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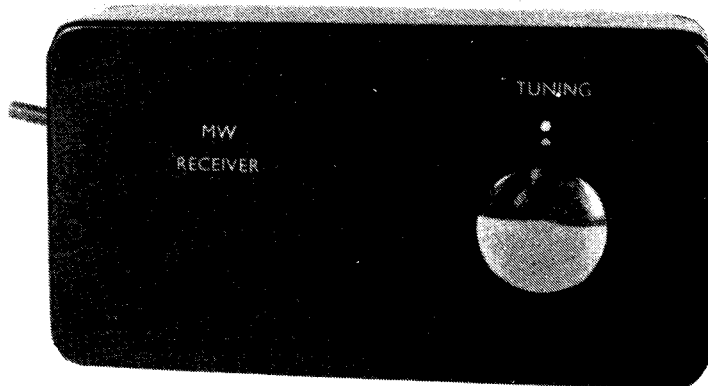
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# 3 TRANSISTOR



## MEDIUM WAVE RADIO

By A. P. Roberts

**SIMPLE DESIGN ● EASY TO CONSTRUCT**  
**STANDARD COMPONENTS**

This article describes a very simple medium wave radio which is designed for use with a crystal earphone but is otherwise self-contained. The set is quite small, measuring about 120 by 65 by 40mm., standard and readily available components are used and construction is easy and straightforward.

### THE CIRCUIT

Although a superhet receiver can provide superior performance to a simple t.r.f. type, the complexities of such a receiver make it impractical for an application such as this. The set described here is therefore of the t.r.f. (tuned radio frequency) type.

The two main deficiencies of t.r.f. receivers are the limited sensitivity and selectivity (the ability

to pick out just one of two or more closely spaced stations) that can be obtained. This type of receiver often suffers from a comparatively poor signal-to-noise ratio as well. Selectivity can be improved by the use of regeneration, but even then the level of selectivity can never be equal to that of a superhet. Even so, it is usually quite adequate. In the author's extensive experience with t.r.f. designs he has found that sensitivity and signal-to-noise ratio are best when a large amount of r.f. gain and little or even no a.f. amplification are used. (Conventionally, it would be expected that the gain distribution should be the other way round.)

With these facts in mind, the circuit of Fig. 1 was devised. This consists of two r.f. amplifiers (TR1 and TR2) and a transistor detector (TR3). No audio stage is incorporated.

RADIO AND ELECTRONICS CONSTRUCTOR

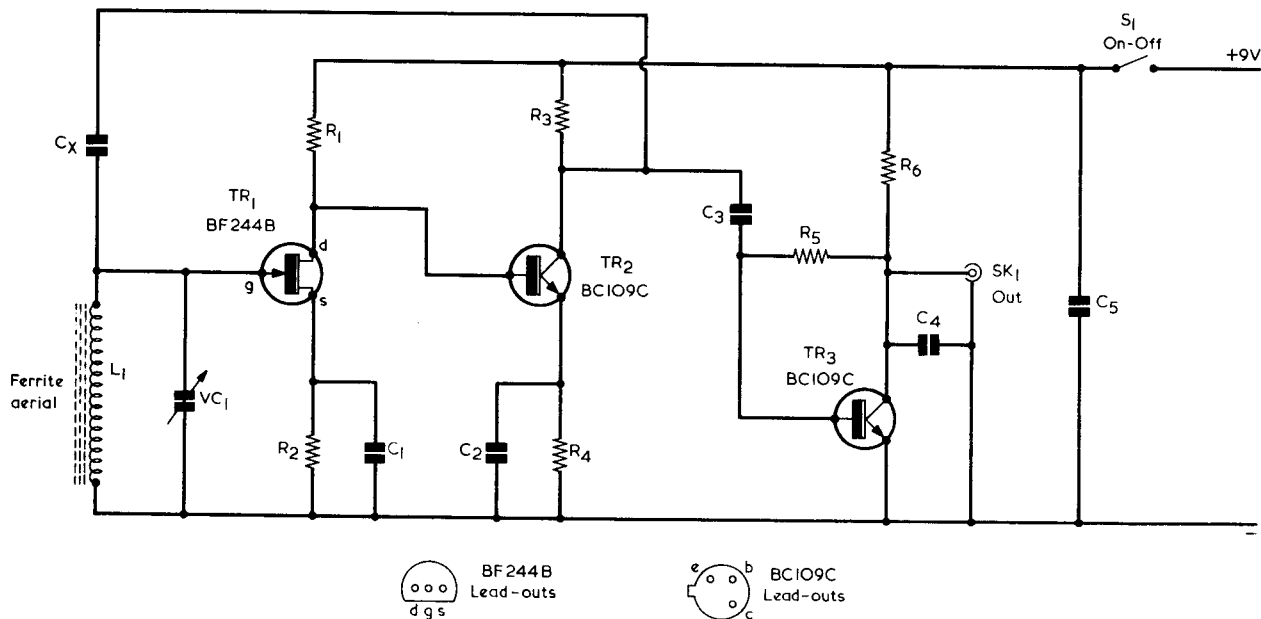


Fig. 1. The circuit of the 3-transistor medium wave receiver. As can be seen, very few components are required

## COMPONENTS

### Resistors

(All  $\frac{1}{4}$  watt 10%)

- R1 4.7k  $\Omega$
- R2 5.6k  $\Omega$
- R3 220  $\Omega$  (see text)
- R4 4.7k  $\Omega$
- R5 1.8M  $\Omega$
- R6 4.7k  $\Omega$

### Capacitors

- C1 0.01 $\mu$ F type C280 (Mullard)
- C2 0.01 $\mu$ F type C280 (Mullard)
- C3 0.047 $\mu$ F type C280 (Mullard)
- C4 0.022 $\mu$ F type C280 (Mullard)
- C5 0.1 $\mu$ F type C280 (Mullard)
- CX see text
- VC1 300pF variable, "Dilecon" (Jackson)

### Semiconductors

- TR1 BF244B
- TR2 BC109C
- TR3 BC109C

### Switch

- S1 s.p.s.t. miniature toggle

### Socket

- SK1 3.5mm jack socket

### Miscellaneous

- Plastic case, 120 x 65 x 40mm. (see text)
- Ferrite rod, 4 $\frac{1}{2}$ in. x  $\frac{3}{8}$ in. diameter (see text)
- 32 s.w.g. enamelled copper wire
- Crystal earphone with 3.5mm jack plug
- 9 volt battery type PP3 (Ever Ready)
- Battery connector
- Large control knob
- Plain perforated s.r.b.p. panel, 0.1in. matrix
- Wire, solder, etc.

TR1 is a Jufet which is used in the common source amplifying mode. A Jufet transistor has an extremely high input impedance, and so the ferrite aerial, L1, can be coupled direct into its gate circuit without using a coupling winding. A secondary function of L1 is to connect TR1 gate to the negative supply rail, and thus provide gate biasing. VC1 is the tuning capacitor, and this provides coverage of the entire medium wave band.

R2 is the source bias resistor for TR1, and C1 is the bypass capacitor. The output signal is developed across the drain load resistor, R1.

The second r.f. amplifier uses TR2 in the common emitter configuration, and this stage is direct coupled to TR1. R4 is the emitter resistor and C2 its bypass capacitor. TR2 obtains its base bias potential from the drain circuit of the previous stage. The output signal is developed across collector load resistor R3.

Both TR1 and TR2 invert the signal between their input and output circuit points, with the result that TR1 gate and TR2 collector are in phase. Regeneration, which consists of coupling some of the output of an r.f. amplifier back to the input in phase, can therefore be given by way of the capacitor, CX. As would be expected, the regeneration increases the amplifier gain. It also improves selectivity, as it effectively increases the efficiency of the tuned circuit given by L1 and VC1.

In practice CX is not a physical capacitor, as an extremely low value of capacitance is required here. CX is comprised largely of stray capacitance, and adjustment is given by an insulated wire from TR2 collector which is positioned near the gate circuit of TR1. More details of this arrangement are given later on. Regeneration can alternatively be controlled by varying the value of R3 and, again, this process is described later.

## DETECTOR

TR3 is connected as a straightforward common emitter amplifier, but it operates as a simple a.m. detector. R6 is the collector load resistor and R5 provides base biasing. C3 couples the output from TR2 collector to the base of TR3.

This type of detector relies upon the fact that the transistor does not provide linear amplification. In this case the transistor will amplify positive half-cycles at its base more than negative half-cycles, since the gain of the transistor tends to increase as its collector current increases. In this way, TR3 provides an elementary, but nevertheless effective, form of rectification and thus detects the r.f. signal at its base. C4 bypasses the r.f. signal content at TR3 collector, leaving the desired a.f. signal.

Usually, a detector of this type would appear in a circuit offering regeneration in order that the non-linear amplification could be heightened and the detection efficiency increased. Such a treatment is not necessary here as the detector is handling a fairly high level signal and this, in itself, results in high differences in the gain on positive and negative half-cycles. In consequence, the detector is able to operate quite efficiently without regeneration.

The non-linear effect can be clearly shown by measuring the d.c. potential at the collector with respect to the negative supply rail, and then tuning across a strong station. This will produce a very noticeable dip in the meter reading as the set is tuned to the station.

S1 is the on-off switch and C5 provides supply decoupling. The output signal at TR3 collector is taken direct to the output socket without a series d.c. blocking capacitor. There is no need for such a capacitor as a crystal earphone has a very high d.c. resistance and it will not adversely affect the operation of the detector. At the same time, the small direct output voltage will not upset the functioning of the crystal earphone.

Power is obtained from a PP3 9-volt battery. This has an extremely long life as the current consumption of the set is only slightly in excess of 2mA.

## COMPONENTS

A few comments need to be made concerning the components. The variable capacitor, VC1, is a solid dielectric, "Dilecon" Jackson component, and is available from a number of suppliers. The transistor type BF244B specified for TR1 can be obtained from Electrovalue Ltd. Any plastic case measuring about 120 by 65 by 40mm. or larger may be employed.

The ferrite rod may need to be obtained from a longer rod, and further details here are given in the next section of this article.

## FERRITE AERIAL

The ferrite aerial is home-wound and employs a ferrite rod having a diameter of  $\frac{3}{8}$  in. and a nominal length of  $4\frac{1}{2}$  in. The rod does not need to be precisely  $4\frac{1}{2}$  in. long but its length should not be less than  $3\frac{1}{2}$  in. or too great to allow it to be fitted inside the case.

If a rod of suitable length cannot be obtained, it can be broken from a  $\frac{3}{8}$  in. diameter rod of greater length. The ferrite metal is hard and brittle and the breaking process has to be carried out with care. First file a sharp groove all round the circumference of the rod at the point where it is to be broken, using a triangular file. Then tap the rod lightly against the edge of a wooden bench, whereupon it will break at the point where the groove has been cut. The broken end will not present a neat appearance, but any roughness here will not affect performance.

Fig. 2 gives details of the ferrite aerial, which is wound with 32 s.w.g. enamelled copper wire. The winding starts  $\frac{1}{4}$  in. from one end of the rod, the lead-out wire being held in position by a band of p.v.c. insulating tape wrapped round the rod. 80 turns of the wire are then wound side-by-side, after which the remaining lead-out wire is secured by another band of insulating tape. Try to make the winding as neat as possible, so that it has closely spaced turns in a single layer. The lead-out wires should next be cut so that they are about 2 in. long; their ends are then scraped clean of enamel and tinned with solder.

## CONSTRUCTION

Most of the components are assembled on a plain perforated s.r.b.p. panel of 0.1 matrix having 31 by 20 holes. Details of this panel, as well as of the remainder of the wiring, are given in Fig. 3.

Commence construction of the panel by cutting out a piece of the appropriate size using a hacksaw. Be careful when doing this as some types of board are rather brittle, and can shatter if sawn roughly. Next, the 10mm. diameter mounting hole for VC1 is drilled, after which the components are mounted in position with their lead-outs bent flat against the underside of the panel. They are then soldered together in the fashion shown in Fig. 3. The component lead-out wires should be long enough to

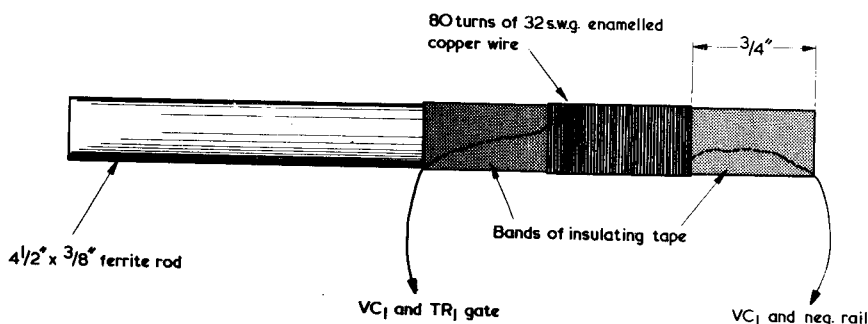


Fig. 2. How the ferrite rod aerial is wound

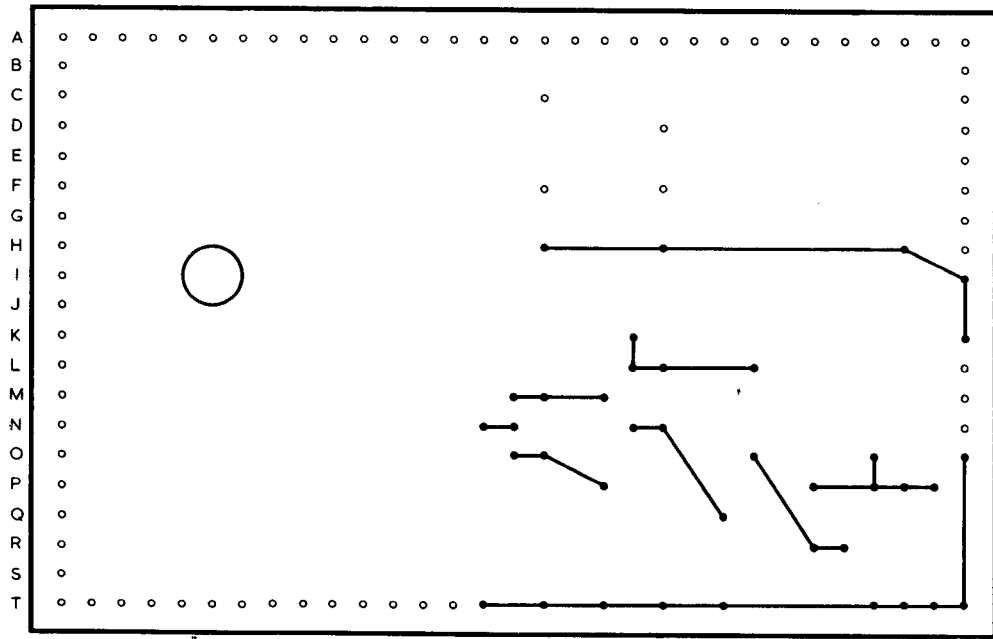
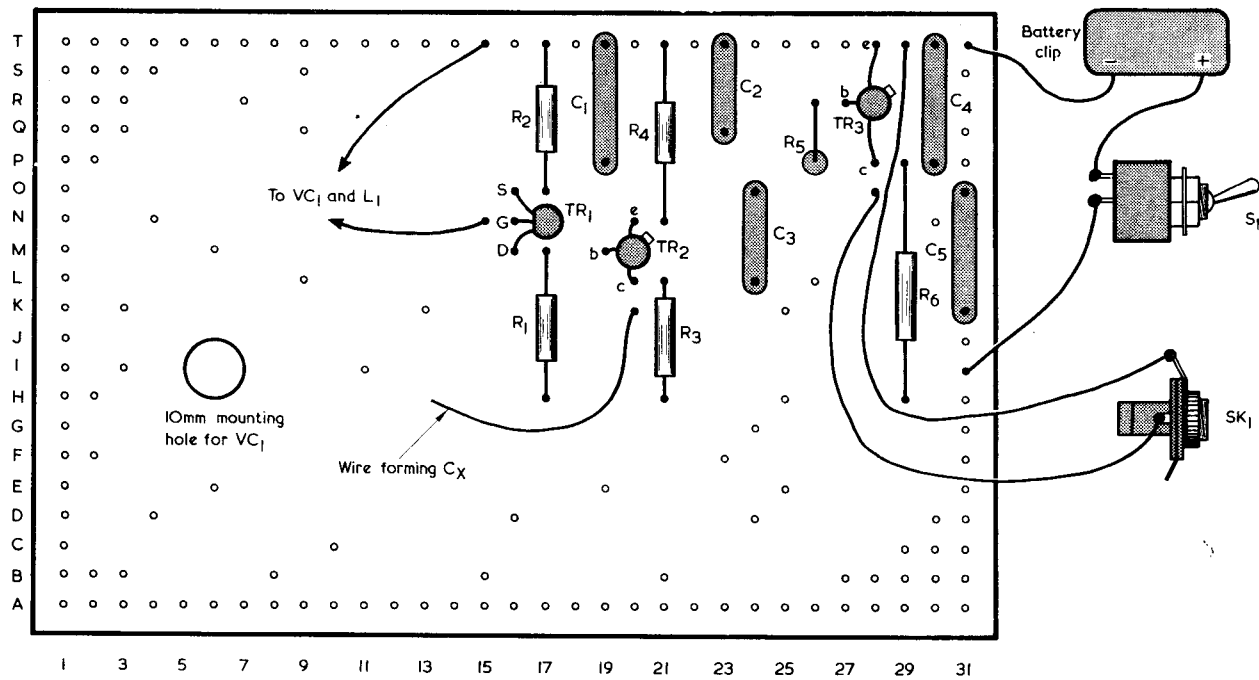


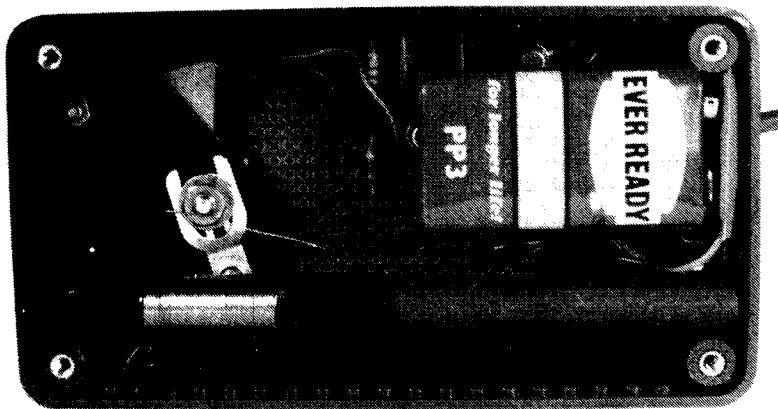
Fig. 3. Wiring diagram for the 3-transistor radio. Most of the components are assembled on a perforated s.r.b.p. board. The text gives details of the connections to VC1

enable all, or nearly all, of the wiring to be completed, but if necessary tinned copper wire of around 22 s.w.g. can be used to bridge any gaps. Of the two wires connecting to VC1 and L1, that from the gate of TR1 connects to the fixed vanes of the variable capacitor and that from the negative supply rail connects to the moving vanes tag. The two leads from the ferrite aerial winding also connect to the variable capacitor tags. When the ferrite aerial is mounted in the case the winding will be at the same end as the variable capacitor, as can be seen in the photograph of the case interior. The lead-out at the end of the rod connects to the capacitor moving vanes tag and that nearer the

centre of the rod to the capacitor fixed vanes tag. The output socket, the switch and the battery clip are connected to the board by way of thin flexible insulated wires.

It is a good plan to test the receiver assembly before it is fitted in the case by connecting these external components and temporarily securing VC1 to the board. The wire which forms part of CX should be about 1¼ in. long and should consist of a single strand insulated lead which is fairly stiff. It should be initially positioned so that it is well away from the gate of TR1 and the lead from the gate which connects to VC1.

The earphone is plugged in and the set switched



*Looking inside the case with the rear cover removed*

on, whereupon it should be possible to tune in several stations. An attempt to improve performance can then be made by positioning the CX lead closer to TR1 gate and the gate lead to VC1. This will increase regeneration and produce enhanced selectivity and sensitivity. If the lead is taken too close to the TR1 gate circuit the regeneration level will be too high and there will be whistles at some part of the band as the receiver is tuned through stations. The desired setting for the CX lead is that which is just short of allowing those whistles to occur.

If transistors with exceptionally high gain figures are employed, it is possible that performance will be adequate with the CX lead well away from the TR1 gate circuit. Should this be the case it will possibly be found that there is no reduction in performance if the lead is simply removed.

An alternative, and in some ways, better approach is to omit the CX lead and experimentally increase the value of R3. Different increasing values may be tried until whistles are produced with stations, whereupon the desired value for R3 is that which is just below the value which causes the whistle to occur. The advantage of this approach is that increasing the value of R3 not only increases regeneration but also the gain of the second r.f. amplifier stage. It has the obvious disadvantage that it necessitates soldering into and out

of circuit a number of resistors, and that it presupposes that the constructor has a stock of spare resistors. Constructors who are unused to experimental work of this nature are advised to fit the specified value for R3 and to employ the approach which involves moving the CX lead.

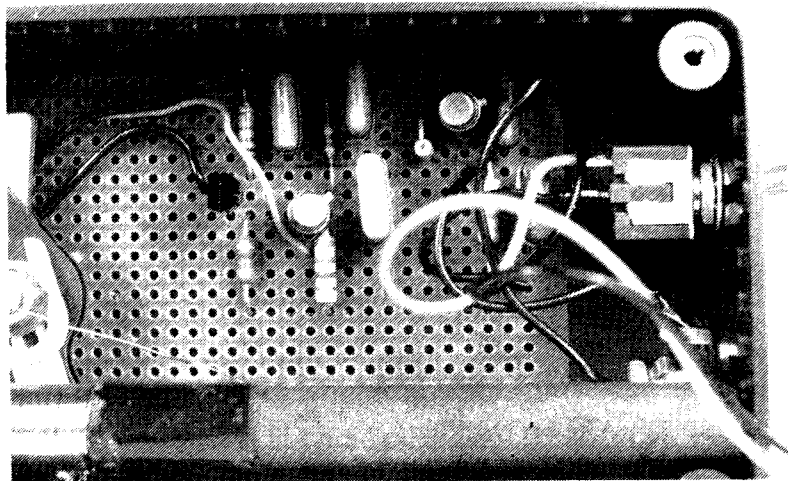
All adjustments for regeneration, either with the CX lead or by varying the value of R3, should be carried out with a new battery connected to the receiver.

#### CASE

When it has been confirmed that the set is performing satisfactorily, it may be installed in the plastic case. The general layout can be seen in the photographs, and it is recommended that this layout be followed.

