PRACTICAL ELECTRONICS

MARCH 1967

PRICE 2/6

PROXIMITY DETECTOR ALARM

Also

SPECIAL IN THIS ISSUE!

RADIATION COUNTER

PHOTOFLASH SLAVE UNIT

THE OSCILLOSCOPE — AND ITS APPLICATIONS

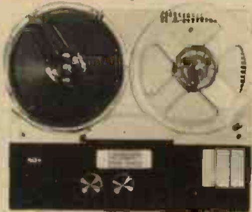
LASKY'S RADIO

For the Finest Value and Service to HOME CONSTRUCTORS & ELECTRONICS ENTHUSIASTS

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.

TAPE RECORDERS

MAGNAVOX 363 DECKS



The very latest 3 speed model—1⅞, 3¾, 7½ i.p.s. available with either ½ track or ¼ track head. Features include: pause control; digital counter; fast forward and rewind; new 4 pole fully screened induction motor; interlocking keys. Size of top plate: 13¼ × 11 × 5¼in. deep below unit plate. For 200/250 v. A.C. mains, 50 c.p.s. operation. New unused and fully guaranteed.

LASKY'S PRICE ½ track model £10.10.0

LASKY'S PRICE ¼ track model £13.9.6

Carriage and Packing 7/6 extra.

SPECIAL FOR OVERSEAS CUSTOMERS — the new Magnavox-Collaro 363 Deck for 110/125 v. 50 or 60 c.p.s. mains now available, prices as above. Post to any part of the world 35/-.

MARTIN RECORD/REPLAY TAPE AMPS.

Latest models now available from stock—for use with the Magnavox 363 Tape Deck

½ track model .... LASKY'S PRICE £14.19.6

¼ track model .... LASKY'S PRICE £15.19.6

Carriage and Packing 4/6 extra

Optional extra: Control panel escutcheon to take deck and amplifier controls. LASKY'S PRICE 12/6. Post and Packing 2/6.

SPECIAL INTEREST ITEMS!

SPECIAL PURCHASE—UHF/VHF T.V. TUNERS

Well known British makers' surplus stocks. Now available for the first time to the Home Constructor. Add 2/6 Post and Packing on each.

VALVE UHF MODEL (*illustrated*)

In metal case size 4 × 6 × 1½in. Fully tunable—complete with PCC86 and PCC88 valves. LASKY'S PRICE 29/6. Without valves 12/6

TRANSISTORISED UHF MINIATURE MODEL I

Shielded metal case only 3½ × 1¼ × 3in. Fully tunable—complete with two AF 139 transistors. LASKY'S PRICE 39/6

TRANSISTORISED UHF MODEL 2

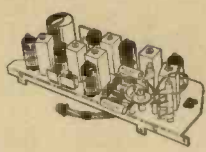
Metal case size 3¾ (plus spindle) × 2¾ × 1½in. Fully tunable with slow motion drive. Comp. with two AF186 transistors and leads. LASKY'S PRICE 25/6

TRANSISTORISED VHF TUNER

Sub-miniature turret type fitted with 12 sets of coils and 3 Mullard AF102 transistors. In metal case size 3 × 1½ × 2¼in. LASKY'S PRICE 37/6

Add 2/6 Post and Packing on each.

MAKERS' SURPLUS TELEVISION IF AMPLIFIERS



38 Mc/s. Contains a large number of components, IF transformers, resistors, capacitors, etc., and the following valves: 2xPCF80, 1xEB91, EF80, EF183 and EF184. Overall size 11½" × 3½" × 4" deep. Ideal for servicemen and experimenters. This IF amp. when used with the Valve model UHF Tuner (above) provides a suitable conversion for B.B.C.2. Circuit supplied.

LASKY'S PRICE 29/6 Post 2/6

SPECIAL PACKAGE OFFER

Free standing table cabinet, size 17½ × 9 × 5¼in., finished in medium Mahogany. Scale marked 21 to 68 (UHF band). Designed to accept the above IF Amplifier with space for a Valve UHF Tuner. Cabinet only 27/6 Post 3/6

Special Package Offer IF Amplifier, UHF Tuner with valves and Table Cabinet. PACKAGE PRICE 59/6 Post 6/-

WATER TEMP. THERMOSTATS

British made—orig. for use in high quality washing machine. range adjustable between 114°F and 230°F. Rating 200/250 V.A.C., 20 amps (also D.C. up to 125 V.A.). Size 2¼×1¾×1¼ with 18in. capillary tube and 6in. bulb. Single hole fixing—3/16in spindle.

LASKY'S PRICE 15/- Post 2/-

CONSTRUCTORS BARGAINS

The "Sixteen" Multirange METER KIT

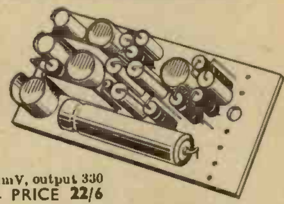
This outstanding meter was featured by *Practical Wireless* in the Jan. '64 issue. Lasky's are able to offer the complete kit of parts as specified by the designer.

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—3¾×5¾×1¾in. 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/-

NEW—LASKY'S MINIATURE TRANSISTOR AMPLIFIER MODULES



Incorporating the very latest circuitry to provide high sensitivity and good quality in conjunction with extreme small size and compactness. High quality Newmarket transistors used throughout. All designed to operate on 9v. miniature battery. Add 1/- on each for post & packing

TYPE LRPC 1. 3 transistor. Input sens. 50 mV., output 150 mW, output imp. 40Ω, size 2×1×⅝in....... PRICE 27/6

TYPE LRPC 2. 5 transistor. Input sens. 1mV, output 330 mW, output imp. 15Ω, size 2¼×1½×⅝in.... PRICE 22/6

TYPE LRPC 3. 5 transistor. Input sens. 5 mV, output 400 mV, output imp. 15Ω, size 2¼ × 1½ × ⅝in. .... PRICE 25/-

TYPE LRPC 4. 5 transistor. Input sens. 150 mV, output 330 mV, output imp. 15Ω, size 2¼ × 1½ × ⅝in. .... PRICE 22/6

TYPE LRPC 5. 6 transistor. Input sens. 8mV, output 3W, output imp. 3Ω, size 5½ × 1¾ × 1in. .... PRICE 59/6

TYPE LRPC 6. Tape record/play back amp. (for use with self oscillating erase head). Output 750mW. output imp. 8Ω. Size 4¾ × 2 × 1in..... LASKY'S PRICE 39/6

FULLY ENCAPSULATED MODULES

Special function modules — all one size 1½ × 1 × 1¼in. Complete with detailed function and installation instructions. Send S.A.E. for data.

TYPE PA-1. Public address amp. for use with carbon, crystal or Dynamic microphones. 3Ω output imp. .... PRICE 30/-

TYPE GR-1. Gramophone amplifier—provides sufficient power to fill average room. 3Ω output imp. .... PRICE 30/-

TYPE CO-1. Morse code practice oscillator — for use with morse key and 3Ω speaker. .... PRICE 20/-

TYPE MT-1. Metronome module—provides audible and visual beat from 30 to 240 beats per minute (for use with 3Ω speaker or ind. lamp).................... PRICE 22/6

SINCLAIR SUPER MINIATURE KITS

We stock the complete range. Write for details of package deals.

THE MICRO-6 miniature radio only 1⅞ × 1 3/10 × 1¾in.	£2 19 6
THE MICRO-FM. (tuner/receiver)	£5 19 6
THE X-20 20 watt P.W.M. amplifier Kit £7.19.6. Fully built	£9 19 6
STEREO 25 pre-amp control unit fully built	£9 19 6
THE Z-12 12 watt amplifier and pre-amplifier. Fully built and tested	£4 9 6
PZ-3 power pack for Z-12	£3 19 6

VEROBOARD — High grade laminated board with copper strips bonded to it and pierced with holes.

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42/1503	2½ × 5 in.	3/11	Terminal pins — pkt. of 50	3/-
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NEW!

THE WORLD'S SMALLEST RADIO

Photograph shows actual size

SINCLAIR MICROMATIC

- ONLY ONE CONTROL
- CALIBRATED DIAL
- SIZE — $1\frac{4}{5}$" x $1\frac{3}{10}$" x $\frac{1}{2}$"
- POLISHED ALUMINIUM FRONT PANEL WITH SPUN ALUMINIUM DIAL
- AMAZING RANGE POWER & SENSITIVITY
- NEW CIRCUITRY
- BANDSPREAD FOR EASY RECEPTION OF 'POP' STATIONS
- A.G.C.
- IN KIT FORM OR READY BUILT
- 5 YEAR GUARANTEE

PROFESSIONALLY RIGHT IN EVERY DETAIL

THE SINCLAIR MICROMATIC is a brand new design from an organisation world-famous for its production of micro-electronic equipment for constructors. It has behind it the Sinclair tradition of specialisation in micro-radio circuitry which, in the MICROMATIC, reaches fantastically high levels of performance. We have combined new circuitry with new elegance to make the SINCLAIR MICROMATIC professionally right in every detail whether you build it yourself or buy it complete in presentation case.

This makes the perfect personal radio, ready to serve wherever and whenever required. Its minutely proportioned case houses transistors, ferrite rod aerial and batteries and yet is considerably smaller than an ordinary matchbox. The MICROMATIC has an elegantly designed aluminium front panel with matching calibrated slow motion dial. New circuitry assures reception from a wide range of stations over the medium waveband, with excellent selectivity and quality. Here is a new set you will be proud to be seen using; you will also find it an ideal gift to give anyone. YET THIS BRILLIANT NEW DESIGN IS THE EASIEST OF ALL SINCLAIR RADIO SETS TO BUILD—AND IT IS BRITISH!

TECHNICAL DESCRIPTION

The Sinclair Micromatic is housed in a neat plastic case with attractive aluminium front panel and aluminium tuning dial to match, calibrated in Kc/s and metres.

Three special Sinclair transistors are employed in a six stage circuit of exceptional power and sensitivity. Two stages of powerful R.F. amplification are followed by a double diode detector from which the signal tuned in is passed to a high gain three stage audio amplifier. Automatic Gain Control counteracts fading from distant stations and maintains signal strength. The set is powered by two Mallory Mercury Cells Type ZM.312 which are readily obtainable from radio shops, Boots Chemists, Stores, etc., and cost 1/7 each. The cells will give approximately 70 hrs. continuous working life. Inserting the earpiece plug switches the set on, withdrawing it switches off.

Complete kit of parts to build Sinclair Micromatic including lightweight earpiece, case and instructions **59/6**

Sinclair Micromatic ready built with lightweight earpiece, in presentation case, **79/6**

FULL SERVICE FACILITIES AVAILABLE TO ALL SINCLAIR CUSTOMERS

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SINCLAIR RADIONICS LTD., 22 Newmarket Rd., CAMBRIDGE

Telephone 52996 (STD Code OCA3)

Order form and more Sinclair designs on pages following

SINCLAIR STEREO 25 DE-LUXE PRE-AMP CONTROL UNIT

THE SINCLAIR STEREO 25 has been designed specially to ensure the highest possible standards of reproduction when used with two Z.12s or any other first class stereo power amplifier. Best possible components are used in the construction of this superb unit, whilst its appearance reflects the professional elegance characteristic of all Sinclair designs in hi-fi, radio and TV. The front panel of the Stereo 25 is in solid brushed and polished aluminium with beautifully styled solid aluminium control knobs. Mounting the unit is simple, and power is conveniently obtainable from the Sinclair PZ.3 which can also be used to supply two Z.12s to make a complete stereo assembly. Hi-fi enthusiasts seeking the ultimate in domestic listening will find all they want from this combination of Sinclair units. With a Micro FM for tuner, they will have an installation to compare favourably with anything costing from four to five times as much.

FOR USE WITH ANY GOOD STEREO SYSTEM

TECHNICAL SPECIFICATIONS

Performance figures obtained using Stereo 25, two Z.12s and a PZ.3.

- **SENSITIVITY** for 10 watts into 1.5 ohms load per channel. Mic.—2 mV into 50K ohms. Pick-up—3 mV into 50K ohms. Radio—20 mV into 4.7K ohms.
- **FREQUENCY RESPONSE** (Mic. and Radio)—25 c/s to 30 kc/s ± 1dB extending to 100 kc/s ± 3dB.
- **EQUALISATION** — Correct to within ± 1dB on RIAA curve from 50 c/s to 20 kc/s.
- **TONE CONTROLS** Treble +12dB to —10dB at 10 kc/s. Bass +15dB to —12dB at 100 c/s.
- **SIZE**—$6\frac{1}{2}$in.x$2\frac{5}{8}$in.x$2\frac{1}{2}$in. overall, plus knobs.
- **FINISH** — Front panel sectioned in brushed and polished solid aluminium with solid aluminium knobs. Black figuring on front panel.

BUILT, TESTED AND GUARANTEED **£9.19.6**

SINCLAIR MICRO-FM

COMBINED FM TUNER AND POCKET FM RECEIVER

ANYONE CAN BUILD IT

7 TRANSISTORS
●
NO ALIGNING
●
PULSE COUNTING DISCRIMINATOR
●
A.F.C.
●
TUNES 88-108 Mc/s
●
SIZE—less than 3"×$1\frac{3}{4}$"×$\frac{3}{4}$"

This unique, superbly engineered FM superhet is the only set in the world which can be used both as an FM tuner and an independent FM pocket receiver just whenever you wish. Problems of alignment have been completely eliminated making the Micro-FM ready for use the moment you have built it. The pulse counting discriminator ensures best possible audio quality; sensitivity is such that the telescopic aerial included with the kit assures good reception in all but the very poorest reception areas. The Sinclair Micro-FM will give you all you want in FM reception and the satisfaction of building a unique design that will save you pounds.

FM superhet using 7 transistors and 2 diodes. The R.F. amplifier is followed by a self-oscillating mixer and three stages of I.F. amplification which dispense with I.F. transformers and all problems of alignment. The final I.F. amplifier produces a square wave which is converted to produce the original modulation exactly. A pulse-counting discriminator ensures better audio quality. One output is for feeding to amplifier or recorder and the other enables the Micro-FM to be used as an independent self-contained pocket portable. A.F.C. "locks" the programme tuned in.

Complete kit, including transistors, case, aerial, earpiece, etc.

£5.19.6

"Although a complete novice to radio I was able to assemble it (Micro-FM) without undue difficulty thanks to your clear and lucid instructions. I receive all B.B.C. programmes and local......very strongly."
H.T., Warrington, Lancs.

"Far more sensitive (Micro-FM) than many commercial models."
M.M. New Romney, Kent

"Z.12 received in perfect order. It is wonderful to hear records properly."
J. de H.S., London, N.2

"I consider your after sales service is excellent. I wish very much that other suppliers treated their customers in the way you do. I have tried out the Micro-FM with the Z.12 and my Quad speaker and am very pleased with the results."
H.A., London, N.6

FULL SERVICE FACILITIES AVAILABLE TO ALL SINCLAIR CUSTOMERS

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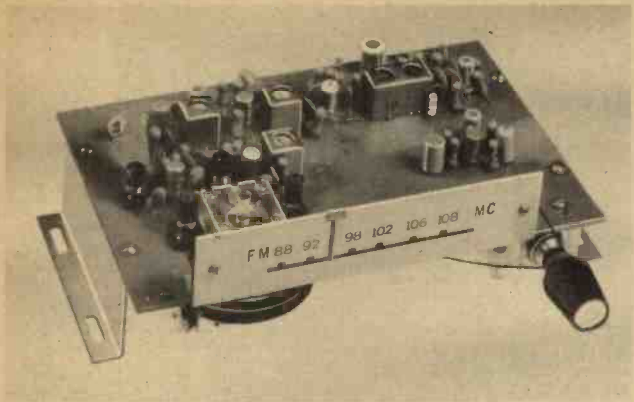

FMT.41 Transistorised FM Tuner

have you...

WI.2. Transistorised Wireless Intercom

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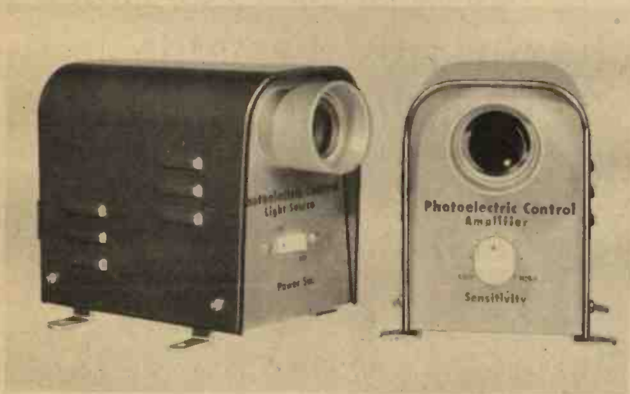

EAGLE products

When the "Eagle" Brand was launched 10 years ago it was impossible to foresee that in such a short time the range would grow to cover over 500 items, all carrying the "Eagle" name. Whether you are interested in Hi-Fi, Amateur Radio, Do-it Yourself projects or any field of Electronics, "Eagle" offer you ihe widest choice of sensibly priced products and by the end of the year we plan to increase our range to cover the formidable total of 700 items.

If you would like to study our entire range in the leisure of your home we will be delighted to send you our catalogue free of charge or why not ask your local dealer (there are over 6,000 "Eagle" stockists) to show you the latest "Eagle" Products today!

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makes better circuits quicker and cheaper

★ INSTANTLY APPLICABLE, INSTANTLY ADAPTABLE
★ NO CHEMICALS, NO ETCHING, NO HEAT
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From stockists everywhere. In case of difficulty, direct from Peak Sound.

CIR-KIT KIT No. 3 contains 12in. x 6in. mounting board, 4in. x 6in. CIR-KIT adhesive copper sheet for land areas and special shapes and approx. 15ft. of ⅛in. CIR-KIT adhesive copper strip. The heat-resistant adhesive used will last indefinitely with normal use. With instructions.

15/-

Think what it means to be able to have just ONE printed circuit to the design you want and you will see immediately just how wonderfully **CIR-KIT** more than fills that long felt need. **CIR-KIT** is quick—you simply lay the self-adhesive copper strip on the board, drill holes for mounting the components and you are ready to solder them in at once. **CIR-KIT** is clean — there are no chemicals, acids or etching processes involved. **CIR-KIT** is adaptable—you can amend a circuit again and again quickly and easily. Ideal for experimenters, this. **CIR-KIT** is economical — No. 3 Kit contains enough material to make up about 10 circuits and components may be closely mounted if desired. You can also repair damaged conventional printed circuits; you can experiment quickly and cheaply. In fact, **CIR-KIT** is the most revolutionary advance in circuit techniques since the printed circuit itself was invented and is already widely used by many of the most famous houses in electronics.

"Cir-Kit" shows the way to economical hi-fi stereo

PEAK SOUND SA. 8-8 Kit complete with instructions **£12. 19. 6**

PEAK SOUND POWER PACK 75/-

PEAK SOUND combined 16 watt stereo amplifier and pre-amp for only £12.19.6 is made possible entirely due to using "Cir-Kit". 14 matched transistors are used in this superb hi-fi kit for crystal and ceramic pick-ups. Over 16 watts output into two 5-ohm speakers in stereo. 8 and 15 Ω speakers may be used. This Peak Sound Kit is complete down to last piece of wire.

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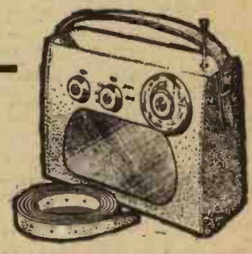
NEW ROAMER SEVEN Mk IV



7 WAVEBAND PORTABLE OR CAR RADIO

Amazing performance and specification ★ *Now with PHILCO MICRO-ALLOY R.F. TRANSISTORS*

FULLY TUNABLE ON ALL WAVEBANDS ● **9 stages—7 transistors and 2 diodes**

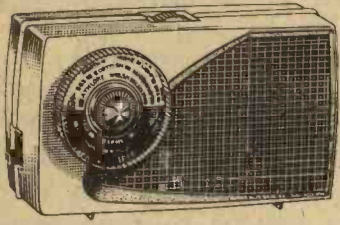
Covers Medium and Long Waves, Trawler Band and three Short Waves to approx. 15 metres. Push-pull output for room filling volume from rich toned 7" × 4" speaker. Air spaced ganged tuning condenser. Ferrite rod aerial for M & L Waves and telescopic aerial for S Waves. Real leather-look case with gilt trim and shoulder and hand straps. Size 9" × 7" × 4" approx. The perfect portable and the ideal car radio. (Uses PP7 batteries available anywhere.)

★ **EXTRA BAND FOR EASIER TUNING OF LUXEMBOURG, etc.**

Total cost of parts now only **£5.19.6** P. & P. 5/6

Parts Price List and easy build plans 3/- (Free with kit)

NEW MELODY MAKER SIX



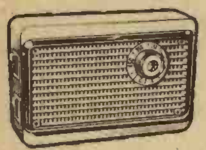
3 WAVEBAND PORTABLE. ● **8 stages. Six transistors and two diodes.**

Covers Medium and Long Waves and extra Band for easier tuning of Luxembourg, etc. Top quality 3" Loudspeaker for quality output. Two RF stages for extra boost. High 'Q' 6" Ferrite Rod Aerial. Approx. 350 Milliwatts push pull output. Handsome pocket size case with gilt fittings. Size 6½ × 3¾ × 1½ in. (Uses long-life PP6 battery). Carrying strap 1/6 extra.

This amazing receiver may be built for only **£3.9.6** P. & P. 3/6

Parts Price List and easy build plans 2/-. (Free with kit)

NEW TRANSONA FIVE



"Home, Light, A.F.N. Lux. all at good volume" *G.P., Durham*

● **7 stages—5 transistors and 2 diodes**

Fully tunable over Medium and Long Waves and Trawler Band. Incorporates Ferrite rod aerial, tuning condenser, volume control, new type fine tone super dynamic 2¾ in. speaker, etc. Attractive case. Size 6½ × 4½ × 1¼in. with red speaker grille. (Uses 1289 battery available anywhere.)

Total cost of all parts now only **42/6** P. & P. 3/6

Parts Price List and easy build plans 2/- (Free with kit)

POCKET FIVE

● **7 stages—5 transistors and 2 diodes.**

Covers Medium and Long Waves and Trawler Band, a feature usually found in only the most expensive radios. On test Home, Light, Luxembourg and many Continental stations were received loud and clear. Designed round supersensitive Ferrite Rod Aerial and fine tone 2¾in. moving coil speaker, built into attractive black and gold case. Size 5½ × 1½ × 3½in. (Uses 1289 battery, available anywhere.)

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Parts Price List and easy build plans 1/6 (FREE with Kit)

STOP PRESS!

Pocket 5 Med and Long wave version with miniature speaker

29/6 P. & P. 3/-

NEW ROAMER SIX

NOW WITH PHILCO MICRO-ALLOY R.F. TRANSISTORS

● **6 WAVEBAND!!**

● **8 stages—6 transistors and 2 diodes**

Listen to stations half a world away with this 6 waveband portable. Tunable on Medium and Long Waves, Trawler Band and two Short Waves. Sensitive Ferrite rod aerial and telescopic aerial for short waves. Top grade transistors. 3-inch speaker, handsome case with gilt fittings. Size 7¼ × 5¼ × 1½in. (Carrying Strap 1/6 extra.)

★ **EXTRA BAND FOR EASIER TUNING OF LUX. ETC.**

Total cost of all parts now only **£3.19.6** P. & P. 3/6

Parts Price List and easy build plans 2/- (Free with kit)

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● **8 stages—6 transistors and 2 diodes**

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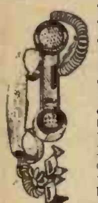

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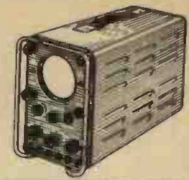

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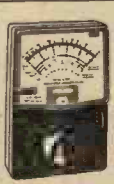

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VOL. 3 No. 3
MARCH 1967

PRACTICAL ELECTRONICS

NEW SYMBOLS

THIS month we introduce "hertz" into our pages as the unit of frequency, in place of the long used and familiar "cycles per second". The symbol Hz replaces c/s. Prefixes k for kilo (10^3) and M for mega (10^6) etc. are used with the new symbol, as with the old.

With this change we come into line with the long standing Continental practice and what now appears about to become also the more general, if not universal, practice.

The U.S. National Bureau of Standards officially adopted hertz in 1964. In the U.K. the "official" position is not entirely clear. Apparently no official recommendation will be issued until some unspecified time in the future when the existing Radio Regulations can be amended by the International Telecommunication Union.

In the meanwhile influential bodies such as the G.P.O. and the B.B.C. have already commenced using hertz, and so there seems little reason to suppose that the U.K. will resist the changeover. Indeed there has been an almost indecent rush on the part of some of our manufacturers to join the hertz band waggon—all in the interest of the export market, of course—we shall no doubt be told.

A slight acerbity in the foregoing paragraph may suggest that we ourselves are not madly enthusiastic about the departure from a time honoured symbol. This is so, but we will not argue the pros and cons here. The commitment appears to have been made and we accept it.

There is another related matter to which it is appropriate to refer at this time. And here it is not too late to join battle.

A new British Standard BS3939 Graphical Symbols for Electrical and Electronics Diagrams was issued in 1966. The introduction to this Standard explains that the intention is to adopt internationally agreed symbols "*as soon as practical in the future.*"

One of the most revolutionary changes proposed is that the well known zig zag for a resistor be replaced by the Continental rectangular box. We join with voices raised in other journals protesting at the stupidity of this move.

What efforts do the British representatives on these International Bodies make in support of *our* symbols? Here surely is an excellent case for the Continent switching over to our symbol—not vice versa.

Why discard a symbol which is the acme of perfection—explicit, simple to draw, and economical in space—for a rectangular nonentity?

We dig our feet in, and will not surrender to this so-called "objective" intruder. And we think readers will have cause to be thankful for being preserved from conglomerations of empty blocks in our circuit diagrams.

THIS MONTH

CONSTRUCTIONAL PROJECTS

SPECIAL SERIES

GENERAL FEATURES

NEWS AND COMMENT

Our April issue will be published on Friday, March 17

All correspondence intended for the Editor should be addressed to: The Editor, PRACTICAL ELECTRONICS, George Newnes Ltd., Tower House, Southampton Street, London, W.C.2. Editorial and Advertisement Offices: PRACTICAL ELECTRONICS, George Newnes Ltd., Tower House, Southampton Street, London, W.C.2. Phone: Temple Bar 4363. Telegrams: Newnes Rand London. Subscription Rates including postage for one year, to any part of the world, 36s.

THE Oscilloscope and its applications

This is the first of two articles providing an introduction to the oscilloscope and some of the many and varied practical uses to which such an instrument can be applied. The oscilloscope is perhaps the most useful instrument available today to the communications and electronics engineer, both professional and amateur. Its applications not only in the radio and electrical fields, but in physics, mechanical and aeronautical engineering, medical and biological sciences, etc. are immense.

PART ONE

176

By P. Cairns

THE modern oscilloscope (generally abbreviated c.r.o.) appears in almost an infinite number of different types whose specifications vary widely. They can vary greatly in size and cost, weighing anything between a few pounds to over a hundredweight and in price between about thirty pounds and over one thousand pounds. Many of these instruments however are of a very specialised nature and are designed principally to meet particular applications. In this article, therefore, only the general purpose c.r.o. and its applications will be considered.

CHARACTERISTICS

All oscilloscopes have a number of basic characteristics and circuit functions in common. The basic block diagram into which the majority of oscilloscopes could fit is shown in Fig. 1, the differences in size, specification and price being principally in the degree of complexity or otherwise of each of the circuits contained in these blocks.

The heart of the instrument is of course the cathode ray tube. This may have a screen diameter of between three and six inches and the type of phosphor required can often be selected to suit individual needs. Phosphors ranging from short persistence green or blue, used mostly for photographic purposes, through the various combinations of medium persistence phosphors to the very long persistence orange-yellow grades often used for the display of transient phenomena, are available.

Tubes designed to give a double beam display may be of the split beam or double gun type. Electronic beam switching can also be used for multi-channel display. Most modern oscilloscopes use a p.d.a. tube (post deflection anode). This is a final anode maintained at a high positive potential with respect to the cathode and deflection plates and placed after these plates in the tube structure. The added acceleration given by this anode to the electron beam allows both sharper focus and faster writing speeds to be achieved. Almost without exception all oscilloscope tubes are of the electrostatic deflection type.

The power supplies, both h.t. and e.h.t., are of conventional circuit design. The e.h.t. unit may be of the voltage doubler type with a d.c. output to the final anode of between one and four kV depending upon the type of tube used. The more expensive types of c.r.o. often have e.h.t. stabilisation, maintained by means of neon discharge tubes. This is a decided advantage as it maintains the sensitivity of the tube at a constant figure and thus the X and Y amplifier calibrations remain constant. A sudden or gradual rise or fall in e.h.t. means a similar decrease or increase in tube sensitivity respectively. R.F. e.h.t. units are seldom used.

The h.t. power unit is again normally a conventional full wave rectifier and smoothing circuit, often with various levels of h.t. voltage being stepped off to suit the h.t. requirements of the various circuits. Electronically stabilised power units are often used and while they are an advantage from the point of view of amplifier and time base, trigger and sync stability, they increase both the cost and size of the oscilloscope.

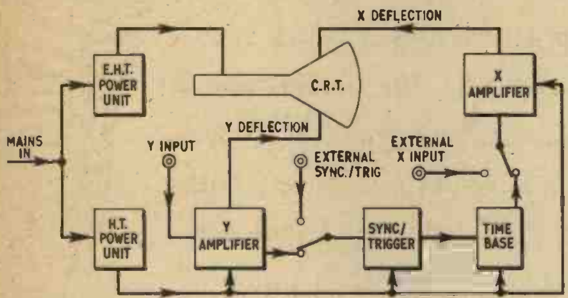


Fig. 1. Block diagram of a typical oscilloscope

Y AMPLIFIER

Few, if any, circuits in an oscilloscope vary so much in type and specification as the Y amplifier. This is the circuit to which the signal under consideration is applied and gives a deflection in the vertical axis. The numerous amplifiers available may be subdivided into a few basic types.

First the general type of d.c. amplifier with selection for a.c. coupling. This can have a frequency response from d.c. to 3MHz or even higher. The less expensive oscilloscopes often have only a.c. coupled amplifiers with a response from about 5Hz to 1 or 2MHz, this being quite adequate for most general applications, though a d.c. amplifier is always preferable.

