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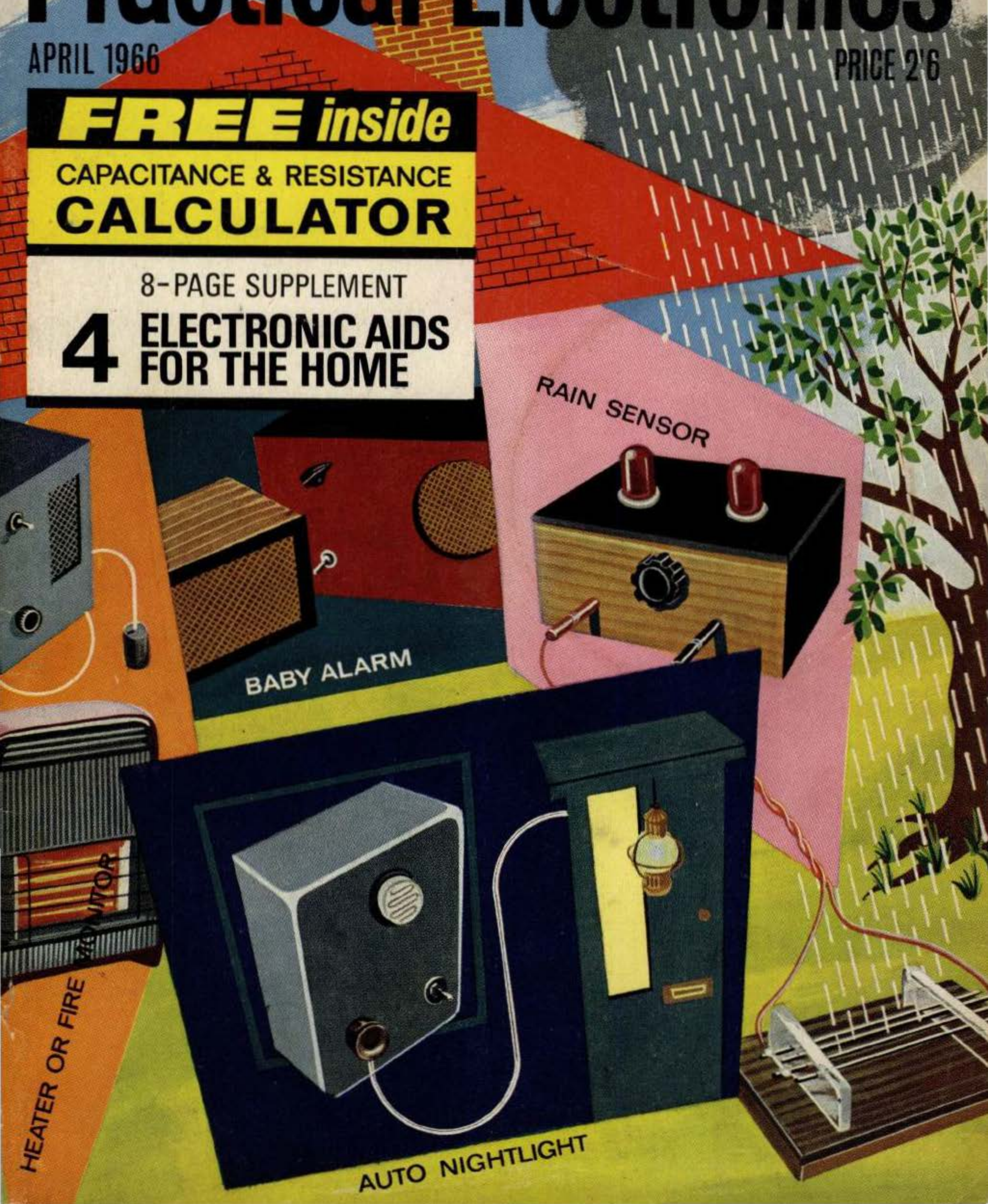


SINCLAIR F.M

Better performance

SINCLAIR MICRO FM

THE WORLD'S FIRST POCKET-SIZE COMBINED F.M. TUNER-RECEIVER

All you want from an F.M Tuner and Receiver in a single unit

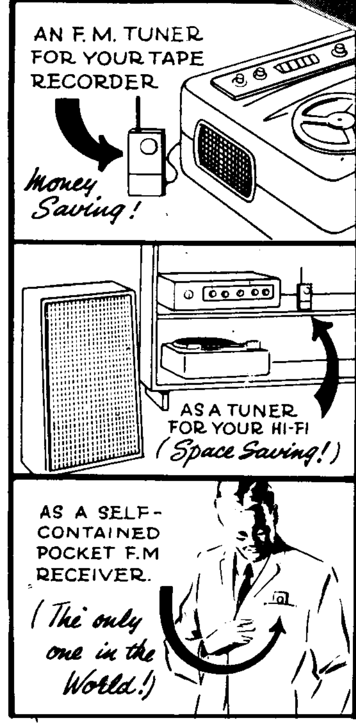
For far less money and trouble you can enjoy building and using the most advanced F.M. design in the world when you buy the Sinclair Micro F.M. This fully fledged 7 transistor, 2 diode F.M. superhet has original features that ensure superb audio quality and great sensitivity together with utmost ease of assembly. There are two separate output sockets. This exclusive Sinclair feature enables you to use your Micro F.M. as a tuner and an independent pocket size portable receiver whenever you wish. This wonderful set is just about as big as a packet of 10 cigarettes, and is as outstanding in appearance as in performance. Many other excellent features are included in the Micro F.M. to make building an F.M. set easy for all enthusiasts. Best of all, it brings first class performance with a saving of pounds.

SIZE —
$2\frac{15}{16}'' \times 1\frac{11}{16}'' \times \frac{3}{4}''$
PLUS 5-SECTION AERIAL

TECHNICAL DESCRIPTION

The Sinclair Micro F.M. is a seven transistor, two diode FM superhet designed to be used both as a tuner and as a self-contained pocket receiver. The R.F. amplifier is followed by a self oscillating mixer. The Low I.F. dispenses with the need for alignment. In this remarkable circuit a three stage I.F. amplifier produces a square wave of constant voltage which is fed into the pulse counting discriminator. This is converted into uniform pulses, the average output from which is directly proportional to the signal frequency. Thus the original modulation is reproduced exactly resulting in excellent audio quality. After equalisation, the signal is fed both to the audio output socket and to the receiver's own audio amplifying stage for using the Micro F.M. as an independent self-contained receiver. A.F.C. "locks" on each station automatically and makes tuning easy. **THE SINCLAIR MICRO F.M. is self-contained within a neat black plastic case faced by an elegantly designed front panel of brushed and polished aluminium with spun aluminium tuning dial to match.**

Use it as —



- **Pulse counting discriminator**
- **Low I.F. eliminates alignment problems**
- **Tunes from 88 to 108 Mc/s**
- **Audio response—10 to 20,000 c/s ± 1dB**
- **Signal to Noise ratio—30dB at 30 microvolts**
- **Operates from standard 9 volt battery, self-contained**

Complete kit including telescopic aerial, case, aluminium front panel, dial, earpiece, 2nd outlet plug and instructions

£5.19.6

Hi-fi quality plus a saving in pounds!

MICRO F.M. CONSTRUCTORS WRITE

"I must say how delighted I am with the performance of the Micro F.M. Nothing I could have bought at the price could have given me greater pleasure."
J.T.J., Middlesbrough

"How pleased I am with the superb tone and performance of my Micro F.M. It looks really professional."
O.C.S., New Milton

SPECIAL MONEY SAVING OFFER No. 2 TO P.E. READERS

Save 19/- NOW

To make it possible for constructors to obtain the best possible standards of reproduction we are offering the Micro F.M. together with the Z.12 described opposite for £9.10.0 instead of the usual price of £10.9.0. Send now for

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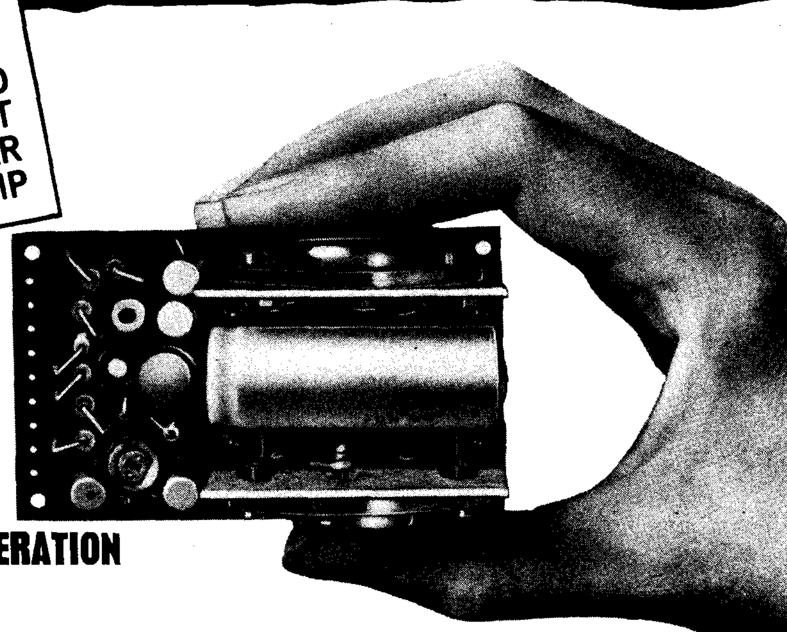
SINCLAIR Z.12

COMBINED 12 WATT AMPLIFIER AND PRE AMP



- 3″ × 1¾″ × 1⅓″
- 12 watts R.M.S. (24 watts PEAK)
- 15-50,000 c/s ± 1dB
- IDEAL FOR 12V. BATTERY OPERATION

The ultimate in SIZE, POWER, QUALITY AND PRICE

WITH THE Z.12 THERE'S POWER IN PLENTY FOR

Mono and stereo hi-fi systems

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Car or portable radio with the Micro-6

•

Quality radio with the Micro F.M.

•

Electric Guitar

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P.A. and Intercom systems, etc.

Never has such power and quality been contained within so compact a size as in the Sinclair Z.12. This eight transistor amplifier includes its own pre-amplifier designed to accept any type of input. The Z.12 incorporates ultra-linear class B output in a circuit in which special H.F. transistors are used to provide exceptionally good performance standards. This newest Sinclair amplifier may be powered from any supply between 6 and 20 volts D.C.; the output can be fed directly into any load from 1.5 to 15 ohms. Thus the scope of the Z.12 is far greater than that of any other amplifier irrespective of price, making it the most dependable, versatile and compact audio amplifier system ever. The Z.12 is supplied ready built, tested and guaranteed, together with manual giving details of tone and volume control circuits by which input sources can be accurately matched to the pre-amp. The quality obtainable from this amplifier is superb in mono and stereo.

TECHNICAL DETAILS

High fidelity amplifier with integrated pre-amp and ultra-linear class B output.

Frequency Response—15 to 50,000 c/s ± 1dB.

Output—12 watts RMS continuous sine wave (24 watts peak); 15 watts RMS music power (30 watts peak)

Output Impedance—suitable for 3, 7.5 and 15 ohms speakers. Two 3 ohm speakers may be used in parallel

Input—2mV into 2K ohms

Signal to Noise Ratio—better than 60dB

Quiescent Current Consumption—15mA

Power Supply—6 to 20V d.c. from power unit available or batteries

Ideal for operation from a 12 volt battery

Power Pack available

Complete Z.12 amplifier and pre-amp, ready built, tested and guaranteed, with Z.12 manual

89/6

PX.1 Power Pack £2.14.0

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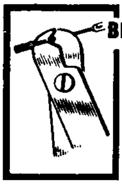

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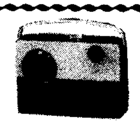

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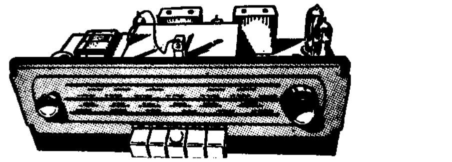

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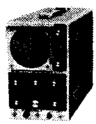
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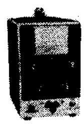
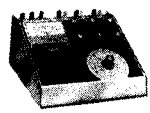
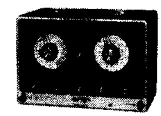

POWER SUPPLIES


TRANSISTOR TESTER


SIGNAL GENERATORS


VALVE VOLTMETERS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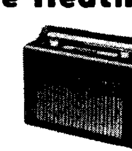
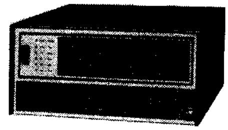

TRANSISTOR PORTABLES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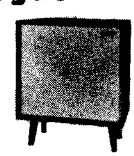
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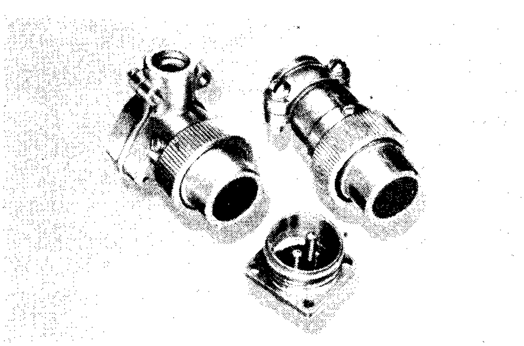

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EBC81	6/6	PABC80	7/6	UCH81	7/3	10P13	12/6
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ECC81	7/4	PC97	7/6	UF41	7/6	20L1	12/6
ECC82	7/4	PCC84	7/4	UF42	9/–	20P1	15/–
ECC83	7/4	PCC85	7/4	UF80	7/6	20P3	12/–
ECC84	7/8	PCC88	12/6	UF85	7/6	20P4	13/–
ECC85	7/4	PCC89	10/6	UF89	7/–	20P5	13/–
ECF80	9/6	PCC189	10/6	UL41	7/6	30C15	9/6
ECH35	13/–	PCF80	8/4	UL46	10/6	30C17	11/6
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ECL83	10/6	PCF806	10/–	5Z4	7/6	30L17	11/6
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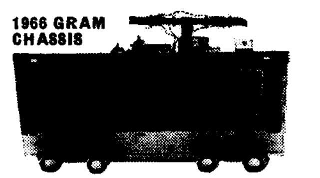
1966 GRAM CHASSIS



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With SPECIAL 12in. BAKER loudspeaker £15.10.0

STEREO RADIOGRAM CHASSIS £14.19.6 Post 5/6 With Long, Med. and Short Wavebands, 15in. x 7in. x 9in.

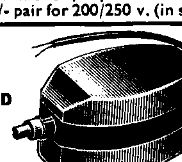
BLANK ALUMINIUM CHASSIS. 18 s.w.g. 4 sides, riveted corners, lattice fixing holes, 2½in. sides, 7 × 4in., 5/6; 9 × 7in., 6/6; 11 × 3in. 6/6; 11 × 7in. 7/6; 13 × 9in. 9/6; 14 × 11in. 12/6; 15 × 14in., 15/-.
ALUMINIUM PANELS 18 s.w.g. 12 × 12in. 5/6; 14 × 9in. 4/6; 12 × 8in. 3/6; 10 × 7in. 2/9; 8 × 6in. 2/-; 6 × 4in. 1/6.

NEW GARRARD GRAM MOTORS

also suitable for models, tapedecks. etc.
100-130 v. A.C. 15/- pair for 200/250 v. (in series)

THE INSTANT BULK TAPE ERASER AND RECORDING HEAD DEMAGNETISER

Leaflet S.A.E.
200/250 v. A.C.

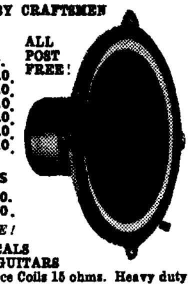


35/-

BAKER LOUDSPEAKERS

HANDMADE BY CRAFTSMEN

HIGH FIDELITY MODELS — ALL POST FREE!



12in. STALWART 15w. 3 or 15 ohms	£5. 5.0
12in. STANDARD	£8. 0.0
12in. DE-LUXE	£9. 0.0
12in. BASS	£12.10.0
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LABORATORY STANDARD MODELS
12in. with D.W.I. £22.10.0.
15in. with D.W.I. £28.10.0.

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GROUP MODELS FOR VOCALS BASS LEAD and RHYTHM GUITARS
Freq. res. 30-10,000 cps. Voice Coils 15 ohms. Heavy duty outputs.

'Group 25'	'Group 35'	'Group 50'
12in. 25w. 5gns.	12in. 35w. 8½gns.	15in. 50w. 18gns.

LOUDSPEAKERS P.M. 3 OHMS. 2½in., 3in., 4in., 5in., 7in. × 4in., 15/6 each; 8in. 17/6; 6½in. 16/6; 12in. 30/-; (15 ohms 35/-); 10in. × 6in. 22/6; 8in. × 5in. 21/-; 9in. × 6in. 21/-. E.M.I. Double Cone 13¼ × 8in., 3 or 15 ohm models, 45/-. Stentorian 10in. HF1012, £5; 8in. HF812, £4. Crossover 35/-. Horn Tweeters 3-16 Kc/s. 10 w 29/6; 20 w 20 Kc/s. 99/6.

T.V. REMOTE CONTROLLER. For Philips 19TG111A, 121A, 125A. 142A, 23TG111A, 113A, 121A, 131A. Stella ST1033A, 39A, 43A, 53A. Cossor CT1910A, 21A, CT2310A, 21A, 31A. Ready to plug in, with 11ft 7 way cable, dual pot Volume and Brightness, OA81 diode, etc., etc. List 3gns. NEW, MAKERS BOXES, OUR PRICE 12/6 POST FREE.

WAVE-CHANGE SWITCHES WITH LONG SPINDLES. 2 p. 2-way, or 2 p. 6-way, or 3 p. 4-way or 1 p. 12-way; ea. 3/6 4 p. 2-way, or 4 p. 3-way, 3/6; 8 p. 4-way, 2 wafer, ... 6/6 Wavechange "MAKITS" 1 p. 12-way, 2 p. 6-way, 3 p. 4-way, 4 p. 3-way, 6 p. 2-way. Prices include click spindles, adjustable stops, spaces, etc., 1 wafer, 8/6; 2 wafer, 12/6; 3 wafer, 16/-; 4 wafer, 19/6; 5 wafer, 23/-; extra wafers, 2/6. TOGGLE SWITCHES, s.p., 2/-; d.p., 3/6; d.p.d.t., 4/-.

★ RADIO BOOKS ★ (Postage 9d.)

Radio, T.V. Valves, Diodes, Transistor equivs.	10/6
Mullard Maintenance Manual	16/-
High Fidelity Speaker Enclosures	5/-
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JACK SOCKETS Std. open-circuit 2/6, closed-circuit 4/6. Lead 6/-, Grundig 3-pin 1/3; Lead 3/6.
Phono Plugs 1/-. Socket 1/-. Banana Plugs 1/-. Sockets 1/-.
JACK PLUGS STANDARD. Screened 3/-. Grundig 3-pin 3/6.
BULGIN NON-REV PLUGS and SOCKETS. P74 2-pin 4/3; P73 3-pin 4/6; P194 6-pin 6/6; P466 6-pin 12/6; P360 4/-.
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5 watt	0.5 to 8.2 ohm 3 w.	1/6
10 watt	WIRE-WOUND RESISTORS	1/9
15 watt	10 ohms to 6,800 ohms	2/-

10K, 15K, 20K, 25K, 10W. 3/-
MAINS DROPPERS. Midget. With sliders. 0.3 a., 1K. 0.2 a., 1.2 K., 0.15 a., 1.5 K., 0.1 a., 2 K.,6/- each.
LINE CORD 100 ohms ft. twin plus resistance. 1/- ft.

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Miniature T.V. Type. All values 10 ohms to 25 K., 3/- ea.; 30 K. 4/-; Carbon 30 K. to 2 meg., 3/-.	STANDARD SIZE POTS. LONG SPINDLE VALUES 50 OHMS to 50 K., 6/6; 100 K. 7/6.

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EXPANDED METAL. Gold or Silver 12 × 12in. 6/-.
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D3034, 1.75 : 1 CT. Push Pull Driver for OC72, OC81 .. 11/-
D3058, 11.5 : 1 Output to 3 ohms for OC72, OC81 .. 11/-
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for heater cathode short circuit or tubes with failing emission. Full instructions supplied, mains input. Optional 25% and 50% boost 2v. or 6.3v. or 12.6v. State voltage required. PRICE 15/6

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For the Finest Value and Service to the HOME CONSTRUCTOR AND THE ELECTRONICS ENTHUSIAST

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

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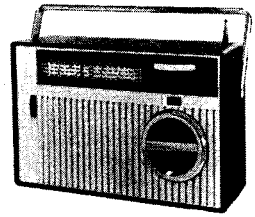
THE SKYROVER RANGE

7 transistor and 2 diode superhet portables—covering full med. plus 6 SW Bands.



The SKYROVER Mk III.

(Illustrated). Now supplied with redesigned plastic cabinet in black, grey and chrome with edgewise controls.

Controls: Waveband Selector, Volume Control with on/off Switch, Tuning Control. In plastic cabinet, size 10 × 6½ × 3½in. with metal trim and carrying handle.

Can now be built for £8 . 19 . 6 Post 5/- extra

H.P. Terms: 27/- deposit and 11 monthly payments of 15/9. Total H.P.P. £10. 0s. 3d.

The SKYROVER De Luxe

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

Can now be built for £10.19.6 Post 5/- extra.

H.P. Terms: 33/- deposit and 11 monthly payments of 19/2. Total H.P.P. £12. 3s. 10d.

★ LONG WAVEBAND COVERAGE IS NOW AVAILABLE FOR THE SKYROVER

A simple additional circuit provides coverage of the 1100/1950M. band (including 1500 M. Light programme). This is in addition to all existing Medium and Short wavebands. All necessary components with construction data.

Only 10/- extra Post Free.

This conversion is suitable for both receivers that have already been constructed.

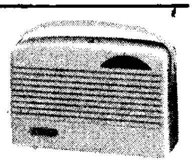
Data for each receiver: 2/6 extra. Refunded if you purchase the parcel. **Four U2** batteries 3/4 extra. All components available separately.

REALISTIC SEVEN

Fully tunable long and medium bands. Uses 7 Mullard Transistors; plus Diode OA70.

STAR features:

● 7 Transistor Superhet. ● 350 Milliwatt output 4in. high flux speaker. ● All components mounted on a single printed circuit board, size 5¼in. × 5¼in. in one complete assembly. ● Plastic cabinet, with carrying handle, size 7in. × 10in. × 3½in., in blue/grey. ● Easy to read dial. ● External socket for car aerial ● I.F.-frequency 470 Kc/s. ● Ferrite rod internal aerial. ● Operates from PP9 or similar battery ● Full comprehensive data supplied with each Receiver. ● All coils and I.F.s, etc., fully wound ready for immediate assembly. An outstanding Receiver.



Can be built for

£5 . 19 . 6

P. & P. 4/6

REALISTIC SEVEN De Luxe

With the same electrical specification as standard model—PLUS A SUPERIOR WOOD CABINET IN CONTEMPORARY STYLING covered in attractive washable material, with super-chrome trim and carrying handle. Also a full vision circular dial, externally mounted to further enhance the pleasant styling. **ONLY £1 EXTRA**

Both models: Battery 3/9 extra. (All components available separately.) Data and instructions separately 2/6, refunded if you purchase parcel.

SINCLAIR SUPER MINIATURES

We stock the complete range of Sinclair Super-miniatures.

THE MICRO-6 miniature radio only $1\frac{4}{5} \times 1\frac{3}{10} \times 1\frac{1}{2}$in.	£2 19 6
THE SLIMLINE 2-transistor pocket radio	£2 9 6
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THE X-20 20 watt P.W.M. amplifier	£7 19 6
Available ready built, tested and guaranteed	£9 19 6
THE X-10 10 watt amplifier and pre-amp	£5 19 6
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VEROBOARD —

Veroboard is a high grade laminated board with copper strips bonded to it and pierced with a regular matrix of holes. Ideal for producing single items.

Boards			Accessories	
42/1503	2½ × 5 in.	3/8	Terminal pins — pkt. of 50	3/-
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45/1507	3¾ × 5 in.	5/2	Pin inserting tool	9/9
46/1508	3¾ × 3¾ in.	3/8	**Post 6d. per item extra.**	
44/1505	3¾ × 17 in.	12/6	**Orders of 10/- and over post free.**	

TRANSISTORS

ALL BRAND NEW AND GUARANTEED

GET 81, GET 85, GET 86 **2/6**; 873A, 874P **3/6**; OC45, OC71, OC81D **4/6**; OC 44, OC 70, OC 76, OC 81 **5/6**; (match pair **10/6**); AF 117, OC 75, OC 200 **6/6**; OC 42, OC 43, OC 73, OC 82D **7/6**; OC 201, OC 204 **15/-**; OC 205, OC 206 **19/6**; OC 28 **24/6**.

TRANSFILTERS By BRUSH CRYSTAL CO. Available from stock.

TO—O1B 465 kc/s. ± 2 kc/s.
TO—O1D 470 kc/s. ± 2 kc/s.
TO—O2B 465 kc/s. ± 1 kc/s.
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TF—O1B 465 kc/s. ± 2 kc/s.
TF—O1D 470 kc/s. ± 2 kc/s.

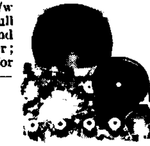
7/6 EACH Post 6d.

CONSTRUCTORS BARGAINS

SPECIAL PURCHASE OFFER

7 TRANSISTOR RADIO CHASSIS

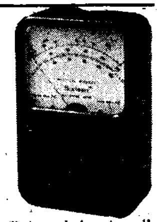
Superhet chassis, fully built—by famous British manufacturer—on printed circuit. Uses 7 Newmarket transistors giving 500 m/w push-pull output—3 I.F. stages; ferrite rod aerial. Covers full long and medium wavebands—200/550M and 1200/2000M and switched band spread on 208M (Luxembourg). 4¼in. speaker; fitted: volume control on/off switch, tuning dial and position for car aerial socket. Uses any 9V battery. Overall dimensions—7in. × 4¼in. × 2in. Absolutely complete except for cabinet.



LASKY'S PRICE 69/6 Post 5/-.

Recommended battery PP6 2/9 or PP7 3/3 extra.

The "Sixteen" Multirange METER KIT



This outstanding meter was featured by *Practical Wireless* in the Jan. '64 issue. Lasky's are able to offer the complete kit of parts as specified by the designer.

RANGE SPECIFICATION: D.C. volts: 0-2.5-25-50-250-500 at 20,000Ω/V. A.C. volts: 0-25-50-250-500 at 1,000Ω/V. D.C.current: 0-50μA, 0-2.5-50-250mA. Resistance: 0-2,000Ω, 0-200kΩ, 0-20 MΩ. Basic movement: 40μA f.s.d. moving coil. With universal shunt full scale deflection current is 50μA. Black plastic case—3¾ × 5¾ × 1⅞in. Controls: 12 position range switch; separate slide switch for A.C. volts—D.C. ohms; ohms zero adjustment pot, meter, meter zero. Power requirements: One 15v. and one 1.5v. batts. Complete with all parts and full construction details. H.P. Terms available.

Data and circuit available separately, 2/6; refunded if all parts bought. Pair of batteries 2/- extra.

LASKY'S PRICE £5.19.6. P. & P. 5/-

FROM PRE-AMP TO 20 WATT HI-FI STEREO ASSEMBLY WITH MARTIN AUDIOKITS

Using specially developed circuits, the very latest transistors and printed circuits—these kits are all fully checked and tested before leaving the factory. Although the kits are basically designed for use together the pre-amplifier and mixer stages may be used to great advantage with existing valve or transistor equipment.

KIT 1.	5-stage Matching Input Selector Unit	**LASKY'S PRICE 47/6.**
KIT 2.	Pre-amplifier with volume control	**LASKY'S PRICE 37/6.**
KIT 3.	3-Channel Mixer with plug-in adaptors for individually matching each circuit. Adaptors 8/6 each	**LASKY'S PRICE 79/6.**
KIT 4.	Pre-amplifier with tone/volume control stages	**LASKY'S PRICE 62/6.**
KIT 5.	10 and 3 watt Main Amplifier	**LASKY'S PRICE £5/12/6.**
KIT 6.	Power supply converter unit	**LASKY'S PRICE 52/6.**
KIT 7.	15 ohm version of Kit 5	**LASKY'S PRICE £6/12/6.**
KIT 8.	Power supply for Kit 7	**LASKY'S PRICE £2/15/-.**

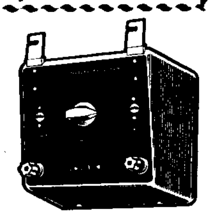
SPECIAL INTEREST ITEMS!

Give a Lasky's Gift Voucher

The ideal gift for all special occasions. Any value in multiples of 10/6 (min.) upwards.

You give pleasure with a Lasky's Gift Voucher.

TEST METER ADAPTOR



Type P.E. 220—this is a fully transistorised device which enables any 50 microamp D.C. Multimeter to be used in place of a valve volt meter. On the 1V. range an impedance of 1 megohm is offered which increases on the 1000 V. range to 100 megohms. 7 ranges: 1 to 1000 volts. Designed for immediate connection to Avo 8 and similar size meters but quite suitable for use with any other 50 microamp meter. Size 6 × 6 × 5 in. New and boxed. **List Price 7 Gns.**

LASKY'S PRICE 39/6

Post 2/6. Set of batteries 7/5 extra.

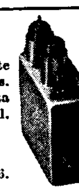
GORLER UT 340 FM/VHF TUNING HEART

Permeability tuned — covering 87 to 108 Mc/s. For use with one ECC85 valve. In metal case, size 3 × 2½ × 1½in. Circuit supplied

LASKY'S PRICE 19/11 Post 2/-.

ECC85 valve 9/- extra

U.H.F. TUNERS



Only a few available. Complete with PC86 and PC88 valves. We regret no circuit or data is available. Knobs included.

LASKY'S PRICE 69/6 Post 2/6.

207 EDGWARE ROAD, LONDON W.2 Tel: PAD 3271
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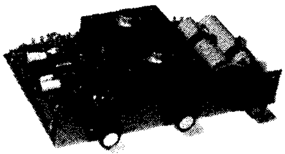
USERS ACCLAIM *Kedoco* PRODUCTS

★ BEAUTIFULLY ENGINEERED ★ OUTSTANDING PERFORMANCE

KEDOCO CLASSIC 20 WATT TRANSISTORISED AMPLIFIERS NOW AVAILABLE IN THREE ALTERNATIVE DESIGNS



SS20/7 £9.19.6

The now well proven model as illustrated comprising pre-amplifier measuring 4.7" × 2.3" and main amplifier measuring 4.5" × 4" both mounted on base plate and supplied complete with bass, treble and volume on/off controls.

SS20/8 11 GNS.

De luxe version complete and ready to mount into your cabinet. With three controls mounted on front of stove enam. chassis and moulded plastic and spun aluminium control knobs fitted as standard. Tag strip mounted on back of chassis in addition to facilitating the L/S and H.T. connections provides sep. inputs for crystal, ceramic cartridge, magnetic pick-up, radio and tape recorder. Max. dimensions of whole unit 6¼" × 9¼" × 2".

SS20/9 19 GNS

A beautiful table model version with own power supply and in keeping with the modern trend to build hifi systems from self contained separate and compact units. Ready to operate and connect to tape, gram and radio via coax sockets at the back of the cabinet. The amplifier and power supply are housed in attractive pressed steel case finished in a greystoved enamel and embellished with a gilt brushed aluminium front panel engraved and displaying the four controls. Treble, bass, volume on/off and three position input selector. Cabinet measurements 12" × 6.5" × 2.1"

TECHNICAL SPECIFICATION

All three models employ similar circuits, have the same electrical specification and are fully transistorised. Six silicon planar transistors and two germanium power. Two diodes. All therefore have the benefits of negligible noise and distortion, high efficiency, low power consumption, compact design and no warm up time when switching on. The amplifiers are D.C. coupled throughout (no distortion) and there is a transformerless coupled output having a very low output impedance. Power output, 20 watts peak into 3 ohm speaker. Input impedance, selected to suit input. Output impedance, 0.25 ohms. Bass boost, 12 dB at 100 c/s max. Treble boost, 12 dB at 16 Kc/s max. Distortion, 0.1% typical. Frequency response, 16 c/s to 20 Kc/s. Noise, 80 dB down on max output. Power requirements, SS20/7 and SS20/8 only. 20 mA quiescent. 3 amps peak. 30 volts.

KEDOCO COMPONENTS

A COMPLETE RANGE TO SATISFY ALL YOUR NEEDS

ZENER DIODE

Silicon planar diffused units featuring very sharp knee. Type No. specifies voltage. KZ5.1 Types KZ7.5, KZ5.6 KZ8.2, KZ6.2 KZ9.1, KZ6.8 10% tolerance.

Slope resistance nominally 10 ohm at 5mA, I_z.

Dissipation 250 mW Temperature coefficient 0.01% per degree C.

3/11 EACH

UNDOUBTEDLY THE FINEST RANGE OF TAPE RECORDER EQUIPMENT ON THE MARKET TODAY

THE COMPLETE 12 VOLT SYSTEM

TAPE PRE-AMP SSTR/7

All silicon transistor. Zero hum. High gain and equalised at 7½" per sec. to give flat response output. Simple mod. described in accompanying instructions allows equalisation at all speeds. Suitable for all medium impedance heads. ASSEMBLED **29/6**

Record pre-amp SR/8 couples SSH/9 to ribbon and dynamic mic. High gain all silicon transistor. **29/6**

TAPE OSCILLATOR SS013

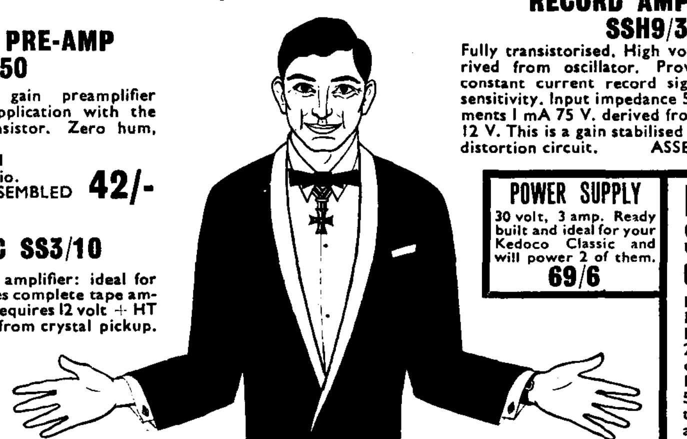
Complete unit incorporating push pull silicon transistor oscillator giving adequate erase power and recording bias. The only unit on the market at such an economical price. Ferrite pot core oscillator. Frequency 50-60 Kc/s. Unit also provides high voltage D.C. rail for the record amplifier. A high efficiency oscillator operating from 12 volt supply at approx. 250 mA. COMPLETE **69/6**

RECORD AMPLIFIER SSH9/3

Fully transistorised. High voltage H.T. rail derived from oscillator. Provides substantially constant current record signal. 1 volt input sensitivity. Input impedance 5 k. Power requirements 1 mA 75 V. derived from SS013 and 1 mA 12 V. This is a gain stabilised low distortion circuit. ASSEMBLED **45/-**

MINICLASSIC PRE-AMP SSPA/50

Tone controlled high gain preamplifier designed specially for application with the SS3/10. All silicon transistor. Zero hum, requires 12 volt + H.T. Separate inputs for crystal ceramic cartridge and radio. ASSEMBLED **42/-**



MINICLASSIC SS3/10

High fidelity 2 watt main amplifier: ideal for use with SSTR/7 and makes complete tape amplifier. 16 c/s to 30 kc/s. Requires 12 volt + HT and will operate directly from crystal pickup. 6 transistors and two diodes all mounted on precision printed circuit board. Max. music power 4 watts into 3 ohm speaker ASSEMBLED **69/-**

POWER SUPPLY

30 volt, 3 amp. Ready built and ideal for your Kedoco Classic and will power 2 of them. **69/6**

PLANAR EPITAXIAL SILICON TRANSISTOR

GOLD PLATED, ALL WELDED

KPS 24 7/11, KPS 25 9/11, KPS 26 12/-, KPS 27 16/6

Double diffused npn. Suitable from audio to RF power applications. I_{co} less than 100 nA. B_{vcbo} greater than 20 volts. Power output at 28mc/s typically 300mW. Emitter/base breakdown voltage greater than 5 volts. Typical F_t 300 mc/s. h_{fe} KPS 24 min. h_{fe} 20 KPS 25 min. 50. KPS 26 and 27 are two special low level transistors specially designed for front end amplification. H_{fe} at I_c = 200μA, 25 and 40 min. respectively.