VC1 is mounted at the right hand end of the front panel, as seen from the front. Its threaded bush passes through the 10mm. hole in the component board, several washers are placed over the bush and this then passes through a 10mm. hole in the front panel of the case. The securing nut finally passes over the protruding end of the bush, and is tightened up. Thus the component board is held in place inside the case by the mounting of VC1. The washers between the component board and the inside surface of the case front panel provide spac-

*The parts assembled on the perforated component board*

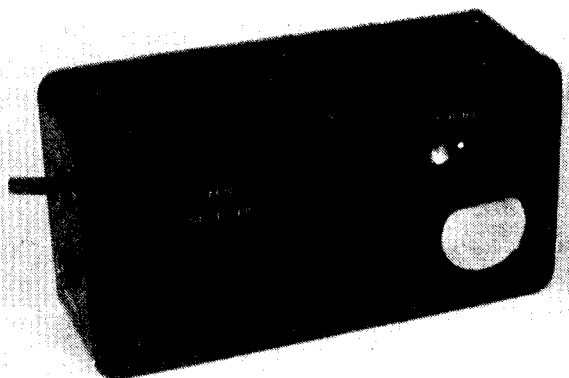


ing. If they were not fitted the component board would be strained and could break as the mounting nut of VC1 is tightened.

S1 and SK1 are mounted on the left hand end panel of the case, with S1 above SK1. They should be positioned fairly close to the front so that there is room between S1 and the case back panel for part of the battery. With the prototype the ferrite rod was a tight push fit inside the case and required no further mounting. With other sets it will almost certainly be necessary to devise a simple mounting, and this can consist of a small block of wood drilled with a hole through which the ferrite rod passes. The rod is secured to the wood block with adhesive and the block, in turn, is glued to the inside of the case. The rod should not be mounted with metal brackets, particularly if these cause the rod to be completely encircled by metal, as this would constitute a "shorted turn" and seriously reduce performance.

If the CX lead approach has been employed for control of regeneration, the lead should be given a final adjustment after all the parts have been installed in the case.

The battery fits behind the component board and S1, a piece of foam plastic being interposed



*Three-quarter view of the radio, showing the switch and output socket mounted at the left hand end of the case*

between it and the components on the board. A further piece of foam plastic between the battery and the rear cover will hold the battery in place when the cover is fitted. ■

# BOOK REVIEW

**THE FABULOUS PHONOGRAPH 1877-1977.** By Roland Gelatt. 349 pages, 215 x 135mm. (8½ x 5½in.) Published by Cassell and Company Ltd. Price £6.50.

"Mary had a little lamb." As most of us know, these were the first recorded words on earth, shouted by Thomas Alva Edison in 1877 into the horn of his experimental phonograph on which whirled a tinfoil covered cylinder. The sound impinged on a diaphragm to give hill and dale indentations in the tinfoil, these being reproduced when the cylinder was once more rotated. From that incident sprang the whole history of mechanically reproduced sound, culminating 100 years later in the standard stereo microgroove disc.

Although Edison originally intended his "talking machine" to be employed for commercial business use, it was not long before popular demand caused it to enter the entertainment field. A description of a recording session in the early Nineties makes delightful reading. Ten huge cylinder phonograph horns are directed, in a circle, at a regimental band. The title of the item is announced in stentorian tones into each horn in turn, after which the band strikes up with all cylinders in motion. When it appears that the cylinders have taken nearly all the music they can hold the band simply stops at the end of the next musical phrase. Ten new cylinders are then loaded on the machines and the procedure is repeated over and over again as the day proceeds.

It was Emile Berliner who, in 1887, started the development of the lateral cut disc which was to oust the cylinder and lead to records which could be pressed from a single master. But these are only small individual items to be gleaned from this eminently readable book, which traces not only the technical achievements which continually improved the acoustic performance of the gramophone but also the fortunes of the companies and the people who were responsible for its financial viability. We are taken well up to modern times and in 1963, for instance, we find the major record companies trying to evaluate a market taking in such best-sellers as Elvis Presley. And then, states Mr. Gelatt, "the Beatles appeared and all bets were off."

The book includes 32 pages of photographs, and it offers a fascinating wealth of detail on the advances in mechanical recording which stemmed from Edison's original tinfoil phonograph.

## NEW KIT EDITS AND REPAIRS CASSETTES

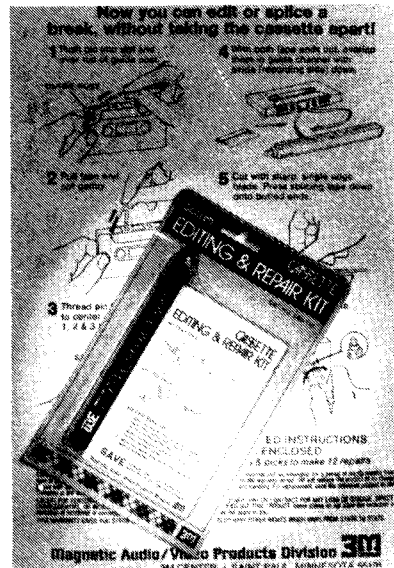
Have you ever had the misfortune to suffer from a jammed or broken cassette tape — your favourite top pop or expensive orchestral concerts unplayable, perhaps even irreplaceable?

If so, 3M United Kingdom Ltd. have just introduced the very thing to get you out of trouble: the Scotch Cassette Editing and Repair Kit.

This — like all brilliant ideas — is simple, and is easy to use, because the cassette does not have to be unscrewed and opened for the tape to be repaired. Furthermore, it can be used for editing recorded tapes.

The kit consists of a pencil-like splicing block that contains adhesive-tipped polyester strips. These strips are inserted into the cassette, and pick up the tape ends. Splicing is simplified by means of splicing tabs and cutting guides at 45° for normal splicing and 90° for close editing, giving a professional finish.

The Scotch Editing and Repair Kit is now available from outlets where records are sold, major department stores and hi-fi equipment retailers. The suggested retail price is £1.52 + VAT.



## FERRANTI I.C. COMPETITION

The Ferranti "Win A Rollei" competition for integrated circuits application designs, was enthusiastically received and from an initial response of over 800, a short list of 45 entries was prepared, 15 for each product. Class winners each received a Rollei A110 camera currently worth £100.

For the competition, Ferranti chose three of their integrated circuits.

The first the ZN425E, an 8 bit dual mode A-D/D-A converter which includes not only the R-2R ladder network and precision switches, but also a 5MHz counter and a 2½V precision voltage reference.

The second the ZN1034E, a precision analogue timer which covers timing periods from milliseconds to weeks, and which features high current drive with low internal current consumption; it is capable of repetitive or cascade operation and can work directly from a battery or any mains voltage.

The third the ZN1040E, a universal 4 digit display counter, this is capable of counting from DC to 8 MHz with direct interfacing to LED displays; it has up to 80mA drive per segment and includes such functions as automatic multiplexing, automatic zero suppression, power on reset, and cascading by direct connection.



The judges and prizewinners of the Ferranti "Win a Rollei" competition for integrated circuit application designs

## RADIO & ELECTRONICS EXHIBITION

This is the title adopted by the Northern Radio Societies for their annual exhibition to be held at Bell Vue, Manchester on Sunday 2nd April commencing at 11 a.m.

The organisers, who represent various radio societies in the North of England, recognise that there is a growing trend towards the use of micro-processors in amateur radio and this interest will be catered for particularly by some of the trade exhibitors.

As in previous years — amateur radio and communications equipment will still constitute the larger part of the exhibition, and a considerable number of components suppliers will also be represented.

NRSA club members will have their own individual club stands. Some of these will be showing home construction projects and a trophy will be awarded for the best club stand.

Other highlights will include a Grand Raffle, an Inter-Club Quiz, a Construction Contest and exhibits by the Radio Amateurs' Emergency Network (RAYNET) and UKFMGW and NWRG radio repeater groups. (For the Construction Contest rules send a stamped addressed envelope to: Mr. John D. Clifford, 22 Jubilee Court, Bramhall Drive, Holmes Chapel, Crewe, Cheshire CW4 7HA).

Talk-in facilities will be provided for FM mobiles on 145 MHz channels S22, S0, R6 and on 433 MHz channels SU8, SU20, RB4 and RB14 via GB3NRS and G8NRS/A.



# COMMENT

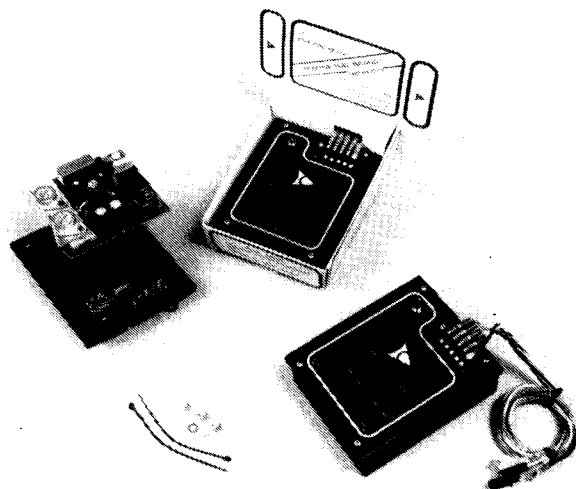
## ELECTRONIC IGNITION KIT

Automotive electronic ignition is rapidly gaining popularity as more people realise the benefits that it has to offer. These include optimum economy and performance, easier starting and reduced maintenance.

Generally however, if you require a good system to fit to your existing car, then you have to buy a unit priced between about £23 and £40. Now Surefire Electronic Systems, who sell their ready built capacitive discharge system for £31.50 plus VAT, are offering it in kit form for only £15.75 and this figure includes VAT, post and packing.

This unit includes a switch enabling you to switch from electronic to conventional ignition or to isolate the ignition circuit completely as an anti-theft device. The unique feature of the Surefire unit is a plug-in circuit module. If for any reason the unit needs servicing then only the circuit board has to be returned to Surefire leaving the case still on the vehicle and the car running on conventional ignition. The board and edge connector contacts are all gold plated for reliability.

A great deal of thought has gone into the preparation of this kit as it includes all of the components needed and even the solder. All information that one could want is supplied for assembly



The Surefire electronic ignition system. Left to right — inside of lid with plug-in circuit module, unit in box, complete kit

and fault finding, from a circuit diagram to an operation description. All parts are covered by a twelve-months guarantee.

The kit is available from: Surefire Electronic Systems, Piccadilly Place, London Road, Bath BA1 6PW.

## POLDHU 75th ANNIVERSARY MESSAGES

As reported in *Radio Topics* in this issue, the 75th Anniversary of the first two-way radio communication with the USA was commemorated with messages from US President Jimmy Carter and Italian President Giovanni Leone and were received on 19th January by the Cornish Radio Amateur Club radio station, GB3MSA, at Poldhu, Cornwall.

75 years previously President Theodore Roosevelt first used the Marconi wireless to send a message to King Edward VII from a station in Cape Cod and Edward VII replied via the Poldhu station in Cornwall.

President Jimmy Carter, in his message from The White House, after quoting the text of the 1903 messages said:

"That exchange marked a milestone in the history of communications. Since then we have built on the invention of the distinguished Italian physicist Guglielmo Marconi and others, a global communication system that allows instant contact, not only between Heads of State, but people of all Nations. In recalling that historic message, it is fitting that we commemorate that event both with gratitude for the way in which science and engineering have helped to unite us, and with fervent hopes that such communications will serve the future course of peace and human progress everywhere."

Signed Jimmy Carter  
President, United States

The text of the reply by station GB3MSA, Cornwall, to President Carter via station KM1CC at South Wellfleet, Cape Cod was:

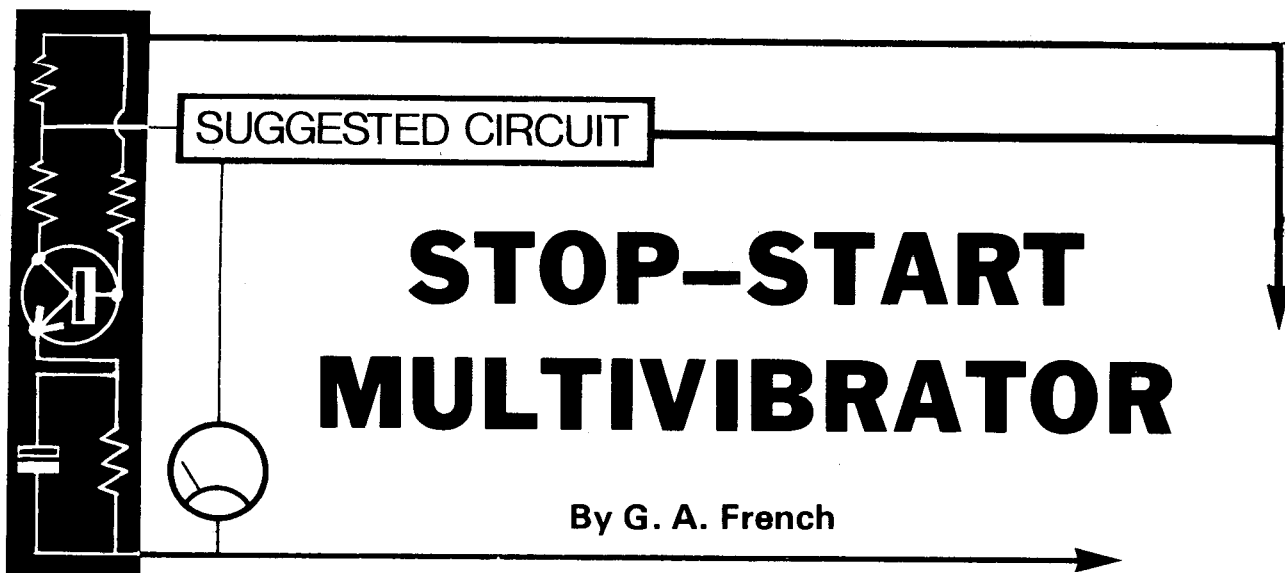
"Thank you for your message received at Poldhu. We reciprocate the sentiments expressed

and look forward to continued progress in international communications and goodwill as pioneered by Guglielmo Marconi."

Our congratulations to the Cornish Radio Amateur Club on staging such a successful commemoration of this historic event.



"Mine's invisible hair — what's yours?"



# STOP-START MULTIVIBRATOR

By G. A. French

One of the easiest relaxation oscillators to design is the symmetrical bipolar transistor multivibrator, the basic circuit of which is shown in Fig. 1. Due to the very high level of regeneration given at the changeover points in the cycle, roughly approaching the product of the gains of the two transistors, the multivibrator will oscillate with a very wide range of capacitor and resistor values.

## "STICKING"

It is still nevertheless possible to make up a multivibrator which "sticks", or refuses to start, when its power supply is turned on. The most common causes of "sticking" are too high or too low a value of base bias resistor for one or both of the transistors. If a base bias resistor has too high a value the corresponding transistor cannot draw a collector current sufficiently large to produce an adequate negative-going excursion (assuming a positive upper rail, as in Fig. 1) at the opposite base. And if a base bias resistor value is too small the corresponding transistor approaches, or goes into, saturation and cannot function as an amplifier. It is not generally realised that advantage can be taken of this last effect to produce a multivibrator which may

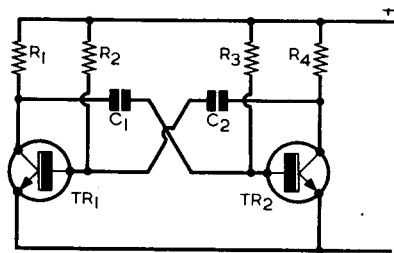


Fig. 1. A standard symmetrical multivibrator. Points concerning the value of R3 are discussed in the text

be started by pressing one push-button and stopped by pressing a second push-button.

Let us assume that, in Fig. 1, R3 has a value which is so low that TR2 is nearly saturated. If the supply voltage is allowed to gradually increase from zero to its full voltage, instead of being applied abruptly, TR2 will be nearly saturated as soon as the supply voltage passes a level which allows a meaningful collector current to flow. TR1 will also be conductive, but nowhere near the saturation level, and the final result when the supply potential is at its full level is that both the cross-coupling capacitors will be charged to low voltages only. The multivibrator does not start under these conditions because the nearly saturated TR2 cannot amplify and because it therefore breaks the regeneration loop in the circuit.

If, now, the base of TR2 is short circuited to the negative rail, TR2 will be turned off, and its collector voltage will rise, via R4, to the full supply voltage. C2 in consequence becomes charged. When the short-circuit is removed, the collector of TR2 goes rapidly negative, taking TR1 base similarly negative by way of the charged C2. TR1 turns off, its collector goes positive, and C1 charges. When C2 has discharged sufficiently, TR1 turns on again and its collector goes negative, causing TR2 base to go negative also. Since C1 has been charged, the negative excursion at TR2 base is now sufficient, despite the low value of R3, to turn off this transistor and cause C2 to charge once more. The multivibrator will continue to run quite reliably in this manner, and it has been started by temporarily short-circuiting TR2 base to the negative rail.

The multivibrator can be caused to stop again by short-circuiting TR2 collector to the negative rail. This breaks the regeneration loop,

whereupon TR1 becomes conductive with a collector current governed by the value of its base bias resistor, and the voltages across the capacitors fall to the previous low levels. The multivibrator remains in the stopped condition after the short-circuit has been removed, but it will start again if TR2 base is momentarily short-circuited to the negative rail.

## WORKING CIRCUIT

A practical working circuit which utilises the effect is given in Fig. 2. Here, R1, R2, R4, C1 and C2 are in the same circuit positions that they held in Fig. 1, whilst R3 is now replaced by a fixed resistor in series with the pre-set variable resistor, VR1. Also, the base-emitter junction of a third transistor, TR3, has been interposed between the emitter of TR1 and the negative rail. When during the multivibrator cycle TR1 turns on, so also does TR3. The only function of TR3 is to drive a pair of high resistance headphones without entering the multivibrator circuit proper. The rather low supply voltage of 4.5 volts is employed to avoid complications due to the 5 volt maximum reverse base-emitter voltage rating of the BC107. (This rating is, incidentally, given as 6 volts in some data sources.)

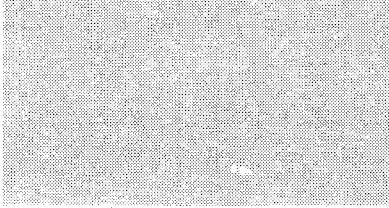
VR1 has been previously set up for the desired stop-start function, with the result that, when on-off switch S3 is closed, the sudden application of the supply causes the multivibrator to start. It produces a loud tone at around 700Hz in the headphones and can be caused to stop by momentarily pressing S2. If S1 is next pressed, the multivibrator commences to run again as soon as this push-button is released. Further stopping and starting can be achieved by pressing the appropriate push-buttons.

To set up the circuit, VR1 is in-

initially adjusted to insert maximum resistance into circuit after which S3 is closed. The multivibrator will then run. The resistance inserted by VR1 is slowly decreased until the multivibrator stops. VR1 is then set back to insert a slightly higher resistance, whereupon it should be found possible to start and stop the multivibrator by means of the two push-buttons. Experimental adjustments of VR1 around this point will reveal a fairly wide range of resistance values which allow the push-buttons to exert control, and VR1 is finally left at a setting in the centre of this range. It may be found that, at some settings of VR1, the multivibrator may not always start when S1 is closed although the push-buttons still control circuit operation. Such settings, which will be near the ends of the range which give control, are best avoided.

## APPLICATIONS

Apart from its interest, the circuit has a number of practical applications. It can, for instance, be used to detect momentary short-circuits in suspect equipment by connecting the negative rail to one side of the circuit concerned and either the base or the collector of TR2 to the other side. The multivibrator will then either start or stop when the momentary short-circuit occurs. The sound from the headphones, if laid on the bench,



will be quite loud enough to be heard in average workshop conditions. The headphones should be 4,000  $\Omega$  types, with 2,000  $\Omega$  in each phone. Alternatively, a single 2,000  $\Omega$  headphone on its own can be connected between the positive rail and the collector of TR3.

The current drawn from the 4.5 volt supply, with 4,000  $\Omega$  headphones, is about 1.7mA when the multivibrator is running, and 2.8mA when it is stopped. With a single 2,000  $\Omega$  headphone the currents are approximately 2.5mA and 3.6mA respectively.

The alternative output circuit shown in Fig. 3 can be used if a much louder output is required. In this circuit the emitter of TR1 is returned direct to the negative rail, and the third transistor, connected as an emitter follower, now has its base coupled to the collector of

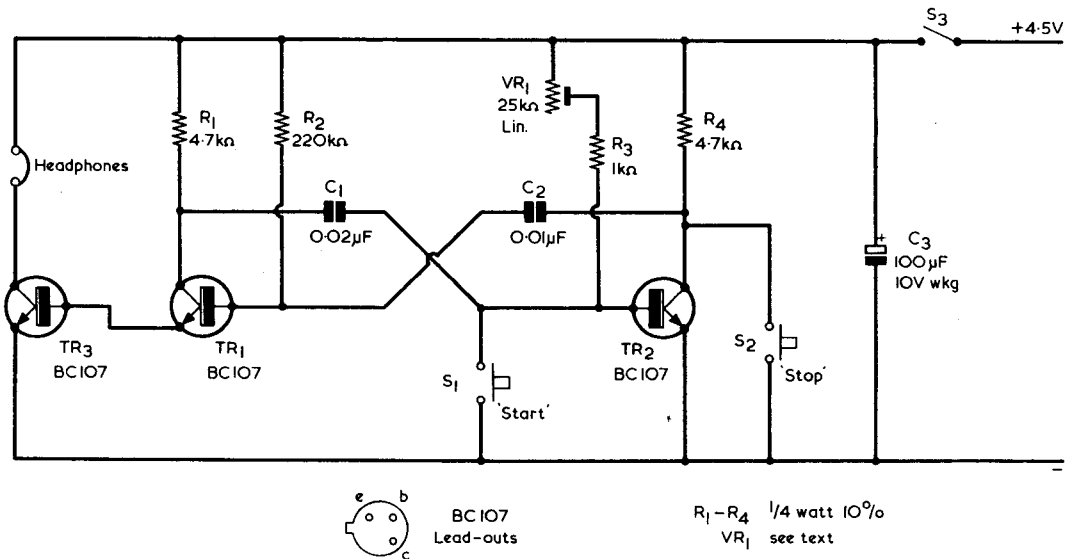


Fig. 2. A working circuit in which the multivibrator can be started and stopped by pressing the appropriate push-buttons

This setting-up procedure may seem a little complicated but in practice it can be carried out quite quickly. The adjustment of VR1 will hold good for battery voltages down to some 3.8 volts or lower, and it has very good long term stability.

So far as components are concerned, the only part which requires comment is VR1 itself. Since this potentiometer can pass a track current of about 4mA when it is inserting a very low resistance it requires a wattage rating of 0.4 watts. In consequence it should be a standard panel-mounting potentiometer and not a skeleton type. A 22k  $\Omega$  potentiometer may be used if it is found difficult to obtain a 25k  $\Omega$  component.