The maximum sensitivity of these general types of amplifier may be anything between about 10 to 250 mV/cm. Such amplifiers have numerous applications in radio, television, servo and computer work, electrical engineering, etc.

Rather more specialised types of amplifier are the high gain low bandwidth d.c. amplifier and the differential type of d.c. amplifier. These may have an upper bandwidth limit of 1 to 100kHz and a sensitivity down to 1mV/cm. A high common mode rejection figure is desirable with these types of differential amplifier, a figure of 10,000:1 being reasonable. This type of amplifier is much used in electromechanical, medical and biological applications.

Another class of amplifier often met with in practice, particularly in the electro-acoustic and magnetic recording fields, is the very high gain a.c. amplifier. A frequency response of 5Hz to 100kHz or more being quite average while they may often have a sensitivity as high as 10μV/cm.

Many modern oscilloscopes have facilities for plug in amplifiers, a whole range of different amplifiers being available. To have a range of three or four such amplifiers is a decided advantage, particularly in research work though the initial cost is rather large. The majority of good oscilloscopes have an adjustable stepped attenuator preceding the Y amplifier, this being frequency compensated if necessary.

TIME BASE

Time bases and X amplifiers tend to vary rather less widely than Y amplifiers. The purpose of the time base is to generate a saw-tooth waveform having an extremely linear slope, and the time duration of this waveform must be variable over a very wide range while maintaining this linear rate of rise. The flyback period must be as fast as possible over this range.

This waveform is fed into the X amplifier before being applied to the tube horizontal deflection plates. While the smaller oscilloscopes may have only five or six time base ranges, the larger instruments have up to 18 ranges. The sweep speeds available may lie between 100ms/cm–10μs/cm with the smaller instruments to 1s/cm–0·5μs/cm on the larger instruments.

The X amplifier can be either a.c. or d.c. coupled, the latter being preferable. Facilities are also available to allow the input of the X amplifier to be switched to an input terminal on the front panel, thus allowing external signals to be applied to the X deflection system. In this position the time base and sync/trigger circuits are muted to prevent possible interference and interaction between the time base circuit and the applied signal.

The gain control on the X amplifier controls the amplitude of the external signal in the normal way. With the time base running the gain control gives a trace expansion of many times the screen diameter; trace expansions of up to 5 or 10 times being normal. This facility can be extremely useful when it is required to examine a small part of a complex waveform. Generally speaking the X amplifier has a smaller bandwidth and lower sensitivity than the Y amplifier.

SYNC/TRIGGER CIRCUIT

The purpose of the sync/trigger circuit is to synchronise the signal being applied to the Y amplifier to the time base scan. When these two are locked together a steady picture or trace is the result; an unsynchronised signal "free runs" across the tube face.

A signal is synchronised when a portion of the Y signal is applied to the time base to lock them together. In the case of a triggered circuit the time base is not free running and the spot remains stationary (usually blanked out) until the trigger pulse "fires" the time base. The time base then sweeps once across the tube face, returns, then waits for the next trigger pulse to fire it again.

Sync/trigger circuits vary greatly in complexity and reliability, often being extremely susceptible to voltage changes, valve or component ageing, etc. Internal-external switching controls are often available for trigger or sync on both positive or negative waveforms and in many cases television line and frame sync separator circuits are included in the c.r.o.

Other facilities which increase the usefulness of an oscilloscope are an internal calibration source and an input point for Z or intensity modulation. The simpler forms of calibration signal are usually square waves derived from the mains supply and having a constant amplitude. This can be used for calibrating Y deflection sensitivity and also, within limits, for time base calibration.

The Z or intensity modulation access point is a.c. coupled to the c.r.t. grid or cathode. An external alternating signal applied to this point allows the trace to be blanked out (or brightened up) during either the negative or positive half cycle. This method, when used in conjunction with a phase shift circuit or Lissajous figures, allows spot wheel patterns to be obtained. This can make frequency comparison measurements much simpler.

CALIBRATION

Before commencing work with an oscilloscope a calibration check should be carried out on both X and Y amplifier sensitivities and time base accuracy. While the more elaborate oscilloscopes have attenuator and shift controls (besides normal X and Y shifts) which are calibrated in terms of amplifier sensitivity in centimetres per voltage input (V/cm), many oscilloscopes depend upon visual measurement on the screen graticule. In many such amplifiers the gain control is calibrated in terms of V/cm, say from 0 to 10, while a stepped attenuator gives various increases in this sensitivity scale (X3, X10, etc.).

Graticules are normally divided into 1cm squares, all measurements, both voltage and time, being given in terms of this unit. To check the Y calibration a signal source of known amplitude, the internal calibration signal being used if available, is connected into the Y input, the time base being adjusted to give a few cycles of the signal across the tube face. The gain and attenuator are set to give a definite vertical deflection. This peak to peak deflection is then measured on the graticule and can be expressed in terms of the signal input.

Signal levels are normally expressed in terms of peak to peak voltage though if the signal is a sine wave it can be simply converted to r.m.s. value by dividing by $2\sqrt{2}$. For example, if a 0·5V peak to peak calibration source is available and the Y gain is adjusted until the signal occupies exactly 4cm in the vertical plane, the calibration at that point is 0·125V/cm, or in general:

$$\text{Calibration in V/cm} = \frac{\text{Input peak to peak voltage}}{\text{Vertical deflection in cm}}$$

By this method either a full calibration scale can be made or the existing scale may be checked. The same calibration checks can be carried out on the X amplifier, this being switched to the external input position. In this case the signal will appear as a horizontal line as there will be no signal deflection in the vertical axis.

Having checked the sensitivity calibrations of both amplifiers, the time base sweep speeds can be checked. Assuming that the calibration signal is 50Hz, if the time base is adjusted until one cycle occupies exactly 2cm the sweep speed at this point is 10ms/cm (1 cycle of 50Hz equals 20ms). While using only 50Hz obviously limits the range of time calibration (about 2 to 150ms on a three inch tube), if an audio signal generator is available the complete range of time base speeds may be calibrated. For example, with a signal of 1,000Hz, 1 cycle equals 1ms, therefore if the time base is adjusted until one cycle occupies say, 4cm, the sweep speed is then 0·25ms/cm or 250μs/cm, or in general:

$$\text{Time per cm} = \frac{\text{Period of signal}}{\text{Horizontal deflection in cm}}$$

and the time duration of a signal can be found from the period of one cycle equals $1/f$ seconds. Where f is the frequency in hertz of the applied signal.

The calibrations described above are extremely important if any accurate work of an experimental nature or work requiring reasonably reliable results are required. The accuracy of oscilloscope measurements depend in the first instance upon the accuracy of the initial calibration and while good commercial instruments achieve accuracies of 5% or even 3%, a figure of 10% is a more realistic target in the case of most home constructed oscilloscopes.

MEASUREMENTS

The three basic units which normally have to be measured in practice are voltage, current and power; all of these can be measured on an oscilloscope. In the case of reactive circuits the phase angle can also be measured. To measure the voltage level of a signal it is simply applied to the Y input, the time base adjusted to suit the frequency of the signal and then the signal level is read off the calibrated Y gain scale.

Current is measured in a similar manner except that a shunt is connected in series with the circuit under test, the Y input being connected across the shunt. The shunt should be of a non-reactive type (carbon resistors meet this requirement), be of low ohmic value compared with the circuit in which it is to be connected and also be of known value.

Typical shunt values are 100, 10, 1, 0·1 ohms, and as the voltage drop across the shunt will be small the Y amplifier will have to be set to a high sensitivity level. The shunt should be chosen to have negligible effect on the circuit under test, e.g. a 10 ohm shunt connected in a 10 kilohm circuit will affect the circuit by only 1 part in 1,000 or 0·1 per cent. This ability to view and measure current waveforms can be very useful when working with transistors, these being current operated devices.

POWER FACTOR VALUES

By combining the two measurements just described, power may be measured. The circuit is connected as shown in Fig. 2a, the voltage across the series shunt being applied to the Y input, this normally having the greater sensitivity. The X amplifier is switched to external input, the time base being switched off. The X and Y gain controls are adjusted to give a similar deflection in each axis.

The resultant trace will be as in Fig. 2b. That is, a straight line (assuming a purely resistive circuit) at an angle across the tube face. The power can be calculated by dropping a vertical line from each end of the trace to the horizontal axis and measuring the area of the resultant triangles, see Fig. 2b.

Should the circuit be reactive, instead of a straight line, an ellipse will appear (Fig. 2c). The ellipse may be used to determine the phase angle or power factor of the circuit. The straight line represents a resistive circuit (unity power factor) and the greater the reactive component or phase angle, the wider the ellipse will become. A 90 degree phase shift appears as a circle, this representing zero power factor. The value of the phase angle represented by an ellipse can be calculated by either of the methods shown in Figs. 2d and e.

Large power factor values can be rather difficult to measure due to the negligible width of the ellipse. This can be overcome by shifting one of the deflecting voltages by 90 degrees, i.e. putting it through a phase shift circuit before applying it to the oscilloscope. A suitable variable phase shift unit that can be used in a number of applications is described in Part 2 next month. If the above procedure is carried out a straight

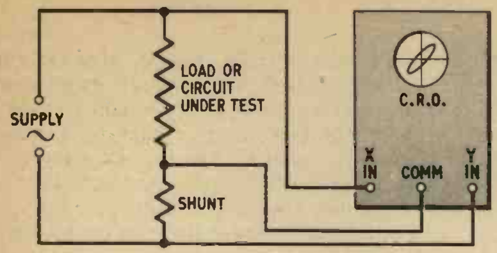
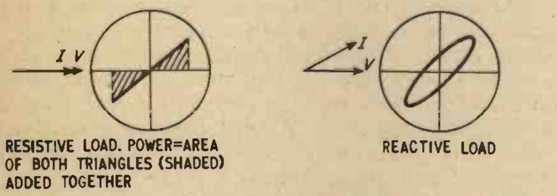
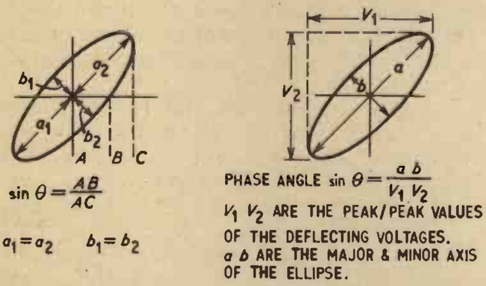


Fig. 2a. Test set-up for power factor measurements



Figs. 2b and c. Oscillograms for resistive and reactive power factor measurements



Figs. 2d and e. Two methods of calculating phase angle

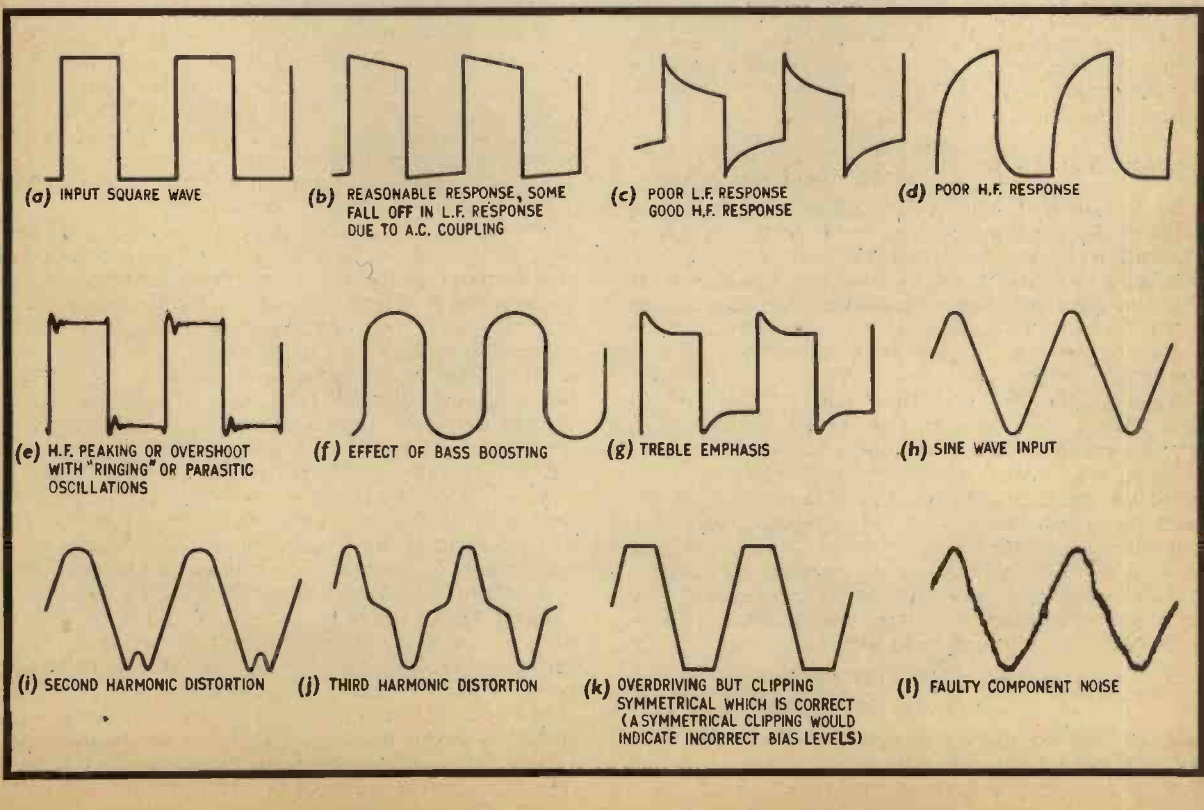
line will then represent zero power factor and a circle unity power factor, thus making the measurement of small angles much easier. Due to the artificial phase shift of 90 degrees the intercept of the ellipse on the horizontal axis now gives cos θ direct from the ratio AB/AC, Fig. 2d. It may be of interest to note also that the area of the ellipse represents the energy used per cycle and can represent either "wattless" or "watt" power depending upon whether an artificial phase shift of 90 degrees has been introduced into the circuit or not.

When carrying out measurements on an ellipse care must be taken to ensure there are no phase shifts in the test circuit, test leads, or oscilloscope itself. Such phase shifts can always be measured first by connecting the test circuit to a purely resistive load and the resultant phase shift, if any, measured and taken into account when carrying out tests on a reactive circuit.

Another interesting feature is that if the current waveform is applied to the Y input and the time base is switched on, the quantity of electricity can be estimated. Any waveform can be regarded as an area traced on a screen having a magnitude proportional to the product of the two deflecting quantities. Thus, if the current waveform is drawn on a time scale, the area of the trace will be proportional to the quantity of electricity in coulombs.

One of the advantages of using an oscilloscope for voltage or current measurements is that an actual picture of the waveform is given besides its peak or peak to peak value. Conventional measuring instruments using a moving coil or moving iron meter are generally only calibrated in r.m.s. values and thus any

Fig. 3. (below). Typical deficiences in an audio amplifier are shown by these waveforms when using a square wave input (a to g) and sine wave input (h to l)



waveform other than a sine wave will result in an incorrect reading.

If the waveform present in the circuit under test is not known, such readings taken on a meter may not be a true representation of conditions present in the circuit and in many cases can be extremely misleading. The only method of obtaining the accurate phase relationships and values of an irregular voltage and current waveform is by means of an oscilloscope.

AUDIO ANALYSIS

The performance of audio amplifiers, high quality or otherwise, can be quickly checked by injecting a square wave of suitable level into the amplifier and using the oscilloscope to examine the waveforms at various points in turn throughout the amplifier. Many defects which would not show up if a sine wave signal were used quickly come to light if a good square wave signal with a fast rise time and negligible overshoot is used.

Some of the various waveforms which may be encountered are shown in Fig. 3. By such tests many so called "hi fi" amplifiers have been shown to be of a much lower quality than was previously thought. If the signal levels into and out of each stage are measured when carrying out such tests the effective stage gains throughout the amplifier can be found. The effects on overall gain and quality by increasing or decreasing the amount of negative feedback can also be measured. The effectiveness or otherwise of bass and treble tone controls can also be checked by observing their effect on the output waveform.

If a variable audio signal generator is connected to the amplifier input, a complete frequency response curve of the amplifier can be taken. The input signal should be kept constant in amplitude over the complete frequency range (about 10Hz to 20kHz), the output level being measured on the oscilloscope. A typical response curve is shown in Fig. 4.

The total phase shift in the amplifier can also be found by applying the input signal to one deflection system and the output to the other deflection system, the time base being switched off. Any phase shift will result in an ellipse which can be measured as previously described. If this test is carried out at various audio frequencies, a complete phase shift characteristic over the audio range can be plotted. Thus the optimum values of phase shift compensation components can be easily found by observing the changes in the ellipse when altering the components in question.

When using a variable frequency audio generator the cross-over point and efficiency of cross-over networks in multi-speaker systems can also be found. The output levels of both bass and treble output points are measured in turn over the audio range for a constant value of input signal. A curve similar to that in Fig. 5 can then be plotted. If the constant input signal level is also measured on the oscilloscope the attenuation factor of the network in dB can be calculated for both curves and a further set of curves drawn showing the loss characteristics.

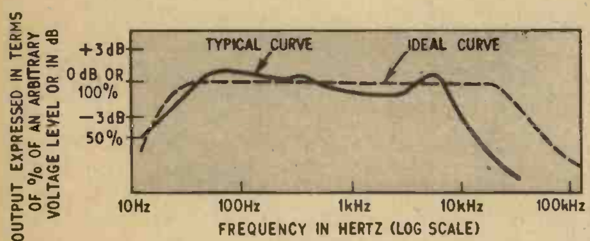


Fig. 4. Typical frequency response curve, determined by using an oscilloscope, compared with a desired ideal curve (shown dotted)

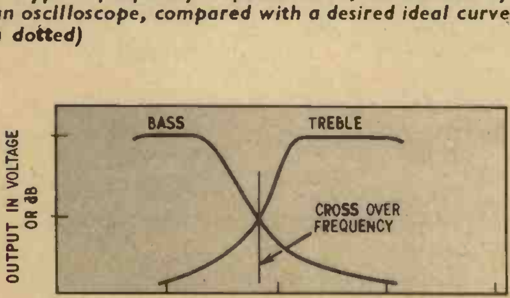


Fig. 5. By using the frequency response technique, cross-over filters can be measured

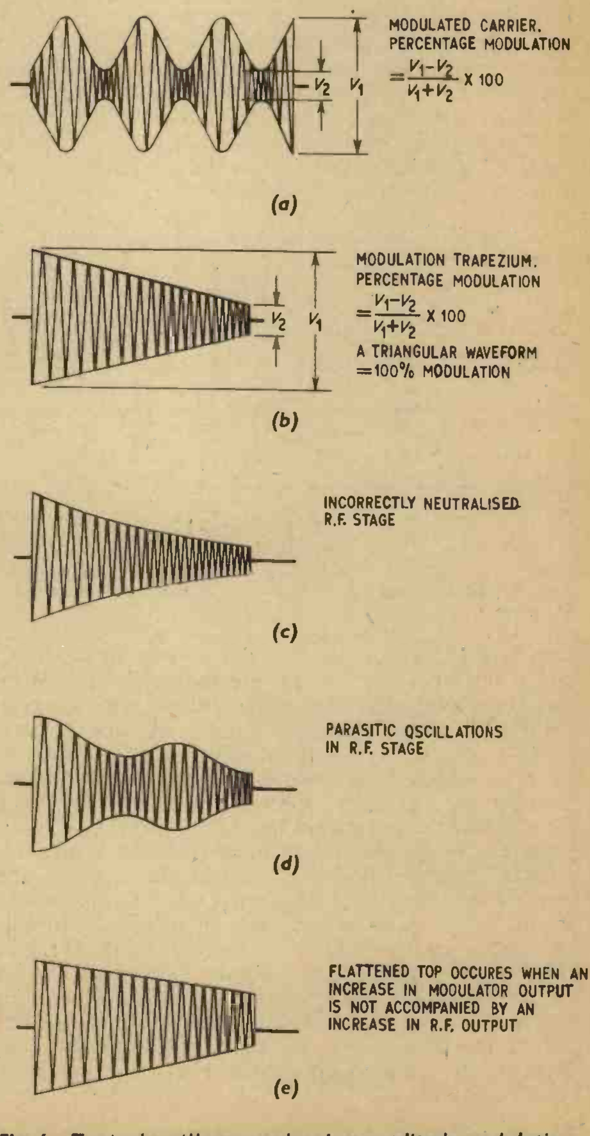


Fig. 6. Typical oscillograms showing amplitude modulation and various distortion characteristics

By a few such simple tests as have been described the principle characteristics of an amplifier can be quickly tabulated and any improvements or modifications can be quickly and visually carried out.

It must be remembered when carrying out such tests not to overload the amplifier, the input signal being kept below the maximum input level. If necessary the pre-amplifier and main amplifier stages can be tested individually. If the loudspeaker or speakers are disconnected during the tests a dummy load resistance of the correct impedance and wattage value should be connected across the secondary of the output transformer.

MODULATION MONITOR

Another useful oscilloscope application is the measurement of amplitude modulation depths in transmitters. For the experimental amateur transmitter the oscilloscope can often prove invaluable. A typical amplitude modulated carrier waveform is shown in Fig. 6a, the percentage of modulation being calculated as shown.

This shows the modulated carrier applied to the Y input and displayed on a linear time base. Modulation patterns are very often displayed in the form of a trapezium, such displays having a number of advantages. To achieve this pattern the modulated carrier is applied to the Y deflection system and the modulation signal only, to the X deflection system.

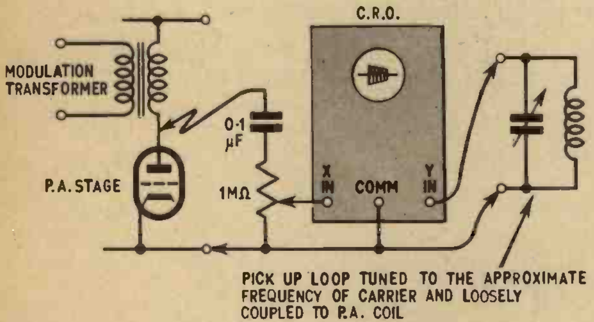


Fig. 7. Test set-up for transmitter amplitude modulation measurement

A typical test set up is shown in Fig. 7. Various forms of trapezium patterns are shown in Figs. 6b to 6e. Providing no phase change takes place between the modulator and the stage from which the carrier is taken, the sloping edges of the trapezium will be straight. Thus, both linearity and percentage modulation can be checked as shown in Fig. 6b. To check for the presence of second harmonic in the modulated voltage, reduce the modulation input to zero, this leaving a vertical line of carrier on the screen. The modulation input is then increased gradually, an unequal expansion on each side of this line indicates even or second harmonic content. The presence of third or odd harmonics is generally indicated by a line of increased brilliance across the trace. Should a phase difference be present between modulation and carrier the sloping lines bounding the trapezium will form an ellipse and the figure will appear to be wrapped round a cylinder.

Next month: Television servicing, Lissajous figures, Z modulation, and phase shift network.

Book review

ITV 1967
Published by the Independent Television Authority
224 pages, 7in × 9in. Price 7s 6d

This well established year book which has proved increasingly popular since its first edition in 1963 as a guide and work of reference, now appears completely restyled primarily to make its 250 pictures as large as possible.

It contains such visual information as viewing audience charts and TAM pictograms showing growth over the last 10 years and a comprehensive coverage of the U.K. network of transmitting stations and programme companies. These chapters provide technical information on channel frequencies, radiation power, patterns and site topography which includes contour maps, and a great deal of general company information.

A third of this guide is devoted to programme categories each of which are supported by a profusion of representative photographs and programme lists for 1966.

G.G.

Meetings . . .

SOCIETY OF ELECTRONIC AND RADIO TECHNICIANS

SALISBURY
Date: February 23
Title: Microwave Techniques and Applications to Radar
S. V. Judd
Time: 7 p.m.
Address: Salisbury College of Further Education, The Friary, Salisbury.

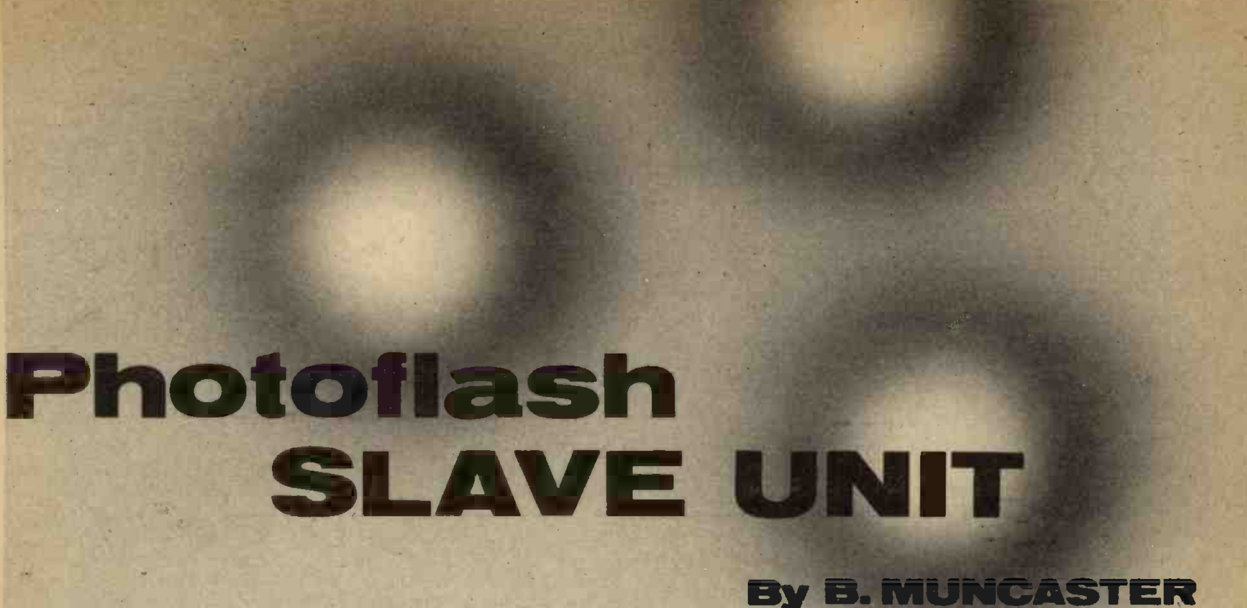
INSTITUTION OF ELECTRONIC AND RADIO ENGINEERS

LONDON
Date: February 22
Title: Dual Standard Colour Television Receiver
P. L. Mothersole, D. S. Hobbs and D. J. King
Time: 6 p.m.
Address: London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1.

BOURNEMOUTH
Date: February 22
Title: Development of Satellite Communications
J. K. S. Jowett
Time: 7 p.m.
Address: Bournemouth College of Technology, Bournemouth.

SLOUGH
Date: February 21
Title: Pulse Code Modulation
J. R. Jarvis
Time: 7.30 p.m.
Address: Lecture Theatre, Slough College, Slough.

TORQUAY
Date: February 21
Title: Automatic Landing Systems
R. A. Bailey and J. Meadows
Time: 7 p.m.
Address: South Devon Technical College, Torquay.



Photoflash SLAVE UNIT

By B. MUNCASTER

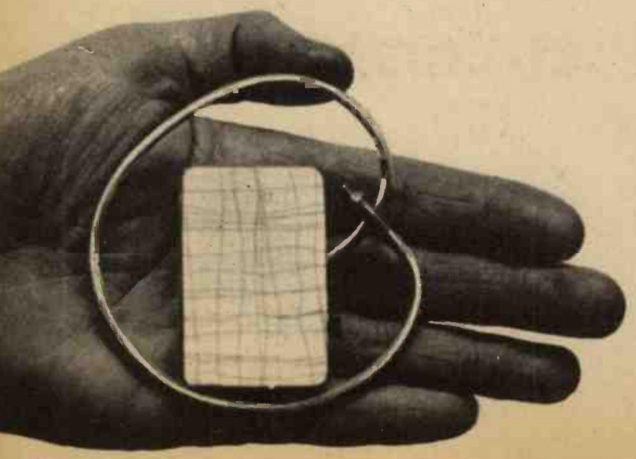
In recent years the photographer, professional or amateur, has come more and more to rely on electronics for assistance in the production of his photographs. The slave unit about to be described is yet another instance where the electronic device gives more freedom and versatility to the photographer.

what is a slave unit?

- *In short . . . it is a device which will fire one or more flash guns from the light emitted by a single flash gun connected to the camera.*
- *It does away with the need for interconnecting wires, but enables as many flash guns as required to be synchronised from the camera shutter.*
- *It makes possible the use of additional flash lights with the consequent improvement in the quality of the resulting photographs.*
- *Furthermore, it enables friends and clubs to pool their equipment making possible photographs approaching professional studio quality.*

HAVING acquired, over a period of years, some half a dozen flash guns of the electronic type the writer found the need for a synchronising device which would permit the use of multiple flash lighting. Since all the flash guns were not of the same type it was not possible to effect synchronisation simply by connecting all the trigger leads in parallel. In any case this practice would be very detrimental to the shutter contacts within the camera. As most readers will know, an electronic flash gun is triggered by discharging a capacitor which may be at a potential of up to 250 volts and although the usual trigger capacitor is between $0{\cdot}1\mu F$ and $0{\cdot}25\mu F$, when several are connected in parallel quite a hefty spark can result when contact is made.

The unit which is the subject of this article will function from the light of either an expendable bulb flash or an electronic flash, and it will also fire both types. It can be built using all new components for a good deal less than half the price of the commercial units, and by taking note of the advertisers in PRACTICAL ELECTRONICS it is possible to get the cost down to about 50s per unit.



CIRCUIT DESCRIPTION

Fig. 1 shows the theoretical circuit of the slave unit. The photo-sensitive device is the phototransistor OCP71 (TR1). When the primary flash (i.e. the one fired from the camera) is set off, the light impinging on the OCP71 causes a momentary increase in the current through it, the capacitor C1 then charges and draws current through the base of TR2; the latter switches on and passes a pulse of current through the gate terminal of a thyristor SCR1, the thyristor is itself turned on and fires the slave flash gun.