RADIO MICROPHONE

80-100 mc/s. Proven performance. A quality product. Professionally engineered. All silicon transistor. Dimensions 20 mm. × 55 mm. × 45 mm. Ideal for stage work, intercom, broadcast clarity.
SS007 (standard power) **£9.9.0**
SS008 (increased power) **£13**

TV/FM BOOSTER

WHY PUT UP WITH A WEAK PICTURE. Suitable for Bands I and 2. Battery operated. **32/3** COMPLETE

Mains operated model housed in steel case and covering Band III in addition. **45/-**

BOOK

Theory and applications of planar epitaxial transistors. Explains significance of these new transistors and gives many interesting circuits. 3/11

RESISTORS ½ watt HYSTAB

4·7Ω, 10, 27, 100, 150, 270, 470, 1K, 1·5K, 2·2K, 3·3K, 4·7K, 10K, 15K, 18K, 24K, 33K, 56K, 100K, 330K, 560K, 1M. **5d. each**

ELECTROLYTIC CAPACITORS

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VOL. 2 No. 4
APRIL 1966

Practical Electronics

BENEFITS ALL ROUND

Some hobbies are strictly individualistic pursuits providing mental and physical exercise to the participant alone. There are other hobbies which, while still in every respect satisfying the individual's creative instincts, do also produce certain results which can be enjoyed or appreciated by other members of the family or circle of friends. These achievements may be in the form of intangible services, or are more likely to appear as concrete examples of the hobbist's skill in devising and building some material article or equipment.

We feel that amateur electronics is a hobby that is in many respects unique. Admittedly we are biased—nevertheless we believe the truth of this claim can be well demonstrated.

Despite the somewhat mystical aura that, in popular imagination at least, surrounds this subject, electronics is certainly no "closed shop" or restricted preserve for "boffins". Some technical knowledge is a prerequisite obviously, but one can become actively involved in this absorbing and stimulating subject at various levels of technical proficiency. The most important requirement at the outset is enthusiasm and interest. The special knowledge and skills are developed almost painlessly in the practice of the hobby. This of course is also perfectly true of many other amateur activities.

Electronics is a subject capable of providing ample mental and intellectual stimulus. Indeed there are people to whom an unusual circuit diagram offers a greater challenge and more enjoyment in its solution than a crossword puzzle. However, we are chiefly concerned with those who translate abstract into reality. Here again modern methods of construction are most attractive to the amateur, who probably has very limited workshop facilities at his disposal.

The growth of the electronics industry is phenomenal. The horizon is ever receding as fresh developments in materials, components, and circuit techniques are continually being made and new prospects thus opened up for further exploitation. In his humbler way, the amateur designer or builder reaps the benefits of this progress. He knows that his hobby is not likely to become static or bereft of new ideas.

Now to our main argument. The individual constructor need not be the sole beneficiary of this spare time activity, for the applications of electronic techniques know hardly any bounds. As is only right and proper, we offer some practical examples to support our argument that the electronics enthusiast need not be an introvert or self-centred character—but quite the opposite in actual fact. Among this month's constructional projects are four devices of relatively simple design, which perform worthwhile functions particularly appropriate to the domestic scene. Here then is just one attempt to demonstrate the general usefulness of applied (amateur built) electronics.

In conclusion, a discreet hint. May we suggest that any husband or son who may have been guilty of devoting too much time to projects of strictly personal appeal, has now an opportunity to rehabilitate himself in the eyes of the maternal side of the family? And, who knows, as a result of this perhaps a more tolerant view will then be taken in future of any unconventional work performed on the kitchen table.

To work men!

THIS MONTH

CONSTRUCTIONAL PROJECTS

SPECIAL SERIES

GENERAL FEATURES

NEWS AND COMMENT

Our May issue will be published on Thursday, April 14

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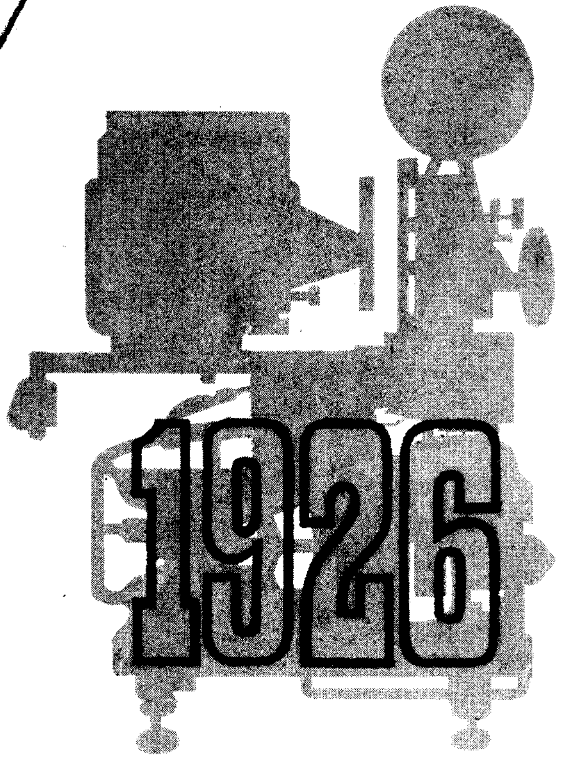


ELECTRONICS AND AUTOMATION IN THE CINEMA

PART ONE

Reference to *electronics*, when speaking of the cinema, may perhaps sound strange to many, and *automation* more so. What electronics are involved, one may ask, in putting over a performance in a modern "super"? How does *automation* help?

The first part of this article briefly relates how electronics have affected the cinema. It describes the early forms of sound equipment and proceeds to the advent of automatic control.

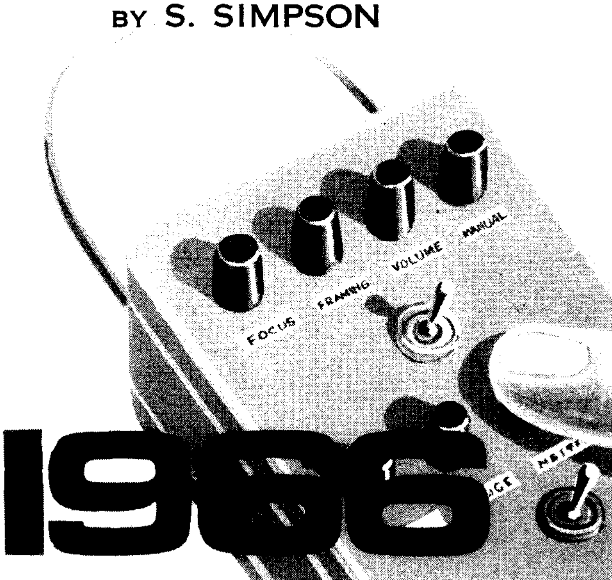
The second part will begin by outlining stereophonic and wide-screen equipment and end with a detailed description of the *Cinemation* system of fully automatic control of a cinema. This system, the most advanced of its kind, was commissioned in July 1965, in the Twin-Odeon Theatre, Nottingham.

BY S. SIMPSON

To realise fully the progress made in the cinema and before we can consider the futuristic *Cinemation* equipment, it will be helpful briefly to review sound film since its inception.

Some of us may remember the "village hall" cinema with its single, hand-driven projector and its jingling out-of-tune piano providing so-called background music. These "village halls" were the forerunners of luxury theatres, palaces of chrome, crystal and comfort, many housing a forty-piece orchestra and an electronic organ, both of which provided music for B.B.C. programmes. The production techniques of silent films kept pace with the progress of the "trade" and altogether most of the productions from the giant studios were of superlative quality, the illusion of "life" in the film was continually destroyed by printed sub-titles which conveyed the dialogue.

That was the situation when, in 1926, Warner Brothers recorded sound on 16-inch discs, synchronised it to a film and showed the first *Vitaphone* sound film, *Don Juan*, to a selected trade audience.



THE FIRST "TALKIE"

The excitement aroused in the trade was as nothing compared to the enthusiastic public welcome which greeted the first general release in the Warner Bros. theatre chain—Al Jolson's *The Jazz Singer*. Elsewhere, other exhibitors, hitherto scornful of the new "talking film", began to think; when *The Jazz Singer* was closely followed by *The Singing Fool* (perhaps Jolson's finest film), thought became swift action. Theatres were re-decorated, using sound-absorptive materials to cut down the reverberation essential to the orchestra. (Cross-phasing of reflected sound-waves causes distortion and possibly loss of volume.) "Operating boxes", hitherto housing two small projectors, one slide lantern, one "operator" and a "rewind-boy", became "projection suites" to house complicated projection and sound equipment (which we shall look at in a moment), together with a "chief projectionist", "second projectionist", and an "apprentice". The trade took the matter quite seriously.

Initial problems were complicated by the rumour of optical recording on film; the rumour became fact when Fox Films introduced the *Movietone* system. Almost on the heels of *The Singing Fool*, *Movietone News* was born, to become the most popular newsreel of those days. Before we discuss "sound on film", however, let us look at the *Vitaphone* disc installation.

SOUND FROM DISC

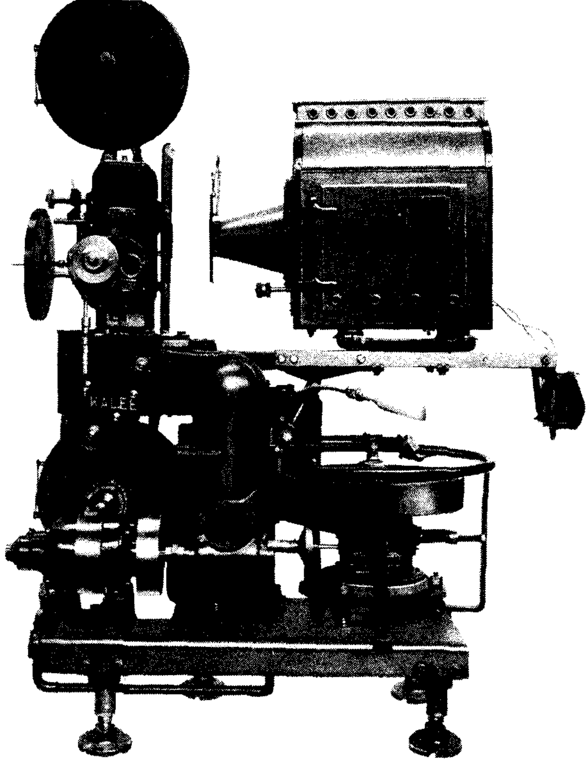
In many small theatres, the "silent" projector was incorporated in the sound system, because the aspect ratio (4 × 3) of silent and disc-sound films was the same. Most concerns renewed the lot, and many projectionists, handling only disc recordings, wondered about a small shutter which vertically masked off part of the picture gate on the new head. They learned why, presently.

The projector was mounted on a heavy base which carried a double-ended motor to drive at one end a gearbox coupled to the projector and, at the other, a gearbox to rotate a massive 16-inch turntable on which the disc was "played". These discs turned at 33 r.p.m., and were played "inside out" by electro-magnetic pick-ups using replaceable steel needles. The needle pressure was 5 oz. The pick-up output passed to a selector switch taking the output from either of two projectors, then to a common volume control, sync/non-sync switch, pre-amplifier, main amplifier, and to the hall speakers placed behind the screen. The plaster screen had given way to the "dishcloth", a multi-layer cotton sheet of fairly open weave to give good sound-transparency (but a poor light reflector; of this, more later).

The amplifiers (typically, 500 watt output at very low distortion levels) were duplicated and could be cross-connected or paralleled, depending on audience conditions. (The larger the audience, the greater is the sound-absorption and the need for more output.) Audience variation required a telephone (later simplified to a simple buzzer) between the hall and the projection room. The buzzer proved very amusing to perceptive small boys; however, the projectionist soon knew by the volume from the monitor speaker alongside him, and by the audience he dimly saw below, what was necessary.

UNSYNCHRONISED MUSIC

Not all the films were "talkies" in the early days. As the majority of orchestras had gone or were going, a means of providing music to accompany silent films was introduced and colloquially called the "non-sync" since it provided unsynchronised music. Typical equipment comprised two 78 r.p.m. turntables each with an electro-magnetic pick-up (steel needles) and a dual control providing changeover and volume level. Its output passed through the sync/non-sync selector switch, thence to the amplifier system. Sophisticated versions had provision for pick-up placing and for automatic changeover between recordings (the first hint of automation, perhaps?).



Kalee projector with Western Electric universal base. This is the type of apparatus used for the first "talkie". The heavy 16-in turntable and the electro-magnetic pick-up are at the right of the picture immediately beneath the arc lamp housing. ***Copyright: Rank Organisation.***

Minor faults and troubles were frequent, to begin with. One must remember that a quite new technique of film presentation had to be learned by the projection staff, in addition to coping with mechanical troubles in the "settling-down" period of new gear. Synchronising sound to film was quite easy when lacing the film on the projector, but a rough-running projector could cause needle-jump which spoiled it; so also did damaged film cut from the reel, since one can't cut sound out of a disc recording. Also, one had to turn the disc over when setting up a new reel, Part 3 being the "flip" side of Part 1; forgetfulness caused havoc now and then!

Sync after needle jump could be restored by the skill of knowledgeable projectionists, and the process barely noticed by the average audience. Lost film, however, had to be replaced by opaque pieces and—remember, some old projector heads were still in use—these patches were sometimes lengthy and numerous; audience reaction in "family" theatres was quite strong in such cases.

"Wow" had to be avoided when the "talkie" became "all singing, all dancing", especially in theatres operating from "town power" or their own plant. The answer was provided by a tacho-generator, directly coupled to the drive motor shaft. This generator provided an a.c. output which was amplified, rectified, and passed to the motor field to control motor speed.

At normal speed, the amplifier gave no output; any variation was self-cancelling. The constancy of these motors was remarkable, but now that the a.c. grid is universal, they are no longer required.

The standard-groove, 16-inch disc gave way to an experimental micro-groove 12-inch disc in order to cope with longer film reels; these discs, in the hands of unskilled personnel, wore badly and intensified sync trouble. The trade, generally, was relieved when Warner Bros., Fox, and Western Electric eventually discarded discs altogether in favour of sound-on-film.

ENTER SOUND-ON-FILM

The "soundhead", for sound-on-film, was located on the base immediately below the projector. It carried a small, high-intensity "exciter" lamp containing a horizontal filament whose light was focused by an optical system to form a strip of light, about 0·003 inch thick and 0·1 inch long, at one side of a film gate. The gate carried a similar slot through which the light could pass to a photo-electric cell, backed by a pre-amplifier. Output from the pre-amplifier passed to the projector selector switch, volume control, etc., as the disc output had done. The film which had passed through the projector was pulled by a sprocket through the sound gate, whence it reached the take-up spool.

Sound, initially, was recorded by the Western Electric "variable-density" system in which a shutter, operated by modulation from amplifiers, allowed a fine strip of light to fall on sensitive film. Frequency depended upon the number of lines per centimetre, amplitude upon the density of the line. In projection, the recording, which was printed on a 0·1 inch strip of the picture area adjacent to the sprocket holes and was several frames "ahead" of the relevant picture so as to achieve synchronism, passed over the slit in the sound gate and thus modulated the light reaching the photo-cell.

Life became much easier for the projectionist whose sync troubles were at an end. Other troubles arose, however. "Flutter", caused by the intermittent motion of part of the projector, was transmitted to the sound sprocket through the projector mechanism: an effective answer was a sound sprocket mounted on a shaft

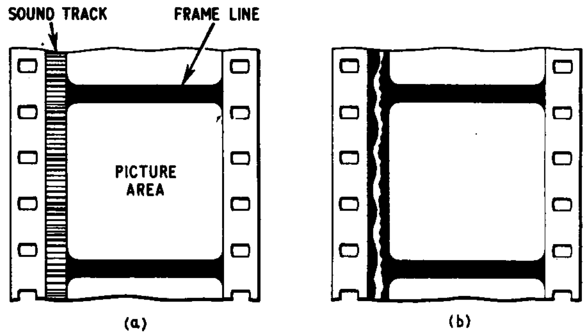
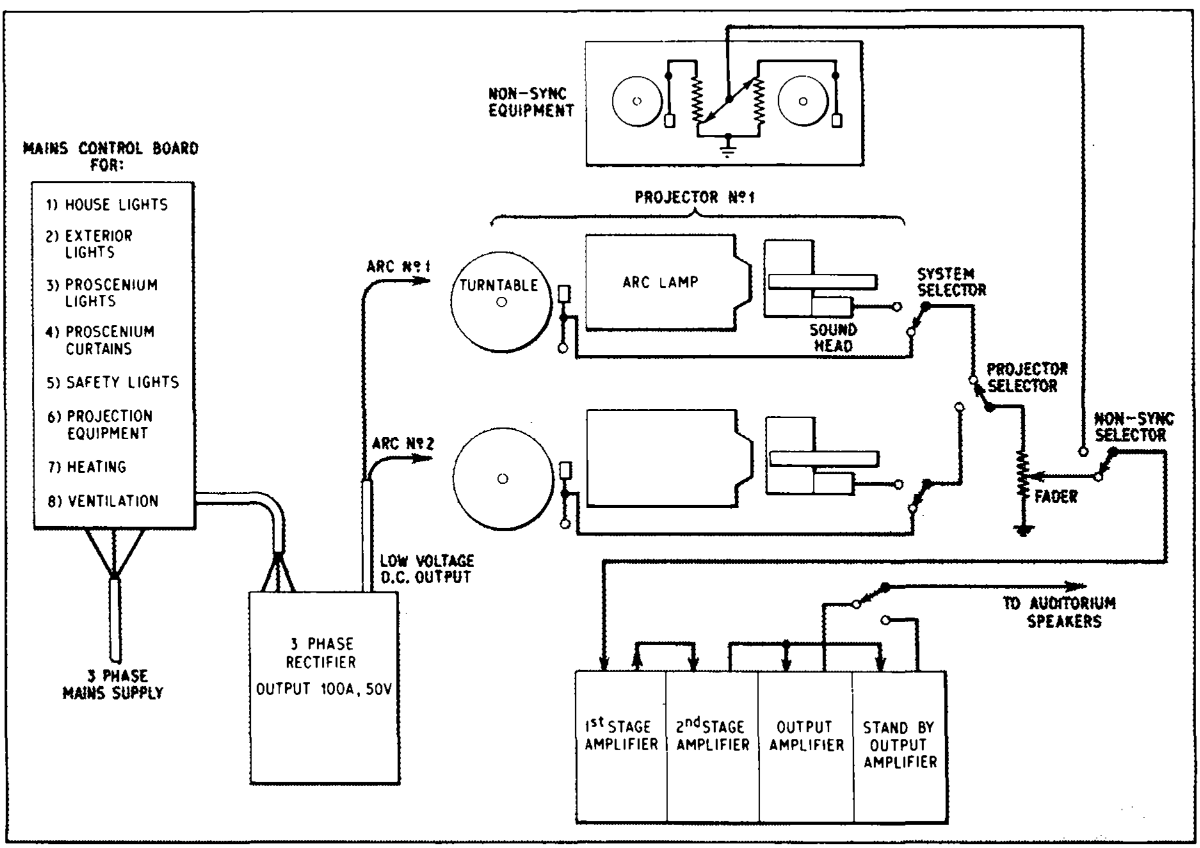


Fig. 1. Two methods of recording sound on film

(a) The Western Electric variable density system in which lines of varying thickness and frequency provided modulation

(b) The variable area system in which one half of the sound wave envelope was photographed. The "slow" contour wave on the left reduced noise in low-level modulation sequences

Fig. 2. Layout of a typical cinema projection room, about 1935



carrying a heavy, spring-loaded flywheel. Noisy backgrounds, due to fingermarks on the sound track, were removed by cleaning the entire length of the programme (perhaps 15,000 feet of film), using carbon tetrachloride and special pads. Joints in film involved doubling the film thickness—and density—so causing "thuds" in sound until triangular black patches were painted over the joint to give a gradual cut-off and cut-on of the light falling on the photocell.

Perhaps the biggest nuisance was failure of the accumulators used to light the exciter lamp; these might fail in the middle of a programme and cause a hurried changeover to the standby set. Some early versions of a.c. operated lamps caused hum modulation by temperature variation until an improved filament became available, then accumulators were discarded.

PROJECTOR ARC LAMPS

Another nuisance (which eventually proved to be a blessing in disguise) was the "dishcloth" screen, whose snowy whiteness, within a few days of the screen being "hung", became yellow with tobacco smoke. These screens were changed very frequently, but wear and tear made this a costly procedure. A partly successful solution was the introduction of the medium intensity, 40-amperes arc lamp to replace the 15-amperes affair of the silent day.

A short description of a low-intensity arc lamp will help us appreciate the problems inherent in a high-intensity version. The lamp operates on a d.c. low-voltage high-current supply and uses a thin, negative carbon, opposing a much thicker positive carbon; the extra thickness is necessary because, in all arcs operating on d.c., it is the positive which produces an intensely brilliant tongue of flame, and burns up much faster in doing so. A parabolic mirror focuses the light on the projector gate, covering only sufficient area to illuminate evenly each frame passing the gate aperture. As the carbons burn away, they are manually kept about half an inch apart by operation of control knobs. Other controls re-position the carbons if they tend to burn unevenly, and cause unwanted colouring of the picture.

In the medium-intensity arc based on the foregoing, new troubles arose. Carbons burned very rapidly and required constant attention; also, the tendency to burn unevenly and produce colouring was much greater. Heat, focused by the mirror, became so intense that the projected film buckled in the gate during the milliseconds it remained stationary; continually sharp focus was practically impossible in these conditions.

AUTOMATED ARC

Much thought was given to these problems, added to by the advent of *Technicolor*. Eventually, two solutions were found which combined in producing one of the greatest advances since the arrival of sound. One was a perforated rubber screen, surfaced with powdered glass which gave it a reflecting power far beyond that of the "dishcloth"; also, the new screen was as sound-transparent as the "dishcloth", perhaps more so. The second was automation of the arc lamp. The arc was manually "struck" and initially adjusted, but thereafter was controlled by a motor, itself controlled by the voltage drop across the arc. This voltage drop, as the arc gap widened, caused the motor to speed up and close the gap to the preset width, thus maintaining a light constancy which the projectionist could not manually equal. Another small motor (sometimes the arc-feed motor) rotated the "positive" as it burned and thus prevented unevenness of lighting.

Further study of the arc led to magnetic control of the flame (which is, in fact, an electric current possessing a magnetic field). An electro-magnet, powered by the arc current and positioned near the carbons repelled the magnetic effect of the flame, thereby concentrating the flame into a ball which permitted much improved focusing, and assisted the carbon-rotator to obtain even burning. Heat in the gate was reduced by air-blowers directed at the aperture, and in some experimental lamps, by passing the arc light through a water screen—a hollow glass disc through which chilled water flowed continuously. (Recent semi-manual lamps now use, in addition to the foregoing, a dichroic heat-transparent mirror which, although reflecting light with high efficiency, is a very poor reflector of heat.)

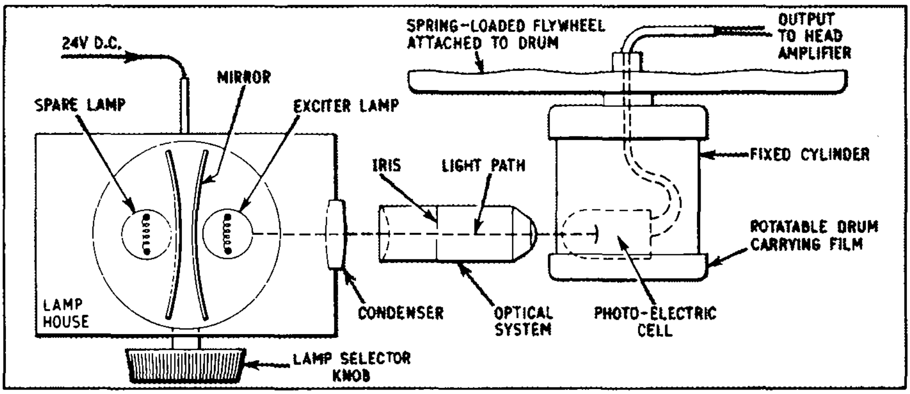


Fig. 3. Outline of typical soundhead.

HIGH INTENSITY XENON LAMP

The demand for higher powers has risen steadily and resulted in the 100-amperes, fully automated lamp. One starter button and extinguisher for standby or emergency use are provided, but the arc can be struck by remote control. Thereafter, all adjustments are motor-controlled; the arc mechanism itself is now water-cooled and air-blown. A serious competitor has also arrived in the Xenon lamp which produces a high-intensity light from an arc contained in an evacuated bulb. The life of the bulb is in the region of 300 hours, and its generated heat is much lower than that from a carbon arc. The lamp is readily automated. So far, widespread adoption of the Xenon lamp in the larger theatres has been delayed while development of very high-powered Xenons proceeds. *To be continued.*

BONANZA BOARDS

PART TWO

by A. J. BASSETT

THIS month's series of "Bonanza Board" projects follows similar lines to those published last month. For readers who did not see last month's PRACTICAL ELECTRONICS, let us briefly go over some of the salient features of this interesting exercise.

BASIC THEME

Each of the "Bonanza Board" projects described uses a basic theme on which is built a number of different circuits. One common pattern of printed circuit board is used for each, with link wires added as required (see Fig. 1). The pattern of this board will be found at the beginning of each "Bonanza Board" article, together with a code number relating to each project. The complete list of projects will be found at the foot of this page.

It is, of course, helpful to the reader to refer back to last month's issue, to familiarise himself with the techniques involved in producing the basic printed circuit board, which incidentally is only 2in square. This board is reproduced (right) so that readers can make a fresh start if they wish.

PRINTED CIRCUIT BOARD

A printed circuit kit can be obtained from one of the many component stockists advertising in this journal; the board and chemicals are usually supplied in the kit. Full constructional step-by-step details with photographs were published last month in the article "Printed Circuit Techniques".

It should be stressed again that the chemicals can be harmful to the skin; rubber gloves should be worn. It can be dangerous to the eyes; wear goggles if possible.

If each board is made with the same pattern of copper, it is a simple matter to alter the components of one circuit to make another. Soldering the components on the board is a simple operation if a hot iron is used and is only allowed to remain in contact with the copper and component wires for long enough to make good electrical joints. Use a heat shunt wherever possible (a pair of pliers will do) especially on transistors and diodes.

Last month's projects included a Pre-amplifier and Treble Booster, a Driver Amplifier, an A.M. Radio Tuner, and a Guitar Practice Adaptor.

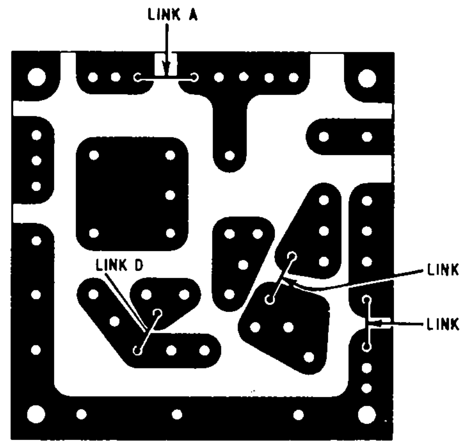
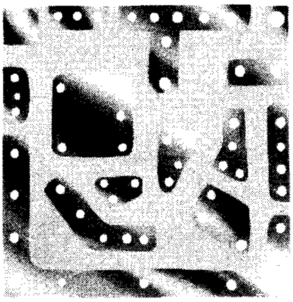


Fig. 1. Pattern of the printed circuit board with the positions of the four link wires

Look for these projects:



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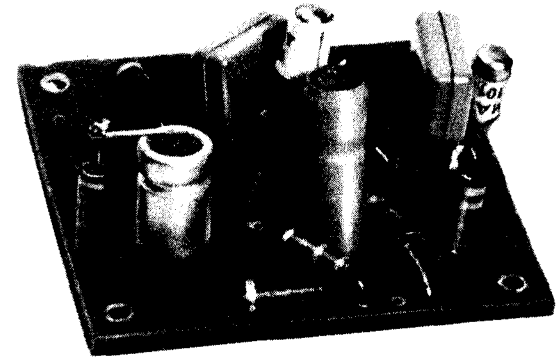


WIDE RANGE HARMONIC OSCILLATOR and METRONOME

This circuit will generate harmonics which will cover the entire audible frequency range. The presence of such harmonics will be found in two basic waveforms: the sawtooth waveform contains even harmonics; the square wave or pulse contains odd harmonics. The frequency of each waveform is, in fact, the fundamental frequency relating to these harmonics.

The oscillator is suitable for providing musical tones and sound effects. The output from either SK1 or SK2 can be amplified by connecting to SK1 of the "Simple Pre-amplifier" described in last month's issue. The circuit is shown in Fig. 1. It is recommended that high stability type resistors should be used for R2, R3, and R4, although ordinary 10 per cent carbon resistors will give an adequate performance.

MAKE

The layout of components is shown in Fig. 2; link wires are used at positions B, C, and D. Most of the components are mounted on the printed circuit board, but the potentiometer VR1 is mounted on a suitable sized housing and connected to the base of TR1 and emitter of TR2 by short flexible wires. The wiper (centre tag) and only one of the outer tags of VR1 are used. Similar sockets SK1 and SK2 are mounted on the box and connected to R1 and R6 respectively by short lengths of screened wire or coaxial cable.

CHECK

When the unit is completed and the wiring checked, VR1 should initially be set to maximum. Monitor each of the outputs by connecting a crystal earpiece or oscilloscope to SK1, then SK2.

Connect the battery BY1 and listen for a low pitched buzz in the earpiece or appropriate waveform (as shown in Fig. 1) on the oscilloscope. Slowly rotate the spindle of VR1; the pitch of the tone should change, according to the setting of VR1. If this change in pitch does not take place check the connections to VR1.

USE

The sawtooth output is the most suitable for sound effects, being a little less harsh than the pulse output.

continued on page 261

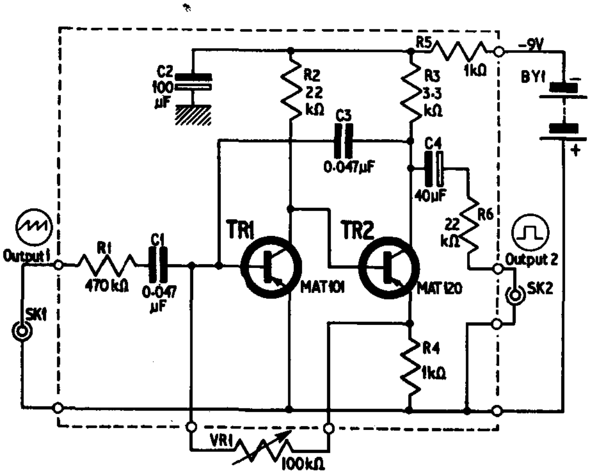


Fig. 1 Circuit diagram showing "output 1" (sawtooth waveform) and "output 2" (pulse waveform). The components inside the dotted line are mounted on the printed circuit board

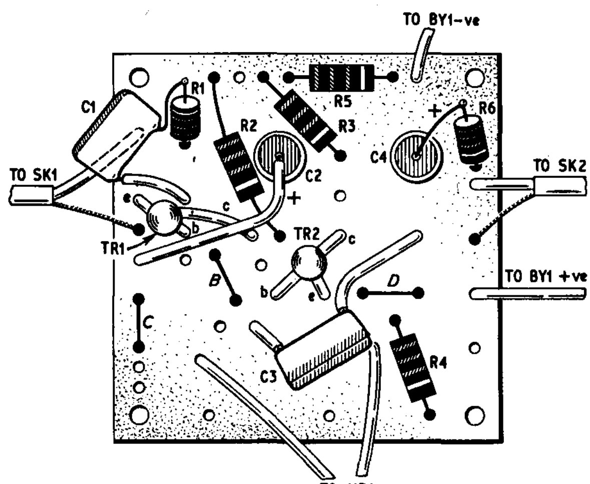
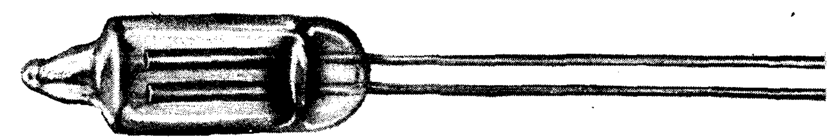


Fig. 2. Layout of components on the printed circuit board. Notice the link wires at B, C, and D. VR1 is not mounted on the board

NEON NOVELTIES



THIS is this eighth of a series of short articles illustrating some of the many uses of neon lamps. The neons employed are all miniature wire-ended types as shown above.

Two examples which are ideally suited to these applications are those supplied by Radiospares (striking voltage 65 volts), and the Hivac type 3L general purpose neons. The latter type requires a striking voltage of 80 volts and maintaining voltage of 60 volts.

Some neon indicators have a resistor wired in series with one of the neon wires to make them suitable for mains voltages. These would normally be unsuitable for the circuits described unless the resistor is removed or short-circuited.

EIGHT MULTI-PURPOSE TEST UNIT

by R. Bebbington, GRAD., I.E.R.E.

THIS SIMPLE unit was primarily devised as a capacitor tester. A batch of capacitors was needed for an application that required low leakage. With this circuit a leakage having an equivalent resistance of 40 megohms causes the neon to glow faintly, whilst higher leakages (lower resistances) cause the neon to glow correspondingly brighter. Capacitors over the range of 0·001μF to 1μF were tested and the really good ones caused the neon to flash once when connected.

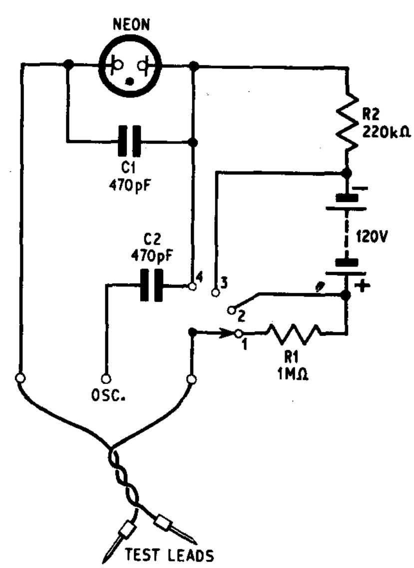
The circuit may also be used for insulation testing. The intensity of the neon's glow will give a rough idea of the degree of insulation: the better the insulation the fainter the glow and vice versa. A few comparison checks using known values of resistance will serve as a means of checking the actual value.

So far the tests have only needed the simplest of circuits: a neon, a battery and a resistor, in series with the component to be tested. However, the addition of a single-pole 4-way switch, a resistor and two capacitors extends its use considerably. The functions of the four switch positions are:

1. Audio Oscillator.
2. Capacitor and Insulation Tester.
3. Mains Tester.
4. 65V Neon (direct connection).

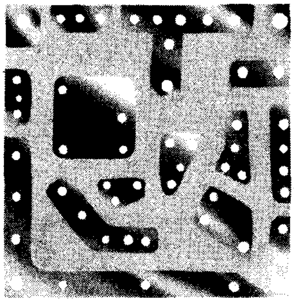
The audio oscillator is useful for fault finding in audio circuits. The frequency may be varied by either changing the value of the capacitor C1 across the neon or by inserting a resistor across the test leads, which otherwise should be shorted together to form one oscillator output lead.

Switch position 3 connects the neon in series with a limiting resistor R2 and provides a simple method of identifying the "live" mains lead, or whether an a.c./d.c. radio chassis has been connected properly. The chassis should not be connected to the mains "live" lead. Do ensure however that the test leads and prods are well insulated to avoid shocks. The neon will light when connected between "line" and "earth" but not between neutral and earth.



Switch position 4 isolates the neon from d.c. via C2, except for the small charge left in C1. The neon can therefore be connected to any external circuit. Remember, however that it strikes at about 60–70 volts and this potential should not be exceeded without a limiting resistor in series.

BISTABLE TRIGGER CIRCUIT



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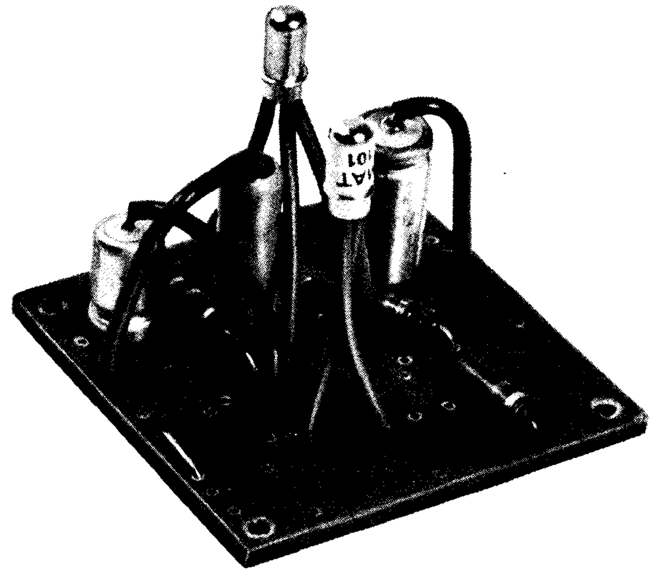


Low power trigger circuits hold a well deserved position as one of the most useful types of "building block" in modern electronics, especially in pulse coded transmission techniques.