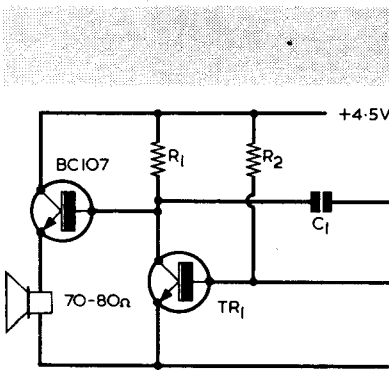


Fig. 3. An alternative drive circuit suitable for connection to a loudspeaker

TR1. This circuit will drive a speaker having an impedance of 70  $\Omega$  to 80  $\Omega$  and gives battery economy since the third transistor is turned off when the multivibrator is stopped. Current consumption is about 2mA when the multivibrator is stopped, rising to some 40mA when the oscillator is running. This output circuit could be used to drive high resistance headphones, if desired, at the saving of a milliamp or so when the multivibrator is stopped.

The circuit of Fig. 3, with the speaker, could be used as a door alarm, S1 being pressed by a caller and S2 being pressed by the occupant to subsequently silence the alarm. ■

# SINE WAVE SIGNAL INJECTOR

By R. J. Caborn

Low cost a.f. signal injector incorporating a readily available transformer.

A.F. oscillators with outputs capable of being attenuated can be useful items of test equipment. A common practice here is to take advantage of relaxation oscillators employing such devices as the 555 timer i.c. or a unijunction transistor. These oscillators provide outputs which are, with the 555, close to being square waves or which are, with a unijunction transistor, voltage spikes spaced out at an audio frequency.

Relaxation oscillators have the advantage of considerable simplicity, but they also have the disadvantage that the outputs are rich in harmonics of the fundamental frequency. These can give rise to misleading results when they are used for checking some types of audio equipment.

## SINE WAVE OSCILLATOR

An a.f. oscillator which produces a reasonably pure sine wave does not suffer from this last disadvantage, and it can be made up with only a few more components than are required for a relaxation oscillator. Normally, sine wave oscillators are either of the phase shift type or they incorporate an LC circuit resonant at the oscillator frequency. The circuit to be described in this short article is of the LC type. The inductance is provided by a readily available transformer, this being the Eagle output transformer type LT700.

The signal injector circuit is given in the accompanying diagram. The 9 volt supply is dropped to around 4 volts by R2 before being applied to the collector of TR1 via half the primary winding of T1. C1 functions as a bypass capacitor. The end of the primary remote from the collector couples to the base of TR1 via C2 and VR1, thus providing the positive feedback necessary for oscillation.

Feedback level is adjusted by VR1. The primary of T1 is tuned by C3 to resonate at approximately 1kHz.

## COMPONENTS

### Resistors

(All fixed values  $\frac{1}{4}$  watt 10%)

R1 47k  $\Omega$

R2 4.7k  $\Omega$

R3 470  $\Omega$

VR1 100k  $\Omega$  pre-set potentiometer, skeleton

VR2 1k  $\Omega$  potentiometer, linear

### Capacitors

C1 47 $\mu$ F electrolytic, 10 V. Wkg.

C2 0.01 $\mu$ F plastic foil

C3 0.022 $\mu$ F plastic foil (see text)

C4 0.047 $\mu$ F plastic foil

C5 47 $\mu$ F electrolytic, 10 V. Wkg.

### Transformer

T1 output transformer type LT700 (Eagle)

### Transistors

TR1 BC107

TR2 BC107

### Switches

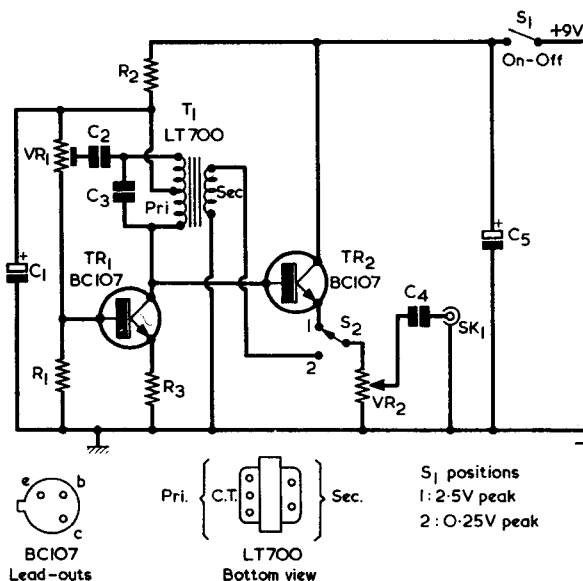
S1 s.p.s.t. toggle

S2 s.p.d.t. toggle

### Socket

SK1 phono or jack socket

The circuit of the sine wave a.f. signal injector. By taking advantage of the transformer secondary winding, two output voltages can be selected by S2.



VR1 and R1 form a d.c. potential divider which, in company with R3, causes TR1 to pass a collector current of about 1mA. R3 has no bypass capacitor across it, and the consequent negative feedback improves the oscillator waveform. The collector of TR1 connects directly to the base of the buffer amplifier, emitter follower TR2. When S2 is in position 1 the sine wave on TR1 collector appears across the output attenuator VR2, from the slider of which the signal is taken to the output socket via C4. Since the collector of TR1 is at an average voltage of about 4 volts, that at the emitter of TR2 is about 3.4 volts, causing an average current to flow in VR2 of some 3.4mA.

When S2 is set to position 2 the emitter of TR2 is taken out of circuit and this transistor merely presents a reverse biased base-collector junction to TR1 collector. At the same time, S2 connects VR2 to the secondary of T1, allowing a stepped-down version of the sine wave at TR1 collector to be applied to the potentiometer.

The total current consumption is a little in excess of 4mA when S2 is in position 1, falling to approximately 1mA when S2 is in position 2.

## DESIGN POINTS

It is necessary for the supply for TR1 to be lower than that for TR2 because the potential on the collector of TR1 rises above its supply potential during positive oscillatory half-cycles. This rather surprising effect is due to the fact that on negative half-cycles the collector voltage is equal to its supply potential (across C1) less the voltage across the lower half of the transformer primary, whilst on positive half-cycles the voltage across the transformer winding assists the supply potential. If the centre-tap of T1 primary were connected to the same positive supply as TR2 collector, TR2 simply could not amplify the positive half-cycles.

It is found that the peak value of the alternating voltage at TR1 collector is approximately 2.5 volts. The same voltage should be given with other circuits incorporating the Eagle transformer specified. The transformer has a step-down ratio of 1.2k  $\Omega$  to 3.2  $\Omega$ , which is very nearly equal to an

impedance step-down of 400:1. The corresponding turns ratio between the whole of the primary to the secondary is therefore 20:1, and that of half the primary to the secondary 10:1. As a result, a peak voltage of one-tenth of that available at the collector, i.e. 0.25 volt, is applied to S2 at position 2 of this switch.

The Eagle LT700 transformer used in the prototype signal injector is the printed circuit type, with connection spills projecting at the underside. Their layout is shown inset in the diagram. If the transformer employed is the version having flexible lead-out wires, they leave the bobbin with the same layout. The transformer is manufactured as an output transformer rather than as an oscillator transformer, with the result that there may be small differences in primary inductance between one transformer and the next. Because of this it may be necessary to alter the value of C3 to obtain a frequency at around 1kHz. Increasing the capacitance lowers the frequency, and vice versa. Also, there appear to be a number of transformers on the market which are labelled "LT700" but which may not be of Eagle manufacture. Such transformers may also necessitate changes in the value of C3.

To set up the circuit, the slider of VR1 should be adjusted fully to the positive end of its track, S2 set to position 1 and VR2 adjusted for maximum output. A pair of high resistance headphones, or the input of an a.f. amplifier, is connected to SK1. The signal injector is then switched on at S1, and the slider of VR1 moved slowly along its track away from the positive end. After some travel a weak oscillation will be heard, this building up into a strong oscillation as the slider is moved further. The correct setting of VR1 is that just after the strong oscillation appears. If it is necessary to change the value of C3, VR1 should be set up again with the new capacitor.

The setting of VR1 should hold good for all battery voltages down to 6 volts. The output peak voltage will, of course, be reduced with supply potentials as low as this. ■

# 50:50 OUTPUT FROM THE 555

By J. R. Davies

## MAKING THE 555 A SQUARE WAVE GENERATOR

The 555 timer i.c., when employed in its standard astable multivibrator configuration, appears in the circuit shown in Fig. 1. In this the capacitor C1 charges via R1 and R2 until the voltage across it reaches two-thirds of VCC, and then discharges via R2 until the voltage across it falls to one-third VCC. As such, it is impossible for the 555 output to be a square wave because the capacitor has to charge via two resistors and to discharge via only one.

In his article "Heads or Tails?", which appeared in the April 1977 issue, the author described a method of modifying 555 circuit operation by adding a pre-set potentiometer and resistor as in Fig. 2. The potentiometer slider is taken positive of half supply voltage, with the result that the length of the charge section of the multivibrator cycle is reduced and that of the discharge section is increased. The potentiometer can be adjusted such that the 555 output, at pin 3, is a true 50:50 square wave. It should be noted that when the potentiometer has been set up the 555 output will be 50:50 whatever value, within reason, is given to the capacitor. (In the previous article the circuit of Fig. 2 offered a frequency of about 7Hz, and the component values used in it are included to give an idea of the resistances involved.)

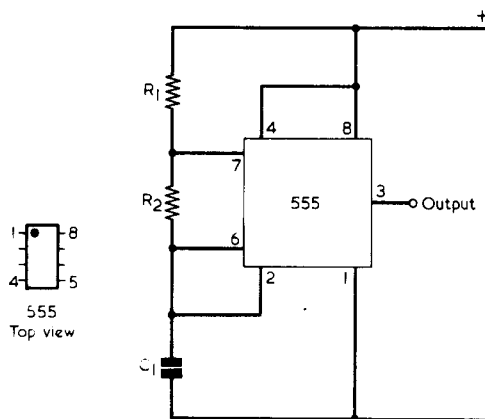


Fig. 1. The standard 555 astable multivibrator circuit cannot produce a square wave

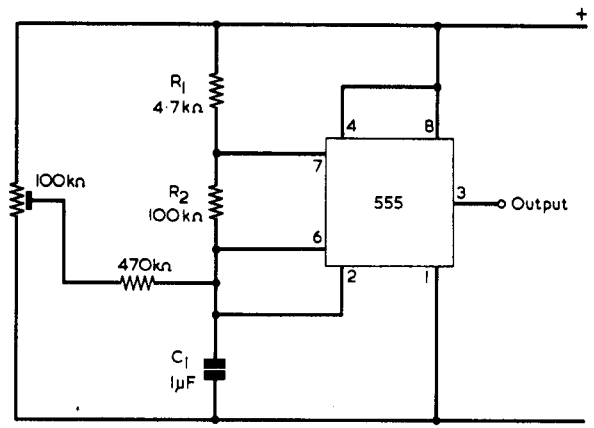


Fig. 2. A circuit modification which allows a square wave to be given

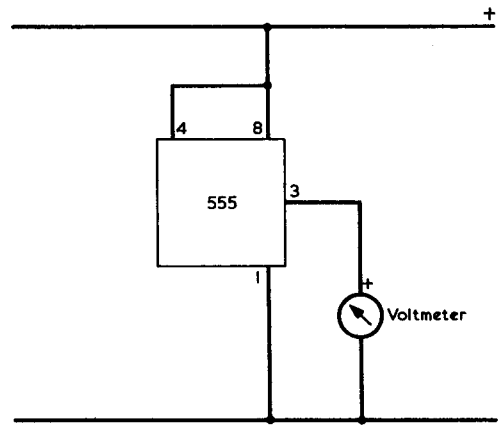
### CHECKING OUTPUT

The 555 output waveform may be checked by means of an accurate oscilloscope or, more simply, with the aid of a voltmeter. In the latter case, no load is connected to the output and a voltmeter connects between pin 3 of the i.c. and the negative rail as in Fig. 3. The voltmeter can consist of a multimeter offering a sensitivity of 10,000  $\Omega$  per volt or better which is switched to a suitable volts range.

When the 555 output is low under these conditions it is virtually at zero potential with respect to the negative rail. When it is high, it is about 1.2 volts negative of the positive rail, due to the presence of two internal emitter followers in tandem. To set up the potentiometer of Fig. 2 the output is taken to its high state, by temporarily connecting pins 2 and 6 to the negative rail, and the output voltage is noted. The multivibrator is next allowed to run, and the potentiometer is then set up so that the voltmeter reading is precisely half the noted high output voltage. The 555 output is then a 50:50 square wave.

The writer recently returned to the question of obtaining a 50:50 square wave from the 555, and

Fig. 3. A voltmeter connected to the 555 output can indicate when the output is a 50:50 square wave



this time he used the circuit shown in Fig. 4. Here the potentiometer and added resistor of Fig. 2 are replaced by the single resistor, R3. As with the previous arrangement, R3 increases the charge rate of the capacitor and decreases the discharge rate.

Can the value of R3 be calculated in terms of R1 and R2? The author has found that it can and with quite a high degree of accuracy.

### RESISTANCE VALUES

When in Fig. 4 the capacitor charges, charge current flows into it via R1 and R2 in series, and via R3. When the capacitor discharges, the discharge current flows into R2, whilst a competing smaller charge current flows via R3. Both the charge and discharge voltages follow exponential curves, which are fairly linear between the limits of one-third and two-thirds of VCC. Let us assume that the curves are linear and then examine the currents which flow when the capacitor voltage is exactly one-half of VCC.

In Fig. 5(a) the capacitor is charging and the charging current flows via the sum of R1 and R2 in

parallel with R3. In Fig. 5(b) the capacitor is discharging and the discharge current is that flowing in R2 minus that flowing in R3. If we now say that the two capacitor currents of Figs. 5(a) and (b) are

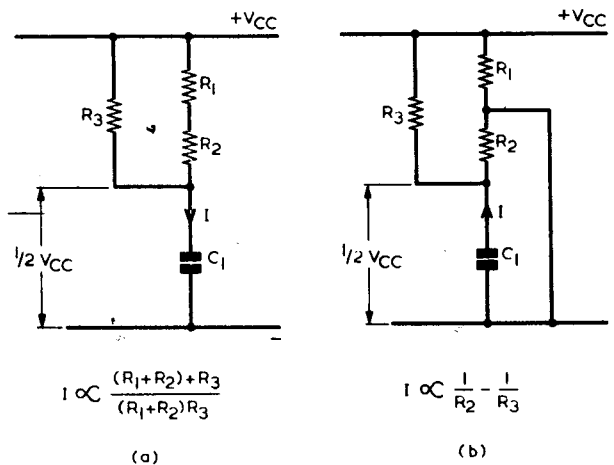


Fig. 5(a). Circuit conditions when the capacitor charges (b). The junction of R1 and R2 is taken to the negative rail by the 555 when the capacitor discharges

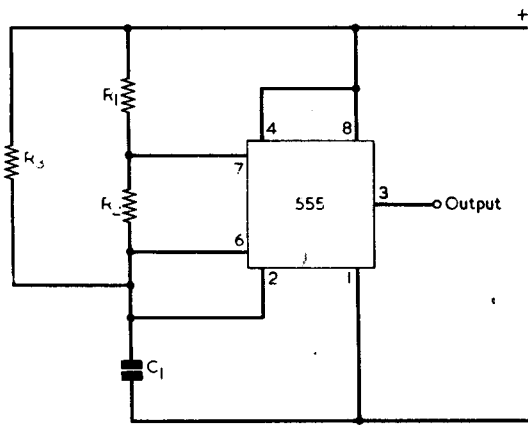


Fig. 4. Another method of obtaining a square wave output

equal at the half supply voltage condition, our assumption of linear capacitor voltage curves leads us on to state that the values of R1, R2 and R3 will then be such that the 555 gives a true 50:50 output. This is so, because the circuit conditions are symmetrical, so far as currents are concerned, about the half supply voltage point.

Since the same voltage (one-half of VCC) appears across the resistances concerned in both Figs. 5(a) and (b) the voltages cancel out, whereupon the currents become directly proportional to the reciprocals of the resistances. In Fig. 5(a) the capacitor current is proportional to the reciprocal of the sum of R1 and R2 in parallel with R3, whilst in Fig. 5(b) the current is proportional to the reciprocal of R2 minus the reciprocal of R3.

$$\frac{2R_2(R_1+R_2)}{R_1}$$

R1

Thus, if R1 is, say, 10k $\Omega$  and R2 is 50k $\Omega$ , the 555 will give a 50:50 output when R3 is equal to 600k $\Omega$ . The value of R3 may be similarly calculated for any other values of R1 and R2.

### SPECIAL CASE

A special and very neat case is given when R1 and R2 have the same value, and the equation involved is also shown in the inset. As can be seen, the result is that R3 is equal to 4 times R1. If it is desired to make the circuit of Fig. 4 a square wave generator, R1 and R2 can be, for instance, each 20k $\Omega$ , whereupon R3 is 80k $\Omega$ .

The writer has checked out these results in practice and has found that the calculated value for R3 was, in all instances, within some 2% of that needed for true 50:50 operation. Any error introduced by assuming linear charge and discharge capacitor voltage curves is, therefore, of a low order. Bearing in mind the fact that the internal 555 comparator potential divider resistors must themselves have a fairly wide tolerance, these results can be of quite significant help to the 555 circuit designer. ■

$$\frac{(R_1 + R_2) + R_3}{(R_1 + R_2)R_3} = \frac{1}{R_2} - \frac{1}{R_3}$$

$$\frac{1}{R_3} + \frac{1}{R_1 + R_2} = \frac{1}{R_2} - \frac{1}{R_3}$$

$$\frac{2}{R_3} = \frac{1}{R_2} - \frac{1}{R_1 + R_2}$$

$$= \frac{R_1}{R_2(R_1 + R_2)}$$

$$R_3 = \frac{2R_2(R_1 + R_2)}{R_1}$$

When R1 = R2

R3 = 4R1

The calculations shown inset reveal that, for 50:50 operation, the value of R3 is then equal to

## CAN ANYONE HELP?

*Requests for information are inserted in this feature free of charge, subject to space being available. Users of this service undertake to acknowledge all letters, etc., received and to reimburse all reasonable expenses incurred by correspondents. Circuits, manuals, service sheets, etc., lent by readers must be returned in good condition within a reasonable period of time.*

**"Radio Constructor" Back numbers Feb.-July 1967** — Paul Raven, 57 Bronwen Court, Grove End Road, St. John's Wood, London NW8. — To borrow or purchase.

**ERSKINE 13A OSCILLOSCOPE** — J. M. G. R. Martin, 7 Hurrell Road, Kenilworth, Bulawayo, Rhodesia — Manual or circuit diagram with component values.

**CODAR P.R. 30 (1 valve) Preselector** — K. Armstrong, 11 Woodville Gardens, Ruislip, Middlesex — Coil and switch connections wanted.

**COSSOR OSCILLOSCOPE MODEL 1049** — Paul Tomlinson, 27 Peplins Way, Brookmans Park, Hatfield, Herts. — Any information, service manuals or circuit diagrams to buy or borrow.

**HEATHKIT LABORATORY OSCILLOSCOPE 0-12U** — D. Coxell, 17 Caenby Road, S. Humberside — to borrow or buy circuit and or manual.

**DULCI Valve Amplifier Model DP10** — G. W. Barrow, 60 Bledisloe Crescent, Wainuiomata, New Zealand — Any information.



## ● VIETNAM

Hanoi on **6450** at 1520, YL with songs, local music, OM announcer in Vietnamese. This is the Domestic Service 1st Programme which is scheduled on this channel from 2055 to 1630. Other frequencies used by this service are **4944**, **7375** and **10060**. A further channel is that of **3998** but having a slightly differing schedule — from 1045 to 1430 and from 2200 to 0058. All programmes are, of course, in Vietnamese.

The Domestic Service 2nd Programme operates on **6430**, **7415**, **9987** and on **10225** from 2245 through to 1600, all programmes being in Vietnamese, although there are English language lessons from 2300 to 2315 and from 1415 to 1430. Another channel is that of **4995**, the schedule being from 0930 to 1430 and from 2245 to 0100.

Hanoi on **4944** at 1518, YL with songs, local music — see above.

## ● THAILAND

Radio Thailand, Bangkok, on **4830** at 1533, YL in Thai followed by local-type music at 1535. With a power of 10kW, this one operates from 2300 to 1600 daily.

## ● SRI LANKA

Colombo on a measured **4902** at 1522, YL with songs in Sinhala, YL announcer. This is the Home Service 1 in Sinhala, having a schedule from 1030 to 1715 and from 0015 to 0230. On full-moon dates the transmitter is continuously on the air from 0930 to 0230. The power is 10kW.

## ● NEPAL

Radio Nepal on **5004.5** at 1511, YL with a newscast of local events in English. Listed on **5007**, this one has a schedule from 1150 to 1720 and from 0020 to 0350. The programme in English is from 1435 to 1520. The power is 5kW and a parallel channel is that of **3425**.

## ● BURMA

Rangoon on a measured **4724** at 1434, OM in Burmese, local songs and music. The schedule is from 1030 to 1500 and the power is 50kW. (Listed **4725**).

## ● CAMBODIA

Phnom-Penh on a measured **4908** at 1455, a programme of local music, YL announcer. This is the Home Service which is scheduled from 0400 to 0500, 1100 to 1600 and from 2300 to 2400 on this channel. The power is 50kW.

## ● UGANDA

Kampala on a measured **5026** at 2020, local music, OM announcer, YL's with songs in typical local-style. The National Programme has a schedule from 0300 to 1130 and from 1300 to 2110 weekdays and from 0300 to 2110 on Saturday and Sunday. The power is 7.5kW.

## ● AFGHANISTAN

Kabul on a measured **4774** at 1443, YL with songs, OM announcer. This is the Home Service 1,

scheduled from 1230 to 1740 (except the Foreign Service transmission from 1300 to 1530). The English programme is listed from 1400 to 1430. The power is 100kW.

## ● CHINA

Radio Peking on **7080** at 2000, YL in English to North and West Africa, scheduled from 1930 to 2030.

Radio Peking on **7620** at 2035, YL in English to North and West Africa, scheduled from 2030 to 2130.

Radio Peking on **9920** at 1150, OM with songs in the Domestic Service Minority Programme Service to Tibet, scheduled from 1100 to 1155. Sign-off with "Internationale" at 1155.

Radio Peking on **11650** at 0930, OM in Standard Chinese to South East Asia, scheduled from 0900 to 1000 on this channel.

Lanchow on **4865** at 1525, YL with songs in Chinese, orchestral music. The schedule of this regional transmitter is from 0950 to 1600, 2120 to 0100 and from 0320 to 0600.

Radio Peking on a measured **4883** at 1450, OM in Russian. This is the Foreign Service operating in Russian and Mongolian, scheduled from 1000 to 2300.

Urumchi on **4970** at 1423, YL in the Kazakh programme, scheduled from 1400 to 1455.

