

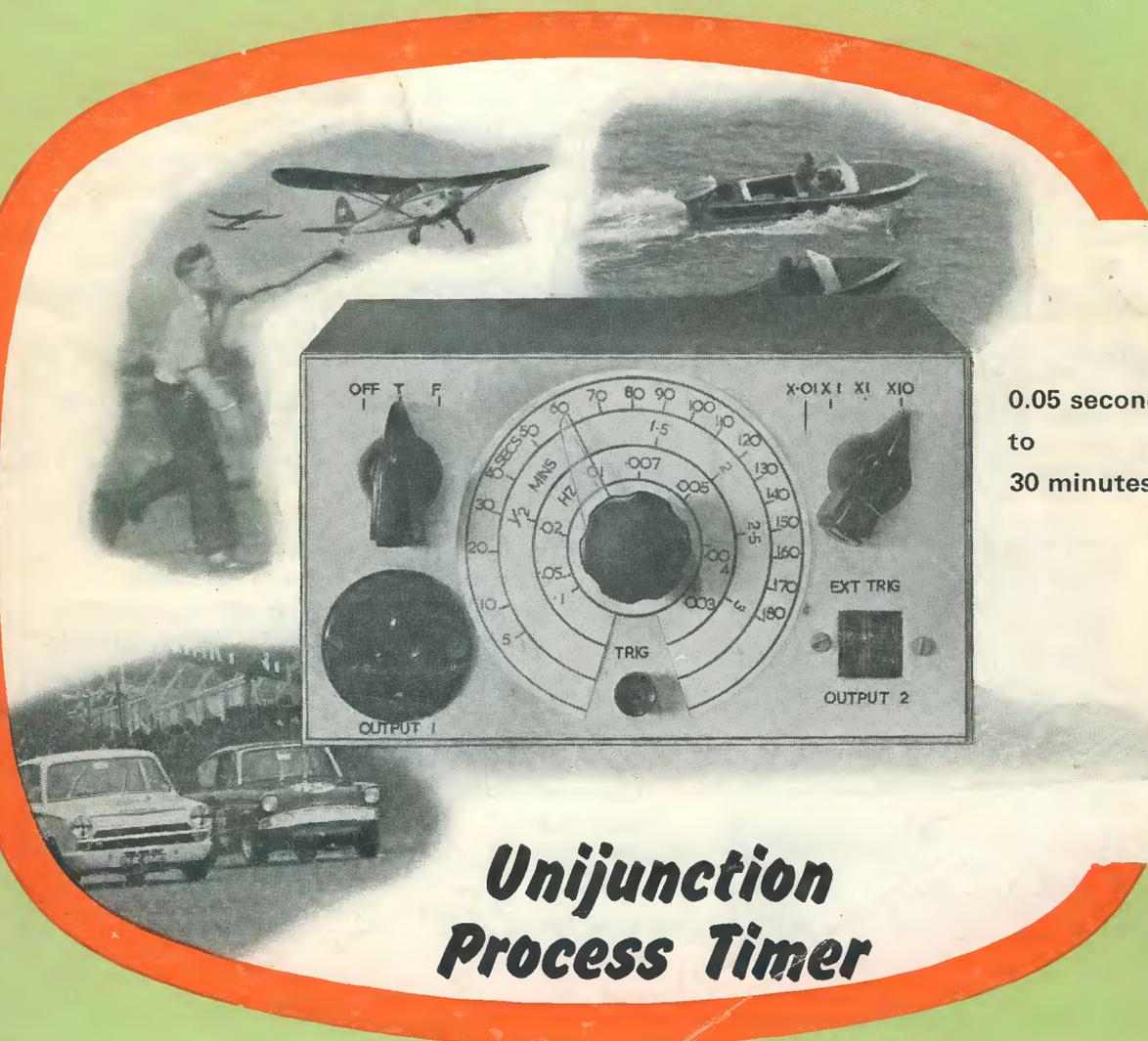
THE
RADIO CONSTRUCTOR

Vol 21 No 7

FEBRUARY 1968
2/6

A DATA PUBLICATION

RADIO . TELEVISION
ELECTRONICS . AUDIO



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NOW AVAILABLE FOR THE FIRST TIME IN GREAT BRITAIN

TWO NEW TRIO COMMUNICATIONS RECEIVERS

These receivers offer the enthusiast high quality and the latest design developments at a realistic price

MODEL JR-500SE

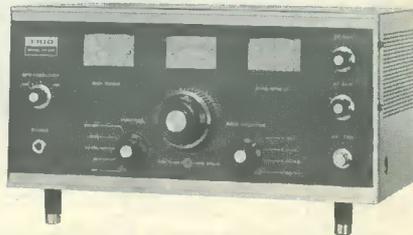
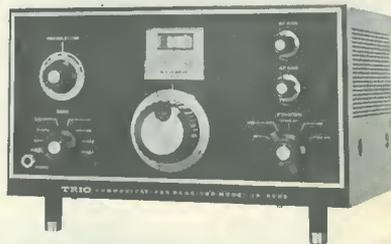
This high performance receiver is made especially to cover the amateur bands and utilises a crystal controlled double heterodyne circuit for extra sensitivity and stability
Brief spec.: Covers all the amateur bands in 7 separate ranges between 3.5 and 29.7 Mc/s. Circuit uses 7 valves, 2 transistors and 5 diodes plus 8 crystals; output 8 and 500 ohm and 500 ohm phone jack. Special features: Crystal controlled oscillator ● Variable BFO ● VFO ● AVC ● ANL ● S meter ● SSB-CW ● Stand-by switch ● Special double gear dial drive with direct reading down to 1 kc/s ● Remote control socket for connection to a transmitter. Audio output 1 watt. For use on 115/250 V A.C. Mains. Superb modern styling and control layout—finished in dark grey. Cabinet size 7 x 13 x 10in. Weight 18 lbs. Fully guaranteed, comp. with instruction manual and service data.

LASKY'S PRICE 59 Gns. Carriage and Packing 12/6.

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Brief spec.: 4 band receiver covering 500 kc/s to 30 Mc/s continuous and electrical band spread on 10, 15, 20, 40 and 80 metres. 8 valve plus 7 diode circuit. 4/8 ohm output and phone jack. Special features: SSB-CW ● ANL ● Variable BFO ● S meter ● Sep. band spread dial ● IF frequency 455 kc/s ● Audio output 1.5 W ● Variable RF and AF gain controls. For use on 115/250 V A.C. Mains. Beautifully designed control layout finished in light grey with dark grey case, size: 7 x 15 x 10in. Weight 19 lbs. Fully guaranteed, comp. with instruction manual and service data.

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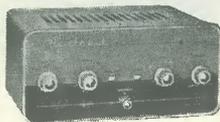
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**S-33H
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Ready-to-Use price on request



Automatic playing of 16, 33, 45 and 78 rpm records. All transistor—cool instant operation. Dual LP/78 stylus. Plays mono or stereo records. Suitcase portability. Detachable speaker enclosure for best stereo effect. Two 8in x 5in. special loudspeakers. For 220-250V a.c. mains operation. Overall cabinet size 15 $\frac{1}{4}$ " x 3 $\frac{3}{4}$ " x 10 $\frac{1}{4}$ in.

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Finished models provide years of superlative performances

INSTRUMENTS

3" LOW-PRICED SERVICE OSCILLOSCOPE. Model OS-2. Compact size 5" x 7 $\frac{3}{4}$ " x 12" deep. Wt. only 9 $\frac{1}{2}$ lb. "Y" bandwidth 2 c/s-3 Mc/s \pm 3dB. Sensitivity 100mV/cm. T/B 20 c/s-200 kc/s in four ranges, fitted mu-metal CRT Shield. Modern functional styling.

Kit £23.18.0 Ready-to-Use £31.18.0

5" GEN-PURPOSE OSCILLOSCOPE. Model 10-12U. An outstanding model with professional specification and styling. "Y" bandwidth 3 c/s-4.5 Mc/s \pm 3dB. T/B 10 c/s-500 kc/s.

Kit £35.17.6 Ready-to-Use £45.15.0

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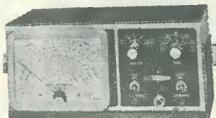
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OS-2



IM-13U



V-7A



RF-1U

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12 × 12 watts output.

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Ready-to-Use £42.10.0

Cabinet £2.5.0 extra



FOR THIS SPECIFICATION

● 17 transistors, 6 diode circuit ● ± 1dB, 16 to 50,000 c/s at 12 watts per channel into 8 ohms ● Output suitable for 8 or 15 ohm loudspeakers ● 3 stereo inputs for Gram, Radio and Aux. ● Modern low silhouette styling ● Attractive aluminium, golden anodised front panel ● Handsome assembled and finished walnut veneered cabinet available ● Matches Heathkit models TFM-1 and AFM-2 transistor tuners.

Full range power . . . over extremely wide frequency range. Special transformerless output circuitry. Adequately heat-sinked power transistors for cool operation—long life. 6 position source switch.

FULL SPECIFICATION SHEET AVAILABLE

NEW! STEREO TAPE RECORDER, STR-1

Fully portable—own speakers

Kit £45.18.0

Ready-to-Use £59.15.0



FOR THIS SPECIFICATION

● ¼ track stereo or mono record and playback at 7½, 3¾ and 1½ ips ● Sound-on-sound and sound-with-sound capabilities ● Stereo record, stereo playback, mono record and playback on either channel ● 18 transistor circuit for cool, instant and dependable operation ● Moving coil record level indicator ● Digital counter with thumbwheel zero reset ● Stereo microphone and auxiliary inputs and controls, speaker/headphone and external amplifier outputs . . . front panel mounted for easy access ● Push-button controls for operational modes ● Built-in stereo power amplifier giving 4 watts rms per channel ● Two high efficiency 8" × 5" speakers ● Operates on 230V a.c. supply.

Versatile recording facilities. So easy to build—so easy to use.

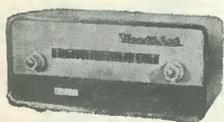
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Low-priced STEREO FM RADIO



FM TUNER FM-4U



STEREO DECODER SD-1

HI-FI FM TUNER. Model FM-4U. Available in two units. R.F. tuning unit (£2.15.0 incl. P.T.) with I.F. output of 10.7 Mc/s, and I.F. amplifier unit, with power supply and valves (£13.13.0). May be used free standing or in a cabinet. Total Kit £16.8.0 (Multiplex adapter available. as extra.) Ready-to-Use price on request

STEREO DECODER. Model SD-1. Converts FM Mono receivers to stereo at low-cost. Styled to match Heathkit models FM-4U and AFM-1 Tuners. Kit £8.10.0 Ready-to-use £12.5.0



SSU-1

SPEAKER SYSTEMS

HI-FI SPEAKER SYSTEM, Model SSU-1
Ducted-port bass reflex cabinet in the white; Two speakers, vertical or horizontal models with legs. KIT £12.12.0, without legs, KIT £11.17.6 incl. PT.



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6½" Bass, 3¼" Treble speakers and crossover unit. Kit £4.18.0 incl. PT. Beautiful. Walnut veneered fully-finished cabinet, £8.18.0, Total price Kit £13.16.0 incl. PT.

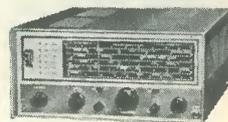
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THE "MOHICAN" GENERAL COVERAGE RECEIVER. Model GC-1U. With 4 piezo-electric transistors, variable tuned B.F.O. and Zener diode stabiliser, this is an excellent fully transistorised general purpose receiver for Amateur and Short wave listeners. Printed circuits, telescopic aerial, tuning meter and large slide-rule dial. Kit £37.17.6 Ready-to-Use £45.17.6



GC-1U

AMATEUR BANDS RECEIVER. Model RA-1. To cover all the Amateur Bands from 160-10 metres. Many special features, including: half-lattice crystal filter; 8 valves; signal strength "S" meter; tuned R.F. Amp. stage. Kit £39.6.6 Ready-to-Use £52.10.0



RG-1

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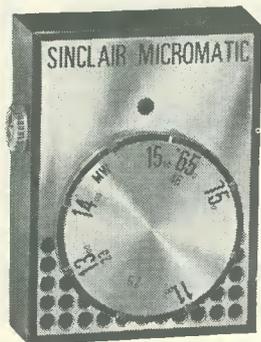
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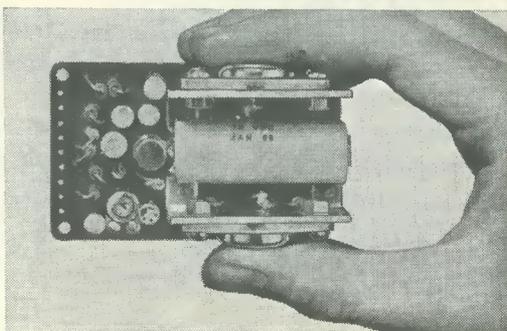
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89'6

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Long Range Light Modulator and Receiver

By J. P. DAKIN

In this novel approach to a.f. communication by modulated light beam, our contributor employs a simple mechanical shutter coupled to a loudspeaker voice coil in front of the light source. Reception is by way of a cadmium sulphide cell, but readers wishing to use faster-acting receiving devices could alternatively employ one of the receiving systems described in previous articles on modulated light beam communication. These are listed at the end of this present article

IN THIS MAGAZINE THERE HAVE BEEN MANY ARTICLES on modulated light transmitters and receivers. The simple transmitters described in earlier articles had one thing in common: they all changed the brightness of the filament of a light bulb at audio frequencies, as in Fig. 1.

This arrangement is ideal for low power transmission but for higher powers there are two limiting factors. The first factor is the power of the modulating amplifier. To modulate the brightness of a 100 watt bulb an amplifier of the order of 30 watts is required and for higher powers the cost of the amplifier becomes prohibitive. The second limiting factor is the thermal inertia of the filament. This becomes more noticeable as the power of the bulb used increases, for high power bulbs use thick filaments of high thermal capacity.

The only way to overcome the second problem is to use several low wattage bulbs in parallel as in Mr. Letts' broadcast transmitter in the March 1965 issue. However, this leads to more expense and adds difficulties in focusing, as shown in Fig. 2. When more than one bulb is used separate images are formed at the receiving end and a large photosensitive area is required.

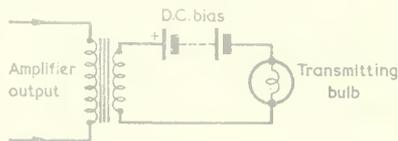


Fig. 1. The basic circuit for an a.f. modulated bulb

These comments do not apply to systems described later, which employed a modulated arc beam and a modulated fluorescent tube ("Wide Band Photophone"), but the writer would now like to introduce a completely different method of obtaining light modulation.

The writer's modulator works on a similar principle to naval light signalling, using an opening and closing shutter. However, in this case the shutter is opened and closed at audio frequencies and can be used to modulate the light beam with speech. An important advantage is that the modulator only requires a power of some 1 to 3 watts and actually functions as a power amplifier. Also, the problem of thermal lag given with simple filament bulb transmitters is completely removed.