COMPONENTS . . .

Resistors
- R1 330Ω
- R2 3·3kΩ
- R3 2·2kΩ
- R4 1kΩ
- All 10% ½ watt carbon

Potentiometer
- VR1 20kΩ linear carbon or wire wound

Capacitors
- C1 40μF elect. 12V
- C2 100μF elect. 15V
- C3 100μF elect. 15V

Transistors
- TR1 MAT101 } (Sinclair)
- TR2 MAT120 } (Sinclair)

Battery
- BY1 9 volt light duty

Miscellaneous
- Printed circuit board (see text)
- Battery connectors (if required)
- P.V.C. covered wire

TRIGGER CIRCUIT

Although this particular circuit has little use on its own, this article shows the construction of the individual unit, which will be incorporated in the "Guitar Sound Effects Unit" described later. Fig. 1 shows the circuit diagram of a simplified trigger circuit or bistable amplifier. It is built on the same pattern of printed circuit board as in all the other "Bonanza Board" projects. A full size drawing of the copper pattern is shown on page 250.

The layout of components is shown in Fig. 2; links A and C are used. The potentiometer VR1 is not mounted on the board but, since the unit is to be built into a larger box later, the leads to VR1 can be soldered as shown in Fig. 2. Each wire can be left about 6in long and connected to VR1 later. Similarly the output and input leads should be left for subsequent connection to another units.

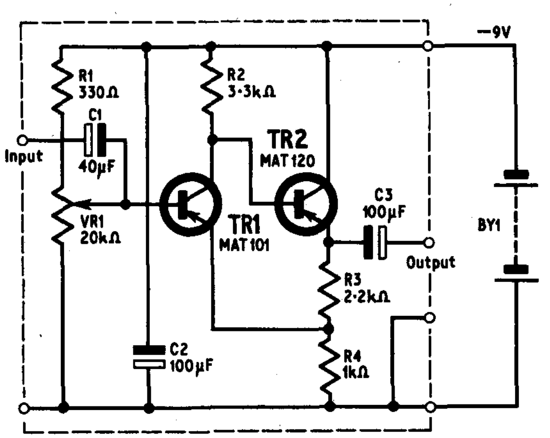


Fig. 1. Circuit diagram of the bistable trigger. No input and output sockets are necessary. All components within the dotted line area are mounted on the printed circuit board

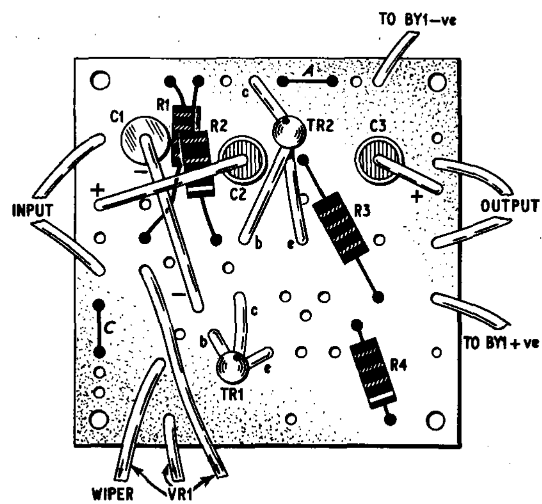


Fig. 2. Layout of components on the printed circuit board. Notice the link wires at A and C

GUITAR SOUND EFFECTS UNIT

THE sound effects unit described in this article is made up from a combination of two "Bonanza Boards" with additional switching and a filter circuit. It can be used with melody lines, where only one note is played at a time. An organ-like tone can be produced; if a tremolo arm or vibrato unit is incorporated with the guitar and power amplifier these effects may be made to fluctuate in pitch. The sound effects unit has been designed to offer three effects or changes of "sound" by using a switch.

(a) pre-amplifier for extra gain.
(b) treble booster for extra "tops".
(c) "fractured" sound.

A well known "pop" guitar group produces a sound similar to that made by this guitar sound effects unit, although the method of producing this sound is not exactly the same. By introducing a degree of inter-modulation and "switching noise" this unit will produce a "fractured" sound. There is no need to use any other special equipment apart from an electric guitar and guitar amplifier.

The basis of the device described here is the simplified trigger circuit, which converts the guitar signals to square waves. The filter circuit removes some unwanted harmonics, although interesting effects can be obtained if this is replaced by a 270 kilohm resistor connected across the output of the trigger circuit.

The basic idea is open to amendment or elaboration, by extending the switching to cover further combinations of the pre-amplifier and treble booster with the trigger circuit, and variations on the filter unit described later.

Each switched channel has its own volume control (VR1, VR2, or VR3) with a master to control the whole output (Fig. 1). Thus each channel can be quickly set up, before being switched into use, without upsetting the other two.

MODIFY BB1

The guitar pick-up is connected to the input of the "Pre-amplifier and Treble Booster" unit described in **BB1** last month. Both outputs of this unit are used as shown in Fig. 1. The modification to the emitter circuit of TR2 can be carried out (according to last month's article) if selective stepped treble boost is required; otherwise the plain pre-amplifier can be used. In the latter case C4 should be changed to 10μF; "output 2" is connected to a 100μF capacitor C4g via a switch S1b as shown in the diagram of the sound effects unit (Fig. 1 below). This will provide a simple treble boost of only one fixed amount when S1 is operated. VR1 on BB1 can be omitted if desired as can SK2, SK3, and BY1.

TRIGGER AND FILTER

There is no modification necessary to the trigger circuit, which is described on page 253 of this issue. However, the wiring of its flying leads should be carried out according to Fig. 1 below.

The filter unit is a simple passive circuit which need not be built up on a board as the components can be self-supporting. However, component board assembly is neater and facilitates changing the components for different values. The circuit diagram of the filter unit is shown in Fig. 1 and is a basic treble cut circuit. Fig. 2 shows how the filter can be assembled on a small piece of laminated wiring board (Veroboard). The copper strips run horizontally; no breaks need be made in these strips. The filter is used to "kill" unwanted harmonics.

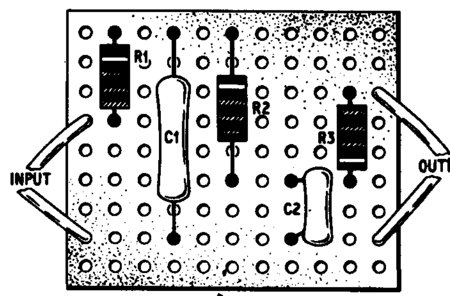


Fig. 2. Layout of the filter components on a piece of Veroboard. The copper strips run horizontally. No breaks are necessary

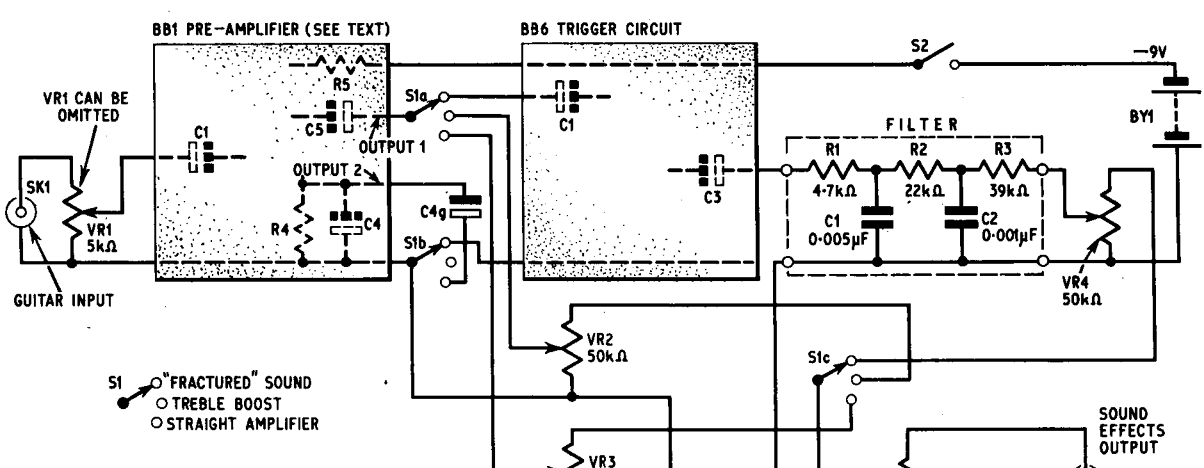
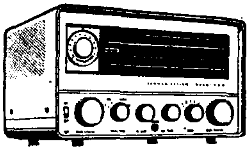


Fig. 1. Complete circuit of the guitar sound effects unit using a modified BB1 and BB6



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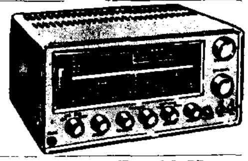

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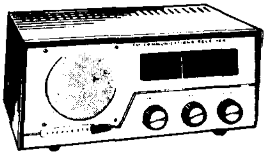

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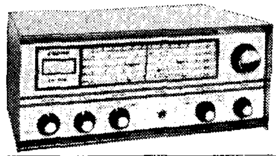

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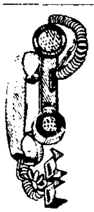

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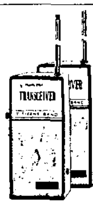

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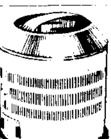

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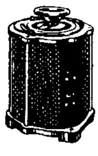

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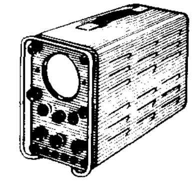

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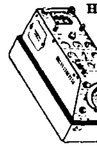

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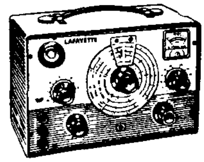

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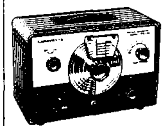

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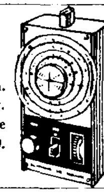

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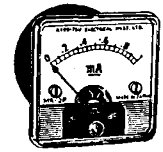

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1mA	**22/6**	750mA.	**22/6**	500V D.C.	**22/6**
2mA	**22/6**	1A D.C.	**22/6**	750V D.C.	**22/6**
5mA	**22/6**	2A D.C.	**22/6**	15V A.C.	**22/6**
10mA	**22/6**	5A D.C.	**22/6**	50V A.C.	**22/6**
20mA	**22/6**	3V D.C.	**22/6**	150V A.C.	**22/6**
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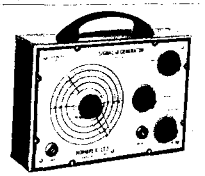

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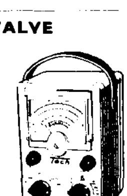

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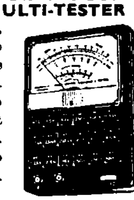

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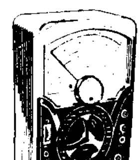

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7 VALVE AM/FM RADIOGRAM CHASSIS

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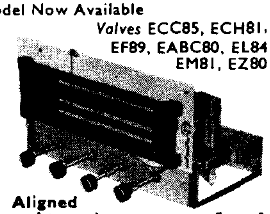

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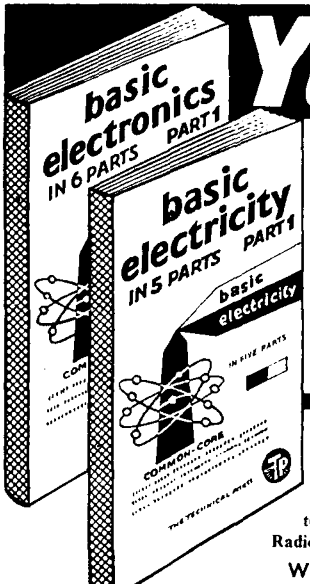

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COMPONENTS . . .

PRE-AMPLIFIER as shown on p. 182 last month but:
C4 should be changed to $10\mu F$ elect. 12V
VR1 can be omitted if desired
BY1 can be omitted
SK2 and SK3 can be omitted

BISTABLE TRIGGER as shown on p. 253 in this issue

FILTER UNIT (see text)

Resistors

R1 4·7kΩ, R2 22kΩ, R3 39kΩ — All 10% ½ watt carbon

Capacitors

C1 $0{\cdot}005\mu F$ 12V, C2 $0{\cdot}001\mu F$ 12V — Minimum working voltages permissible
These can be paper, plastic, ceramic, or mica types

OTHER COMPONENTS

Potentiometers

VR2, VR3, VR4 — 50kΩ log. carbon (3 off)
VR5 50kΩ log. carbon with single-pole on/off switch

Capacitor

C4g $100\mu F$ elect. 15V (Supplementary to the Pre-amplifier)

Switches

S1 Rotary switch 3 poles, 3 ways
S2 Single pole on/off switch (can be ganged to VR5)

Battery

BY1 9 volt light duty

Plugs and Sockets

PL1 and SK1 Two-way jack or coaxial for input
PL2 and SK2 Two-way jack or coaxial for output

Miscellaneous

Connecting leads for guitar to sound effects unit and power amplifier;
Metal box or chassis 6in × 4in × 2½in;
Crystal earpiece (if required)
Six control knobs, p.v.c. wire

The pre-amplifier, trigger circuit, and filter can be assembled in a metal box 6in × 4in × 2½in; an aluminium chassis would suit very well. Insulating backing boards should be fitted to the underside of all wiring boards. These can be thin s.r.b.p. sheet. The insulating board and printed circuit board are screwed together to wooden blocks glued on the inside of the box.

TRY IT OUT

When the construction is complete and all wiring checked, connect the guitar to the input. The output can either be connected to a guitar amplifier or, for monitoring only, a crystal earpiece. All volume controls should be set about half way. S1 is set to the "straight amplifier" position first to make sure a reasonable sound is heard from the guitar, via the pre-amplifier. Switch on S2.

Next switch S1 to "treble boost" and check for the appropriate change in sound quality. Now switch S1 to "fractured sound". Without plucking any strings slowly rotate the spindle of VR1 (trigger circuit) until a click is heard in the earpiece. Two positions will be found to provide this click between which the guitar sound will be heard through the earpiece, but with a rather unusual tone. If not, careful adjustment of VR1 should give the required results. Once VR1 has been set up it should not need any further adjustment. It would be best if it was made a preset control with a screwdriver slot instead of a knob.

Now, turn down all volume controls on the unit (i.e. VR2, 3, 4, and 5) and on the guitar amplifier (if used). With S1 set in each appropriate position adjust the volume controls to provide a balanced output. VR5 will be the master control which will control the sound from the other three by a proportional amount.

A different kind of effect can be obtained if the value of R3 in the trigger circuit is changed to 3·3 kilohms. The circuit will no longer give the "fractured" trigger action, but will alternate from one state to the other. A simple modification can be made so that the two values of resistance can be selected by another 2-way switch.

TECHNICAL BOOKS IN
NATIONAL LIBRARY WEEK

The first British National Library Week was held from 12 to 19 March 1966. The purpose of the "Week" was to interest everyone in making more use of public and special libraries of all kinds and in building up their own personal libraries. Nearly 300 local committees throughout Great Britain organised book exhibitions, talks, competitions, and other features during the "Week".

Scientific and technical books were specially featured by many centres, with displays of students' textbooks, industrial books, "do-it-yourself" books and books linked with local crafts. Talks by authors of scientific and technical books were arranged, and some centres staged exhibitions and discussions on the production and publication of technical books.

ELECTRONIC BUILDING BLOCKS

PART THIRTEEN

by R. A. DARLEY

Last month we dealt with the basic principles of timer counter instruments. This month's article is the last of the series in which mathematical circuits, both passive and active, are described.

COMPUTERS AND ELECTRONIC "BRAINS"

Computers fall into two distinct types, digital and analogue. Digital computers generally work on the basis of a binary code and employ many of the circuits and principles already outlined in parts 10, 11, and 12 of this series. They are capable of giving results to a high order of accuracy, and are very complex and expensive.

Analogue computers, on the other hand, are rather like electronic slide rules, with typical accuracies of about 2 per cent. In principle, the main difference between an analogue computer and a slide rule is that, on the slide rule, numbers are represented by the difference in distances between the scale markings, whereas in the analogue computer the numbers are represented by voltages, currents, resistances, or some other electrical quantities.

Electronic "brains" are computers with memory and logic circuits. The "memory" may take the form of a magnetic recording tape or it may be a system of electromagnetic matrices for storing "bits" of information.

The principles of storing "bits" of information in the memory are perfectly simple. A very crude example of a "memory" is an ordinary light switch; this is just a "two-state" device, which will switch the light "on" or "off". Any piece of information, no matter how complex, can be stored or "remembered" in coded form by a series of "two-state" circuits. The diagram shown in Fig. 11.2 (Part 11 of this series) shows just one of the many ways in which a circuit can be made to "remember" any one of ten alternative "bits" of information.

"Logic" circuits may be used to decipher the coded memory circuits, and Figs. 11.3a and 11.4a (Part 11) show two of the logic circuits that might be used. These again are perfectly simple circuits. There is a rather unfortunate tendency amongst many people to imagine that electronic "brains" are some sort of near mystical wonder, which can be understood only by our most brilliant scientists. Such notions are far from the truth, and electronic "brains" are, in principle, basically simple devices.

We shall now deal with specific circuits for carrying out mathematical functions, giving particular attention to circuits that are suited to use in analogue computers.

ADDITION AND SUBTRACTION CIRCUITS

Addition can be carried out in a number of ways; Fig. 13.1a shows the simplest method of carrying out this function, using passive elements. If, say, 1 volt is connected to input 1, and the values of the resistors are as shown, a current flows through R1 and R5. Since these two resistors form a voltage divider network, 0·1 volt is available at the output. If 1 volt is also connected to input 2, a current will flow through R2 and R5, of such a value that, if input 1 is disconnected, 0·1 volt would be available at the output. Thus, each input causes a current to flow in R5, and the output voltage is a function of the sum of these currents. The output would be 0·2 volts for two like input voltages. Similarly, no matter how many inputs are connected, the output voltage is a function of the sum of the input voltages provided all input resistors are of equal value.

If the circuit is required to give an output that is directly equal to the sum of the inputs, it can be modified by adding an amplifier to the output of the passive network, as shown in Fig. 13.1b, the amplifier having negative feedback applied from its output to its input to stabilise its gain. The gain should be made equal to the attenuation factor of the combined input passive network.

Fig. 13.1c shows the equivalent circuit of the passive network as seen between any two input terminals, one with an input signal of 1 volt connected, and the other with no input signal connected.

The input signals must be fed from some particular source impedance, and this should be low compared to the input impedance of the adding circuit; a source impedance Z_0 of 100 ohms is shown in the diagram. Thus, when 1 volt is connected to input 1, 0·1 volt appears at the output across R5, ignoring the shunting effect of R2 and R7. This output voltage is connected across R2 and Z_0, which act as a potential divider network, and approximately 1·1mV appears across input 2. Thus, a certain amount of interaction takes place between the input signals, detracting from the accuracy of the unit. Generally, the greater the attenuation factor of the network and the lower the source resistance, the less interaction will there be between inputs and the more accurate will be the readings.

This passive adding network can also be used for subtraction, by simply reversing the polarity of the input signal that is to be subtracted.

The network can be used with either a.c. or d.c. inputs; for a.c. work, the resistive elements may be replaced by inductive or capacitive components

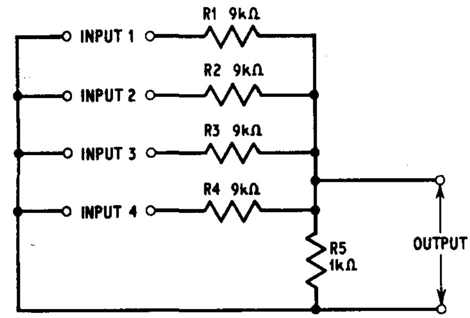


Fig. 13.1a. Passive adding circuit. The output is proportional to the sum of the inputs

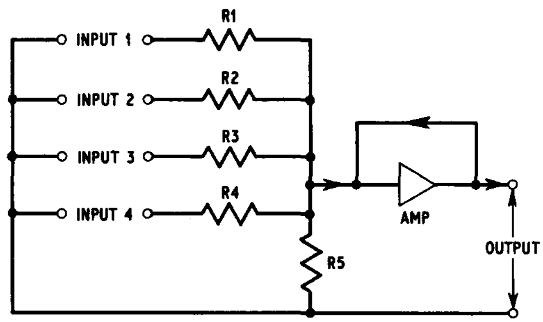


Fig. 13.1b. By adding an amplifier with gain equal to the attenuation factor of the passive network, the output is made equal to the sum of the inputs

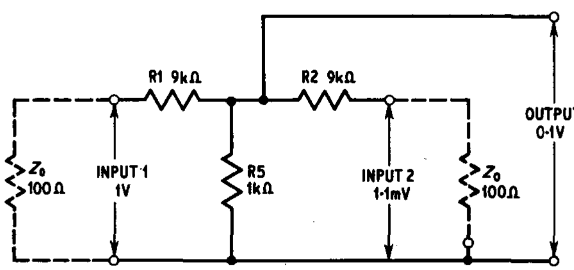


Fig. 13.1c. Effective circuit between input 1 and input 2 of the arrangement shown in Fig. 13.1a. Z_0 is the source impedance of each input

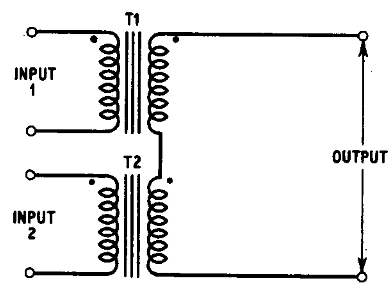


Fig. 13.2. Two transformers wired in series can be used for addition if the inputs are in phase, or for subtraction if 180 degrees out of phase. The dots indicate in-phase connection

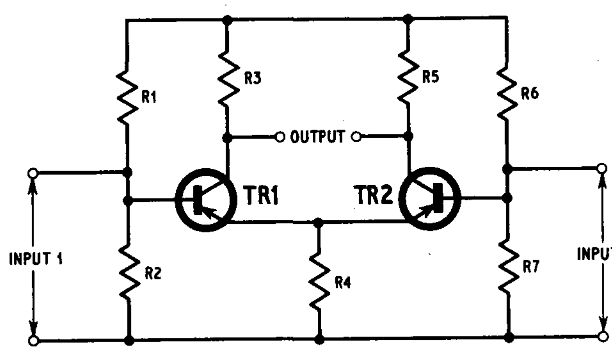


Fig. 13.3 Long-tailed pair circuit may be used for either subtraction or addition according to the phase of the two inputs

without in any way changing the principles of operation, but making it possible to operate at high frequencies.

The passive network, using resistive components, is widely used as a mixer in audio frequency circuits.

Addition and subtraction of a.c. signals can also be carried out using transformers wired in series, as shown in Fig. 13.2, the inputs being in-phase for addition and in anti-phase for subtraction.

Again, the long-tailed pair circuit, shown in Fig. 13.3, can be used for addition of two inputs, either a.c. or d.c. Basically, the circuit is a "difference amplifier", there being two input terminals, one to the base of TR1 and the other to the base of TR2, the output signal being a function of the difference between the two inputs; thus, subtraction functions are naturally carried out. By reversing the phase of one of the inputs, the circuit is made to subtract a negative value, which is the same as adding a positive one. This circuit was dealt with in detail in Part 5 of this series.

MULTIPLICATION

Multiplication can be carried out in any one of a number of ways. A step-up transformer may be used to carry out this function, one number being represented by a suitable signal connected to the primary input, and the second number being represented by a suitable tapping point on the secondary, as shown in Fig. 13.4a, the output signal then being proportional to the product of the two numbers. Again, a simple calibrated potential divider can be used to carry out multiplication functions, as shown in Fig. 13.4b. This is, in fact, a divider circuit, but division and multiplication are, after all, interchangeable functions as long as the position of the decimal points is known. The potential divider should be calibrated inversely, as shown.

An amplifier that has its gain closely controlled by negative feedback may also be used to carry out multiplication, the input signal level being made to represent one number and the gain of the amplifier another. The output signal level is then proportional to the product of the two numbers.

The most popular way of carrying out multiplication involves, as in the case of the slide rule, the addition of logarithms of the relevant numbers. Fig. 13.5a shows one method that may be used; VR1 and VR2 are log. potentiometers, calibrated with a linear scale from 0 to 10 to correspond with the log. of those numbers. The readout system employs an ohmmeter to measure the total resistance of the circuit in use by the two potentiometers in series, the scale being calibrated so as to convert the log. values back to real numbers.

Alternatively, regulated voltage supplies may be connected across two log. potentiometers wired in parallel. The resulting log. voltages available at the two outputs are added in a passive network, the sum of the two voltages, and thus the product of the two input numbers, being indicated on a moving coil meter.

In some cases it may not be required that the two input numerals be set manually, but that they should be set automatically. For example, an electronic circuit may have two outputs, one giving an output voltage that rises proportional to the magnitude of the number, the other rising proportional to the increment. A control signal may be required that is proportional to the product of the two signals. In this case, the fact that some diodes exhibit approximately logarithmic forward characteristics with applied voltage can be made use of, as shown in Fig. 13.5b. Resistor R1 is

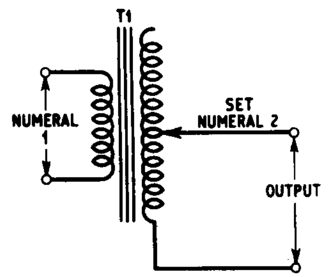


Fig. 13.4a. Multiplication using a step-up transformer

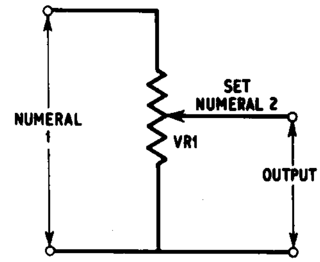


Fig. 13.4b. Potentiometer can be calibrated for division

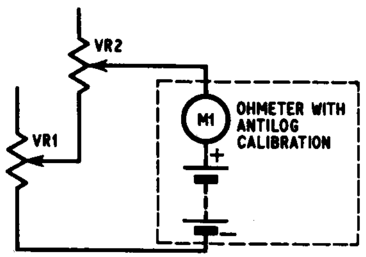


Fig. 13.5a. Multiplication using two potentiometers

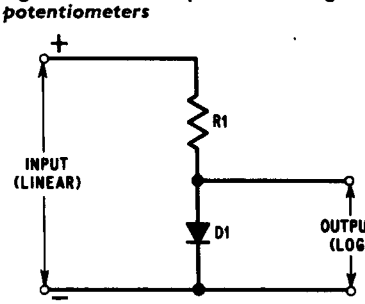


Fig. 13.5b. A semiconductor diode connected to give a log. output from a linear input

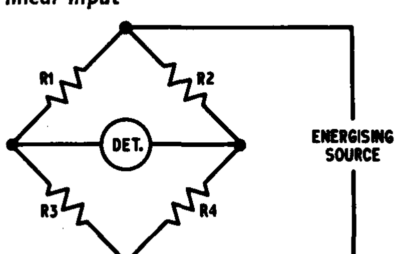


Fig. 13.6. Wheatstone bridge can be used for multiplication

wired in series with the diode, the two components forming a potential divider network across which the input voltage is applied. The logarithmic output voltage would be taken from across the diode and fed to the input of a passive adding network, which would automatically give an output voltage that is proportional to the product of the two input signals once it has been reconverted in an antilog. circuit.

Another circuit that may be used in an analogue computer to carry out multiplication is the simple Wheatstone bridge, shown in Fig. 13.6. An a.c. or d.c. energising source can be used, and a moving coil meter or head-phones used as a balance indicator. At balance $R1 \times R4 = R2 \times R3$, which is the same as saying that $R1/R2 = R3/R4$. To use the circuit for multiplication, R1, R2, and R4 can be calibrated potentiometers with linear scales, and R3 can be represented by a series of switched decade resistors. To find the product of two numbers, one number is set up on R1 and the other is set up on R4; the bridge is then balanced by adjusting R2 and R3 for balance and the result read off on R2. The position of the decimal point is determined by estimation, as in the case of a slide rule.

DIVISION

Many of the techniques that are used for multiplication can also be used for division, either directly or with some slight modification. The transformer system can be used by employing a step-down, instead of step-up transformer. The potential divider system can be used directly for division.

Instead of using an amplifier, as for multiplication, an input can be fed through an attenuator, the amplitude of the input signal being made to represent the number that is to be divided, and the attenuation factor equalling the number by which it is to be divided.

The two numbers that are to be divided can be converted into log. form and the resulting signals subtracted and converted back into decimal form in an antilog. circuit to give the required results.

Again, the Wheatstone bridge circuit can be used to give the result of dividing one quantity into another. In this case, the numerator is set up on R1 and the denominator is set on R2. The bridge is then balanced by adjusting R3, which should be a calibrated linear potentiometer, and R4, which could be a series of switch selected decade resistors. The result is then read out by R3, the decimal point being established by estimation. Note that the same bridge can be used for both multiplication and division by using a switch to transpose the positions of R3 and R4 to suit the particular mode of operation.

SQUARING AND OTHER CIRCUITS

To square a number, it is simply multiplied by itself. Thus, almost any of the circuits that are used for multiplication can be adapted as "square" resolving circuits. Alternatively, some transistors, that have characteristics approximating to the square law can be used to give the square of a number more directly.

By suitably arranging electronic components, almost any mathematical function can be carried out fairly simply. Circuits can be devised to resolve square roots, to integrate or differentiate with little difficulty, and many of these functions can be carried out by using an analogue computer. Strictly numerical calculations, as opposed to quantitative calculations, are performed by a digital computer. ★

WIDE RANGE HARMONIC OSCILLATOR

continued from page 251

The "colouring" of this tone can be altered by using suitable filter networks in the output. These filters reduce certain harmonics according to their circuit component values. More details are given in the article "Guitar Sound Effects Unit".

The pulse output can be used as a signal injector for testing amplifiers. Some radio control enthusiasts consider pulse modulation of the transmitter signal to be superior to sine wave modulation, especially where the receiver uses LC tuned circuits instead of reed banks. A pulse can be used with an amplifier and transducer as a source of sound waves for the Kundt's "tube experiment" to determine the speed of sound.

METRONOME

With minor alterations to the circuit this unit can be converted to a metronome. The following modifications will be necessary:

(a) Remove C3 and insert in its place a capacitor 8μF, with the positive end connected TR1 base.

(b) C1 and R1 can be omitted altogether as only "output 2" is required.

Almost any type of audio frequency transistors can be used although the MAT 101 and MAT 120 are quite suitable.

Using a crystal earpiece or audio amplifier connected to "output 2" a regular beat will be heard. The frequency, or time interval between beats, can be controlled as before by VR1.

COMPONENTS . . .

Resistors

R1	470kΩ	R4	1kΩ*
R2	22kΩ*	R5	1kΩ
R3	3·3kΩ*	R6	22kΩ

All resistors $\pm$10% ½ watt carbon (but * see text)

Potentiometer
VR1 100kΩ log. carbon

Capacitors
C1 0·047μF polyester
C2 100μF elect. 15V
C3 0·047μF polyester
C4 40μF elect. 12V

Transistors
TR1 MAT 101 } (Sinclair)
TR2 MAT 120 }

Battery
BY1 9 volt light duty

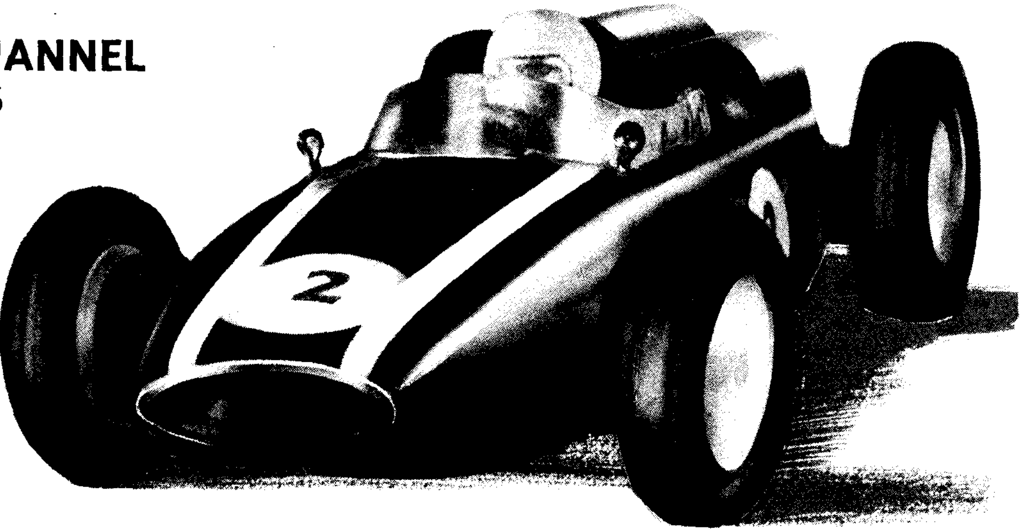
Plugs and sockets
PL1 and SK1 coaxial for output 1
PL2 and SK2 coaxial for output 2

Miscellaneous
Printed circuit board (see text)
Switch, single-pole, on/off (optional) for battery
Battery connectors and p.v.c. covered wire

Conversion to Metronome
Change C3 to 8μF elect. 12V
Delete C1, R1, and SK1

Part Three...

SINGLE CHANNEL RECEIVERS



Radio Control

UNTIL comparatively recently, most model radio control receivers have been of the super-regenerative type, based originally on a single "hard" valve (triode). Later on a gas filled valve (thyratron) was used, then a combination of a "hard" valve detector circuit plus a transistor amplifier and more recently the all-transistor receiver. The superheterodyne receiver has appeared as a practical proposition with the advantage of superior selectivity, the only real disadvantages being the bulk and cost of the additional mixing stage. Very little use has been made of the t.r.f. receiver largely because the ideal amount of amplification cannot be realised without the risk of amplified noise interfering with consistent operation. Such t.r.f. receivers that have proved workable have had a strictly limited practical range.

SUPER-REGEN

Although it is a simple practical circuit, the operation of the super-regen. receiver is actually quite complex. Basically, it uses a simple oscillator circuit which is tuned to be just on the point of oscillation. In this condition it is very sensitive to small voltages applied from the aerial tuning coil, and the resulting change from non-oscillating to oscillating state is accompanied by a marked fall in anode current. This current change is great enough to operate a sensitive relay in the anode circuit.

Oscillations are controlled or suppressed in bursts at a predetermined "quench" frequency, either by the use of a second quench oscillator injected in the first stage or by making the original oscillator capable of acting as its own quench oscillator (i.e. self-quenching). This can be done by coupling the grid in such a manner that the fundamental oscillation gives rise to its own intermittent suppression. The particular virtue of quench control is that the quench can be increased to a point at which the receiver will not oscillate, unless the oscillation is started and continuously boosted by an incoming signal of the same fundamental frequency, and hence acts as a sensitivity control.

A typical basic circuit is shown in Fig. 3.1. The grid/anode coil L2 is split at its centre with the inner ends connected to a transformer (quench coil L1). Oscillation is initiated in the r.f. circuit and immediately quenched by L1, the quench frequency being determined by the values of L1 and C1. Signal voltage is applied directly to L2b from the aerial. The relay in the anode h.t. circuit provides an on-off switch (via its contacts) controlling the external actuator circuit and is simply adjusted to operate just below the maximum anode current and drop out above the minimum anode current. Current change is typically of the order of 1 to 2 milliamperes, calling for the use of a sensitive relay and precise adjustment of differential. The larger the current change the less critical the relay operation becomes, and thus the less critical the relay performance and adjustment will be.

The main disadvantage of such a circuit is that sensitivity is affected by falling voltage (particularly the l.t. battery voltage). Also within the limitations of a single-valve circuit a greater anode current change can only be produced by an increase in h.t. battery voltage, calling for a more expensive and bulkier battery and making the receiver more expensive to operate.

Up to 90 volts h.t. may be necessary with a single valve receiver to produce a satisfactory current change for reliable relay operation, the relay being a critical factor. If desired, a further "adjustment" may be provided in the form of a potentiometer inserted in the h.t. lead between the relay and the battery, enabling a satisfactory level of relay current to be established.