## ● INDIA

Delhi on **4860** at 1527, OM with a newscast in Hindi. This is a transmission in the Home Service, scheduled from 1030 to 1215, 1445 to 1810 and from 0245 to 0400. The power is 10kW.

Hyderabad on **4800** at 1545, OM in Arabic, local-type music. The schedule is from 1200 to 1830 with newscasts in English at 1230 and 1530. The power is 10kW.

## ● COLOMBIA

Radio Surcolombiana on **5010** at 0350, OM with announcements in Spanish, many mentions of Colombia. With a 24-hour schedule, this one has a power of 2.5kW.

La Voz del Norte on **4875** at 0300, OM with identification, LA music and songs. A new station.

## ● VENEZUELA

Radio Sucre, Cumana, on a measured **4959** at 0211, OM in Spanish, local-type music, jingles. Schedule is from 1000 to 0400 and the power is 1kW.

Radio Bolivar, Ciudad Bolivar, on **4770** at 0150, guitar music, jingles, songs in Spanish. The schedule is from 1000 to 0300 and the power is 1kW.

## ● COSTA RICA

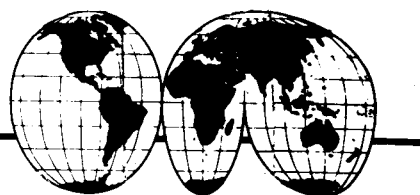
Emisora Radio Reloj, San Jose, on a measured **4832** at 0203, YL with songs, OM announcer. The schedule is around the clock and the power is 1kW. Sometimes identifies as Radio Capital.

## ● NOW HEAR THIS

Radio Chinchaycocha, Junin, Peru, on **4860** at 0417, OM in Spanish, Andean flute music, announcements muffled owing to echoes in the studio.

# SHORT WAVE NEWS

## FOR DX LISTENERS



By Frank A. Baldwin

*Times = GMT*

*Frequencies = kHz*

Information concerning clandestine stations may be of interest to some readers and the hope is that even more will be interested after the next few paragraphs have been read by them.

The "Voice of Lebanon" currently operating on **6550** from 0455 to 0930 in Arabic and from 1100 through to 2100 in Arabic, Armenian, French and English, has for some time been presenting a newscast in English at 1745. The station is pro-Phalangist.

The "Voice of Arab Syria" is reported as operating on **6060** and **9510** from 0500 to 0600; 0800 to 0900 and from 1800 to 1900.

"Voice of the One Lebanon" also uses the frequencies **6060** and **9510**.

"Voice of the People of Burma" on **6304** now broadcasts in Burmese from 1330 to 1430.

### REVERSED TAPE TRANSMISSIONS

Regular readers will recall that we dealt with the subject of reversed tape transmissions emanating from Radio Peking some while ago. To briefly recap, these broadcasts are in Russian and the channels quoted may vary up to 10kHz in attempts to avoid interference.

For those who would like to 'have a go', the schedule is from 0900 to 0955 on **5220** and on **8260** and from 1830 to 1925 on **5030** and on **6550**.

Should you consider the above all a load of fun, why not try **17490** at the unearthly hour of 0300 (until 0355 if you want to listen to five programmes, each a repeat of the first) when your ears will be assailed by a reversed tape transmission in the SSB mode — and the very best of luck to you!

### CURRENT SCHEDULES

#### ● CUBA

"Radio Havana" has an External Service in which the English programme for Europe is radiated from 2010 to 2140 on **17885**. An evening programme in English to the Americas, often logg-

ed by U.K. Dxers, is from 2050 to 2135 on **11865** and on **17750**.

#### ● CHINA

"Radio Peking" broadcasts in English to Europe from 2030 to 2130 on **6185**, **6590**, **6860** and on **7590**; from 2130 to 2230 on the same channels and to North and West Africa from 2030 to 2130 on **5030**, **7080**, **7620** and on **9470**.

#### ● BANGLADESH

"Radio Bangladesh", Dacca, beams programmes in English to Europe from 1230 to 1300 on **15520** and on **17720**; also from 1815 to 1900 on **9495** and on **11652**.

#### ● ARGENTINA

RAE (Radio Argentina al Exterior), Buenos Aires, radiates a programme in English from 2300 to 2400 (Monday to Friday only) on **11710**.

### AROUND THE DIAL

#### ● SOUTH AFRICA

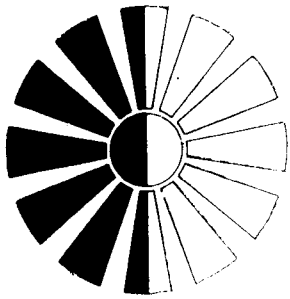
Johannesburg on **4835** at 1910, OM with a newscast of local and African events in English. This is the English Service which operates from September to May on this channel from 0358 to 0635 (Saturday from 0430, Sunday from 0500); 1520 to 2115 (Saturday until 2205). The power is 100kW.

#### ● CONGO

Pointe Noire on a measured **4843** at 2010, OM in French. This transmitter relays Brazzaville and is scheduled on the air from 0400 to 1200 and from 1700 to 2100. The power is 4kW.

#### ● SPAIN

Madrid on **7155** at 2122, programme in English about Spanish agriculture.



# THE END OF OSCAR 6

By Arthur C. Gee

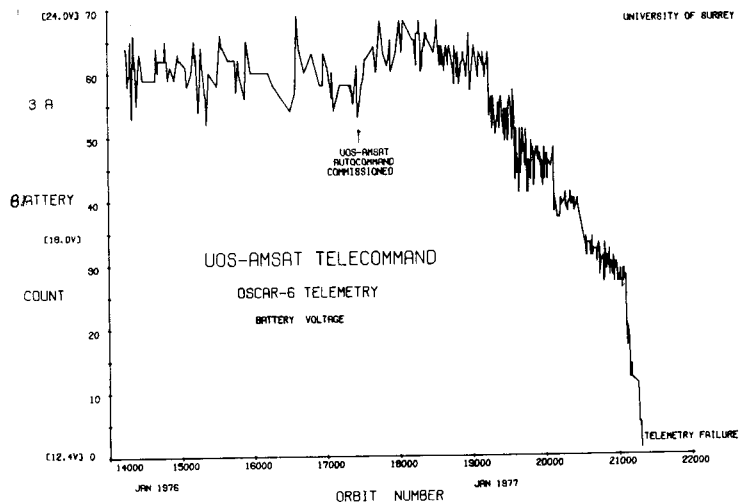
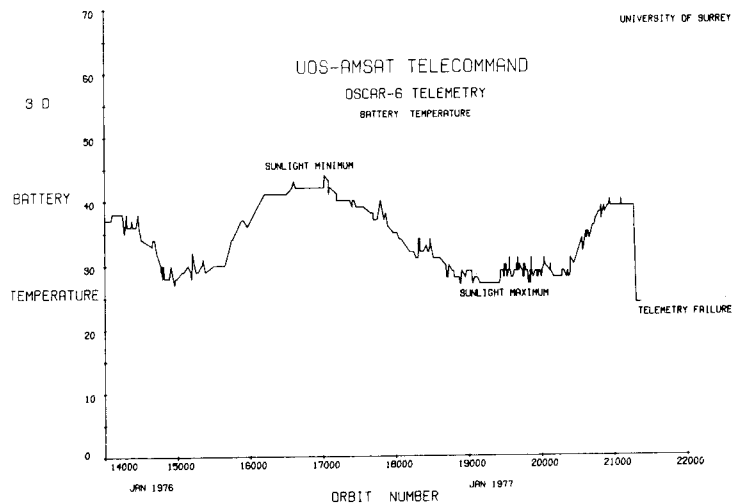
It seems that the amateur radio satellite OSCAR 6 must now be "presumed dead".

From the beginning of 1977, concern for its future was felt, as its battery voltage began to fall and one after another of the cells making up the battery failed. It was hoped that the period during which it would be in maximum sunlight would enable its solar panels to give the battery a real boost, so, to help this, the satellite was turned off permanently for several weeks at a time, for communication purposes. However, the ailing battery did not respond to this treatment, and in June, the telemetry failed entirely, so that no more information on what was happening on board was available and it has not been heard since.

We are indebted to Martin Sweeting, G3YJ0, the Director of the University of Surrey Command Station, for the graphs reproduced herewith, showing the battery temperature and the battery voltage counts from the beginning of 1976 up to the date when OSCAR 6 failed in 1977. It should be noted in reading these charts, that the numbers shown on the left hand side of the charts are the telemetry numbers transmitted by the satellite. In the case of the battery temperature, the higher the count number, the lower the temperature. As a guide to the actual values, a count of 26 indicates a temperature of 57.3 degrees F, whilst a count of 44 indicates a temperature of 30.7 degrees F. In the case of the count, the higher the voltage. Count 0 indicates a voltage of 6.4 volts, whilst a count of 70 indicates a voltage of 13.4 volts.

It is interesting to note how the battery voltage improved following the control on the use of the satellite which came regularly into action when the U. of S. autocommand equipment was brought into use.

OSCAR 6 will surely go down in the annuals of amateur radio history, as one of its most remarkable achievements. It was

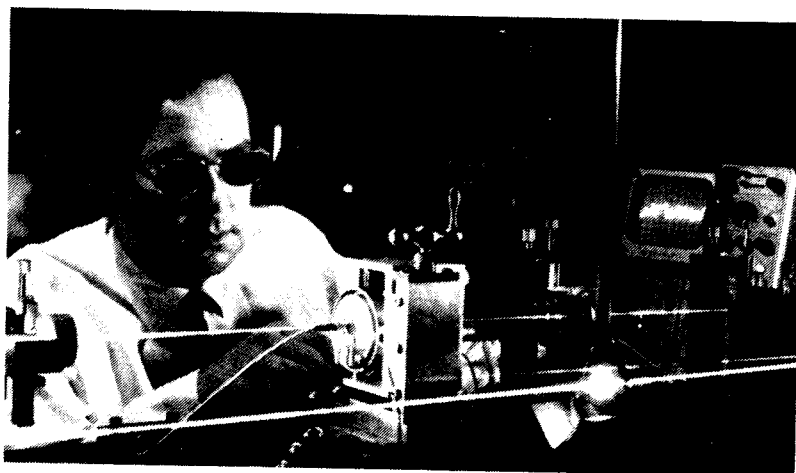


the first of the amateur radio communication satellites and was launched in October 1972, with a life-expectancy of one year. It lasted however, through to 1977!

One must congratulate those who built it, and those who had the responsibility for controlling it, for the really superb job they made of their activities. ■

RADIO AND ELECTRONICS CONSTRUCTOR

# Gigabit Laser Communication



*A Bell System scientist adjusts the optical modulator which impresses 1,000 million bits of information on the laser beam. This modulator is part of Bell's new experimental communication system. Similar systems, employing laser light instead of microwaves or cable, will be able to carry hundreds of thousands of voice, television and data channels simultaneously.*

By Michael Lorant

**Laser beams can now be modulated by 1,000 million binary digits per second.**

Recent advances in new types of high speed electronic circuits have helped scientists at Bell Systems, U.S.A., to transmit 1,000 million bits of information (a gigabit) per second over a single laser beam. This is four to five times the capability of previous communication methods and is equivalent to transmitting 200 books per second or a library of 50,000 volumes in about four minutes.

Because of this, a communication system employing laser light provides the prospect of carrying data messages and television signals simultaneously in bundles about 10,000 times larger than is now possible with microwaves.

## MULTIPLEXING

Until recently, relatively "slow" electronic circuits were employed in the process of transmitting information-carrying signals over laser beams. The widely accepted method for increasing information rates was to modulate a number of laser beams which were then multiplexed, or combined, by optical means. The high speed electronic circuits enable information streams to be multiplexed electronically prior to impressing them on a single laser beam. The expense and problems inherent in optical multiplexing are then eliminated.

Bell's high speed circuits are comprised of four semiconductor switches or gates fabricated in thin

film microstrips. Four different pulse streams, each capable of handling 250 million bits (megabits) of information are multiplexed by way of the gates into a single pulse stream of one gigabit per second capacity. This pulse stream is impressed on the laser beam by means of a crystal device called an "optical modulator".

Ordinarily, the optical modulator requires a signal level of about 30 volts to function efficiently, but the voltage required is reduced by a technique described as "etalon tuning". This is a frequency filtering system which eliminates all but one frequency from the laser beam, whereupon the resulting pure optical beam can be modulated satisfactorily with only about 5 volts signal level at the modulator. It then becomes possible for both electrical and optical signals to interact efficiently at the optical modulator, and at approximately the same ultra-high speed.

Once modulated, the laser beam acts as a "carrier" for the high speed information signals, the original multiplexed signals being recovered by sophisticated electronic circuits at the receiving end. Thus, the gigabit laser communication link enables a number of already very high rate individual bit streams to be carried simultaneously, and without costly and complex optical combination at the transmitting end.

# SWITCH-SELECTION ENLARGER TIMER

by R.

This enlarger timer has been designed to provide a range of times suitable for large and small prints, together with a quarter second feature which provides the precision necessary for applications such as slide duplication. Time setting is by means of switches which gives high repeat setting accuracy and easy adjustment in the dark. The actual range of the unit is from 0 to 99 and three-quarters seconds in quarter second increments. It can be used to control an enlarger lamp having a rating of 150 watts or less.

## THE CIRCUIT

The circuit diagram of the unit appears in Fig. 1 and, as will be apparent from this, the design is based on the popular 555 timer i.c. This controls the load, i.e. the enlarger lamp, by way of a triac. C1 is the timing capacitor and this is normally held discharged by the internal transistor in the i.c. which connects to pin 7. Also, the i.c. output, at pin 3, is held low. When S1 is pressed, however, the output is triggered high and the short-circuit is taken off C1. C1 commences to charge exponentially through the timing resistance. This resistance is actually formed by a network of fixed resistors, and it is discussed more fully later on.

When, on pressing S1, the 555 output goes high, a gate current is passed to the triac by way of current limiting resistor R4, and in consequence the triac turns on. The triac is in series with the mains supply and the enlarger lamp, and so power is applied to the lamp via the triac.

As the potential across C1 reaches two-thirds of the supply voltage (assuming a standard 555 circuit) the internal flip-flop in the i.c. is triggered to its previous state, and the output at pin 3 goes low again, thereby causing the triac and, in turn, the enlarger lamp, to be turned off. At the same time the internal discharge transistor in the i.c. turns on and C1 is rapidly discharged. The circuit remains in this state until S1 is once more closed.

The length of the timing period is approximately equal to  $1.1CR$  (where C is in microfarads and R is in megohms) and so theoretically the length of the timing period can be set by choosing appropriate values for the timing resistance and capacitance. In practice there is a problem here since the timing capacitor will require a value in the order of tens of microfarads and this makes it necessary to use an electrolytic component. Unfortunately, electrolytic capacitors have wide tolerances on value, being typically plus 50% and minus 10% or even more, whereupon it is impossible to accurately set the

## RAPID AND ACCURATE TIMING PERIODS

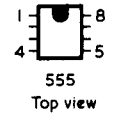
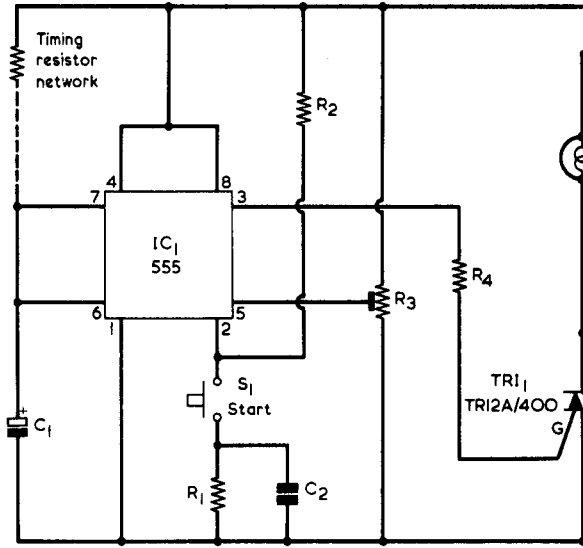
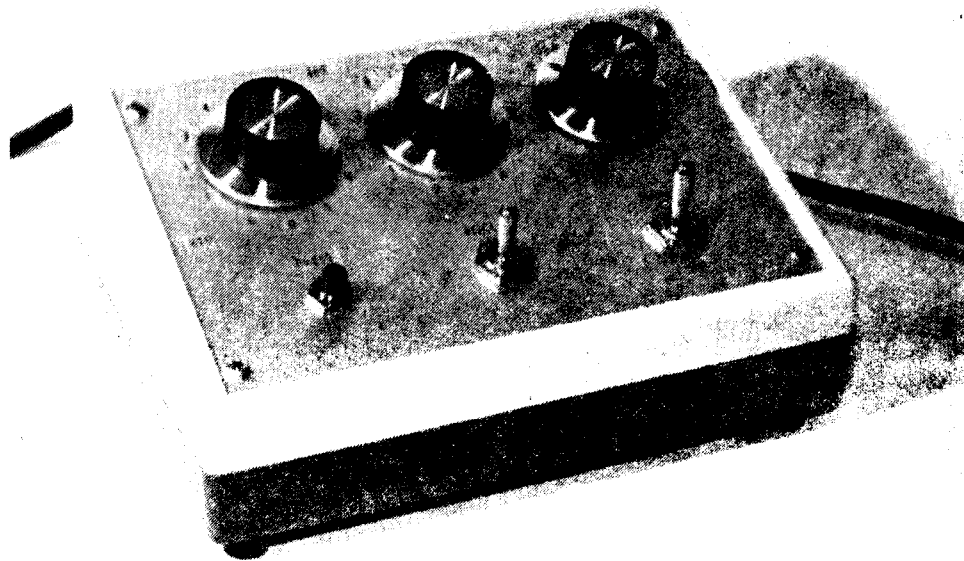


Fig. 1. The circuit of the switch-selection enlarger timer.

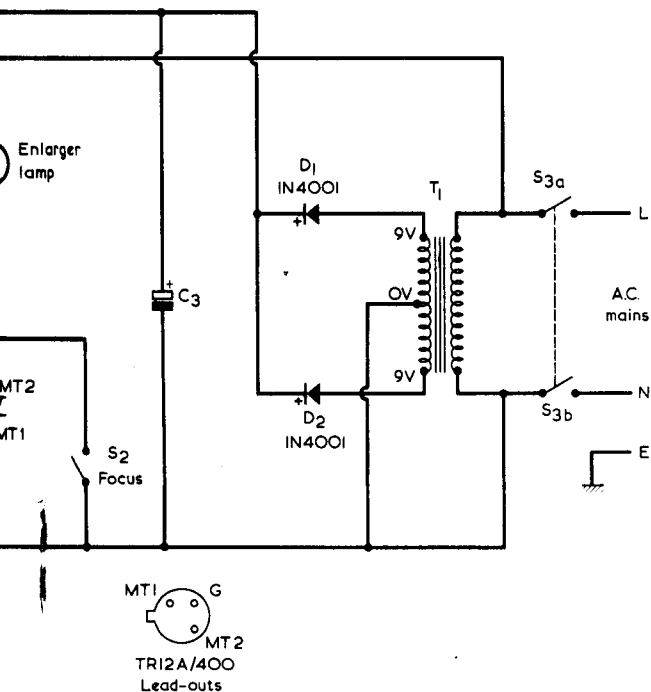
# ON R



A. Penfold

## ADJUSTMENTS OF IN THE DARKROOM

*Switch selection of timing periods affords precise repeatability. The three controls at the top of the panel select tens of seconds, seconds and fractions of seconds*



er timer. The triac is a small device in a TO-5 can

timing period by choosing appropriate component values.

Some means of compensating for the inaccuracy of the timing capacitor must be incorporated in the design, and this is the purpose of R3. The slider of R3 connects to a junction in an internal potential divider in the i.c. which provides the reference voltage of two-thirds supply potential, with the result that adjustments in R3 change this reference voltage. The reference voltage can be reduced to allow for a timing capacitor with a high value, or increased for a timing capacitor having a low value. Once R3 has been set up to accommodate the particular timing capacitor employed it is then possible to select the requisite values for the timing resistor network.

The start circuitry around S1 is a little unusual and perhaps requires some further explanation. Pin 2 of the i.c. must normally be held high, and this is the purpose of R2. Taking pin 2 low causes the commencement of the timing period, but it is important that pin 2 should be returned to the high state before the end of the timing period as the latter will otherwise be elongated. To meet this requirement, S1 does not connect pin 2 direct to the negative rail but instead connects it to that rail via C2. Closing S1 causes pin 2 to be momentarily taken low, but it will very quickly return to the high state again as C2 charges through R2. A brief trigger pulse is thus supplied to pin 2 of the i.c. When S1 is released, C2 discharges through R1 and is therefore ready for the next operation.

It may appear that R2 has an unusually low value and C2 a similarly high value. However, it was found necessary for the wiring in the circuit around pin 2 to be at low impedance, as spurious triggering otherwise tended to be troublesome.

# CH-SELECTION ARGER TIMER

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by R. A. Penfold

## RAPID AND ACCURATE ADJUSTMENTS OF TIMING PERIODS IN THE DARKROOM

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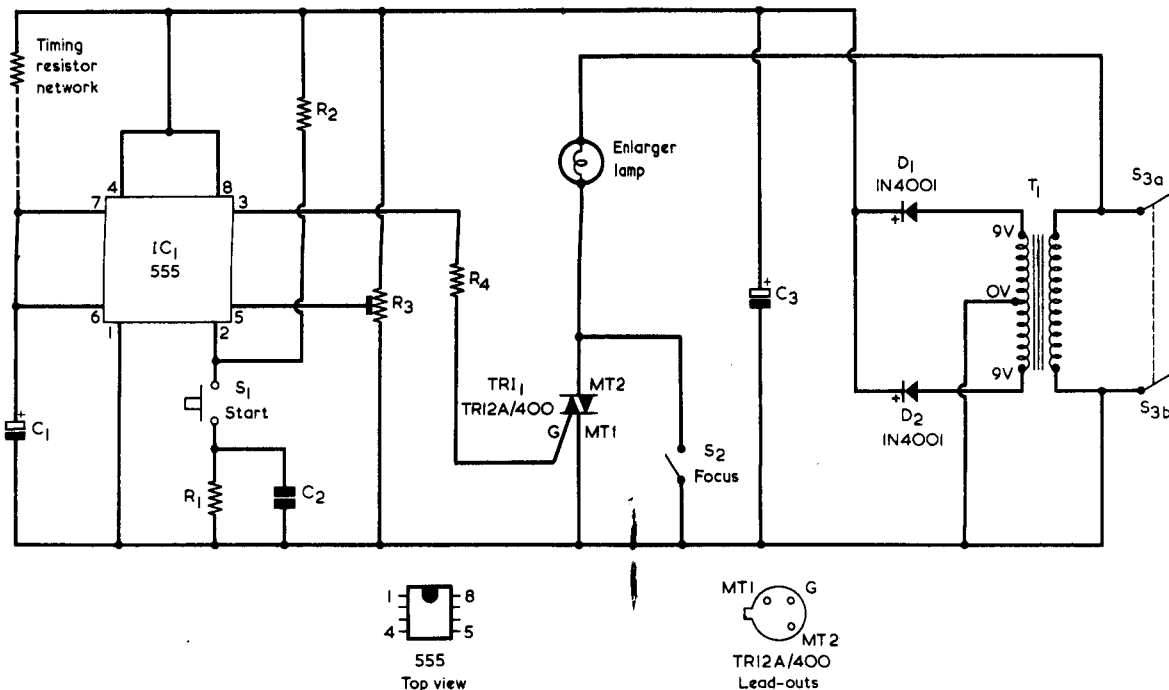


Fig. 1. The circuit of the switch-selection enlarger timer. The triac is a small device in a TO-5 can

## COMPONENTS

### Resistors

(All fixed values  $\frac{1}{4}$  watt 5% unless otherwise stated)

- R1 100k $\Omega$
- R2 10 $\Omega$
- R3 22k $\Omega$  pre-set potentiometer, 0.1 watt horizontal
- R4 560 $\Omega$   $\frac{1}{2}$  watt
- R5-R13 470k $\Omega$  2% (9 off, see text)
- R14-R22 47k $\Omega$  2% (9 off, see text)
- R23-R25 12k $\Omega$  2% (3 off, see text)

### Capacitors

- C1 15 $\mu$ F electrolytic, 16V. Wkg.
- C2 0.22 $\mu$ F type C280 (Mullard)
- C3 470 $\mu$ F electrolytic, 16V. Wkg.