Construction

The modulator can be constructed from an old

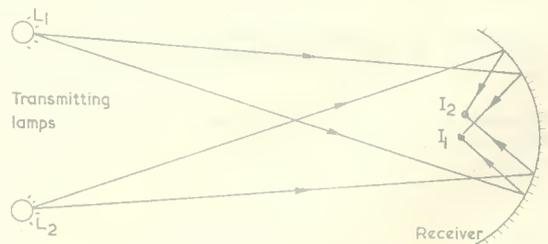


Fig. 2. If more than one transmitting bulb is employed, correspondingly separate images may be formed at the receiving end

speaker with, say, a ripped cone. The remains of the cone are removed carefully without damaging the coil and suspension. The centre part of the cone covering the coil is left in. If the leads to the coil are fastened to the cone the part of the cone holding the leads must also be left in. The speaker should then be tested to check that the connections to the coil are still intact. The speaker is tested by connecting the terminals to a 1.5V battery and if the coil jumps in or out all is well. If not the speaker is useless and another must be used. Next, the frame of the speaker must be cut as in Figs. 3 (a) and (b) to accommodate the variable shutter.

The shutter is constructed from $\frac{1}{8}$ in balsa wood. A piece is cut out as in Fig. 4 and a second piece is then marked from the first and cut similarly. The shutters are placed over each other to check that they are identical.

One of the shutters is then glued vertically to the top of the moving coil with balsa cement as in Fig. 5 (a). This sets hard and a firm joint can be made after several applications of the glue. The second shutter is then fixed to the frame of the speaker by thin aluminium strips as in Fig. 5 (b), and adjusted until it is close to, and parallel with, the first shutter. The second shutter must then be moved vertically until the combination of the two shutters is half open, (see Fig. 5 (c)), where-upon movement of the first shutter in one direction will allow more light to pass through, and movement in the other direction will allow less light to pass through. The shutter assembly is then complete and is capable of modulating a beam of light according to the a.f. fed to the speaker coil. The shutter combination must be adjusted to the half-way position when there is no signal, for if it were shut or fully open the frequency at which the light is modulated would be twice the frequency of the signal applied to the speaker.

Use Of Modulator

The modulator is placed in front of a high power

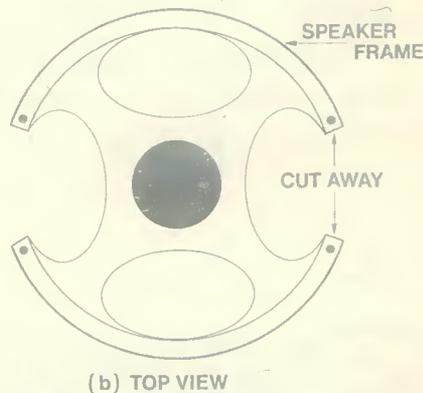
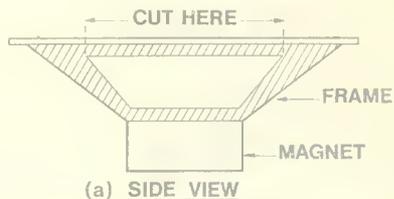


Fig. 3. First steps in preparing a speaker for use in the shutter modulator

spotlight and the spotlight is shone through the shutter towards the receiver. The output from an amplifier is then connected to the modulator as with a normal speaker, and the light becomes modulated with speech if a microphone is connected to the amplifier input. If the modulator is working the speech input to the microphone will be heard from the cut-away speaker.

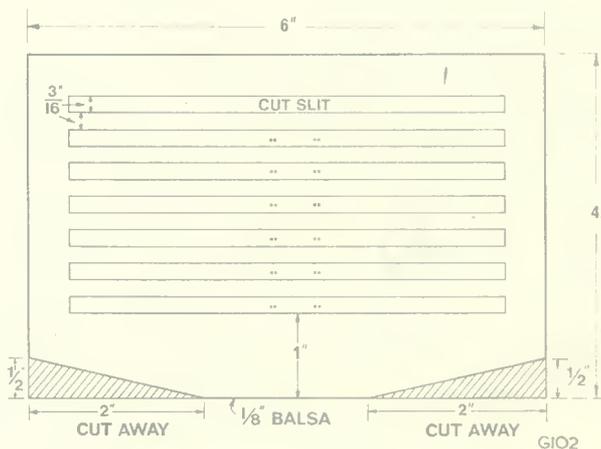


Fig. 4. Details of the balsa shutter. Two are required

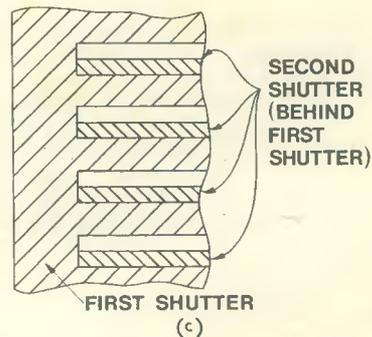
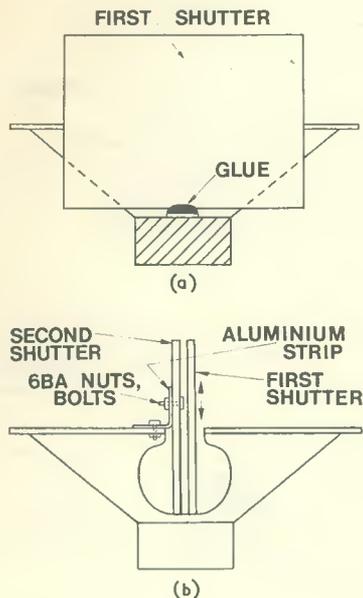


Fig. 5 (a). Fitting the first shutter to the speaker coil
 (b). Adding the second, fixed, shutter
 (c). Under no-signal conditions, the shutter assembly should be half-open, as indicated here

The Receiver

Although many receivers for modulated light have been described in this magazine more experiments were performed with photosensitive devices. Very satisfactory results were obtained with cadmium sulphide photoconductive cells although these have a reputation for having a slow response to light changes. These devices are highly sensitive and it was found experimentally that they perform well at audio frequencies. The receiver circuit used is shown in Figs. 6 and 7.

The cadmium sulphide photoconductive cell was

mounted at the focus of a car headlight (i.e. in the position normally occupied by the filament of the bulb) with the sensitive surface pointing towards the reflector. The positioning is not very critical because of the large surface area of the photoconductive cell. The associated components used to separate the a.c. signal for amplification were built into a small metal box outside the receiver amplifier so that the amplifier could be used as a preamplifier for other equipment. If desired all these components can be built into a single box to make a more compact unit. In this case C_1 of Fig. 6 is not required and the input from the $0.05\mu\text{F}$ capacitor in Fig. 7 may be applied direct to the base of TR_1 . (C_1 is only included to allow the amplifier to be

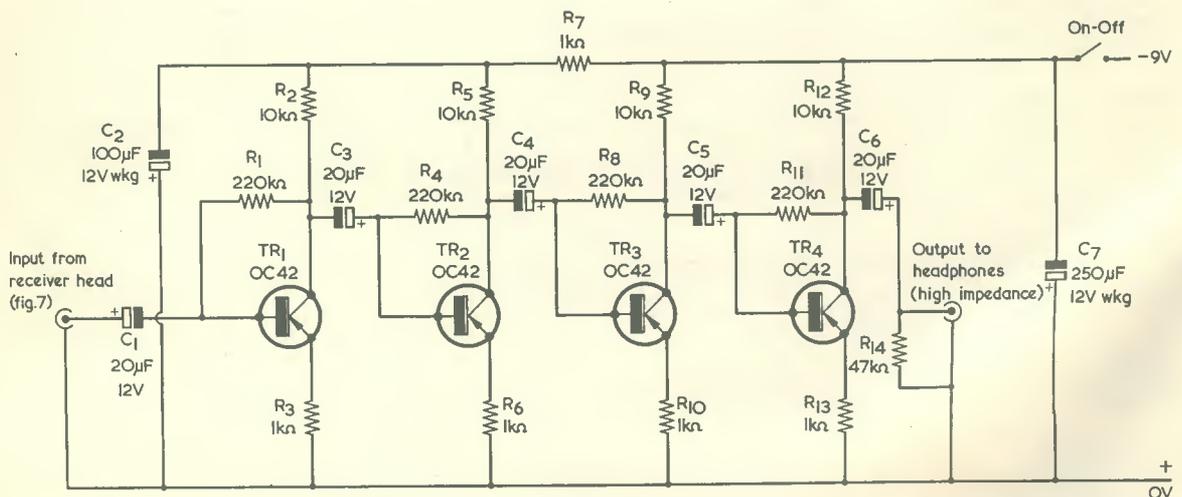


Fig. 6. Receiver a.f. amplifier employed by the writer. This is not a critical part of the system and any other amplifier offering a comparable degree of gain may be used instead

used for other functions.) The h.t. battery and amplifier boxes were fastened together with rubber bands for easy carriage, and contact was made to the battery with wander plugs. These must be left out when the receiver is not in use or the battery will run down.

When the receiver is completed it can be tested with an ordinary a.c. lamp. If the headlight is turned towards the lamp a loud 100 c/s buzz will be heard in the headphones. At night the receiver will detect street lamps hundreds of yards away in this manner.

Performance

The maximum modulation given depends on the accuracy with which the slits are cut. With perfectly parallel and similarly sized slits 100% modulation is possible, but in practice the maximum modulation is about 60% corresponding to an average power of about 3 watts input. In the use the lowest percentage modulation which will enable the required range to be achieved is employed.

Speech is transmitted satisfactorily except for attenuation of the higher frequencies due to the inertia of the shutter attached to the speaker coil. This is corrected at the receiver end by the 0.05 μ F capacitor of Fig. 7, which forms part of a high-pass filter. The shutter tends to resonate at certain low frequencies but this is only noticeable when transmitting music, where the troublesome notes are of longer duration.

Using a normal broad beam car headlamp for the transmitter, strong signals were obtained over 400 yards away. With a narrow beam spotlight far greater ranges can be obtained.

Conclusion

The range which can be obtained with the transmitter and receiver depends only on the brightness of the transmitting lamp, as the percentage modulation is independent of this. Hence in theory an infinite range is possible using only 1 to 3 watts modulating power. However, in practice the power of the transmitting lamp is limited by the surroundings, for a very bright light can be a great nuisance to motorists and to people who object to bright lights flashing across their gardens. The light can however be collimated by a long tube with the lamp at one end, and in this case the modulator can be mounted inside the tube. The transmitting lamp must be run from batteries or

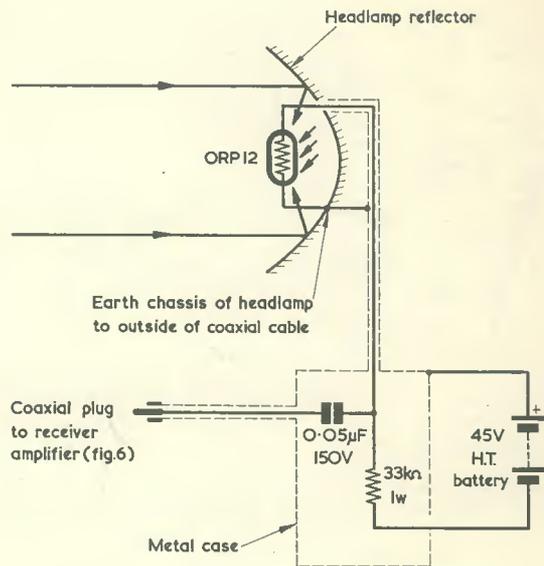


Fig. 7. How the photoconductive cell is mounted in its reflector and connected into circuit

smoothed d.c. to prevent mains hum.

One useful application for the transmitter-receiver system is speech communication between boats or ships for there will then be no obstructions to the beam and, also, any eavesdroppers would have to be in line with the beam to receive messages. The receiver is designed to operate at night, when the cadmium sulphide cell will match the 33k Ω series resistor reasonably well.

References

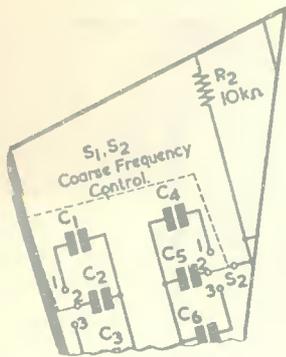
Previous articles on modulated light systems, all appearing in *The Radio Constructor*, are: "Wide Band Photophone" by D. Bollen (January, March and May 1967); "Communication by Modulated Arc Beam" by H. S. King (February 1966); "Modulated-Light Broadcast Transmitter" by Douglas Letts (March 1965); "Modulated-Light Transmitter and Receiver" by M. J. Banthorpe (September 1964); "Speech-on-Light System for Communication" by C. Morgan (January 1964); "Light-Beam Transmitter-Receiver" by J. Emmett (April 1963); and "Light Modulation" by G5UJ (February 1960). See also "Radio Topics" in the January 1968 issue, which gives a condensed description of a system by R. J. Ward.



We regret that, commencing with our next issue, the cover price of THE RADIO CONSTRUCTOR will be increased to 3s.

The increase in price will enable us to meet the additions to our printing and paper costs which we have recently incurred, without substantially reducing our content and standards. We shall also be enabled to continue our improvements and the next issue will contain 2 detachable data sheets and additional text.

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D.C. Voltage Multiplier

SUGGESTED CIRCUIT No. 207

by G. A. FRENCH

THE WRITER RECEIVES A NUMBER of requests from readers for "Suggested Circuit" designs to meet personal requirements. These requests are always welcome and, if they would be of general interest, are usually acted upon. A recent reader's letter raised a particularly interesting point and a projected solution to the problem posed forms the subject of this month's article.

The reader stated that most published designs for transistor equipment which may be employed in a car are based on the assumption that the car is fitted with a 12 volt battery for powering the equipment. However, quite a large number of cars are fitted with 6 volt batteries, and the reader asked whether it would be possible to produce a "Suggested Circuit" for a device which would step the 6 volts d.c. given by this battery up to the 12 volts d.c. needed for running transistor equipment. The device to be described here meets this requirement by providing an output of between 11 and 10.2 volts for load currents up to 50mA when exactly 6 volts is applied to the input terminals. For a 6 volt car battery, whose actual voltage in use can be expected to be around 6.5 to 7, the output voltage will be of the order of 12 for load currents of this order.

The voltage multiplying device uses semiconductors throughout, the provision of square wave switching enabling small transistors to be employed in the voltage multiplying

stage proper. Although this multiplying stage is very simple in operation and requires only two transistors, complexity is introduced by the necessity for a square wave generator and a squarer/driver transistor. In consequence, the overall circuit uses five transistors, and this fact may make the design unattractive to some readers who might find the initial outlay on components somewhat excessive for the function carried out. Nevertheless, the circuit includes a number of novel features and, for this reason alone, should be of particular interest to the experimenter. An incidental point is that, although the voltage multiplier stage is actually a voltage doubler, about 1 volt is dropped in two silicon rectifiers which are necessary for its operation. This explains why a 6 volt input produces an output of 11 instead of 12 volts.

The Circuit

The circuit of the voltage multiplier appears in Fig. 1. In this diagram an input of 6 volts is applied, by way of on-off switch $S_{1(a)(b)}$, to the stages incorporating TR_1 to TR_5 .