In the quiescent state the current taken by the unit is in the order of 150 to 200 microamps and only at the

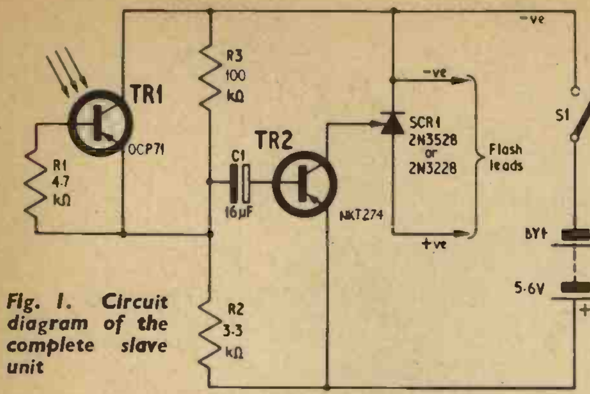
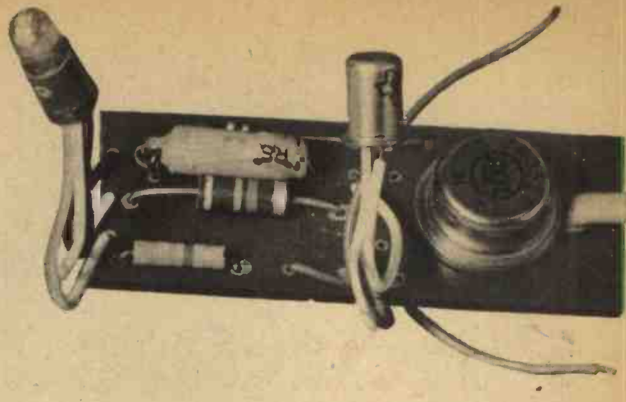


Fig. 1. Circuit diagram of the complete slave unit



moment of the flash does the current taken rise into the milliamp range. This low consumption means that a very small battery may be used to power the unit and battery life is reckonable in terms of the shelf life of the battery.

SELECTION OF COMPONENTS

All the resistors are miniature types, as is the capacitor.

The second transistor TR2 is an NKT274, although OC72, OC81, and NKT224 have also been used successfully by the author, the difference in overall sensitivity being marginal.

The thyristor is the most important item and several factors govern the actual type to be used.

When used with electronic flash guns the voltage rating of the thyristor needs to be quite high, at least 300 volts, and the leakage through the device in the "off" state must be very, very low indeed. Trigger circuits of electronic flash units are supplied through very high value resistors and any leakage more than a few microamps drains current from the circuit faster than it can be supplied. The consequence is that there is insufficient power in the trigger circuit of the flash gun to fire the tube. The gate sensitivity of the thyristor must be quite high to obviate the need for a multistage amplifier after the OCP71, and finally the cost of the thyristor must be low enough to make the construction of the slave unit worthwhile.

The writer finally settled on the R.C.A. thyristor type 2N3228 which cost about 15s and fulfilled the other requirements ideally. In fact, since making the first few slave units R.C.A. have introduced a further thyristor under type number 2N3528. This latter type is supplied with a separate heat sink base which is not necessary in this particular application and which allows the slave unit itself to be made even more compact. The current rating of this type is 1·3A average with a maximum single cycle limit of 60A. This means that the slave unit is capable of accepting several flash guns connected to it without fear of overloading. There is no heat dissipation problem since the thyristor is in the "on" state for only a fraction of a second in several minutes.

As readers will know, once a thyristor has been switched on the gate has no further control over the conduction through the device, and in order to turn it off the anode circuit has to be broken or the current reduced to a very low value.

In the slave unit this switching off is done automatically when the flash trigger capacitor has discharged: the thyristor switches "off" and is then ready for the next cycle of operation.

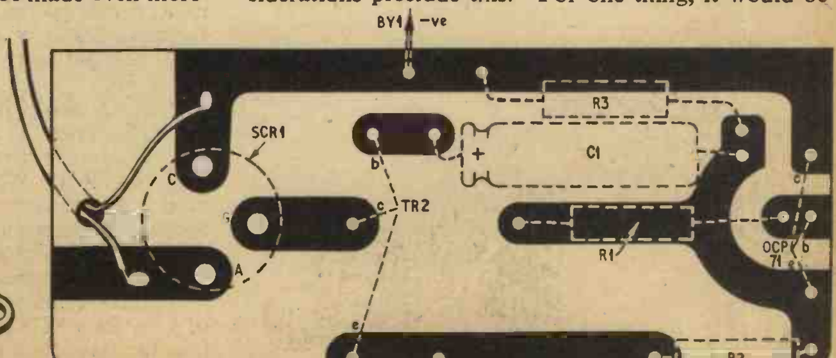
One other fact that will be of interest is that thyristors must not be subjected to high voltage transients in the reverse direction. In practice the transients which might be expected from the trigger coil in the flash gun seem to be effectively suppressed by the trigger capacitor itself. One absolute requirement of the thyristor is that the anode must be connected to the positive flash lead and this matter is dealt with in the paragraphs on construction.

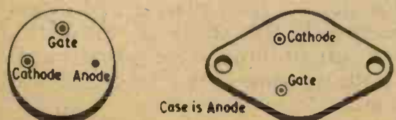
NO SENSITIVITY CONTROL

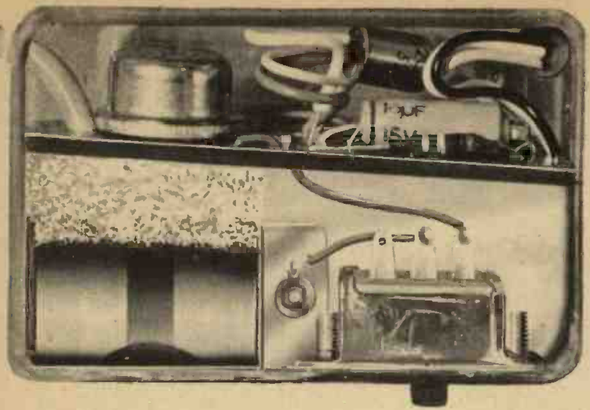
The writer would emphasise that this circuit is not the most sensitive one which can be devised, but from the photographer's point of view it is very practical. There are no adjustments to make and the slave will function in the presence of a fair amount of ambient lighting so that it is possible to make use of modelling lamps when setting up the flash guns.

Sensitivity would be increased enormously if d.c. coupling was used in the slave unit but other considerations preclude this. For one thing, it would be

Fig. 2. Layout of components (shown dotted) on the reverse side of the printed circuit board







necessary to have some form of sensitivity control to take care of differing lighting conditions, and when used in this application the gate current must either be fully off, or at a level which will trigger the thyristor.

It is an unfortunate characteristic of thyristors that as the gate current approaches the level at which triggering takes place, so is there an increase in the forward leakage current through the junction. Since this must be prevented for reasons already given, capacitor coupling is the only method which will avoid the addition of some form of control.

With the present circuit the slave is switched on, coupled to its flash gun and it is then immediately ready for action. Experience will soon indicate to the photographer when it is necessary to point the slave at the primary flash and when it is quite sufficient to point it in the general direction of the scene being photographed.

The sensitivity is such that in a room 30 feet long the slave unit will trigger when another flash is set off anywhere in the room even if the primary flash and the slave are pointed away from each other. When used with electronic flash guns the slaved flash is only microseconds behind the primary flash and for all practical purposes this delay may be discounted. With expendable bulbs the photographer must allow for the burning time of the foil in the bulb (typically 25 milliseconds from contact to peak light) and the shutter must be set at a speed which will allow the light from both primary and slaved flashes to be utilised.

CONSTRUCTION

The layout of the photoflash slave unit is in no way critical and the physical size of the unit is dependent to some extent on the skill of the constructor. The writer has used plastic boxes which appear to be a stock item at most radio shops and which measure 2¼in × 1½in × ⅞in overall, but as can be seen from the photograph of the internal layout, there is still plenty of room to spare and the unit could be tucked into a smaller space.

The photograph shows a unit which incorporates a 2N3528 thyristor, but Fig. 2 shows the pin connections of both this and the 2N3228 types.

A word of warning here. The case of both types of thyristor is at the same potential as the anode. Depending on the flash gun being used, the thyristor case may be at a potential of up to 250V with respect to the negative side of the slave unit supply. SCR1 must therefore be insulated with the appropriate mica washers, and the layout should be such that there can be no accidental touching of SCR1 case or any other components.

The prototype units are each built on a small piece of printed circuit board cut to fit into the case. Fig. 3 is a diagram of the printed circuit board using a 2N3528, and if this is followed the various components fit in with ease.

The usual precautions should be taken when soldering the semiconductors into place and the leadout wires should not be cut short. When soldered in, the OCP71 should be carefully positioned so that the active side of the junction faces out of the case. The photosensitive side of the OCP71 is towards you when the stripe indicating the collector lead is on the left.

continued on page 226

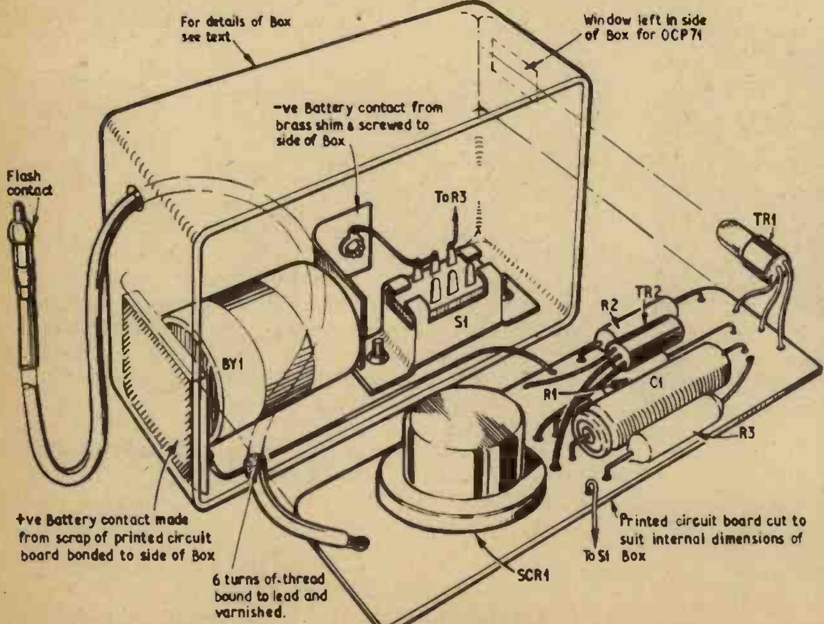


Fig. 3. Complete pictorial layout of the slave unit

COMPONENTS . . .

Resistors
R1 4·7kΩ
R2 3·3kΩ
R3 100kΩ
All ⅛W carbon

Capacitor
C1 16μF miniature elect. 10V

Transistors
TR1 OCP71
TR2 NKT274 (see text)

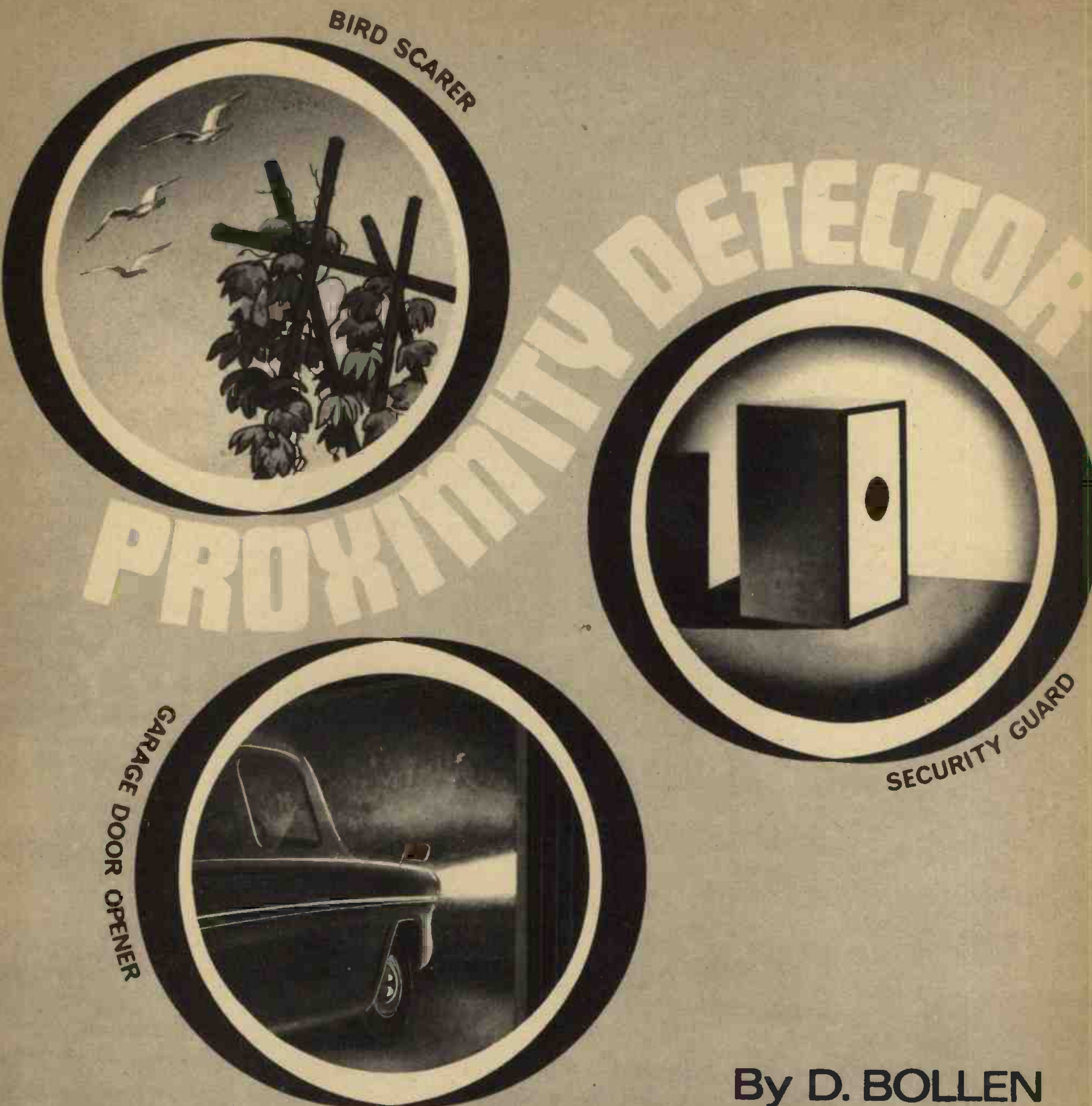
Thyristor
SCR1 2N3528 or 2N3228 (R.C.A.)

Switch
S1 Miniature slide on/off switch

Battery
BY1 5·6V battery (Mallory PX23)

Miscellaneous
Plastics box, 2¼in × 1½in × ⅞in. Small piece of laminated plastics board. Flash extension lead.

PROXIMITY DETECTOR



By D. BOLLEN

PROXIMITY detectors are often used to guard property and can be used to prevent operators of machines from coming into contact with lethal moving parts. The usefulness of a device which responds to movement of a nearby human body is not restricted to purely industrial applications, however. In the home, a proximity detector can function as an automatic doorbell, a near infallible burglar alarm, garden bird scarer, and garage door opener, to mention only a few possibilities.

Optical proximity detectors are among the simplest to use and set up, and they can be highly sensitive. When a photocell, or similar light-sensitive cell, is arranged to "view" an illuminated space, then a person or object moving across that space will cause minute fluctuations of current in the cell, which may be amplified to operate a relay.

In turn, the relay can be made to ring a bell, open doors, and operate machinery in direct response to the approach of a human being.

The device described here exploits this principle and, with a quiescent battery consumption of only 3mA, will detect a person moving at distances in excess of 6ft in ordinary daylight without the need for mirrors, pencil beams of light, or lenses.

TIME CONTROL

When a selenium cell is exposed to light it will generate a steady d.c. current, proportional to the light intensity. If the light reaching the cell is momentarily increased or reduced, even by quite a small amount, the selenium cell will emit a pulse. Depending on how the light fluctuates, the pulse will be of a certain duration; the secret of success here lies in the correct selection of a suitable amplifier RC time constant.

If the time constant is too slow, a cloud obscuring the sun will cause the unit to trigger; if too fast it will fail to respond to the relatively slow movement of a human body. Assuming that a bell is to be operated by the unit, it must ring for several seconds to be effective, even though the trigger pulse from the selenium cell may last for only a fraction of a second.

There must therefore be a built-in time delay to keep the bell ringing. On the other hand, for burglar alarm applications, the bell will be required to ring continuously after the initiating event.

The circuit of Fig. 1 shows how these different requirements are met. A positive going pulse from the selenium cell, produced when the light to the cell suddenly diminishes, is amplified and inverted by the pulse amplifier TR1. C1 and C2 values are selected to give the appropriate time constant.

TR2 and TR3 form a Schmitt trigger, which is noted for its stability and freedom from drift. VR1 is so adjusted that TR2 is normally off and TR3 is on. As the pulse arrives from the collector of TR1, the Schmitt "flips" and TR3 is switched off. The Zener diode D1 performs the useful function of isolating the base of TR4 when TR3 is conducting, but it allows a heavy current to pass to TR4 base when the voltage at the collector of TR3 rises above the Zener turnover potential. C3 assists, at the instant of switching, to give positive relay action.

The feedback link from the collector of TR4 to R1 is responsible for the time delay—typically 15 seconds. When the relay is energised, the collector of TR4 drops to almost positive rail voltage, and bias is removed from the base of TR1, thus isolating R2.

It follows that C2 is then connected to the negative rail via R2 and, until it has charged to the new potential, will hold the Schmitt hard on. If the delay is not wanted, R1 can be wired directly to the negative rail and the link from TR4 collector can be removed. The circuit will then provide a short output pulse to operate, say, an electromagnetic counter.

When S2 is closed, the relay will hold itself on permanently, after the trigger event, and the bell will continue to ring until BY2 is exhausted. With two 1289 batteries in series for BY1, at a current drain of 3mA, several weeks of continuous operation will be realised.

When setting up the unit, S1 is closed, and the bell will ring for about one minute while C1 and C2 attain equilibrium. VR1 is then adjusted for maximum sensitivity, consistant with reliable operation, while triggering the unit by waving a hand in front of the selenium cell tube opening.

AUTOMATIC DOORBELL

Postmen, milkmen, and advertiser's agents do not always ring the doorbell when they call; it might be that a special letter is expected, or there is some good reason for knowing immediately that somebody is standing at the front door.

The complete board assembly, with its cover, can be placed to view the front porch, and any daytime caller will unknowingly announce his presence. In this case, the bell will be mounted remote from the box, somewhere inside the house, and BY1 would be replaced by a mains powered, low voltage d.c. supply.

There is plenty of room in the box, when BY1 is removed, to take a battery eliminator of the type employed as a direct replacement for PP9 transistor radio batteries. Fig. 2 gives a suggested circuit for those wishing to construct their own eliminator. T1 is any small transformer giving a nominal output of 9 volts, and could well be an inexpensive bell transformer.

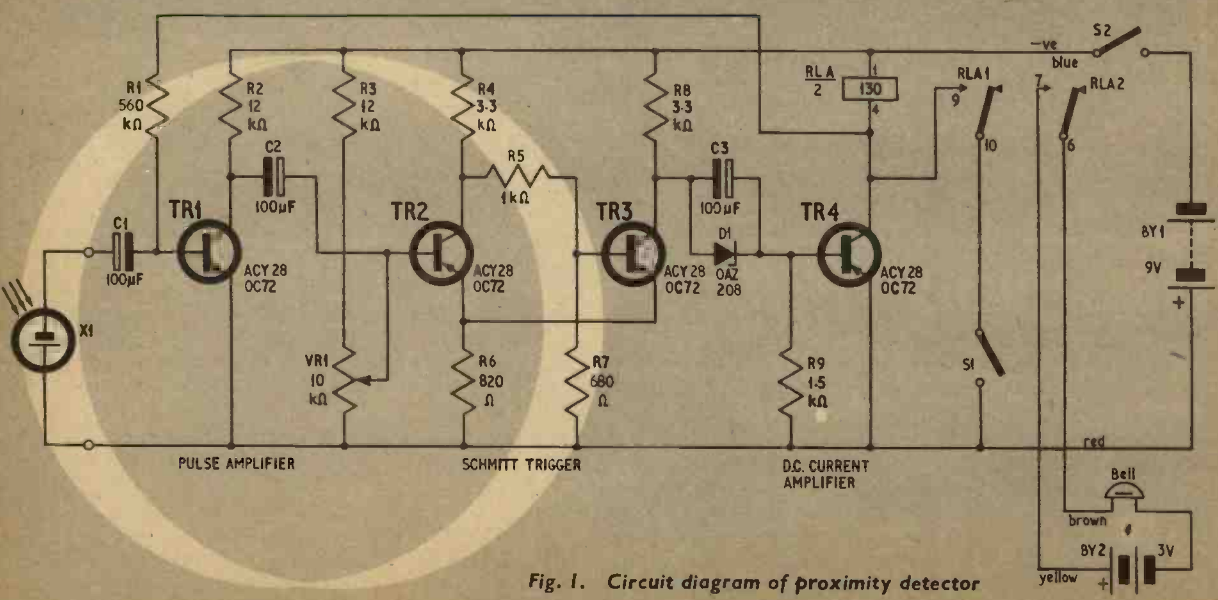


Fig. 1. Circuit diagram of proximity detector

When the automatic doorbell is to supplement an existing doorbell, then contacts 6 and 7 on the relay, see Figs. 1 and 5a, are wired across the bell push. So arranged, the doorbell will ring automatically in daylight, by detecting the caller before he has time to press the bell push, and manually at night.

If 24-hour automatic operation is contemplated, a small, low power lamp could be positioned in the porch, facing the selenium cell, so that the caller will interrupt its light and trigger off the bell.

It is probably better to let the automatic unit work its own bell independently, then one may distinguish between callers who press the button and those who do not, which also gives "fail safe" equipment duplication.

PORTABLE BURGLAR ALARM

There is sometimes a need to protect a sum of money, or documents, for a brief period, where a wall safe is not available. If the temporary hiding place is in the locked drawer of a desk, the warning device could be placed on the desk top so that the intruder must come within its field of view when attempting to open the desk drawer.

If the device is to be successful as a portable burglar alarm, it must be self powered, and tamper-proof. The photograph shows how "secret" switches—taken from old switched potentiometers—were mounted on a thick wooden base, together with batteries, circuit panel, and cell tube. The switches were operated by inserting a slim screwdriver through holes in the cover of the unit (Fig. 3). This, in itself, requires some juggling, and the intruder would take an appreciable time to work out how the switches should be operated.

The burglar therefore finds himself in a room with a featureless box containing a ringing bell, with no way of silencing it, short of dashing the box repeatedly to the floor, or hitting it with an iron bar, thus contributing to the noise already being made by the bell.

Obviously, publication of any secret switch system renders it no longer secret, but a simple solution to this is a key switch, such as the Bulgin type S321. The constructor might like to devise his own form of secret switching, however.

A suitable cover, designed to fit the wooden mounting board, is given in Fig. 3. When used as a burglar alarm, the bell is mounted internally, shown dotted, and small holes should be drilled to allow the sound to pass out of the box.

Ideally, the cover should be as stout as possible, preferably fabricated from sheet steel, with a steel panel bonded to the back of the wooden mounting board. This is not to say that a hardboard box is useless, in fact it will take considerable force to break open if the epoxy glue has been liberally applied.

At night, a small table lamp could be used to provide enough light to sensitise the selenium cell, but the light from a burglar's torch, as it falls on the unit, would be enough to set off the alarm.

If, in daytime, it is not convenient to site the desk close to a window, a white wall may provide enough ambient light to give correct functioning of the alarm. Optimum positioning of the alarm must be found by experiment, but is usually far from critical.

GARAGE DOOR OPENER

With the early warning device mounted close to a garage door, it will detect flashing headlamps at a considerable range, and the car may be driven straight into its garage, without the need for the driver getting out, when a door motor is activated by the unit.

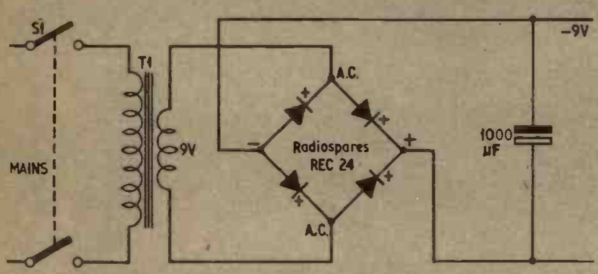


Fig. 2. Suggested battery eliminator power supply circuit for the unit when used as a "doorbell"

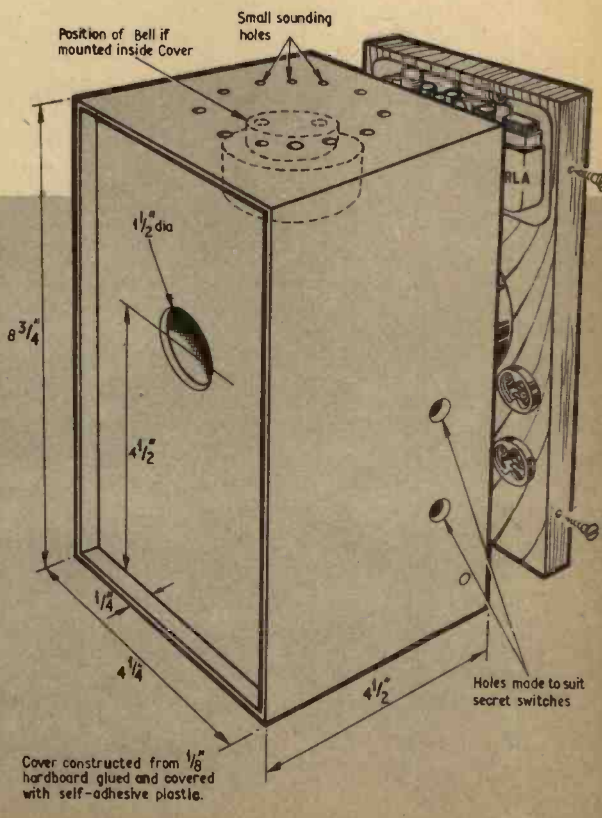


Fig. 3 (right). Case construction details. Note the switches on the baseboard and the related access holes

COMPONENTS . . .

Resistors

R1	560kΩ	R6	820Ω
R2	12kΩ	R7	680Ω
R3	12kΩ	R8	3·3kΩ
R4	3·3kΩ	R9	1·5kΩ
R5	1kΩ		

All 10%, ¼ watt carbon

Potentiometer
VR1 10kΩ log. carbon miniature skeleton pre-set

Capacitors
C1 100μF elect. 12V
C2 100μF elect. 12V
C3 100μF elect. 12V

Transistors
TR1, TR2, TR3, TR4 } ACY 28 or OC 72 (Mullard).

Diode
D1 OAZ 208 (Mullard)

Relay
RLA 130Ω four changeover contacts (S.T.C. type 25)

Photo Cell
X1 Selenium cell type B3M (International Rectifier Co.)

Batteries
BY1 9V (2 × 4½V type 1289)
BY2 3V (type 800)

Switches
S1, S2 single pole, on/off (see text)

Miscellaneous
Relay socket, 3–8V bell
Laminated plastics board 2¾in × 4in
Baseboard, Cardboard tube and tin

If the sensitivity control VR1 is backed off, fluctuations of ambient light produced by a person walking in front of the garage door will not cause spurious operation, but there will still be a response to the intense glare of headlamps.

Contacts 6 and 7 on the relay will not carry sufficient current to switch a garage door motor, but a supplementary power relay can be installed, working from contacts 6 and 7, to control the motor. Switching circuits will vary, and depend on the type of motor used. The time delay previously discussed may not be required if only a brief switching pulse is necessary, to start the motor sequence.

The selenium cell connections to the amplifier should be reversed if triggering is to commence at the instant headlamps are switched on. In the normal mode, as shown in Fig. 1, the unit will only trigger when ambient light is reduced, when the headlamps are turned off.

GARDEN BIRD SCARER

The unit can be used in the garden. Rapidly fluttering wings will generate a good signal in the selenium cell. The ringing bell will disconcert birds as well as announce that the garden is under attack. In

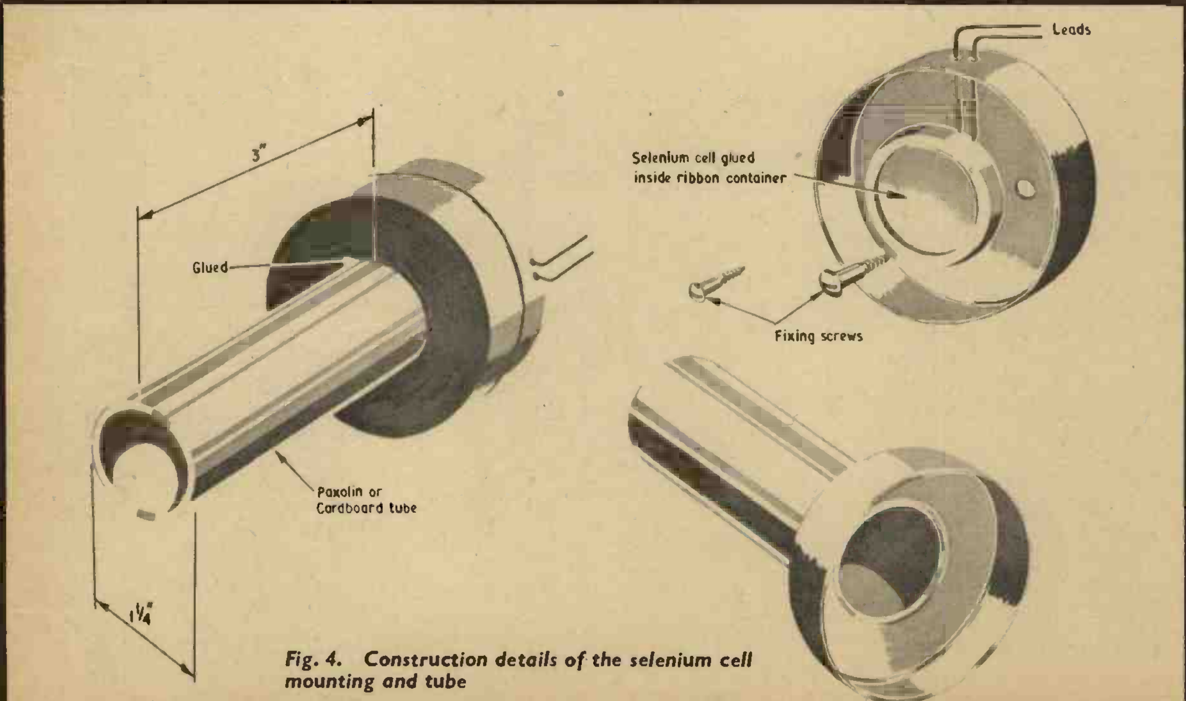
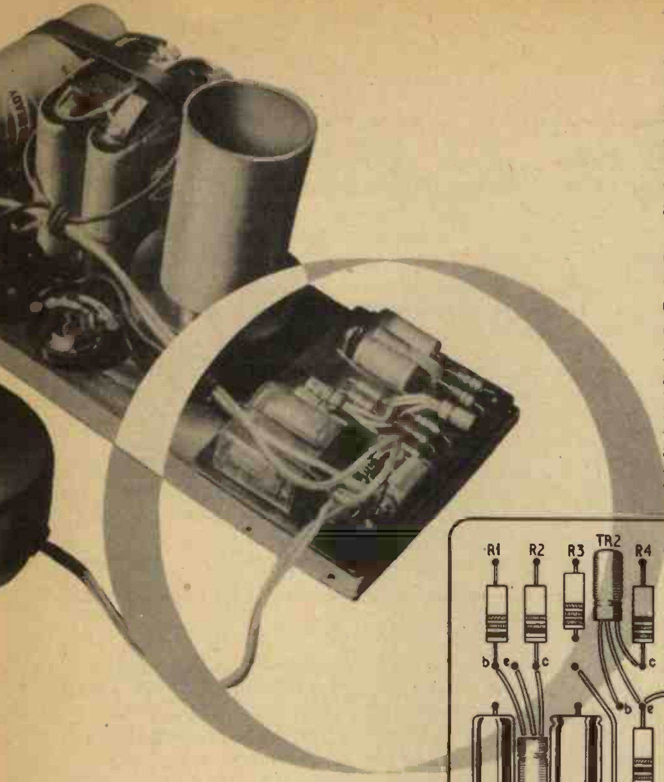


Fig. 4. Construction details of the selenium cell mounting and tube



fact, any marauding creature of sufficient size, such as hens or cats, will be quickly discovered.