### Transformer

- T1 Mains transformer, secondary 9-0-9V at 100mA

### Semiconductors

- IC1 555
- TRI1 400V, 2A, type TR12A/400
- D1 1N4001
- D2 1N4001

### Switches

- S1 push-button, press to close
- S2 s.p.s.t. toggle
- S3 d.p.s.t. toggle
- S4 1-pole 12-way rotary
- S5 1-pole 12-way rotary
- S6 3-pole 4-way rotary

### Miscellaneous

- Verobox Code No. 75-1798K
- 3 control knobs
- Veroboard, 0.1in. matrix
- 9 Veropins, for 0.1in. board
- 8-way d.i.l. i.c. socket (see text)
- 2 nylon bolts and nuts, 4BA
- Mains lead, connecting wire, etc.

S2 is the focus switch, and it enables the enlarger lamp to be turned on independently of the timer circuit in order that enlarger focusing can be adjusted.

The power supply is a straightforward un-stabilized type using full-wave rectification. S3 is the on-off switch.

## TIMING RESISTORS

The circuit of the timing resistor network is shown in Fig. 2. The principle used here is very simple: if a 470k $\Omega$  resistor produces a ten second timing period then two such resistors in series will give a twenty second period, three will provide a thirty second period and so on. Timing periods of one second, two seconds, three seconds etc., can be provided by a series of 47k $\Omega$  resistors. Quarter second increments are then given by a series of 11.75k $\Omega$  resistors. These values are satisfactory, in practice, with a timing electrolytic capacitor having the nominal value of 15 $\mu$ F

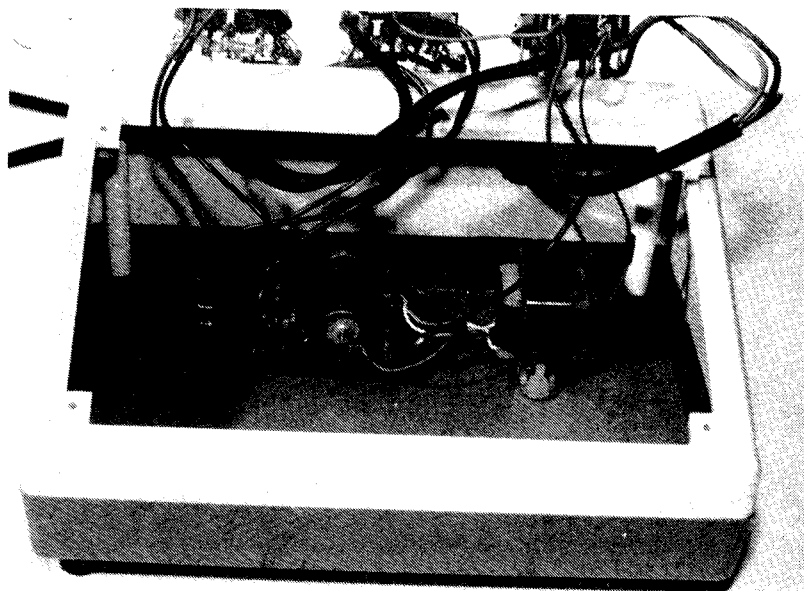
specified for C1.

In Fig. 2 the resistors R5 to R13 are each 470k $\Omega$ , whereupon S4 selects timing periods, in steps of 10 seconds, from zero to 90 seconds. This switch is a standard 12-way rotary component with three ways wired together so that there are only ten effective positions. If a switch having an adjustable end stop is used this can be set for 10-way operation, although it will probably be found more convenient to remove the end stop altogether and wire up the switch as shown in Fig. 2. The switch can then be taken, for instance, from position 9 to position 1 the quick way round.

S5 is wired in the same way as S4, but the nine timing resistors, R14 to R22, each have a value of 47k $\Omega$ . S5 thus selects timing periods of zero to 9 seconds in 1 second steps. The same remarks concerning the end stop and type of switch which have been made with respect to S4 apply also to S5.

The remaining switch, S6, in combination with R23 to R25, selects periods of zero, one-quarter,

*Removing the front panel reveals the interior component module and the mains transformer*





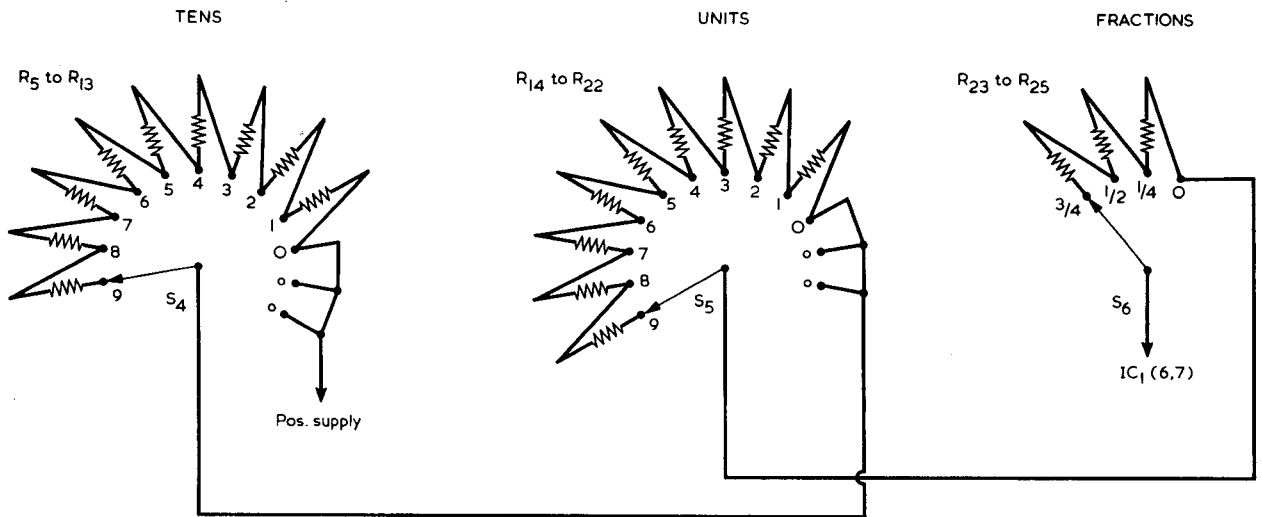


Fig. 2. The timing resistor network. S4 selects tens of seconds, S5 selects seconds and S6 selects fractions of seconds

one-half and three-quarter seconds. Ideally, the three resistors should be  $11.75k\Omega$ , but in practice they may have values of  $12k\Omega$  as the error introduced is negligible. S6 is a 3-pole 4-way switch with no connections made to two of the poles.

On the front panel of the timer S4 is mounted on the left, S5 in the centre and S6 on the right, whereupon the switches take up the same positions as do the numbers of seconds they represent when written down. If, for example, a timing period of  $47\frac{1}{2}$  seconds is required, S4 is set to "4", S5 to "7" and S6 to " $\frac{1}{2}$ ". A period of  $10\frac{3}{4}$  seconds is given by S4 at "1", S5 at "0" and S6 at " $\frac{3}{4}$ ".

R5 to R25 must be high stability resistors with a tolerance on value of 2 per cent or better. They are specified as  $\frac{1}{4}$  watt in the Components List but it will be found that most retail outlets offer close tolerance resistors in  $\frac{1}{2}$  watt. It is, of course, perfectly in order to use  $\frac{1}{2}$  watt resistors here provided they are reasonably small in physical size.

So far as the remaining components are concerned, S2 and S3 should be relatively heavy duty toggle switches capable of switching the enlarger lamp. The mains transformer has a secondary rating of 9-0-9 volts at 100mA. Suitable transformers are available from a number of retail outlets, including Home Radio. The timer is housed in a Verobox Code No. 75-1798K. This has a plastic body and a sloping anodised aluminium front panel with base dimensions of 171 by 121mm. The overall height at the rear is 75mm. and that at the front is 37.5mm. R3 is a miniature 0.1 watt horizontal pre-set potentiometer with 0.2in. spacing between track tags and 0.4in. spacing between track and slider tags. The 555 timer i.c. is fitted to an 8-way d.i.l. integrated circuit holder in the prototype. The use of a holder is not essential, but it does ensure that there is no risk of damage to the i.c. due to excessive heat when soldering. The triac is available from Bi-Pak

Semiconductors. Some nylon nuts and bolts are required and it is necessary to provide a suitable solder tag for earthing the front panel of the case. Details of these items are given in the next section, which describes the construction of the timer.

### CONSTRUCTION

The six switches are mounted on the aluminium front panel of the timer, and the positions of the holes required are shown in Fig. 3. It should be noted that the hole diameters indicated for S1 to S3 are suitable for typical examples of the switches specified; the actual diameters required should be checked from the switches themselves and the diameters modified if this should be necessary. As is explained later, an extra hole may be needed for mounting a solder tag.

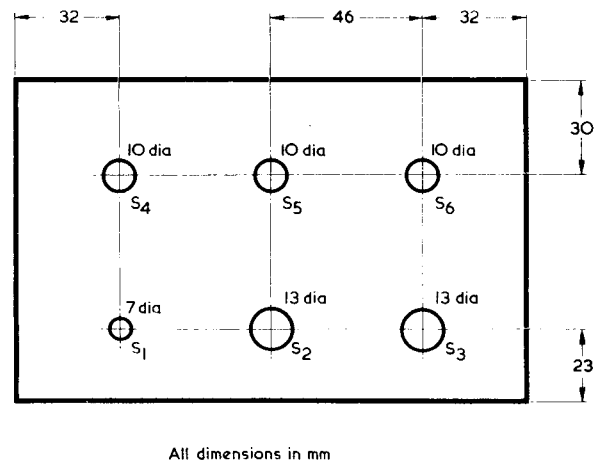


Fig. 3. Drilling details for the front panel. The hole diameters shown for S1, S2 and S3 may need to be modified for some components

Apart from the switches, mains transformer and timing resistors, all the components are assembled on an 0.1in. matrix Veroboard having 25 holes by 16 copper strips. The component and copper sides of this board are illustrated in Fig. 4.

The board is first cut to size, then the two 6BA clear holes are drilled out. After this the breaks in the copper strips are made. The components and link wires are next soldered in with the semiconductor devices being left until last. If the i.c. is mounted direct on the board without a holder, soldering should be carried out carefully and quickly to ensure that it is not damaged by ex-

cessive heat. It is important to ensure that the triac is connected into circuit correctly as it will almost certainly be destroyed if it is wired in wrongly. (Some small triacs in TO-5 encapsulations do not have the same lead-out layout as does the device available from Bi-Pak.) Particular care is required to avoid errors in the triac wiring as this wiring handles mains voltages and currents.

Veropins suitable for 0.1in. Veroboard are fitted at points "A" to "F" as well as at the three points to which the mains transformer secondary connects. The completed board is secured to the base of the Verobox with two 6BA bolts and nuts, short

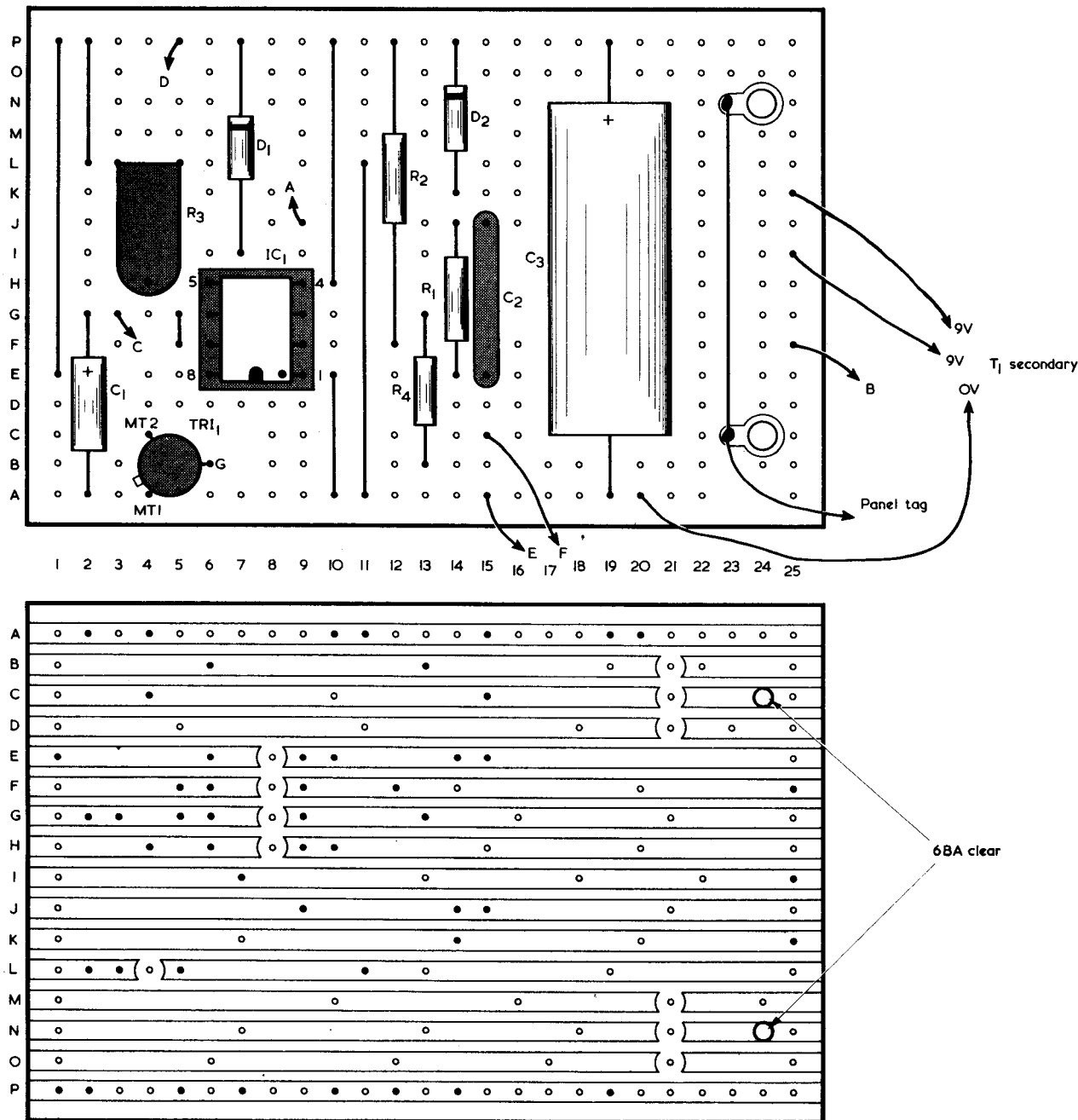
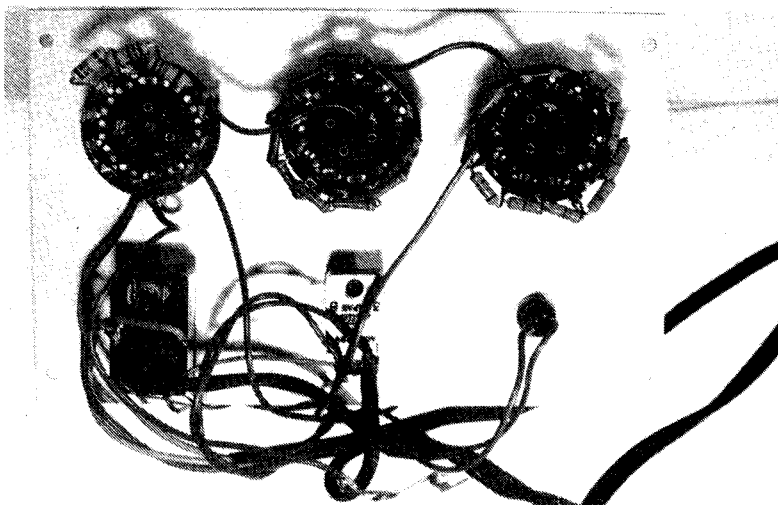


Fig. 4. A Veroboard panel provides a satisfactory means of mounting most of the small components. This diagram shows the component and copper sides of the board

*The wiring to the switches which are mounted on the front panel of the unit. The twenty-one timing resistors can be seen mounted on the tags of the rotary switches*



spacing washers being fitted over the bolts to ensure that the Veroboard underside is adequately clear of the inside surface of the box. The spacing washers are necessary as the board would otherwise be distorted and would crack when the nuts were tightened. Since the bolt heads will be accessible at the outside of the case they must be earthed, and this earthing connection is made via the two solder tags shown in Fig. 4. The tags are connected together by an insulated link wire, and then connect to the earth point on the front panel by way of a flexible insulated lead. These two wires and the two leads from points "E" and "F" in Fig. 4 must be suitable for mains voltages and currents. The Veroboard panel is mounted well to the rear of the case, beneath S4 and S5, ensuring that it will have adequate clearance from the components on the front panel when the latter is mounted in place. As can be seen from the photograph of the interior, the board is oriented such that the two 6BA mounting holes are nearer the mains transformer.

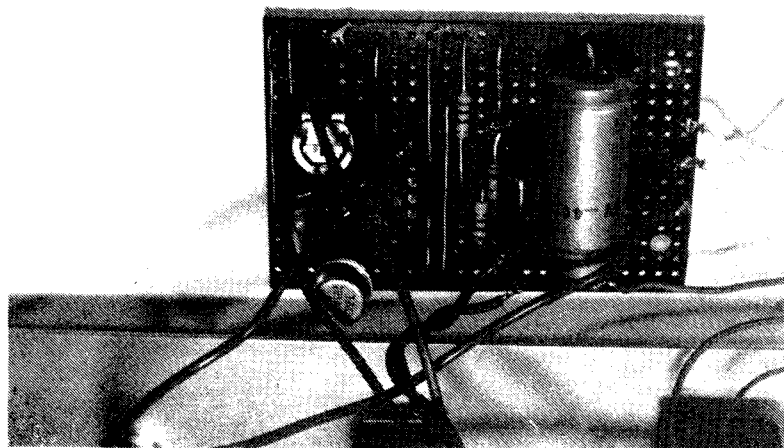
The transformer is mounted near the end of the board, beneath S6. It should also be close to the back of the case, to ensure clearance from the front panel components. It has to be mounted by means of two 4BA nylon bolts and nuts. Metal bolts and nuts are not recommended here as these would necessitate having the transformer mounting clamp earthed. The insulation between secondary

and metal frame of some of these small mains transformers is not of a very high order and, since the secondary is connected to the mains, this insulation could break down (as the author learned the hard way) if the frame were earthed. Provided that nylon mounting bolts and nuts are employed for the transformer it is quite in order for its metal frame to be floating.

#### POINT-TO-POINT WIRING

The timing resistors are mounted on the appropriate switches, and details of this wiring and all the other point-to-point connections are given in Fig. 5. There is not a great deal of space for the timing resistors and it is therefore necessary to trim their lead-out wires quite short. They must be soldered into position quickly and efficiently so that they do not overheat (which could result in a significant shift in resistance value). The resistors must not be allowed to protrude far below the switches as they might then foul T1 and the component panel.

Two holes are drilled in the rear of the Verobox and are fitted with grommets. One of these allows the passage of a 3-way mains lead, which must be correctly terminated at a 3-way mains plug. The other hole takes a lead which connects to the enlarger lamp. If the enlarger lamp metalwork is reliably earthed this second lead can be 2-way, and



*The Veroboard panel in detail. External connections are made by way of Veropins*

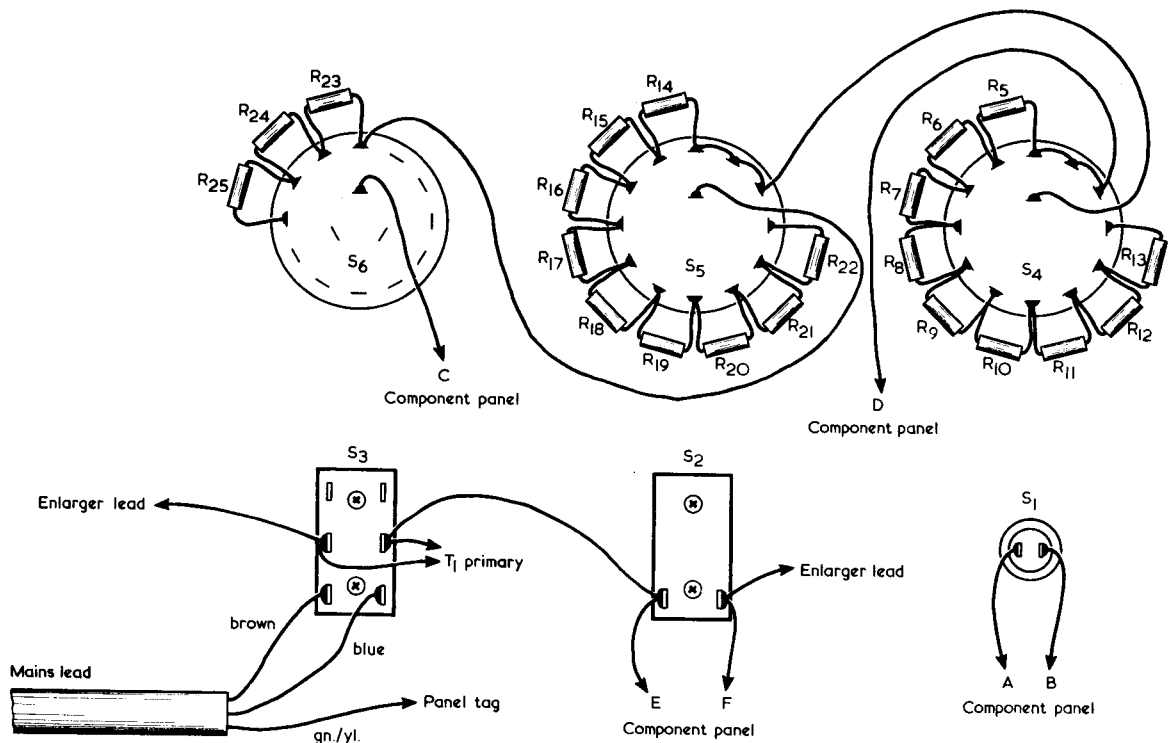


Fig. 5. Illustrating the components and wiring on the front panel. The timing resistors are wired directly to the rotary time selection switches

the two wires concerned are those designated "Enlarger Lead" in Fig. 5. Alternatively, the lead can be 3-way, with the third lead carrying an earth connection to the lamp. This third lead connects to the same panel earthing tag as does the incoming earth wire in the mains lead. When using 3-way wire to the enlarger lamp, follow the usual colour code of Brown for Live, Blue for Neutral and Green-Yellow for Earth. Always remember that all this wiring is at mains potential, and that an incorrect connection may result in a dangerous shock.