TR_1 and TR_2 form a symmetric multivibrator offering a 50:50 square wave at about 250 c/s. The circuit around TR_1 and TR_2 differs from that of a normal multivibrator in that the emitter of TR_1 is returned to the positive supply line by way of the base-emitter junction of TR_5 , and that the emitter of TR_2 is returned to the positive supply

line by way of the base-emitter junction of TR_3 . Both these junctions act as forward-biased diodes when the associated multivibrator transistor is conductive during the cycle, and do not affect multivibrator operation. At the same time, the base-emitter current in TR_5 and TR_3 enables these two transistors to become conductive when TR_1 and TR_2 are similarly conductive during the multivibrator cycle.

When TR_1 is conductive, the base-emitter current in TR_5 is more than sufficient to enable TR_5 to pass the maximum average collector current of 500mA specified for an ACY19. Thus TR_5 is "hard on" during half of the multivibrator cycle. During the other half of the cycle no current passes through TR_1 , and TR_5 is then non-conductive.

At the same time, the emitter current of TR_2 which flows through the base-emitter junction of TR_3 is more than sufficient to enable TR_3 to pass a collector current of 25mA, this figure being the maximum base current specified for the n.p.n. AC127 employed in the TR_4 position. Thus, when TR_2 is conductive, so also is TR_3 and, in its turn, TR_4 , the base current to this last transistor being limited to slightly less than 25mA by resistor R_6 . Thus TR_4 becomes "hard on" when TR_2 is conductive. When TR_2 is non-conductive, the collector of TR_3 rises to the potential of the negative supply line, and TR_4 becomes similarly non-conductive.

Summing up circuit operation up

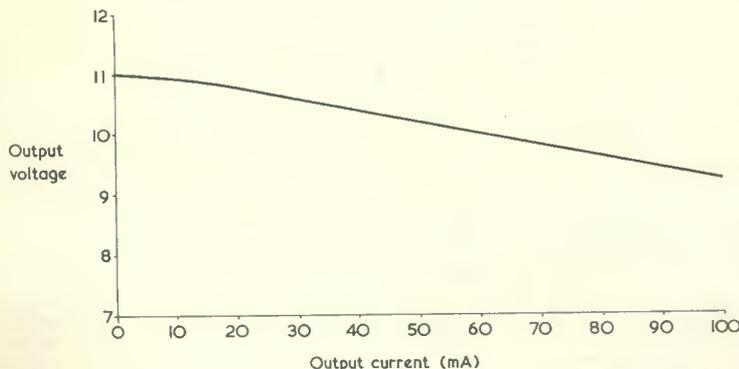


Fig. 2. Output voltage plotted against output current for an input of 6 volts

end of R_6 remote from TR_4 base could be connected direct to the collector of TR_2 , whereupon TR_3 may be omitted from the circuit. Thus, when TR_2 was conductive, so also would be TR_4 , as is required by the circuit. In practice this method of connection has to be avoided because, when TR_2 becomes non-conductive during the multi-vibrator cycle, the voltage on its collector does not change immediately to the potential on the negative supply rail. Instead, the collector voltage changes relatively slowly, because C_1 is charging via the forward-biased base-emitter junction of TR_1 (and, here, TR_5). Thus, returning R_6 to TR_2 collector would result in TR_4 still being partially conductive when TR_5 became "hard on", with the result that current would flow direct from the supply lines through TR_4 and TR_5 , dissipation in TR_4 would be seriously increased, and the switching action of the circuit would be impaired. The inclusion of TR_3 between TR_2 and TR_4 ensures that a true square wave is applied to the base of TR_4 . TR_3 is a relatively high-gain high-current switching transistor, but TR_2 need only be a small r.f. transistor having a base-emitter reverse voltage in excess of the input supply potential. The author found that an OC44 worked quite satisfactorily in the TR_2 position. An audio frequency transistor should *not*, incidentally, be employed for TR_2 .

A problem with a circuit of this nature is given by the necessity for obtaining good regulation. In order that good regulation be given it is first of all necessary to employ large value capacitors for C_3 and C_4 . In Fig. 1. these are specified as $2,000\mu F$ and $3,000\mu F$ respectively. The actual values are not very critical in practice, provided that C_3 is at

least $1,000\mu F$ and (for a reason which will shortly be explained) C_4 has a value at least 50% higher than C_3 . *If the circuit is to be operated from a battery in a car, which may offer some 7 volts to the input terminals, the working voltage of C_3 should be at least 7.5 volts, and C_4 should have a working voltage of 15.*

A second necessity for good regulation is that limiting resistors in the capacitor charging circuits should be kept as low in value as is possible. When the unit is first switched on C_3 is discharged, whereupon a high peak collector current flows in TR_5 for the first few half-cycles when this transistor is "hard on". This current is limited by R_7 . The situation with TR_4 is somewhat different and the only time that this transistor would be called upon to pass a high peak current is if the unit were switched on when C_3 was fully charged and C_4 was fully discharged. A high charging current would then flow

through TR_4 , C_3 , R_8 , D_2 and C_4 . TR_4 is rated at a lower peak current than TR_5 so, instead of inserting the rather high-value limiting resistor in its collector circuit which this current would dictate, an alternative approach is employed. This approach consists of connecting R_9 across C_3 . The presence of R_9 ensures that C_3 always discharges after switching off at least as quickly as C_4 when any anticipated load is connected across the output terminals of the device. Thus, even if the unit is switched off and on again quickly, no excessively high peak current should flow in TR_4 . As an added precaution, in case of accidental excessive load current, the small resistor R_8 is inserted in the C_4 charging circuit. The presence of R_9 across C_3 does not affect the output voltage or regulation, but it does result in a small increase in the input current from the 6 volt supply. To enable R_9 to be kept at a reasonably high value, C_4 should be at least 50% greater in value than C_3 . (It will be noticed, incidentally, that immediately after switching on C_4 receives a charge directly from the 6 volt supply via D_1 and D_2 .)

Whilst discussing the circuit, some further points need to be mentioned. *If the device is to be used with a car battery offering some 7 volts in use, instead of the 6 volt input shown in Fig. 1, R_7 should be increased to 3Ω and R_6 to 330Ω .* These changes will only have a slight effect on regulation. The maximum output current drawn from the device should be of the order of 80mA, a figure which should be quite adequate for most transistorised equipment. Care should be taken to avoid short-circuiting the output terminals, as this might cause damage to TR_4 or TR_5 .

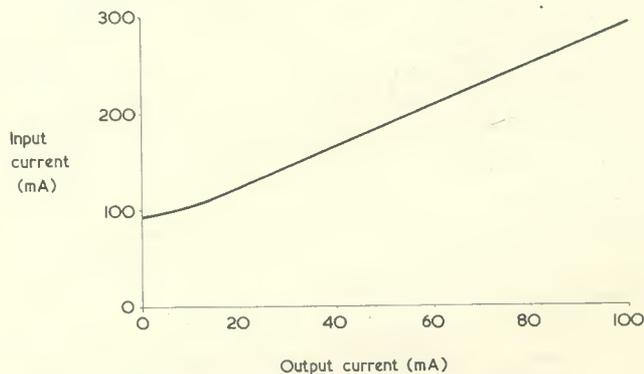


Fig. 3. Curve showing the input current, at 6 volts, plotted against output current

As a final point it may be stated that best results are given if the multivibrator offers a symmetric 50:50 output. Under this condition and with an input of 6 volts, a voltage of 3 with respect to the positive supply line will be given at the junction of R₇ and TR₄ collector, as read by a high resistance voltmeter. Slight adjustments to the values of R₂ and R₃ (say, by adding high value resistors across one or other of them) will enable the junction of R₇ and TR₄ collector to be brought to 3 volts if the multivibrator output is markedly asymmetric. Asymmetry will normally be caused by variations, within tolerance, in R₂, R₃, C₁ and C₂.

Results With The Prototype

The prototype circuit functioned quite satisfactorily over long periods of time with no evidence of overheating in either TR₄ or TR₅. The output voltage took a few seconds to reach full value after switching on, due to the necessity of fully charging C₃ and C₄. There is a slight 250 c/s ripple across the output terminals which increases with output current, but this should not cause trouble with most transistor equipment. Due to the high frequency of the ripple, any smoothing components which may be required after the output terminals need not have high values.

A regulation curve up to 100mA

output current is given in Fig. 2. The output voltage at zero output current is 11, this dropping to 10.4 volts at 40mA and to 9.7 volts at 80mA. The input is 6 volts.

The curve in Fig. 3 shows input current plotted against output current and was, again, taken for a 6 volt input. As may be seen, a standing current of nearly 100mA is drawn at zero output current, this being the sum of the current drawn by the multivibrator, the relatively high base currents in TR₄ and TR₅, and the extra current resulting from the connection of R₉ across C₃. At 100mA output current, the input current is 300mA.



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

Indicator Unit 266 (10QB 6382).—B. J. Aylett-Warner, 116 Watling Street, Newtown, Brownhills, Nr. Walsall, Staffs—circuit diagram or manual and any information on conversion to an oscilloscope.

* * * *

Type 13A Oscilloscope.—A. E. Harvey, 39 Curliu Road, Oakdale, Poole, Dorset—loan or purchase of manual. Circuit or manual for R216 Receiver also required, all expenses met.

Ekcovision TV Type N.—C. Wall, Salt Hill Lodge, Firbeck, Nr. Worksop, Notts—loan or purchase of circuit for this single channel TV (approx. 1951).

* * * *

“Coronet” Transistor Six Receiver.—W. L. Brunsdon, 56 Greenwood Lane, Wallasey, Cheshire—loan or purchase of circuit (set manufactured by Fidelity Radio and uses type 117 transistors with slab ferrite aerial).

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Leonard T. Perriam, M.A.

NEW MANAGING DIRECTOR APPOINTED BY DAYSTROM LTD.

Daystrom Limited, Gloucester, recently announced the appointment of Leonard T. Perriam, M.A. as Managing Director. Mr. Perriam joined Daystrom six years ago as Technical Sales and Service Manager of the Industrial Products Division after holding senior posts involving instrument development at Imperial Chemical Industries Limited for some 15 years.

The Heathkit division at the Gloucester Factory manufactures electronic equipment in kit or ready-to-use form and the Industrial Products Division manufactures X-Ray thickness gauges and special dimensional measuring and control units, in addition to marketing equipment from Weston Instruments Inc., an associated company in the Schlumberger Group.

IDEAL SUBJECT FOR COLOUR TV

"Gardening Club" has moved to BBC-2 and has become "Gardener's World"—in colour.

Says producer Paul Morby, who was producer of "Gardening Club" for 8 out of the 12 years it ran, "No hobby is practised with greater devotion and skill than is gardening in these islands."

The first edition of "Gardener's World" in colour, visits the University Botanic Gardens at Oxford. Future programmes will deal with a wide range of topics from garden design and history to cacti and house plants.

TOMORROW'S WORLD

In the past, at about this time of the year, we have often given extracts from the scientific forecasts of the future made by the late Hugo Gernsback. As many readers will know he died last year and we shall miss the glimpses he gave into the future, all the more because of their probable accuracy, as he lived to see many of his earlier forecasts come true.

However we are fortunate to be able to give extracts from an article by Philip Eisenberg, of the U.S. Library of Congress, entitled *Life in the 21st Century as some scientists see it*.

Artificial arms and legs are motorised and linked to the brain by a computer, enabling the wearer to translate impulse into action.

The world population has nearly doubled since 1967, and most people live in or near big cities.

There exist huge, self-contained cities called "megastructures"—unique worlds of apartments, offices, shops and recreation areas offering all the amenities of 21st-century civilization.

Some of these "megastructures" are almost 200 stories high, and others consist of continuous, multi-tiered structures a mile wide and 20 miles long, connecting with each other like links in a gigantic chain.

Computers have taken over as the central nervous systems of municipalities, businesses, libraries, hospitals, schools and other storage centres of information.

People use computers as casually as they once used telephones. Centralised computers offer "computer public-utility service" to individual homes. Robots with computer insides and telescoping arms, fingers, brushes and suction tubes take care of house cleaning more efficiently than human hands.

The kitchen is entirely automated. The housewife makes out her menu for the week, puts the necessary food into the proper storage spaces and feeds her programme to a small computer.

Shopping is a thing of the past for the resident of a "megastructure". The housewife via her videophone switches on the local supermarket, examines and prices food and other items on the videophone screen, and receives all her essential goods by automated conveyor belts.

Cash and cheques are no longer used in financial transactions or for purchases. A system of credit based on computer networks connects a bank computer with homes, stores, and employers in a community.

An employee's wages are credited to his bank account by his office computer. When he makes a purchase, the store signals his bank's computer to transfer the necessary funds from his accounts.

Computerised education takes place in the home as well as in the classroom. The emphasis is on flexibility. Rigid grade levels have disappeared and students advance at their own speed. Teaching machines plugged into computers drill youngsters in arithmetic, grammar and reading skills, grading them and correcting their mistakes instantly.

The older children go to school for only part of their education and for the rest receive televised instruction directly from a central computer.

Compulsory schooling for the entire population begins at the age of four and continues through until 20, including at least two years of college.

The student wanting information on any subject merely puts a few key words into the computer and within seconds a complete bibliography appears on his TV screen. By pointing to specific items on the bibliography with a "light pen" he obtains a facsimile copy or print-out of the reference.

Communications satellites connect the home with a world-wide network of information, education and entertainment. Huge TV screens completely fill one wall of the living-room and transmit three-dimensional pictures in colour.

Farming is a highly automated and scientific venture. The few farmers left, only about two per cent of the labour force, are executives employing computers as foremen. Robot tractors and other automatic machines produce yields per acre not even dreamed of a few decades earlier.

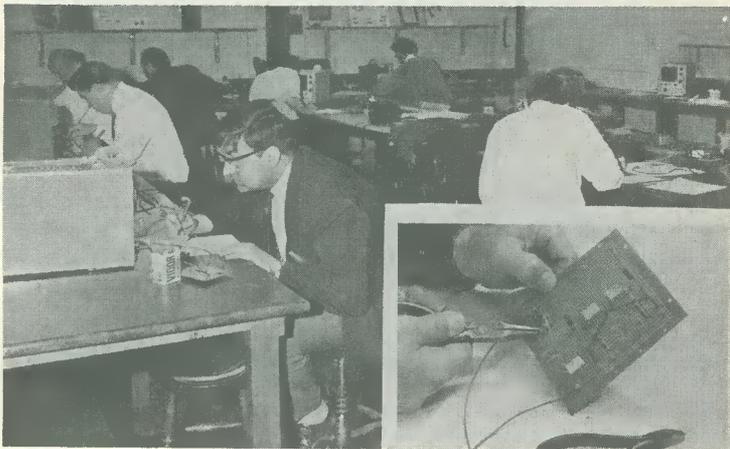
COMMENT

ST. DUNSTAN'S AMATEUR RADIO REUNION

Sound radio is the ideal medium for both the information and the entertainment of blind people as it depends on hearing alone.

A number have become radio amateurs including members of St. Dunstan's. In their annual report, recently published, details are given of their first ever radio amateur reunion held at Ovingdean.