FLAME DETECTOR

The early warning device will make a very efficient flame detector. For example, when pointed at flames in a small domestic fireplace, the bell will function reliably, and repeatedly, at distances of around 12ft. The flickering action of the flames provides an a.c. signal. No modifications to the circuit are necessary for this application and, indeed, the portable burglar alarm already described will also serve as a fire alarm.

CELL TUBE CONSTRUCTION

Details of the selenium cell mounting are given in Fig. 4. A plastics or cardboard tube is employed to enhance directional response and increase sensitivity. The hole to take the tube can be cut in the lid of a typewriter ribbon container with a fretsaw.

The selenium cell need not be circular, the more usual rectangular cell wafers are quite suitable, but the largest available cell is to be preferred if sensitivity is the prime requirement. The cell is glued to the back of the ribbon container and holes are drilled for cell leads, as shown. Holes are also drilled and countersunk to take woodscrews, for mounting the cell tube on a baseboard.

PANEL CONSTRUCTION

All the components of Fig. 1, with the exception of the selenium cell, power supply, and switched circuits, are mounted on a laminated plastics panel measuring 4in × 2¾in, as a module for installation in different types of equipment. The diagram (Fig. 5) shows positioning of components and drilling plan. Although components were wired underneath on the original, the diagram of Fig. 5b could be copied directly on to copper covered laminated board to make an etched circuit.

Almost any relay of 6 to 9 volts, operating at currents of 100mA or less, could be employed with the circuit of Fig. 1, but the type specified will fit neatly with other components on the module panel, mounted by means of a small aluminium bracket. The S.T.C. type 25 relay has four complete sets of changeover contacts, and plugs into a special socket. It is convenient to have these spare sets of contacts available if function lights are incorporated, and other circuits are to be added at a later date. Transistors are laid flat on the panel with their leads insulated by thin sleeving. ★

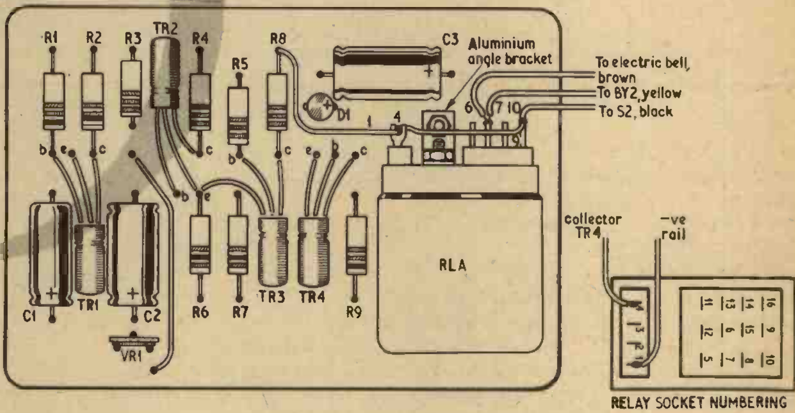
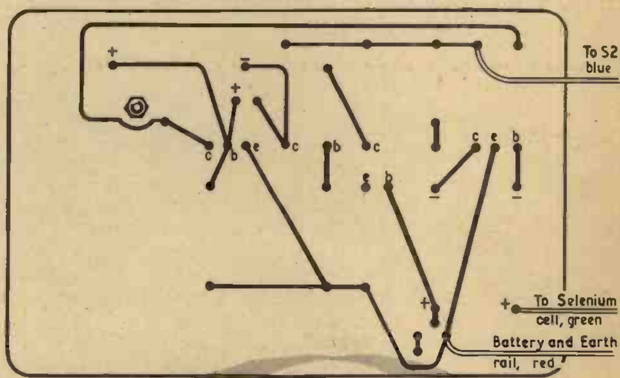
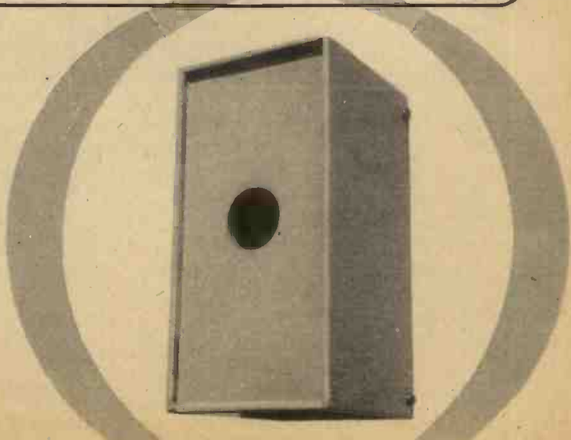


Fig. 5a (right). Component layout and relay socket numbering

Fig. 5b (below right). Wiring on the reverse side of the panel

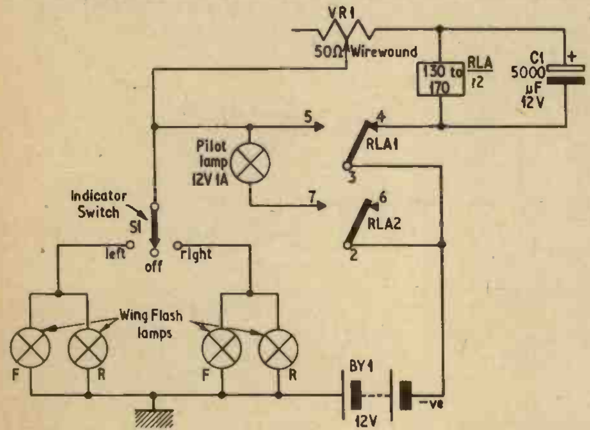




UNLIMITED!

IN THIS feature we hope, from time to time, to be able to publish suggestions submitted by some of our readers on the possible improvement of projects previously described in PRACTICAL ELECTRONICS; short contributions on other subjects may be included. The aim is not to find fault or undermine the abilities or knowledge of our contributors. It may well be that the original article is *par exellence* but it could be improved or adapted to suit individual requirements. The views expressed by readers are not necessarily those of the Editor.

DIRECTION INDICATOR



THE circuit shown in the May 1966 issue seems to be fairly complex for the job. The circuit I am enclosing is simple and inexpensive, and has been working successfully for many years.

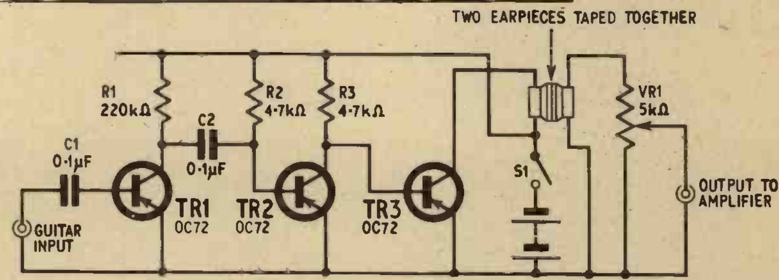
The capacitor is the only component that needs reversing for positive or negative earth systems. The circuit is switched on by the indicator switch which passes current via the flasher lamps (right or left hand) through RLA1 (4) to RLA coil and C1, the contacts of RLA1 (5) and RLA2 (7) are then closed which lights the wing flasher lamps and pilot lamp (on dash). C2 holds RLA in this position until discharged through the relay coil. RLA1 and RLA2 return to contacts four and six and the cycle repeats again, the speed of flash is set by VR1.

C. Caton,
Thaxted,
Essex.

SIMPLE SITAR

FROM an ordinary electric guitar a sound very similar to the sitar, can be produced by the circuit shown here.

It consists of a three transistor amplifier which amplifies the guitar sound and is connected to one of a pair of earphones which are taped together. The second 'phone is connected to the guitar amplifier input; the volume control is not essential.



The earphones should be wrapped in some material, for example foam rubber, when the unit is mounted in a box, to prevent acoustic feedback to the guitar.

M. P. Hamer,
Bath,
Somerset.

SECRET SAFEGUARD

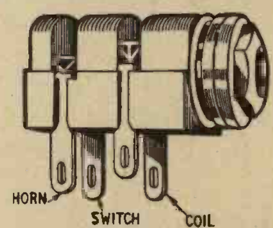
SINCE published car alarm systems can be studied by the best brains in the thieving industry, it is better to suggest ways which can be adapted according to the ingenuity of the owner, so that only *he* knows the key.

The ordinary jack-socket with shorting contacts can be connected in the ignition circuit, starter switch (relay type only), lighting circuits, etc. so that switching on will sound the horn but not start the engine.

Sockets can be obtained with both contacts short-circuited, so that it can be used with the chassis connection to the plug body (sleeve). The plug can be short-circuited, left open-circuit, or replaced by a rod of insulating material.

So there is scope for a range of ideas such as three sockets in a row, one as in the sketch, the other two with HORN instead of COIL. Only the right plug in right socket will start the engine. The plugs are numbered 1,2,3, but only *you* know which socket no. 1 plug goes into safely. If pushed into the wrong one, the alarm would sound at once.

This guards against starting. Protection against entry could be similar, the socket being connected to door switches and boot and bonnet switches.



A jack plug with short-circuited contacts will disconnect the horn and connect the switch to the coil.

E. W. Baigent,
High Wycombe.
Bucks.

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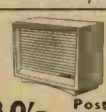

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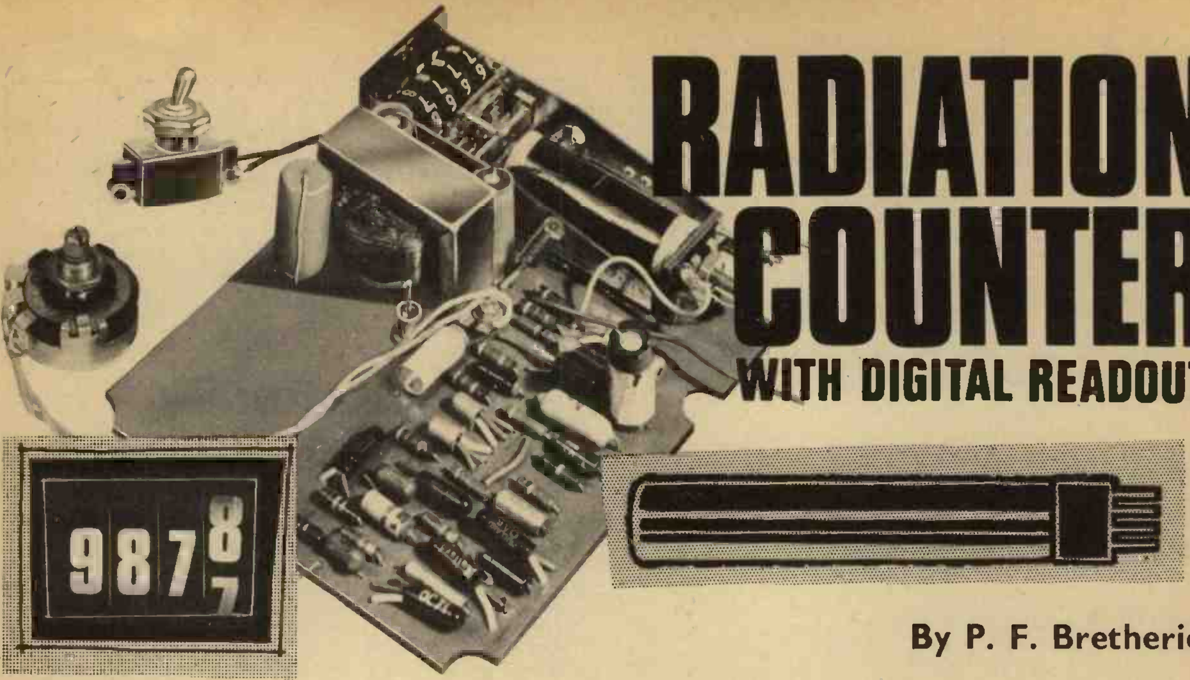


RADIATION COUNTER
WITH DIGITAL READOUT

By P. F. Bretherick

THIS unit was designed to display on a digital relay the background count (i.e. counts from two to five hundred per minute) of a modern halogen quenched Geiger-Muller (G.M.) tube. It is suitable for determining the day-to-day change in cosmic radiation or for accurate quantitative analysis of liquid samples using a suitable liquid sampling tube.

The design employs a Post Office type digital relay, which is rewound to suit the circuit, and a binary divider, which enables very high accuracy and counts at more than double the counting speed of the relay to be obtained.

THE CIRCUIT

The principle of operation is best seen by referring to the waveform diagram Fig. 1 in conjunction with the circuit diagram Fig. 2.

The first two transistors TR1, TR2, form a simple pulse amplifier, the gain of which has proved adequate for even the poorest pulse output from any G.M. tube tried by the author. (This stage could also constitute part of a loudspeaker amplifier if one is used with the counter.)

Base current bias is unnecessary for the first transistor, TR1, since the output from the G.M. tube is a negative pulse. When the transistor receives such a pulse it switches on, this causes the collector to go positive. TR2, however, receives this positive pulse from TR1 collector; it must therefore be biased into the conducting condition so that the pulse may switch it off. A negative pulse then appears at TR2 collector which is passed on to the divider circuit.

Transistors in this stage are not critical; any general purpose audio transistors are satisfactory.

THE BINARY DIVIDER

The second part of the circuit is a conventional Eccles-Jordan divider, more commonly known as a bistable multivibrator, and consists of TR3 and TR4.

The divider is triggered by negative pulses, each negative pulse causing a change of state between: TR3 cut off with TR4 hard on, to TR4 cut off with TR3 hard on.

The purpose of the binary divider is to prevent pulses, that occur faster than the operating cycle time of the relay, being missed. The relay is capable of counting at least 600 to the minute and whilst it is not envisaged that it will be used at this speed (an integrating circuit and average value meter is suitable for counting rates higher than this) it is quite possible that, in a background count of as low as 30 per minute, two pulses will occur consecutively in less time than the counting time of the relay (since the output pulses from a G.M. tube are of completely random nature). The binary divider automatically supresses every alternate pulse no matter how long or short the interval of time between them.

For a pulse to be missed using the divider, three pulses must occur within $\frac{1}{10}$sec which, although not impossible, is far less likely than the occurence of two such consecutive pulses. Thus the accuracy of the digital counter is greatly improved using this section of the circuit, the only drawback being that the reading of the digital counter must be doubled.

The circuit may, of course, be used without the divider, at the expense of accuracy, by coupling the output of TR2 directly to the monostable multivibrator via C6.

Transistors in this part of the circuit are more critical. They should be both of the same type and preferably of low leakage. Silicon transistors are ideal but OC71, OC75, XA101, etc. all function quite well. Most germanium diodes are satisfactory in the pulse steering circuits.

THE MONOSTABLE MULTIVIBRATOR

As can be seen from the waveform diagram Fig. 1c, only half the number of negative trigger edges are now present at TR4 collector. These are passed on to the monostable multivibrator where they trigger TR5 into conduction. C7 in series with R13 is tied across the supply: the capacitor thus charges up with time constant $C \times R$ seconds, until the charge on the capacitor is sufficient to switch TR6 back on, i.e. after time $0{\cdot}7CR$ seconds, and this again is the stable state of the multivibrator. In this way TR6 collector is made negative, due to TR6 being switched off for $0{\cdot}7CR$ sec, and a pulse of this duration is passed to the output stage.

The digital relay is capable of counting up to 10 impulses per second and it therefore requires a pulse of $\frac{1}{20}$sec on and $\frac{1}{20}$sec off at its maximum resolving time. Thus CR is designed to give $\frac{1}{20}$sec pulse at TR6 collector, i.e. $0{\cdot}7CR = 50$msec. If C is chosen as 8μF then R must be 9·1 kilohms, or to be on the safe side 10 kilohms, plus or minus 10 per cent.

In the author's circuit it was found necessary to introduce a diode D3 to prevent the positive pulse from TR4 collector triggering the monostable back to its stable state when a second pulse from the G.M. tube occurred before the $\frac{1}{20}$sec negative pulse had finished.

The transistors used here again are more critical than those for the first stage. They should be of similar type and of low leakage. OC71, OC75, XA101, etc. are all quite satisfactory. Both multivibrators employ fairly high collector load resistors (4·7 kilohms) to reduce the battery consumption to a minimum.

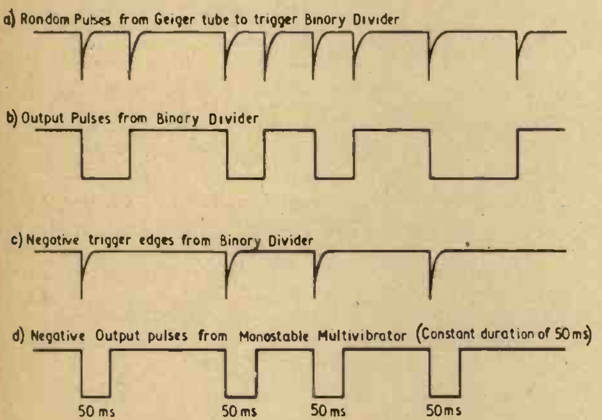


Fig. 1. Function of pulse counting circuit. Timings and amplitudes are not to scale

THE OUTPUT STAGE

The output stage is just a single transistor TR7 switching on and off as it receives its negative pulse from TR6 collector. This final stage is powered from a separate 4·5V battery, since it draws about 110mA per pulse, and a sudden current pulse drawn from the main h.t. rail is likely, to say the least, to upset the pulse divider circuit. This arrangement also makes direct coupling extremely simple. A diode D4 reverse biased is placed across the relay coil to prevent the back e.m.f. destroying the transistor when the relay de-energises.

The output transistor must be capable of passing the current, i.e. 110mA. It is, however, switched on and off, so when it is passing current no voltage exists across it and when it is cut off no current passes through it; its power dissipation is not, therefore, very large. It is advisable, however, to use a transistor of fairly generous rating, say, OC81, OC83, OC84, although OC72 and OC76 will do.

THE DIGITAL RELAY

The digital relay RLA employed by the author is a reset-zero type, but non-resettable types are just as good provided one remembers to take the reading before as well as after the recording time. In either case, however, the relay coil has to be rewound, since these components usually have 1 kilohm coils, although some have 2·3 kilohm and 500 ohm coils.

First remove the relay coil and former complete by unscrewing the retaining nut at the bottom of the relay. The old wire must be completely cut off (a sharp razor blade serves very well for this) and a new coil wound using 34 s.w.g. enamel covered wire. This should be layer-wound to approximately the same thickness as the original coil. However, it is quite satisfactory pile wound with about 4,000 turns, although this takes up more room on the former than the original coil.

The rewind operation is not as tedious as it seems; it can be done easily in half-an-hour on a lathe or a

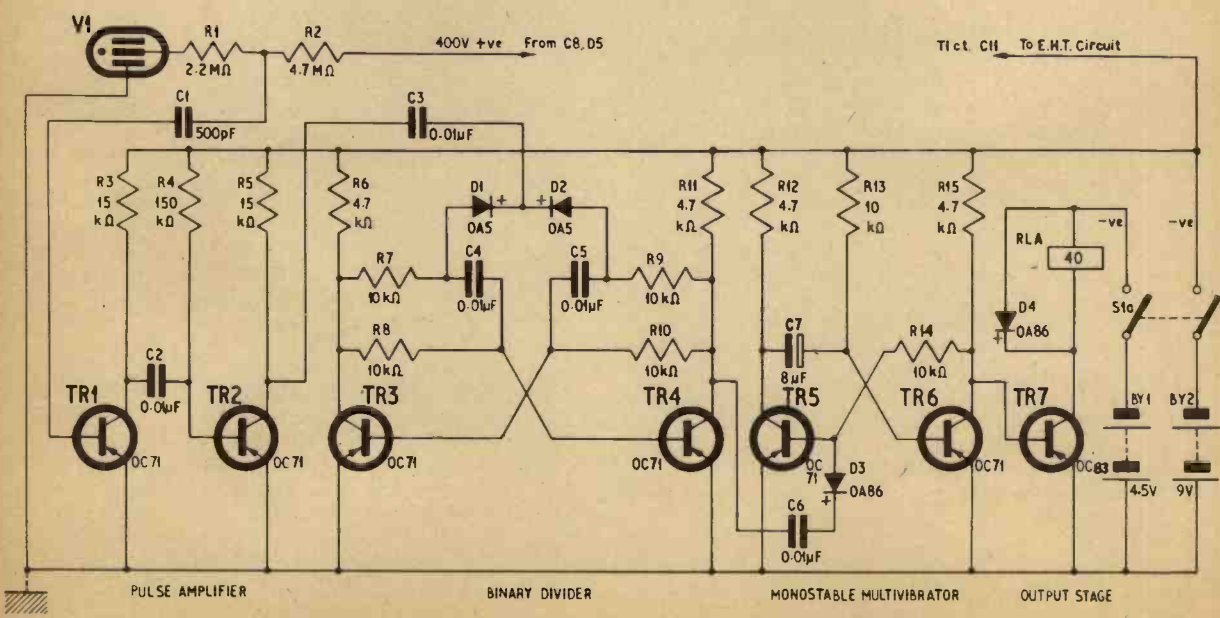


Fig. 2. Circuit diagram of the transistorised pulse counter

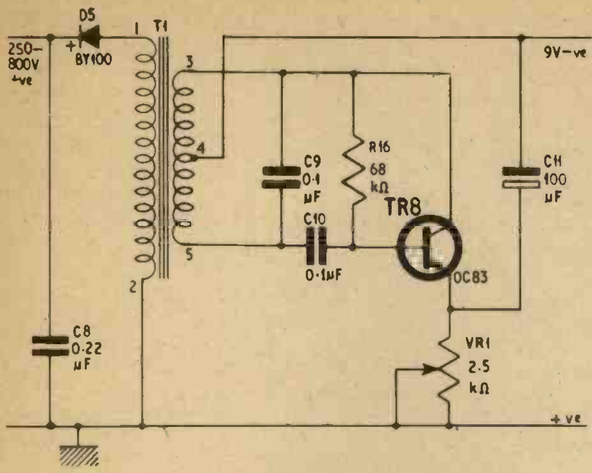


Fig. 3. Circuit diagram of the e.h.t. supply

coil winding machine or even a hand drill held in a vice. Alternatively, it can be wound by hand without much trouble in an evening.

A good policy to follow when winding the coil is to attempt to layer wind it and when it gets a bit "messy" wind a layer of Sellotape on and start layer winding again. The Sellotape also helps to insulate sections of the coil and prevent breakdown due to back e.m.f. The completed coil is, of course, soldered to the original tags on the former. When completed a layer of tape should be wound on the coil to protect it and the counter then re-assembled.

The coil resistance should now be around 40 ohms and it should energise quite satisfactorily on 4·5 volts.

E.H.T. SUPPLY

Considerable thought was given to the design of a suitable e.h.t. supply for the G.M. tube, battery economy being the main consideration. The supply may, of course, be mains-derived, using a suitable transformer, but this would defeat the object of having a battery operated counter. Several types of oscillator were tried, using various step-up transformers. The most reliable and economical was found to be the series fed Hartley oscillator shown in Fig. 3.

This is a very conventional circuit oscillating at about 500Hz and it draws only a modest 2mA from the 9V supply when providing about 3–4μA of e.h.t. Since the G.M. tube is virtually electrostatic in operation, this low current is quite sufficient and if a voltage doubling circuit were employed on the secondary, the supply could operate an organic quenched tube. The only disadvantage is that the e.h.t. cannot be measured on anything but an electrostatic meter or very high resistance valve voltmeter, on which the supply should be set up.

The transformer T1 is a converted battery pentode output transformer, ratio 90 : 1. The secondary winding is removed and rewound with a centre tap. This does not present much of a problem, since the secondary (now the primary) usually consists of only 40–50 turns wound in two layers on the outside. The core must, of course, be dismantled beforehand, but the whole operation takes little more than twenty minutes. Alternatively, a centre tapped heater transformer or an output transformer with a centre tap already on the secondary, if obtainable, is quite satisfactory. In fact, almost any transformer with a ratio within 50 per cent of that stated above will work.

VR1 is the set e.h.t. control. This potentiometer controls the d.c. supply to TR8 and is decoupled by C11.

COMPONENTS . . .

Resistors

R1	2·2MΩ	R7	10kΩ	R13	10kΩ
R2	4·7MΩ	R8	10kΩ	R14	10kΩ
R3	15kΩ	R9	10kΩ	R15	4·7kΩ
R4	150kΩ	R10	10kΩ	R16	68kΩ
R5	15kΩ	R11	4·7kΩ		
R6	4·7kΩ	R12	4·7kΩ		

All 10%, ¼W carbon, unless otherwise stated

Potentiometer

VR1 2·5kΩ

Capacitors

C1	500pF 1,000V	C7	8μF elect. 12V
C2	0·01μF	C8	0·22μF 1,000V
C3	0·01μF	C9	0·1μF
C4	0·01μF	C10	0·1μF
C5	0·01μF	C11	100μF elect. 12V
C6	0·01μF		

All miniature ceramics or paper, unless otherwise stated

Transistors

TR1–TR6 OC71 (6 off)
TR7–TR8 OC83 (2 off)

Diodes

D1–D2 OA5 (2 off)
D3–D4 OA86 (2 off)
D5 BY100

Transformer

T1 Battery pentode O.P. transformer, ratio 90 : 1 (modified as per text)

Relay

RLA Digital relay. Sodeco type TCeZ4E (available from P.C. Radio, 170 Goldhawk Road, London W.12), or Post Office equivalent (see text)

Batteries

BY1 4·5V Flat flash lamp battery
BY2 9V Layer type battery, PP7

Switch

S1 Double pole, on/off toggle switch

G.M. Tube

V1 B6H, B12H (available from P.C. Radio, 170 Goldhawk Road, London W.12)
CV2886 Liquid sampling tube (Henry's Radio, 303 Edgware Road, London W2)

Miscellaneous

Laminated plastics board 4½ in. × 5in. Coaxial plug and socket. ½lb 34 s.w.g. enamelled wire. Battery connectors. Material for case. Socket B2A or octal to suit G.M. tube

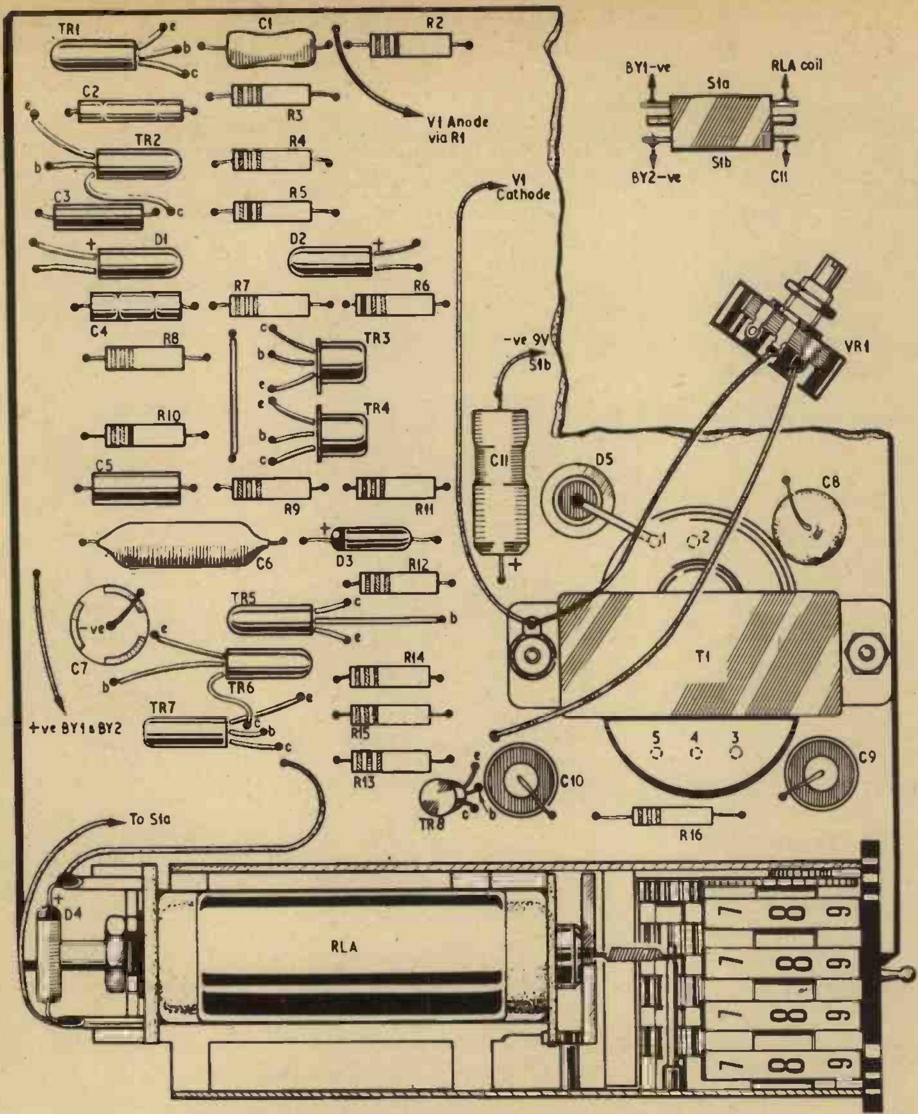


Fig. 4. Component layout on laminated plastics board

The only critical component of the circuit is the diode D5 which must have an extremely high back resistance in the order of 1,000 megohms. BY100's are the most suitable but some specimens tried by the author gave far less e.h.t. voltage and it may be advantageous, therefore, to use two silicon diodes in series.