It is essential that the aluminium front panel of the timer be connected to the mains earth. The author employed a very large solder tag which he happened to have on hand, and which was capable of being secured on the mounting bush of S6. If such a tag is not available, a 4BA solder tag can be secured to the front panel by means of a short

4BA bolt with nut, a suitable 4BA clear hole being drilled in the panel at any convenient point. The earth wire from the mains lead connects to this tag, as also does the flexible wire from the 6BA solder tags in Fig. 4 (and the earth wire to the enlarger lamp if a 3-way lead is employed here).

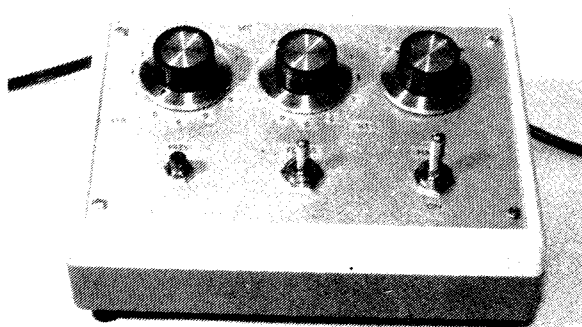
#### ADJUSTMENT

The only adjustment which has to be made is the setting up of R3. However, this procedure must be carried out with considerable care as it has to be done with the timer front panel removed, whereupon all the internal wiring, which is at mains potential, is exposed. R3 must be adjusted by means of an insulated tool. All other precautions against accidental shock must be observed.

Initially adjust R3 so that its slider is at about the centre of its track and set the timing switches for a period of 10 seconds. Then measure the actual duration over which the enlarger lamp is on with the aid of a stopwatch, stopclock, a clock or watch having a seconds hand, or any other suitable timepiece. Then adjust R3 as necessary to correct any error and repeat the process a number of times, adjusting R3 each time, until the timing period is accurate at 10 seconds. Adjusting R3 in a clockwise direction causes the timing period to be lengthened, whilst adjustment in the anti-clockwise direction has the opposite effect.

After a little trial and error the timer should be quite accurate over short periods. The switches are then set up for a 99 second timing period and the procedure is carried out again. Working to a 99 second period allows final fine adjustments in R3 to be carried out.

The front panel of the timer is then secured in place and the unit is ready for use. ■



The Verobox in which the timer is housed has a two-tone plastic outer shell. The upper section is white and the lower section grey. The front panel is anodised aluminium

# OP-AMP PRECAUTIONS

By R. V. Smithson

Some standard op-amp circuits are inherently much more stable than others.

Here are two basic operational amplifier circuits.

The first appears in Fig. 1, in which the op-amp output is coupled back to the inverting input via  $R_2$ , whilst the input signal voltage is applied via  $R_1$ . Assuming that the source of input signal has zero internal resistance, voltage gain is equal to  $R_2$  divided by  $R_1$ . This is easy to visualise if you remember that the two inputs of an op-amp tend to stay at about the same voltage. If  $R_2$  has 3 times the value of  $R_1$  and the input signal goes from earth potential to 1 volt positive the op-amp output will go 3 volts negative. The voltage at the inverting input would then once more be close to that on the non-inverting input, and the op-amp gain would be 3 times.

## SECOND CIRCUIT

The second basic circuit appears in Fig. 2. Here, the input signal is applied to the non-inverting input and a fraction of the output signal is fed back to the inverting input. The fraction of the output voltage fed back is equal to  $R_1$  divided by the sum of  $R_1$  and  $R_2$ . If, once again,  $R_2$  is equal to 3 times  $R_1$ , then one-quarter of the output voltage is fed back to the inverting input, whereupon the overall gain is the reciprocal of one-quarter, or 4 times.

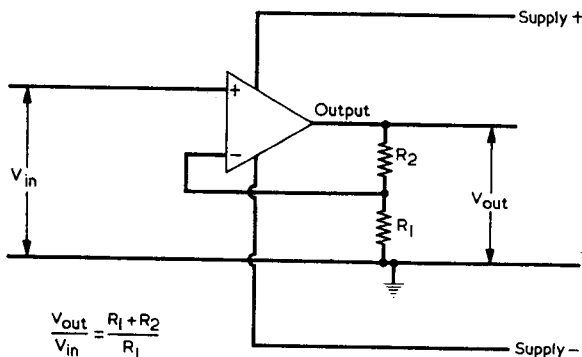


Fig. 1. A simple op-amp voltage amplifier circuit, in which the gain is controlled by the values of the two resistors.

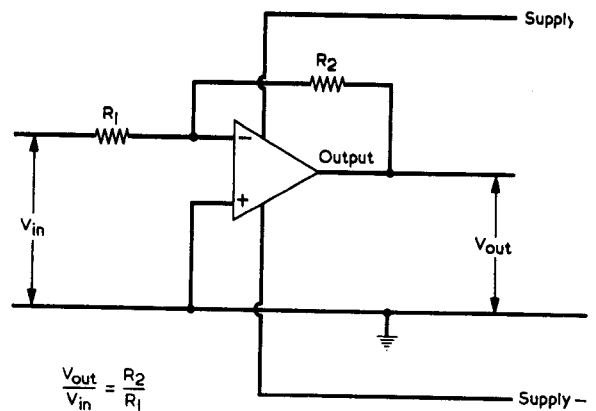


Fig. 2. Another basic voltage amplifier circuit. In this the input is applied to the non-inverting input, which is in phase with the output.

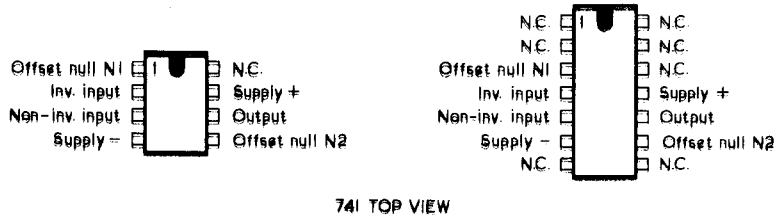
These are both nice simple circuits which are quite easy to understand, and in which voltage gain is determined by the values of two resistors. But one has a serious hidden snag whilst the other has not.

The circuit without the snag is that shown in Fig. 1. It is free of problems because the non-inverting input is tied securely to earth and no unwanted voltage feedback to it from the output due to stray capacitances can take place. If there are any stray capacitances between the output and the inverting input they could in some conceivable cases possibly affect frequency response, but they could not cause instability because the two circuit points are out of phase with each other.

## WIDE OPEN INPUT

Not so with the circuit of Fig. 2. In this circuit the non-inverting input is wide open for positive feedback from the op-amp output via stray capacitances, and if the resistance between the input and earth is high the circuit is quite likely to give instability and oscillation if special care is not taken.

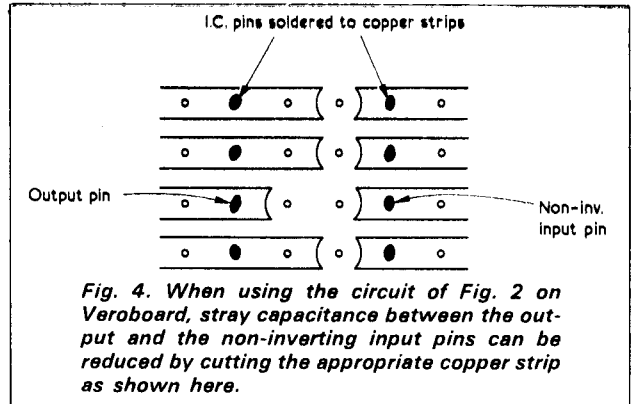
**Fig. 3. Pin functions of the 741 op-amp in both 8 pin and 14 pin d.i.l. packages.**



741 TOP VIEW

As is shown in Fig. 3, the output and non-inverting input pins of the popular 741 (and similar op-amps) are opposite each other, both in the 8 pin and in the 14 pin d.i.l. versions. If, say, you mount either of these i.c.'s on a piece of Veroboard with a single cut in the copper strip between the two pins, don't be surprised if the capacitance across the two copper strip ends is sufficient to allow instability to occur when using the circuit of Fig. 2. A useful technique here is to cut the strip at *both* holes between the pins concerned and remove the cut copper edges, so that there is a good gap between the two copper strip ends. Fig. 4 shows the idea.

But the best approach of all, if a particular application allows you to use either the circuit of



**Fig. 4. When using the circuit of Fig. 2 on Veroboard, stray capacitance between the output and the non-inverting input pins can be reduced by cutting the appropriate copper strip as shown here.**

Fig. 1 or that of Fig. 2, is to select Fig. 1 every time. It's far more free of unseen bugs. ■

## 10th SCOTCH WILDLIFE SOUND RECORDING COMPETITION

A superb Spectra Normende 26-inch colour remote control television suitable for receiving Ceefax and Oracle Teletext programmes worth £1,000 is included in the first prize offered in this year's Scotch Wildlife Sound Recording Contest.



**Keith Biggadyke, 3M Wildlife Sound Recordist winner last year in the open mammals class with his recording of two Muntjac deer and a nightingale.**

The Spectra is capable of receiving Teletext transmissions, which are pages of information broadcast by BBC (Ceefax) and ITV (Oracle). These pages give up to date news, current affairs, sport, gardening, shopping hints—in fact dozens of pages of information at the fingertips in addition to impeccable colour television pictures.

Other prizes include: Philips type 911 portable television, Uher digital radio alarm, Six Kodak EK2 instant cameras and film packs, 60 reels of Scotch recording tape, 50 Scotch recording cassettes.

To complete the prize list, specially commissioned framed water colour paintings are presented to the six class winners.

As before, entries must be of wildlife species (birds, mammals, amphibians or insects), and there are also prizes for 'atmosphere'. Mono or stereo recordings may be on cassette or open reel but must have been made in the British Isles. Recording quality is important, as is originality, for which a special award is offered. Prizes are also given for the best entry originating on cassette and for the best stereo entry.

Excellent advice on producing wildlife sound recordings is given in a book by naturalist, sound recordist, lecture and author Richard Margoschis, whose "Recording Natural History Sounds" is recommended for anyone interested in this competition. It is available by post from Richard Margoschis, 10 Mancetter Road, Mancetter, Atherstone, Warks, priced £3.00 (soft back) or £4.35 (hard back).

The competition closes on October 30, and entry forms and copies of rules and conditions are obtainable from Jeff Chandler, 3M United Kingdom, 380/384 Harrow Road, London, W9 2HU, and at outlets where Scotch recording tapes, cassettes and accessories are obtainable.



**ELECTRICAL AND ELECTRONIC DRAFTING.** By Herbert W. Richter. 286 pages, 235 x 190mm. (9¼ x 7½in.) Published by John Wiley & Sons, Ltd. Price £8.25.

This book, written by an American author, is in the John Wiley Electronic Technology Series in which chapters are laid out rather in the form of lessons complete with "self-evaluation questions". The reader should satisfy himself that he can answer these questions before proceeding to the next chapter. The book starts with instruments and drawing techniques, lettering, block and logic diagrams and electronic component symbols, then proceeds through basic circuits, schematic and wiring assembly diagrams to printed circuit and integrated circuit drawings. Next follow pictorial assembly drawings, electrical building construction wiring diagrams, industrial control wiring diagrams, and graphs and charts. The book concludes with 22 pages of appendices, a glossary and an Index.

The student draughtsman should have a reasonable understanding of how the devices and circuits he draws work, and the book gives very helpful information in this respect. There may be a few small and relatively unimportant differences between the American approach and that prevalent in the U.K., but these do not detract from the usefulness of the book. In the section on orthographic drawing, third angle projection is presented as being the only projection employed, which is very probably the case in the U.S. where engineering follows common-sense rules.

The book will be of value to the student in its subject and it is based on a very successful electronics draughting course taught at the author's college.

**NEWNES COLOUR TELEVISION SERVICING MANUAL, Volume 3.** By Gordon J. King, T.Eng.(C.E.I.), R.Tech.Eng., A.M.I.E.R.E., F.I.P.R.E., F.I.S.T.C., F.S.C.T.E., M.A.E.S., M.R.T.S. 239 pages, 245 x 185mm. (9¼ x 7½in.) Published by Newnes-Butterworths. Price £7.80.

This book is the third in a series which provides complete servicing information on colour television receivers retailed in the U.K., and it deals with leading receivers which were launched in 1974 and 1975. In doing so it describes fully solid-state designs together with thyristor power supplies such as are employed in the Thorn 9000 chassis. Servicing details cover every aspect, including alignment, convergence and all other adjustments.

The designs dealt with are by Rank-Bush-Murphy, Hitachi, I.T.T. B & O, Decca, Thorn and Philips. Amongst the following five appendices are two which deal with p.i.l. picture tubes and quick-vision picture tubes.

This book will appeal not only to the qualified service engineer but also to the student, the servicing apprentice and to the amateur television enthusiast.

**BEGINNER'S GUIDE TO RADIO, Eighth Edition.** By Gordon J. King, T.Eng.(C.E.I.), Reg.Tech.Eng., A.M.I.E.R.E., F.S.C.T.E., F.I.S.T.C., M.A.E.S., M.R.T.S. 240 pages, 190 x 115mm. (7½ x 4½in.) Published by Newnes Technical Books. Price £2.75.

This eighth edition of "Beginner's Guide To Radio" has been completely rewritten by Gordon J. King to take in the latest developments in the field of radio technology. It is intended for the reader who has virtually no technical knowledge about the subject, and it starts right at the beginning by dealing with electron flow, magnetism and basic electricity. It then carries on to radio signals, propagation, reception, transmitter principles and receiver principles. In these last two cases the reader is taken all the way to pulse code modulation and to stereo transmission and reception. The book then turns to components, valves, semiconductors and integrated circuits, after which two final chapters are devoted to the microphone, pickup and loudspeaker, and to modern radio receivers.

There is a minimum of mathematics and the text is written in the clear lucid manner for which Mr. King, a prolific writer on electronics, is justly renowned. There are plenty of clear diagrams, together with a few photographs of equipment and components. Valves are briefly referred to in one section of the book, but only because they represent important radio principles and because, being relatively simple, they help the reader to more readily understand the similar functions carried out by the semiconductor devices which have superseded them. The book will be particularly appreciated by the newcomer who seeks to acquire knowledge in a hitherto unexplored area.

# CLANDESTINE RADIO

by Ron Ham

Have we found another set used by Allied agents in World War II ?

One of our readers, Dave Logan, G4EZF, of Mottram, Cheshire, came across the transmitter-receiver shown in the photographs in a local radio shop. Being interested in wartime equipment he could not resist the pleasure of adding it to his collection.

## TRANSMITTER-RECEIVER

This brand "X" set is inscribed "Type A, Mk III, Serial No. MCL". It weighs 8 lbs., measures 9¼ by 7½ by 3¼ in. deep, and has a total of five valves. Three of these are in the receiver section and two in the transmitter; the receiver valves are a 7Q7 and two 7H7's, whilst those in the transmitter are a 7H7 and a 7C5. These valves are similar to those used in the now-famous "B2" radio, described in "The Set In The Suitcase" in the March 1977 issue of *Radio & Electronics Constructor*.

The "Type A" set has two frequency ranges identified by the colours blue and red, the blue range extending from 3.2 to 5.2MHz and the red range from 5.2 to 8.5MHz. There is an internal power unit for operation on various a.c. supplies between 100 and 240 volts.



The front panel of the "Type A" transmitter-receiver. The meter is scaled 0-75mA, and there are two sockets for a crystal, presumably a 10X type.



Rear view of the set. At bottom left are four "metal" rectifiers of the type used in the 1940's, these being part of the multi-voltage power supply section.

G4EZF is a low power enthusiast, and he recently used the set for a 2-way c.w. contact with G4AHF in nearby Droylsden. He was delighted to find that this old 8 watt wartime rig could still make a contact, and with only a curtain rail aerial.

The earlier article describing the "B2" set produced a welcome response from Dick Rollema, Editor of *Electron*, the official journal of the Netherlands amateur radio organisation, V.E.R.O.N. Amongst other points Dick states that "Quite a few Dutchmen were trained by the S.O.E. and parachuted over Holland during the German occupation. Most of them were accompanied by a radio operator and a radio set, presumably a 'B2' or similar piece of gear". The S.O.E. were of course the Special Operations Executive, whose agents operated in occupied Europe.

As a result of subsequent correspondence, copies of the two accompanying photographs have been sent to Dick Rollema for publication in *Electron*. It is hoped that this joint effort, both in the U.K. and in Holland, will result in a reader contacting the author with some further gen on this intriguing and mysterious set from the last World War. ■



# NOTES FOR NEWCOMERS

## NOUGHT-POINT-ONE

By F. Bowden

### Some tips on the use of a popular home-constructor product

As beginners in the hobby of radio and electronic construction soon become aware, many home projects are assembled on Veroboard. Veroboard is the proprietary name chosen for the product by Vero Electronics Limited, and it consists of an s.r.b.p. backing with parallel copper strips on one surface. The letters "s.r.b.p." stand for "synthetic resin bonded paper", and this is the familiar hard brown insulating material which used to be referred to under names such as "Paxolin".

Veroboard comes in two types. One type has holes spaced from each other, in rows along the strips and at right angles to them, at intervals of 0.15in., whilst the other has holes spaced at intervals of 0.1in. The 0.1in. version is becoming increasingly the more popular of the two because the holes readily accept the pins of d.i.l. (dual-in-line) integrated circuits. This 0.1in. "matrix" or "pitch" explains the title of this article.

#### VEROPINS

When it is necessary to connect external wires to a Veroboard these may be passed through the Veroboard holes at the appropriate points and soldered to the strips. But this is not always the best approach when there is the possibility of a wire being moved around relative to the board, since there is then a strain on the copper strip around the solder joint and the copper may

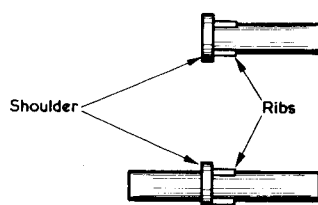
become detached from the s.r.b.p. material.

A better plan is to fit Veropins to the board at the points where external connections are to be made. Veropins are available as single-ended and double-ended types as shown in Fig. 1(a), and the author finds that the most convenient to use in practice are the double-ended types. When soldered into position they take up the appearance shown in Fig. 1(b).

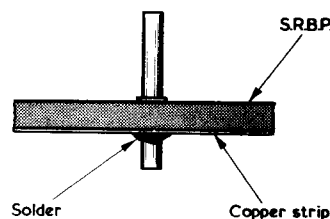
Always make sure you get the correct pins for the type of Veroboard you are using. The holes in 0.15in. Veroboard have a diameter of 0.052in. (1.3mm.) and those in 0.1in. Veroboard have a diameter of 0.04in. (1.02mm.) Veropins are available from nearly all suppliers of Veroboard, and are usually sold in packets of 36 pins. They can be pushed into the board holes by applying pressure on the top shouldered side, but if you want a really professional finish you can use a Veropin insertion tool. There are two types of tool, one for 0.052in. pins and one for 0.04in. pins.

The copper Veroboard strips can be cut, to make circuit breaks, with a small twist drill held in the hand or, better, with a Vero "spot face cutter". The latter is suitable for both 0.15 and 0.1in. boards. Only light pressure is required for cutting a copper strip. Excess pressure of the cutting tool is liable to cause too much of the s.r.b.p. backing to be removed, whilst too little pressure may result in a thin strand of copper around the periphery of the cut

Fig. 1(a). Single-ended and double-ended Veropins. (b). A double-ended Veropin soldered to a Veroboard. The external connecting wire is soldered to the upper end of the pin



(a)



(b)

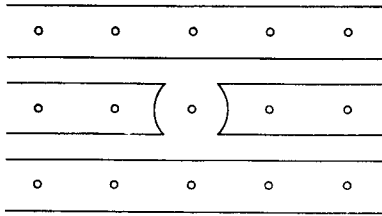


Fig. 2. Making a cut in a Veroboard copper strip. The cut should ensure that the strip is fully interrupted without passing too deeply into the s.r.b.p. backing

bridging the gap. The general appearance of a correctly cut strip is shown in Fig. 2.

In addition to Veroboards there are also Verostrips. These are pieces of Veroboard on which the manufacturer has already removed the copper from the centre, as shown in Fig. 3, which illustrates part of a 0.1in. Verostrip. These are excellent for quick assemblies when you haven't the time to plan out a proper Veroboard layout, because each section of strip can be used like the tags on a double-row tagboard. With the 0.1in. Verostrip, you can also solder a d.i.l. integrated circuit to the board so that its two rows of pins straddle the central gap.

#### I.C. HOLDERS

And now we come to an operation which many newcomers approach with some trepidation: the actual soldering of a d.i.l. integrated circuit to 0.1in. Veroboard. Probably the best advice for the beginner here is to use an i.c. holder. The i.c. holder is soldered to the Veroboard, and the integrated circuit is then plugged into the i.c. holder. Two advantages accrue from this approach. First, the i.c. does not have the soldering iron applied to its pins and so is not liable to be damaged by excessive heat. Second, if there is a connection error all you have lost is an i.c. holder. It is possible to remove a d.i.l. integrated circuit from Veroboard after all its pins have been soldered to the copper

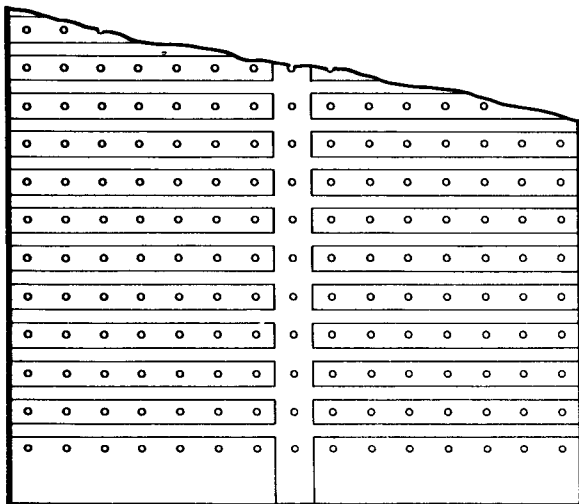


Fig. 3. One end of a 0.1in. Verostrip. The length of the strip is 8.4in.

strips, but the process requires desoldering braid or a desoldering tool and is not a task likely to be relished by the newcomer.