The week-end activities included a speech by Lord Fraser, who was transmitting on the air as long ago as the early '20's, and discussion periods in which experts from the B.B.C., the Radio Society of Great Britain, the G.E.C. Laboratories and Philadelphian Electronics spoke on specialised aspects of this means of amateur communication. Nine St. Dunstaners, two of them handless as well as blind, and all experienced amateur transmitters attended the reunion. Without question, the highlight of the week-end was the link with Miss Iris de Reuck, only South African woman St. Dunstaner, herself a radio amateur, who lives at Port Elizabeth, Cape Province. From the temporary radio transmitter installed at Ovingdean, GB3STD, Lord Fraser spoke to Miss de Reuck and messages were exchanged which included mutual "88's".



Students sitting for the two-hour practical test at this year's R.T.E.B. Electronics Servicing Final, showing the test-piece using a Lektrokit chassis plate.

R.T.E.B. HOLDS FIRST NATIONAL EXAMS IN ELECTRONIC SERVICING

More than 170 students successfully passed their finals in the first national examinations in electronics servicing held by the Radio Trades Examination Board this year.

In conjunction with the City and Guilds Institute, the R.T.E.B. final radio and television servicing and the final electronics servicing certificates are achieved after five years' part time study. These certificates ensure that successful candidates are competent to maintain on the one hand, domestic radio and television equipment and, on the other, 'professional' and industrial electronic equipment.

The Final Electronic Servicing Certificate examination consisted of two three-hour written papers, one two-hour fault diagnosis paper and a two-hour practical test. For the practical exam (see illustration above) students were required to construct and test a transistorised multivibrator circuit.

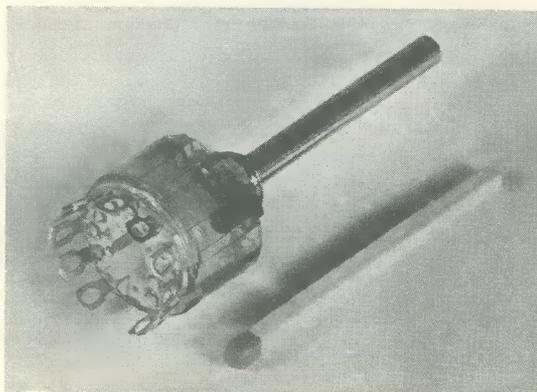
To aid uniform layout and speed of construction—an important feature for examination purposes—Lektrokit No. 4 chassis plates, made by A.P.T. Electronic Industries Ltd, were chosen by the Board. Part of the Lektrokit rack and chassis system, the chassis plate is made from $\frac{1}{16}$ in thick resin bonded paper sheet.

NEW SUB-MINIATURE ROTARY STUD SWITCH

RADIATRON announce a new sub-miniature rotary stud switch type 01 with a fully adjustable 'stop' mechanism. Believed to be the smallest stud-switch in the world, the 01 has up to 12 positions and up to 4 poles per wafer. Wafer diameter is 0.6 inch.

Brief Specification:—Wafer Material—Ceramic, Wafer Insulation— $10^{12}\Omega$, Contact Resistance— $4m\Omega$, Capacitance— $0.8pF$, Max static contact load— $3A$, Switching capacity— $200V$ $0.1A$, Life expectancy—up to 10^6 rotations.

Further details may be obtained from: RADIA-TRON, 7 Sheen Park, Richmond, Surrey.



Temperature Controlled Container

By J. N. Harris

Our contributor describes an unusual and ingenious approach towards temperature control of liquids in small containers for wine-making. If you are a teetotaler there are plenty of other applications in which you can use the device!

THIS ARTICLE DESCRIBES A RATHER UNUSUAL application of electronic control, employing one of the newest semiconductors (i.e. the silicon controlled rectifier) in one of the oldest occupations, wine-making.

When making wine with a wine yeast it is necessary to "activate" the dried yeast first by putting it in a bottle with a nutrient, sugar and water, and keeping it at a temperature of 75-80°F for 48 hours or longer. This may not seem much of a problem but it is surprising how soon the temperature falls in an ordinary room once the heating is off at night, particularly on a very cold night. Temperature soon falls below 50° and the yeast then stops multiplying.

From the circuit shown in Fig. 1 it will be seen that use is made of the increase in collector to emitter leakage current of a transistor when the

temperature rises. This increase is amplified by TR₂ which is d.c. coupled to TR₃, an emitter follower.

Circuit Operation

The circuit operates in the following manner. An increase in collector to emitter leakage current (caused by an increase in temperature) in the OC78, TR₁, increases the base bias in TR₂ and hence its base current. This causes TR₂ collector current to increase, and its collector voltage to fall. The result is a decrease in base current and, in consequence, emitter current in TR₃. The emitter current of TR₃ flows in the cathode-gate junction of SCR₁ and, when this has reduced to a sufficiently low value, the s.c.r. cuts off and no current flows through the heater resistor R₅. There is then a subsequent drop in temperature which is sensed by TR₁. When

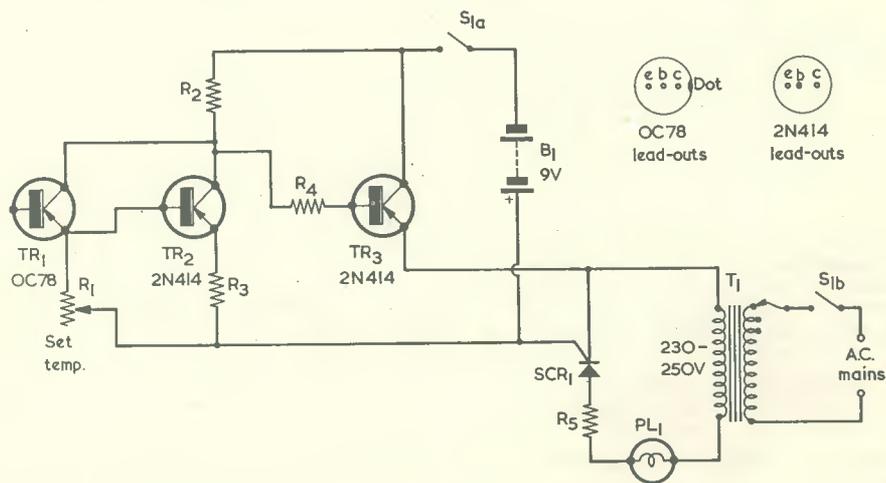


Fig. 1. The circuit of the temperature control unit. TR₁ is the sensing element and R₅ the heating resistor

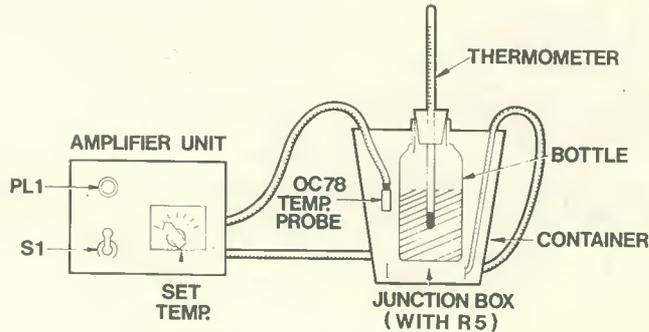


Fig. 2. A practical arrangement for the temperature control equipment. Apart from TR_1 and R_5 , all components may be fitted in the Amplifier case

the drop in temperature is sufficiently great the collector to emitter leakage current in TR_1 reduces to a value which causes a reverse action to occur and the s.c.r. to become conductive again. After a further delay, due to the thermal inertia of the liquid heated by R_5 , the cycle then repeats.

Pilot lamp PL_1 serves both as an indicator and a fuse. It will just glow when the s.c.r. is on.

The heater, R_5 , is a $5.6k\Omega$ wirewound resistor. This dissipates several watts, which is quite sufficient for the present purpose.

The mains transformer can be any component having a secondary capable of offering some 230 to 250 volts at a current of 50mA or more. Its

only function is to provide isolation from the mains and make the circuit safer to handle. The secondary voltage should not exceed 250, or the p.i.v. of the s.c.r. may be approached. The writer used transistors type 2N414, available from the supplier listed in the Components List, for TR_2 and TR_3 . When switching on for the first time, it would be preferable for R_1 to insert maximum resistance into circuit, to avoid the risk of high current flow in TR_3 .

A low current 400 p.i.v. silicon controlled rectifier, such as the CRS3/40, may be used in the SCR₁ position. The s.c.r. employed by the writer was a C10 DR324-452, of American manufacture. This was mounted on a small metal bracket in the case containing the circuitry around TR_2 and TR_3 .

The outside container is a plastic box with a lid, originally made for use in the kitchen as a sugar container. See Fig. 2. The bottle containing the liquid is an Eno Fruit Salts bottle, ideal because of its wide neck which allows easy filling and which is just the right size for a large cork. The thermometer is a loose fit in the cork, and of course the cork must not be pushed in hard or it may blow off. The thermometer was one used in photography, calibrated from 50°F to 90°F; the yeast must not get hotter than this anyway.

An ordinary electrical junction box with holes drilled in the lid makes an ideal holder for the heater resistor, R_5 , the connections to this being made via the terminals inside.

Instead of being fixed in the container, the OC78 is made in the form of a probe as shown, in order that the unit may be used later to control a larger container (for a 1-gallon jar). It is essential that the OC78 takes up the same position in the container all the time or the temperature may vary.

Setting Up

To check the unit connect up to the mains, switch on, and see that the pilot lamp is glowing. Fill the bottle with warm water and dilute until the temperature is about 80°F. The current in the s.c.r. gate circuit should be about 5 to 7mA (possibly slightly higher with the CRS3/40—EDITOR), set

Resistors

(All fixed values 10%)

- R_1 25k Ω potentiometer, wirewound, linear
- R_2 22k Ω , $\frac{1}{2}$ watt
- R_3 1k Ω , $\frac{1}{2}$ watt
- R_4 82 Ω , $\frac{1}{2}$ watt
- R_5 5.6k Ω wirewound, 10 watt

Transformer

- T_1 Mains transformer (see text)

Semiconductors

- TR_1 OC78
- TR_2 2N414
- TR_3 2N414
- SCR₁ 400 p.i.v. (see text)
- (TR_2 and TR_3 are available from L.S.T. Components, 23 New Road, Brentwood, Essex)

Switch

- $S_{1(a)(b)}$ d.p.s.t. toggle

Battery

- B_1 9-volt battery

Lamp

- PL_1 6V 0.06A pilot light, with holder

COMPONENTS

with the 25k Ω potentiometer. Thereafter the s.c.r. will switch on and off as the temperature varies above and below 80°F (the set temperature). The controlled temperature may be varied by means of the potentiometer and if desired a scale can be fitted to this component. The temperature should remain constant within about $\pm 2^\circ\text{F}$.

The author used a PP7 battery for the amplifier supply, but it might be more economical to employ a mains power unit or a larger battery. Although consumption with the prototype was only 5 to 10mA, it had to be used for a continuous 48 hour period and by the end of this time battery voltage was beginning to drop.

It is intended in the future to use the control

unit with a large container for fermenting a 1-gallon jar of wine at constant temperature. Another possible use may be for controlling the temperature of photographic developer in a dish. The temperature probe OC78 could then be put in a test tube filled with oil, the end of the tube being placed in the dish. The oil would provide close "coupling" with the liquid.

In conclusion, it is appreciated that the OC78 is used here for a purpose for which it was not originally designed. Nevertheless, the writer has found that it functions quite satisfactorily in the present circuit. Also, the prototype has given consistently good results over a period of 6 months. *

Automatic Parking Light Operator

by D. H. MACREADY

This neat little unit ensures that your parking lamp lights up automatically in the evening. An added feature is that the light extinguishes when the ignition is switched on. The circuit is intended for vehicles having 12-volt systems with positive earth

THE CIRCUIT ACCOMPANYING THIS ARTICLE DEPICTS an automatic parking lamp operator, but with the essential difference that the parking lamp is automatically extinguished when the vehicle's ignition is switched on.

Circuit Operation

The unit may seem unnecessarily complex but the writer was asked to build something entirely fool-proof and reliable. Essentially, the circuit consists of a Schmitt trigger followed by a relay amplifying stage. The amplifier enables a robust and relatively insensitive relay to be employed, the one used by the writer requiring 20mA to energise. If the coil of such a relay were included in the Schmitt trigger collector circuit the value of R₄ would have to be drastically reduced, thereby causing unstable and unreliable operation.

The circuit is arranged such that when the light dependent resistor LDR₁ is under illumination and exhibits low resistance, TR₁ is conducting and TR₂ is cut off. In consequence, TR₃ is conductive and energises the relay, this transistor being biased on, via R₇, by the collector voltage of TR₂. The normally closed contacts of the relay are thus open, cutting off the supply to the lamp.

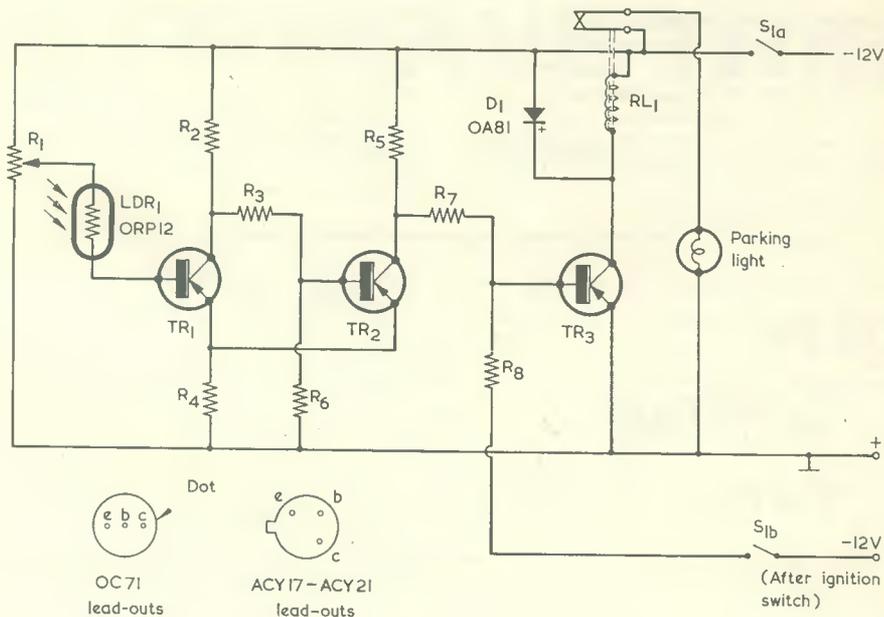
At some preset level of illumination selected by

R₁, TR₁ base current drops to a value which allows the changeover of the trigger to be initiated. TR₂ then becomes conductive, the base current of TR₃ drops and the relay de-energises. Its contacts close and—voilà!—on comes the light.

If, however, the ignition is switched on, a current is fed to the base of TR₃ via R₈, causing it to energise the relay and thus switch off the light for night driving. The feed to R₈ may be taken from any convenient terminal in the car electrical system which becomes live when the ignition is switched on. Suitable points are the "SW" terminal on the ignition coil, the live side of the indicator switch or a spare tag of the ignition switch itself.

The circuit will work with almost any p.n.p. transistors rated at 16 volts but care should be taken to ensure that TR₃ is capable of standing the current demanded by the relay used. (TR₁ and TR₂ may be any a.f. type, such as the OC71. A good choice for TR₃ would be a transistor in the range ACY17 to ACY21 inclusive. Provided that the unit is mounted in a cool place—not the engine compartment—the relay employed with such a transistor should have a coil resistance of 300 Ω or more and should be capable of energising reliably at some 10 volts.—Editor.)