Many a.f. type transistors were tried in the e.h.t. circuit and they all worked; the best results, however, were obtained from an OC83.

CONSTRUCTIONAL DETAILS

The circuit is built up on a small piece of laminated plastics board, measuring 5in by 4½in. The arrangement of the components is shown in Fig. 4, while the underside wiring is given in Fig. 5.

Flying leads are required to connect up the components not mounted on the board, these being as follows: The G.M. tube socket, the set e.h.t. control VR1, the battery supply switch S1, and the two batteries BY1, BY2. There are in all a total of seven flying leads and they are clearly shown in Fig. 4.

The two leads for the G.M. tube should be connected to a coaxial socket, so that the external connection to the tube itself can be made by coaxial cable. Note that R1 must be mounted on the G.M. base (see final paragraph of this article).

The completed assembly can be housed in a wooden or metal box with the on/off switch, set e.h.t. control, and the coaxial socket mounted on the front panel. A suitable aperture should be cut in this panel so as to expose the end of the digital relay.

The top of the box or cabinet should be made removable, thus allowing access to the batteries which can be installed in the unused corner of the component board.

In this way a neat, compact and self-contained piece of equipment is achieved.

USE OF THE COUNTER

The pulse counter is admirably suitable for determining the background count of different tubes or the day-to-day change in cosmic radiation. Measurements are made by leaving the counter running continually for about half-an-hour and dividing the reading by exactly half (since the binary divider is used) the number of minutes.

If used with a liquid sampling tube a reading of background radiation must be taken before the tube is filled with the liquid sample. The two results are then compared. All liquid samples, such as rainwater, tap water, etc. should be concentrated and then acidified to prevent contamination of the tube by solid deposits. This is best done by boiling about half-litre of the sample to dryness (or almost to dryness) and swilling out the residue with about 5cc of dilute nitric acid. This will give a concentration of 100 times, which is quite suitable. Some interesting comparative experiments can also be done by filling the tube with unprepared freshly fallen rain.

For most purposes a count of half-an-hour is sufficient, but for more exact work or when very low background count tubes are used, counts overnight may be done. There is little fear of running the batteries down, since the 9V battery consumption is only around 7mA and the digital relay only demands 110mA for $\frac{1}{20}$sec per pulse which for an actual count of 30 per minute (registered count 15 per minute) is equivalent to 0·3A torch bulb in use for only three minutes when counting for a period of 12 hours.

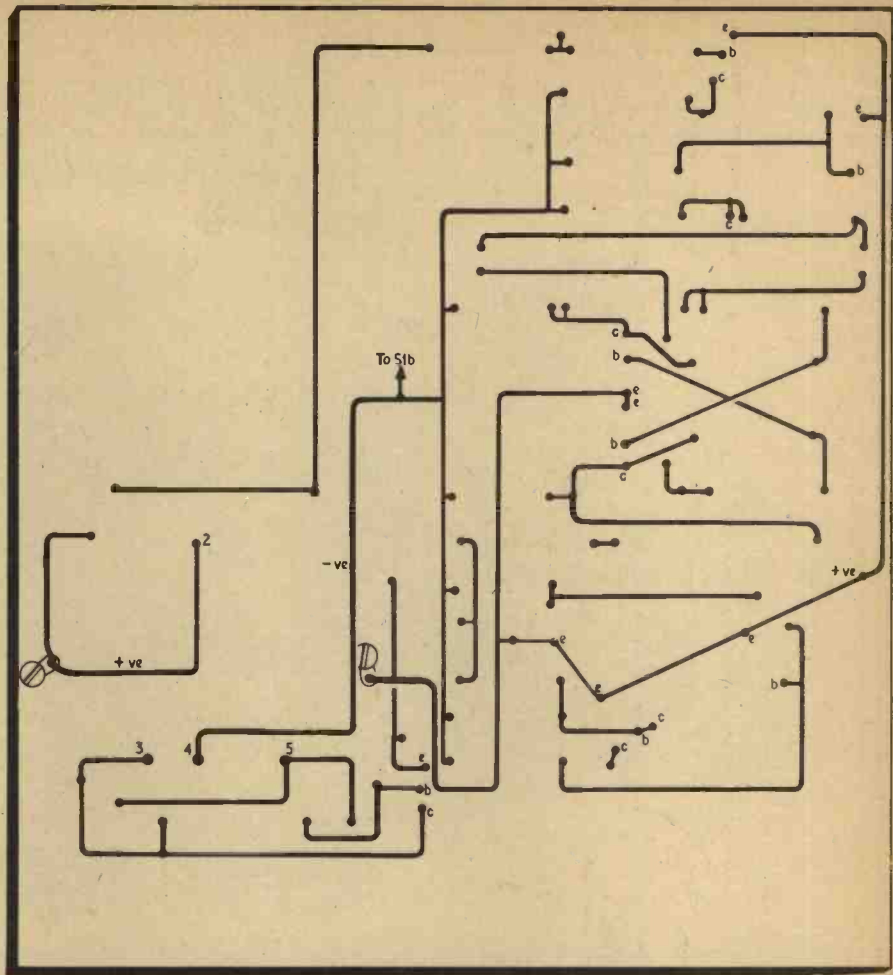
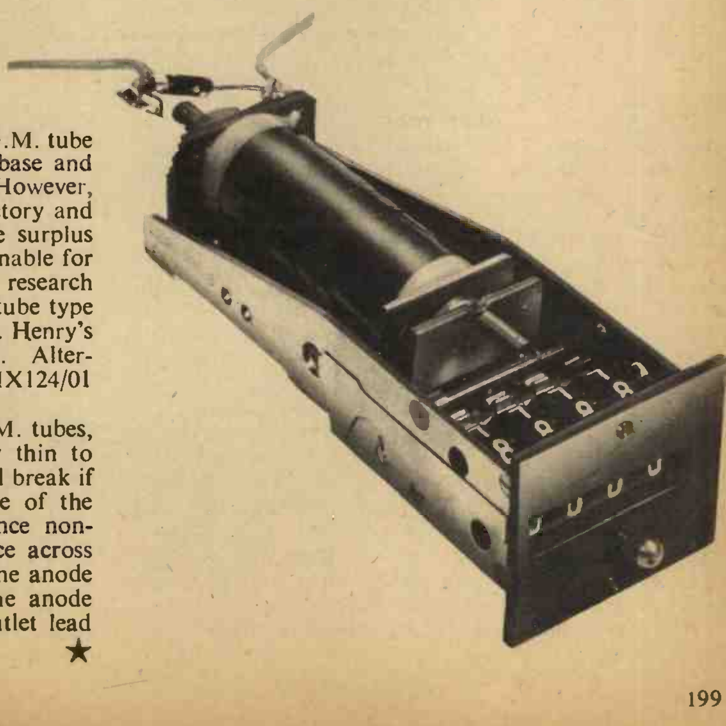


Fig. 5. Wiring on underside of component board

GEIGER-MULLER TUBES

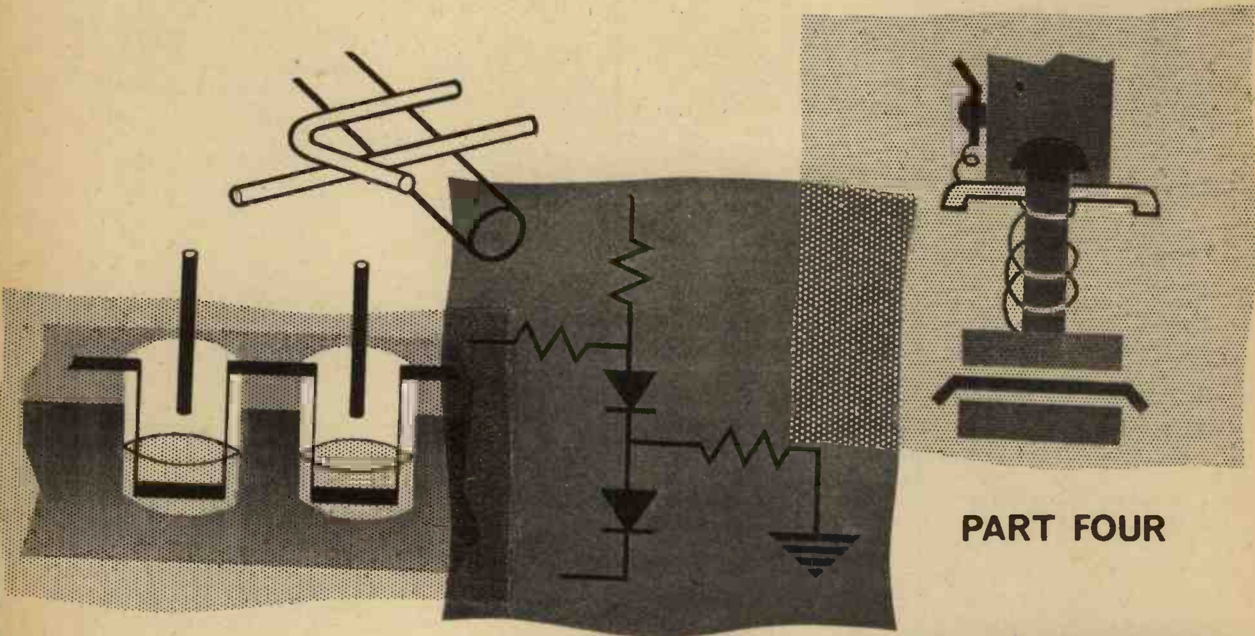
The author used 20th Century Electronics G.M. tube types B12H and B6H, which have an octal base and may in fact be immersed in liquid samples. However, almost any halogen-quenched tube is satisfactory and it is quite advantageous to hunt around the surplus component shops where they should be obtainable for about £1. For constructors wishing to do research into radiation of liquid samples, a very good tube type CV2886 is available for £1 2s 6d from Messrs. Henry's Radio, 303 Edgware Road, London, W.2. Alternatively, the Mullard types MX142 and MX124/01 may be used.

Care must be taken when handling the G.M. tubes, since the glass walls are usually made very thin to allow ease of penetration by beta rays and will break if handled roughly. Also, to conserve the life of the tube, it should be fed into a high impedence non-capacitive load. To avoid excess capacitance across the tube, which should not exceed 5–10pF, the anode resistor R1 must be mounted directly at the anode connection on the tube socket before the outlet lead to the counter unit. ★



THE ELECTRONIC ORGAN

By ALAN DOUGLAS, Sen. Mem. I.E.E.E.



PART FOUR

KEYING ARRANGEMENTS

We still have two very important matters to consider in general terms—since they apply to all electronic instruments—before we can start on a specific organ design. The first is the method of keying the signal. It is here that a major difference arises between pipes and electronics. Even if the synthesised waveform is perfect, the sound will not be the same. But is this very significant? Perhaps it is, in the case of very large instruments; but again, it is one of the attributes of such circuits that they can speak far more quickly than pipes. So for some purposes, this is a great advantage. Why, then, do we find keying a difficulty?

INDEPENDENT OSCILLATOR SYSTEM

In the case of an organ having separately tuned oscillators for each note, no sound is available until one or more of these circuits are energised. Since this can be done by connecting the h.t. line, which is d.c., then a form of charging network can be incorporated just to take the edge off the starting transient. Such oscillators can be made frequency stable over a change in h.t. of some 40V, or if transistorised, a change of perhaps 9V. So a quite appreciable delay can be introduced before the oscillator goes off pitch. Fig. 4.1 shows two ways of doing this—valve and transistor techniques. Organs using this method include Miller, Allen, Gregorian, Conn, and my own circuit which is tolerably well known. No problem arises with such independent tone sources.

But the independent oscillator system is very costly and, moreover, requires a separate set of oscillators for each pitch; so one could soon absorb a couple of hundred generators. Although of course the results are far superior to any other system, this is only true to the extent that one is capable of, or wishes to, develop the kind of tonal spectrum associated with the pipe organ.

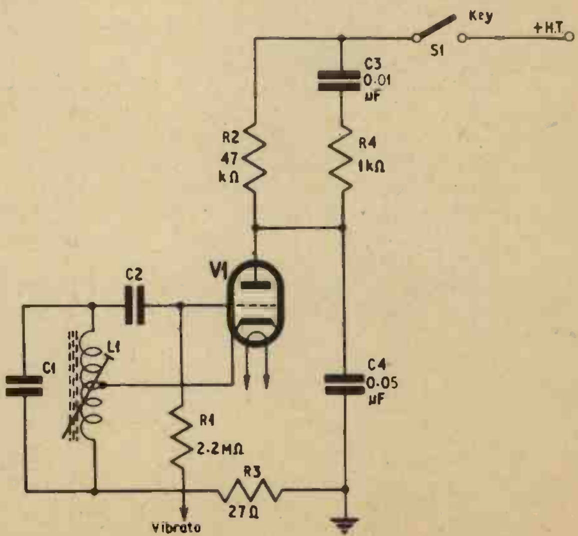


Fig. 4.1a. A method of delayed keying for a valve oscillator

FREQUENCY DIVIDER SYSTEM

Today, the concept of organ tone veers more towards the synthetic quality popularised by Hammond, and if one studies current commercial design it is soon apparent that all modern circuits are directed towards trying to fill out the meagre resources of the frequency divider instrument by such methods as keying compound waveforms, sustain and phase shift devices, multiple vibratos (including the mechanical systems such as the Leslie speakers), and in fact anything which will give the effect of there being more generators than actually exist. In short, the limitations of the frequency divider cannot be improved upon, and secondary circuits have been evolved to pad these out.

A simple example of a compound waveform produced from the one and only wave available from most dividers is shown in Fig. 4.2. Here, the fundamental is mixed with the octave above, which is attenuated to half its normal level. The two waves, each square originally, add to form the staircase waveform which is keyed; thus, a simulation of a sawtooth is obtained at no extra cost, and from this can be formed sounds not possible with a simple square wave. Sounds which consist entirely of square waves having no even harmonics tend to be discordant and "edgy"; even harmonics are always consonant and agreeable. Therefore a good organ would provide both waveforms.

REDUCING TRANSIENTS

If we decide that a frequency division method is the more economic proposition, then we are faced with the fact that all dividers must run continuously whether in use or not; otherwise, one could not drive the next. This being so, the a.c. signal will have to be keyed.

Now if the waveform is square, there is only one instant at which it could be keyed to avoid transients, see Fig. 4.3a. But this is a chance in a million. If then we close the circuit at some other instant of time, the transient will always be large. Should the dividers provide a sawtooth, the case is not quite so bad in theory (Fig. 4.3b), since the amplitude can change with time; but in practice the effect is just as objectionable. Even if it was a sine wave, we would not obtain any advantage as is evident from Fig. 4.3c.

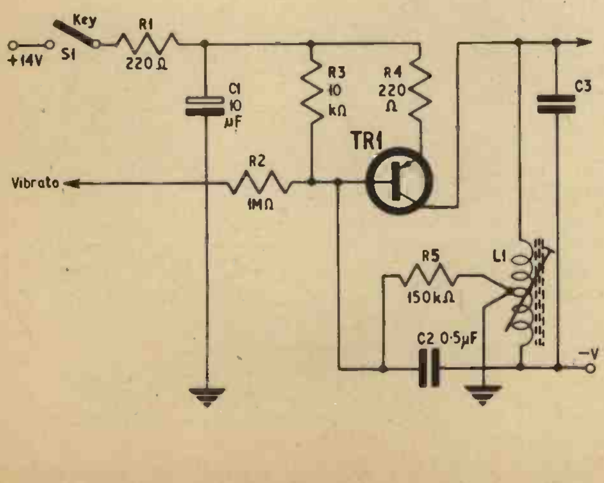


Fig. 4.1b. Keying delay circuit for a transistor oscillator

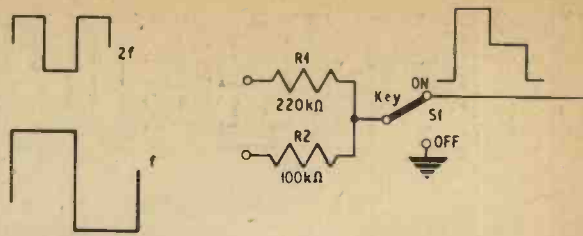


Fig. 4.2. Production of a compound (staircase) waveform by addition of two separate square waves

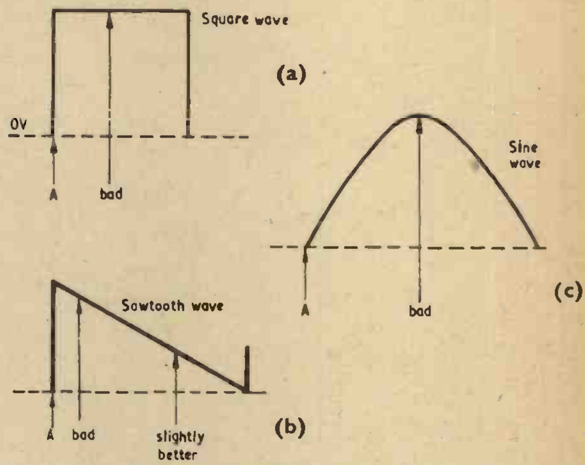


Fig. 4.3. The only possible keying position to avoid transients for these three different waveforms is indicated by "A"

Therefore the transient must be reduced by some means. A delay of perhaps 10–50 millisecond would be satisfactory. How can we do this?

The first thing to bear in mind is that there will not be much room for whatever means of keying we decide on, since the width (or length inside the frame) of a playing key must accommodate the contacts for all pitches. Then we have to remember that clicks due to transients will be most noticeable on high pitched notes since they can be removed by filters on lower pitches. Lastly, of course, is there something we can make without too much precision or the use of difficult materials?

POSSIBLE KEYING METHODS

Let us look at the alternatives available for providing this most necessary delayed action switching or keying.

The simple case is a pair of plain gold wire contacts. A non-tarnishing surface is essential, so a thin gold coat rolled onto a bronze wire is commonly used. Fig. 4.4a shows such a contact for one pitch. The divider output is earthed to a common busbar through a resistor of 100 kilohms to 1 megohm; this prevents crosstalk which is prone to occur by capacitive coupling in the British type of contact block where all the wires for all the pitches (for any one note) are side by side in a bakelite block ½in wide.

The American vertical contact block, see Fig. 4.4 b, is much superior but harder to assemble since it calls for precision mounting. Considerable saving in gold is possible here, since only the tips of the wires need be precious metal. It is usual to make the earthing rod rhodium plated because of mechanical abrasion, yet a gold plated rod is better from a contact point of view.

It will be understood that the methods described in this section are only representative of alternatives, and would be added to in the case of most organs having more than one pitch available. Consequently, in the illustrations of Fig. 4.4a, the busbar is not accepting a tone signal but is used for earthing the unwanted tone sources. The actual tone busbars would consist of extra wires which are closed by the key in the manner of the one example shown.

In the illustration of Fig. 4.4b, the unwanted tone sources are *not* earthed, so the busbars shown are actual tone outlets; in other words, since there is one assembly like that shown for every playing key, depression of a key would make the flexible wires touch as many busbars as there are pitches. So all the 8ft pitch sources would contact one bus, all the 4ft another, etc.

All such simple contacts can give rise to clicks, but many organs use them and adjust their amplifiers to cut off at about 8kHz. This does much to reduce the transient, but of course also reduces the fidelity of strings and reeds.

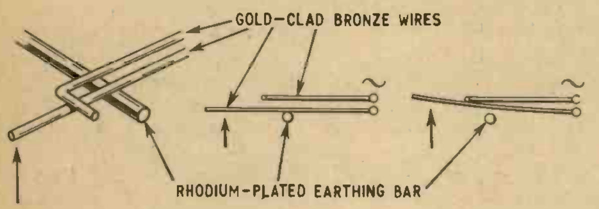


Fig. 4.4a. Conventional key contac

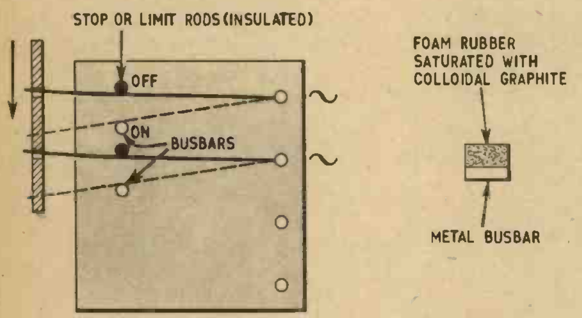


Fig. 4.4b. American type vertical contact assembly

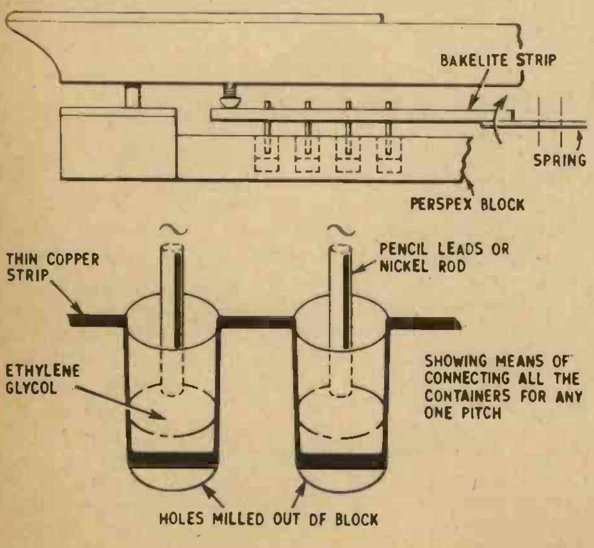


Fig. 4.4c. A liquid resistive keying system

RESISTIVE KEYING

It is possible to apply resistive keying in many forms, and if the busbars of Fig, 4.4b are covered with very thin foam draught excluder, well soaked in colloidal graphite, thoroughly dried and all loose graphite shaken out, some excellent results can be obtained. Although the foam strip must be glued to the busbar, this can only be done with spots of cement between notes, so that when the contact wire is depressed, it forces the graphite-loaded strip down on to the metal busbar and not on to the glue. See small diagram at right-hand side of Fig. 4.4b. This method of keying has been developed by E. A. Heywood.

Another alternative is to use ethylene glycol as a liquid keyer as in Fig. 4.4c. This calls for a more complex contact arrangement as shown, but this system has been highly developed by A. Le Boutillier (founder of the Electronic Organ Constructors Society). Liquid keying has been used in some German instruments for nearly 40 years with success.

Another way to make resistive contacts is to use one of the conductive silastomers (artificial silicone rubber) available from the British Bakelite Company at Birmingham. These, if tried, should be *clipped* to the busbar between each contact wire. This method is used by Baldwin, Thomas, and other American makes. An advantage is that plain bronze contact wire can be used, but a great improvement results from Nichrome V wire. This has been used by Wurlitzer and Gulbransen for many years.

All of the above methods require one contact wire and one busbar for every pitch of every note. There is no control over the time constant after the proportions have been fixed initially. Nevertheless, when correctly designed such contacts can operate for several million cycles without deterioration.

DIODE KEYING

As knowledge of tone forming methods increased, it was found possible to key the signal through diodes with little loss of fidelity, even though rectification of the waveform might take place. The diode method is costly, but has the advantage that a time constant can be introduced. Thus, not only can the transient be abolished, but in fact a sustain effect can be provided; and it is possible to key any number of pitches per note with only one contact per note. The mechanics are thus greatly reduced. An example of this method is shown in Fig. 4.5a.

With the key open, the diodes D2, D4, D6, etc. are biased off, and so the generator outputs are prevented from reaching the busbars.

When the key is depressed, +15V is applied through R1 to capacitor C1. Initially the whole 15V is dropped across R1, but as C1 becomes charged the lower end of R1 reaches +15V and so the diodes D2, D4, D6 become forward biased. Current flows through the path provided by these diodes and the resistors R5, R8, R11.

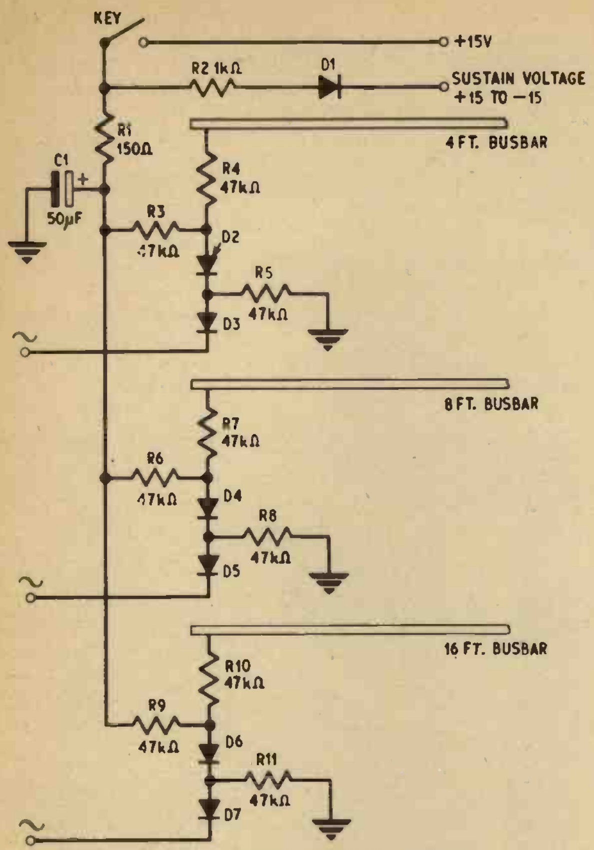


Fig. 4.5a. A diode keying system

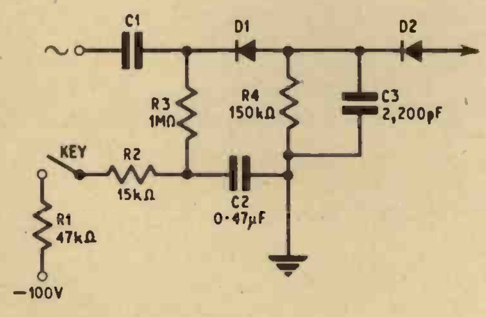


Fig. 4.5b. A diode sustain circuit

The voltage developed across each resistor forward biases the associated diodes D3, D5, D7 and so the generator signal is applied to the busbar.

When the key is released, the charge on C1 dissipates itself through this same circuit and the diodes remain conductive until the voltage drops below the diode cut-off value.

A bias voltage of from +15V to −15V can be applied via D1 and R2, in order to alter the sustain time. Thus we can have −15V applied for a fairly fast release of the note; −4V for a longer time, and if the sustain supply is +15V then the sustain diode D1 is cut off and capacitor C1 can only discharge through the keyed circuits giving a long delay time.

Another way of sustaining the sound and avoiding an abrupt attack is shown in Fig. 4.5b.

These methods of course require many diodes but they could be applied to 4ft and 2ft pitches only where the clicks are most irritating.

In the days when valves predominated, there were many such control circuits, some of which were much more effective than their semiconductor equivalents. But then the complete absence of leakage and the closer gain or slope tolerances together with the very high input impedances (where triodes were used) weighed heavily in their favour. Transistors have still some way to catch up, the most promising device for this application so far being the field effect transistor.

CAPACITIVE KEYER

The last device to be considered is the capacitive coupling. Whilst originally intended to confer some measure of touch sensitivity to an organ, it has been highly developed by Dr H. Le Caine in Canada and Dr Rainer Böhm in Germany. The latter arrangement is the easier to make, and will now be described.

In Fig. 4.6 we see a brass busbar covered with a film of 0·0025in thick Mylar or equivalent insulator. Above this is located a small metal plate, about 11 × 13mm, held by a coil spring so that when it is depressed by the key to touch the Mylar, it assumes a parallel position and the spring, taking up the remainder of the key motion, retains the alignment of the system. Although a certain amount of screening is desirable, this method is excellent for very high frequencies—and in his organs, Dr Böhm uses up to 16kHz.

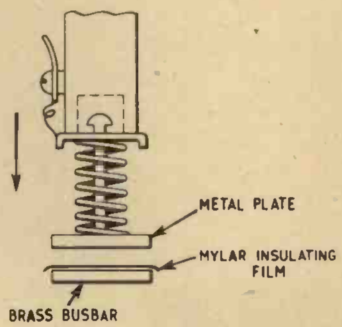


Fig. 4.6. A capacitive keyer

MAKING A CHOICE

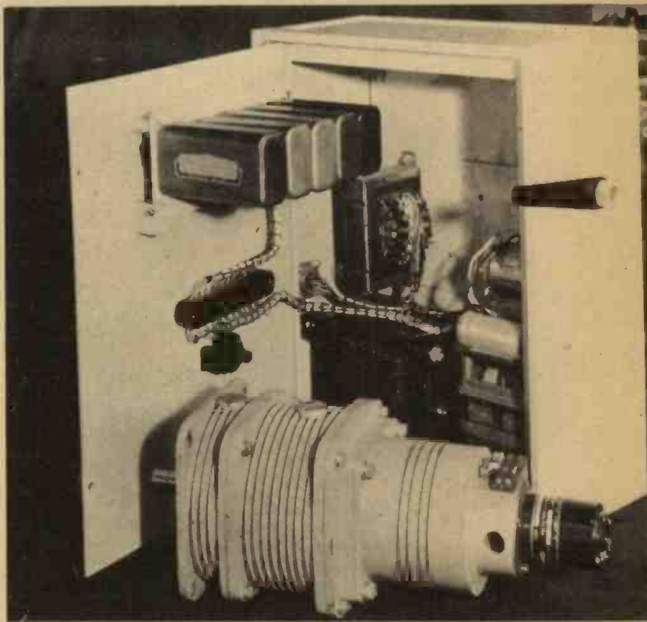
From the foregoing brief account of some of the many and varied systems that have been developed, it will be apparent that the individual constructor must try to form his own conclusions with regard to the kind of keying system to adopt for his own instrument.