All this having been said, it must next be stated that the insertion of an integrated circuit into an i.c. holder is a little fiddling in itself. You'll find that the i.c. pin tips tend to splay out slightly wider than the holes in the holder which are intended to accept them. What is required is a little patience and practice, whereupon you soon acquire the knack.

Taking an integrated circuit out of an i.c. holder can also be rather fraught. If you attempt to pull it out in one go, like we used to pull valves out of valveholders, you may cause one end of the i.c. to be released before the other, with the result that some of the pins become bent sideways, as illustrated in Fig. 4. A good method is to gently lever the integrated circuit out with a small screwdriver, as shown in Figs. 5(a) and (b). First raise one end of the i.c. by a very small amount, as shown in Fig. 5(a), raise the other end by a similarly very small amount, then return to the first end again and repeat here and at the second end until you feel that the i.c. pins have been released from the holder contacts.

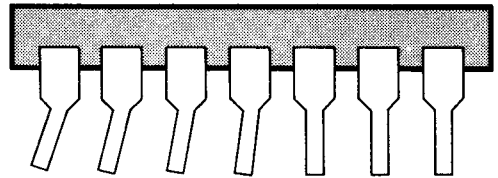
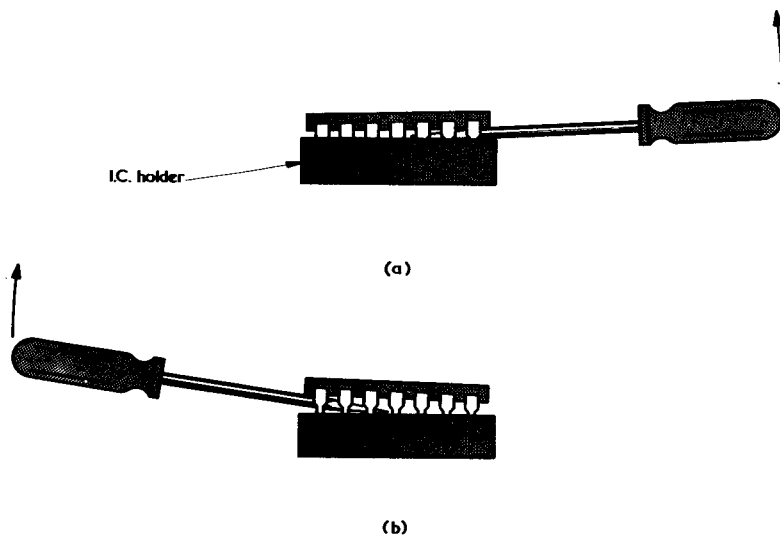


Fig. 4. The unhappy result of carelessly removing a d.i.l. integrated circuit from an i.c. holder

#### BOARD LAYOUT

If you have the time to make up a good Veroboard layout on paper before embarking on a circuit design of your own, this will give you greater pride and pleasure in the finished project. Squared paper is useful here, and you can get this from a number of sources, of which probably the most convenient for the constructor who does not have access to normal drawing materials are the children's school exercise books which are sold by Woolworths. Opening out the centre staples enables you to take out squared double pages measuring about 12 by 8in. You then work out your Veroboard layout, assuming that the intersections of the ruled lines on the paper represent holes. It is necessary to start off by drawing the components which will be mounted in light pencil, so that errors can be quickly erased. Cuts at holes can be represented by crosses. After the pencil rough has been successfully completed, the layout can be drawn in on top of the pencil using a blue ball-point pen for components and wires, and a red ball-point pen for the crosses which stand for the cuts in the strips. Give the ink about a quarter of an hour to become really dry, and you then rub off the original pencil markings.

*Fig. 5. One way of removing a d.i.l. integrated circuit from its holder. One end is raised very slightly, as in (a), then the other end is raised very slightly more, as in (b). The first end is then raised again very slightly, and then the second end, and so on until the i.c. is free*



Solder and the soldering iron are of the utmost importance in assembling projects on Veroboard. The correct solder alloy is 60:40, i.e. 60 per cent of tin to 40 per cent of lead, or Ersin "Savbit" (which has an added trace of copper to extend the life of the soldering iron bit). The solder must be resin-cored. Never use the cheaper 40:60 alloy, which is mainly intended for bulky electrical joints. It can be surprisingly difficult to obtain 60:40 solder in some provincial towns, although you may occasionally find small dispensers of it in Woolworth's or Halford's. A good plan is to buy the solder in advance from the radio component mail-order houses which sell it. The next time you order some components by mail-order remember to in-

clude solder in the list so that you always have a good stock in hand.

The soldering iron should be a miniature mains type rated at around 15 to 25 watts. Beware of some miniature "no-name" irons rated at about 30 watts. It is quite possible that these will be completely useless.

Finally, don't be ashamed to use a magnifying glass to visually check your solder joints on 0.1in. Veroboard. Cheap plastic magnifying glasses are fairly useful here, although the plastic lens may soon get scratched with handling on the bench. A more expensive magnifying glass with a glass lens will, in the long run, prove to be invaluable. ■

## MAIL ORDER PROTECTION SCHEME

The publishers of this magazine have given to the Director General of Fair Trading an undertaking to refund money sent by readers in response to mail order advertisements placed in this magazine by mail order traders who fail to supply goods or refund money and who have become the subject of liquidation or bankruptcy proceedings. These refunds are made voluntarily and are subject to proof that payment was made to the advertiser for goods ordered through an advertisement in this magazine. The arrangement does not apply to any failure to supply goods advertised in a catalogue or direct mail solicitation.

If a mail order trader fails, readers are advised to lodge a claim with the Advertisement Manager of this magazine within 3 months of the appearance of the advertisement.

For the purpose of this scheme mail order advertising is defined as:

"Direct response advertisements, display or postal bargains where cash has to be sent in advance of goods being delivered."

Classified and catalogue mail order advertising are excluded.

**PLEASE MENTION RADIO & ELECTRONICS CONSTRUCTOR  
WHEN REPLYING TO ADVERTISEMENTS**

# Trade News . . .

## DEMAND FOR CORDLESS DRILLS CONTINUES

For some time, battery powered hedge trimmers have been available; nowadays there are also brands of cordless drills that are powered by rechargeable nickel-cadmium cells. In the early sixties, SKIL Ltd introduced a hedge trimmer and a drill with a separate "power pack" which could be fixed to the operator's belt, these "power packs", however, were soon exhausted and required a very long recharging time. Continuous technical research resulted in a better concentration of power and around 1976, almost simultaneously three different brands of new battery drills came onto the market; one of these was the SKIL tool which is in fact a drive-r-drill as it turns clockwise and anti-clockwise.

The applications are numerous — apart from the obvious use on boats, caravans, and in the garden, a market research by SKIL has revealed that quite a few professionals also like to work with a cordless drill; for example on the disassembly and — after repair — assembly of housings of washing machines, refrigerators etc.

The compact design and lightweight model 2006, shown in the photograph, can be carried anywhere.



In order to emphasise this portability, the tool will be supplied during an introductory period with a practical holster that can be fixed to the operator's belt.

Price: £39.90 excl. VAT from SKIL (Great Britain Ltd), 1B Thames Avenue, Windsor, Berkshire SL4 1QJ.

## NEW RADIO-CONTROLLED GARAGE DOOR OPENER

A new radio-controlled garage door opener, which also acts as a security precaution, is now being introduced by the Haos Company Ltd., of 32 Letchworth Drive, Bromley, Kent to electrical and

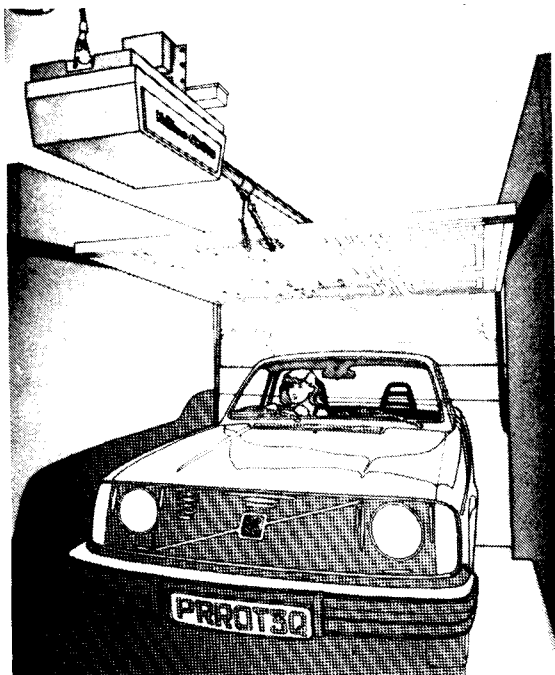
car accessory retailers. Known as the Haos NuTone Automatic Garage Door Operator, it comes from NuTone of America, and it will fit most up-and-over garage doors.

In response to a signal, it has the facility to not only open a heavy garage door, but also to turn on the light, thus illuminating the garage, and then to close and securely lock the door.

Radio controlled models in the range are fitted with British-made controls, which have been approved by the Radio Regulatory Division of the Home Office. It is necessary by law to have a transmitting licence before operating the appliance. A five-year licence is issued by the Post Office for a small fee (currently £4.80). The Haos Company will obtain the first one of these on behalf of the purchaser.


The long wave frequency of the radio controls is not subjected to interference from other radio or electrical equipment; nor does it impair radio or television reception in the area. The small aerial — approximately 10 in. (25.40 cms.) long — can be easily and inconspicuously fixed to the head of the garage door frame.

It is available in two sizes — the Deluxe GB 580XK model has a powerful  $\frac{1}{3}$  h.p. motor capable of lifting any properly balanced sectional or one-piece door up to 18ft. x 7ft. (5.48 m. x 2.13 m.) in size. An additional feature of this deluxe model is the built-in light, which is enclosed in a break-resistant polypropylene lens to diffuse the light evenly. This model costs £221.15 (plus VAT). The standard GB 575XK model has a  $\frac{1}{4}$  h.p. motor to lift doors up to a maximum size of 16 ft. x 7 ft. (£4.87 m. x 2.13 m.). This model costs £195.11 (plus VAT).



*The new Haos NuTone automatic radio-controlled garage door opener. In response to a signal, it has the facility to not only open a heavy garage door, but also to turn on the light, thus illuminating the garage and to close and then securely lock the door.*

# In your work -shop



## LOW COST CAPACITANCE BRIDGE

Smithy's off-the-cuff capacitance bridge requires few components and can be built very quickly.

"It's these darned silvered micas!"

Smithy, sorting through a heap of small  $\frac{1}{2}$  watt resistors, turned round to his assistant.

"What's wrong with them?"

"It's the way their values are marked on them," complained Dick. "The values are printed on the bodies with faint ink which rubs off almost as soon as you pick them up."

Disgustedly, Dick handed one of the offending capacitors to the Serviceman. Smithy examined it gravely. Although the capacitor was obviously brand-new and had never been soldered into any circuit, its markings had not withstood the handling it had received during its sojourn in the Workshop spares cupboard. Smithy was able to distinguish the letters "pF", but the smudged number which preceded them was completely undecipherable.

"Have you got many others like this?"

"A couple of dozen up to now," replied Dick. "There are several boxes full of loose silvered micas and I keep bumping into these badly marked ones all the time."

### CAPACITOR VALUES

Smithy looked once more at the poorly identified silvered mica capacitor in his hand and sighed. The Workshop was going through one of its very rare clearing-up periods, and Smithy had decreed that the contents of the spares cupboard should be fully sorted out. Neither he nor Dick particularly

relished this activity although they both had to admit privately that it was long overdue. In the heat of tracing difficult faults during their normal servicing work they tended to be careless about small components. When not immediately required, these were frequently relegated to any convenient box in which other components of the same type were already present. Thus it was that Smithy was now listlessly working his way through the polychromatic pile of resistors in front of him, setting them out in their different values, whilst Dick, with equal lack of enthusiasm, was tackling the small capacitors which had collected over the years.

Smithy frowned and glanced round at the general test equipment available in the Workshop. There were his own and Dick's multimeters, an a.f. signal generator and an r.f. signal generator and, finally, infrequently used despite the recommendations of the pundits, a gleaming multi-knobbed oscilloscope. He was suddenly struck by inspiration.

"About what values," he asked, "would those badly marked capacitors have?"

"Judging from their size," stated Dick, looking down at the capacitors, "I'd say they were most probably between 10 and 1,000pF."

"Then," said Smithy decisively, "we'll build a capacitance bridge to sort them out!"

Dick's jaw dropped.

"Just like that?"

"Just like that," confirmed Smithy. "We can knock up something simple to measure capacitances in the range of 10 to

1,000pF in no time at all. All we need is an a.f. oscillator, a small plastic or wooden box to mount a few odd parts in, a ferrite rod and a medium wave radio."

Dick's bored expression vanished immediately.

"Now you're talking, Smithy," he exclaimed jubilantly. "I was getting really fed up sorting out those capacitors. Where do we start?"

"We begin by making up the a.f. oscillator," replied Smithy. "And pretty well the simplest oscillator we can use here is one incorporating a unijunction transistor. Three resistors, one capacitor and the transistor itself are all that are needed. Here's the circuit."

Smithy took out a ball-point pen and quickly scribbled out a circuit on the note-pad he kept on his bench. Dick walked over to examine it. (Fig. 1).

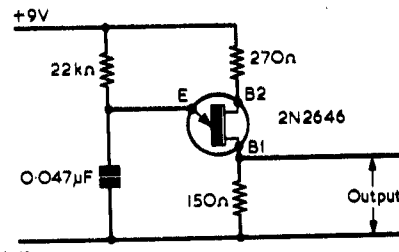


Fig. 1. An a.f. relaxation oscillator employing a unijunction transistor

"That looks easy enough," he stated. "What frequency does it run at?"

"Rough check, around 700Hz. It's so basic that I hardly need to tell you how it works. When the power is applied, the 0.047 $\mu$ F capacitor starts to charge up via the 22k $\Omega$  resistor until the voltage across it reaches the emitter triggering potential of the 2N2646 unijunction transistor. There is then a negative resistance effect between the emitter and the base 1 of the transistor, causing the capacitor to rapidly discharge into the 150 $\Omega$  resistor, after which it starts to charge up again through the 22k $\Omega$  resistor. The result is a series of voltage spikes across the 150 $\Omega$  resistor whose frequency depends on the values of the capacitor and the resistor it charges through. With 0.047 $\mu$ F and 22k $\Omega$  the frequency is of the order of 700Hz."

"Shouldn't there be an electrolytic capacitor across the supply rails?"

"It's not needed," grinned Smythy. "All the important alternating currents flow in the loop given by the capacitor, the emitter-base 1 path inside the transistor and the 150 $\Omega$  resistor. So the circuit doesn't even need a supply bypass capacitor. I know we've got several 2N2646's knocking around because I put them back in the spares cupboard again when I checked our stock of transistors just now. And I'm certain you can find an odd tagboard to assemble the oscillator circuit on. Its layout is not at all critical."

Dick at once snatched up Smythy's circuit and proceeded to get together the few components required. As he did so, Smythy walked over to the "Repaired" rack to pick up a small medium wave and v.h.f. transistor radio he had repaired on the previous day and which was still awaiting collection.

"Hey, Smythy," called out Dick, busy with his soldering iron.

"Hallo!"

"What is it," asked Dick cheerfully, "which floats on the water and says 'knickers'?"

Smythy groaned.

"I think I prefer you when you're all cheesed off and miserable rather than when you're happy and coming out with these dreadful gags of yours. Go on then, what is it which floats on the water and says 'knickers'?"

"Crude oil!"

"All right, all right," retorted Smythy, wincing. "How's that oscillator getting along?"

"It's nearly finished," said Dick. "I'm just soldering on the last battery lead now."

Taking up the little transistor radio, Smythy walked over to Dick's bench. Despite the speed with which he had worked, Dick had, as always, wired up the oscillator with admirable neatness, each solder

joint being impeccably finished. With a flourish he took his soldering iron away from the last joint, which secured a red flexible lead terminated in a crocodile clip to the junction of the 22k $\Omega$  and 270 $\Omega$  resistors. A black lead, similarly terminated in a crocodile clip, was already affixed to the negative terminal of a PP9 battery.

"Shall I connect up?" asked Dick eagerly.

Smythy nodded assent and, switching on the little radio, set it to the low frequency end of the medium wave band in a range free of transmissions. He held it so that its internal ferrite aerial was close to the wiring of Dick's oscillator. A faint tone at about 700Hz became audible from its speaker, and this ceased when Dick unclipped the positive battery connection.

### BRIDGE CIRCUIT

Smythy grunted with satisfaction. "That oscillator's working all

right," he remarked, switching off the radio. "As I told you a few months ago, you can nearly always tell when an a.f. relaxation oscillator like this one is working by the simple expedient of holding an a.m. receiver close to the wiring. The oscillator produces stacks of harmonics modulated at its fundamental frequency, and these extend well up to and beyond the medium wave band. Okay, we've got our a.f. oscillator finished now and so we next proceed to make up a bridge circuit."

"Gosh, Smythy," queried Dick, "isn't that going to be a bit difficult? For a start, won't we have to have a variable capacitor in one of the bridge arms? I can't see us making something like that very quickly." (Fig. 2(a).)

"If we were building a proper laboratory type of capacitance bridge," stated Smythy, "we would have capacitance in all its four arms. But in practice it's possible to make a simple bridge with resistance in two of the arms and

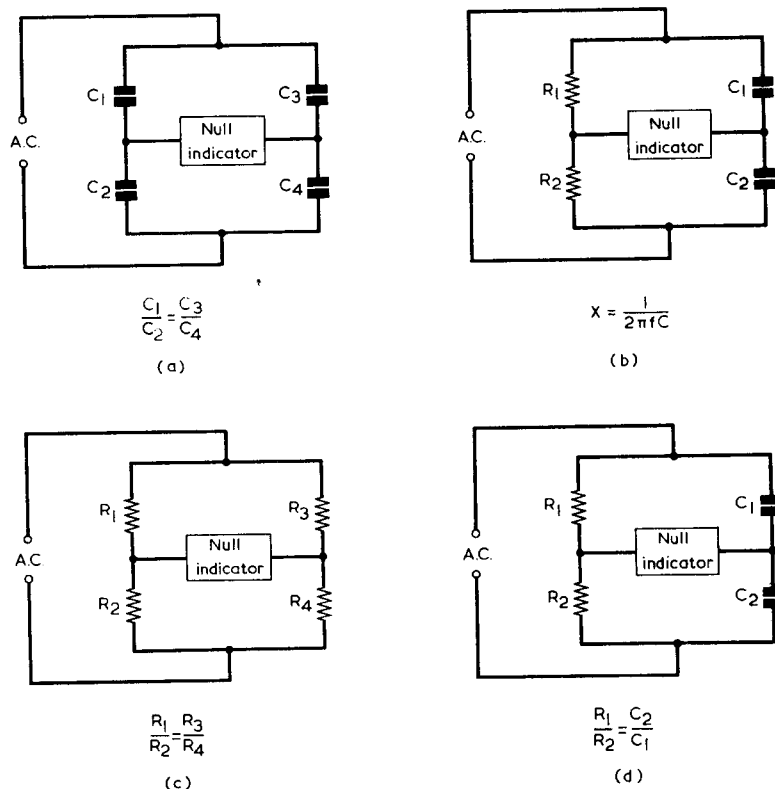


Fig. 2(a). A bridge incorporating capacitors. The bridge is balanced, causing minimum signal to be given in the null indicator, when the capacitance ratios are as shown

(b). In practice, working bridges can be made using resistors in two of the arms. Also shown is the equation for capacitive reactance, X

(c). In a bridge employing resistors, balance occurs for the the resistance ratio shown

(d). In this bridge both capacitors have the same alternating signal applied to them, whereupon their reactances are proportional to the reciprocals of their capacitance values

capacitance in the other two arms. Like this."

Smithy drew out the bridge circuit. (Fig. 2(b).)

"Now this," he went on, "is not quite respectable from the engineering point of view because the signal currents flowing in the capacitive sections of the bridge are out of phase with those flowing in the resistive sections. The circuit also assumes that the capacitors are of good quality with negligible losses due to leakage resistance and things like that. But we can pretty safely make this last assumption when we're dealing with most small value capacitors intended for radio and TV applications. We can certainly do so as far as silvered mica capacitors are concerned. In practice the circuit works quite well provided the resistance values are kept fairly low. You balance the bridge by adjusting one of the resistance values for minimum indication in the null indicator. When this happens the ratio of the upper resistance to the lower resistance on the left is equal to the ratio of the upper capacitive reactance to the lower capacitive reactance on the right."

"Hey, hang on a bit. You're rushing ahead rather with these reactances. I'm trying to remember what the reactance of a capacitor is!"

"Well, reactance is expressed by the letter X," replied Smithy, "and it's equal, in ohms, to  $1 \text{ over } 2\pi fC$ , where f is frequency in Hz and C is capacitance in farads. This means that, at a fixed frequency, reactance goes up when capacitance goes down. The reactance varies as the reciprocal of the capacitance, so that if we halve the value of the capacitance we double the reactance. Got it?"

"Yes, I think so. If the bridge had two resistors instead of two capacitors on the right, would it balance when the ratio of the two resistors on the left was equal to the ratio of the two resistors on the right?" (Fig. 2(c).)

"It would," confirmed Smithy.

"But," persisted Dick doggedly, "we don't have two resistors on the right, we have two capacitors. And, as you say, the reactance of a capacitor varies as the reciprocal of its value. In that case, does the bridge with capacitors balance when the ratio of the upper resistance to the lower resistance is equal to the ratio of the lower capacitance to the upper capacitance? That is to say, you turn the capacitance side of the equation upside-down as compared with the resistors?" (Fig. 2(d).)

"You have," said Smithy, "sized up the situation admirably."

"Have I? Thank goodness for that!"