The precise value of R₇ is best found by experi-



The circuit of the automatic parking light operator

ment, as it depends upon the current gain of TR₃ and the sensitivity of the relay employed. Similarly, R₈ depends upon the same factors, but is not so critical. Adjust R₁ to a suitable setting, illuminate LDR₁ so that TR₂ is non-conductive, and find the value for R₇ which causes the relay to operate reliably. Check that this value provides reliable de-energising when the illumination to LDR₁ is cut off and TR₂ is conductive. It will be of advantage to connect a high resistance voltmeter between the collector of TR₂ and the positive supply line during this operation, this voltmeter indicating the state of TR₂. After finding the value required for R₇, connect this resistor permanently in circuit and find the value needed in R₈. This should be such that the relay energises when TR₂ is conductive. Typical values in practice would be 15kΩ to 100kΩ for R₇ and 33kΩ to 100kΩ for R₈.

Layout and construction is up to the individual, the writer's units, apart from the relay and on-off switch S₁, being built on a piece of Veroboard measuring 1 x 1½ in. This will conveniently accept a skeleton preset potentiometer for R₁.

The prototype has proved entirely reliable and trouble-free. Several further units have been made over a period of two years and all are working satisfactorily. The unit may be mounted at any convenient and reasonably cool point in the car.

The light dependent resistor is separate from the unit with the transistors and the relay, and it may be positioned at a convenient point *inside* the car provided that it receives general illumination from the daylight. In one successful installation, the l.d.r.

COMPONENTS

Resistors

(All fixed values ½ watt 10%)

R ₁	10kΩ preset potentiometer, linear
R ₂	1kΩ
R ₃	10kΩ
R ₄	220Ω
R ₅	1kΩ
R ₆	10kΩ
R ₇	See text
R ₈	See text

Semiconductors

TR ₁ , TR ₂ , TR ₃	See text
D ₁	OA81

Relay

RL ₁	Relay with normally-closed contacts rated at lamp current. (See text)
-----------------	---

Light Dependent Resistor

LDR ₁	ORP12
------------------	-------

Switch

S _{1(a),(b)}	d.p.s.t. on-off switch
-----------------------	------------------------

was mounted on the dashboard just below the windscreen with its sensitive surface facing inside the car. In another instance it was fitted above the windscreen to the right of the sun visor. Light from

the parking lamp must not, of course, fall upon the l.d.r., or the system may go into oscillation with the lamp flashing on and off at a rate determined mainly by the operating speed of the relay.

No trouble has been experienced due to the lamp being switched off, at night-time, by illumination from street lamps, shop lighting or car head-lamps, etc. This is probably due to back-lash in

the Schmitt trigger, and to the fact that diffused sunlight may have a greater intensity per unit area than illumination from most man-made sources of this nature.

The writer's prototype is so precise that, given similar weather conditions and parking positions, one can almost set one's watch by the switch-on, switch-off cycle. *

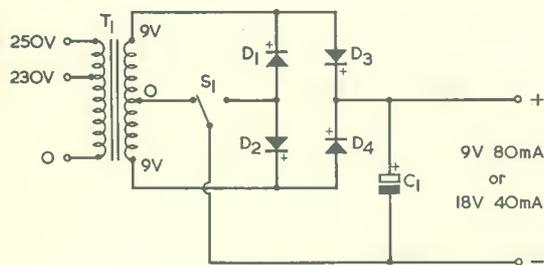
Miniature 2-Voltage Power Supply

by
G. W. SHORT

A neat switching technique allows this, or any other power supply unit with a similar circuit, to offer two full-wave rectified output voltages

THE MAINS POWER UNIT DESCRIBED HERE PROVIDES nominal outputs of 9V, 80mA or 18V, 40mA. Switching from one voltage to the other is particularly simple, and the transformer windings are fully utilised on both voltages.

With the voltage-change switch in the position shown, the rectifier circuit is full-wave push-pull. In this case, only rectifiers D₃ and D₄ are operative. The other two, D₁ and D₂, are connected in series opposition, and since one of them is reverse biased whatever the polarity of the supply voltage they never conduct.



The circuit diagram for the 2-voltage power supply

With the switch in the other position, D₁ and D₂ are brought into action. Together with D₃ and D₄, they make up a full-wave bridge rectifier. The input voltage to the bridge is 9+9=18V, so the output voltage is twice what it was before.

Bridge Rectifier

A conventional bridge rectifier may be used for D₁-D₄. The type specified in the Components List is the B30C150, which is a subminiature selenium bridge. Despite its small size, this type is capable of handling 30V, 150mA, and so is operated well within its ratings here, since the Osmor MT9 subminiature mains transformer is rated at only 80mA at 9V. It is as well to use a generously-rated rectifier, however, since this gives a margin of safety in case of overload.

The voltage-changing method described here may of course be used with larger transformers and rectifiers. The working voltage of the capacitor should be 1.4 times the *total* r.m.s. output voltage of the transformer secondary. In the present case this is 18V r.m.s., and the capacitor must be rated at 25V wkg. at least, preferably more. The rectifiers

COMPONENTS

Capacitor

C₁ 1,000 μ F (or greater, if desired) electrolytic, 30V wkg.

Transformer

T₁ Mains transformer, Osmor MT9 (Amatronic Ltd.)

Diodes

D₁-D₄ Bridge rectifier type B30C150 (Amatronic Ltd.)

Switch

S₁ s.p.d.t. changeover switch

must likewise be able to withstand a peak inverse voltage of 1.4 times the r.m.s. voltage. Point contact rectifiers are not suitable, incidentally, because although their p.i.v. and d.c. ratings may be adequate their peak forward current rating is sure to be exceeded. The reservoir capacitor is charged by short pulses of current and the instantaneous current can be quite large. *

SHORT WAVE THREE

by Arman Sapciyan

Our contributor, resident in Istanbul, gives details of a simple but efficient 3-transistor reflex receiver capable of operating from a telescopic aerial 3ft 9in long when extended, and without an earth connection. The design is based on the "Two + Two Receiver" described by Wallace Studley in our January 1966 issue

THE SIMPLE RECEIVER DESCRIBED HERE IS AN ideal design for those who want to get satisfactory results with the minimum number of components. If this receiver is carefully built the constructor will be able to tune in many distant short wave stations, as well as local ones, with a good level of volume.

The Circuit

The circuit appears in Fig. 1 and consists of a reflex design in which TR₁ functions both as r.f. and a.f. amplifier. Detection is given by diodes D₁ and D₂. TR₂ and TR₃ are a.f. amplifiers.

R₂ is the sensitivity control, whilst C₄ is a trimmer providing regeneration. A fixed capacitor of 30pF

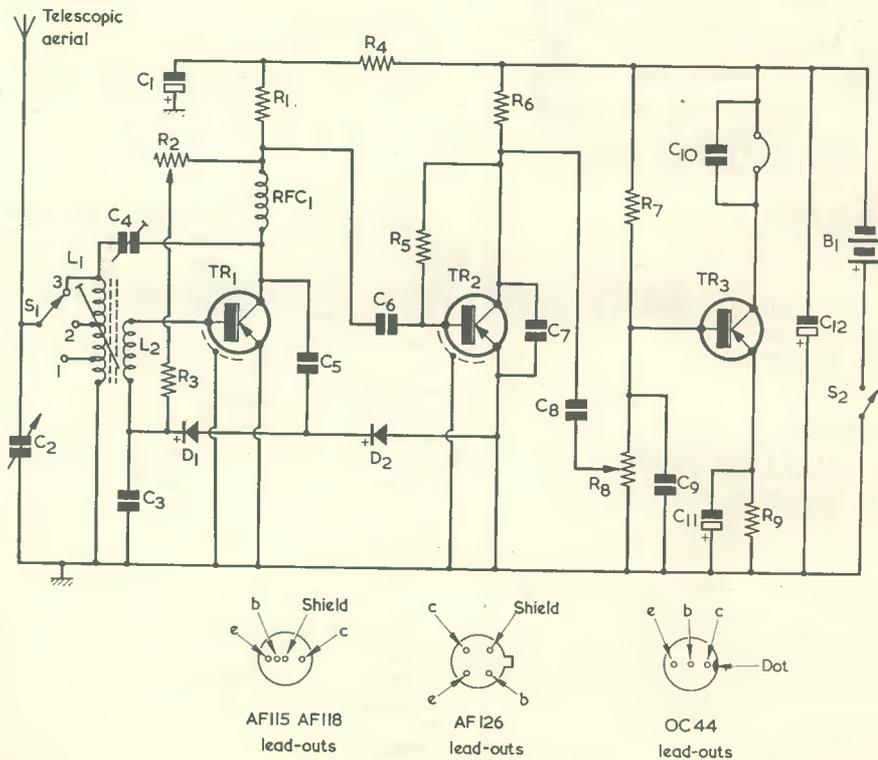


Fig. 1. The circuit of the Short Wave Three

Resistors

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

- R₁ 3.9k Ω
- R₂ 100k Ω potentiometer, linear track
- R₃ 150k Ω (see text)
- R₄ 1k Ω
- R₅ 100k Ω
- R₆ 5.6k Ω
- R₇ 68k Ω
- R₈ 10k Ω potentiometer, log track, with switch
- R₉ 1k Ω

Capacitors

- C₁ 100 μ F electrolytic, 6V wkg.
- C₂ 165pF variable, air-spaced (Wavemaster 160pF, Cat. No. VC75, Home Radio, will be suitable)
- C₃ 0.02 μ F
- C₄ 40pF mica trimmer
- C₅ 220pF ceramic
- C₆ 0.1 μ F
- C₇ 0.01 μ F
- C₈ 0.1 μ F
- C₉ 0.01 μ F
- C₁₀ 0.005 μ F
- C₁₁ 50 μ F electrolytic, 6V wkg.
- C₁₂ 100 μ F electrolytic, 6V wkg.

Inductors

- L₁ see text
- L₂ see text
- RFC₁ 2.6mH r.f. choke (see text)

Semiconductors

(See text for alternatives)

- TR₁ AF118 or AF115
- TR₂ AF126
- TR₃ 2SA30 or OC44
- D₁ OA70
- D₂ OA70

Switches

- S₁ single-pole 3-way
- S₂ s.p.s.t., ganged with R₈

Battery

- B₁ 6-volt battery

Headphones

- 1 pair low impedance headphones (total resistance approx. 100 Ω)

Drive

- Vernier dial, Model T502 (Henry's Radio Ltd.)

Miscellaneous

- Miniature jack plug and socket for headphones
- Former and dust-core for L₁, L₂
- Knobs
- Telescopic aerial

could be employed for C₄, but the trimmer is more convenient since it allows a regeneration level to be obtained which gives best overall results. The tuning capacitor is C₂, and this is connected across the section of L₁ which is selected by range switch S₁. The nominal coverage is from 4.7 to 18 Mc/s with the dust core centrally in the coil but this can, if desired, be changed to 5.5 to 22 Mc/s with the dust core some way out of the coil.

After experimenting with a wide range of transistors it was found that an AF118 gave best results in the TR₁ position. An AF115 may also be used, with R₃ altered to 120k Ω , although the performance is slightly inferior to that offered by the AF118. (Since the AF118 is listed as a video amplifier, the performance of different transistors of this type in the present circuit may vary. We would class its use here as experimental, as compared with that of the AF115 which is specifically intended to give r.f. amplification up to v.h.f.—EDITOR.) For TR₂ an AF126 provided best results, whilst nearly as good a performance was given by AF116, AF117, AF127 and AF115.

Although TR₃ is only a simple a.f. amplifier, by far the best performance was given here with a 2SA30, this being a near-equivalent to the OC44. Since it may be difficult to obtain the 2SA30 in the U.K., an OC44 may be employed in its place.

The performance of the receiver also depends on the type of headphones used and it is highly recommended that these be low impedance types. An earpiece with a resistance of 70 Ω also gave satisfactory results.

The total battery consumption from the 6-volt supply is about 1.8mA only. Since a telescopic aerial is sufficient and no earth connection is required, the receiver can be carried anywhere.

Coil and R.F. Choke

The aerial coil, L₁, consists of 18 turns of 34 s.w.g. silk covered wire close-wound on a former of 0.3 in diameter fitted with a dust-core. Taps are taken at the 4th and 11th turns, as shown in Fig. 2. The former should have 6 eyelets or tags at the base to take the ends of L₂ and the 4 connections from L₁. (This is a normal Bakelite former of the "Aladdin" type, and it could have a length of 1in or more.—EDITOR.) L₂ consists of 1 $\frac{3}{4}$ turns of the same wire and should be wound close to L₁. L₂ should be wound first and L₁ second, coil positioning being such that the upper end of L₁ is close to the top of the former. This enables the dust-core to offer a wide variation in inductance, giving the range of frequency coverage referred to earlier.

The r.f. choke can be either a standard 2.6mH choke with four pies, such as the Denco RFC.5, or it may be home-wound. The writer obtained a satisfactory choke by random-winding four separate pies of 200 turns each on an 820k Ω 2 watt resistor, using the same wire as was employed for L₁ and L₂.

Cabinet

The prototype was constructed on an eyeletted board fitted in a cabinet measuring 8 x 4 $\frac{1}{2}$ x 3in.

This may seem rather large for a receiver of this nature. However, the panel has to accommodate two potentiometers, a switch and a variable capacitor with its drive, and it is desirable to mount these components so that a reasonable amount of space exists between them. Since an aerial is always necessary it is best to screw the panel to the cabinet.

Setting Up

After the components are mounted and soldered, double check all connections and battery polarity, then switch on. First, check to see whether the set is oscillating or not by turning the knob of R_2 towards maximum (minimum resistance in circuit) and adjusting C_2 if necessary. If it is not possible to obtain oscillation, reverse the connections to L_2 . Apply a signal generator set to 4.7 Mc/s and very loosely coupled to the aerial, and tune in this signal with C_2 , adjusting the dust-core if necessary. S_1 should be in position 3. Next, put S_1 to position 1 and check whether 18 Mc/s from the signal generator may be tuned in by C_2 . C_4 has a noticeable effect on the frequency of reception and it may be necessary to adjust this component to enable the 18 Mc/s signal to be received. When C_4 is at its final position it should be possible to obtain oscillation on all ranges with a frequency coverage of the order specified earlier. It should be noted that the 4.7 and 18 Mc/s frequencies just quoted apply to the extreme ends of the coverage given by the prototype coil for one setting of the dust-core. Other coils may offer a similar coverage but with the end frequencies slightly shifted.

EXTRA NEXT MONTH * * *

★ 2 DETACHABLE DATA SHEETS AND ADDITIONAL TEXT

==== **SPECIAL FEATURE** =====

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by J. B. Dance, M.Sc.

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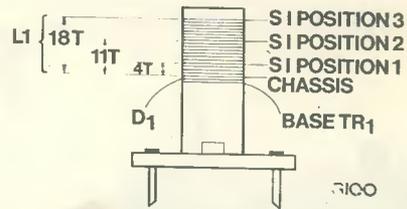


Fig. 2. Details of the coil. L_2 is immediately below L_1

If a signal generator is not available, adjust C_4 so that it is about three-quarters towards maximum capacitance. Obtain the desired coverage by finally adjusting this capacitor and the dust-core, working from received signals.