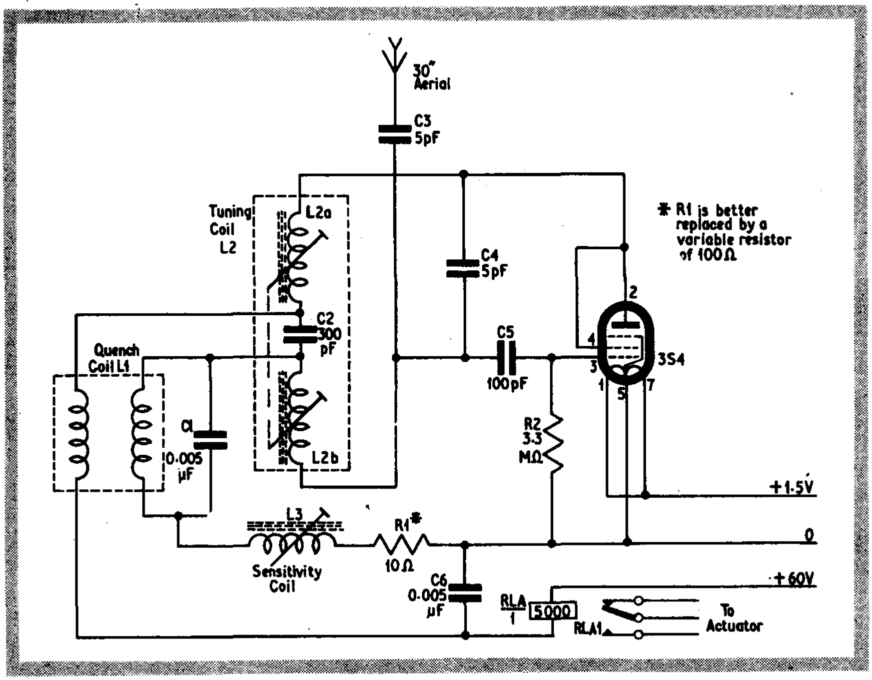


Fig. 3.1 (left). Basic circuit of a typical super-regenerative receiver

Fig. 3.2 (below). Super-regenerative receiver using a gas filled triode

Fig. 3.3 (bottom). An additional gas filled triode is used to amplify the signal

# of Models

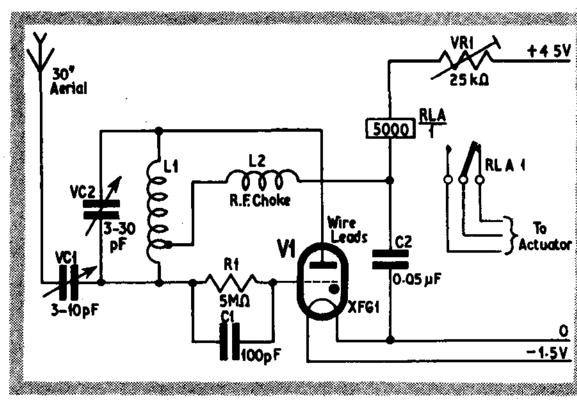
By R.H.WARRING

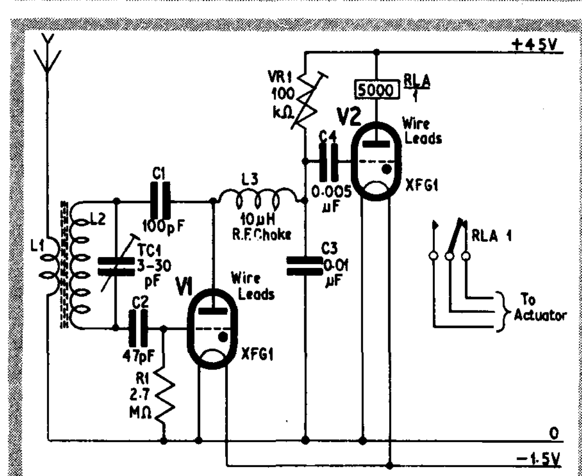
This also allows for some adjustment to compensate for falling h.t. battery voltage. The performance of the complete unit is only as good as that of the relay employed. Special lightweight relays are produced specifically for such circuits.

GAS FILLED TRIODE

A greater current change with lower h.t. voltages can be achieved with the use of a "soft" valve, for example, the subminiature XFG1 gas-filled triode. It is also possible with such a circuit to dispense with the separate coils for controlling the quench frequency, keeping the receiver permanently in a state of self-quenching super-regeneration. On receipt of a signal the strength of the oscillation in the receiver rises, thereby increasing the bias which reduces the anode current. The characteristics of soft valves (i.e. gas-filled types) are such that when ionisation of the gas breaks down the anode current drops sharply. Hence a relatively small signal strength can be made to produce a large change in anode current, provided the standing anode current lies just above the point of discontinuity. A potentiometer is usually provided in the anode circuit to adjust accordingly (see Fig. 3.2).

The soft valve receiver was very sensitive to changes in h.t. voltage, and the actual valve characteristics were affected by ageing. Although this could be compensated for by adjustment of the potentiometer, eventually the anode current will become too unstable or too low for satisfactory working at all, even with readjustment of component values. The particular virtue of this type of receiver was that it weighed only about one third as much as a hard valve receiver, giving an equivalent or better anode current change on a lower voltage h.t. Further improvements were also possible with an additional stage of amplification—see Fig. 3.3.





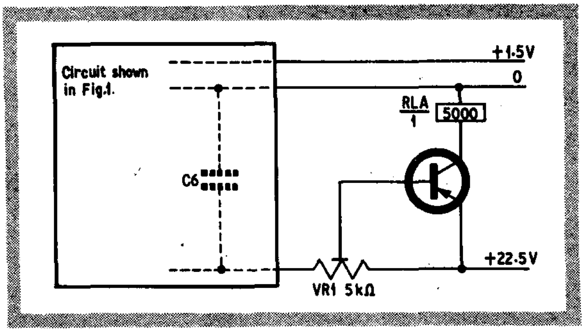


Fig. 3.4. Variation on the circuit shown in Fig. 3.1, using a transistor amplifier to operate the relay

Its equivalent, in hard valve circuitry (but far more stable and reliable) employing a super-regen. hard valve detector, followed by a hard valve amplifier, was a bulky and heavy unit for model work. It did, however, have the specific advantage of making the relay operation less critical and thus the complete receiver unit was more reliable.

One of the most satisfactory two-valve arrangements used the first valve to bias off the second. Such a circuit had an inherently low idling current, usually of the order of only 0·2 to 0·3 milliamperes, falling to virtually zero on receipt of a signal. This change triggered the second valve which then passed a current of anything between 3 and 5 milliamperes for as long as the signal was held on.

TRANSISTOR AMPLIFIER

When suitable transistors became available a greater degree of miniaturisation was possible. Transistor amplifier stages could follow a conventional valve type detector, or transistors could be used for all stages. Both basic types are used and have their own individual merits. The valve detector continues to score, generally, as regards stability under extreme weather conditions, high temperatures and varying battery voltages (i.e. overall operating stability). However, it requires a bulky h.t. battery, although this can be reduced to 22½ volts, typically, with transistor amplifier stages following, and a separate l.t. battery. The all-transistor circuit scores in being more compact and "solid state" (apart from the relay) and requires only a single low voltage battery.

One of the simplest circuits employing a valve detector followed by transistor amplification is shown in Fig. 3.4. This is basically nothing more than a single transistor stage added to the circuit of Fig. 3.1. The relay shown in Fig. 3.1 is reconnected as shown in Fig. 3.4. The immediate advantage is that the same current change (of the order of 3mA down to 1mA) can be obtained with the h.t. reduced to 22·5 volts, thus affecting a substantial saving in battery weight and cost.

Yet a further extension of this basic circuit for carrier wave operation is to add two further stages of transistor amplification, when the current change is raised to a sufficient level to operate an actuator direct and dispense with the relay.

A well proven valve-transistor receiver[2] for tone operation is shown in Fig. 3.5. This uses an XFY34 sub-miniature valve followed by three 2N217 transistors in simple circuitry. It is designed to respond to a 350–700c/s tone with 80–100 per cent modulation. The output load is a 5,000 ohm sensitive relay. The change in receiver current on receipt of the signal would be from about 0·6mA (idling) to approximately 4·5mA. A single tuning control only is employed (L1) to tune to the signal frequency.

This basic circuit has been used by individual constructors and commercial manufacturers, and probably represents the ultimate in basic practical requirements from a simple single-channel valve receiver. Its sensitivity is of the order of a few microvolts. It is still, however, a relatively bulky circuit and largely outdated by the all-transistor type of circuit.

The simplest possible type of transistor receiver can employ a semiconductor diode in place of a valve detector. Unfortunately a diode has only a fraction of the sensitivity of a valve used for the same purpose.

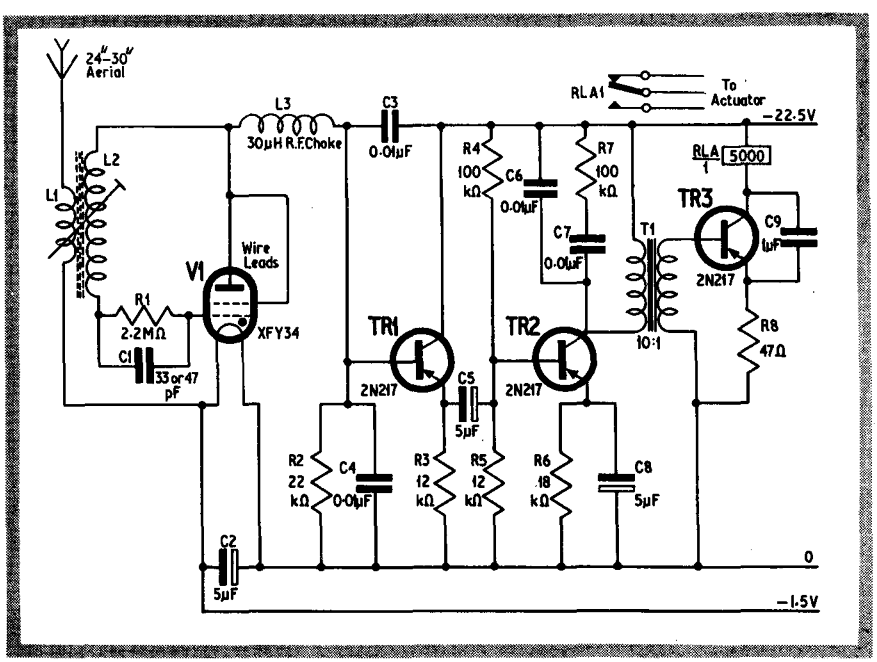


Fig. 3.5. A gas filled tetrode is used in this circuit with a three-stage transistor amplifier for tone operation

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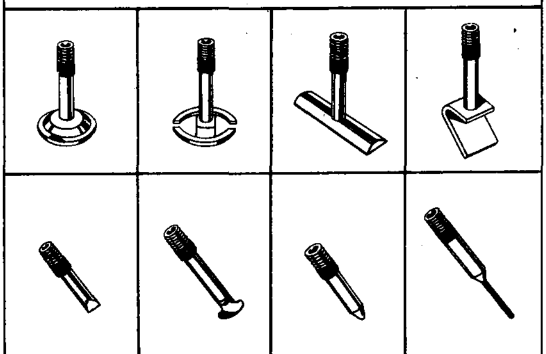

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Range is normally only a few yards. Such a circuit is interesting to build as an experiment, however, and a typical circuit is given in Fig. 3.6. It should be workable at close range with any reasonable c.w. transmitter. VR1 is adjusted to suit individual transistors.

ALL-TRANSISTOR RECEIVERS

The ultimate success of the all-transistor type of receiver depends to a large extent on the degree of stabilisation as well as individual transistor characteristics. With transistor amplification it is fairly simple to add further stages of d.c. amplification to provide a final current change sufficiently high to operate an actuator direct.

Basically, whilst it is a perfectly practical proposition to produce an all-transistor receiver circuit for carrier wave operation, a tone receiver, although slightly more complicated in circuit design requirements, will generally be easier to tune and less likely to be affected by changes in transistor characteristics. There are advantages in employing a tone transmitter as noted in Part 2 last month. Thus, most of modern transistor receiver designs are based on tone operation. The same basic receivers, of course, then have the possibility of being extended to multiple-tone operation, for example, via a reed bank switching output.

The transistor circuit design shown in Fig. 3.7 lends itself to extreme miniaturisation. A typical commercial receiver of this type[3] has been built on a printed circuit board 1¼in × 1in. An output current of up to 350mA is available for operating an actuator with an 8 ohm coil direct.

One of the main operating characteristics of the super-regen. receiver is very broad tuning. Although individually tuned to a specific transmitter frequency, such a receiver will normally pick up any other signals within, and even adjacent to, the 27 Mc/s band. Equally, most tone receivers will respond to superimposed tone frequencies between 200 and 1,000c/s, although performance may be rather more critical as regards percentage modulation of the carrier.

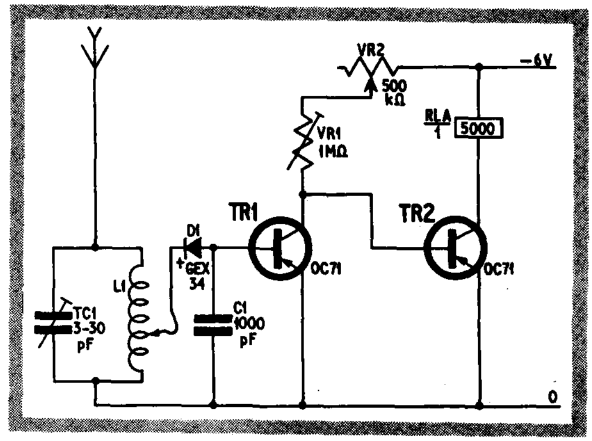


Fig. 3.6. Simple transistor receiver using a semiconductor diode for detection

It is thus virtually impossible to operate two or more transmitter/super-regen. receiver combinations simultaneously in close proximity, although each may be tuned to nominal "spot" frequencies at opposite ends of the band. Furthermore, one super-regen. receiver is likely to interfere with the operation of another adjacent super-regen. receiver operating at the same time. All super-regen. receivers are particularly susceptible to interference from any stray signals of sufficient strength which may be present in the 27Mc/s band.

SUPERHET

The superheterodyne receiver overcomes this limitation by virtue of its extreme selectivity, albeit at a considerable complication of the additional front-end circuitry, and in alignment for initial setting up. Although individual superhet designs have appeared over the years, commercial production of this type of receiver is a very recent innovation and, in line with modern development, is invariably based on the all-transistor receiver of the "tone" type—see Fig. 3.8.

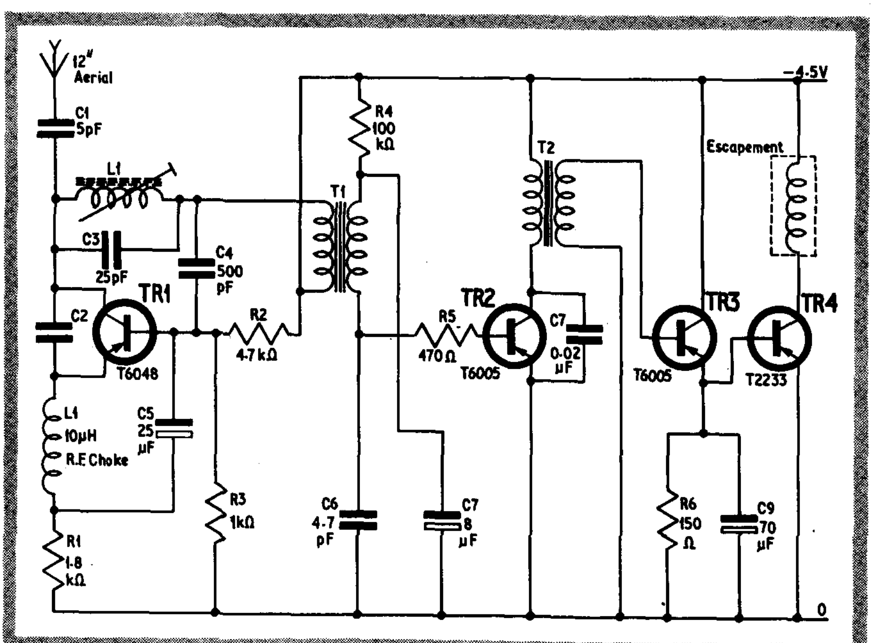


Fig. 3.7. All-transistor super-regenerative receiver

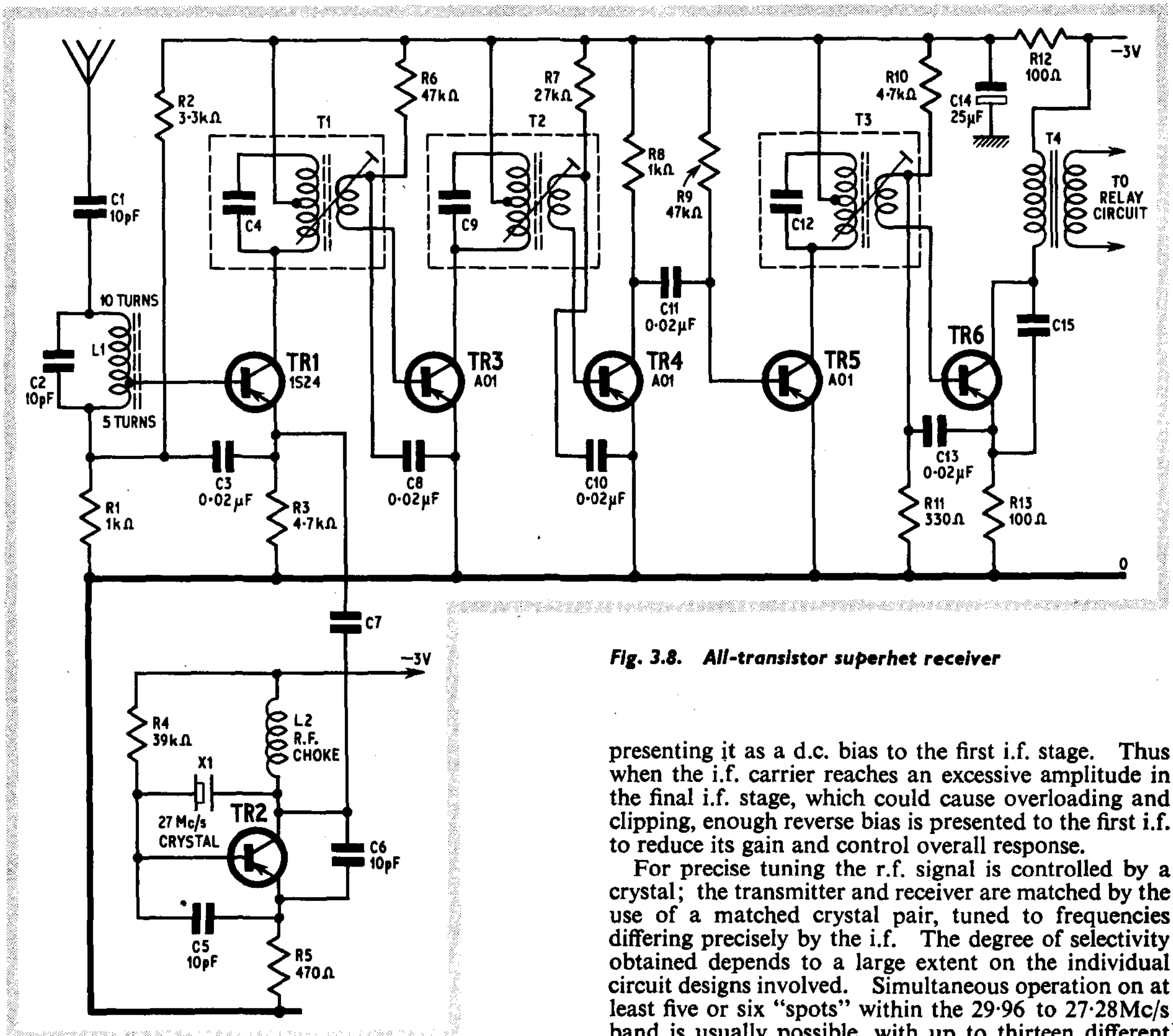


Fig. 3.8. All-transistor superhet receiver

The i.f. normally chosen is between 450 and 475kc/s, 455kc/s being generally used in America and 470kc/s in this country. Receiver oscillator frequency is normally made lower than the signal frequency as this gives greater efficiency in the tuned circuits. After mixing, up to five stages of i.f. amplification may be used, although some circuits may be worked with only a single i.f. stage; although two i.f. stages are a more usual minimum.

Automatic gain control (a.g.c.) is more or less obligatory since the gain through the i.f. amplifiers is not self-limiting, and overloading can prevent operation of the receiver. The stronger the input signal from the transmitter the stronger the output from the i.f. coils. When using a transmitter with less than 100 per cent modulation, clipping and distortion takes place to the point of elimination of modulated or tone signals within the i.f. stages. This is particularly significant in the case of multi-channel receivers, which are basically similar in design to single-channel tone receivers. The function of a.g.c. is to limit the total overall gain, proportional to the strength of the input signal, by rectifying part of the i.f. signal at the last i.f. stage and presenting it as a d.c. bias to the first i.f. stage. Thus when the i.f. carrier reaches an excessive amplitude in the final i.f. stage, which could cause overloading and clipping, enough reverse bias is presented to the first i.f. to reduce its gain and control overall response.

For precise tuning the r.f. signal is controlled by a crystal; the transmitter and receiver are matched by the use of a matched crystal pair, tuned to frequencies differing precisely by the i.f. The degree of selectivity obtained depends to a large extent on the individual circuit designs involved. Simultaneous operation on at least five or six "spots" within the 29·96 to 27·28Mc/s band is usually possible, with up to thirteen different spot frequencies available and capable of being worked. Simultaneous operation, in this respect, means that this number of separate transmitter-receiver combinations can be operated simultaneously without interfering with one another.

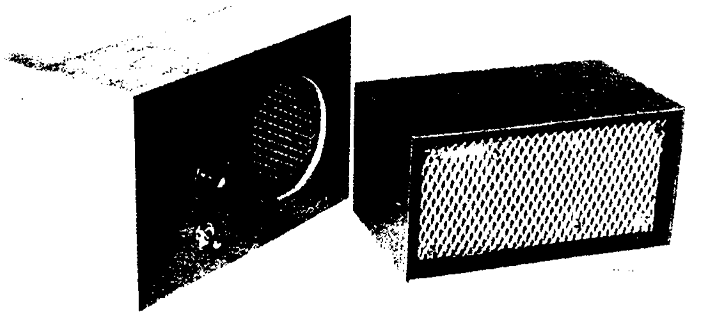
The superhet-receiver, of course, is also not likely to be affected by spurious signals within the 27Mc/s band, unless these coincide exactly with, or embrace, the actual "spot" frequency of operation, and then only if present at a suitable strength. The superhet. receiver is regarded as the preferred type for model radio control work because it is possible to operate more than one transmitter-receiver combination simultaneously with general freedom from interference. It is, however, considerably more expensive to produce than its super-regen. counterpart; and the additional cost is less justified in the case of single-channel receivers than multi-channel receivers.

References

1. Ivy AM carrier receiver (also produced in kit form by Macgregor Industries.)
2. Orbit single-channel tone receiver.
3. Otarion sub-miniature receiver.

Next month: Design aspects for single channel actuators

HOME AIDS SECTION



BABY ALARM

by G. GODBOLD

A REMOTE indicator provides an invaluable aid in monitoring a child's distress calls, when the parents are so engaged to be normally unaware of its discomfort. The alarm system described here can be adapted to form a communications link between any two rooms in the house. It is extremely sensitive, powerful, and of reasonable quality to make the calls intelligible.

Some baby alarms can be unreliable if the sensitivity is poor; this circuit overcomes this problem and, indeed, is so sensitive that sound many feet away can be picked up without difficulty.

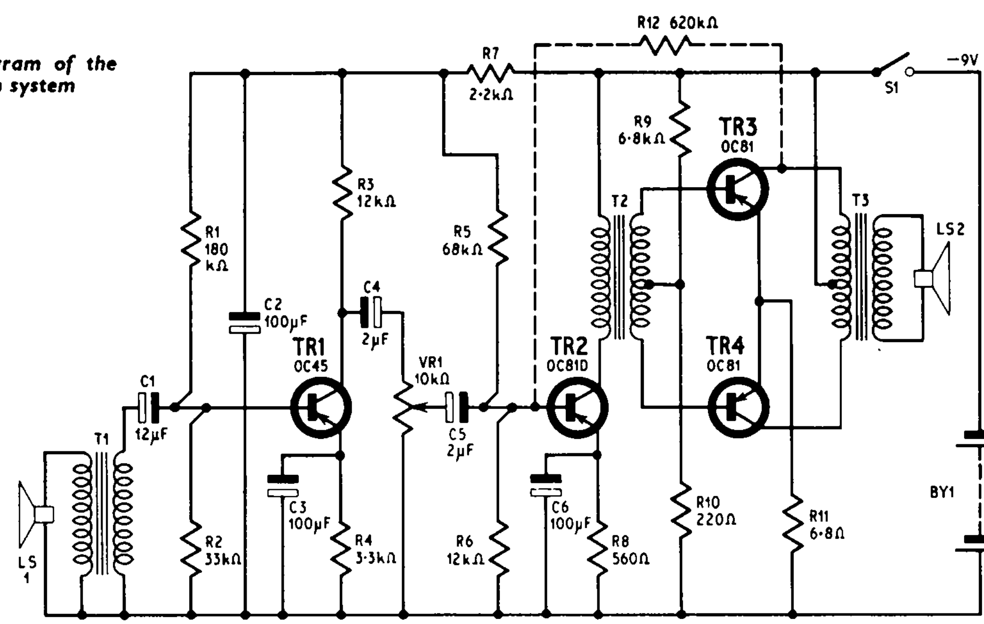
HIGH GAIN

The circuit is, in essence, a three-stage audio amplifier providing a high gain output from a push-pull class B pair of transistors. A loudspeaker is used as a microphone connected to a 1:50 input transformer, which provides a voltage step-up and impedance matching to the input impedance of TR1. Resistors R1, R2, and R4 provide a stabilized bias to the transistor with C3 acting as an a.c. bypass.

The output from this stage is tapped off by the wiper of VR1, which serves as a sensitivity control, and fed to the base of TR2. This is the driver which supplies the signal to the output pair TR3 and TR4, via a phase splitting transformer T2. Both TR3 and TR4 must be matched to avoid undue distortion arising from differing current gains.

Overall negative feedback was not found necessary, as the degree of distortion was quite acceptable for the purpose intended. Also gain was considered of greater importance. If this distortion is unacceptable a negative feedback resistor (620 kilohms) can be connected between TR3 collector and TR2 base. This is shown dotted in Fig. 1. Output linearity and hence distortion will be improved at the expense of some gain.

Fig. 1. Circuit diagram of the complete baby alarm system



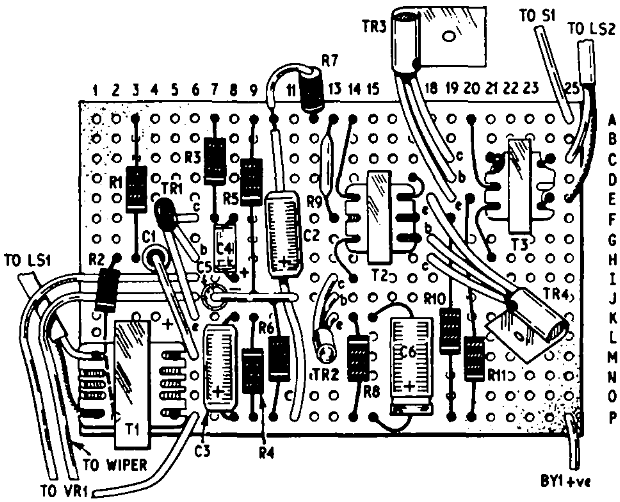


Fig. 2a. Assembled components on a piece of Veroboard. The two loudspeakers, the sensitivity control VR1, battery, and switch are not mounted on the board but the connections for these are shown. TR3 and TR4 are fitted with cooling clips (see text)

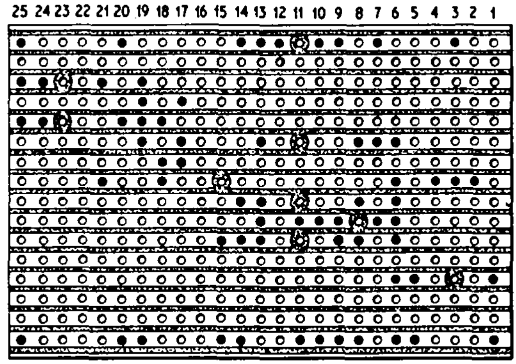


Fig. 2b. Underside view of the wiring board showing the copper strips. These strips need to be cut in nine places (as shown) using a spot-face cutter or sharp knife. The black dots show where components and wires are connected

HEAT SINKS

It is recommended that heat sinks should be used on TR3 and TR4 to contribute to thermal stability. The transistors are fitted with copper cooling clips (obtainable from most component specialist shops), which are bolted to two pieces of 16 s.w.g. aluminium or copper measuring at least 7cm × 5cm.

In the prototype box, a piece of 16 s.w.g. aluminium was bent to a right-angle and screwed to the top in such a position that it was close to the transistors standing up on the component board. They are easily fastened to this heat sink.

The output transformer matches TR3 and TR4 to a 3 ohm loudspeaker. The other loudspeaker LS1, used as a microphone, is also a 3 ohm type, which is mounted separately in its own case, 7in × 4in × 3½in.

The amplifier, switch, and battery were housed in a box 8in × 4½in × 5in. The battery is held in place by a spring clip screwed to the box.

Single core screened microphone cable was used to connect LS1 to T1. No hum was apparent when a 25ft length was used on the prototype. ★

COMPONENTS . . .

Resistors
R1 180kΩ
R2 33kΩ
R3 12kΩ
R4 3·3kΩ
R5 68kΩ
R6 12kΩ
R7 2·2kΩ
R8 560Ω
R9 6·8kΩ
R10 220Ω
R11 6·8Ω 5% 3 watts
R12 620kΩ (see text)
All 10% ½ watt carbon, except R11

Potentiometer
VR1 10kΩ log. carbon

Capacitors
C1 12μF elect. 25V
C2 100μF elect. 15V
C3 100μF elect. 15V
C4 2μF elect. 10V
C5 2μF elect. 10V
C6 100μF elect. 15V

Transformers
T1 "Miniature" type output transformer 50:1 (Radiospares)
T2 Driver transformer (Repanco TT45)
T3 Output transformer (Repanco TT46)

Switch
S1 single-pole, on/off toggle

Transistors
TR1 OC45 (Mullard)
TR2 OC81D }
TR3 OC81 } (Mullard package LFH3 matched set)
TR4 OC81 }

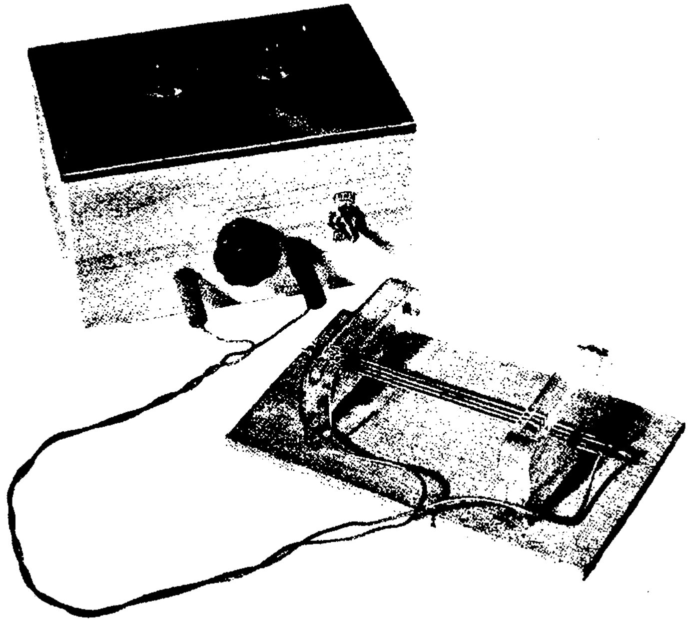
Loudspeakers
LS1 3 ohms 2½in dia.
LS2 3 ohms 3⅝in dia.

Battery
BY1 9 volts (Vidor VT3)

Miscellaneous
Veroboard 3¾in × 2½in, 0·15in pitch
Wood for amplifier case 4½in × ½in × 2ft
Plywood front panel 8in × 5in
Wood for LS1 case
Cooling clips for TR3 and TR4
Copper or aluminium heat sinks (see text)
Expanded metal loudspeaker grille

RAIN SENSOR

by G. M. HARVEY



WITH this simple electronic device the clothes line can be left fully laden, without the housewife worrying about the possibility of rain. A rain sensor can be left in the garden; its two connecting wires lead to a flashing alarm in the house.

SENSOR CIRCUIT

The sensor is an arrangement of parallel thick wires, alternate wires being electrically connected together as shown in the photograph. If a raindrop is caught by two adjacent conductors of the sensor it forms a relatively low resistance path to d.c., which virtually connects TR1 base to VR1 wiper via R1.

VR1 acts as a sensitivity control which can be preset to provide the correct bias condition for TR1. The conductance of the raindrop and separation of the conductor wires on the sensor will determine the setting of VR1. Resistor R1 acts as a base current limiting resistor to prevent accidental damage to TR1 in the event of a dead short across the sensor wires.

The potentiometer is normally set so that maximum collector current is drawn when the input (base) circuit is complete; the transistor is said to be "bottomed". This is about 6mA higher than the operating current of the relay RLA, so its action is immediate.

The diode D1 acts as a low resistance load, which suppresses high transient currents induced by the inductive load RLA. This will avoid undue damage to the transistor.

ALARM FLASHER

The relay's operation closes RLA1 and connects the battery supply to a multivibrator circuit. The indicator lamps at the collector of TR3 are made to flash due to the interchange of cumulative action between the transistors TR2 and TR3. The flashing time is determined by C1 and R3, and C2 and R4. The time per cycle in this circuit is approximately 0·5 second but if required this can be altered by reducing the values of C1 and C2 for faster flashing. Two 6 volt lamps are connected in series and will have almost the whole battery voltage across them at the commencement of each cycle, due to the "bottoming" of TR3. If low current lamps are used (6V, 0·06A) the current drawn should be well within the maximum rating of TR3 collector.

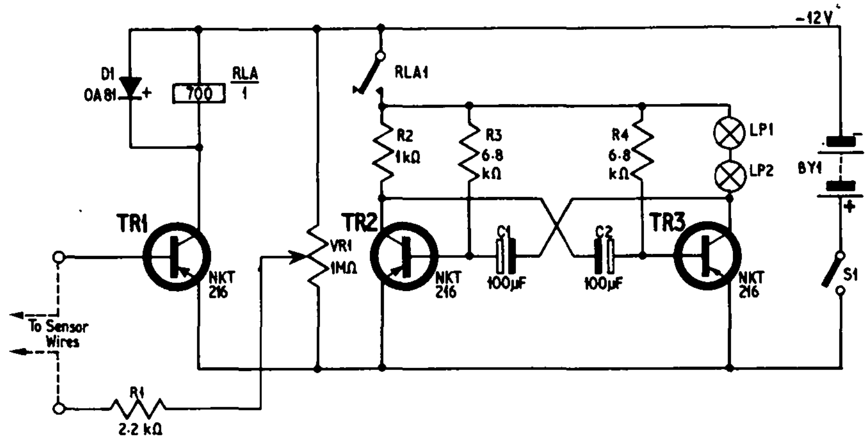


Fig. 1. Circuit diagram of the rain sensor unit. The sensor wires are connected alternately together as shown in the photograph above

COMPONENTS . . .

Resistors
R1 2·2kΩ R3 6·8kΩ
R2 1kΩ R4 6·8kΩ
All resistors 10%, ½ watt, carbon

Potentiometer
VR1 1MΩ linear carbon

Capacitors
C1 100μF elect. 25V
C2 100μF elect. 25V

Transistors
TR1, TR2, TR3 NKT 216 (3 off) (Newmarket)

Diode
D1 OA81 (Mullard)

Relay
RLA 700Ω 12V Type MH2 (Keyswitch Relays Ltd.)