"And now," said Smithy, returning to his note-pad, "having sorted out that little bit of business we can

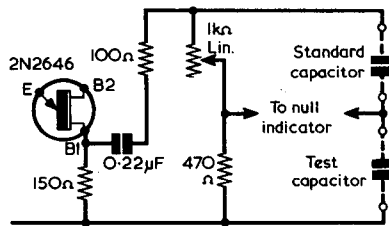


Fig. 3. The bridge circuit of the capacitance meter. The standard capacitor and the test capacitor (which is that to be measured) are connected into circuit by way of terminals

tackle the actual bridge circuit we're going to use. We'll couple the signal from our unijunction transistor via a  $0.22\mu\text{F}$  d.c. blocking capacitor and a  $100\Omega$  resistor to the bridge circuit. All that the  $100\Omega$  resistor does, incidentally, is to limit the transistor base 1 current to a safe level if, for any reason, the upper and lower lines of the bridge should be accidentally short-circuited together. These last two components can be added to the tagboard on which you've already wired up the oscillator. The bridge itself consists of a  $1k\Omega$  linear carbon pot and a  $470\Omega$  resistor, together with two pairs of terminals. A known capacitor which acts as a standard will connect to one pair of terminals and the unknown capacitor to the other pair of terminals." (Fig. 3.)

## BRIDGE LAYOUT

"Stap me," said Dick, impressed, "you couldn't have things more basic than that."

"There's one important point," remarked Smithy, "and that is that it's necessary to use a fairly well spaced out layout to keep down stray capacitances. Something like this."

The Serviceman sketched out a component layout on his pad, alongside the bridge circuit which he had just drawn. (Fig. 4.)

Fig. 4. General layout of the components on the front panel of the bridge as seen from the rear. The bridge should be assembled in an insulated and not a metal case as the latter could increase stray capacitances and capacitances to earth

"That layout shouldn't be difficult to follow," commented Dick. "Does the pot *have* to be a carbon type? We've got stacks of wire-wound  $1k\Omega$  pots available."

"A wire-wound pot wouldn't do because it has inductance, which might upset operation due to the nature of the signal which energises the bridge. The inductance in a carbon pot will be more than negligibly low for the likes of a simple instrument such as we are making. As you can see, I've shown the pot wired such that the resistance it inserts into circuit increases as its spindle is turned clockwise. This means that the test capacitance values it balances out also increase as it is turned clockwise. That's only a minor point but it meets the general convention that a quantity increases when a control knob is moved clockwise."

"That seems fair enough," said Dick. "Hey, I've just remembered something!"

"What's that?"

"You've got two points here which are marked for connection to the null indicator. We haven't even discussed that yet. Will the null indicator be a pair of headphones?"

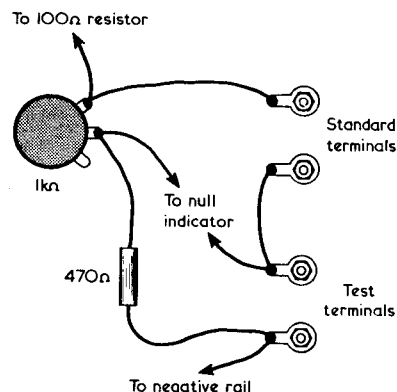
"Oh no," said Smithy. "A pair of headphones would be much too insensitive."

"Then what will it be?"

"You'll see," promised Smithy. "For the time being just make up that bridge circuit and couple the oscillator to it. Assemble it in a plastic or wooden box, by the way, and not a metal one."

"Okeydoke," replied Dick equably.

Smithy's assistant rummaged around and eventually located a plastic case which had once been used for the conveyance of Smithy's lunch-time sandwiches until the lid had got lost. Frowning, he noticed that it now contained a further random selection of silvered mica capacitors and he added these to the unsorted pile already on his bench. Then, using the base of the case as a front panel he drilled out holes for the potentiometer and the two pairs of terminals, following Smithy's recommended layout.



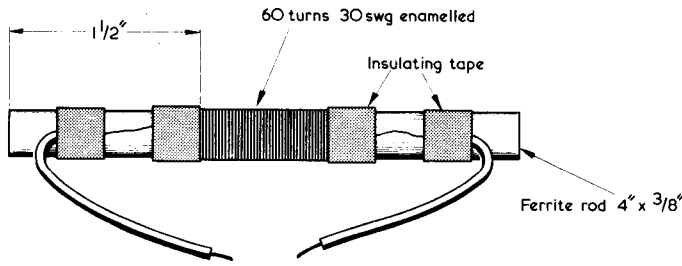


Fig. 5. Details of the null indicator ferrite rod winding

In the meantime, Smithy had risen from his stool and had set off in search of a few items for himself. After some foraging he located a 4 inch length of  $\frac{3}{8}$  inch diameter ferrite rod and a small reel of 30 s.w.g. enamelled copper wire. Returning to his stool he sat down and cut off some 3 yards of the wire.

"Hey, Smithy!"

"What is it now?"

"What is it that floats on the water . . ."

"You've already asked me that one," Smithy interrupted him irritably.

"No I haven't — this one's different. What is it that floats on the water and says 'panties'?"

"All right," said Smithy resignedly, "what is it?"

"Refined oil!"

Muttering to himself, the sorely tried Serviceman applied himself to his task. He secured one end of the enamelled wire to the ferrite rod with p.v.c. insulating tape then carefully proceeded to close-wind 60 turns of the wire onto the rod. He secured the end of the last turn with a further piece of insulating tape and cut the wire so that about 1 inch of lead-out was available at each end of the winding. He then scraped off the enamel and tinned the lead-out ends, after which he soldered a 3 in. length of thin flexible p.v.c. covered wire to each lead-out. He next wrapped two more turns of insulating tape around the

rod, and anchored the solder joints and the flexible wires on top of these and below two final layers of tape. Some grades of ferrite are conductive and Smithy, never one to take chances, had ensured that the flexible leads were held in place without their solder joints being in contact with the rod. (Fig. 5.)

### NULL DETECTOR

"I've finished wiring up the bridge circuit," called out Dick from his side of the Workshop.

Smithy walked over to Dick's bench again. The bridge components were neatly mounted and wired up on the erstwhile plastic lunch box. Dick had also mounted the oscillator tagboard on one side of the box so that the leads from it to the bridge were around  $2\frac{1}{2}$  inches long. The two battery leads now passed under the open edges of the box at the bottom. Smithy was pleased to see that his assistant had fitted a pointer knob to the potentiometer spindle.

"Very good," he commended. "We'll now couple up the null detector to the bridge, and we do this with about 2 feet of ordinary twin flex. Are *all* the mica capacitors you've got there badly marked?"

"No," said Dick, "only about a third of them."

"Good," replied Smithy. "Well, you find one for me which has a

value of — let me see now — 200 or 220pF. Whilst you're doing that I'll get the flex."

Dick was soon able to hand a 220pF silvered mica capacitor to Smithy, who then proceeded to connect his ferrite rod winding to the bridge circuit by way of the flex. Finally, he soldered the 220pF capacitor across the ends of the flex at the ferrite winding end. (Fig. 6.)

"We next," he announced, "want a very small bit of capacitance across the test terminals."

He connected the oscillator battery sulated wire, connected its bared end to one of the terminals and screwed the other terminal down onto the wire insulation. Finally, he turned the potentiometer knob fully anti-clockwise. (Fig. 7.)

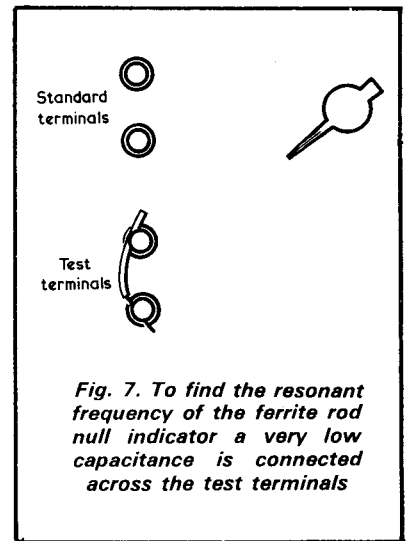


Fig. 7. To find the resonant frequency of the ferrite rod null indicator a very low capacitance is connected across the test terminals

"Right," he announced briskly. "That ferrite rod winding of mine should be resonating somewhere at the low frequency end of the medium wave band. Let's see if we can pick it up on this set."

He connected oscillator battery clips to the PP9 battery, switched on the radio and held it so that its internal ferrite aerial was close to and parallel with the null indicator ferrite rod. Tuning carefully, he was able to pick up the tone of the oscillator at about 500 metres on the receiver scale.

"Blow me," gasped Dick as he watched unbelievably. "What's this, black magic or something? We've got an *audio* frequency oscillator here, not an r.f. one!"

"True," agreed Smithy, "but as I've already demonstrated to you, our oscillator generates harmonics which extend well above the medium wave band. That oscillator is producing voltage spikes at around 700Hz and these are shock-exciting the tuned circuit given by the ferrite rod winding and the 220pF capacitor into producing

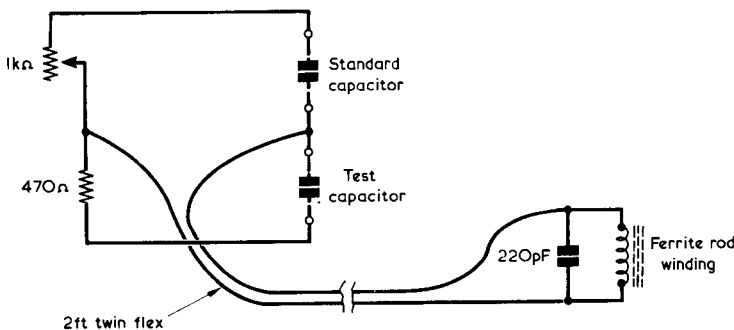


Fig. 6. The ferrite rod winding, tuned by a 220pF capacitor, connects to the bridge via a length of 2-core flex



damped trains of r.f. oscillation after each spike. The tuned circuit has a high Q and its output at around 500 metres tunes in quite sharply in the receiver."

"Blimey, that's crafty. Is the length of the ferrite rod very important?"

"Not really. I used a 4 inch length myself, but anything from 3½ to 7 inches will be all right. If the rod is longer than 4 inches it may be necessary to use a capacitor value lower than 220pF to make it resonate at 500 metres, but that's a matter for simple experiment, of course. Well now, let's see if this gubbins works!"

As he spoke, he removed the piece of wire from the test capacitance terminals.

"How about trying it with a couple of 100pF capacitors?" said Dick, reaching into the capacitors in front of him.

"Fair enough," replied Smithy.

Dick handed him two capacitors and he connected one to the standard terminals and the other to the test terminals. He then rotated the potentiometer knob. A very pronounced null was produced from the radio loudspeaker when the potentiometer slider was at about mid-travel. A similar effect was given with two 10pF capacitors and with two 1,000pF capacitors.

"Hey," said Dick excitedly, "this is pretty good. How about trying two 0.01µF capacitors?"

"Their values will probably be too high for an instrument like this," responded Smithy. "They'll probably reduce the amplitude of the voltage spikes across the bridge to too low a level."

But Smithy's forebodings were unfounded. After Dick had presented him with two 0.01µF capacitors in polyester, and not silvered mica, the bridge was still capable of resolving a satisfactory null with the potentiometer at about the centre of its range. It was only when Dick and Smithy checked operation with two 0.1µF capacitors that they found that a null could not be obtained.

## POTENTIOMETER SCALE

"I'm very pleased with this bridge of ours," commented Smithy cheerfully. "It looks as though it will give useful readings with standard capacitances from 10pF right up to 0.01µF. Considering its simplicity, that's not bad going at all."

"What about measuring values below 10pF?"

"You should get successful readings down to test capacitances of 3pF or even less," stated Smithy, "but the readings will start to become inaccurate at these low values because of stray capacitances. Well, the next thing to do is to prepare a scale for the potentiometer. To give us an idea of

what's to be expected here, let's make up a table which assumes that the value of the resistor below the potentiometer in the bridge section is exactly 500Ω instead of 470Ω."

Smithy walked over to his bench then returned with his note-pad.

"Now, the scale of the potentiometer will be marked up in terms of multiples of the standard capacitance. Let's say that this is 100pF. If the test capacitance is also 100pF the bridge will obviously balance when the potentiometer inserts 500Ω. So, 500Ω corresponds to a multiplier of 1. The bridge will balance with 200pF test capacitance when the potentiometer inserts 1,000Ω. So, 1,000Ω corresponds to a multiplier of 2. A test capacitance of 50pF corresponds with 250Ω in the pot, so 250Ω gives a multiplier of 0.5. Let's fill in the intermediate figures now."

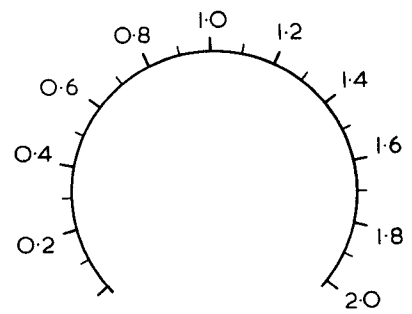
It was not long before Smithy had completed a table having two columns of figures, one for resistances inserted by the potentiometer at balance and the other showing the number by which the standard capacitance should be multiplied to give the value of the test capacitance. (Fig. 8).

POTENTIOMETER RESISTANCE (OHMS)	CAPACITANCE MULTIPLIER
50	0.1
100	0.2
200	0.4
250	0.5
300	0.6
400	0.8
500	1.0
600	1.2
700	1.4
800	1.6
900	1.8
1000	2.0

*Fig. 8. Table showing potentiometer resistance values and corresponding capacitance multipliers if the 470Ω resistor is assumed to have a value of exactly 500Ω*

"That seems very straightforward," commented Dick.

"I'm afraid the process of calibration won't be quite so easy in practice," said Smithy. "That table only shows you what to expect under an ideal set of conditions. What you have to do is make up a scale by measuring known values of capacitance. It would be best to use a 100pF capacitor for the standard and then mark up the scale accordingly for known values of test capacitance. Since the scale is linear you will only need about five reasonably well spread out calibration points to be able to make up the complete scale. You should be able to get a useful range from 0.2 to 2 times the value of the standard capacitance." (Fig. 9).



*Fig. 9. An example of the potentiometer scale likely to be obtained after calibration. As a demonstration of usage, if the bridge balances at 0.6 with a standard capacitance of 1,000pF, the test capacitance is 600pF*

POTENTIOMETER RESISTANCE (OHMS)	CAPACITANCE MULTIPLIER
50	0.1
100	0.2
200	0.4
250	0.5
300	0.6
400	0.8
500	1.0
600	1.2
700	1.4
800	1.6
900	1.8
1000	2.0

"Would it be best to do the calibration with silvered mica capacitors?"

"Yes, it would. These are usually available in quite close tolerances, and this will help things out so far as accuracy is concerned."

"Talking about tolerances, what about the tolerance of the 1kΩ pot? these carbon pots have quite wide tolerances, so what happens if you happen to choose one whose track resistance is quite a bit less than 1kΩ?"

"If you're unlucky enough to use such a potentiometer," said Smithy, "You'll find that the multiplier scale won't go up to the times 2 point. The solution here is to use a slightly lower value than 470Ω for the fixed resistor below it in the

bridge. A value of 430Ω should do the trick, but in bad cases it might even have to be as low as 390Ω."

"Fair enough," said Dick. "Well, I'll make up a scale for the potentiometer next. After that I'll start sorting out these capacitors I've got here. Dash it all, I've just thought of another question!"

"What's that?"

"Well, when you're testing low values of capacitance these won't upset the tuning of the ferrite rod winding and the 220pF capacitor which couples into the receiver. But won't the tuning be messed up as the standard and test capacitance increase?"

"The tuning will become broader as these capacitances go up," replied Smithy. "And that is because the tuned circuit becomes more and more damped by the

## COMPLETE CIRCUIT

Smithy returned to his bench whilst Dick fitted a temporary paper scale to the bridge potentiometer. It occurred to Smithy that, since the capacitance bridge had now entered the Workshop inventory of test equipment, it deserved to be recorded in fitting fashion. Accordingly, he drew out its complete circuit, embellishing its hitherto unidentified resistors and capacitors with proper R and C numbers and giving it the accolade of an on-off switch. He then put the circuit in a drawer in his bench. (Fig. 10.)

Behind him, contented sounds indicated that Dick's calibration was proceeding satisfactorily. Smithy resumed his sorting out of resistors.

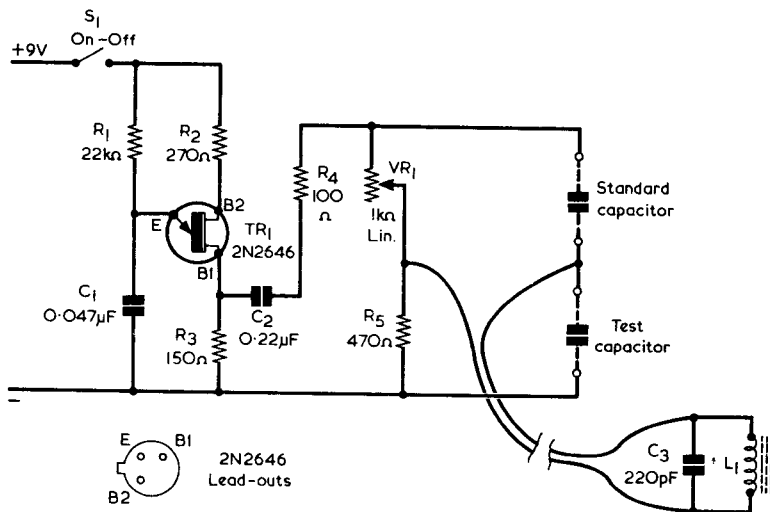


Fig. 10. Complete circuit of the capacitance bridge. All fixed resistors are  $\frac{1}{4}$  watt 5%. Current consumption from the 9 volt battery is approximately 1.4mA

resistances in the bridge. But this effect is compensated for by the fact that the higher capacitances allow more energy to be fed into the ferrite rod winding, and so you still get a strong transference of signal into the radio. Incidentally, the capacitance tuning the winding is really 220pF plus the small self-capacitance in the 2-core flex. The purpose of the flex is to keep the ferrite rod winding well away from the unijunction oscillator and the bridge components. The only coupling to the radio is then by the winding itself."

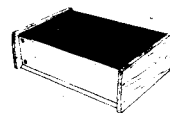
"Hey, Smithy!"  
 "Hallo!"  
 "You're a crossword fan, aren't you?"  
 "I am."  
 "Well, here's a clue then. 'Overloaded postman'."  
 "'Overloaded postman'? Just that?"  
 "That's right. 'Overloaded postman'."  
 Smithy frowned.  
 "How many letters?"  
 Dick chuckled.  
 "Millions of them!"

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# Radio Topics

By Recorder



## VOLTAGE REGULATOR

Have you ever seen a TO3 device with *four* lead-outs? You're looking at one right now in the accompanying photograph, which shows the new Fairchild adjustable voltage regulator type  $\mu$ A79HG.

The main feature of this regulator is that it provides stabilized voltages that are negative of earth or the common rail of an equipment. It is an adjustable four-terminal device capable of supplying currents in excess of 5 amps over a negative voltage range of 2.2 to 24 volts, and it provides a complement to the Fairchild  $\mu$ A78HG positive adjustable regulator.

The  $\mu$ A79HG offers full thermal overload and short-circuit protection. If the output voltage and current are taken outside the safe operating area the regulator simply shuts down. This attribute obviates the need for costly output circuitry and heat-sinking arrangements. The absolute maximum ratings include an input voltage of 40 volts negative and an internal power dissipation of 50 watts at a case temperature of 25°C.

Internally, the device has its own voltage reference which is applied, in company with an external control voltage derived from the out-

put, to an error amplifier. The latter, which couples to an internal emitter follower output transistor, maintains the output voltage at the desired level relative to the control voltage. Also incorporated are short-circuit limit and thermal shutdown stages.

Fairchild are represented in the U.K. by Fairchild Camera & Instrument (UK) Ltd., 230 High Street, Potters Bar, Herts, EN6 5BU.

## ELECTRIC BANDITS

Provided you are sensible and realise that excessive playing of them is a mug's game, you can obtain quite a little relatively harmless pleasure from the one-armed bandits which are now part and parcel of the U.K. entertainment scene. When they first appeared in our locals they were very simple and unsophisticated, but they soon sprouted no end of intriguing addenda such as "flash" features, "hold" buttons and "nudge" facilities. The usual pub machines pay out larger sums up to 50p in tokens which can of course be spent over the bar. Or fed back into the machine.

You can always spot the compulsive bandit addict. He waits im-

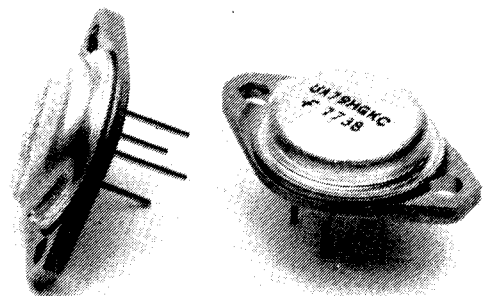
patiently to get at the machine, and his ears are always alerted for the "bang, bang, bang" of other people retrieving their booty. Like Quasimodo he wails: "The bells, the bells!"

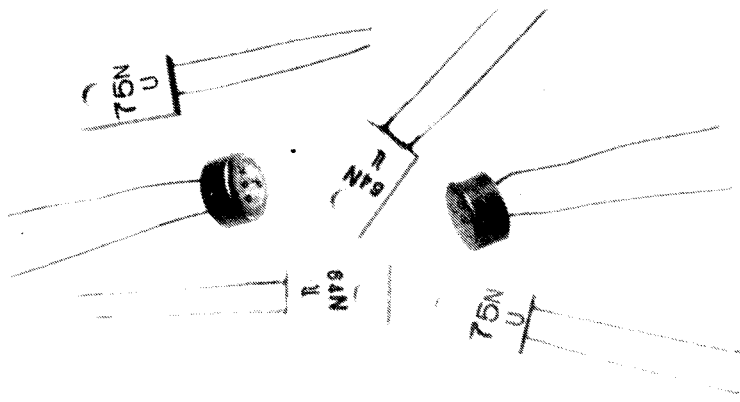
I occasionally wonder if some of the engineers who design these gambling machines have found their way into the ranks of the Post Office development teams responsible for coin-slot telephone installations. Now and again I find that I can indulge in quite long conversations after insertion of the initial coin. Perhaps I have unwittingly pressed a secret "hold" button.

The really impressive bandits are, of course, those encountered in clubs which occasionally produce a deluge of 50p pieces up to a value of £30 or so. I am told that in Australia they have halls filled with these super-bandits and that, when you hit the jackpot, no money comes out. Instead, a signal flashes up on a console in the office adjoining the hall and an attendant appears to present you with the cash, thereby reducing the risks of mugging and other money-oriented mayhem.

Obviously, the most sensible thing to do is to simply watch other people play the machines. You can always have the odd side-bet on their performance.

The newly introduced Fairchild  $\mu$ A79HG voltage regulator. This provides stabilized negative voltages from 2.2 to 24 volts and has an output current capability in excess of 5 amps.





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