In practise, the obvious approach is to set up the highest required frequency on a variable oscillator, preferably giving a square wave output; adjust the signal level to 0·5 to 1V, and try the effect of one method of keying at a time. But bear in mind that it is *not* desirable in domestic organ systems to exceed 8 to 10kHz at the upper end of the spectrum. When we have a look at tone forming methods in the next article, it may become possible to find, with a single note, the highest frequency required for realism.

◀High Speed Fibre Control

ELECTRONIC control of industrial processes spreads rapidly. Another example is in the man-made fibre industry where, at the Klinger Organisation plant at Margate, a world speed record was recently set up with a speed revolving at a million revolutions per minute.

The picture here shows the AMI twist crimping machine and control console designed by Abbey Electronics and Automation. The electronics controls temperature, turns per linear inch, and time lapse before doff and the condition of ancillary services.



'Concorde' Fatigue Testing

AN ADVANCED computer-controlled industrial automation system which will help to ensure greater safety for airline passengers of the future is now being installed at the Royal Aircraft Establishment, Farnborough, by English Electric.

A rig is being built at Farnborough in which the forward section of the fuselage of the Anglo-French Concorde supersonic airliner will be structurally proved.

The rig will be able to carry out a new type of fatigue test which not only takes into account mechanical stresses, but the effect on the air-frame of the severe heating and cooling encountered in supersonic operation. During the next four and a half years or more, the fuselage will be subjected to many thousands of test cycles. Each test cycle simulates a typical flight covering taxi-ing, climb, cruise and descent but to an accelerated scale.

It is expected that the tests will continue day and night with brief stops every month or so for a physical inspection of the fuselage.

Two English Electric Leo Marconi KDF7 computers are used. One will control the tests, and the other will be used as a monitor to establish the integrity of the test programme. The system will simulate flight conditions more accurately than has been possible before, and will give more precise knowledge of fatigue life at supersonic speeds.

Marine Servo System ▲

A NEW a.c. servo unit for control and power actuation has been developed by Vosper Electric.

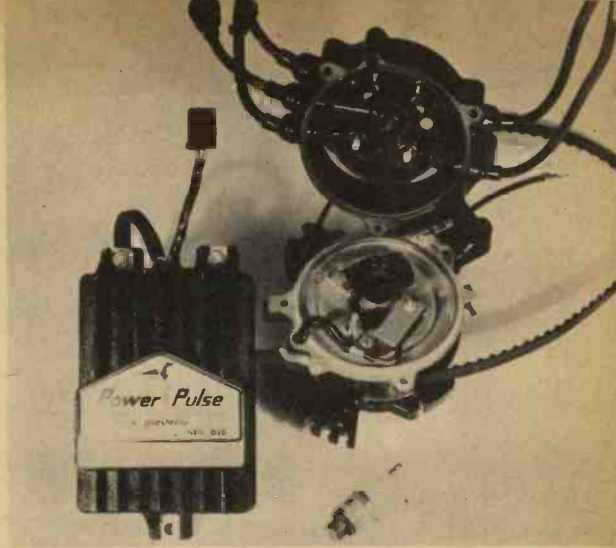
This unit consists of a synchro-transmitter coupled to the lever or other operating device, with a corresponding synchro-receiver coupled to the final output of a geared a.c. servo-motor. When an error signal is generated at the synchro-transmitter it passes to a phase discriminator which will sense the angular displacement and actuates one or other of the trigger control circuit amplifiers, which in turn feeds control pulses to the phase commutator unit containing Triac power circuitry. Appropriate rotation of the servo-motor will reduce the error in a proportional manner until a null error is reached. A d.c. tachogenerator feedback loop controls the speed and damping of the system.

ELECTRONORAMA

Power Pulse Ignition

AN EXAMPLE where capacitor discharge ignition systems are used is in the 100 h.p. outboard motors made by an American firm Johnson. These systems deliver a high voltage to the sparking plugs in 5μs, twenty times faster than conventional systems. The encapsulated power pack steps up the 12 volts from the battery to a pulse of 20,000 volts at the plug.

These systems are imported by E. P. Barrus (Concessionaires) Ltd., 12–16 Brunel Road, London, W.3.



Radar for Small Boats

THE WORLD'S first high-quality marine radar specially designed for small boats was on display at the International Boat Show in London. Known as the Decca 101, it has a maximum range of 15 nautical miles and can also be set to cover ½, 1½ or 5 miles; it is suitable for 12, 24, 32, 110, 220 volts d.c. and 115 or 230V a.c. 50 or 60Hz single-phase operation.

The scanner unit shown below combines both the aerial and the transceiver. The aerial is 3ft wide and rotates at the high rate of 36 revolutions per min. The transceiver has a peak power of 3kW. The display unit houses a cathode ray tube with a diameter of 7in (178mm).

Operational features include range rings on the screen at equally spaced intervals representing ½ or 2 miles, depending on the range in use.

L/S Telephone with a Difference

LOUDSPEAKING telephones have taken some time to be accepted as a normal piece of office equipment, but are now looking ahead with this futuristic design (below) from Gustav A. Ring of Norway. This "Triphone" combines optical, acoustic, and "pocket" paging from any other station in the Triphone network.

The user can have background music from it without disturbing normal services. Any person wishing to have complete privacy can set his Triphone face down (left of picture). Vital calls with still be announced by a short tone signal. Callers also hear an "engaged" tone.

Executives can tilt the instrument to ensure that all incoming calls go to his secretary.

MARKET PLACE

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

COMPONENTS

Many readers must have experienced at some time the frustration and annoyance when, being engrossed in constructing apparatus, the electric drill suddenly packs up, and on examination it is found that the armature has burnt out. Now a solid state module from **STC Components Group**, Footscray, Sidcup, Kent, reduces the possibility of overheating due to any form of malfunction or abuse. Operated in conjunction with a thermistor embedded in the motor windings, it automatically cuts off the supply immediately the motor windings exceed a safe temperature.

Still on the problem of heating, the **Lektrokit** LKU.511 is a cooling unit for electronic equipment. It is designed for improving the efficiency of transistor heatsinks and for lowering the temperature level inside assemblies.

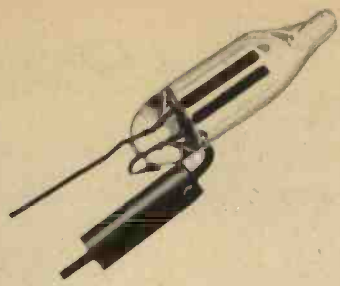
Although the unit is dimensioned to fit into both chassis and rack system constructions, fixing holes being provided to enable it to be used as a replacement for the normal side plate of any Lektrokit assembly, it can be incorporated into the design of any electronic equipment. The price of the LKU.511 is £3 and is available from the Lektrokit Division of A.P.T. Electronic Industries Ltd., Chertsey Road, Byfleet, Surrey.

New high intensity neon/resistor indicators, produced with insulated resistor already welded on and folded ready for assembly, are now available from **West Hyde Developments Ltd.**, 30, High Street, Northwood, Middle-

SOLDERING

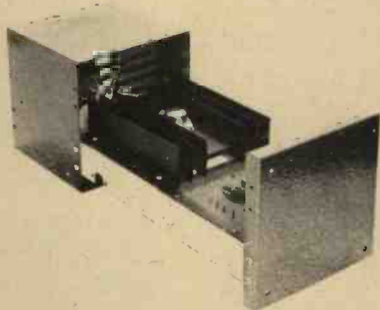
A new soldering process that should gain a wide and varied use on the amateur market, once a simple and cheap method of heating has been devised, is the Thermofit Solder Sleeves by **Raychem Ltd.**, Cheney Manor, Swindon, Wiltshire.

Designed specifically for earthing screened wire and joining equipment wire, the solder sleeves are prepackaged insulated solder joints. They consist of heat-shrinkable, non-flammable polyvinylidene fluoride (Kynar) sleeves, each containing a preform of fluxed solder at the centre and a thermoplastic sealing ring at each end.



Neon Indicator by West Hyde Developments

Heathkit CR-1 Car Radio



LKU.511 Cooling Unit from Lektrokit

Thermofit Solder Sleeves by Raychem

When placed over a cable screen and earth lead and briefly heated, the outer sleeve shrinks and the solder and thermoplastic inserts melt, forming an insulated encapsulated soldered termination. The melting of the sealing rings controls the solder flow and maintains the wires in contact.

Practical advantages of this method is that inspection of the joint is possible since the entire joint is visible through the transparent sleeve. In this way, improperly stripped or bunched strands can be detected and the solder flow studied.

In many applications the tedious stripping of braid is simply replaced by cutting the insulation and, since there is no inner ferrule, the insertion of screen ends between ferrules is eliminated.

Due to their small size, these solder sleeves may often be installed adjacent to the termination of the wire at a connecting pin, but even where this proves difficult, terminations of adjacent cables may be staggered (see photograph).

Thermofit solder sleeves may be reheated for removal of the insulation and continued heating can then be used to melt the solder so that the earth lead can be removed and replaced as required.

For full details readers should write direct to Raychem Ltd. We understand the Ronson Butane soldering guns make an ideal heat source for the sleeves.

LITERATURE RECEIVED

Readers interested in computers may find a brochure entitled "Staffing a Computer Installation", offering advice on the sort of qualities to look for in selecting staff and discussing the use of aptitude tests, worth obtaining. Copies of the brochure are available from **English Electric-Leo-Marconi Computers Ltd.**, Portland House, Stag Place, London, S.W.1.

A technical bulletin entitled "Magnetising of Permanent Magnets", written by F. Knight, A.M.I.E.E., may interest readers studying magnetism. Copies available from **The Permanent Magnet Association**, P.O. Box 121, 301, Glossop Road, Sheffield, 10.

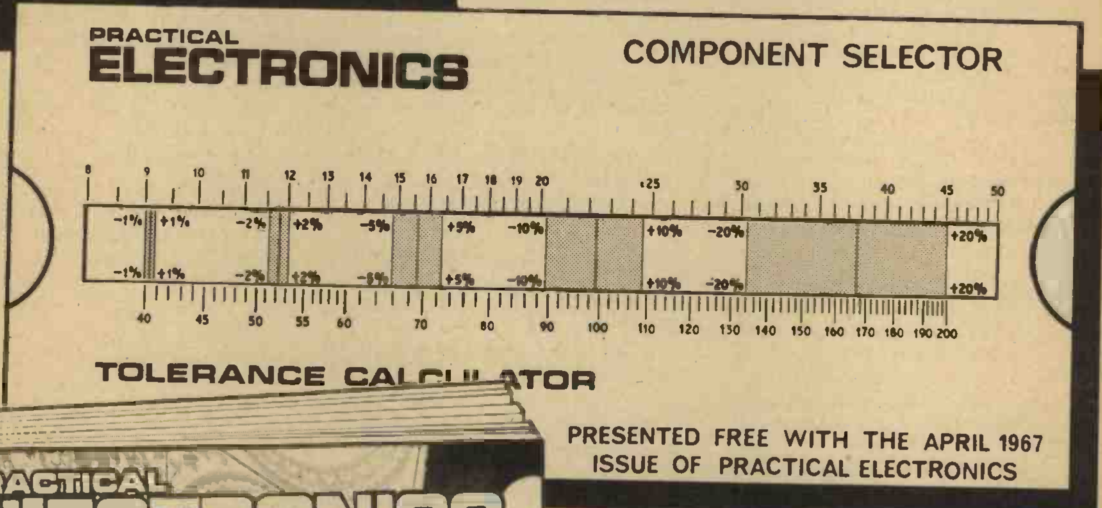
A new catalogue from **Heathkit** has just been issued and amongst its new kits is a car radio type CR-1 with an output of 4 watts, suitable for driving two loudspeakers if required.

LUMOSTAT

Finally, it has been pointed out that the term "Lumostat", which was used for the photographic control unit described in our November, December and January issues, is a trademark of **Londex Ltd.**, and has been applied to their combined push-button switch/indicator lamps. We were unaware of its previous use by Londex and regret any confusion this may have caused.

FREE
Inside Next Month's Issue

COMPONENT SELECTION CALCULATOR



A double-purpose slide rule for the electronic experimenter. It gives you exact at-a-glance findings on:

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PUBLIC ANNOYANCE

A propos of the editorial comment a short while ago regarding broadcast music, I note that one rail traveller (at least) has been sufficiently provoked by the "noise" emanating from the loudspeaker system at Manchester Piccadilly station to write to the press on this subject. British Rail's well meaning attempt to provide a cheerful atmosphere is not at all appreciated by the customers nor indeed by the station staff—according to an on-the-spot enquiry conducted by this correspondent to a newspaper.

I must admit being a little surprised at the unanimity expressed in this platform poll. Rarely does one find a group of people single-minded on this subject.

The kind of background music I myself find most annoying is the furtive kind: you know—the soft, slinky sound which is always present, although you can never with certainty locate its source. This insidious music pervades the bar, store, or what have you, from decorative louvres in the same mysterious manner as the heating and air conditioning enters. Unfortunately it has nowadays become more often than not the custom for such sound distribution systems to be considered as indispensable as these other more essential and desirable services.

FAIR DINKUM

Those of you who have been with us from the start will recall that our first issue included a design for an electronic didjeridoo.

That genial character Rolf Harris who was responsible for introducing the didjeridoo to a wide public has started a new series on BBC-1. It is his intention to bring over to this country two Aborigine didjeridoo players so we all may see and hear the genuine article played by a native expert. A wonderful opportunity too for any reader who has built up the electronic version to compare the synthesised sound with that of the original instrument!

THE OLD ORDER CHANGETH

Of course I should have been prepared for it. After all, I seem to remember mentioning the subject many months ago. Now a curt directive has arrived from the editor that *hertz* is in, real gear, while *c/s* is out—old hat and all that stuff.

I will try to remember, but I reckon my colleagues in the subbing dept. will have to expunge a few inadvertant c/s from my notes for a month or so yet.

A suspicion lurks in my mind that the acceptance of Heinrich Rudolf Hertz was all part of a clever scheme to smooth the path of Harold and George on their Grand Tour of European capitals. But as students of the Common Market scene will agree, this would have been more effective if Hertz had been *a Frenchman* and not a German.

With this impending change in mind, I have just been looking through some other periodicals and one interesting thing comes to light.

Hertz, you will recall, established his reputation on account of his discovery of electromagnetic waves. Now, it would appear that support for the adoption of Hz is somewhat tardy in those journals particularly associated with radio. On the other hand, the audio boys, strangely enough, have been quick off the mark in acceptance of Hertz. "Strangely enough"—for they have no vested interest in electromagnetic waves. Indeed, should they not be rushing to to honour one of the renowned men of science who contributed much to the theory of sound waves; Lord Rayleigh or Hermann von Helmholtz, for example?

Why not *two* separate units for frequency—the distinction between electromagnetic waves and sound pressure waves (audio and ultrasonic) could then be clearly made. NO? ah well, I was only trying to be helpful.

"Take me back now please nurse. North Cones are being hoisted."

DISTRESS CALL

We have come a long way since H. Hertz discovered the properties of electromagnetic waves. The multiplicity of devices using radio waves for communication, telemetering, or control purposes is immense. Allocation of frequencies to properly authorised users is a major headache for the international and national bodies responsible for this task. However carefully such allocations are made, it seems unlikely that any user can be guaranteed complete immunity from interference of one kind or the other.

Certain patients in a South Coast nursing home can vouch for the truth of the foregoing statement. These elderly gentlemen had been fitted with radio controlled electronic devices to assist the emptying of their bladders. When, on a number of occasions, all devices became operative simultaneously, the medical staff were naturally enough dumbfounded. A little research however soon established the fact that the control frequency was the same as that used by the local lifeboat's radio.

When the lifeboat was launched to provide succour for some ship at sea it was unwittingly responsible for creating a number of distress calls on shore!

I should add that this little story was gleaned from the official journal of H.M. Coastguard.

AMPLIFIERS and radio equipment reaching the U.K. market from foreign sources increases in variety and quantity. New units from Sansui have now arrived to join products from other prominent Japanese manufacturers. The distributors are Lasky's Radio, and Londoners wishing to inspect the range at first hand should visit their showroom at 42 Tottenham Court Road, London, W.1.

Examples from Sansui's extensive list are the AU-70 integrated stereo amplifier and the TU-70 stereo tuner. These can be purchased together at a special "package deal" price of 130 gns—a saving of 11 gns. The amplifier is rated at 20 watts r.m.s. per channel and has a full complement of inputs, including a magnetic pick-up input with the high sensitivity of 1·1 mV. The styling of this unit, like others in the range, is crisply modern.

The TU-70 tuner, equipped for stereo, covers the medium wave band as well as f.m. Other Sansui units at present available include four different tuner-amplifiers, and items promised for the near future are speaker systems, stereo headphones and tuner-amplifiers with the lower rating of 10 watts per channel.

SHELF UNITS

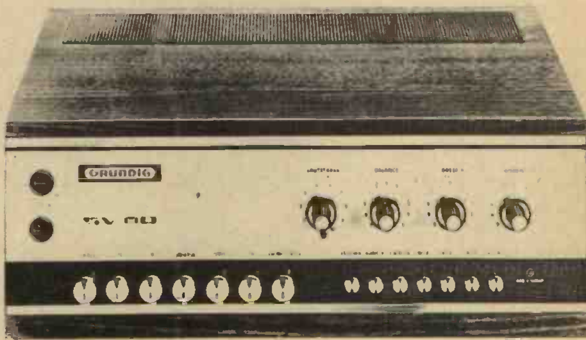
Stereo equipment by J. B. Lansing of the U.S.A. was mentioned very briefly on an earlier occasion. An interesting selection of Lansing units now reaches us via the London agents, Ad Auriema Ltd. Although rather expensive these are claimed to have advanced specifications. They include the SA600 integrated amplifier, which gives an output of 40 watts r.m.s. per channel from silicon transistor circuits. A high performance stereo power amplifier, which Lansing call an "energiser", can be installed in a speaker enclosure and used with a separate control unit.

Lansing solid state stereo "energiser"

Other items from this firm include several speaker systems, mostly based on a compact free-standing enclosure incorporating a 15in bass speaker unit with aluminium voice coil. There is also the "Graphic Controller", an elaborate music control centre with a novel display of control functions and pre-amplifier circuits to suit any low output devices.

Still on the subject of shelf units, Grundig's most recent additions to hi fi equipment are the SV80, a transistor stereo amplifier rated at 30 watts per channel, and the matching RT40 a.m./f.m. tuner unit. The amplifier caters for all the usual inputs (pick-up sensitivity is 4mV) and has a 5 ohm output impedance. Suitable speakers are available. No fewer than 44 semiconductor devices of various kinds are used in this amplifier.

Model RT40 radio tuner, like the amplifier, is fully transistorised. It incorporates a stereo decoder, switched automatic frequency control on f.m., and variable a.m. bandwidth. The tuner and amplifier match in every sense (they have identical dimensions) and there is a choice of wood finishes for the cabinets.



Grundig SV80 30 + 30 watt transistor stereo amplifier

Another shelf unit introduced recently is the Tripletone Stereo 8-8, claimed to be the first quality transistor model in its price range. It is rated at 8 watts r.m.s. per channel and designed to match other items in this Company's range. The amplifier, which sells at £29 19s 6d, is compact with dimensions 11in × 7¼in × 3¾in. The pick-up input is for ceramic cartridges, but there is to be a separate "booster" pre-amplifier to match magnetic types.

A small speaker, the Avon, has been introduced by Heathkit at £13 16s in kit form. It measures only 13¼in × 8¾in × 7¾in and is of the sealed type. Drive units are a 3½in tweeter and 6½in bass unit with 2,000Hz crossover unit and 15 ohms impedance. An interesting feature is a metal plate which is fixed in the cabinet to give a rigid mounting for the speaker units. A fully finished walnut veneered cabinet is provided in the kit.

TAPE EQUIPMENT

A new range of semi-professional stereo tape recorders by Ampex—the 2100 Series—have something in common with the 2000 machines which have been on the market for some time. In particular, simple tape threading and the automatic direction reversal facility are once more in evidence. The recorders can record and replay in either direction of tape travel and thereby give an unusually long programme without the interruption of spool changing.

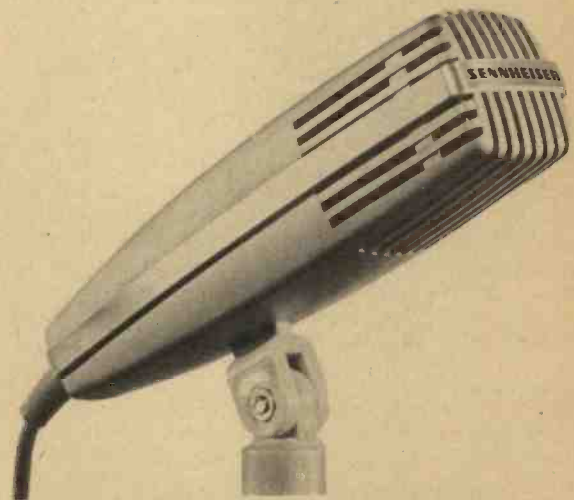
The transistor Model 2100 is available in three versions—as a portable machine, as a complete recorder in a wooden case, or as a deck with preamplifiers. The specifications, instructive for amateurs, are available from Ampex Great Britain Ltd., Acre Road, Reading. Facilities include mixing, three speeds and recording level meters. Recording in either direction is made possible by a fourth head.

Dynatron's new STR1 stereo recorder is fitted in a teak veneered plinth and equipped with a transparent dust cover. Priced at 79 gns, this attractive machine employs the Garrard three-speed deck and the quarter-track system. It is fully transistorised with "advanced modular construction" and, by virtue of separate amplifiers and controls, provides multi-play facilities.

The "Belgravia" by Truvox also has a teak finished cabinet. The deck facilities are identical to those on the standard R102 and R104 recorders, and both half-track and quarter-track versions are available. This model employs silicon transistors. Price 93 gns.

A microphone with highly directional characteristics, suitable for amateur use, was introduced by Sennheiser recently. This is the MD411 super-cardioid model, priced at £13 9s and marketed by the London agents, Audio Engineering Ltd. With a design derived from a more expensive professional microphone, the MD411 incorporates a triple impedance transformer giving 200, 800 and 25,000 ohm outputs, the latter being suitable for connection to valve equipment. The price includes a case and stand.

Dynatron STR1 stereo recorder



Sennheiser MD411 super-cardioid microphone

CABINETS

For details of inexpensive hi fi furniture, enthusiasts should write to Medley Musical Ltd., 134 Plumstead Road, London, S.E.18. Products include an equipment cabinet in low-line styling and priced at 18 gns. This model has a Perspex lid over the turntable and a door to cover the control section. It will house numerous alternative assemblies of stereo units.

Then there is the Duo cabinet (also 18 gns) which can be either fitted to a stand or screwed to a wall to isolate the equipment from vibration. Wall mounting is of course the ideal solution for any equipment housing where there is danger of movement due to flexing of floor-boards or where acoustic feedback problems are encountered.

Also made by this firm is the Musette speaker system, measuring 30in × 7½in × 10in and available in 15 ohms or 3 ohms impedance. This system houses a 4in tweeter and 8in bass unit. Teak and walnut are among the finishes offered. Another useful item is a teak finished turntable cabinet for shelf mounting. This is fitted with a transparent lid and is suitable for popular makes of player.

A new 6½in bass speaker unit will be seen in low-cost stereo equipments by leading makers. This ferrite magnet unit, made by Plessey, can be used with the firm's tweeter in small, wide-range systems. Its low nominal resonance (not above 60Hz) is achieved by the use of a flexible bellows-type cone surround of plasticised linen. Standard coil impedances are 15 and 8 ohms and the recommended enclosure is 14in × 9in × 9in minimum, with suitable internal damping.

ACCESSORIES

All the usual Metrosound accessories, as well as some new additions, may now be seen on a display rack supplied to retailers. The new products include a spirit level for turntables 6s, and a stylus balance at the unusually low price of 7s 1d. A lubrication kit, selling at 6s, is intended for turntable and tape recorder maintenance. Tape editing aids and a stylus cleaning kit are among the items which are already familiar to amateur enthusiasts.

CUT PRICE

Beocord recorders by Bang and Olufsen were reduced in price not long ago. The Beocord 1500 was 105 gns and is now 97 gns; and the 2000K comes down by 10 gns to 125 gns. Portable radios by Bang and Olufsen, as well as the Sony portable television receiver, are also the subjects of price cuts. Also cutting the cost of good audio equipment are Rectavox, whose Ambi and Omni speaker systems are now considerably cheaper.

AUTO CALENDAR

PART TWO

By D. F. MOODY, B.Sc.

FOLLOWING the theory of the auto-calendar, and the construction and testing of the ring counters on Board 1 (last month), this second part concludes with the construction and testing of the trigger circuitry and assembly of the complete calendar.

CONSTRUCTION OF FACEPLATE

As considerable accuracy is required in drilling the holes in the faceplate, so that they are aligned correctly with the cold cathode tubes mounted on Board 1, a piece of perforated board the same size as Board 1 was used as a drilling template. This provides a convenient way of mounting Board 1 to the back of the faceplate with either wire straps or nuts and bolts.

Using this method, cut a piece of the board to the same size as Board 1 (i.e. 50 holes × 23 strips). Obtain a piece of sheet aluminium (preferably already painted in a dark grey) with dimensions about 1½in higher and ½in wider than this piece of board, and cement the template board to the unpainted side with an impact adhesive.

When completely dry mark the holes to be drilled on the board. The holes to drill will be those directly under the base of each cold cathode tube (i.e. one per tube), for example, holes B4, B8, B12, etc.

Drill the holes with a $\frac{1}{16}$in drill right through the aluminium. Then turn the faceplate over and drill through the holes again with a $\frac{3}{16}$in drill. This should leave neat holes. Turn the faceplate over again and clear any burrs from around the holes with a ¼in or $\frac{5}{16}$in drill.

If the holes have been drilled accurately the faceplate and Board 1 should mate perfectly. If not then the tubes can be tilted slightly. The faceplate should now be labelled with day names, months and day numbers (see photograph).

Board 1 can now be fitted in position and held by means of straps to the perforated board template.

Holding Board 1 in position, feed a piece of tinned copper wire through a vacant hole in Board 1 and locate the end of it in the corresponding hole in the template. Fix it to the template and, keeping a firm pressure on the board, solder the wire to Board 1. Cut off the excess and put in about six straps (three each side). This should hold Board 1 firmly in position.

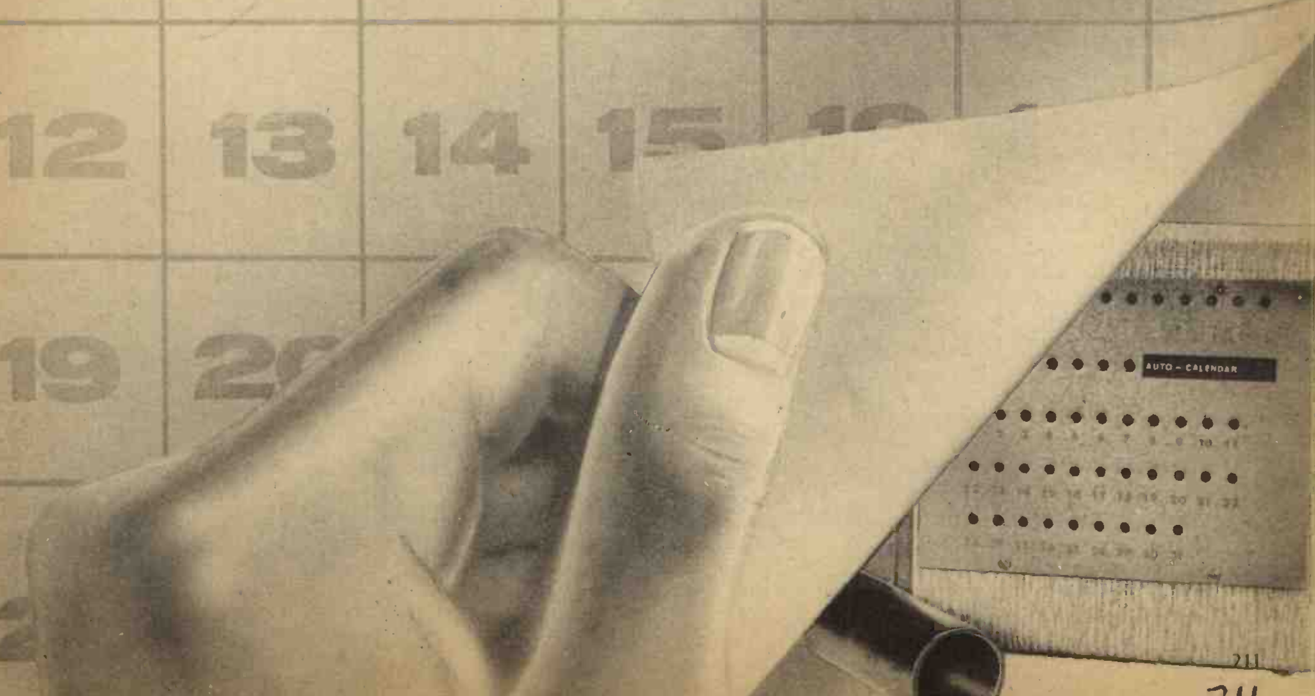
BOARD TWO—CONSTRUCTION

The circuitry for Board 2 is reproduced here in Fig. 5 with a guide to connections to other parts of the circuit. Copper strip code letters are shown in italics.

The layout will depend entirely on the size of the components obtained. Probably the best way to go about planning the layout in detail is to cut a piece of Veroboard the same size as Board 1 (it has to go in the same case) and have all the components in front of you.

Lay the components on the board—starting with the largest, and move them in different configurations until you think you can fit them all on.