Lamps
LP1, LP2 Panel lampholders, m.e.s. with bulbs, 6V, 0·06A, m.e.s. (2 off each)

Battery
BY1 12V, made up from four 3 volt batteries (type 72, Ever Ready)

Switch
S1 Single pole, on/off, toggle switch

Miscellaneous
Veroboard 3½in × 2½in (or as required)
Wander plugs and sockets (2 off each)
Battery connectors and plastics case (see text)
P.V.C. covered wire
Wood for box 4½in × ½in × 18in
Wooden baseboard, plastics sheet, and wires for the sensor (see text)

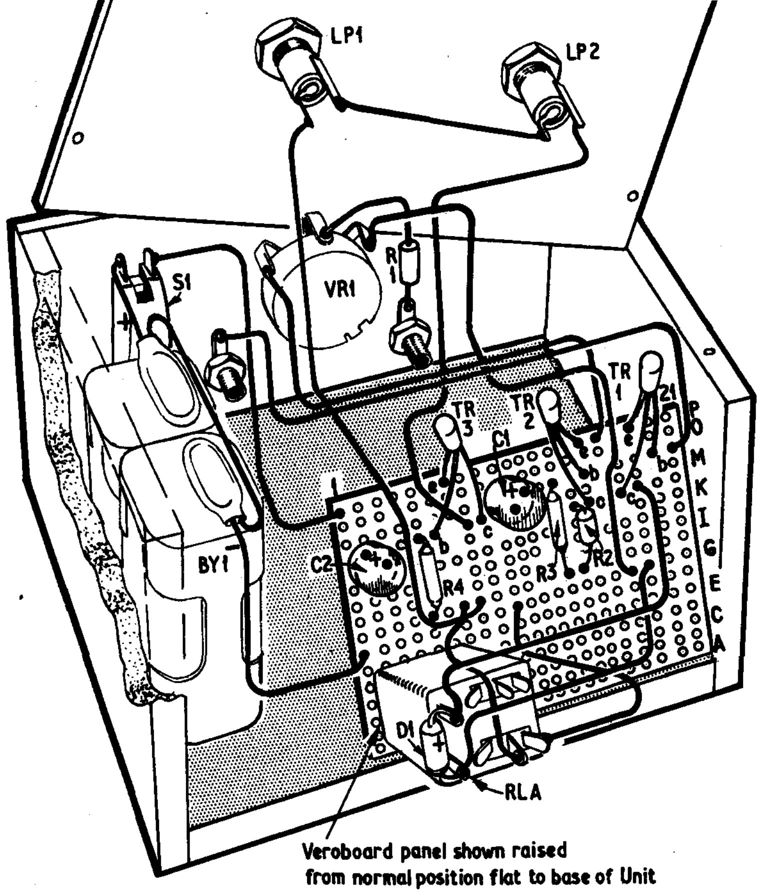


Fig. 2. Layout of the components in the box. The top-side of the wiring board is tilted forward to show the component wiring clearly

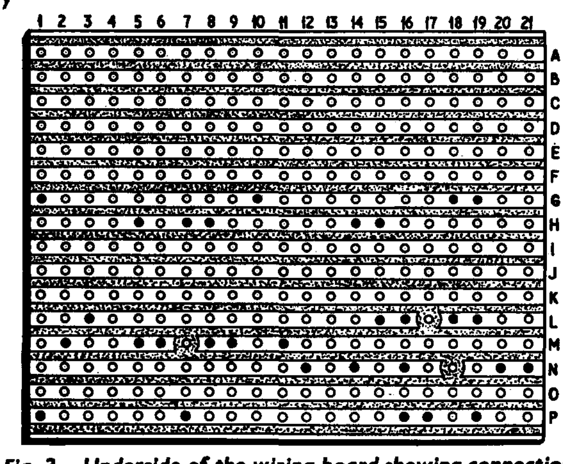


Fig. 3. Underside of the wiring board showing connections (black dots) and breaks in the copper strips

On "stand-by" the current drain is negligible. When operative an average of about 60mA per flashing cycle is drawn. This led to a choice of power supply made up from four 3 volt batteries arranged in series to give 12 volts. This voltage is required to operate RLA.

The battery pack can be made up from four batteries, type 72, each of which consists of two cells, type 1915. They can be conveniently housed in two plastics containers specially made and fitted with connecting strips for the purpose. These containers are obtainable from G. W. Smith & Co. (Radio) Ltd., 3 Lisle Street, London, W.C.2.

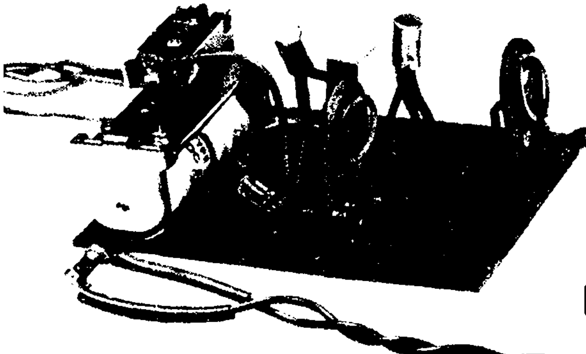
MAKING THE SENSOR

The sensor itself is made by fitting four (or more) straight parallel tinned copper wires to two plastics side supports. These supports should be impervious to moisture, as any absorption by the supports would trigger the alarm unintentionally; hence, wood is not recommended.

If 16 s.w.g. wire is used the holes in the side supports can be drilled with a $\frac{1}{16}$in diameter drill. The distance between any two wires should not exceed $\frac{1}{16}$in so the pitch between centres would be ⅛in. Alternate wires are connected together (see photograph). The length and number of wires used is a matter of choice, but obviously the larger the "catching" area the greater the sensitivity to a passing shower. When soldering on the wires, it is recommended that pliers are applied between soldering iron and plastics support, to prevent the plastics melting and loosening its grip on the wires.

The layout of components on the wiring board is not critical and it would be possible to reduce this layout area on a smaller board, thus reducing the size of the finished article.

The housing is a made up wooden box 6in × 4½in × 3in, but a metal box would probably provide a more pleasing appearance. ★



HEATER OR FIRE MONITOR

by GORDON J. KING

THIS unit was designed as a greenhouse heat failure system. It can of course be adopted for other temperature monitoring purposes, as will be appreciated from the following description of its function.

With the kind of application in mind, close temperature tolerance is not essential and since the relatively high temperature at the top of the correctly working heater can easily be "monitored", a thermistor has been employed as the temperature sensing element. This device works in conjunction with a two-stage transistor d.c. amplifier, the second stage being suitable for energising a magnetic relay which, in turn, switches the alarm bell.

CIRCUIT OPERATION

If the base current of TR1 is turned off either by disconnecting the thermistor X1 or the thermistor battery connection at point "A" on the battery pack, the conductivity of TR2 is then governed by the base current delivered by the base potential-divider comprising R2, VR2, R3. The smaller the total value of the top section (R2, VR2), the greater the base current and hence the greater the collector current.

The preset control VR2 allows the conductivity of TR2 to be adjusted until the collector current is suitable to energise the relay RLA. The maximum, safe amount of collector current is, of course, governed by the type of transistor used, so a relay must be chosen whose operating sensitivity falls within the power capabilities of TR2.

The Mullard OC72, or equivalent, has sufficient power reserve to work a relay calling for up to about 20mA at a voltage not greater than about 10. The Post Office type 3000 relay with a 500-ohm coil satisfies these requirements. There are other relays suitable for instance, the Omron, supplied by Keyswitch Relays Limited, type 2051 is available with a 650-ohm coil, which operates at about 12mA. This component is illustrated in the accompanying diagrams.

SETTING TR2

The second preset potentiometer VR2 is adjusted so that the relay energises, ensuring that TR2 collector current does not exceed 20mA. This can be achieved either by putting a milliammeter in series with TR2 collector circuit or by measuring the d.c. voltage across the relay coil, assuming that the coil resistance is known. The voltage is equal to the current in amperes times the resistance. Thus, a 500 ohm relay would be passing 20mA when the voltage measured across it is 10.

It will be seen that the collector/emitter circuit of TR1 is across R3, the bottom arm of the potential-divider of TR2. With the thermistor (hence, base circuit of TR1) disconnected, the effect of TR1 across R3 is negligible. However, when the thermistor circuit is connected TR1 base current flows and causes TR1 to conduct.

The degree of conductivity of this transistor depends on (*a*) the setting of the "set temperature" preset VR1 and (*b*) the resistance of the thermistor. The thermistor is an element whose resistance falls as its

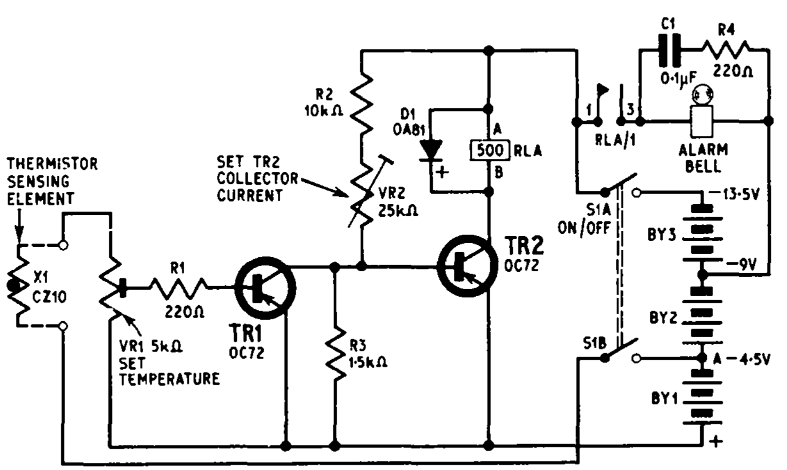


Fig. 1. Circuit diagram of the heater or fire monitor. IMPORTANT: The left hand relay contact should be marked "2" and not "1" as shown

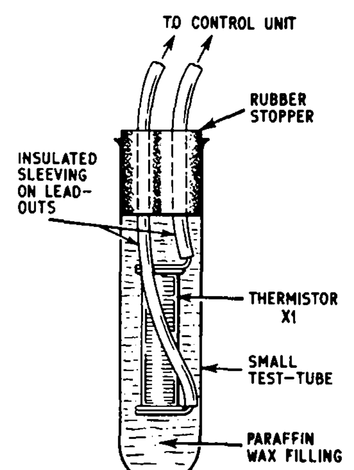


Fig. 2. Housing for the sensing element

temperature rises. The resistance at nominal ambient temperature, say, 25°C differs between thermistors of different types, though the ratio of resistance change with temperature change does not differ greatly. Ambient or "cold" resistance can be less than 400 ohms or greater than 140 kilohms, depending on type.

A thermistor with a medium value cold resistance is best suited to the application in hand, and the Brimar CZ10 was found to be suitable. This component drops to about 150 ohms at its maximum temperature (about 200°C).

ENVIRONMENT TEST

Assuming that TR2 has been adjusted as previously explained, the thermistor battery circuit should next be connected and the thermistor should be subjected to an environment whose temperature is in the order of that likely to be encountered in the greenhouse, room, or other premises with the heater inactive.

The relay must remain energised under this condition. This is achieved with VR1 correctly adjusted because in spite of the thermistor battery circuit being connected the conductivity of TR1 is still limited by the high, cold resistance value of the thermistor. Thus, the collector-emitter circuit of TR1 will still have little shunting effect across R3.

When the temperature of the thermistor rises, or at the temperature of the heater monitored as previously described, the resistance of the thermistor will be considerably lower than its cold value. This will incite TR1 base current, thereby increasing the conductivity of the transistor, the effect of which is to increase the shunting across R3. This pulls back the base current of TR2, and thus reduces the collector current to a value where the relay de-energises.

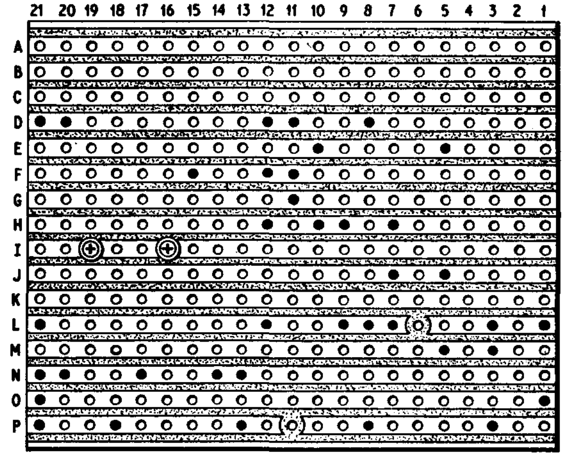


Fig. 3. Strip-side of the Veroboard

SETTING VR1

To get the system working properly, therefore, VR1 must be set for maximum sensitivity at the required temperature. The idea, then, is to adjust VR1 so that the relay is truly energised when the temperature immediately above the heater is considered too low for safety. When the relay is so energised, the contacts close and put the bell in series with BY3 battery section. If the setting of VR1 is correct, the relay will de-energise when the air from the top of the heater is allowed to increase the temperature of the thermistor. This is the "normal" condition, of course, with the alarm bell muted.

COMPONENTS . . .

Resistors
R1 220Ω
R2 10kΩ
R3 1·5kΩ
R4 220Ω
All 10%, ½W carbon

Potentiometers
VR1 5kΩ open skeleton type preset (Radiospares)
VR2 25kΩ preset

Capacitor
C1 0·1μF paper

Thermistor
X1 CZ10 (Brimar) or similar

Transistors
TR1, TR2 OC72 (2 off)

Diode
C1 OA81

Relay
RLA Omron type 2051, 650 ohm coil (Keyswitch Relays Ltd.)

Switch
S1 D.P.S.T. toggle

Batteries
BY1-3 3 × 4·5V flat flashlamp type (3 off)

Miscellaneous
Veroboard, 16 strip × 21 holes
Test tube, rubber stopper, paraffin wax.
Electric bell 4·5/6V d.c.

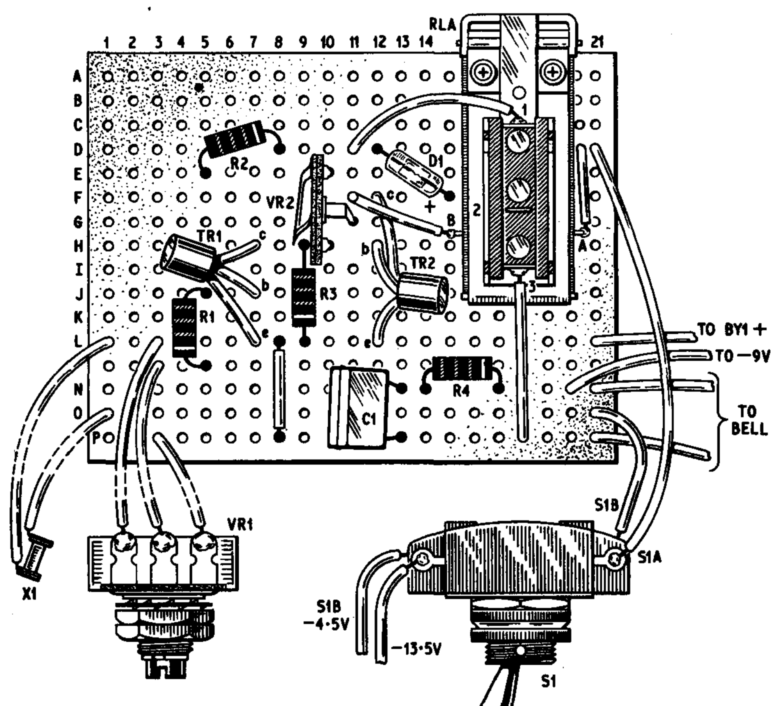


Fig. 4. Arrangement of components. IMPORTANT: The lead shown connected to tag "1" on the relay should in fact go to tag "2"

BATTERIES

The unit is run from three 4·5 volt flat flashlight batteries. The full 13·5 volts is applied to TR2, via the relay, the 4·5 volts of BY3 operates the bell and the 4·5 volts of BY1 supply the base current of TR1, via the thermistor and VR1. R1 is a current limiting resistor, but on no account should the thermistor or its leads be short-circuited as this could result in a damaging current in the emitter-base junction of TR1.

Diode D1 across the relay winding suppresses transient pulses that may otherwise harm the transistor, while the capacitor-resistor series network C1, R4 across the bell minimises interference from this source.

A double-pole, single-throw switch disconnects the supply from both the base of TR1 and from TR2 when the unit is switched off.

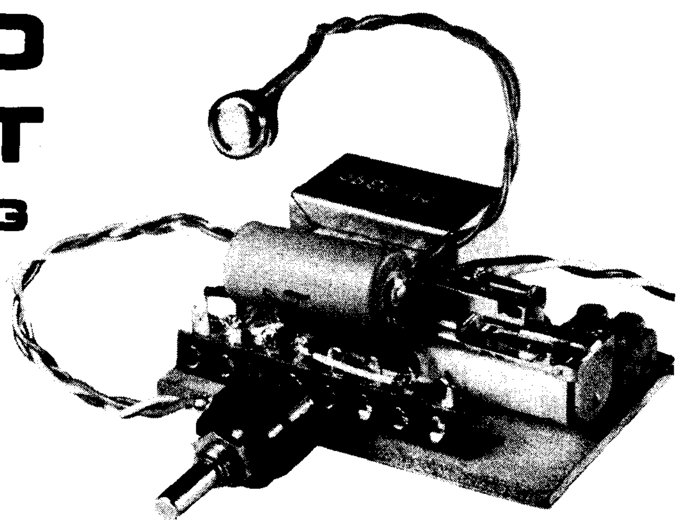
HOUSING THE EQUIPMENT

The circuit can be built upon a piece of Veroboard or eyelet board, or a printed-circuit could be produced to accommodate it. This board can then be housed along with the three batteries in a suitably-sized wooden box. It is important to place the unit at a site of fairly normal ambient temperature. On no account should the unit itself be allowed to sample heat direct from the heating appliance.

The thermistor should be connected to the unit through a length of flexible cable, and one way of housing this component is shown in Fig. 2. Here the thermistor is contained within a small test-tube filled with a heat conducting insulating material, such as paraffin wax. The tube is sealed with a rubber stopper, through which the connecting leads are passed. ★

AUTO NIGHTLIGHT

by GORDON J. KING



This project illustrates very simply a useful application of the photoconductive cell. It is a device that automatically switches on an electric light (i.e., a hall lamp or a table lamp) at dusk and switches it off again at dawn. Many readers have written to us of their interest in such a device, especially as a means of discouraging intruders when the house is left unoccupied over night, the light switching on at dusk, of course, giving the impression that a human element is present in the house.

PHOTOCONDUCTIVE CELL

The prime component of the project is the photoconductive cell, sometimes called a light-sensitive resistor. This component is made of cadmium sulphide and has a resistance value that changes widely with changes in light intensity falling upon it. The particular cell used here is the Mullard type ORP12 and this has a dark resistance (i.e. unity lux) of about 10 megohms. Under full light conditions this resistance falls to between 75 and 300 ohms.

The ORP12 is encapsulated in plastic, and is of "button" construction, one side of which is transparent to allow the unrestricted passage of light. The other side carries the two leadout wires which should not be bent nearer than 1·5mm to the seal. When these leadout wires are soldered the heat conducted to the encapsulation should be kept to a minimum by the use of a "heat shunt".

In many applications, the photoconductive cell is arranged to control the bias of a transistor or valve or some primary circuit to give rise to a secondary action, like the operation of a relay in the anode or collector circuit of a valve or transistor. However, in the device under discussion the cell is arranged to operate a relay direct. This is possible provided the maximum power dissipation and the maximum voltage of the cell are not exceeded.

The author has discovered that consistent results are possible with the ORP12 which has a maximum power dissipation of 200mW from 20 to 40°C, falling to 110mW at 50°C. The maximum voltage rating is 110. The relay required should have a coil resistance of about 10,000 ohms, pulling in at about 5mA at 50 volts.

HOW THE DEVICE FUNCTIONS

The circuit of the auto nightlight is shown in Fig. 1. It is powered from the mains supply through the mains transformer T1, which has isolated primary and secondary windings. The specified transformer has a

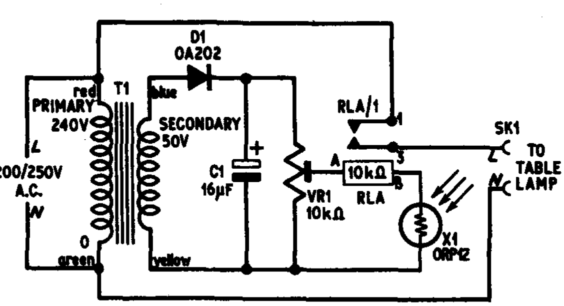


Fig. 1. Circuit diagram of the auto nightlight

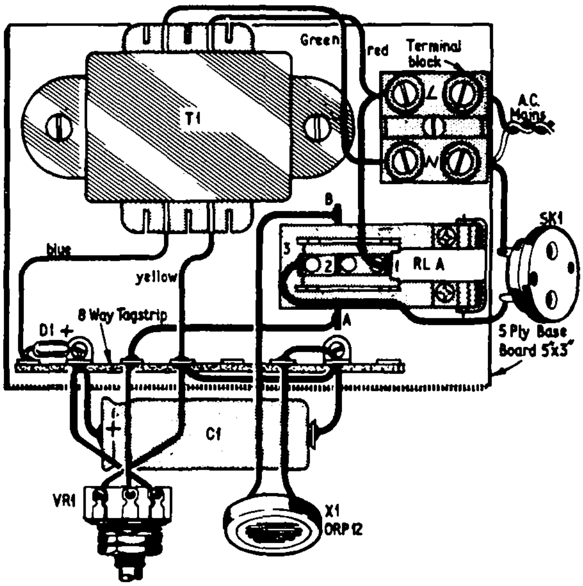


Fig. 2. Layout of components and wiring. The baseboard can form the bottom panel of a wooden case

240V primary which will suit most domestic installations. The secondary winding delivers about 50 volts (r.m.s.) at 30mA.

This secondary supply is rectified by D1, which can be a small germanium or silicon diode of suitable p.i.v. rating and C1 is the reservoir capacitor. The resulting d.c. voltage is applied across a preset resistor VR1 controlling the sensitivity of the device.

The photoconductive cell X1 is connected in series with the winding of the relay, and VR1 is adjusted for relay "hold-on" under the ordinary daylight ambient lighting conditions at the site of the cell.

Clearly, then, when the ambient illumination falls below a level preset by VR1, the current in the relay will fall below its "hold-on" value, the relay will de-energise and the contacts will *make*, switching on the light. Conversely, when the light intensity at the cell rises again the relay will re-energise and the lamp will be switched off.

DESIGN CONSIDERATIONS

There are one or two design factors that must now be considered. Assuming that the maximum d.c. voltage across VR1 is 60 and that VR1 is adjusted for full output voltage, *maximum* dissipation occurs in X1 when the light falling upon it causes its resistance to equal the resistance of the relay winding (about 10,000 ohms). Under that condition the voltage across the cell will be *half* the supply voltage, or 30 volts.

Now, power dissipation in such a circuit is equal to E^2/R, where E is the voltage across the element. Thus, we have $30^2/10{,}000$, which works out to 90mW, well within the 200mW rating of the ORP12.

However, the voltage across VR1 should never exceed about 80, and if a voltage of this magnitude is necessary to operate the relay properly, then a cell with a higher maximum dissipation and a suitable voltage rating should be employed.

It should also be noted that the cell should not be operated at below −30°C and if its temperature (due to sun etc.) rises above 40°C it must be derated powerwise.

COMPONENTS . . .

Potentiometer
VR1 10kΩ wire wound preset

Capacitor
C1 16μF electrotype 150V

Transformer
T1 Miniature main transformer. Primary 0-240V. Secondary 50V 200mA. Type MS 3390. Belclere Co. Ltd., 385/387 Cowley Road, Oxford

Diode
D1 OA202 Mullard (or similar silicon diode with p.i.v. of 150V and 30mA forward current)

Relay
RLA Miniature relay. 10kΩ coil, 50V approx., 4-5mA. Single pole contacts rated at 5A. Omron type 2051 with 48 volt coil. Keyswitch Relays Ltd.

X1 Photoconductive cell. ORP12 Mullard

Miscellaneous
Material for housing (wooden or plastic case). Two-way terminal block. Eight-way tag strip. Connecting wire.

MOUNTING ARRANGEMENTS

The cell should be placed so that it is capable successfully of monitoring external light conditions. Moreover, it should be shielded from the room lights. There would not be a lot of point if the device operated at dusk and was then promptly affected by the light going on in the room!

The photoconductive cell can either be integral to the unit or it can be connected to it through a length of plastic-covered flex. In the former case, the unit as a whole can be mounted in the corner of a window, while in the latter case the cell can be built into a small tubular housing, this being sited for maximum response to outside light and minimum response to inside light.

Attention should be given to the insulation on the external leads and cables, for although there is only a maximum of 60 volts on the photoconductive cell cable, this could give a nasty shock to sensitive people. Even more important is the insulation on the mains supply circuit, and the plugs, sockets and cable connecting to the electric light. Poor insulation here could be lethal.

It is best to build the unit as a whole into a small plastic or wooden (non-metallic) box, for in any event the relay should be well protected both mechanically and from dust. The relay contacts must have a rating of, at least, 2 amperes at 240 volts a.c., but usually the contacts are rated at 5 amperes.

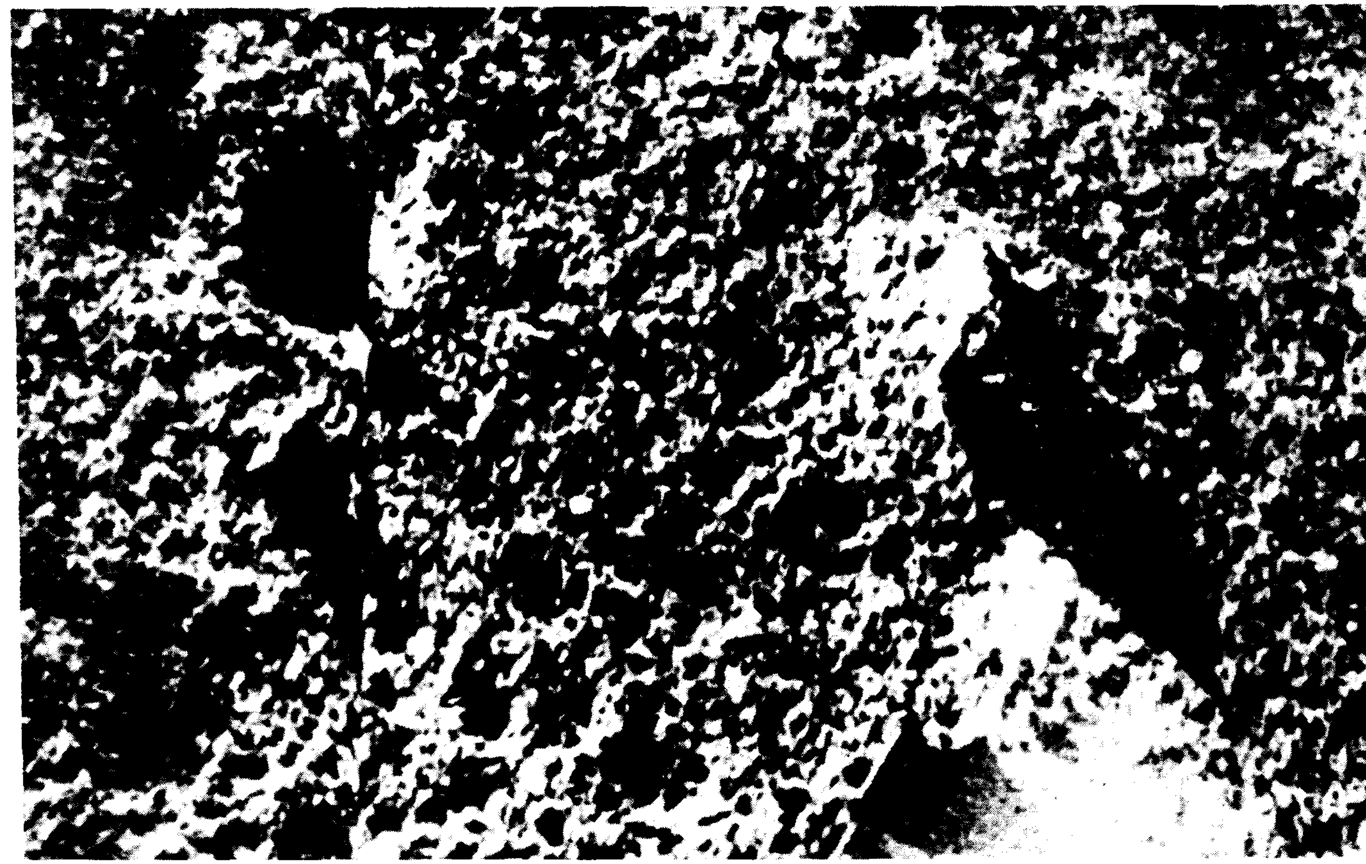
AN ADDITIONAL REFINEMENT

One refinement that may be considered worthwhile is the inclusion of a thermistor in series with the relay winding. This would give a delay in operation of the relay, so that should, for instance, the cell be illuminated intensely, say, from the headlight of a passing motor vehicle, the delay in relay operation would keep the winding de-energised during a normal period of time expected by this kind of transient illumination.

A suitable thermistor is a Mullard VA1067, but it must be remembered that this will act as a current limiter and thus call for a greater d.c. operating voltage. ★

ELECTRONORAMA

HIGHLIGHTS FROM THE CONTEMPORARY SCENE



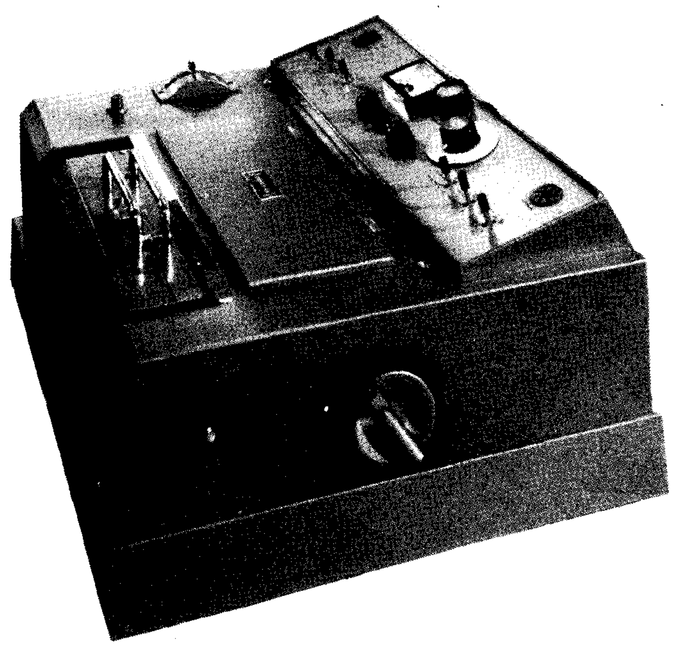
Receiving Moon Signals

TOUCH-DOWN on 4 February to U.S.S.R. and, indeed, to the rest of the world meant the first soft landing on the moon. The photograph above was the result of some quick thinking in the offices of the *Daily Express*. With the help of their Muirhead FM/AM Converter type K-129 and photographic receiver type D-700 (shown right) this remarkable picture was composed at Jodrell Bank from signals received via the radio telescope.

The camera installed in the spacecraft *Luna 9* scanned the moon's surface at a distance of only a few feet after touch-down. The black blunted triangle at the bottom is believed to be the nose cone of the rocket. Intense light and shade show the rocks on the surface of the moon.

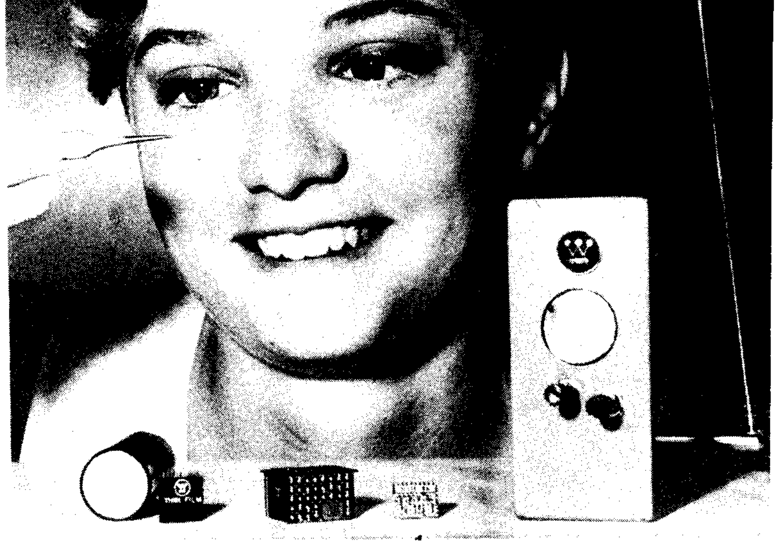
The signals were converted to a.m. then fed into the receiver, which is an electro-mechanical optical unit with signal compensation, oscillator, and comparator circuits. The scanning of the optical unit over sensitised paper is controlled by the drum speed and phasing circuit, the scanning path being helical.

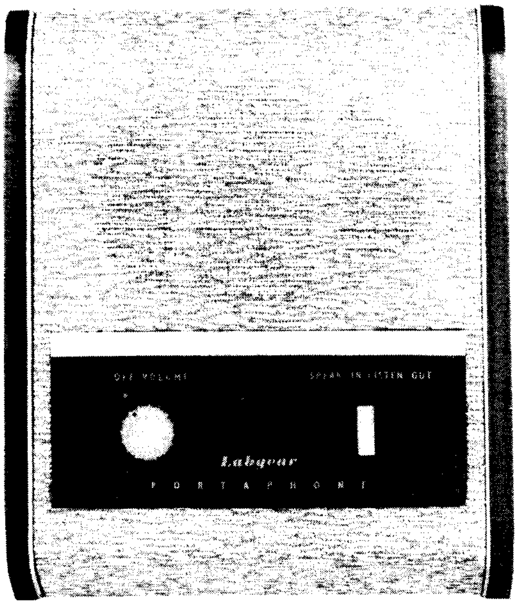
The incoming signals were monitored by a loudspeaker amplifier and a pictorial monitor.



Tiny Television

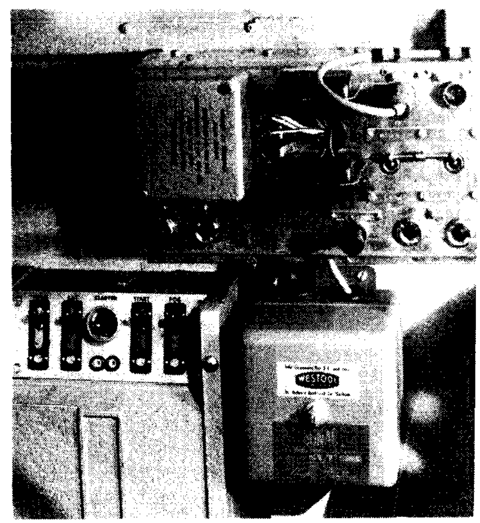
THIS photograph shows what is claimed to be the smallest television set ever produced (right). Beside it, some of the components including a 1in tube and microcircuits are shown. The technician is holding one such microcircuit with tweezers. The cathode ray tube shown here is not likely to be placed on the commercial market. The set measures $4\frac{1}{2}$in × $3\frac{1}{2}$in × 2in and can operate from battery or mains. It has been developed by Westinghouse Defence and Space Center in U.S.A.





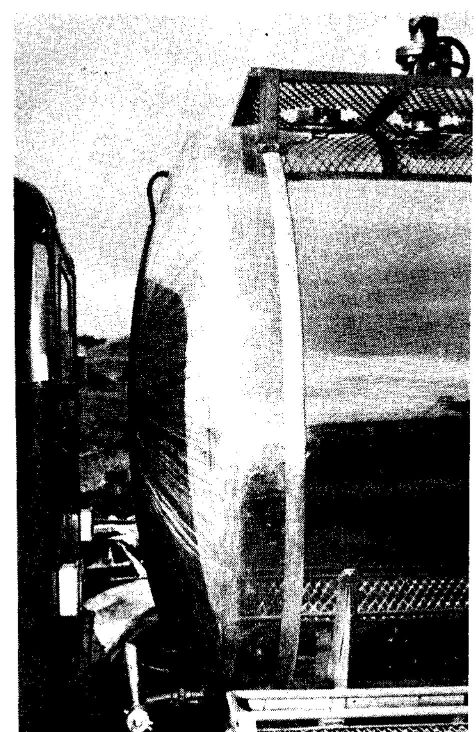
Home Emergency Aid

THE Post Office is conducting an experiment with Manchester Corporation and the N.W. Electricity Board to see whether a device will help housebound persons to contact neighbours when an emergency arises. The device is a Labgear intercommunications system (shown left) which requires no inter-unit wiring and can be plugged into the mains.



