size $2\frac{3}{8}$in. × 2in. × $1\frac{3}{4}$in. **14/6**, postage 2/9.

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

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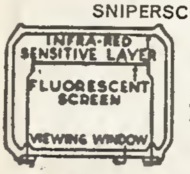
Made by Smith's Electrics, these are almost silent running, but are very powerful. They operate from normal to 240V. mains and the final shaft speed is 16 r.p.m. **15/-**. Post & ins. 2/9.

## SNIPERSCOPE




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

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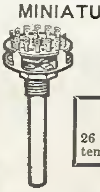

4 pole, 2 way—3 pole, 3 way—4 pole, 3 way—2 pole, 4 way—3 pole, 4 way—2 pole, 6 way—1 pole, 12 way. All at **3/6** each. **36/-** dozen, your assortment.

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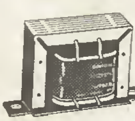

Making a power pack for amplifier or other equipment? These transformers have normal mains primaries (230/40v.) and isolated secondaries two types (1) 12v. 500mA. at **8/6**; (2) 15v. 500mA. at **8/6**.

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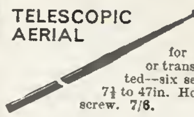
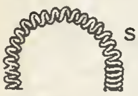


for portable, car radio or transmitter. Chrome plated—six sections, extends from $7\frac{1}{4}$ to 47in. Hole in bottom for 6BA screw. **7/6**.



## SPRING COIL LEADS

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

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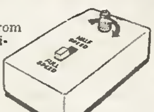

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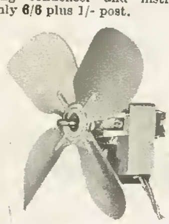

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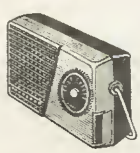

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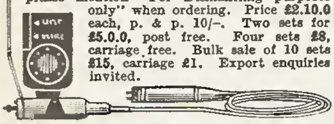

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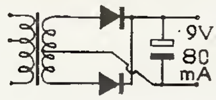


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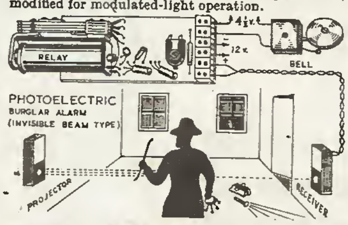


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| 0·12μF .. .. .. .. .. | **3/9** | **30/3** | **65/10** | **202/–** |
| 0·15μF .. .. .. .. .. | **4/3** | **34/2** | **73/7** | **228/–** |
| 0·18μF .. .. .. .. .. | **5/–** | **37/10** | **81/11** | **252/3** |
| 0·22μF .. .. .. .. .. | **6/–** | **47/–** | **101/10** | **313/4** |
| 0·27μF .. .. .. .. .. | **6/9** | **53/9** | **116/8** | **358/4** |
| 0·33μF .. .. .. .. .. | **7/3** | **58/10** | **126/11** | **390/–** |
| 0·39μF .. .. .. .. .. | **7/9** | **65/–** | **140/10** | **433/4** |
| 0·47μF, 0·5μF .. .. .. .. | **9/9** | **75/2** | **137/7** | **500/–** |

**POTENTIOMETERS (Carbon)**
Miniature, fully enclosed, rear tags, carbon brush wiper. Long life, low noise. Body dia., ¾in. Spindle, 1in. × ¼in. ¼W at 70°C. ±20% ¼M, ±30%. ¼M Lin. 100 Ohms to 10 Megohms, Log. 5 Kohms to 5 Megohms.
Prices—per ohmic value.

| each | 10 off | 25 off | 100 off |
|---|---|---|---|
| **2/3** | **20/–** | **45/10** | **186/8** |

**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 ¼M. 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** |

**JACK PLUGS**
¼in. Type P1. Standard. Screened. Heavily chromed.
¼in. Type P2. Standard. Unscreened. Unbreakable moulded cover.
¼in. Type SE/P1. Side-entry version of P1 plug.
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** |
| P2. | **2/6** | **23/4** | **54/2** | **200/–** |
| SE/P1. | **3/6** | **30/10** | **66/8** | **280/–** |
| P5. | **2/2** | **19/2** | **43/9** | **158/4** |
| P6. | **1/8** | **15/–** | **33/4** | **116/8** |

**JACK SOCKETS**
¼in. Type S.5. Standard. Moulded body. Chrome insert.
3·5mm Type S.6. Specification as above.
Available with make/make, make/break, break/break, break/make contacts.

| Prices— | | | | |
|---|---|---|---|---|
| S.5 | **2/9** | **25/–** | **56/8** | **216/8** |
| S.6 | **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, 0·022μF, **7d.** 0·033, 0·047μF, **8d.** 0·068, 0·1μF, **9d.** 0·15μF, **11d.** 0·22μF, **1/–.** 0·33μF, **1/3.** 0·47μF, **1/6.** 0·68μF, **2/3.** 1μF, **2/8.**

400V: 1,000, 1,500, 2,200, 3,300, 4,700pF, **6d.** 6,800pF, 0·01, 0·015, 0·022μF, **7d.** 0·033μF, **8d.** 0·047μF, **9d.** 0·068, 0·1μF, **11d.** 0·15μF, **1/2.** 0·22μF, **1/6.** 0·33μF, **2/3.** 0·47μF, **2/8.**

**Modular,** metallised. P.C. mounting, 20%, 250V: 0·01, 0·015, 0·022μF, **7d.** 0·033, 0·047μF, **8d.** 0·068, 0·1μF, **9d.** 0·15μF, **11d.** 0·22μF, **1/-.** 0·33μF, **1/5.** 0·47μF, **1/8.** 0·68μF, **2/3.** 1μF, **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/–.**

**SWITCHES (Chrome finish, Silver contacts):** 3A 250V, 6A 125V.. Push Buttons: Push-on or Push-off **5/-.** Toggle Switches: SP/ST, **3/6.** SP/DT, **3/9.** SP/DT (with centre position) **4/-.** DP/ST, **4/6.** DP/DT, **5/-**

**PRINTED CIRCUIT BOARD** (Vero).
0·15in Matrix: 3¾in × 2½in, **3/3.** 5½in × 2½in, **3/11.** 3¾in × 3¾in, **3/11.** 5in × 3¾in, **5/6.**
0·1 Matrix: 3¾in × 2½in, **4/-.** 5in × 2½in, **4/6.** 3¾in × 3¾in, **4/6.** 5in × 3¾in, **5/3.**

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