R_2 will require different settings for each band selected by S_1 . As is to be expected, adjustment is more critical at the higher frequencies, and a little skill is needed at first to obtain optimum results.

Performance

The writer has found that this receiver gives very satisfactory reception. At Istanbul he can tune in B.B.C., V.O.A., Kol Israel, Cairo, Moscow, Vatican, Prague, Deutsche Welle, and a lot of other distant stations at a very high volume. Even Peking comes in at satisfactory level. Although not an extraordinary performance, this still represents a remarkable achievement for so simple a receiver.

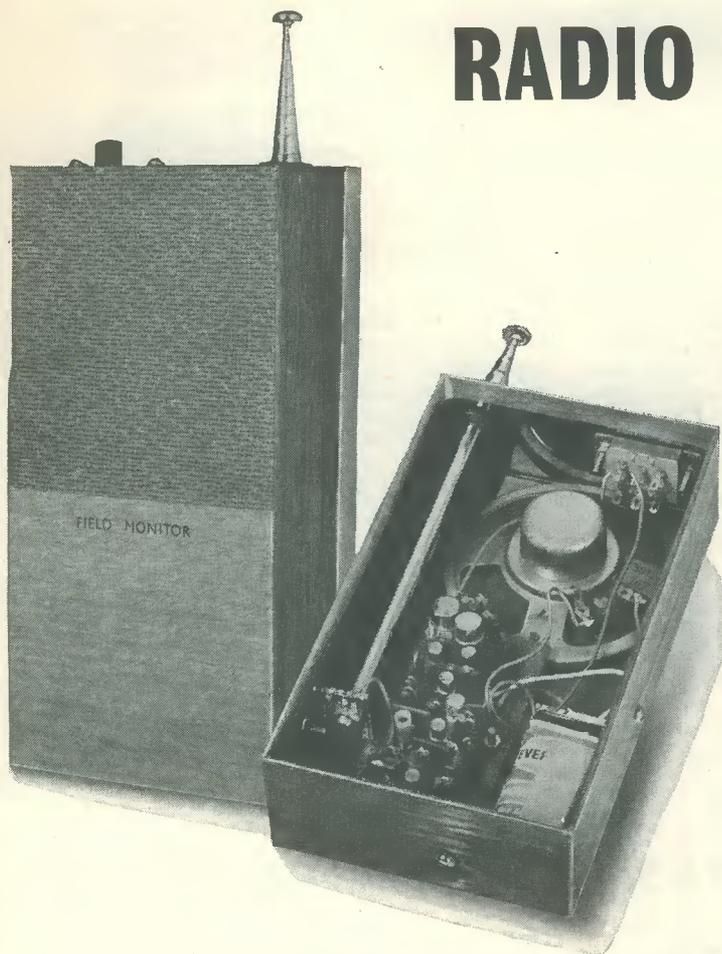


RADIO CONTROL FIELD MONITOR

by

F. L. THURSTON

CONSTRUCTIONAL
DETAILS



Last month our contributor described the circuit and operation of this neat wide-band pocket receiver, which monitors all local transmissions in the 27 Mc/s radio control band. Full details of construction and setting-up are given in this concluding article

Construction

THE MAJOR PART OF THE ELECTRONIC CIRCUITRY is wired up on a piece of Veroboard panel with 0.1in hole spacing (available from Tele-radio Electronics), and construction should be

Basic Radio Control (10)
by F. L. Thurston

started by cutting this panel to size, as shown in Fig. 3, and drilling three small mounting holes to clear 6BA screws and the single hole for L4. Next, break the copper strips with the aid of a small drill where indicated, and cut back the copper from around the mounting holes to prevent any risk of short circuits occurring when the mounting screws are later fitted.

Component assembly is best carried out in stages, each stage being given a functional check before proceeding with the next. In this case, the following assembly and test system is recommended. When fitting the components, it should be remembered

A—mounting holes; drill 6BA clear
 B—L₄ mounting hole; drill 7/32" dia and file locating slots

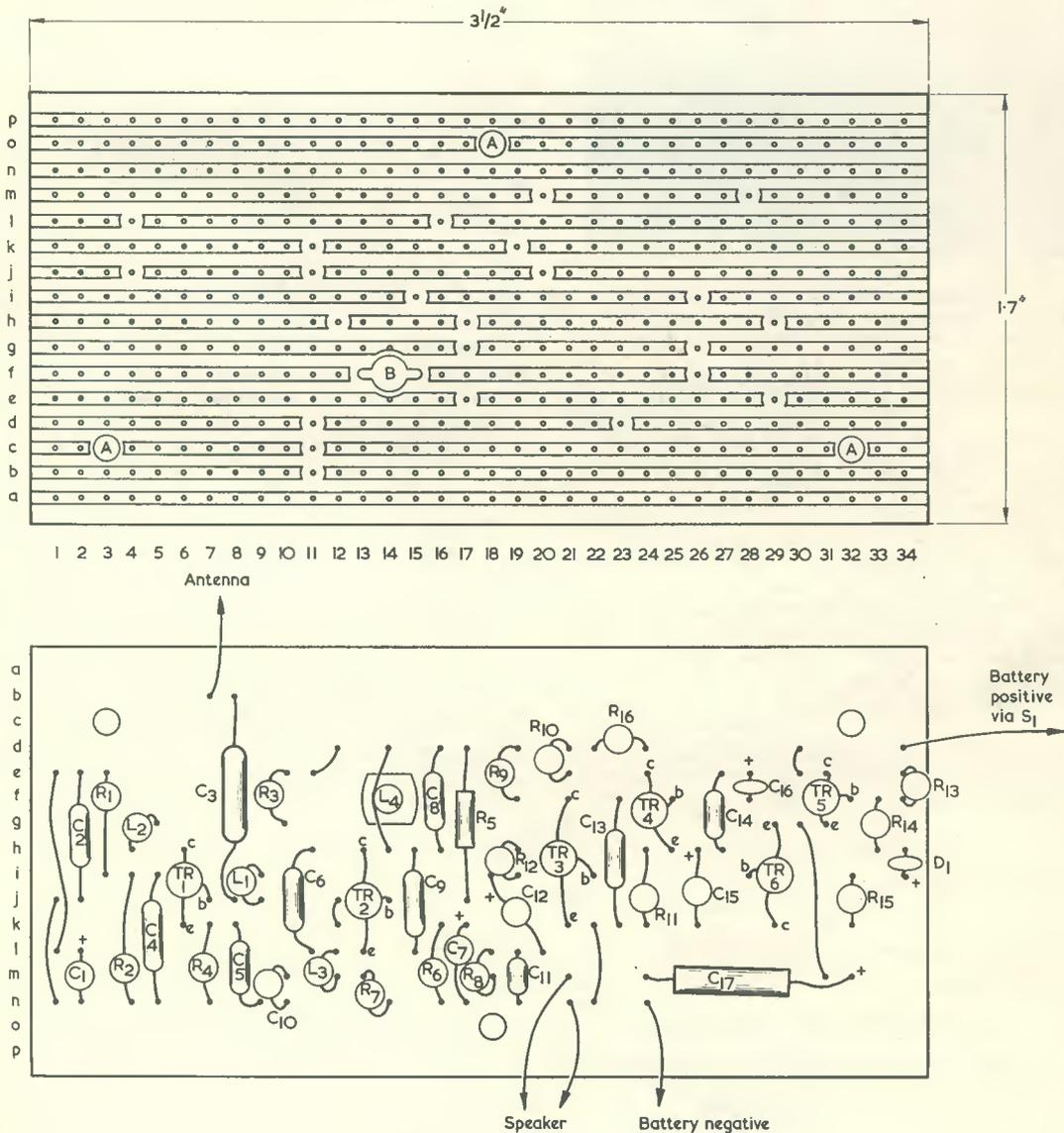


Fig. 3. The copper and component sides of the Veroboard panel

that the cans of TR₁ to TR₄ inclusive are common to the collectors and should not touch any component lead-outs. Where there are any risks of short-circuits on the Veroboard, the appropriate wires should be sleeved.

(1) Fix the L₄ former in place in its mounting hole with the aid of Bostik, Araldite, or a similar adhesive; pass a thin piece of cotton through the centre of the former and screw the iron dust core

in place. The cotton ensures that the core remains in position despite vibration, etc. Bare one end of a length of 28 s.w.g. enamel-covered wire and solder in hole 14h, then, winding upwards from the base of the former, tightly close-wind 11 turns and finish off by soldering the free end of the wire in hole 14d. Wire plain shorting links between 11e and 12d, 22k and 22n, 30d and 30e, and 12j and 12k. Wire sleeved links between 1e and 1l, 1j and 1n,

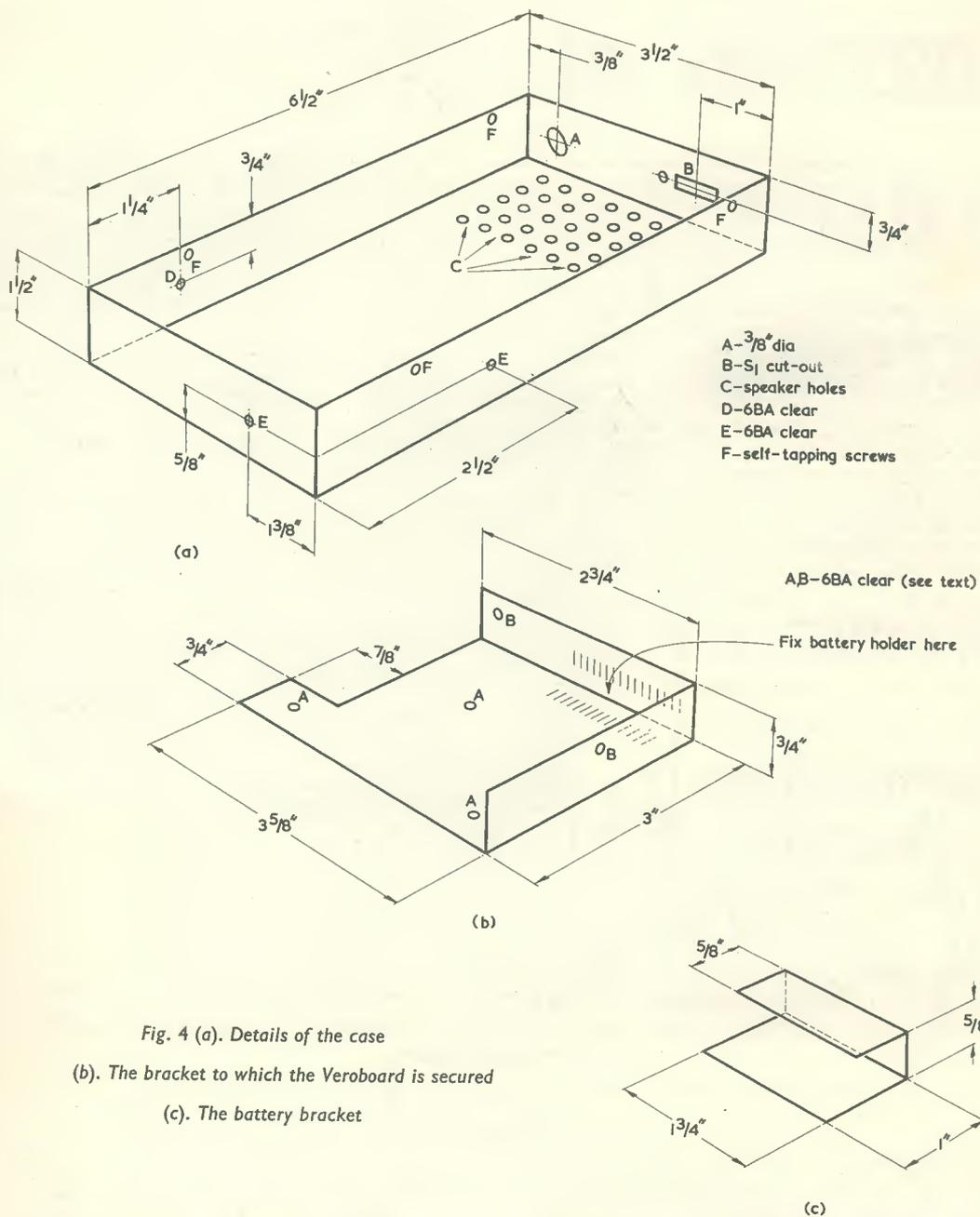


Fig. 4 (a). Details of the case

(b). The bracket to which the Veroboard is secured

(c). The battery bracket

and 30g and 31m. Connect a short length of antenna wire to hole 7b, the battery positive lead to hole 34d, and the battery negative lead to hole 24n. Now solder in place C_1 , C_2 , R_5 , R_6 , R_7 , C_7 , C_8 , C_9 , C_{10} , TR_2 , L_3 and R_{16} . Now test the circuit by connecting to a 9-volt battery and checking that a slight rushing noise is heard when a crystal earpiece is connected across R_7 . This rushing noise should

be replaced by a tone signal when a tone transmitter is operated within a few inches of the circuit; adjust the core of L_4 for maximum signal.

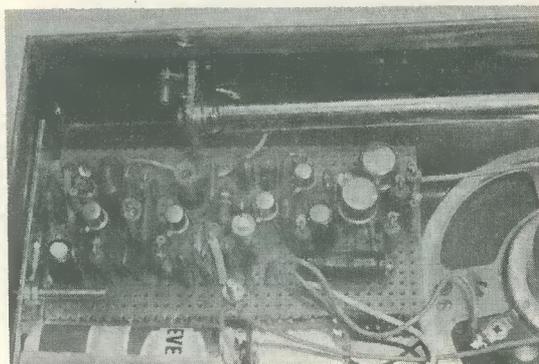
(2) Solder in place R_8 , C_{11} , C_{12} , TR_3 , R_9 , R_{10} , C_{13} , R_{11} , R_{12} , TR_4 , C_{14} , C_{15} . Test the circuit by connecting the battery, applying the crystal earpiece between TR_4 collector and the negative supply line, and checking that results similar to

those in (1) are obtained, but at greatly increased volume.

(3) Solder in place R_1 , R_2 , TR_1 , L_1 , L_2 , C_3 , C_4 , R_3 , R_4 , C_5 and C_6 . Test the circuit by connecting the battery, applying the crystal earpiece between TR_4 collector and the negative supply line, and checking that results are similar to those obtained in (2); but note that in this case tone signals should be heard when the transmitter is several yards away. Adjust the core of L_4 for maximum range.

(4) Solder in place C_{16} , TR_5 , TR_6 , R_{13} , R_{14} , D_1 , R_{15} , and C_{17} . Solder speaker leads to holes 21m and 21n, but do not connect the speaker at this stage. Now connect the battery and check that the circuit draws a total battery current of about 6mA. If the total current is substantially greater than 8mA, reduce the value of R_{14} until the correct current is obtained. When satisfactory, connect the speaker in place and check that, in the absence of a carrier signal, the characteristic rushing noise is heard at good volume and that, in the presence of a modulated carrier, tone signals are also heard at good volume. This completes the assembly and test procedure for the main Veroboard panel.