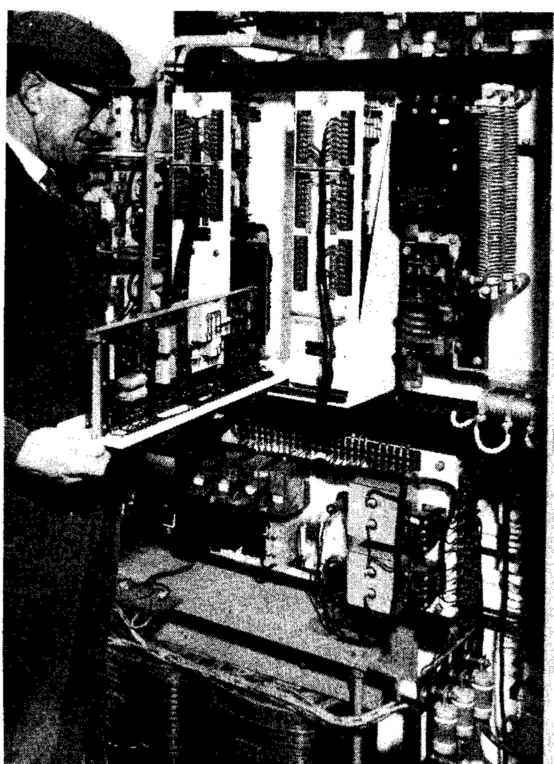
Anti-slop Probes

A PAIR of Sonac ultrasonic liquid level probes, fitted into a road tanker built by Durham Industries Limited, have overcome a problem of spillage involved in the transportation of a hazardous liquid. The probes give visual indication of when the diaphragm of the sensor is covered and when the liquid level falls below the diaphragm. The control panel (above right) is inside the driver's cab. The tank (right) is fitted with high and low level sensors.



Thyristor "Cranestat"

CRANES supplied by Stothert & Pitt Limited are to be controlled by English Electric thyristor equipment called "Cranestat" (left), which provides accurate closed-loop speed control from the driver's lever position. It also provides speeds up to three times normal full speed on light hook.



BEGINNERS start here... 18

An Instructional Series for the Newcomer to Electronics

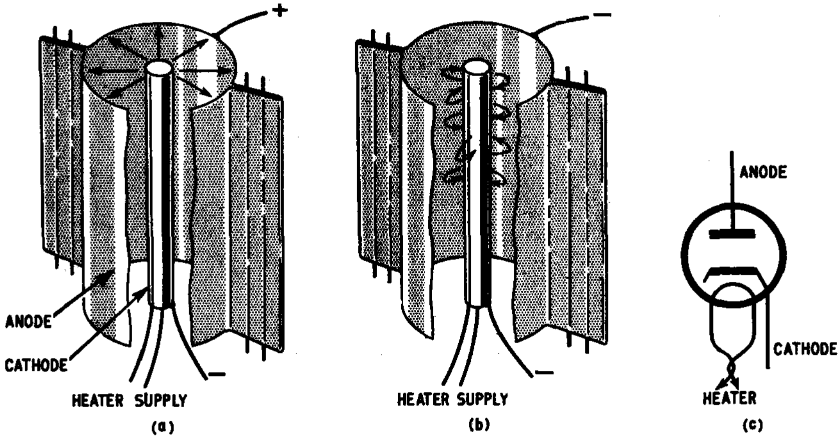


Fig. 18.1. The thermionic diode or two-electrode valve. The general form of construction is shown in (a). Electrons emitted from the cathode are attracted to the anode because the latter has a positive charge. In (b) we see the effect of applying a negative charge to the anode—the free electrons are repelled and remain in the vicinity of cathode. The circuit symbol for an indirectly heated diode is shown in (c)

LAST time, we ended up by saying that electronic equipment produces, and makes use of, *signals.* This word signal has been handed on from the radio communication field; before then it had been used in connection with the telegraph, flag, and earlier methods of sending intelligence. It originated in the Latin word *signum,* meaning a sign. Any electrical waveform, or pulse carrying information qualifies, therefore, to be described as a signal.

As we mentioned before, the odd thing is that after taking pains to obtain smooth steady d.c., we then convert this back to a.c. This is because signals are nearly always a.c. waveforms and pulses. Information can be conveyed by these a.c. signals—by varying the *amplitude, frequency timing,* or the *shape* of the waveform.

Signals are generated by *electronic circuits,* or by devices known as *transducers.* We shall discuss transducers later. When signals are available, they can be *amplified,* and/or *stored* (recorded). They can also be *distorted* by the electronic circuitry. This is something we usually wish to avoid, because we lose information that way, or else introduce false information.

THE HEART OF ELECTRONICS

All these possibilities arose because of the advent of one extremely important electronic device, namely the *thermionic valve.* Now, its younger brother the *transistor* is taking over more and more the functions of the valve. Both these devices, although working on slightly different principles, enable *amplification* and *rectification* to be obtained. Without electronic amplification nothing much could have evolved in the way of radio, television, or other electronic developments.

Rectification is the property of allowing a flow of current in one direction only. This enables valves and transistors to be operated like switches (with no moving parts!) to control and divert different signals (that is, information) around a circuit.

Amplification is the possibility of boosting the size or power of signals—thus enabling a very weak signal source (such as a gramophone pick-up) to do a large amount of work (such as fill a large concert hall with sound). *Linear* amplification is the most important type, meaning that the output is a faithful copy of the input, i.e. there is no (or in practice, little) distortion.

It appears, then, that valves and transistors are the heart of all the circuitry of electronic devices, and an understanding of these devices will enable you to grasp what is going on, quite easily.

THERMIONIC VALVES

A quick look at the history of the electronic valve is of great interest. The simplest valve, now called the *diode* or two electrode valve, was first made, in England, by Fleming. He had read a paper about darkening of electric lamp glass envelopes, written by the American inventor Edison. Edison reported that, whatever was coming off the glowing carbon filament and darkening the envelope could be stopped by sealing into the bulb a small plate, and connecting this to the positive side of the filament. Fleming developed his valve using this idea.

The important action upon which valves are based is called the thermionic effect. This is the fact that electrons can be "boiled off" the surface of a heated substance and the electrons then form a "cloud" in the space adjacent to the surface.

Now, *electrons* is the name we give to tiny particles of negative electricity, and they are attracted to a positive charge (and if you remember, repelled by other negative charges). The cloud of electrons will not move very far unless as much air as possible is removed. This means a vacuum must be produced, and under these conditions you probably agree that it will be easy to attract the electrons across the vacuum to a positive plate nearby. This plate is called the *anode*. If the plate is charged negatively, no electrons stream across. This is because none is being emitted by the cold plate, and those at the hot filament are repelled by its negative charge.

You have just covered all the important ideas concerning the diode valve. It is quite easy to see now why the valve allows current through in one direction only. (Hence the name "valve".) The electron emitter is called the *cathode*, and it is either a filament heated directly by an electric current, or more commonly now, an indirectly heated surface. In the later case the heater is separate from the cathode itself, acting rather like a small electric fire.

Moving on to a remarkable development of the diode, we will see how much of electronics was made possible by the addition of a third electrode. The idea of having free charges of electricity moving through a vacuum from one electrode to another begs the question: what would happen if other electrodes are placed in the electron stream? The more complicated valves which make use of these extra electrodes give rise to the types known as triodes, tetrodes, pentodes—and so on, together with the rather specialised variety known as cathode ray tubes.

THE TRIODE VALVE

The addition of one further electrode into the space between the cathode and the anode makes three altogether, and accounts for the name "*triode*".

Suppose a metal mesh is placed between the cathode and the anode. Electrons will flow through the gaps in this mesh, or *grid* and reach the positive anode as before. But if an electric potential is placed between this grid and the cathode, the flow of electrons will be greatly affected. If there is a negative voltage on the grid, the electrons will be repelled and slowed down, and fewer will reach the anode. In fact, if the grid is made sufficiently negative, all the electrons will be repelled back, and none will pass to the anode, despite its positive potential. We say the valve is *cut off*, or in electronics, *switched off at the grid*, when this condition occurs. See Fig. 18.3.

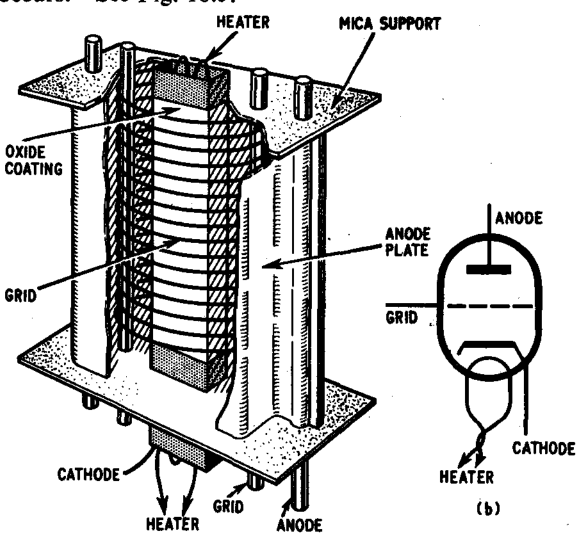


Fig. 18.2a. This cut-away view of a triode electrode assembly shows the three main electrodes, plus the heater

Fig. 18.2b (right). Circuit symbol for an indirectly heated triode

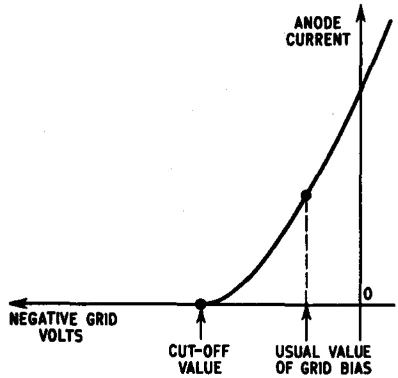


Fig. 18.3. The graph shows how the current flowing through a triode is influenced by the voltage applied to the control grid. As the grid is made more negative, a point is finally reached where the anode current ceases altogether. This is the "cut-off" value of grid bias

The importance of this third electrode can be appreciated now: small changes of the grid voltage can produce much greater changes in the current passing through the valve. Not without justification is this third electrode frequently referred to as the *control* grid. You can see that a triode can be looked on as a voltage-change to current-change converter, and is in fact, an *amplifier* of signals. Amplifications of 50 to 100 times are possible with modern valves.

In practice, the grid is held at a small negative voltage with respect to the cathode. This is called the *grid bias* and the small signal voltage variations increase and decrease the value of the grid voltage about this point. Only in exceptional cases is the grid allowed to rise positive to the cathode, and therefore attract electrons to itself.

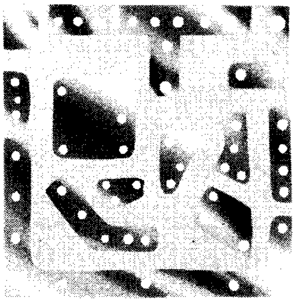
VALVE CONSTRUCTION

Most substances must be heated to a very high temperature before an appreciable number of electrons are given off. Early valves used tungsten filaments, which had to be heated to 2,200° Centigrade before electrons were emitted. They glowed like an electric lamp, and much power was consumed to heat them. An alloy of tungsten and thorium came into use next, and operated at about 1,600°C. The great break-through came when "oxide coated" filaments (and soon after, separate cathodes) became possible.

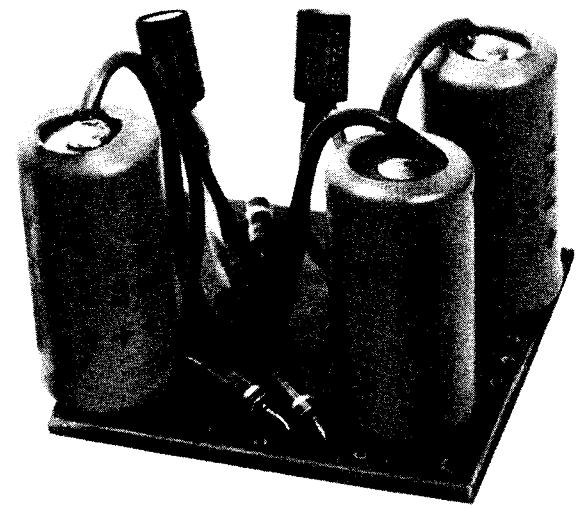
The filaments of directly heated valves are usually made of tungsten. The separate cathodes are cylinders of nickel or molybdenum. The carbonate of the metal barium or strontium is painted onto the cathode, and this is heated to quite high temperatures during the pumping of the vacuum, which forms the oxide. This delicate oxide coating emits electrons readily at temperatures of about 750°C, so that only a dull red heat is required.

The anode plate is usually of nickel or molybdenum, blackened to radiate heat. It is held by welding thick wires to it, these passing through mica end supports wedged into the glass envelope. In use, the bombardment of the anode by the speeding electrons produces heat. The anode must remain cool, or electrons might be emitted from it also, although other damage is usually done long before the temperature rises to the electron emission point.

Now to the grid. There are very few materials suitable for this electrode, and again tungsten or molybdenum are the usual metals employed. The grid is formed by winding a spiral of fine wire round two stout support wires (held in the mica pieces).



REGENERATIVE COINCIDENCE DETECTOR



BB7

MANY readers will be aware that recent advances in transistor circuitry have culminated in obtaining high efficiency and high power output from transistor audio amplifiers. The secret to this is called "pulse code modulation", which employs pulsating techniques to drive the output transistors hard at brief regular intervals, while maintaining low heat dissipation.

This article describes how a regenerative coincidence detector can be built on our "standard" pattern of printed circuit board, described in "Bonanza Boards". Later an ultrasonic sawtooth generator, suitable for driving this unit, will be described.

The basic circuit is shown in Fig. 1. Many readers will recognise it as a "flip-flop", in which the outputs are switched on alternately by a trigger pulse applied to one of the transistor bases. The circuit reverts to normal when that pulse is removed.

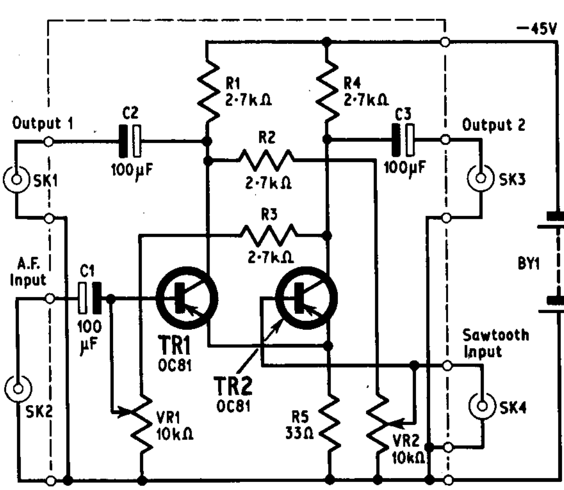


Fig. 1. Circuit diagram of the regenerative coincidence detector. All components inside the dotted line area are mounted on the printed circuit board

The component layout on the printed circuit board is shown in Fig. 2 and should present no problems. A link wire is used at C. For this particular circuit it will be necessary to cut the square piece of copper laminate into two strips and drill an extra hole, making three holes in each strip. This is shown dotted in Fig. 2, the copper being on the reverse side of the board. Careful cutting and lifting of the unwanted piece can be done with a sharp knife.

COMPONENTS . . .

Resistors
R1 2·7kΩ
R2 2·7kΩ
R3 2·7kΩ } All resistors 10% ½ watt carbon
R4 2·7kΩ
R5 33Ω

Potentiometers
VR1, VR2 10kΩ linear carbon (2 off)

Capacitors
C1 100μF elect. 50V
C2 100μF elect. 50V
C3 100μF elect. 50V

Transistors
TR1, TR2 OC81 (Mullard) (2 off)

Battery
BY1 45 volt (Ever Ready type B104) (or a suitable 40V d.c. power supply unit)

Plugs and Sockets (optional)
PL1 and SK1 coaxial for "output 1"
PL2 and SK2 coaxial for "a.f. input"
PL3 and SK3 coaxial for "output 2"
PL4 and SK4 coaxial for "sawtooth input"

Miscellaneous
Printed circuit board (see text)
Switch, single-pole, on/off (optional) for battery
Battery connectors and p.v.c. wire

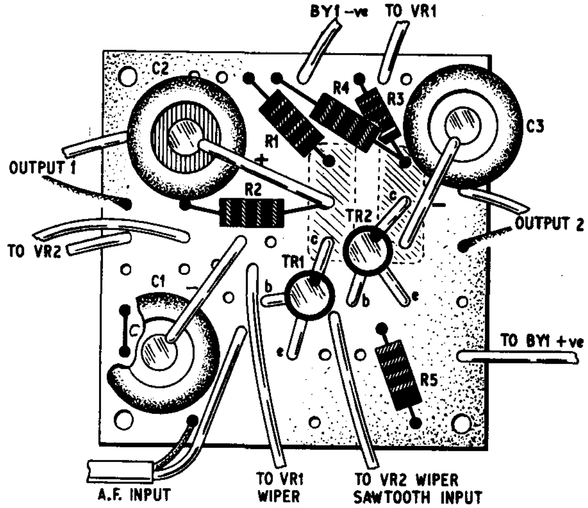
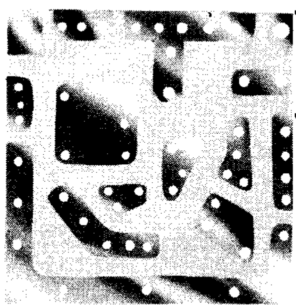


Fig. 2. Layout of components on the regenerative coincidence detector board. Link wire C only is required. Notice that the square piece of copper (shown dotted) is cut into two strips, each with three holes

Coaxial plugs and sockets can be used for the inputs and outputs if the unit is to be self-contained, but if used with the sawtooth oscillator the units can be connected direct as will be shown later.

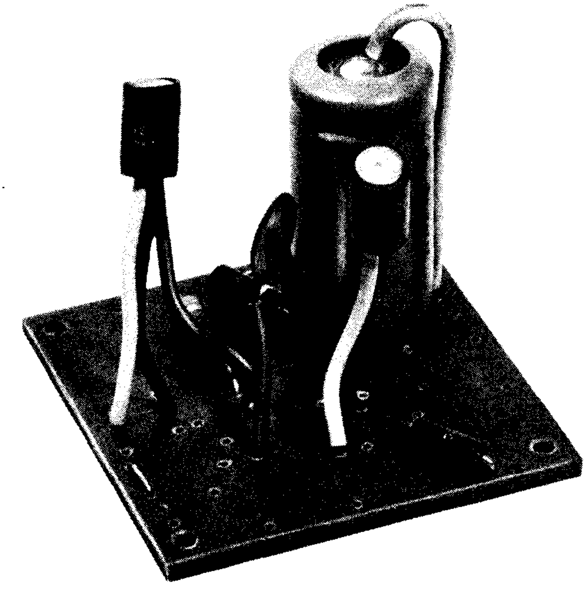
To set up this unit for use, connect a 40 to 45 volt power supply or battery. Adjust the two potentiometers so that the wipers are nearest to the common positive line connection, i.e. with the base of TR1 and TR2 at zero potential. Connect an earphone across "output 1". Measure the voltage between TR1 collector and common positive with a high resistance voltmeter (observe polarity). This reading should be almost equal to the power supply voltage (on load). Adjust VR1 until the meter reading has dropped to a minimum obtainable voltage. Turn back VR1 the opposite way until the meter reads about 0·5 volt higher than this minimum value. Leave VR1 set at this point.

Now transfer the meter to measure the voltage between the collector of TR2 and common positive. Adjust VR2 until a similar reading is obtained on the voltmeter. Carefully rotate the spindle of VR2 a short distance in each direction so that a series of pops can be heard in the earphone. The circuit should change state; as the TR1 collector voltage rises, that of TR2 falls and vice versa. If this does not occur, there is probably too much negative bias on the base of TR1, reduce this slightly by adjusting VR1 until the "popping" of the two states is evident from the earphone, when VR2 is rotated back and forth. Set VR2 to a point in between the two trigger "pops" and the unit will be ready for use with the "Ultrasonic Sawtooth Generator".



ULTRASONIC SAWTOOTH GENERATOR

BB8



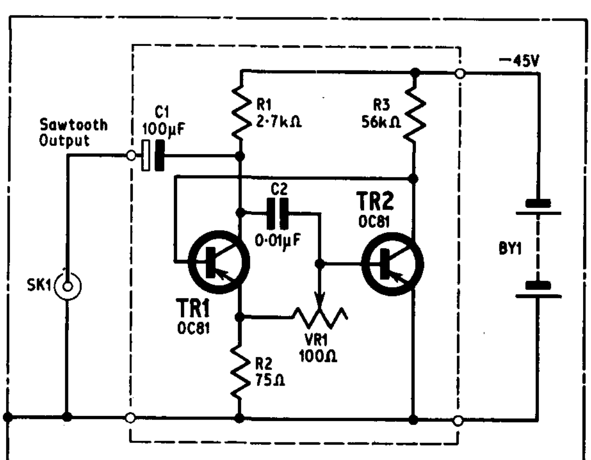


Fig. 1. Circuit diagram of the ultrasonic sawtooth generator. Components inside the dotted line are mounted on the printed circuit board. The chain-dotted line represents the metal housing which is necessary and should be earthed

This unit is useful for a wide variety of functions including the testing of h.f. and r.f. circuits. The ultrasonic sawtooth generator is not so useful for direct a.f. checking without an oscilloscope, but it will be found that, when combined with BB7 (Regenerative Coincidence Detector), it can be used in electronic switching applications, where a very high speed is required, such as "pulse code modulation" for audio power amplifiers.

The circuit is shown in Fig. 1. High quality components should be used and the whole unit should be mounted in a metal box. If possible the box should be

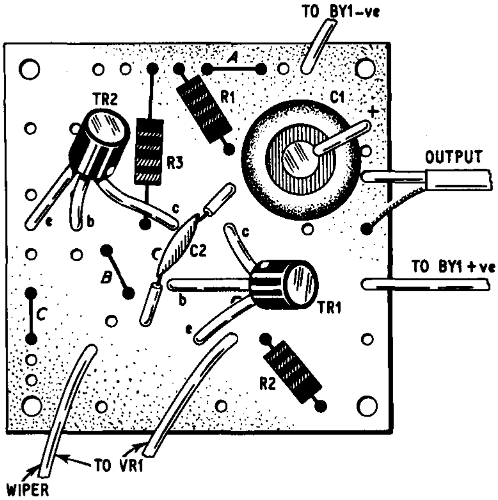


Fig. 2. Layout of components on the printed circuit board. Link wires are required at A, B, and C

COMPONENTS . . .

Resistors
R1 2·7kΩ
R2 75Ω
R3 56kΩ
All resistors 5%, ½ watt, high stability carbon

Potentiometer
VR1 100Ω linear wire wound

Capacitors
C1 100μF elect. 50V
C2 0·01μF ceramic 30V

Transistors
TR1 TR2 OC81 (Mullard) (2 off)

Battery
BY1 45V (Ever Ready B104) or d.c. power supply 40 to 45V

Plug and Socket
PL1 and SK1 coaxial for output

Miscellaneous
Printed circuit board (see text)
Switch, single pole, on/off (optional) for battery
Battery connectors (optional)
Metal box (aluminium) fully enclosed, size to suit application
S.R.B.P. backing board for the printed circuit board

connected to "earth" to prevent unwanted radiation interfering with domestic receivers. All cables carrying the sawtooth signal must be screened, with the screen connected to the metal box. The box is indicated in Fig. 1 with a chain-dotted line around the whole circuit.

The layout of components on the "standard" pattern printed board (see "Bonanza Boards") is shown in Fig. 2. The potentiometer VR1 is not mounted on the board, but is fitted to the metal box, and connected to the appropriate points on the board by short flying leads.

When the unit is complete it can be checked for errors. If everything is correct, connect the output to an oscilloscope, and a battery or power unit supplying 40 to 45 volts d.c. to points indicated in Fig. 2. A high frequency sawtooth waveform should be displayed on the oscilloscope.

AUDIO POWER

Many push-pull transistor power amplifiers, both commercial and home-built, utilise high frequency output transistors for the relatively low frequency purpose of audio amplification. By interposing a Schmitt trigger circuit or a coincidence detector with an ultrasonic sawtooth oscillator, it is possible to drive these transistors more efficiently in an a.f. coded ultrasonic switching mode.

This could give a higher output power with less strain on the components of the amplifier, less heat dissipation from the output transistors, and higher conversion efficiency of electrical power into a.f. power output.

Transformerless class AB and bridge type amplifiers are particularly amenable to conversion in this manner; the power output rating may be easily doubled or quadrupled, with the transistors actually running noticeably cooler, and the output quality unimpaired.

This kind of operation is known as "pulse code modulation". This article will describe how an existing audio amplifier can be modified to provide that extra power.

USING BB7 AND BB8

The output from the pre-amplifier or driver stage of an existing amplifier is applied to the input of the power booster. The booster output is applied to the subsequent stages of the amplifier.

A suitable set-up uses the "Regenerative Coincidence Detector" (BB7) and the "Ultrasonic Sawtooth Generator" (BB8) described elsewhere in this issue, and the combined circuit is shown in Fig. 1. Component values (shown in the respective articles) were chosen for a booster to suit an amplifier running from a 40 volt d.c. power supply. Allowance must be made for the extra current drain, and the power supply should be capable of handling this. However, the circuits shown will operate satisfactorily between about 35 and 45 volts; hence the battery quoted was a 45 volt type which is readily obtainable. Higher voltages may require different values for some components.

Before connecting the units together the following adjustments should be made: follow the setting-up instructions given in the article on the "Regenerative Coincidence Detector". Now switch off the power supply, disconnect the earphone, and connect the "Ultrasonic Sawtooth Generator" as shown in Fig. 1. It is not advisable to attempt to listen to the high note produced through the earphone.

Switch on the power supply again and measure the collector voltages of TR1 and TR2 on BB7. Adjust VR2 on BB7 until there is very little difference between

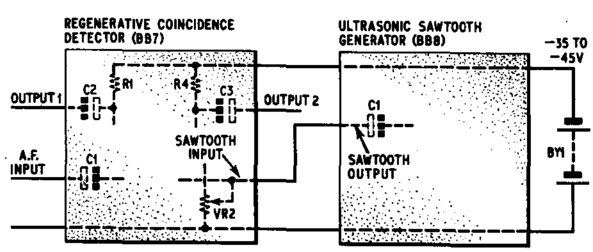


Fig. 1. Connecting BB7 to BB8 for initial checking and setting up procedure

BOOSTER

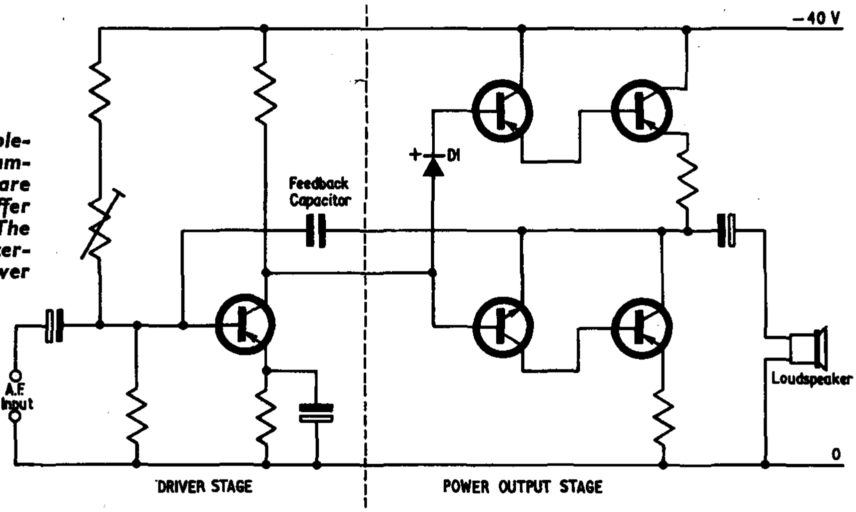


***Fig. 2.** An example of a complementary-symmetry type of amplifier. Component values are not given since they can differ from one design to another. The dotted line represents the intersection for connecting the power booster (see Fig. 3.)*

these two voltages (i.e. less than ½ volt). Adjust VR1 on BB7 *only if necessary.* This will give a mark/space ratio of 1 : 1, subject to component tolerances, which can be monitored on an ocilloscope.

CONNECTING TO AUDIO AMPLIFIER

If a push-pull output is required from the booster, both outputs may be used in order to supply this. If only one output is required (as in the following example) only output 1 need be used.

As an example of one application of the booster, let us consider the conversion of a "complementary symmetry" type of output. A simplified form of this circuit is shown in Fig. 2. The conversion is shown in Fig. 3. Notice that the base diode D1 has been removed and the bases of TR6 and TR7 joined together. The coupling capacitors C2 and C3 in BB7 have been omitted; C3 because output 2 is not required, C2 because TR1 in BB7 can be directly coupled to the bases of TR2 and TR3 in this existing amplifier. Capacitor C1 in BB7 is reversed so that the negative lead is connected to the "negative" collector of the preceding stage. An additional resistor (1 kilohm) is connected in series with this capacitor. The feedback capacitor has to be removed to avoid upsetting the operation of the power booster. Tone correction should, if necessary, be applied to earlier stages.

If a mains operated power supply unit is used, it is worth incorporating some extra smoothing. This is shown in the form of an LC circuit in the sawtooth generator negative line, and would prevent excessive hum modulation reaching the loudspeaker.

Make sure, before applying the booster to the power unit, that the voltage and current ratings of all its components will handle the extra load. If not they must be replaced by different types of adequate rating. This extra load current should be measured before connecting to the amplifier

COMPONENTS . . .

Bonanza Boards

BB7 Regenerative Coincidence Detector (see page 282)
Reverse polarity of C1 and add
Rx 1kΩ 10% ½ watt carbon (see text)
Delete C2 and C3

BB8 Ultrasonic Sawtooth Generator (see page 283)
Add capacitor Cx 100μF elect. 50V
and choke L1 10H 100Ω (minimum current rating 20mA)

Power Supply Unit (see text)

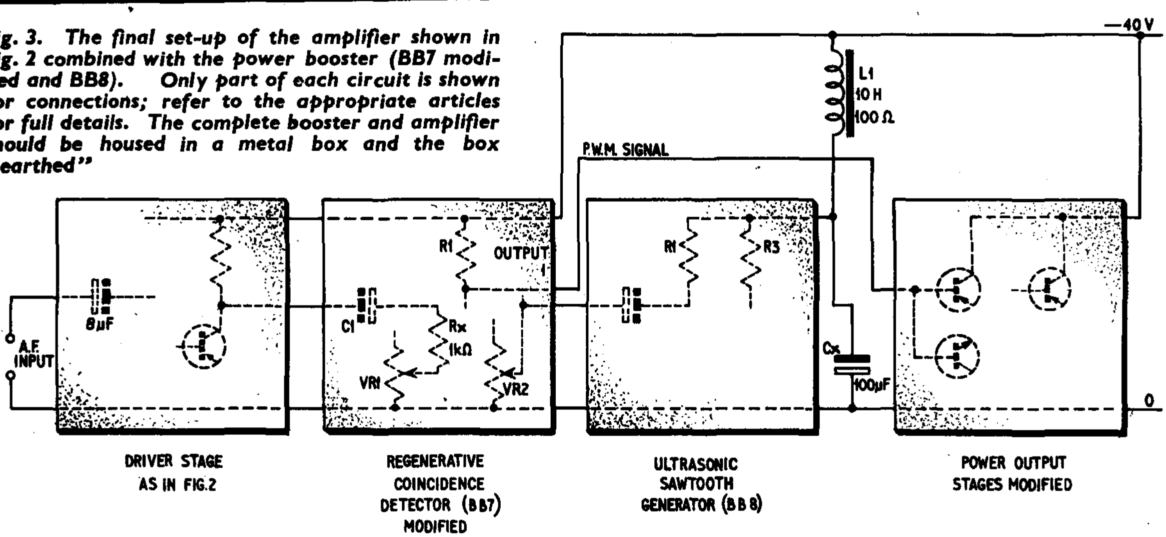


***Fig. 3.** The final set-up of the amplifier shown in Fig. 2 combined with the power booster (BB7 modified and BB8). Only part of each circuit is shown for connections; refer to the appropriate articles for full details. The complete booster and amplifier should be housed in a metal box and the box "earthed"*

PORTABLE RATEMETER

Part Three

By D.V. SMITH

THE five sub-units are built on pieces of Veroboard. The approximate overall dimensions of board used in each case are given in the caption to the appropriate diagram (See Figs. 19 to 23).

It should be noted that those four boards which are installed below the chassis must measure 2⅜in in depth in order to fit into the cradle. This means that boards containing 15 or 16 copper strips will be required, although only 11 strips are actually used for wiring purposes. Two or three spare strips should be allowed at either edge, and the 11 "used" strips numbered from the common positive line (No. 1) to the minus 9 volt line (No. 11). The "spare" strips are not shown on the diagrams of these boards.

In the case of the power supply sub-unit, there are 20 copper strips, and again No. 1 is the common positive edge (no surplus strips are necessary here).

In addition to the numbering of the strips, each end of every board has an individual alphabetical code, e.g. ends *G* and *H* on the G.M. amplifier board. In this way, every interconnection is coded and the corresponding points are similarly marked in the circuit diagrams and component layout diagrams.

ASSEMBLING THE SUB-UNITS

Proceed with the construction of these sub-units as follows: First prepare the reverse side of the board by cutting away portions of the copper strip where indicated (Figs. 19 to 23). Then mount the components on the plain side of the board passing their leads through the appropriate holes and then soldering to the copper strip. Be sure to add any wire links shown in the component layout diagrams.

The power supply board requires somewhat different treatment. When preparing the strip-side of this board, drill three holes and fix two metal mounting brackets as shown in Fig. 23. Three large capacitors are mounted on this side of the board. Referring now to the plain side of the power board, it will be seen from the illustrations that special arrangements are made for mounting the three transistors TR15, TR16, and TR17. Each of these components is fitted in a heat sink which in turn is bolted to a piece of 18 s.w.g. copper approximately 1in × 2½in and this is mounted off the board on ¼in pillars.

THE CRADLE ASSEMBLY

Four of the completed boards may be temporarily mounted within the cradle with the latter out of the chassis to facilitate most of the inter-board wiring. The correct positioning of these boards and the aluminium screens is shown in Fig. 16. The screens are made of 18 s.w.g. aluminium and are the same width as the boards and are mounted in slots in exactly the same way as the boards. The plate between the s.s.b. amplifier and the expander stage is cut away where necessary to clear the grommet and the wires it carries through the chassis, etc.

Refer to Fig. 1 for the inter-unit wiring. Interconnections should take the shortest convenient routes and should be screened and earthed only where indicated in Fig. 1. With this wiring completed, the cradle assembly should be installed inside the chassis and secured with two 4 B.A. bolts and nuts. Finally the retaining strip should be secured in position (Fig. 16).

The power supply board is mounted on the top of the chassis and is secured by the two metal brackets (bottom edge) and also, at the top edge, by a plastic rod drilled and tapped 4 B.A. at either end. The other end of this support rod is screwed on to one of the meter fixing bolts. See Figs. 11 and 15.

COMPLETING THE WIRING

The final stage of the ratemeter wiring can now be undertaken. Three grommets are mounted in the most convenient positions on the chassis for taking through the necessary connections. Again, take care to use screened leads wherever these are indicated in Fig. 1.

The various interconnecting leads should be soldered to the ends of the appropriate strips on the circuit boards. Most of these leads are identified in Fig. 15: other connections, such as those to transformers T1 and T2, can be taken from Fig. 1. The individual circuit diagrams should also be consulted for interconnection details.

The output link on the s.s.b. amplifier must be set according to requirements. See Figs. 8 and 10.

The method of fixing the loudspeaker unit within the instrument case is shown in Fig. 18. Holes must of course be made in the rear of the case to allow access to the mains connector and fuse.