Fig. 6 shows a diagram of a suggested layout which will form a rough guide. When you have settled on the layout, fix some of the larger components on to the



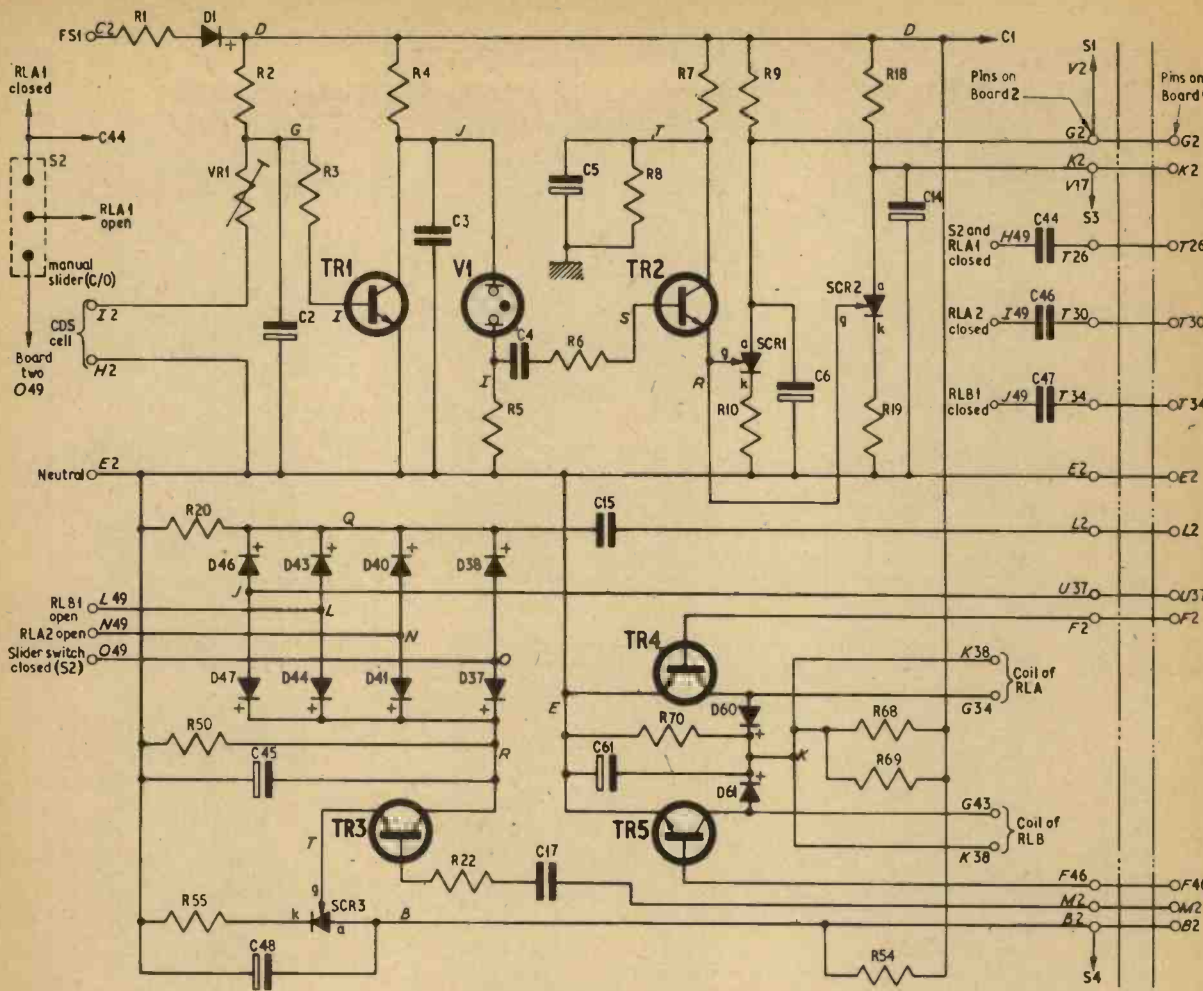


Fig. 5. Circuitry of components mounted on Board 2. Italic letters, denoting copper strips, are for guidance only. Connections from Board 2 to Board 1 are shown on the right

board. Insert terminal pins to connect Board 2 to the rest of the circuitry and keep a record of the pin co-ordinates and the point to which the pin must be connected. In this way risks of making wrong connections are avoided.

A line of larger holes is drilled along the top edge of the sheet of Board 2. These should not be cut off as they will serve to mount the board in the case (see section on unit construction).

Provided that you work slowly and carefully, checking all the time with the circuit diagram, then there should be no great difficulty. If necessary, components may be mounted on the copper side of the board, but be sure to put sleeving on component leads and any wire links used. Make sure all necessary copper strip breaks are made as shown in Fig. 6.

Considerable space may be saved if vertical mounting is used wherever possible, for example with small resistors and diodes. Components longer than about ½in should be mounted flat to keep overall depth small (see unit construction) and to keep component rigidity. The thyristors are fitted to the board by using copper or aluminium brackets screwed down to strips *V* and *W* to make the anode connections. The strip is broken at *V10*. Nearby copper is cut away to isolate the brackets from these strips. Try to keep all terminals to be wired to a similar location together. This helps to keep wiring much neater, and more compact. Subsequent access for servicing is also possible.

BOARD TWO—TEST

Before completing the construction it is advisable to make a brief test on the operation of Board 2. Mainly of interest is the circuitry around TR1. To protect the remainder of the circuit with h.t. voltage supplied it is essential to make the following connections to Board 1.

Connect pins *B2*, *E2*, *F2*, *G2*, *K2*, *L2*, and *M2* of Board 2 to the appropriate pins on Board 1 and connect pin *E2* to the common line. Connect the CdS cell to *I2* and *H2* with about 3ft of twin flexible wire and the potentiometer VR1 on the copper side of the board. Connect the common line *E2* to the negative pole Z of the voltage supply (as shown in Fig. 4 last month for testing Board 1) and connect the positive pole Y to the cathode side of diode D1, pin position *D2*. Adjust the supply voltage to 300V and switch on.

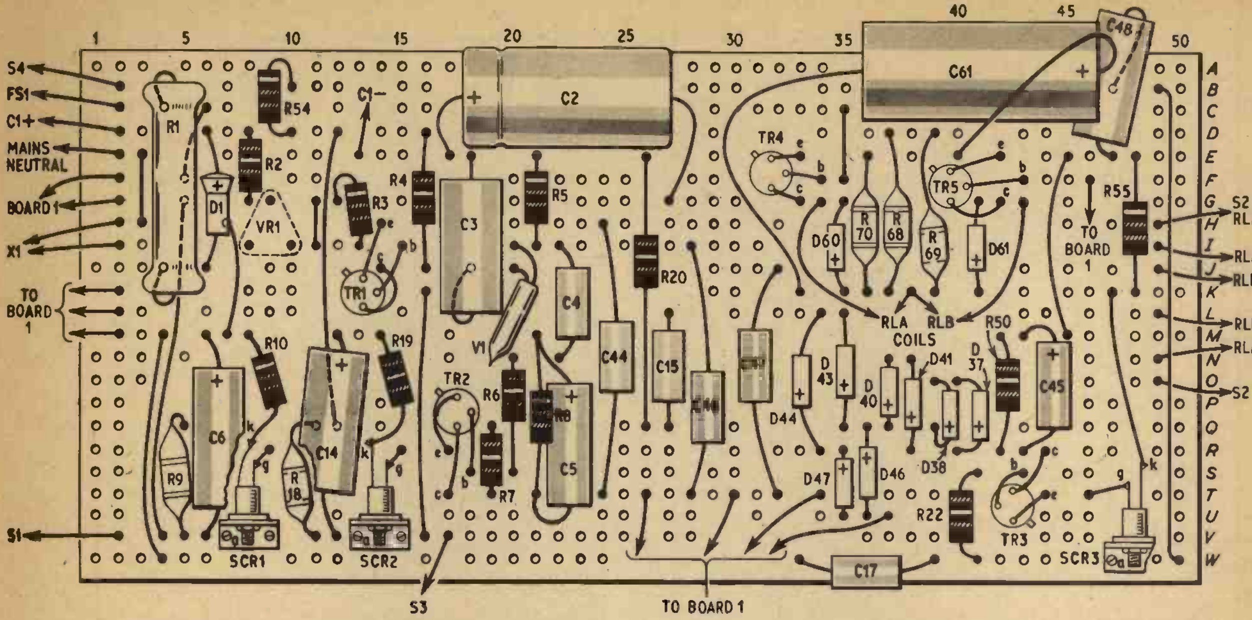


Fig. 6a. Component layout of Board 2. Sizes of components are not necessarily in true proportion so allowance must be made where necessary to alter their positions. The thyristors are mounted on small aluminium brackets (see text)

The following hole positions denote breaks to be made in the copper strips on the reverse side of Board 2:

C5, F7, F14, F38, G7, G31, H23, I9, I12, I17, I27, J7, J31, K17, K46, L28, M5, M31, N36, O36, Q23, R30, S40, T23, T27, T31, T37, U7, U8, U9, U10, U13, U14, U15, U16, V10, V45, V46, V47, V48, W36, W42

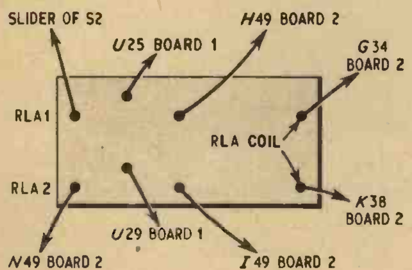


Fig. 6b. Relay connections for RLA

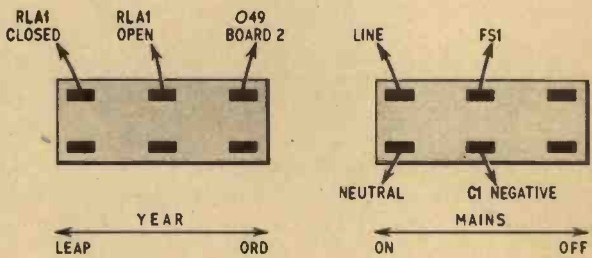


Fig. 6d. Connections to slide switches S2 (left) and S5 (right)

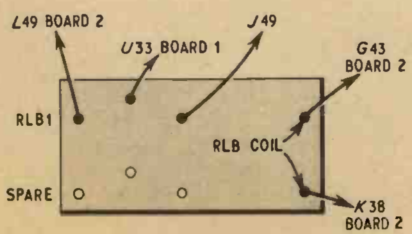


Fig. 6c. Relay connections for RLB

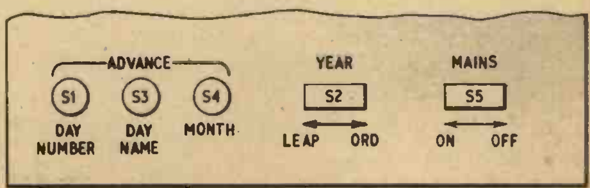


Fig. 6e. Notation of switches on back panel

No doubt many cold cathode tubes will light up—this does not matter at present. Set VR1 to maximum resistance and illuminate the CdS cell. If done during daytime hold the cell pointing towards a window; if at night ordinary room lighting should be sufficient.

If V1 is not glowing reduce VR1 until it does. Now completely mask the CdS cell by wrapping it with some thick, dark cloth. V1 should now extinguish. If it does not then probably TR1 has an extraordinary low gain, when the only solution is to reduce the value of R3. This should not be necessary as in calculating values the gain of TR1 was considered as low as 10.

It should be possible to set VR1 so that V1 ignites when the CdS cell is illuminated with very feeble light after being in darkness for a few seconds.

Every time V1 ignites a change should occur in the day name and day number rings indicating that the thyristors are firing and cutting off correctly. It would be better to disconnect C2 when doing these tests so that the response of the circuit is relatively rapid.

As the feedback path between month and day number rings is not connected, erratic behaviour of the day number ring is to be expected.

R1 ascertained from Table 1. Also as the value of R1 is increased so the rating of fuse FS1 should be reduced to give effective protection.

It should not be thought that the value of R1 is very critical, as the operation of the calendar should not be affected by mains voltage variations of, say, 10 per cent, but nevertheless it is desirable that the nominal working conditions are as favourable as possible. R1 should be a wirewound resistor of about 6 watts so that it can take the high surge current that occurs when switching on, and its value should be greater than 100 ohms to protect the diode from excessive surge currents.

UNIT CONSTRUCTION

With Boards 1 and 2 constructed and tested the complete calendar may be assembled. The prototype was housed in a small loudspeaker cabinet which gives a very handsome finish to the unit. If the reader has constructed Boards 1 and 2 as described then he should allow for the overall size to be bigger to accomodate the larger boards shown here (see Fig. 7). The case should be made in wood and not metal as the calendar is run straight off the mains.

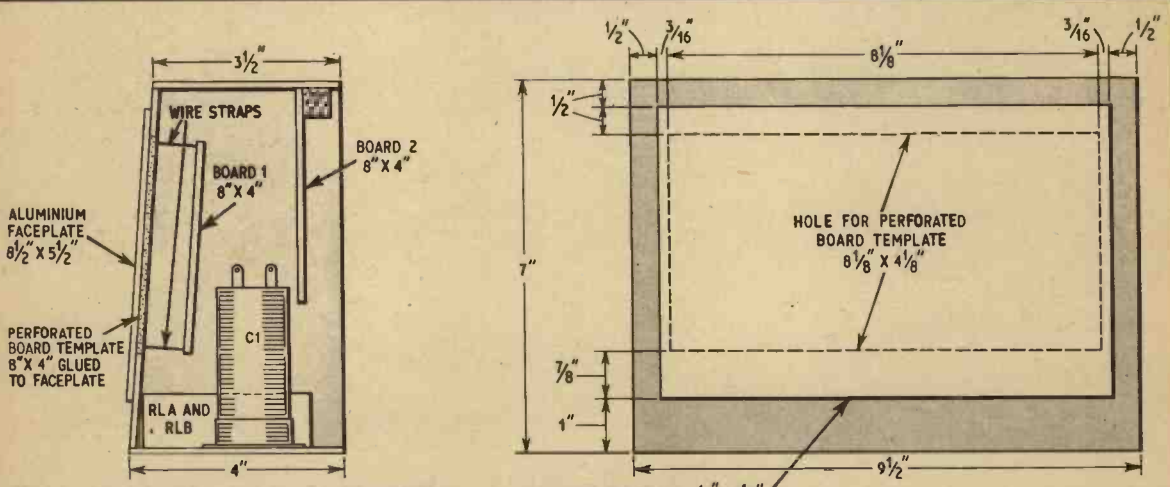


Fig. 7. Construction and layout of cabinet

It should be noted here that the value of R1 should be chosen so that the nominal h.t. voltage is 300V with your local a.c. mains supply voltage at its nominal level. This should be found out or measured and then

Table 1. VALUE OF R1 FOR DIFFERENT A.C. MAINS SUPPLY VOLTAGES

Supply voltage r.m.s.	R1 (ohms)	FS1 rating
250	2,000	250mA
240	1,000	500mA
230	500	700mA
220	200	1A
210	100	1A

Mark out and cut the rectangular opening in the front of the case to accept the perforated board. Mark out on the front the size of rectangle you require which should only be about $\frac{1}{16}$in larger all round than the actual size of Board 1. If it is made too large there will be difficulty fixing the front-plate screws. The easiest way to cut the hole is to drill a $\frac{1}{4}$in hole near one of the corners of the rectangle to be cut out, and then using a band saw cut out the rectangular hole.

Check, by holding the face-plate in position, that the relays will fit in without fouling Board 1 (see photograph). At this stage stand the large smoothing capacitor C1 upright in the case (left-hand side), and move it towards the front as far as it will go without touching Board 1. Hold it and mark its position by marking around its base with pencil. The holding clip should now be fixed in using small wood screws.

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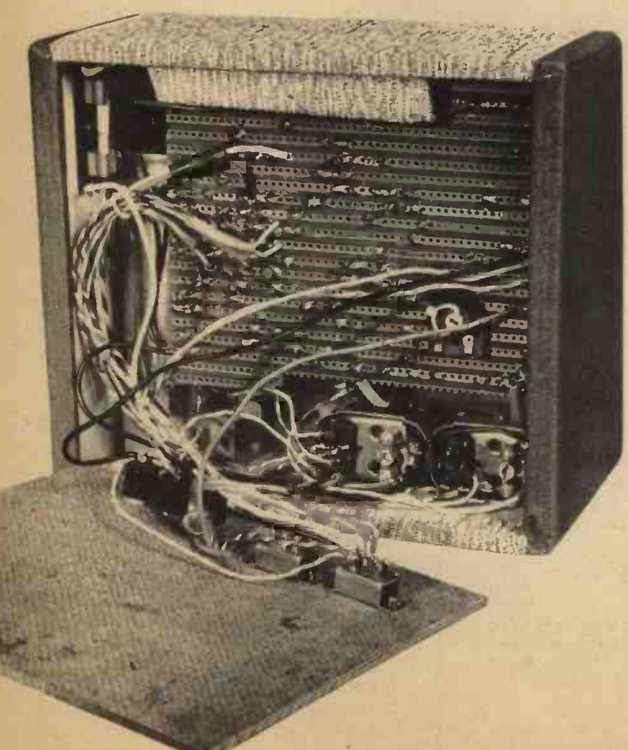
The relays should be fitted next. This can be easily done by removing the dust cover and drilling a ⅛in hole through the closed end. Smear one side of the dust cover with impact adhesive. Likewise put some on the wooden cabinet base (right-hand side facing rear). Press the dust covers (side by side) right up into the corner of the case and fix with two small wood screws into the front panel. Before the relays can be inserted into the dust covers remove the aluminium fixing brackets from the base of the relays.

With C1 in position make sure that Board 2 will fit in position. If it does then take it out and solder 8in leads to the pins on the component side of Board 1 which require to be connected to Board 2. There should be 12 connections to make, so colour coding is essential. If a record of each connection and colour is made risks of wrong connections will be avoided.

In the wiring diagram these inter-board connections use corresponding holes (e.g. *B2* on Board 1 to *B2* on Board 2). All 12 wires can be laced together into a cable form. The pins on Board 1 requiring connections to Board 2 are pins: *B2, E2, F2, F46, G2, K2, L2, M2, T26, T30, T34,* and *U37*.

Fix Board 2 in position as shown in diagram taking the leads from it out through the front opening. Now solder leads from pins *D2* and *E13* on Board 2 to the positive and negative tags respectively on capacitor C1.

The rest of the connecting wires for Board 1 are soldered to pins *U25, U29, U33* for relay wiper connections on RLA1, RLA2, and RLB1 respectively. Now place the face-plate in position, pull the three wires to go to the relays through the gap under Board 2, and screw the face-plate in position. Wire up the relays next with the three wires from Board 1 and the other eight leads from Board 2.



Controls to be fitted on the back plate are three push button switches and two changeover slide switches. Holes should also be drilled to accept the mains cable and CdS connecting wire. When fitting the controls on the back plate make sure that their tags do not touch any other components or wiring, especially the relays and Board 2. The fuse is fitted inside the case on the left-hand side (looking at the rear) above the capacitor C1. Connect a few feet of twin mains wire to FS1 and C1 negative (line and neutral mains respectively), or via slider S5 if used. Label each control, especially the slider switch so that you know when the calendar is in leap year mode or ordinary year mode.

INSTALLATION

The finished calendar will be small enough and sufficiently good-looking to be installed in a living room or study. Preferably it should be fitted near a spare mains socket (one provided for an electric clock is ideal) so that there is no chance of it being switched off inadvertently. The CdS cell is required to be mounted near a window or door for maximum light sensitivity.

The CdS cell should be mounted at the end of a short cardboard or metal tube to limit incidental illumination only from the right direction. It should be preferably pointing east or north-east to avoid trouble from a bright full moon, and kept fairly horizontal. In this way the maximum amount of light is detected when it is most required, i.e. in the early morning. If however mounting in this way is impossible, then direct the tube more vertically and more northerly, again to avoid detecting light from the moon.

If horizontal mounting is used Terry clips provide a suitable clamping arrangement especially if the tube is mounted under the eaves of the house. The open end of the tube can be covered with transparent polythene, held by a rubber band. This will protect the tube from the elements.

When the tube and unit have been installed the sensitivity will have to be adjusted. This must be done at night. Switch on the unit, when several tubes will probably light up. By pressing the advance controls it should be possible to get one tube per ring glowing.

In the day name counter a stage may be reached when all tubes try to conduct resulting in oscillation; this is because the number of elements in this ring is small. If this condition develops the only way to remove it is to switch off the mains supply and press the day name advance switch. Due to the high value of C1 the h.t. will drop only slowly.

Keep pressing the day name advance button until only one tube is glowing. Then turn the mains on again. Hence with only one tube glowing in each ring remove the back plate so that you can see whether or not V1 is glowing. This can be seen through Board 2.

Turn VR1 down to the minimum value. If V1 is not glowing then leave VR1 at this value. If V1 is glowing then increase VR1 until it goes out; give it "a little bit more", and then replace the back plate and set up the correct date on the calendar.

If VR1 has been set correctly and the CdS cell mounted in a favourable position then the calendar will change date very early in the morning in the summer and later on winter days.

CORRECTION

In Fig. 1 (last month) R52 should be connected to the common line with R51 and R53, *not* to D40–D43 line.

★

Unijunction TRANSISTORS

By A. THOMAS

THE unijunction transistor (u.j.t.) was one of the first of the three terminal semiconductor devices to be described. A patent was applied for in France in 1948, by Heinrich Welker, for a unijunction type device. In 1949 Dr W. B. Shockley had written an article describing the operation of the u.j.t. Books published in the 1950s, referred to the u.j.t. as a double base diode.

Fig. 1 shows the symbol for the u.j.t. and it is always presented in this manner to prevent confusion with the bipolar junction transistor and the field effect transistor (f.e.t.). Figs. 2, 3 and 4 show the symbols for these two latter devices.

Referring to Fig. 1, B1 and B2 are Base 1 and Base 2, and E is the emitter. The two base leads are shown at 90 degrees to the base because they are non-rectifying contacts, and the emitter is shown with an arrow because it is a rectifying junction; the direction shows the emitting properties of the junction. The base is *n* type semiconductor material, and the emitter is *p* type. The power supply polarities are the same as for the *npn* junction transistor, and are shown in Fig. 5.

NEGATIVE RESISTANCE REGION

The device exhibits a stable incremental negative resistance region under certain conditions. The negative resistance characteristic is described as being the portion of the characteristic where, as the current through the device increases, so the voltage across the device decreases.

Fig. 6 shows the u.j.t. emitter characteristic. It can be seen from this, that for each specific emitter current there is a unique emitter voltage but as many as three separate values of emitter current may exist for a specified emitter voltage. The negative resistance region is the portion between points A and B, D is the cut-off region, and C is the saturation region. Point A is known as I_{FM}, V_{FM} which is the peak current and voltage, and B as i_{ev}, v_{ev} which is the valley current and voltage.

This negative resistance makes possible the design of circuits which contain fewer components than comparable junction transistor circuits. Due to the high input impedance in the off condition, the device may also be used for voltage discriminating circuits.

PARAMETERS AND SYMBOLS

r_{BB} is the static interbase resistance and is measured between the two base terminals with the emitter open circuit. This is simply the resistance of the silicon bar. The parameter is slightly voltage dependent and is specified at a low voltage and current to eliminate self-heating effects.

r_{B_1} is the static resistance of the silicon bar from the emitter to the base 1 lead.

r_{B_2} is the resistance from the emitter to the base 2 lead. The sum of r_{B_1} and r_{B_2} is equal to r_{BB}.

I_{FM} and V_{FM} designate the peak current and voltage. The peak is approached as the emitter becomes forward biased causing the device to go into its negative resistance region. V_{FM} is dependent on interbase voltage and η.

i_{ev} and v_{ev} designate the emitter current and voltage at the valley point as shown in Fig. 6. The valley point is dependent on V_{BB} and temperature.

η is the "intrinsic stand off ratio" and is defined in the following formula, $V_{FM} = \eta . \quad V_{BB} + V_D$. Where V_D is the forward volt drop of the emitter to base 1 diode. The ratio η determines the firing voltage of the device for a constant interbase voltage.

$I_{B(mod)}$ gives an indication of the current gain of the device from emitter to base 2. $I_{B_2(mod)}$ is specified at a constant $V_{B_2B_1}$ and emitter current. With a resistor in base 2 and $I_{B_2(mod)}$ known, the pulse amplitude at base 2, when the emitter fires, may be calculated.

V_{BB} is the total voltage supplied to the bases.

$V_{B_2\,B_1}$ is the voltage between the base leads.

V_{EE} is the emitter supply voltage.

R_{B_1} and R_{B_2} are the resistors in the base leads.

CIRCUIT SYMBOLS

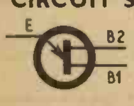


Fig. 1. PN u.j.t.

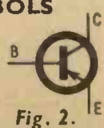


Fig. 2. PNP junction transistor

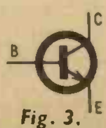


Fig. 3. NPN junction transistor

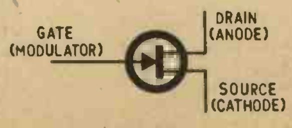


Fig. 4. F.E.T. (with n-type base)

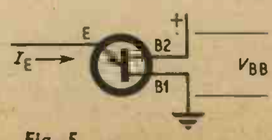
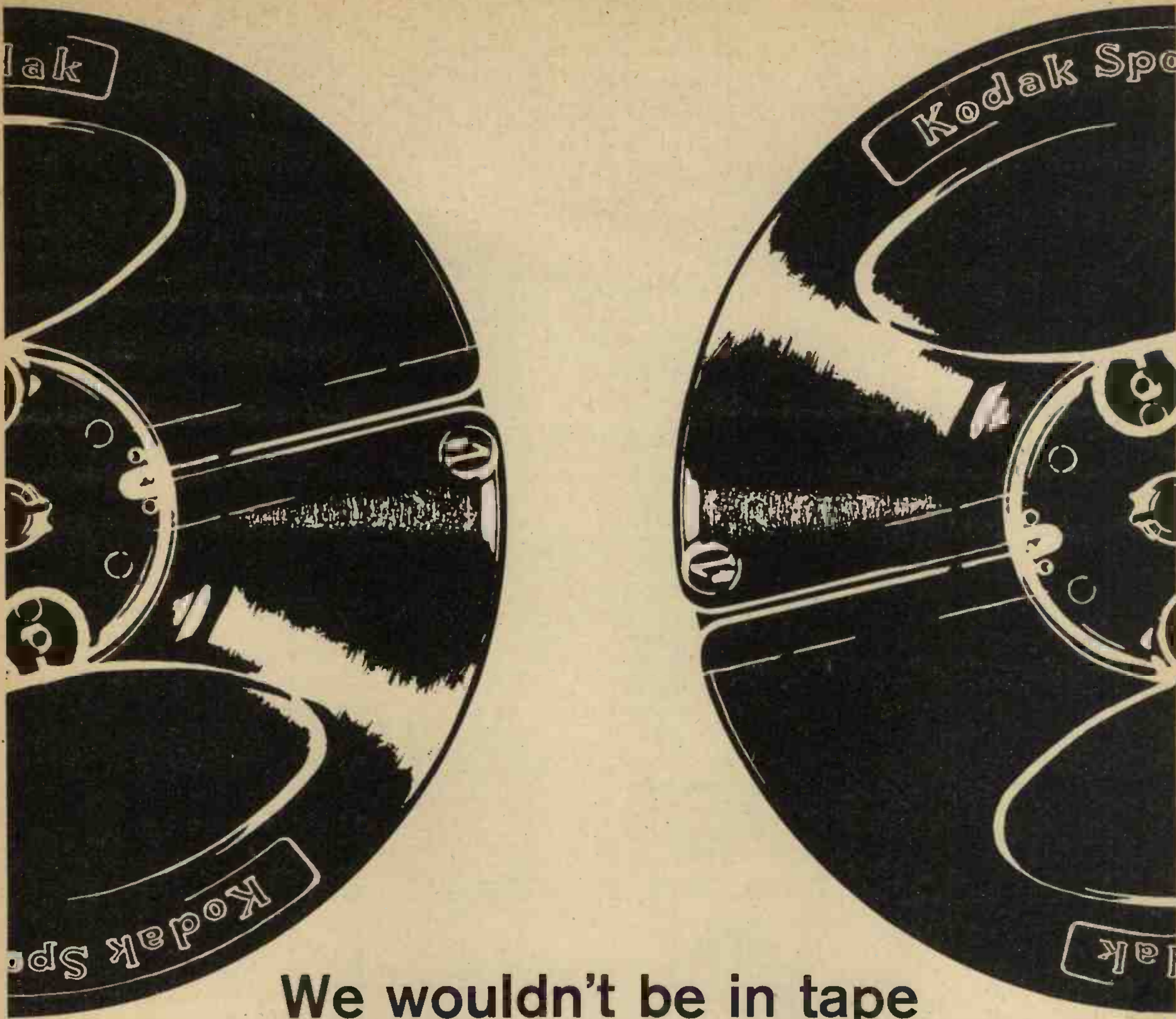


Fig. 5. PN u.j.t. supply polarities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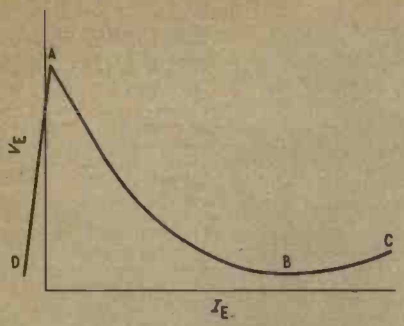

Fig. 6. Emitter characteristic for u.j.t.