(5) Construction of metalwork, etc., can now be undertaken. Start by cutting and bending the main case, as shown in Fig. 4 (a), using a medium gauge aluminium, and drill in the following manner. Hole A is the antenna grommet hole, and has a diameter of $\frac{3}{8}$ in. The rectangular hole B, with the two mounting holes on either side, is for switch S_1 . Holes C are a group of holes drilled for the speaker, and appear in front of its cone. Hole D is 6BA clear and later takes the antenna securing bracket (shown in Fig. 5). The two holes E are 6BA clear and are for the Veroboard bracket (shown in Fig. 4 (b)). Holes F are back-plate securing holes and are drilled to take self-tapping screws.



A close-up view of the Veroboard panel inside the transmitter case. When this photograph was taken, the antenna wire was not connected to the antenna bracket

They may be drilled after the back-plate (shown in Fig. 6) has been made.

The case can, if required, be covered with a self-adhesive decorative plastic, as with the prototype, the holes for the speaker being cut with suitable fabric or cloth.

Next make up the Veroboard bracket as shown in Fig. 4 (b); the two small holes (B) on the sides of this bracket should line up with holes E in the main case, and the three remaining holes (A) should line up with the mounting holes in the Veroboard panel. Finally, bend the battery bracket to shape, as shown in Fig. 4 (c). Both the Veroboard and battery brackets should be made from a light gauge aluminium.

(6) Secure the battery holder to the Veroboard bracket with the aid of Bostik or a similar impact
(Continued on page 424)

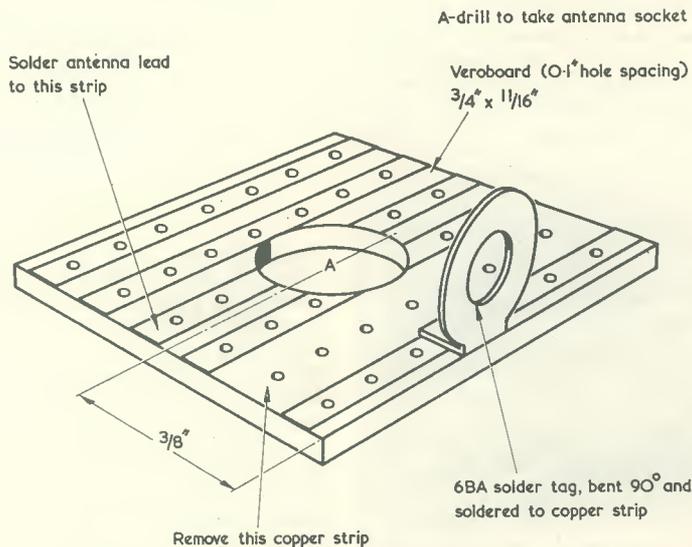


Fig. 5. The antenna bracket. This is made up from a small piece of Veroboard

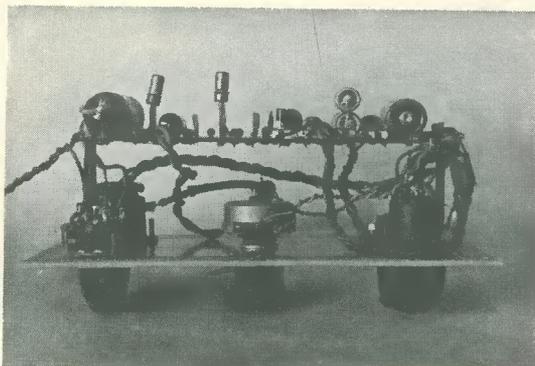


Cover Feature

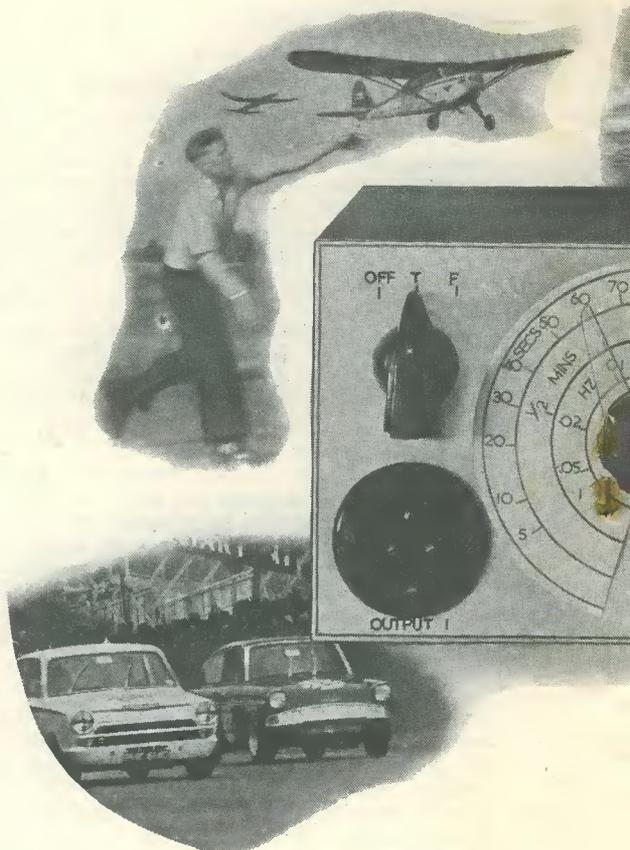
Unijunction Process Timer and Oscillator

by D. BOLLEN

MANY TIMER APPLICATIONS DEMAND REASONABLY precise and repeatable timing periods, where day-to-day and short-term drift is negligible. The timer described here uses a unijunction to trigger a transistor bistable switch. As the operation of the circuit is entirely "solid-state" it is fast acting and free from the difficulties usually associated with mechanical relay switching. Timed intervals from 0.05 seconds to 30 minutes are covered in four overlapping ranges. The unit will also serve as a square wave oscillator with a frequency range of 10 c/s-0.0003 c/s.



As may be seen from this illustration, the panel on which the components are mounted is secured to the front panel by long bolts with spacing bushes



Due to a number of unique features, including a unijunction circuit and a reed switch, this timer achieves very low timing errors. The accuracy is maintained over wide ranges of temperature in battery voltage

Timing Errors

Several factors affect timer performance, among these being leakage across the RC time determining components, temperature dependence, supply voltage drift, and erratic on-off triggering. Repeatability error is the most important where, for any given timer dial setting, successive timing periods tend to vary, and this may be expressed as a percentage error. For example, if a timer is carefully set for 10 seconds and is switched on, the first timed interval may actually be 9.5 seconds. The next interval, initiated at random as when making a photographic exposure, might have increased to 9.6 seconds, and subsequent intervals may be longer still. After several minutes' use, the timer



and is slowly charged via R_1 and timing control VR_1 until the voltage across the capacitor rises to a level where the emitter-base 1 junction of TR_1 switches to its low resistance state and quickly discharges the capacitor. At the same time, a steep sided positive-going pulse appears at the base 1 connection of TR_1 . $S_{1(b)}$ selects pre-set variable resistors (VR_2 - VR_5) which are in series with base 2, and these allow the breakdown voltage of the emitter-base 1 junction to be individually adjusted for each range, so that a single calibration scale can be used for the four ranges with S_1 in the role of decadal multiplier. An advantage of this arrangement is that the poor tolerance of high value electrolytic capacitors can be allowed for, within reasonable limits, by appropriate adjustment of pre-set resistors.*

Assuming that TR_2 is normally conducting and that $S_{2(a)}$ is set to position 3, the collector of TR_2 will be close to the positive rail and there will be insufficient voltage across TR_1 to allow it to operate. In this condition, there is almost zero current flowing through the reed coil and TR_3 , and the contacts of the reed switch will be open. Capacitor C_7 is kept charged by resistor R_x , and S_3 is a normally open press button. When S_3 is pressed, C_7 discharges rapidly into the shared emitter resistor R_{11} , causing the bistable to change its state. Thus, current starts to flow through the reed coil; simultaneously, the reed switch contacts close, the collector of TR_2 rises to nearly negative rail voltage and the selected range capacitor commences to charge. At the end of the timing period, when the capacitor is discharged, the positive-going pulse from TR_1 switches off TR_3 and the reed coil, the

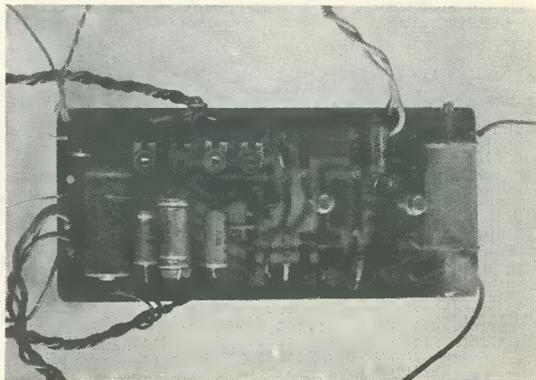
cluding the use of a unijunction relaxation
ives very low long-term and repeatability
wide temperature ranges and changes
y voltage

could be yielding intervals of 10.5 seconds duration; a total repeatability error of $\pm 5\%$. Often it is found that the repeatability error is less predictable, taking the form of fluctuations above and below the time indicated on the dial, and can be accounted for by variations of supply voltage and temperature changes. In the case of a timer which uses a relay to initiate and end an event, and especially where the interval is short, dirty contacts and contact bounce can lead to large discrepancies.

Timer Circuit

The circuit of the complete timer to be described in this article is given in Fig. 1. One of the range capacitors C_1 , C_2 , C_3 , or C_4 , is selected by $S_{1(a)}$

* For those unfamiliar with unijunction transistor operation, the circuit around TR_1 operates, with $S_{2(a)}$ in position 2, as a relaxation oscillator. The selected capacitor charges until the emitter turn-on voltage is reached, whereupon the emitter-base 1 junction becomes suddenly conductive, and rapidly discharges the capacitor. The cycle then repeats. Turn-on voltage varies with base 1-base 2 voltage. —EDITOR.



The component side of the printed circuit board

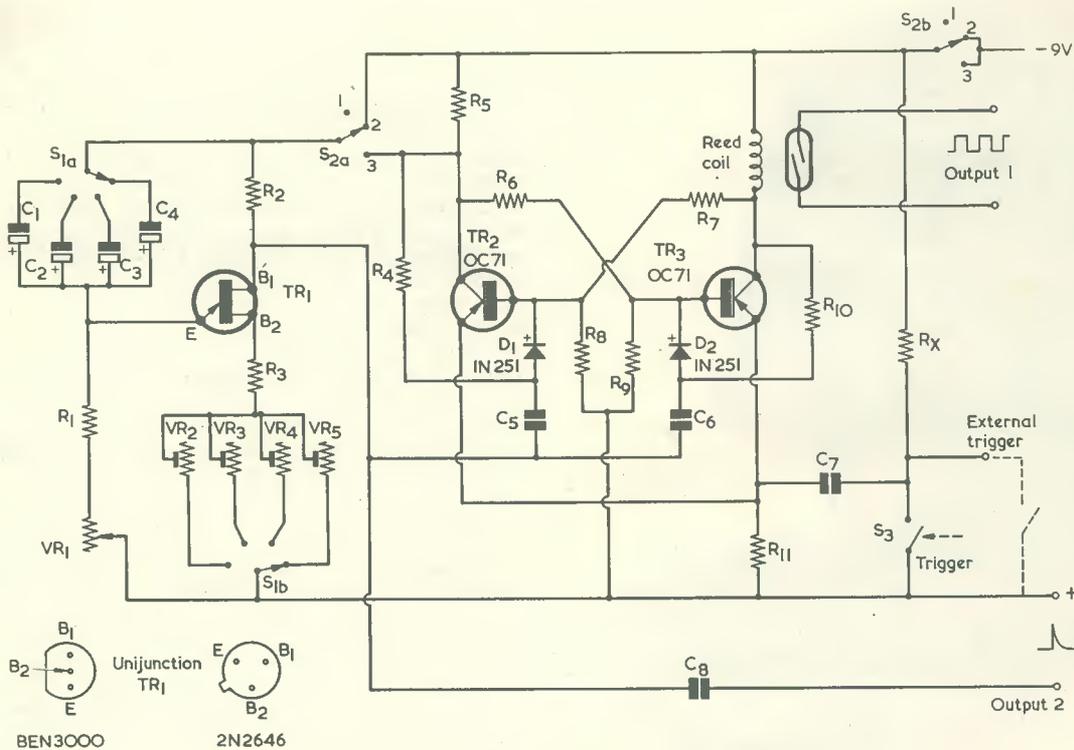


Fig. 1. The full circuit of the timer. TR₁ is a unijunction transistor

bistable reverting to its original state. The unijunction supply from the collector of TR₂ is also turned off, so the timer returns to its dormant condition. If the timer button is pressed during a timing period, while the capacitor is still charging, this will automatically terminate the interval and reset the timer, a useful facility when a mistake has been made in setting the timer dial.

Resistor R_x is selected to give a "dead-time", so that the timer will not switch more than once when S₃ is pressed hesitantly. To prevent such spurious triggering the "dead-time" need only be

a small fraction of a second, but can be increased by a larger value for R_x. Approximately 2MΩ per second of "dead-time" is required.

For the unit to function as an oscillator, S_{2(a)} is set to position 2, so that the unijunction becomes free-running. Successive pulses then switch the bistable alternately from one state to the other, giving rise to a square wave output for which the contacts of the reed switch are open and closed for equal periods.

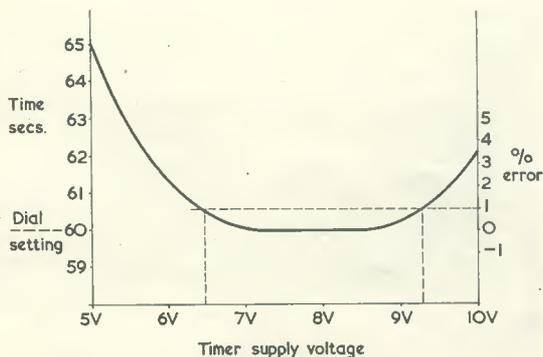
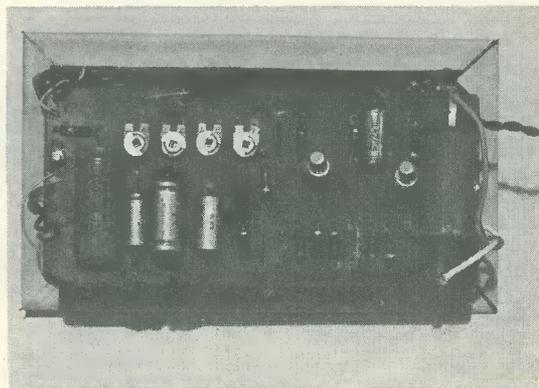


Fig. 2. Graph showing timing error resulting from change in supply voltage



Back view, showing the printed circuit board fitted in the instrument case

Resistors

(All fixed values $\frac{1}{8}$ or $\frac{1}{4}$ watt, 10%)

R ₁	10k Ω
R ₂	100 Ω
R ₃	100 Ω
R ₄	1.5k Ω
R ₅	1k Ω
R ₆	6.8k Ω
R ₇	6.8k Ω
R ₈	10k Ω
R ₉	10k Ω
R ₁₀	1.5k Ω
R ₁₁	200 Ω
R _x	Approx. 300k Ω (see text)
VR ₁	1M Ω carbon linear
VR ₁	1M Ω carbon linear
VR ₂ -VR ₅	1k Ω skeleton pre-set, horizontal mounting

COMPONENTS

Capacitors

C ₁	1 μ F mixed dielectric* polyester, or electrolytic, 15V wkg.
C ₂	10 μ F electrolytic, 15V wkg.
C ₃	100 μ F electrolytic, 15V wkg.
C ₄	1,000 μ F electrolytic, 15V wkg.
C ₅	0.1 μ F paper
C ₆	0.1 μ F paper
C ₇	0.47 μ F mixed dielectric or polyester
C ₈	0.1 μ F paper

* Mixed dielectric capacitors use a combination of paper and polyester in their construction.