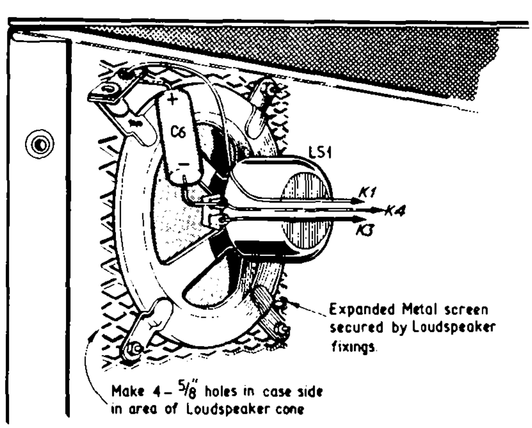


Fig. 18. The loudspeaker unit installed inside the case

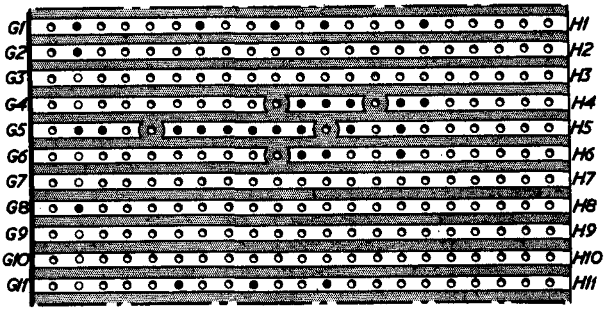
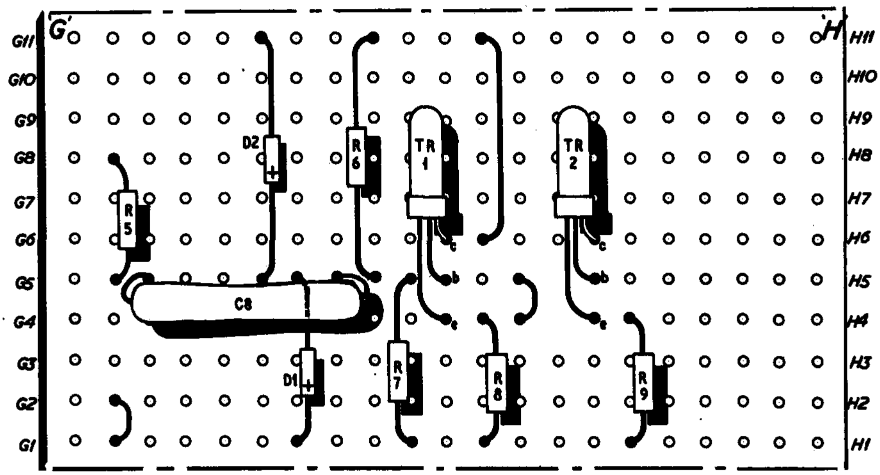


Fig. 19. Geiger-Muller tube amplifier sub-unit. Size of board 2⅜in × 3⅛in. a (left): Underside of Veroboard. b (below): Component layout on top (plain) side of board. (For circuit diagram see Fig. 2)



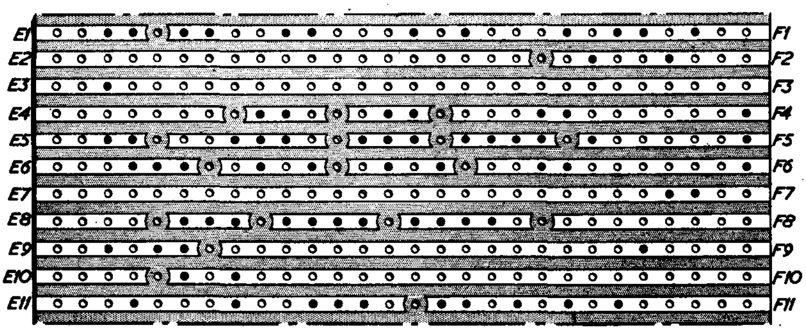
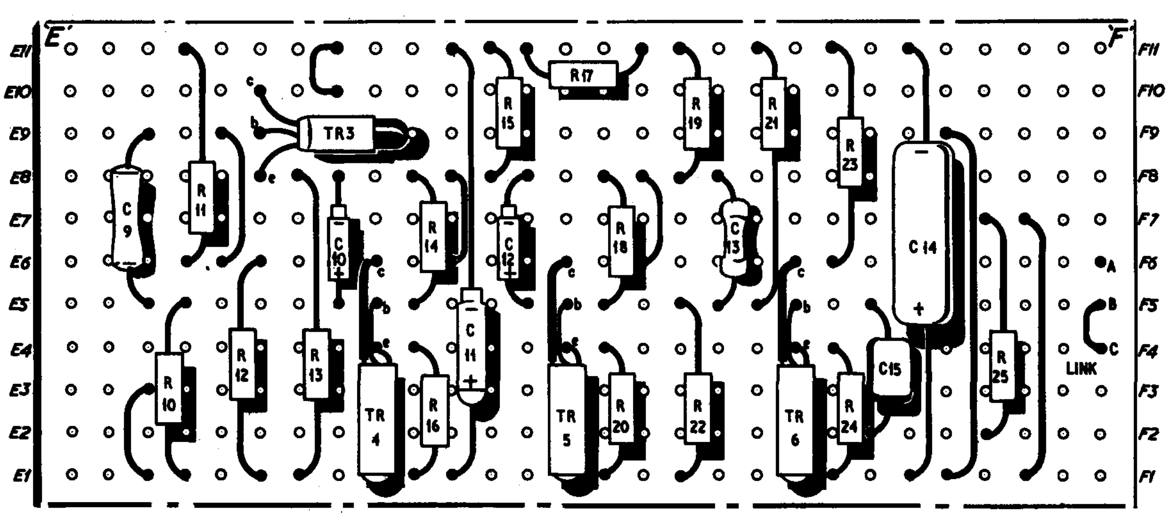


Fig. 20. S.S.B. amplifier sub-unit. Size of board 2⅜in × 4⅛in. a (left): Underside of Veròboard. b (below): Component layout on top (plain) side of board. (For circuit diagram see Fig. 3)



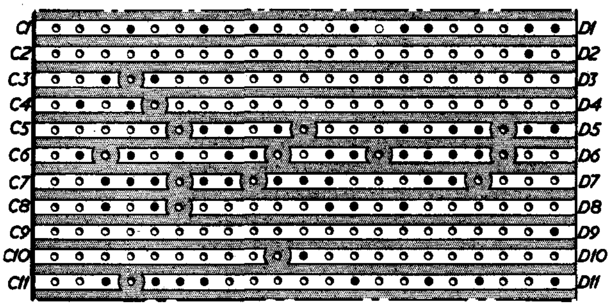
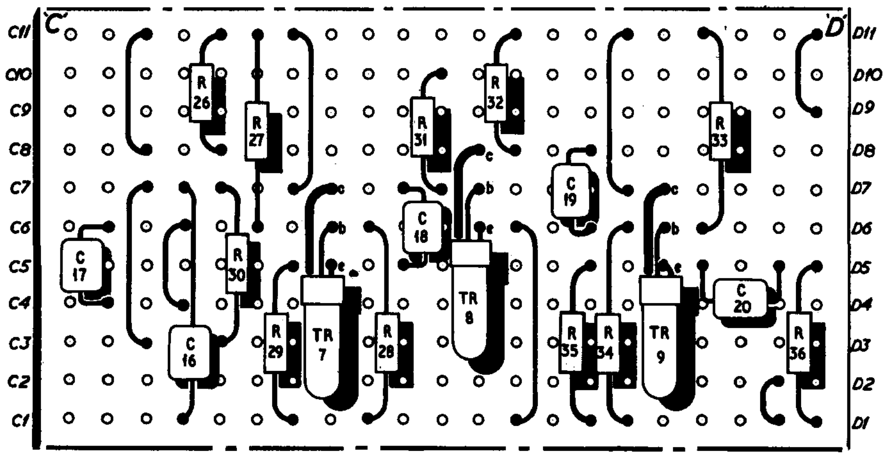


Fig. 21. Expander stage sub-unit. Size of board 2⅜in × 3⅛in. a (left): Underside of Veroboard. b (below): Component layout on top (plain) side of board (For circuit diagram see Fig. 4)



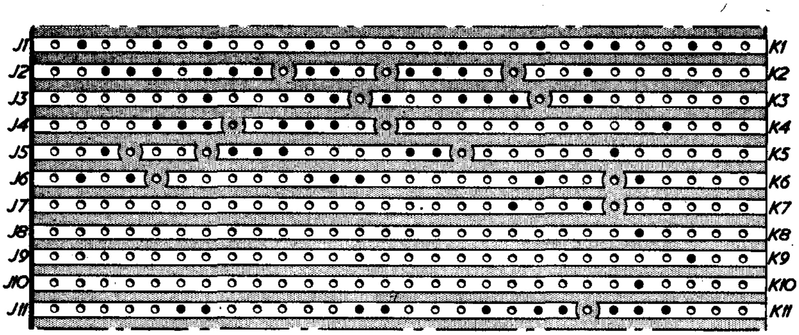
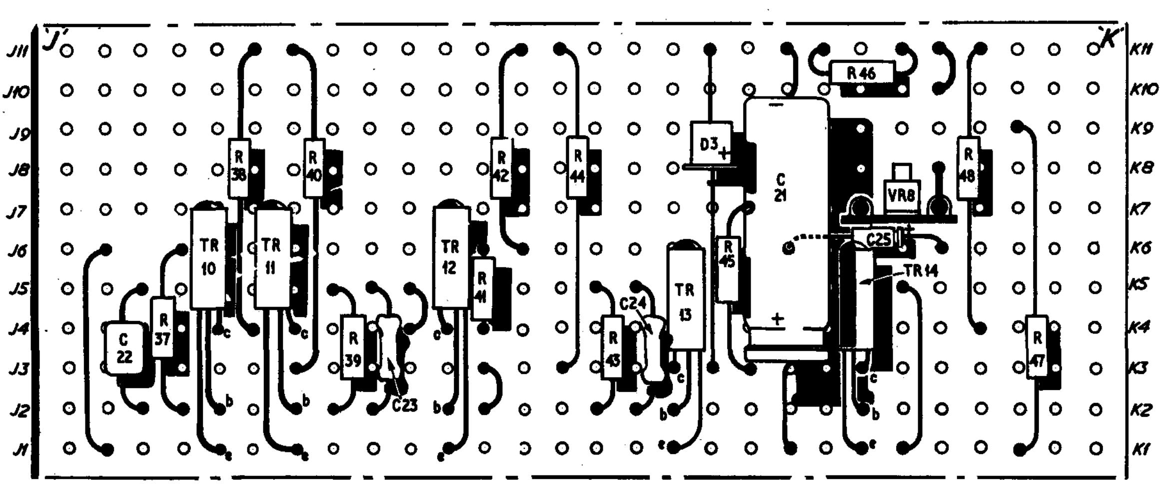


Fig. 22. Ratemeter sub-unit. Size of board 2⅜in × 4⅛in. a (left): Underside of Veroboard. b (below): Component layout on top (plain) side of board. (For circuit diagram see Fig. 5)



CALIBRATION OF E.H.T. CONTROL

Calibration of the "G.M. E.H.T." control VR1 is fairly simple. For this operation a 20,000 ohms per volt meter is required. An AVO model 8 on the 1,000V d.c. range was used on the instrument described.

The meter is connected across the e.h.t. output point *B20* (with no connection to the rest of the circuitry) and the control VR1 varied from zero to maximum, calibrating VR1 at 100 volt intervals on the front panel and marking the points with Indian ink. Maximum output under these conditions is about 800 volts.

When the calibration is complete and the e.h.t. is reconnected at point *B20*, R3 loads the output to the same extent as the meter and so the calibration is still valid. R3 also provides a discharge path for the e.h.t. when it is required to reduce its value quickly.

This e.h.t. supply is not dangerous but is quite capable, at full output, of dealing out quite a "cringer" to careless fingers!

Calibration of the "SSB VOLTS" control VR3 is not quite as straightforward as that of VR1, because of the finite resistance of these semiconductor devices which varies slightly from detector to detector.

Probably the best way to overcome this would be to individually calibrate for a particular s.s.b. detector. One way this could be done is by temporarily connecting the device to the s.s.b. input and then comparing the applied voltage with a known variable supply. If a voltmeter is used for the comparison then, when the two voltages are equal, no current will flow and therefore no extra load is imposed on the s.s.b. output. The SSB voltage at that particular setting can therefore

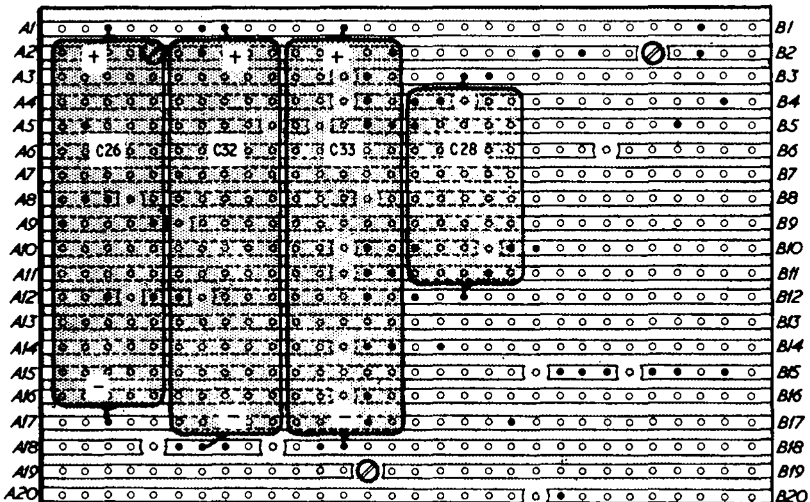
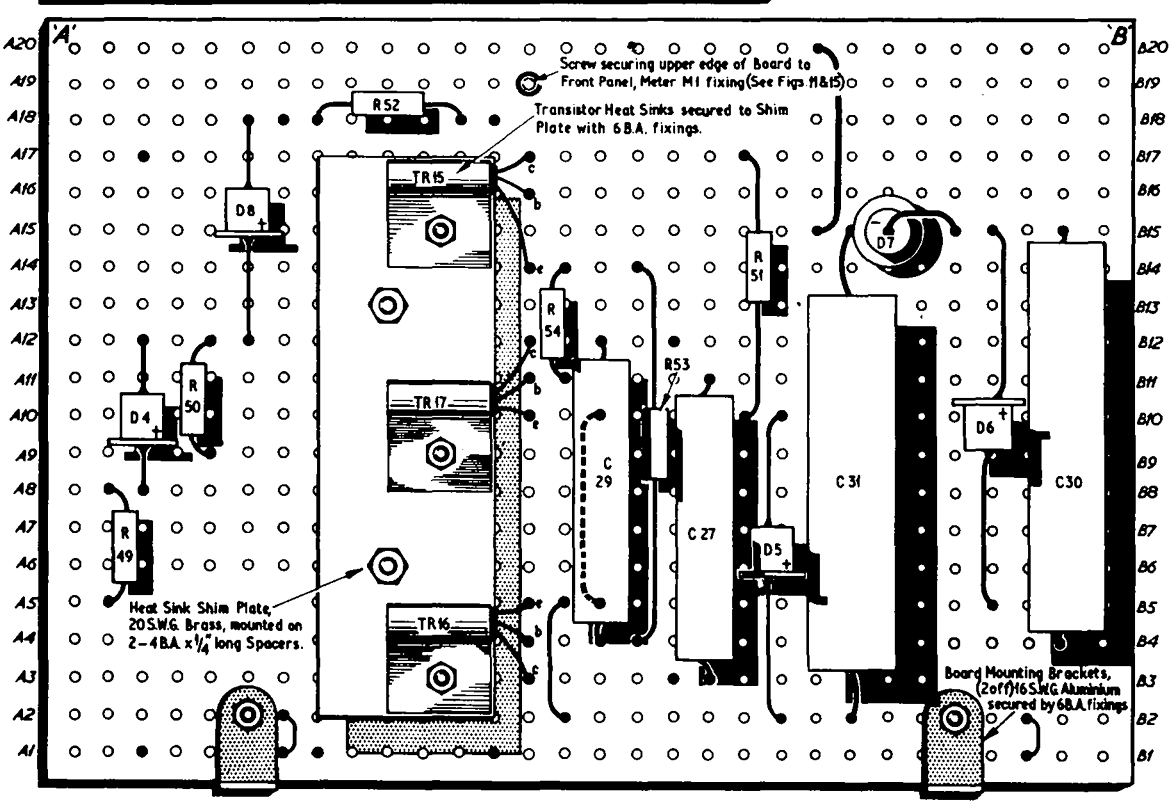


Fig. 23. Power supply sub-unit. Size of board 3¾in × 4¾in. a (left): Underside of Veroboard. b (below): Component layout on top (plain) side of board. (For circuit diagram see Fig. 6.)



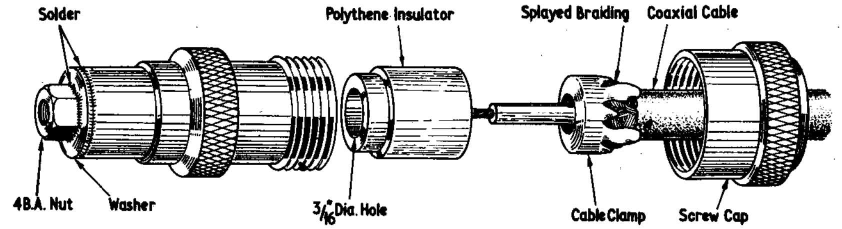


Fig. 24. A mounting for the s.s.b. detector. a: modifications to the coaxial connector

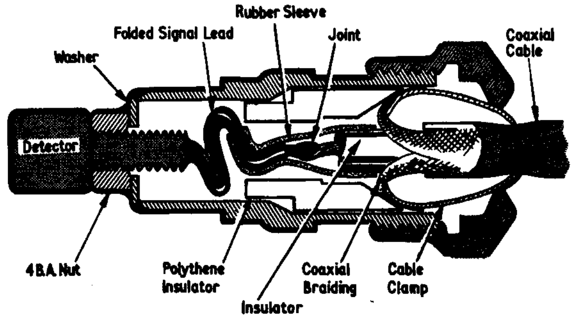


Fig. 24. b: Section through the completed assembly of the s.s.b. detector mounting.

be determined. This process can be repeated at convenient voltage intervals within the range of the control.

MOUNTING THE S.S.B. DETECTOR

A useful arrangement for mounting the s.s.b. detector on a short length of coaxial is shown (Fig. 24). The coaxial connector required is the nickel-plated brass (Belling-Lee) type. Stage-by-stage instructions follow.

The cable clamp and polythene insulator are removed from the coaxial connector.

For SSNO3K detector a 4 B.A. nut and washer are then soldered to the outer case, as shown, taking care to avoid fouling the thread. In the case of the SSNO5K detector a 2 B.A. nut only will be required instead.

Allow the assembly to cool. The central pin is then removed from the polythene insulator. A short application of the soldering iron to the pin will assist in its removal by softening the surrounding polythene. The remaining hole should be enlarged to about $\frac{3}{16}$in diameter. The insulator can then be replaced in the connector body.

The detector is then screwed into position, taking care at the same time to feed its signal lead through the hole in the insulator. A *gentle* tightening with a small pair of pliers will be sufficient to retain the unit. The detector signal lead should be protruding from the other end of the connector body. Cut this back until about $\frac{1}{4}$in protrudes. Bare and tin about $\frac{1}{8}$in at the end. Over the signal lead slip half an inch of $\frac{1}{8}$in diameter rubber sleeving leaving the tinned end of the wire still exposed.

Cut off about 2ft of coaxial cable. Remove about $\frac{1}{2}$in of the plastic outer cover and push back the copper brading to expose the insulated inner conductor. Bare and tin about $\frac{1}{8}$in of the inner conductor wires. The brading is cut back until about $\frac{1}{4}$in long and is then "combed" straight.

Slide the cable clamp over the brading in the usual way and splay the brading round the clamp. Solder the tinned wires together. Having done this the rubber sleeving is then worked back up the signal lead to cover the joint. The screw cap is then slid up the cable from the free end to engage with the cable clamp. The $\frac{1}{2}$in or so of slack in the signal lead before the screw cap can engage with the screw thread on the connector body, will be taken up by the signal lead folding inside the connector.

The cap is firmly screwed up and the unit is then ready for connection to the ratemeter.

OPERATING THE S.S.B. DETECTOR

When using the s.s.b. detector for beta or gamma radiation detection, the highest voltage compatible with acceptable noise must be used, as stated in the introductory article *A Solid State Radiation Detector*—PRACTICAL ELECTRONICS, June 1965. In fact it is still possible to get some beta and gamma counts with 20 volt or so using the s.s.b. amplifier without the expander stage. This is explained by the sensitivity of the ratemeter circuit. If discrimination against beta and gamma to leave only alpha pulses is required, then the voltage on the detector must be reduced until no response to beta and gamma is obtained with S2 in the "ALPHA" position.

The expander stage, when properly set up and with the detector voltage as described above, will allow detection of alpha, beta and gamma radiations with S2 in the "ABG" position, while in the "A" position the beta and gamma signals will be removed.

It can also be shown that the s.s.b. detector can detect radiation with no applied voltage—but with reduced efficiency.

HANDLE WITH CARE

A warning must be given concerning the handling of the s.s.b. detector. The gold window of the detector will be damaged if it comes into contact with anything, and so it is a very good plan to leave in position the small piece of plastic sleeve which is fitted when the detector is supplied. This sleeving will not generally affect the detector operation in most circumstances and will give protection from many causes of damage, the most likely of which is careless fingering.

MOUNTING THE GEIGER-MULLER TUBE

Geiger-Muller tubes may have a variety of terminations, depending on the type. The 20th Century Electronics type G10H, which is used for the purposes of this article, has a British 4 pin base. A hand-held probe for this tube may be constructed from a small aluminium screw-top container as shown in the illustration on the final page of this article.

But first, a precautionary word on some of the aspects of connecting G.M. tubes.

A pitfall which some people fall into when dealing for the first time with G.M. tubes is to connect them directly to lengthy festoons of cable and after getting very short, gay lives from the tubes, curse the manufacturer for his cunningly executed policy of "limited product life." This is very unfair. The reason why early failures occur in these circumstances is the

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300–0–300v. 130mA. 6.3v. 4a, 6.3v. 1a for **Mullard 510 Amplifier**	**35/9**
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300–0–300v. 100mA. 6.3v. 4a, 5v. 3a	**29/9**
300–0–300v. 130mA. 6.3v. 4a, C.T. 6.3v. 1a for **Mullard Amplifier**	**36/9**
350–0–350v. 100mA. 6.3v. 4a, 0–5–6.3v. 3a	**29/9**
350–0–350v. 150mA. 6.3v. 4a, 0–5–6.3v. 3a	**38/9**
425–0–425v. 200mA. 6.3v. 4a, C.T. 5v. 3a	**57/9**
425–0–425v. 200mA. (6.3v. 4a Twice), 5v. 3a	**59/9**
450–0–450v. 250mA. 6.3v. 4a, C.T. 5v. 3a	**69/9**

FILAMENT TYPES
6.3v. 1.5a, **5/9**; 6.3v. 2a. **7/6**; 12v. 1a, **7/11**; 6.3v. 3a, **8/11**; 6.3v. 6a, **17/6**; 12v. 1.5a, twice **17/6.**

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Push-Pull 20 watts, sectionally wound 6L, KT66, EL34, etc. **49/9**

CHARGER TYPES. 0–9–15v. 1¼a, **12/9**; 0–9–15v. 2a, **14/9**; 0–9–15v. 3a, **16/9**; 0–9–15v. 5a, **19/9**; 0–9–15v. 6a **23/9**; 0–9–15v. 8a, **28/9**

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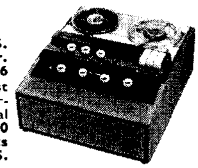

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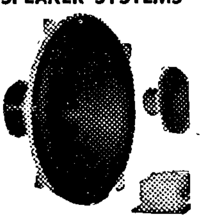

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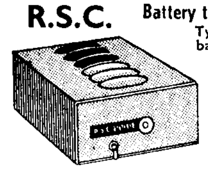

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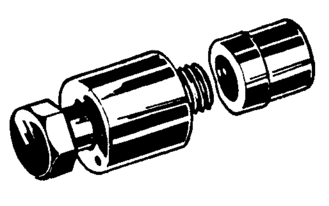

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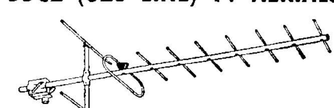

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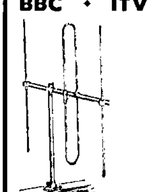

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excessively high current flowing as the cable charges with each Geiger pulse. The G.M. cathode is soon impaired under these conditions and is apparent by a shortening and steepening of the plateau region of the characteristic which is finally lost altogether.

The most usual method of avoiding this is to place a series resistor in the anode lead between the tube and the cable (R4 2·2 megohm see Fig. 1) to form part of the anode load. There are two unused pins on the valveholder which are convenient for mounting this resistor in the probe. The cable should still be kept as short as possible and about 2ft should be sufficient with a portable unit such as this particular ratemeter. Any good quality low capacity TV coaxial cable will suffice for this purpose.

Two different types of input plug and socket combinations are used on the instrument to avoid wrong connection, but it might be more acceptable to the constructor more concerned with the cost to omit these altogether. If, instead, the cables are taken through grommets in the front panel and permanently anchored inside, this should be a perfectly satisfactory arrangement.

OPERATING THE G.M. TUBE

Setting up the G.M. tube is quite simple and can be done using a luminous wrist watch as a source of radioactivity. The e.h.t. is then increased from zero until the ratemeter just begins to count, and then if it is increased a little more, say another 50 volts, this will ensure operation in the plateau region.

If the e.h.t. is increased too much and the tube is taken beyond the plateau it will go into discharge which is apparent by a sudden increase in count rate. Provided that the e.h.t. is immediately reduced no damage will be done to the tube, but this condition should be avoided if possible. If the tube does not appear to give results at the voltage stated by the manufacturer, then increasing the e.h.t. is not the answer. G.M. tubes have been made for quite a few years now and almost invariably do exactly as the maker predicts. If they don't then usually something else is wrong and the tube should only be suspected as a last resort.

SAFE LEVELS OF RADIATION

The first question most people ask when they see a "Geiger counter" being used is whether the amount of radiation present is dangerous.

This is an easy question to ask but it is not so easily answered.

At the moment the recognised basic safe level for controlled personnel, that is medically supervised personnel, in a radioactive environment, is 2·5m.r/hour for a 40 hour working week and this is a very good guide. The prototype ratemeter was operated in a gamma flux of this intensity using the G10H tube and the observed count rate was about 250 counts per sec. The 500 c.p.s. range therefore read 0–5m.r/hr. It will soon be realised how insignificant are the levels from a luminous watch by comparison.

The best attitude to adopt, however, is "any radiation is too much radiation" and not unnecessarily expose oneself to it.

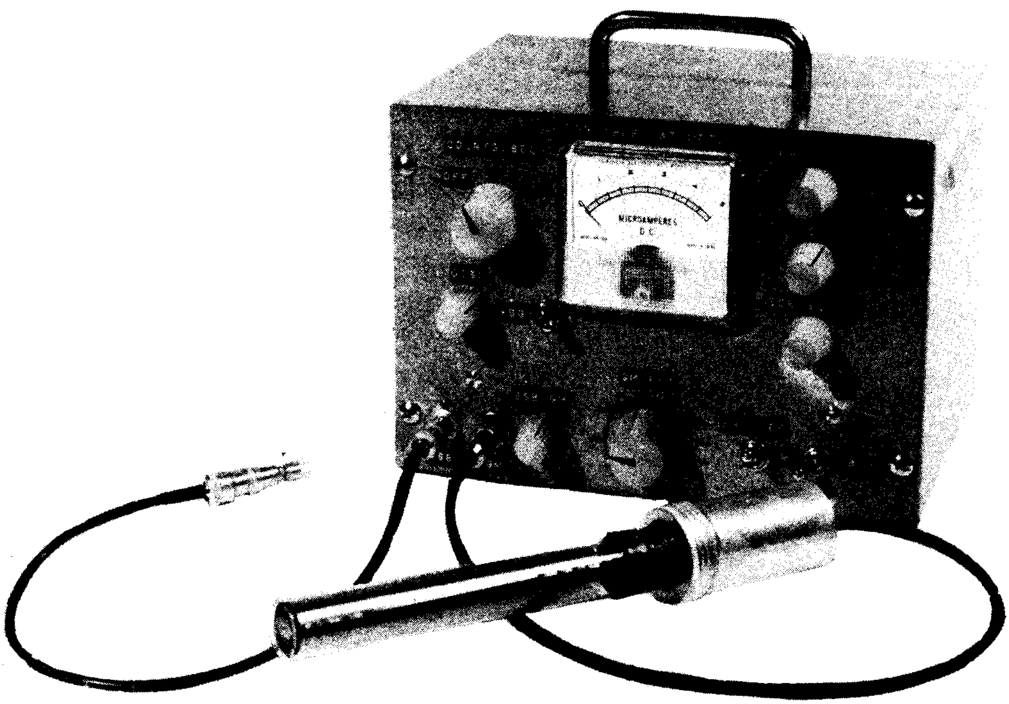
SELECTING AN APPROPRIATE DEVICE

There is not sufficient space in an article of this nature to discuss all the possible types and applications of either type of radiation detecting device, and although only one type of G.M. tube has been mentioned it should not be assumed that it will suffice for all purposes.

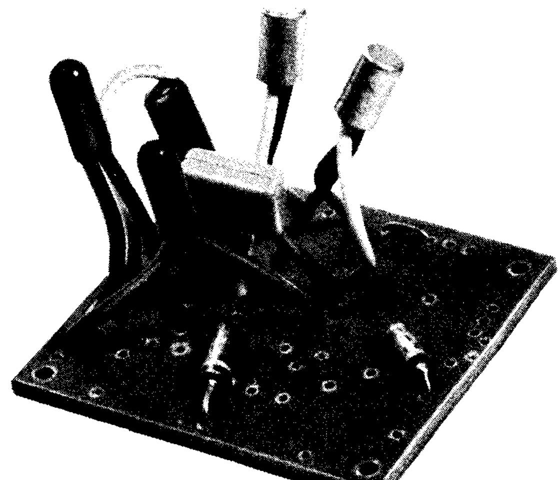
The best policy is to get in touch with the tube manufacturers, who are usually very helpful in such matters.

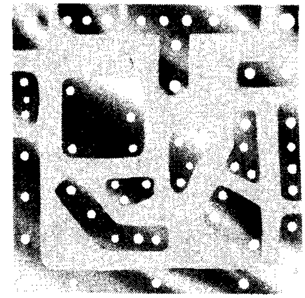
ACKNOWLEDGEMENT

The author wishes to thank the Directors of 20th Century Electronics Ltd. for permission to publish this article. ★



ENVELOPE AMPLIFIER





BB9

THE "envelope" amplifier described in this article is intended primarily for use in the vocal sound effects unit, which will be found elsewhere in this issue. The purpose of this circuit is to convert an a.c. signal into a variable d.c. signal proportional to the amplitude of the a.c. waveform. This d.c. is known as the "envelope" of the a.c. signal.

Diodes D1 and D2 detect and rectify the a.c. signal. TR1 and TR2 act as a d.c. amplifier to provide a power supply to the bell gate amplifier described in the "Vocal Sound Effects Unit" article. The bell gate amplifier is, in fact, a variation of the "Pre-amplifier" circuit described last month.

Fig. 1 shows the circuit diagram. The output is taken from the emitter of TR2 and fed to an LC network to smooth the d.c. The signal input is derived from the emitter (output 2) of the "Pre-amplifier" described last month.

Fig. 2 shows the layout of components. It is not essential to use plugs and sockets for the input and output, since the unit can be connected direct to the other circuits in the "Vocal Sound Effects Unit". Only one link wire is required at A.

The circuit is built upon the "standard" pattern printed board as used in the other "Bonanza Board" projects.

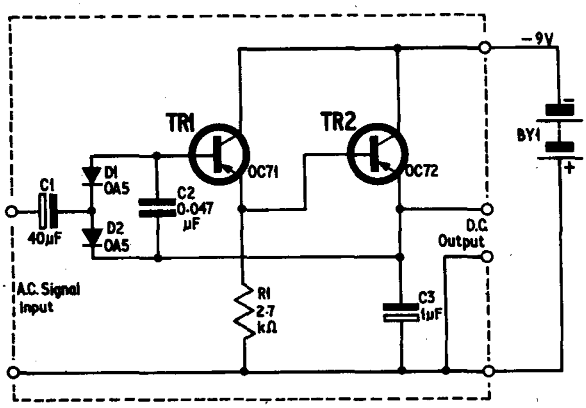


Fig. 1. Circuit diagram of the envelope amplifier. Input and output sockets are not necessary. All components within the dotted line area are mounted on the board

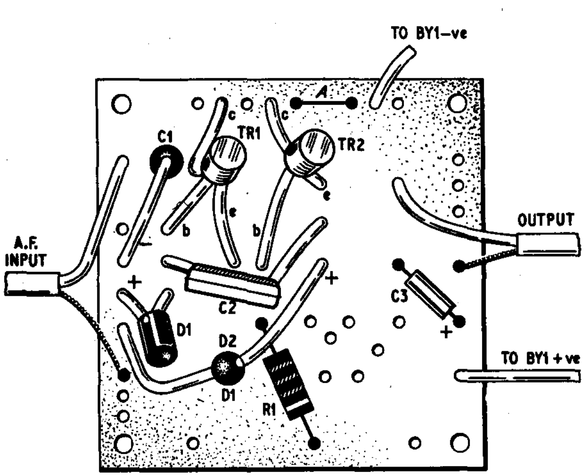


Fig. 2. Layout of components on the printed circuit board. Only one link wire is needed at A

COMPONENTS . . .

Resistor
R1 2·7kΩ 10% ½ watt, carbon

Capacitors
C1 40µF elect. 12V
C2 0·047µF mica
C3 1µF elect. 12V

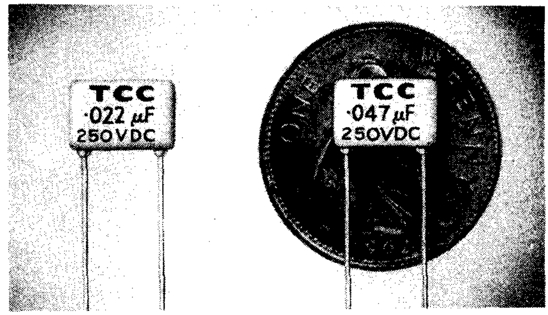
Transistors
TR1 OC71 } (Mullard)
TR2 OC72 }

Diodes
D1, D2 OA5 (Mullard)

Battery
BY1 9 volt light duty

Miscellaneous
Printed circuit board (see text)
Switch, single pole on/off (optional) for battery
Battery connectors and p.v.c. wire.

MINIATURE METALLIZED POLYESTER CAPACITORS



These small moulded metallized polyester capacitors are ideally suited to the applications of printed wiring panels and transistorised circuits. The use of the new dielectric material and unique construction combine the advantages of small physical size and superior electrical characteristics which meet the requirements of H.5 DEF. 5011 Specification.

CONSTRUCTION

The windings are virtually non-inductive and the wire terminations are soldered direct to the metal electrodes eliminating contact resistance and ensuring the minimum possible inductance.

Cap. Tolerance : ±20%.

Voltage Rating :
Peak ripple voltage and D.C. voltage must not exceed rated D.C. voltage.

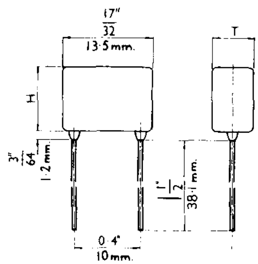
Power Factor :
≤0.01 at 1 Kc/s. at + 20°C.

Temperature Rating :
Suitable for working at + 85°C. without derating.

Insulation Resistance :
10,000 megohms or 2,000 ohm farad whichever is less.

Terminations :
22 SWG solder-coated parallel wires for vertical mounting.

Finish :
Insulated—special non-cracking heat resisting thermosetting compound providing good insulation and good protection against the ingress of moisture.