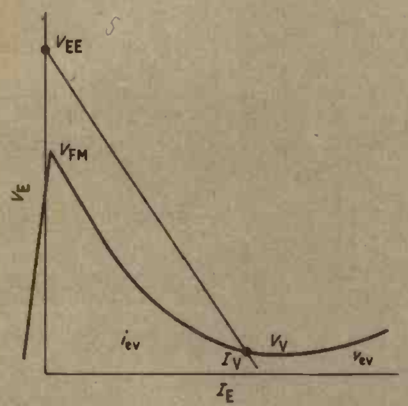

Fig. 7. Load line in negative resistance region

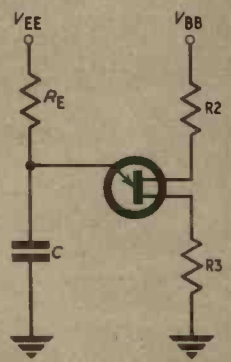

Fig. 8. Basic astable circuit

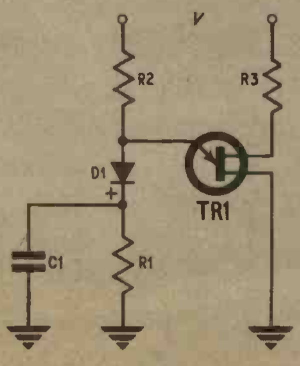

Fig. 10. Modified version of Fig. 8

BIASING CONDITIONS

Astable Trigger Circuit

A load line, placed as shown in Fig. 7, intersects the negative resistance region of the u.j.t. curve and, together with capacitive reactance at the emitter, produces an astable circuit. Fig. 8 shows a basic circuit of an astable trigger or multivibrator which has a load line as shown in Fig. 7. It can be seen from the waveform of Fig. 9 that the rise time of the emitter waveform is governed by R_E and C1 of Fig. 8, but the fall time is governed by the value of r_{B2}, r_{B1} and C1.

The modified circuit in Fig. 10 enables the rise and fall time of the emitter waveform to be controlled. The circuit operation is as follows. Assume the u.j.t. is in the off condition, C1 begins to charge to V_{EE} through D1 and R2. When V_{FM} is reached, the u.j.t. fires lowering the emitter potential and reverse biasing the diode D1. The u.j.t. now stays in the on condition, C1 is isolated by D1 from the remainder of the circuit and can only discharge through R1. When C1 has discharged to below the voltage at the emitter, D1 conducts. This diverts some of the emitter current into the capacitor, causing the u.j.t. to turn off. C1 then starts to recharge to V_{EE} through D1 and R2, and the cycle repeats. The waveforms for the circuit of Fig. 10 are shown in Fig. 11.

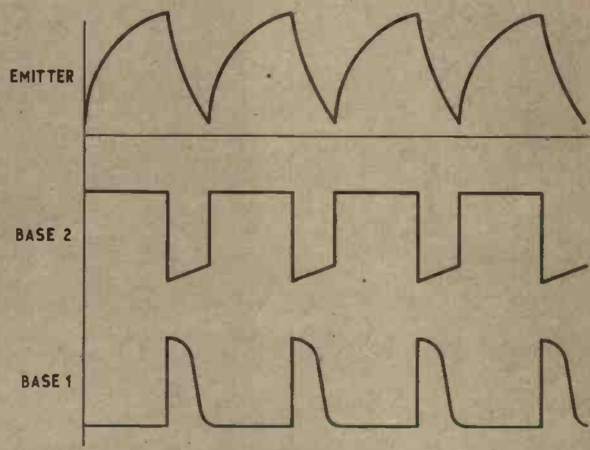

Fig. 9. Waveforms for circuit in Fig. 8

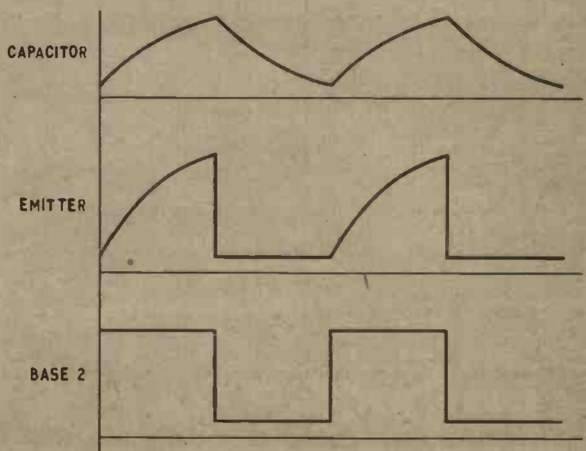

Fig. 11. Waveforms for circuit in Fig. 10

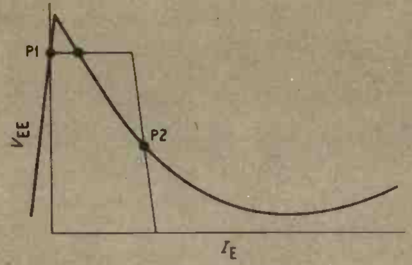

Fig. 12. Load line for bistable trigger

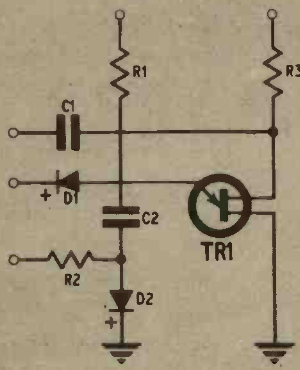

Fig. 13. Bistable trigger

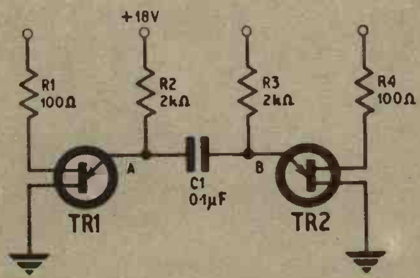

Fig. 14. Practical astable trigger

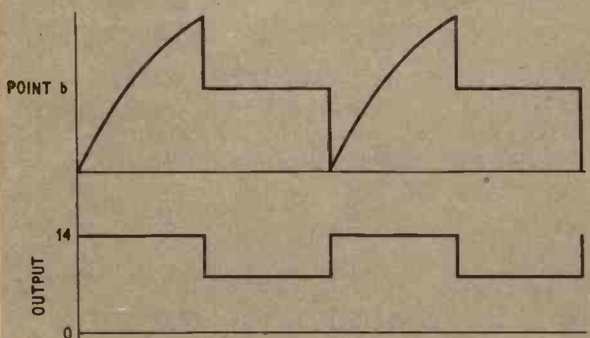

Fig. 15. Waveform of astable trigger

Bistable Trigger Circuit

As in the astable circuit the load line may be shaped by a diode to obtain more useful characteristics. This is shown in Fig. 12, and the actual circuit is shown in Fig. 13.

When the u.j.t. is off, operation is at point P1 (Fig. 12) and the emitter is clamped to V_{EE} by D1. Operation can be shifted to the on condition by the application of a negative pulse at C1. This lowers V_{FM} to below V_{EE} and causes the circuit to switch to P2 in the negative resistance region. If the junction of C2 and D2 is returned to a negative supply via R2, then the diode D2 is reversed biased and C2 isolated from the circuit. If R2 is then made positive, the resistance of D2 decreases. When this is reduced to a certain limit, C2 will cause the circuit to be unstable and flip back to P1.

Monostable Trigger

The circuit of Fig. 10 may be made into a monostable trigger if the load line of Fig. 7 is lowered to cross the voltage axis at a point less than V_{FM}.

The u.j.t. will lock up somewhere in the off condition just below V_{FM}. When a positive trigger pulse is applied to the emitter, the u.j.t. turns on, D1 becomes reversed biased, and C1 begins to charge through R1. The u.j.t. stays on until the voltage across C1 is equal to the emitter voltage, and when D1 becomes forward biased the u.j.t. turns off.

PRACTICAL CIRCUITS

Astable Trigger

The circuit of Fig. 14 shows a practical astable trigger. The circuit operation is as follows. Assume that TR1 is on with point A held at V_{sat}. Point B will be charging towards V_{BB}. When V_{FM} is reached, TR2 will fire, bringing point B to V_{sat}. Because of the voltage on the capacitor, point A is reversed biased and TR1 turns off. Point A then begins to charge towards V_{BB} and the cycle repeats itself. Waveforms are given in Fig. 15.

TECHNICAL DATA FOR THE 2N2160 UNIJUNCTION TRANSISTOR

Emitter-base reverse voltage	30V
Inter base voltage	35V
D.C. emitter current	70mA
Peak emitter current	2A
Total device dissipation at 25°C	450mW

CHARACTERISTICS

Parameter	*Test conditions*	*Min.*	*Max.*
r_{BB} interbase resistance	$V_{B_2B_1}$ 3V, I_E 0	4kΩ	12kΩ
η Intrinsic stand-off ratio	$V_{B_2B_1}$ 10V	0·47	0·8
$I_{B_2(mod)}$ modulated interbase current	$V_{B_2B_1}$ 10, I_E 50mA	6·8mA	30mA
$I_{EB_{20}}$ emitter reverse current	V_{B_2E} 30, I_{B_1} 0	—	12mA
I_{FM} peak point emitter current	$V_{B_2B_1}$ 25	—	25μA
i_{ev} valley point emitter current	$V_{B_2B_1}$ 20, R_{B_2} 100	—	8mA
V_{0B_1} base 1 peak pulse voltage	V_1 20, R_{B_1} 20Ω	3V	—

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2N1748	10/-	OA10	6/-	OC77	7/-
AC107	9/-	OA47	3/-	OC78	5/-
AC127	9/-	OA70	2/-	OC78D	5/-
ACY17	8/6	OA79	2/6	OC81	5/-
ACY18	5/6	OA81	2/6	OC81D	5/-
ACY19	6/6	OA85	3/-	OC82	5/-
ACY20	5/6	OA90	2/6	OC83	5/-
ACY21	6/-	OA91	2/6	OC84	6/-
ACY22	4/6	OA200	3/3	OC139	8/6
AF114	7/-	OA202	4/3	OC140	12/6
AF115	6/6	OC22	10/-	OC170	5/-
AF116	7/-	OC23	17/6	OC171	6/-
AF117	5/-	OC24	22/6	OC200	9/-
AF118	12/6	OC26	7/6	OC201	12/6
AF139	17/6	OC28	15/-	OC202	13/6
AF186	19/6	OC29	17/6	OC203	12/6
AFZ12	15/-	OC35	12/6	OCP71	19/6
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BY100	5/6	OC44	5/-	SB078	6/6
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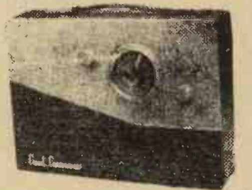

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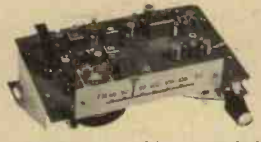

of exceptional quality, giving really fantastic results with virtually no noise. Suitable for mains or battery operation. 6 transistors, three I.F. stages, double tuned discriminator. Complete, new and built up all ready to work on chassis. Size 6" × 4" × 2" with tuning scale and slow motion drive. A £12.12.0 tuner for only £8.10.0.

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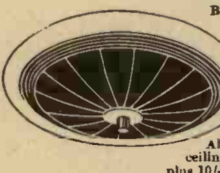

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Pulse Generator

The circuit of Fig. 16 shows a free running pulse generator whose frequency and pulse width may be preset. The operation is as follows. Normally TR2 is held in the off state by the 47 ohm resistor from base to emitter. The voltage dropped across this resistor due to r_{BB} and V_{BB} is small. When the voltage on C1 reaches V_{FM}, TR1 fires and C1 discharges. Most of the discharge current passes through the base emitter junction of TR2, this causes TR2 to turn hard on and bring the collector from 15 volts to almost earth. When the capacitor has discharged sufficiently, TR1 and TR2 turn off and the collector returns to 15 volts. The table of Fig. 17 shows typical frequencies and pulse widths which may be obtained with the circuit.

Step Waveform Generator and Frequency Divider

The circuit shown in Fig. 18 is capable of frequency dividing an input signal by up to 100. The circuit operation is as follows. The signal is applied at point A, and may be sinusoidal or a positive going pulse, the minimum amplitude being 1 volt peak. This turns TR1 hard on and the *pnp* constant current stage TR2 is also turned on. Constant current is applied to C2 for the duration of the input pulse, the capacitor therefore receives a charge for each input pulse, and the voltage across it increases in a series of steps. When the voltage exceeds the product of the intrinsic stand-off ratio η, times the supply voltage V, the u.j.t. will fire and discharge C2 through the base 1 resistor. TR1 is a germanium *npn* transistor and TR2 a silicon *pnp*; the latter is necessary to ensure that C2 does not continue to charge through TR2 in the off condition. As the step waveform approaches the firing potential of the u.j.t., some leakage at the u.j.t. emitter is noticeable on the waveform as shown in Fig. 19.

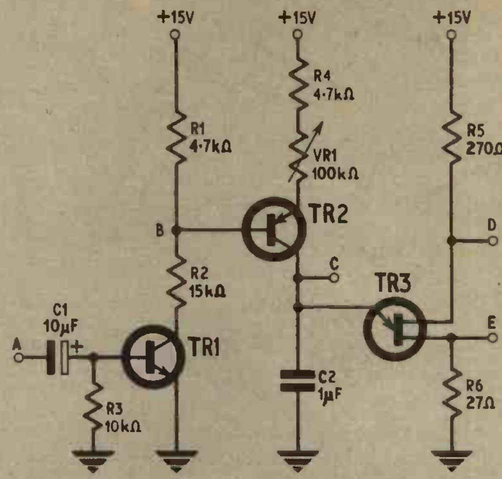


Fig. 18. Step waveform generator

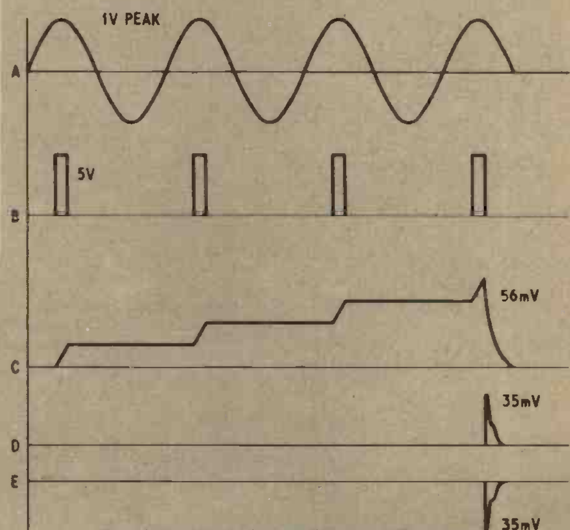


Fig. 19. Waveforms for Fig. 18 circuit

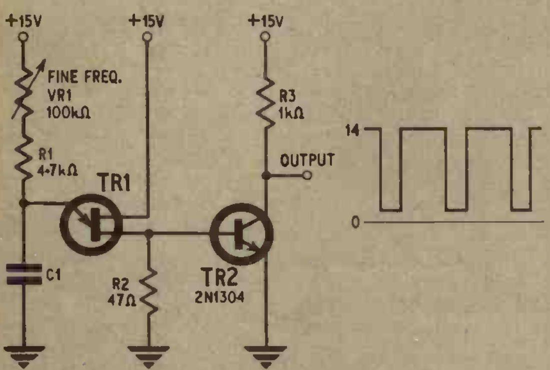


Fig. 16. Pulse generator

C μF	f kHz	PULSE WIDTH μ sec	RISE & FALL TIME μ sec
0·1	·120 3	15	0·5
0·047	·330 6	10	0·5
0·01	1 20	5	0·5
0·0047	3 40	5	1
0·001	12·5 180	4	1

Fig. 17. Table of capacitor values

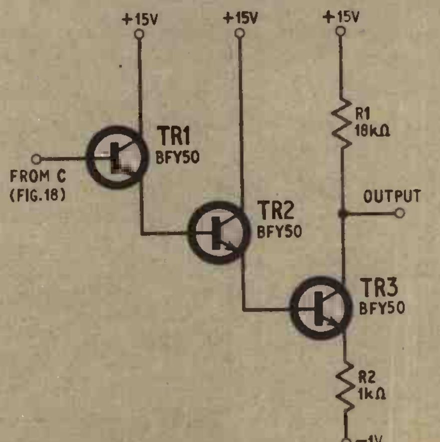


Fig. 20. Compound emitter follower amplifier

Point C is the step waveform output and this may be fed to the circuit of Fig. 20 which provides a high input impedance and amplifies the signal. Points D and E provide antiphase output pulses which may be fed to the circuit of Fig. 21 and amplified.

The potentiometer VR1 in the emitter of TR2 enables the number of steps to be varied from 1 to 100; this means that the output frequency may be up to 100th of the input. A step linearity control may be added between the emitter of TR3 and the 15 volt line. It will be in the order of 10 megohms and enables the increased slope of the step to be compensated for on the last few steps prior to the u.j.t. firing. If a germanium transistor is used for TR2, the circuit will still divide satisfactorily, but the step waveform will have sloping steps.

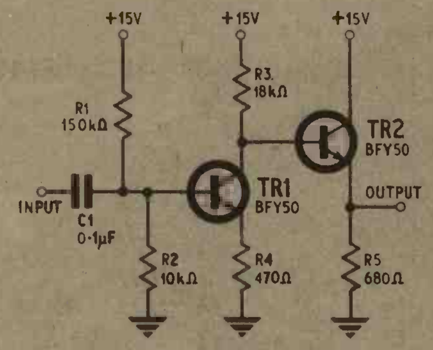


Fig. 21. U.J.T. pulse amplifier

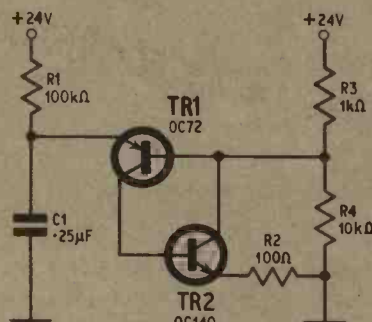


Fig. 22. Simulated u.j.t. astable circuit

SIMULATED U.J.T.

The action of the u.j.t. may be simulated by a *pnp* and an *npn* transistor connected as in Fig. 22. This may be used by those who would like to try circuits before investing in some unijunction transistors. The characteristics are not the same, but the circuit function is similar.

The u.j.t. is a very useful device for use where a minimum of components and space are necessary. The code of the particular u.j.t. used in the circuits shown here is 2N2160, and the approximate cost is 16s. each. Other codes include 2N489, 2N491, 2N492, 2N494, 2N1671, 2N2646, 2N2647.

Manufacturers of the device 2N2160 are: International Rectifier Co. Ltd., Hurst Green, Oxted, Surrey, and Texas Instruments Ltd., Manton Lane, Bedford. ★

PHOTOFLASH SLAVE UNIT

continued from page 184

The battery is a Mallory mercury type PX23 and the connections are made by cementing a small piece of printed circuit board to the side of the case, using this as one terminal, and bolting into the case a piece of springy brass to make the other terminal. This can be seen in the general assembly diagram Fig. 4.

FLASH GUN LEADS

The flash leads to the slaved flash gun are terminated in the usual 3mm coaxial socket. Note that the connector is a socket similar to the one on the camera. It is possible to purchase these sockets from photographic dealers and make up a lead, but Boots the Chemists sell a flash extension lead at a very modest price and this can be cut to a suitable length and the appropriate end used for the slave unit.

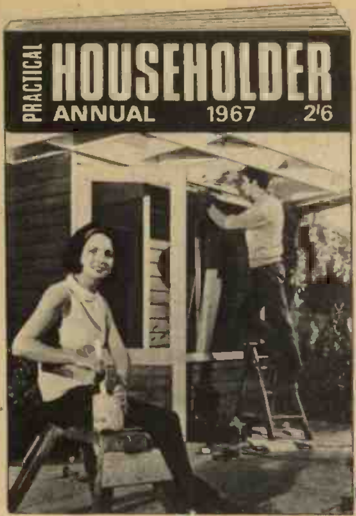
As mentioned before, it is essential that the positive flash trigger lead is connected to the thyristor anode. It is a simple matter to check the polarisation of the trigger leads of the flash gun to be used and arrange that the connections are made correctly. If the constructor is building the slave for use with his own equipment only, it is easy to ensure that the connections are correct. If the slave is required to accept any other flash gun it is necessary to make up a reversing lead consisting of a male and female connector so wired that the centre pin of one connector is wired to the case of the other and vice versa. Here again, it is possible to buy both types of coaxial connectors but it is easier to buy an extension lead, cut it to a suitable length and rejoin the wires the opposite way round. No damage will be done to either the slave unit or to the flash gun if connections are the wrong polarity, but the slave will not function.

The writer has found that there is no accepted standard amongst the manufacturers of flash guns as to which terminal (the centre pin or the case) is positively polarised; indeed, some manufacturers have made different models of their flash guns with the leads differently polarised and one must either check the polarity with a meter or proceed by trial and error. Note that a meter will not measure the actual voltage on the terminals of the flash gun but it will give sufficient indication to determine the polarity. Capacitor flash guns using expendable bulbs have a fairly standard 22½ volts on the leads but electronic flash guns may show voltages up to 250V.

RELIABLE AND EFFICIENT

It may be of interest to relate that a couple of these units have been used during a photo club outing, when reliable triggering was obtained in the open air at 8 p.m. mid July at distances in excess of 50 yards.

Of the half dozen units which the writer made for his own use, in almost two years it has not yet been necessary to change any of the batteries and no snags have arisen in their practical use. Each unit weighs just under 2oz and they are small enough to pack into the pocket or gadget bag without any trouble. On the very few occasions when the slaved flash has failed to trigger it has been found that the reason was always in the actual connector. Unfortunately there is no practical alternative to the standard coaxial connector and it behoves the constructor to ensure that the wiring to the connector is good and that the plugs and sockets are pushed well home. ★



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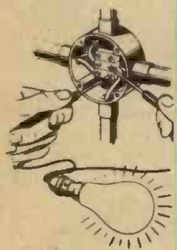

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Having some experience in radio and electrical wiring, I could perhaps construct such a device myself, if there is not one on the market. Any help in the matter would be much appreciated.

W. J. McFerran,
Newtownards,
N. Ireland.

All fluorescent lighting systems of proprietary makes are suppressed against radio and electrical interference to the minimum degree required by law. In the event of any system causing excessive interference due to working in an area of weak signal strength, special precautions can be taken, but each case will need to be investigated on its own merits. The Post Office are glad to help in cases of this kind.—G.J.K.

Stage effect

Sir—Your *Integrated Stereo Amplifier* in the December 1966 issue looks very impressive, and I shall probably decide to build it. Particularly interesting is the use of the field effect transistor in the input stage, which I shall certainly incorporate.

Is the circuit for the f.e.t. stage correct as published? I am puzzled by the resistor R10 value 47kΩ. I would have thought the input impedance of TR3 was about 1 kilohm, in which case the 47kΩ resistor in series with the input would produce a serious loss of signal. I cannot think that this was intended, as the loss would have been better used in more negative feedback, for example by omitting the by-pass capacitor C7.

If 47kΩ for R10 is correct could you please explain its function.

G. W. Waters,
Oxford.

There is considerable attenuation due to the inclusion of R10 in the base of TR3. The reason for this is that this circuit preceeds the volume control circuitry and it is very difficult to cater for the very wide range of transducers that may be used and the output of some of these elements may be in the order of 1V or more, and others in the order of 50mV.

Therefore, there has to be sufficient gain to amplify the lower output units and at the other end of the scale the high output device must not be in a position to overload this circuit. In order to preserve both the d.c. and a.c. parameters it was found necessary to isolate the devices to some degree due to the rather wide variation in the action of the more economical type of f.e.t.

The other problem lies in the lower frequency stability factor where if further feedback is applied over a circuit, when part of a high gain unit that is dissipating large power output, the amplifier tends to oscillate at very low frequencies. The inclusion of C7 reduced the bass response of the amplifier below approximately 5Hz, consequently assisting in the reduction of this type of hazard.—R.H.

The British Amateur Electronics Club

Sir—This club was founded to enable all who are interested in electronics as a hobby to get together, both directly and through the Newsletter, and learn about electronic devices through experiments and technical films. A special scheme has been devised for the benefit of the members in other parts of the country who cannot attend the meetings held in Penarth, so that they can participate in the activities of the club.

The first anniversary dinner and social evening was held at the Queens Hotel, Cardiff on January 21, 1967. It is hoped to hold an anniversary dinner every year so that members and their wives can criticise the past and plan the future of the club.

The membership fee is 10s per year and currently meetings are being held at the Penarth Secondary School, St. Cyres Road, Penarth at 7 p.m. on Thursdays, and all readers who are interested or would like further details should write to me at the following address:

C. Bogod, "Dickens", 26, Forrest Road, Penarth, Glam.

Post-haste, please!

Sir—Among the more brilliant of the ideas thought up by the firms who advertise in PRACTICAL ELECTRONICS are priced lists covering the various construction projects. The object is defeated however if the items priced are not available or competitive in price, and here are two such examples.

Firm number one still owes me a 10 kilohm preset potentiometer—that was three months ago. A reminder from me was ignored, but he is still advertising. Firm number two took two weeks to send me lists and the items I sent for have still not arrived after a further ten days, so there are two firms that I will not deal with in future.

A further complaint concerns prices and their diversity. OC20 transistors cost 50s each from one source, but 10s each from another; 2N2160 u.j.t. 25s from one source, but 15s from another. Why is this?

The cheaper items bought were not listed as substitutes and I find most firms very honest about this, so why this large disparity in price?

Generally speaking, the larger firms are pretty rapid on postal transactions, but there are still too many who nullify their good ideas and ingenuity by poor follow up.

In conclusion I would be glad if you would publish a summary of my "moans", it might wake up some of the culprits and we might all be better off as a result.

H. M. Sherry,
Llanfwrog,
Anglesey.

We understand that quite an enormous amount of business is transacted through the post by these firms and it is not altogether surprising that slip-ups do on occasion occur, although we do agree this is very irksome and disheartening to the individual concerned. Perhaps part of the explanation lies in the fact that these advertisers have to obtain their goods from manufacturers or wholesalers. It well may be that difficulties in supply of particular components are beyond their own control.

We do not pretend to know the complete answer to this question of wide discrepancy in transistor prices. Undoubtedly, there are many different outlets. Sometimes manufacturers have to dispose of surplus stocks and enterprising dealers manage to acquire large quantities at very reasonable prices; some of these they sell direct to individuals at rock bottom prices and some they pass on in bulk to other retailers who naturally have to add their own profit margin before selling these to readers.

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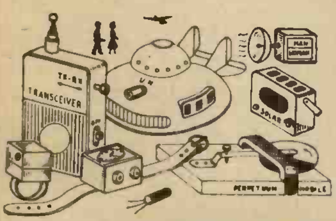

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2N1304/2N1305, 9/- 2N2926/2N3702, 9/- 2N3705/2N3702, 11/2 2N3053/40319, 27/6

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BC108 20V, β125-500 6/3.
BC109 20V, β240-900 (low noise) 7/3. Resistors ½W 5% carbon film 2/3 doz. 17/3 100. Skeleton presets 100Ω to 10MΩ. Horizontal or vertical mounting 1/-. Disc ceramics, 50V, ·01 5d, ·02, ·05 6d.

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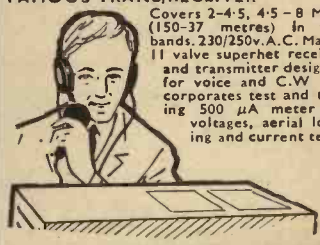

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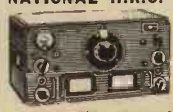

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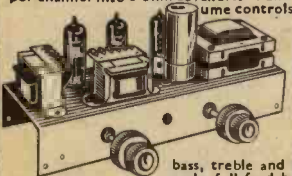
Incorporating 2 ECL86s and 1 EZ80, heavy duty double wound mains transformer. Output 4 watts per channel into 3 ohm speakers. Full tone and volume controls. Absolutely complete.



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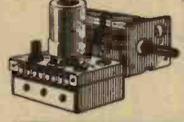

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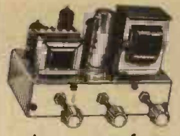
3-VALVE AUDIO AMPLIFIER MODEL HA34

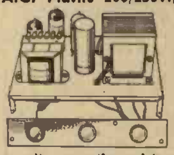


Designed for Hi-Fi reproduction of records. A.C. Mains operation. Ready built on plated heavy gauge metal chassis, size 7½in. w. x 4in. d. x 4¾in. h. Incorporates ECC83, EL84, EZ80 valves. Heavy duty, double wound mains transformer and output transformer matched for 3 ohm speaker, separate Bass, Treble 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

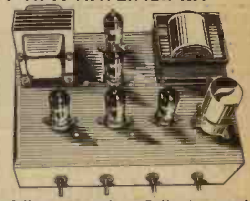


★ Heavy duty double-wound mains transformer with electrostatic screen. ★ Separate Bass, Treble and volume controls, giving fully variable boost and cut with minimum insertion loss. ★ Heavy negative feedback loop over 2 stages ensures high output at excellent quality with very low distortion factor. ★ Suitable for use with guitar, microphone or record player. ★ Provision for remote mounting of controls or direct on chassis. ★ Chassis size only 7½ in. wide x 4 in. deep. Overall height 4¾ in. ★ 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 lists 2/6 (free with kit).

This kit although similar in appearance to HA34 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. Carrying Case for above 28/6. P. & P. 7/6.

MATCHED PAIR AM/FM I.F.'s. Comprising 1st I.F. and 2nd I.F. discriminator. (465 Kc/s/10.7 Mc/s). Size 1" × 1¼" × 2½" H. Will match FM/AM Tuner head on left. 11/- pair. P. & P. 2/-.

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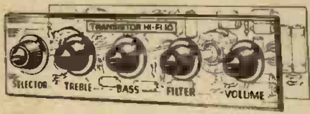

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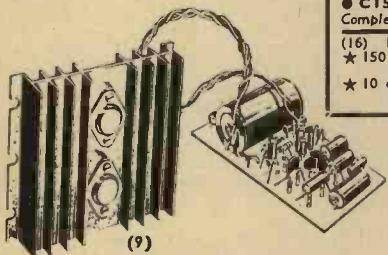

(9)

12 AND 20 WATT MONO AND STEREO TRANSISTOR AMPLIFIERS

(9) POWER AMPLIFIERS. 12 watts RMS output. 100mV input. 30 c/s to 20 k/cs ± 1dB. 6-Transistor Push-pull. Panel size 4 × 2½ × 1 in. H/S 4 × 4in. Leaflet on request.
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MPA10/15 8-16 ohm spkr. £5.5.0, p.p. 2/6
(Mains unit 1 or 2 amplifiers, 59/6, p.p. 2/6)

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25 WATT AMPLIFIER
8-Transistor design. Push-pull output for 7½ to 16 ohm speaker. 150mV input. 30c/s to 20k/cs ± 1dB. For use with valve or transistor pre-amplifiers as item (10) above.
PRICE BUILT AND TESTED £7.19.6 P.P. 3/-
(Mains unit 79/6. p.p. 2/6)

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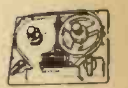

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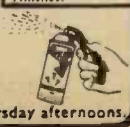

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