Cap. μF	Dimensions H	Dimensions T	T.C.C. Type No.
250 V. D.C. at 85°C working			
0.01	11/32in. 9 mm	7/32in. 5.5 mm	PMX1
0.015	11/32in. 9 mm	7/32in. 5.5 mm	PMX7
0.022	11/32in. 9 mm	7/32in. 5.5 mm	PMX2
0.033	11/32in. 9 mm	7/32in. 5.5 mm	PMX5
0.047	11/32in. 9 mm	7/32in. 5.5 mm	PMX3
0.068	7/16in. 11 mm	9/32in. 7.2 mm	PMX8
0.1	7/16in. 11 mm	9/32in. 7.2 mm	PMX4
400 V. D.C. at 85°C working			
0.01	11/32in. 9 mm	7/32in. 5.5 mm	PMX41
0.022	11/32in. 9 mm	7/32in. 5.5 mm	PMX42
0.033	7/16in. 11 mm	9/32in. 7.2 mm	PMX45
0.047	7/16in. 11 mm	9/32in. 7.2 mm	PMX43

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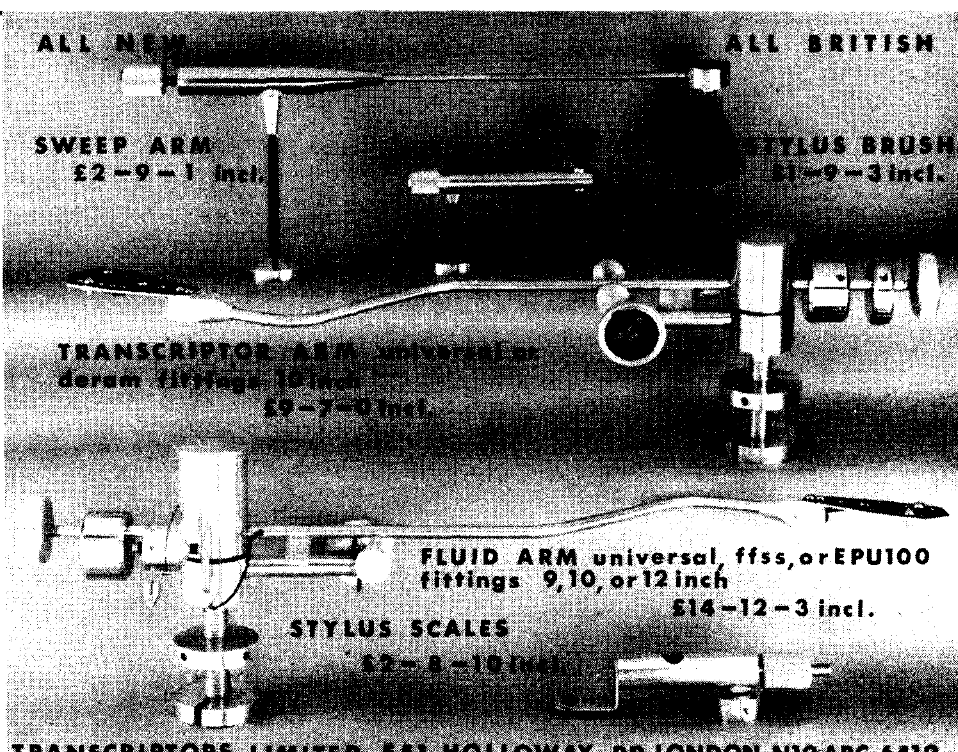


VOCAL SOUND EFFECTS UNIT

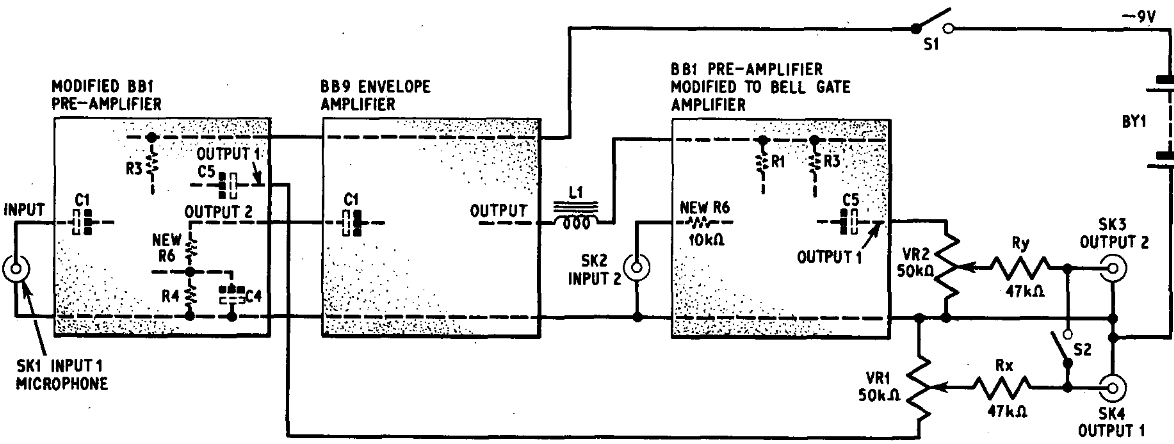


Fig. 1. The complete vocal sound effects unit after circuit modifications. A tone generator is connected to SK2

Doctoring of the sound of the human voice is widely practised for both recording and public address purposes. This tone bending is quite simple to achieve and gives apparently artificial effects.

The basic circuit is shown in Fig. 1. The signal from the microphone is amplified by a slightly modified version of the "Pre-amplifier" described last month. Both outputs of this unit are used: the signal from output 1 is made available through a volume control VR1 and Rx for listening to the "true" sound. The signal from output 2 of the pre-amplifier is fed into an "Envelope Amplifier" (see BB9 article) which converts it to d.c. proportional to the amplitude of the a.c. signal. This d.c. drives the bell gate amplifier. No other power supply is needed for this amplifier.

The bell gate amplifier is another modified version of the "Pre-amplifier" (BB1). The input to this is applied to SK2 and can be an electronic tone or chord which is modulated by the fluctuating d.c. from the envelope amplifier. Thus, the bell gate amplifier acts rather like an electronic volume control. The unusual effects produced are passed to SK3 (output 2) via a volume control VR2 and Ry.

Both outputs can be electronically combined by closing switch S2, providing sufficient output to drive a power amplifier. Alternatively, each output can drive its own individual power amplifier.

The main purpose of the unit is to amplitude modulate the electronically generated tone with an "envelope" waveform similar to that provided by the human voice, or any other sound picked up by the microphone. This electronic sound is mixed (by using S2) with the original vocal sound to give some "colouring". Some intriguing and sometimes startling effects can be produced.

MODIFICATIONS

The best way to start is to assemble the three basic units with the necessary modifications outlined as follows:

Referring first to the *pre-amplifier*, make up this unit according to the article (BB1, Figs. 1 and 2, page 182 last month) and carry out the following modifications:

(1) R5 should be omitted and replaced by a shorting link *A*;

(2) Omit VR1 of the pre-amplifier;

(3) Change C1 to 40μF and connect + to SK1;

(4) Change R4 to 560 ohms;

(5) Insert new resistor R6 470 ohms as shown in Fig. 2 below. Remove link *D* and replace by R6. The centre wire of the coaxial cable to "output 2" should be removed and connected to the vacant hole next to TR2 emitter (see Fig. 2b);

(6) SK2, SK3, and BY1 (in Fig. 1, page 182) can be omitted.

The *envelope amplifier* (BB9) should be made up as shown in the appropriate article elsewhere in this issue.

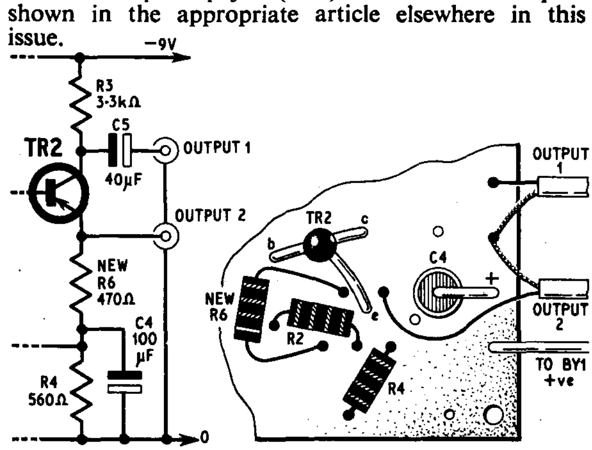


Fig. 2a (left). Part of the "pre-amplifier" modified for use in the vocal sound effects unit. Also change C1 to 40μF

Fig. 2b (right). Part of the component layout showing the modification to the TR2 emitter circuit. Note the change in position of output 2 wire

The *bell gate amplifier* is another pre-amplifier unit (BB1) with different modifications as follows:

(1) Change R1 to 6·8 kilohms;
(2) Change R2 to 150 kilohms;
(3) Change R3 to 1 kilohm;
(4) Change R4 to 220 ohms;
(5) Omit VR1, C4, SK1, SK2, and R5;
(6) Change C1 to 40μF, connect + to R6;
(7) Insert new resistor R6 10 kilohms in series between C1 + and SK1;
(8) Insert link wire *A* in place of R5;
(9) Change C3 to 1μF.

Refer to Figs. 1 and 2 on pages 182 and 183 of last month's issue when carrying out the modifications.

ASSEMBLY

The three units can now be assembled and wired together according to the circuit in Fig. 1. Be sure to get the interconnections between units correct. Extra components will, of course, be required and these are specified in the components list. The choke L1 has an inductance of 10 henries which, when combined with C3 in the bell gate amplifier, smooths the d.c. from the envelope amplifier. It is likely to be a bulky item so it will have to be mounted separately in the box.

The three Bonanza Boards and associated components are assembled in a metal box which can be an aluminium chassis with a cover plate. This should be large enough to house everything; a suggested size would be not less than about 8in × 6in × 2½in. Readers may like to incorporate the tone generator for feeding the bell gate amplifier within the box and, of course, allowance should be made for this. If a pure sine wave tone generator is not essential the Harmonic Oscillator BB5 could be used.

COMPONENTS...

BB1 Pre-amplifier modified according to text

BB9 Envelope amplifier (see page 296)

BB1 Bell gate amplifier modified form of preamplifier (see text)

Additional components not included in the above units

Resistors
Rx 47kΩ, Ry 47kΩ } 10%, ½ watt carbon

Potentiometers
VR1, VR2 50kΩ log carbon (2 off)

Inductor
L1 10H 100mA l.f. choke

Switches
S1, S2 Single pole, on/off toggle (2 off)

Plugs and Sockets
PL1 and SK1 coaxial or jack for input 1
PL2 and SK2 coaxial for input 2
PL3 and SK3 coaxial for output 2
PL4 and SK4 coaxial for output 1

Miscellaneous
Chassis 8in × 6in × 2½in with cover plate
Coaxial and p.v.c. wire

As recommended in other articles in this series, it is worth using insulating backing boards to protect the copper strips from short circuits. The choke must be firmly clamped and bolted to the box.

SETTING UP

Connect a milliammeter temporarily in series with the battery negative lead to measure the quiescent current (i.e. with no signals applied to the circuit). This should be about 5mA when S1 is switched on. If it rises rapidly to more than about 10mA, switch off quickly and check that the wiring is correct. When a signal is applied via, say, a microphone to SK1 the current consumption from the battery will rise to quite a high value, depending on the signal strength.

Set VR1 and VR2 to minimum volume, close the switch S2, and connect one of the output sockets to a power amplifier and loudspeaker. Increase the volume setting of VR1 gradually until the audio input signal can be heard at a reasonable level from the loudspeaker.

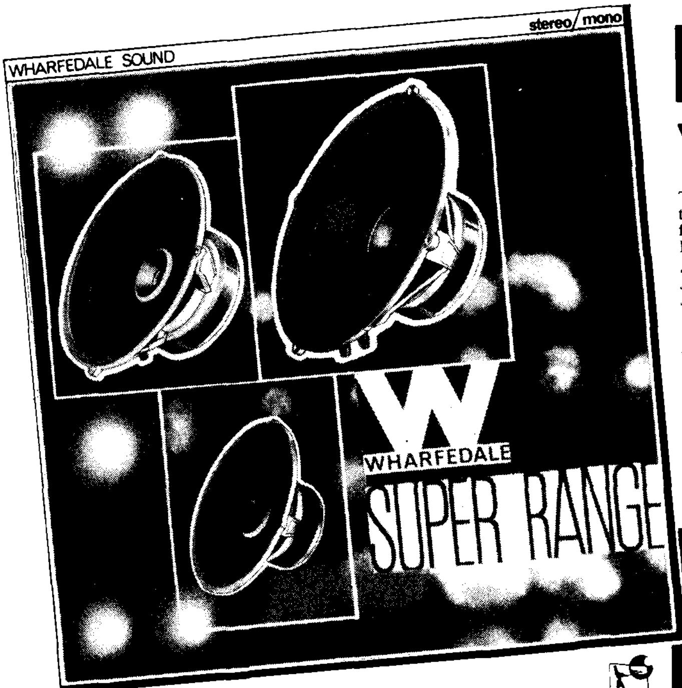
Connect an audio oscillator (sine wave, square wave, or sawtooth) to input 2. Increase the volume setting of VR2 until the oscillator signal can be heard in the loudspeaker. This will only be heard when an audio signal is fed into input 1.

This setting up procedure applies to obtaining a combined signal from both outputs. If you want the two signals separated, open switch S1 and feed each output to its own power amplifier. Use VR1 and VR2 to obtain a reasonable balance between the two signals.

BEAT FREQUENCY

Interesting effects are obtainable when the two inputs are *almost* the same pitch, a beat frequency (the difference between the two fundamental input frequencies) will be heard as well. Some dissonance will be heard, but the good singer should be able to avoid this by matching his voice to the oscillator frequency. It is useful to be able to adjust this frequency to match the voice; VR1 on BB5 (Wide Range Harmonic Oscillator) is inserted to perform this function.

This sound effects unit is not necessarily confined to vocal sound effects. There is no reason why one should not use musical instruments and tape recorded sounds. The scope is enormous—the effects fascinating. ★



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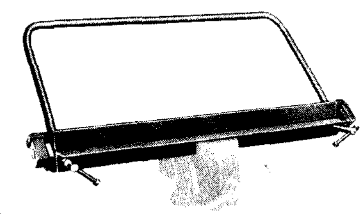

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JOHN VALENCE

CURRENT FLOW

I have already referred to one great difficulty encountered by the novice to electronics. Unlike the student of mechanical or pneumatic engineering, for instance, the budding electronics engineer has to take an awful lot on trust or prove it to himself mathematically.

The *effects* of electron currents we can observe with our various senses. The character and behaviour of the atomic particles that make up these currents are still very mysterious, despite the efforts of physicists to explain in word and by pictorial representation. Most elementary text-books fall back on the water system analogy when explaining electron current flow. This seems to be a useful aid during the first steps. It now occurs to me that the student of logic circuits seeking a more tangible analogy could not do better than to take a peep into the world of pneumatics. Seemingly all the familiar binary logical and switching functions can be found in pneumatic systems such as are used in process industries, mechanical handling and so on.

Following upon my mention of fluid computers last January, I have received from AEI some literature describing their AIRLOG logic units, or relays. These devices, as the makers point out, operate on more conventional principles than the fluid devices I previously wrote about.

The AIRLOG devices are about 2in high and something less than 1½in in diameter, and incorporate three chambers stacked one above the other. Three diaphragms enclose the three separate chambers each of which may receive an input signal (pulse of air) through entries in the base. A signal in either of the two upper chambers causes a downward force sufficient to operate the relay. A signal in the bottom chamber acts upwards and has the effect of inhibiting the effect of one but not of two signals acting in the other two chambers. By making appropriate signal connections the basic switching functions OR, AND, NOT, etc. may be performed.

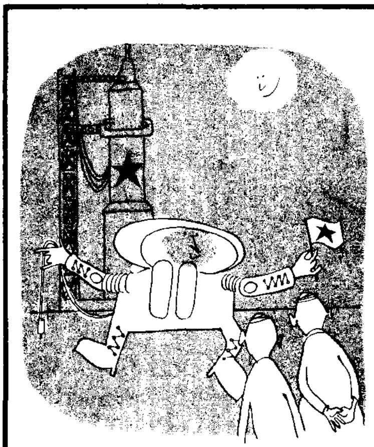
Another AIRLOG device called a solenoid probe can be used to operate pneumatic systems from transistor switches. And this brings me back to more familiar ground again.

A SHRUNKEN IMAGE

The Russians' Space Spectacular with *Luna 9* was made especially memorable for us by the publication in our newspapers of close-up views of the moon's surface. Publication of these pictures also brought forth a strong protest from Moscow. Indeed the Russian accusation that this enterprise amounted to piracy was later echoed by a leading Canadian research scientist Dr. P. Millman, who claimed that this was the same as contravening the copyright laws. Sir Bernard Lovell has vigorously defended his action, stating that as the Russians were well aware that Jodrell Bank would easily receive the picture signals, this implied that they were not really concerned with maintaining exclusive rights on these transmissions.

Since it is clear that the Russians employed the standard international facsimile system for this operation, the following question comes to mind: was it due to technical difficulties that more elaborate equipment providing some measure of "security" in the transmissions was not used on this sensational lunar project?

Now back to Earth. Admitting that the signals were directly translatable, the further query arises: was it ethical for Sir Bernard to feed these signals to the British Press before the "owners" had released any pictures? The Russians think it was bad form, piracy in fact, to publish the pictures without prior consultation with their own scientists, and they make the technical point that the British reproductions were shrunk in the horizontal scale by about two and a half times.



"I agree comrade Ivan is no Nureyev but no doubt Sir Bernard will slim him a bit!"

My view is that this last point really does demolish Sir Bernard's claim to have acted purely in the interest of science. No, I think here he succumbed (perhaps understandably) to the excitement of the occasion and to the prompting of the Press!

Some people may view the whole argument as only a storm in a tea cup. But surely there is food for thought here. The question of copyright of radio transmissions, of whatever kind, from outer space will have to be sorted out on an international basis before many more years have passed if we are to be saved from continual international bickering—if not worse!

SOUR GRAPES?

Unfortunately another rather sour note was added to this affair by one of the heads of the American National Aeronautics and Space Council, Dr. E. Walsh. This spokesman went out of his way to emphasise that the U.S.A. did not have to wait for "Russian statements or British pronouncements to find out something about what was going on". From these remarks it seems likely that the worldwide tracking and data collection system known as SPADATS picked up some of the photographs transmitted by *Luna 9*. (Copyright? But I doubt if the American Press were in on this!)

However we must not allow any acrimony to obscure what an amazing achievement the *Luna 9* episode adds up to.

Luckily radio waves at anyrate do not recognise terrestrial or space boundaries. All those responsible for the aerial and electronic equipment which enabled the minute signals to be captured and amplified, whether located in Moscow, Jodrell Bank, or Colorado Springs, have cause to be pleased with themselves; perhaps only a trifle less than those responsible for initiating this unique O.B. from our satellite the moon.

Readout—
A SELECTION FROM OUR POSTBAG

A good buy

Sir—I have copies, complete with blueprints, etc., of PRACTICAL ELECTRONICS from No. 1 to January 1966.

If any of your readers are interested I would be willing to sell them at a reasonable price.

H. S. Copping,
25 Peartree Avenue,
Yiewsley,
Middlesex.

Three-gang pots

Sir—I have been reading about the Fletcher-Munson curves and I have come across a circuit for a volume control which gives a close approximation to these curves. The circuit involves the use of a three-ganged potentiometer. I have tried in vain to obtain one.

The specified pot was I.R.C. type LC-1. I would be grateful if anyone could give me details of where I could obtain one.

A. D. Hart,
Ramsgate,
Kent.

Current flow

Sir—I note you use the conventional theory of current flow in "Electronic Building Blocks". As a relative beginner I always found the theory of electron flow easier to understand. I notice also this is used by the more up-to-date text books.

R. V. Walley,
Abbots Leigh,
Bristol.

With regard to your directional problems on current flow, we would suggest that you learn to appreciate both conventional and electron flow in their application to a circuit's interpretation. In thermionic emissive devices, such as valves, electron flow lends itself readily to the circuitry they are employed in, but in transistor circuits, since pnp types are most commonly employed, and the majority carriers are "holes" or positive charges, it is easier to interpret circuit action in terms of conventional current flow.

The choice of current flow directions is an arbitrary one for text-book authors and always rather confusing to students, and it is well to acquire a facility in using both systems.

Sounds good

Sir—I am interested in the electronic manipulation of sound and music. Your articles on vibrato units and electronic music have been most useful.

I hope that you will continue this series, and give some information on electronic reverberation or echo without resorting to the expense of tape loops or mechanical devices such as springs and transducers.

D. A. Somerville,
Gerrards Cross,
Bucks.

Question of power

Sir—I am interested to see your new series of articles on "Radio Control of Models" by Mr. R. H. Warring, who is well known in this field.

I am surprised by the statement in the February issue that output power must not exceed five watts. Whilst the statement is true it conveys the impression that up to five watts is permitted. In fact power should not exceed 1½ watts e.r.p. on 27Mc/s and ½watt e.r.p. on 468Mc/s, according to my licence.

T. J. Froggatt,
Solihull,
Warwickshire.

Sorry for this slip! The current regulation allows a maximum of 1½ watts transmitter output. With older types of transmitter where battery consumption was not a major problem, we did use up to 5 watts d.c. input at times, but doubt that even then we got 1½ watts radiated output! R.H.W.

Neon polyphonia

Sir—With reference to the article on "Unstable Neons", *Readout*, February '66 issue), where your reader appears to have an unfortunate experience with the cheap type of neon bulbs when used in an electronic organ, I feel obliged to say a few words in their defence, so that any intending constructor is not discouraged from using them.

I too have constructed a fully polyphonic organ (two manual and pedal) using the same type of neon indicators as used in your *Neon Novelties* series. Yet, although played daily, it never needed retuning after the original setting three years ago. It is also completely insensitive to any change in temperature.

Perhaps a good, stabilised h.t. supply for the neons, as well as employing the "two neons in series" type of divider, may provide the answer. It is also essential to test each neon so that it can stand a variation of ±2·5V about its nominal voltage. Any bulb unable to stay locked within that variation must be changed.

J. M. Stejskal,
Thorney Island,
Hants.

About turn!

Sir—With reference to M. J. Bunce's letter on page 142 of the February 1966 issue I am afraid that your contributor R.W.S. is perhaps being a little misleading in his description of the action of a Crookes' Radiometer.

A true radiometer—as invented by Sir William Crookes to demonstrate the physical pressure of lightwaves—does not contain any gas at all.

Under this condition the paddle wheel revolves in a counter-clockwise direction. If, however, a small amount of gas is introduced into the evacuated bulb then the phenomena as described by R.W.S. predominates—the paddle wheel revolving in the *opposite* direction.

This latter effect is known as the "radiometer effect" and it occurs at its maximum between about 10^{-2} and 10^{-5}mm mercury gas pressure.

Should M. J. Bunce obtain a radiometer, he should carefully check in which direction it revolves.

S. J. Colgan, B.Sc., A.R.C.S.
London, S.W.7.

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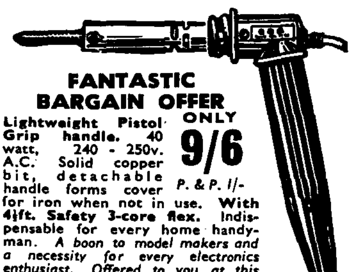

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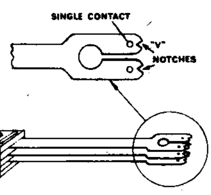

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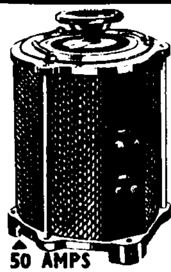
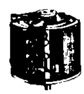
VARIABLE VOLTAGE TRANSFORMERS





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Transformer to suit the above. Input 200-240 v. A.C., 12 volt 36 watts, 16/6; P. & P. 2/6. Input 200-240 v. A.C. 12 volt 60 watt, 22/6. P. & P. 3/6.

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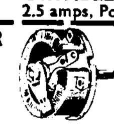

AVAILABLE IN THE FOLLOWING 9 VALUES

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Type S32 2½ Edgwise Meter
250 Micro-amp., scaled in dB's. New 29/6. P. & P. 1/-.

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Type 1.2 c/o. 2 amp. contacts, 9/6. Type 2.2 x 15 amp. break, 2 x 2 amp. make, 1 x 2 amp. break. 11/6. Both types, ex new equip. P. & P. 1/6 each.

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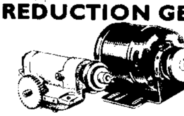

Reversible 1/12 h.p. 1,450 r.p.m. ⅜" dia. 1" long shaft. Mounted in anti-vibration cradle.
Supplied complete with precision 20—1 reduction gear box and pulleys.
Made to highest standard for computor work. Ex equip. First class condition. Price £3.5.0. P. & P. 7/6.

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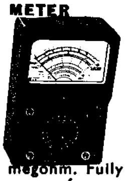

Model B40. D.C. volt, 0·5 v., 2·5 v. at 10,000 ohm per volt. Ideal for transistor circuit testing. A.C. and D.C. volt, 10 v., 50 v., 250 v., 500 v., 1,000 v. at 4,000 ohm per volt. Resistance, 2K ohm, 200 K ohm, 2 megohm, 20 megohm. Fully guaranteed, complete range of spares available from stock. Price includes Test Leads, Battery, Instruction book, Packing and Post (U.K.). £6/2/6. 3 additional models available from 54/- to £14/14/-. Leaflet gladly sent on request.

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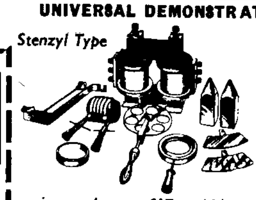

A complete composite apparatus, comprising a Transformer and electro-magnet with removable coils and pole pieces. Coil tapped for 230 v, 220 v, 110 v, 115 v; 6, 12, 36, 110 v. A.C. These coils are also used for D.C. experiments. Complete with all accessories as shown. £17 + 10/- carriage. Leaflet on request.

14,000 OHM SEALED RELAY

High Speed single c/o, Platinum contacts. Super-sensitive, ideal for Transistor circuitry. Will operate on 1 milliamp, 25/-. P. & P. 1/-.

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Single c/o, 600ohm coil, New. 2 for 10/- plus 1/6 P. & P.

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168 ohm coil, 3 × 5 amp. N.I. c/o contacts. New. 16/6 plus 1/- P. & P

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4 figure 10 impulses per second. Type 100D, 4.1 ohm coil, 3-6 v. D.C. operation. Type 100A, 500 ohm coil, 18-24 v. D.C. operation. Type 100B, 2,300 ohm coil, 36-48 v. D.C. operation. Any type, 15/- each, plus 1/6 P. & P.

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6	6, 12, 20 v. at 20 amps.	£4/15/0	7/6
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Kit of parts, including ORP12 Cadmium Sulphide Photocell, Relay, Transistor and Circuit, etc., price 25/- plus 2/6 P. & P. ORP 12 including circuit, 10/6 each, plus 1/- P. & P.

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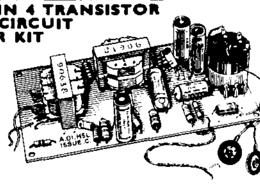
HIGH GAIN 4 TRANSISTOR PRINTED CIRCUIT AMPLIFIER KIT
Type TA1



● Peak output in excess of 1½ watts. ● All standard British components. ● Built on printed circuit panel, size 6 x 3in. ● Generous size Driver and Output Transformers. ● Output transformer tapped for 3 ohm and 15 ohm speakers. ● Transistors (GET 114 or 81 Mullard OC81D and matched pair of OC81 o/p). ● 9 volt operation. ● Everything supplied, wire, battery clips, solder, etc. ● Comprehensive easy to follow instructions and circuit diagram 1/6 (Free with Kit). All parts sold separately. **SPECIAL PRICE 45/-.** P. & P. 3/-. Also ready built and tested, **52/6.** P. & P. 3/-. A pair of TA1s are ideal for stereo.

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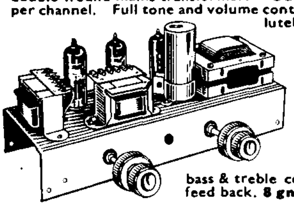
Incorporating 2 ECL82s and 1 EZ80, heavy duty, double wound mains transformer. Output 4 watts per channel. Full tone and volume controls. Absolutely complete.



ONLY £4.19.6 P. & P. 6/6

Super Deluxe version with ECL86 valves, sep. bass & treble controls, full feed back. **8 gns.** P. & P. 6/6

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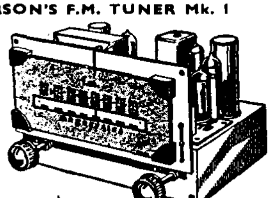

● F.M. tuning head by famous maker. ● Guaranteed non-drift. ● Permeability tuning ● Frequency coverage.88-100Mc/s ● Balanced diode output ● Two I.F. stages and discriminator. ● Attractive maroon and gold dial (7 x 3in. glass). ●Self powered, using a good quality mains transformer and valve rectifier. ● Valves used ECC85, two EF80s, and EZ80 (rectifier) ● Fully drilled chassis. ● Size of completed tuner 8 x 6 x 5½in. ● All parts sold separately. Set of parts if purchased at one time **£5/19/6,** plus 8/6 P.P. and ins. Circuit diagram and instructions 1/6 post free. **Mark II Version as above** but complete with magic eye, front panel and brackets, **£6/12/6.** P. & P. 8/6.
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Uncut motor board. Will take above amplifier and B.S.R. or GARRARD Autochanger or Single Record Player Unit. Size 18 x 14 x 8½ in.
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BRAND NEW. 12" 15w. H/D Speakers, 3 or 15 ohm. Current production by well-known British maker. Offered below list price at **89/6.** P. & P. 5/-. (25w. guitar model **£5.5.0).** (35w. guitar model **£8.8.0).**

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7-10 watt OUTPUT TRANSFORMERS to match pair of ECL 86's in push-pull to 3 ohm output. ONLY **11/-.** P. & P. 2/6.

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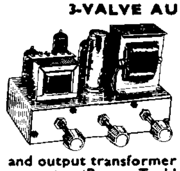
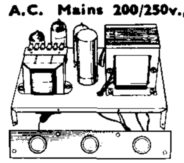


Designed for Hi-Fi reproduction of records. A.C. Mains operation. Ready built on plated heavy gauge metal chassis, size 7½in. w. x 4in. d. x 4½in. h. Incorporates ECC83, EL84, EZ80 valves. Heavy duty, double wound mains transformer and output transformer matched for 3 ohm speaker, separate Bass, Treble and volume controls. Negative feedback line. Output 4½ watts. Front panel can be detached and leads extended for remote mounting of controls.
The HA34 has been specially designed for us and our quantity order enables us to offer them complete with knobs, valves, etc., wired and tested for only **£4.5.0** P. & P. 6/-

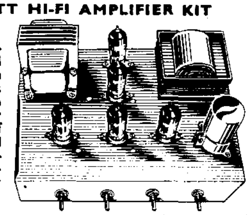
HSL 'FOUR' AMPLIFIER KIT.

A.C. Mains 200/250v., 4 watt, using ECC83, EL84, EZ80 valves.



★ Heavy duty double-wound mains transformer with electrostatic screen. ★ Separate Bass, Treble and Volume controls, giving fully variable boost and cut with minimum insertion loss. ★ Heavy negative feedback loop over 2 stages ensures high output at excellent quality with very low distortion factor. ★ Suitable for use with guitar, microphone or record player ★ Provision for remote mounting of controls or direct on chassis. ★ Chassis size only 7½in. wide x 4in. deep. Overall height 4¾in. ★ All components and valves are brand new. ★ Very clear and concise instructions enable even the inexperienced amateur to construct with 100% success. ★ Supplied complete with valves, output transformer (3 ohms only), screened lead, wire, nuts, bolts, solder, etc. (No extras to buy.) PRICE **79/6.** P. & P. 6/-.
Comprehensive circuit diagram, practical layout and parts list 2/6 (free with kit).
This kit although similar in appearance to HA34 it employs entirely different and advanced circuitry.

10/14 WATT HI-FI AMPLIFIER KIT



A stylishly finished monaural amplifier with an output of 14 watts from 2 EL84s in push-pull. Super reproduction of both music and speech, with negligible hum. Separate inputs for mike and gram allow records and announcements to follow each other. Fully shrouded section wound output transformer to match 3-15Ω speaker and 2 independent volume controls, and separate bass and treble controls are provided giving good lift and cut. Valve line-up 2 EL84s, ECC83, EF86, and EZ80 rectifier. Simple instruction booklet 1/6. (Free with parts.) **All parts sold separately.** ONLY **£7/9/6.** P. & P. 8/6. Also available ready built and tested complete with std. input sockets, **£9/5/-.** P. & P. 8/6.
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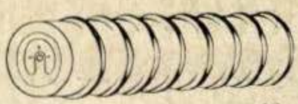

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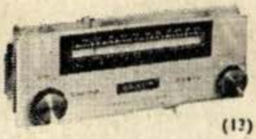

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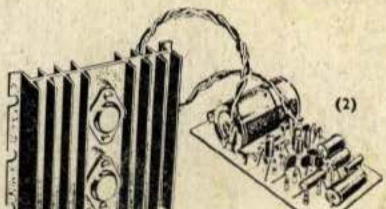

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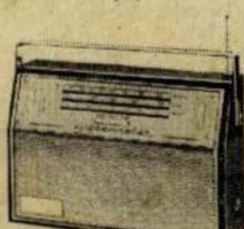

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87/105 Mc/s Transistor Superhet. Geared tuning. Terrific quality and sensitivity. For valve or transistor amplifiers. 4 × 3½ × 2¼in.

TOTAL COST TO BUILD £6.19.6 P.P. 2/6.
(Cabinet Assembly 20/- extra)

10 AND 20 WATT TRANSISTOR MONO AND STEREO HI-FI UNITS

(2) **POWER AMPLIFIERS.** 10 watts RMS output. 100mV input. 30 c/s to 20kc/s ± 1dB. 6-Transistor Push-pull. Panel size 4 × 2½ × 1in. H/S 4 × 4in.

TPA10/3 3-5 ohm spkr. **£5.10.0**, pp. 2/6

TPA10/15 12-16 ohm spkr., **£5.19.6**, p.p. 2/6

(Mains unit for 1 or 2 amplifiers, **59/6**, p.p. 2/6)

The Finest High Fidelity at Unbeatable Prices

(3) **PREAMPLIFIERS.** 8 input selector. Treble, bass, volume, filter controls. 1½mV to 300mV inputs. Battery operated or from Mains Unit. Output up to 150mV RMS.

MP2 Mono 9½ × 2½ × 2in. **£5.10.0**, p.p. 2/6 (brown and gold front panel 8/6)

SP4 Mono/Stereo, 9 × 3½ × 1⅝in., **£10.19.6**, p.p. 3/6 (front panel plate 12/6)

● ALL UNITS BUILT AND TESTED

(5) BUILD A TAPE RECORDER

Three speeds—3 watts.

Complete kits with new "363" decks. Supplied as preassembled sections. Complete with portable cabinets and Speaker—excellent quality. 1,200ft. tape and spool.

★ TWO TRACK **£26** P.P. 8/6 ★ FOUR TRACK **£30** P.P. 8/6

(7) 5 WATT AMPLIFIER

6-Transistor Push-pull, 3 ohms. 6mV into 1K. 12/18V supply. 2¾ × 2 × 1½in.

BUILT AND TESTED 79/6 P.P. 2/-
(optional mains units **54/-** p.p. 2/-)

New matching Preamplifier, 6 inputs, treble/bass/selector/volume controls. 6-10mV o/put. 9-18V supply. **79/6**, p.p. 2/-
For use with any Transistor Amplifier

(8) REGENT-6 MW/LW POCKET RADIO

6-Transistor superhet. Geared tuning. Push-pull output. Moulded cabinet 5 × 3 × 1¼in. Phone socket.

TOTAL COST TO BUILD 85/- P.P. 2/-

HI-FI

Special parcel prices. Let us have your enquiries for equipment.

(4) 'DEALS'

RECHARGEABLE BATTERIES

● 3·6 volt 500 mA/H. Size: 1¾" × 1¾" dia. .. 12/6, p.p. 1/6
● 9·6 volt 225 mA/H. Size: 2⅛" × 1" dia. .. 20/-, p.p. 1/6

BRAND NEW — Offered at a fraction of normal retail price.

(9) 25 WATT AMPLIFIER

New 8-Transistor design. Push-pull output for 7½ to 16ohm speaker. 150mV input. 30c/s to 20kc/s ± 1dB. For use with valve or transistor preamplifiers as item (3) above. Size 2⅝ × 2⅝ × 6¼in.

PRICE BUILT AND TESTED £8.19.6 P.P. 3/-
(Mains unit **79/6**, p.p. 2/6)

(10) ROADSTER MW/LW CAR RADIO

Supplied as Preassembled Panels. Permeability tuned superhet. Push-button wave-changer. Push-pull output. Fits any car. 7 × 4 × 2in. 12 volt (+) earth.

ASSEMBLY TOTAL COST £8.19.6 P.P. 3/6
(Speaker/Baffle/Car Fixing Kit, **20/-**)*

(11) GARRARD DECKS

(p.p. 5/- any type)

1000 mono	**£6.10.0.** stereo	**£6.19.6**
2000 mono	**£6.19.6.** stereo	**£7.10.0**
*SP25 mono	**£10.19.6.** stereo	**£11.10.0**
*utoslim mono	**£5. 9.6.** stereo	**£5.19.6**
*AT6 mono	**£8.19.6.** stereo	**£9.10.0**
*AT/ mono	**£11.19.6.** stereo	**£11.19.6**
3000LM stereo **£8.19.6**		

(*D[illegible] cartridge add 60/- to mono price [illegible] autochange (except SP25), complete with cartridge. Brand new.

(12) MULTIMETERS

PT34	1kV	**39/6**	TP5S	20kV	**£5.19.6**
M1	2kV	**47/6**	EP30k	30kV	**£6.10.0**
TP10	2kV	**75/-**	EP50k	50kV	**£8.15.0**
EP10k	10kV	**79/6**	500	30kV	**£8.17.6**
IT1-2	20kV	**89/6**	EP100k	100kV	**£10.10.0**
EP20k	10kV	**99/6**			

(13) VHF FM TUNER

Supplied as 2 Preassembled Panels, plus metal work Superhet design, 88-108 Mc/s, [illegible] volt operated.
Tota[illegible] cost **£[illegible].17.6**, p.p. 2/6.

(14) NEW MW/LW TUNER TO BUILD

Fully tunable superhet with excellent sensitivity and selectivity. Output up to ½ volt peak. Complete with front panel, etc. 9 volt operated.

TOTAL COST TO BUILD 79/6 P.P. 2/6

HENRY'S RADIO LTD.

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