Semiconductors

TR ₁	BEN 3000 (Rastra Electronics Ltd., 275 King St., Hammersmith, London, W.6)
	or 2N2646 (Henry's Radio Ltd)
TR ₂	OC71 or equivalent
TR ₃	OC71 or equivalent
D ₁	1N251, OA81, etc.
D ₂	1N251, OA81, etc.

Switches

S _{1(a)(b)}	2-pole 4-way, rotary
S _{2(a)(b)}	2-pole 3-way, rotary
S ₃	s.p.s.t. press-button, normally open

Reed Switch

Reed switch type DRT-5, 60-80 AT. (Flight Refuelling Ltd.) Available from R.T.S. Ltd., P.O. Box 11, Gloucester Street, Cambridge

Battery

9-volt battery type PP9 (Ever Ready)

Miscellaneous

2 pointer knobs
1 instrument knob, with cursor
Copper clad panel, 2 $\frac{1}{2}$ x 6in (if required)
Mains insulated 3-way output socket, and plug
Miniature 4-way socket and plug
Front panel, etc.

Timer Performances

The timer was tested for temperature dependence and no detectable error resulted when the unit was subjected to a change of 0°C to 40°C. The low leakage of the silicon planar unijunction, typically 2 μ A at 9 volts, corresponding to an equivalent resistance of some 4.5M Ω , is mainly responsible for this freedom from ambient temperature drift. There is some drift immediately after switch-on, but this is short lived. It is best to cycle the timer a few times before use, just to make sure that the range capacitor is adequately polarised, particularly when the unit has been out of service for some time. It would appear that, according to the state of the bistable, the timer might go through a timing period when initially switched on, after which it would then become controllable by S₃ in normal manner. In practice, however, the inductance of the reed coil in the collector circuit of TR₃ tends to bias the circuit in such a way that the relay does not energise when the power supply is switched on.

On the first three ranges, 0.05 seconds to 180 seconds, repeatability is better than $\pm 0.5\%$, and is less than 1% on the fourth range. As the timer was designed to be battery powered, dependence on supply voltage is important if the full useful life of the battery is to be realised. The curve of

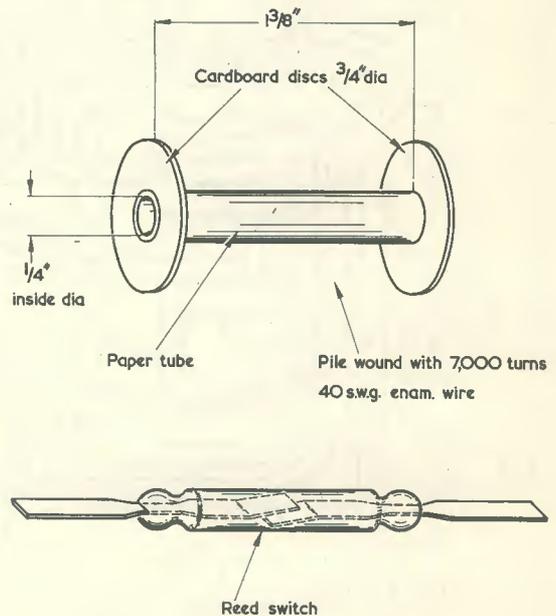


Fig. 3. Details of the reed switch and its energising coil

Fig. 2 shows the error resulting from a change in supply voltage. With a nominal 9 volt supply, an error of less than 1% will occur from a supply voltage change of 22%, corresponding to a final battery voltage of 7 volts. With the configuration and component values chosen for the circuit of Fig. 1, the capacitor charge time tends to remain constant, irrespective of supply voltage, within the limits given.

Reed Relay

A reed relay is used in the timer because it need

occupy only a small space, is sensitive, fast acting, and offers a good long-term reliability. With the DRT-5 reed switch specified, the timer can switch a load of up to 50 watts resistive at mains voltages, and will handle a d.c. current of 3 amps. If the intention is to switch a lighter load at lower voltages, a low-cost reed switch could be used instead. (See Editor's Note at end.)

The reed coil is quite simple to wind with a hand-drill and approximately 7,000 pile-wound turns of 40 s.w.g. enamelled wire will give the required pull-in sensitivity. With the prototype, a current of 9mA sufficed to close the reed switch. Bobbin details are given in Fig. 3.

Construction

The writer employed a printed circuit board for the prototype assembly, but any other conventional method of wiring and mounting the components would cope equally well and could be used by constructors wishing to make the timer. When using the printed circuit method the final assembly should be carefully checked against Fig. 1 to ensure that all connections are correct.

The layout of the etched circuit used by the writer is given in Fig. 4, with component positioning as in Fig. 5. Controls S_1 , S_2 and press-button S_3 , together with VR_1 and the output sockets, are mounted on the front panel, which can be made of Paxolin, hardboard, or aluminium. The etched circuit panel is bolted to the front panel by means of long screws with stand-off bushes.

It is advisable to solder the various switch leads to the circuit panel before final assembly, and colour coded wires will assist in the correct identification of switch connections. R_x (see Fig. 1) is not mounted on the etched circuit panel but, instead, forms a link on the front panel assembly between $S_{2(b)}$ and S_3 , thus facilitating a change of resistor value if the timer "dead-time" is to be altered for a special application. For normal use, a value of about $300k\Omega$ will give reliable manual triggering of the bistable with a short "dead-time". The 1N251 diodes used for the original timer may be replaced by other types of diode, such as the OA81, as these are not critical components.

Provision is made on the front panel for external remote triggering, and for two outputs. Output

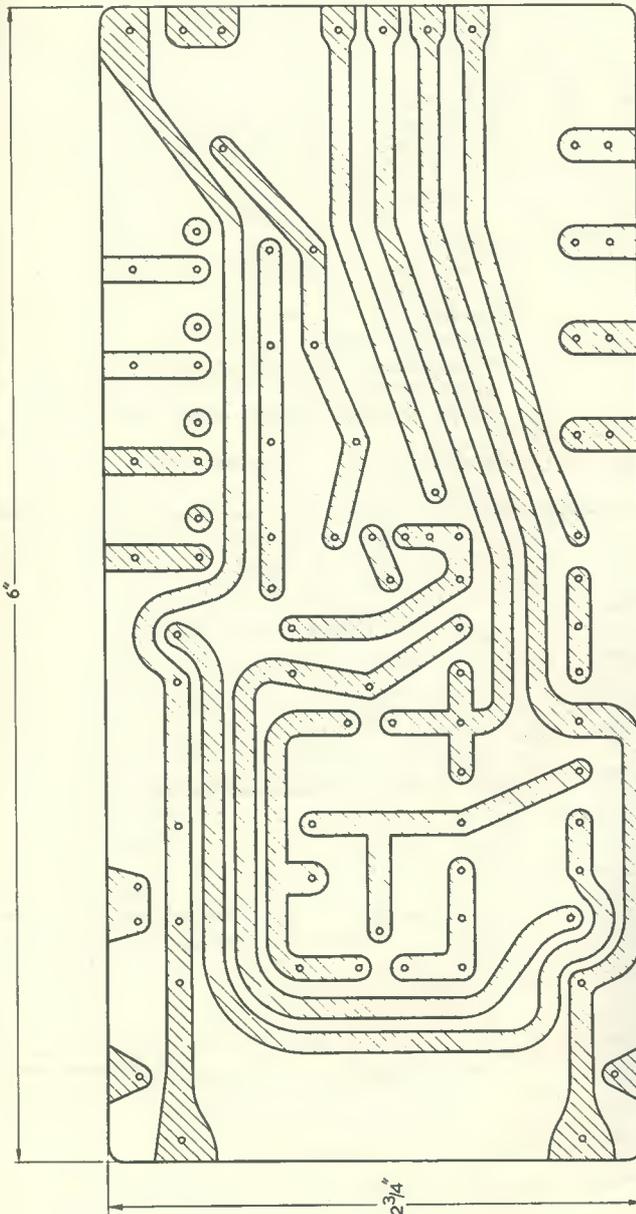


Fig. 4. The printed circuit layout employed by the writer. This is reproduced full-scale and may be traced

1 is taken from the reed switch to a connector which has insulation suitable for mains voltage working. Output 2 provides a steep-sided low voltage pulse at the end of each interval, which may be amplified to trigger an electromagnetic counter or similar pulsed device requiring a short duty-cycle. If the timer is switched to its oscillation mode, a "clock-pulse" at set intervals will be available at Outputs 1 and 2.

Calibration

The prototype dial calibration is illustrated in Fig. 6, this being shown here to give a guide to what may be expected after calibration has been carried out. Range coverage is as follows, with S_1 serving as a range multiplier: 0.05-1.8 secs, 0.5-18 secs, 5-180 secs and 50 secs-30 minutes. The corresponding oscillator ranges are: 10 c/s-0.3 c/s, 1 c/s-0.03 c/s, 0.1 c/s-0.003 c/s and 0.01 c/s-0.003 c/s. The scale is not quite linear, being cramped towards the long time interval end of the scale.

The basic scale can be calibrated on the 5-180 second range, with a stop watch, or sweep second hand wristwatch, with output 1 coupled to a battery and torch bulb as a visual indicator. It is well worth while spending time on this calibration process, double checking each graduation of the scale.

The oscillator scale does not conform to the equivalent $\frac{1}{2t}$ time scale, being displayed slightly, so is best calibrated on the two fastest ranges of S_1 , counting every other "click" from the reed switch, to see how many clicks per minute there are. A better arrangement is with an electromagnetic counter wired to output 1 and a battery so that the oscillator rate can be sampled over a longish period. When all time ranges are correctly aligned by means of pre-set resistors VR_2 to VR_5 , the oscillator ranges will also then correspond to the common frequency scale, and the decadal steps offered by S_1 will simplify further range calculations.

The only difficulty likely to be encountered is with the long interval, low frequency, capacitor C_4 . If C_4 is not a good quality component, or has a poor tolerance, the capacitor charge time may lie outside the adjust-

ment provided by VR_5 . In this case the only thing to do is change the capacitor. Calibration of long time intervals is somewhat laborious, as it involves waiting for several minutes before a result is obtained. A good idea here is to wire Output 1 of the timer in series with the battery of a transistor radio, playing background music. As soon as the music is cut off at the end of an interval the time is noted on a conveniently placed watch.

Applications

For photographic film development, Output 1

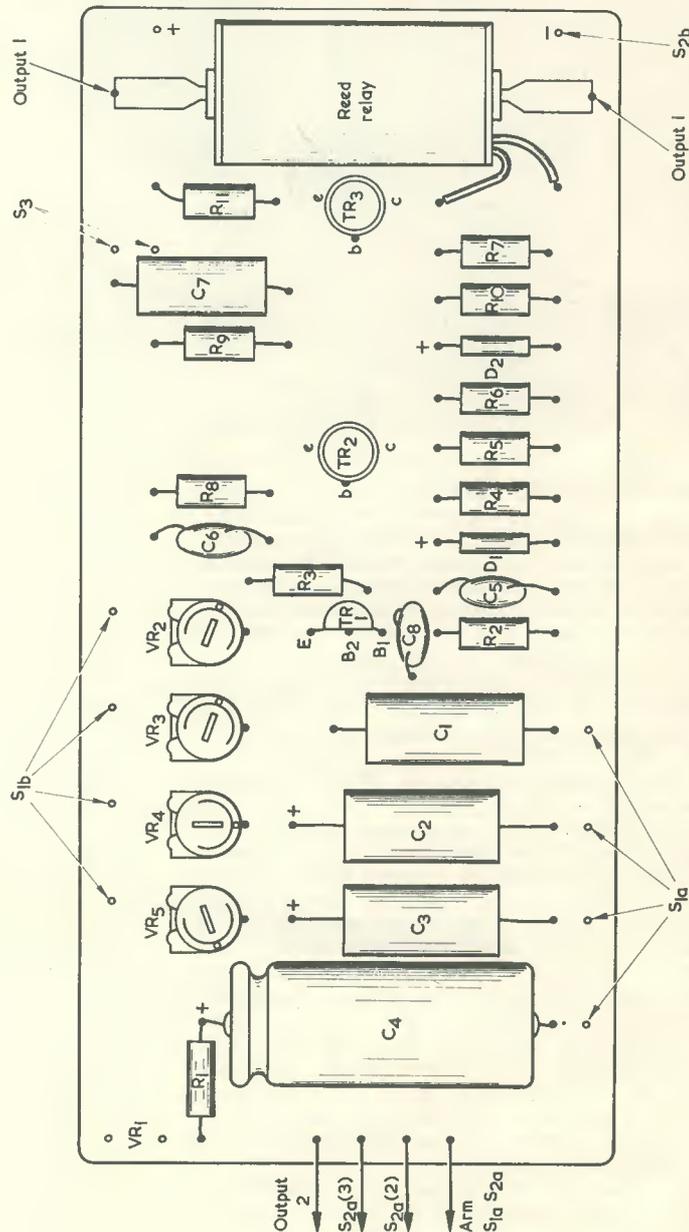


Fig. 5. How the components are mounted on the plain side of the panel

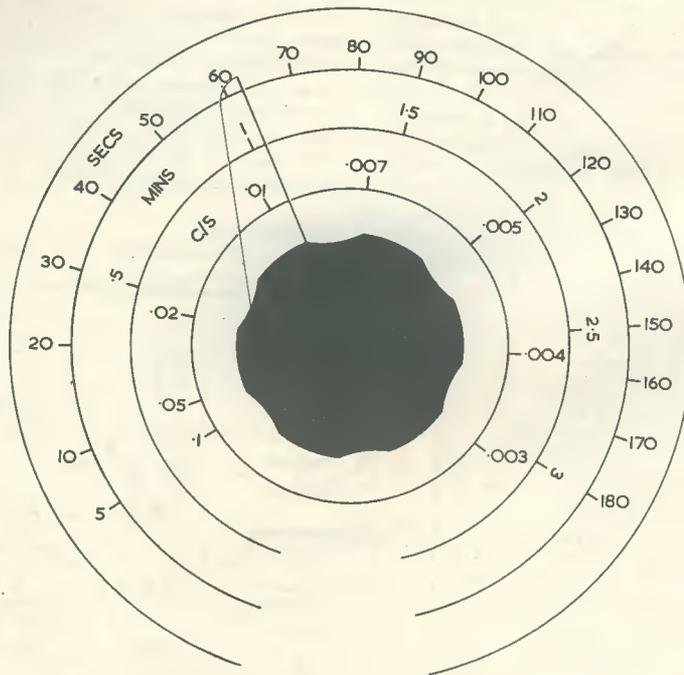


Fig. 6. The dial calibration of the prototype timer

of the timer may be wired in series with a spare safelamp, or a buzzer, depending on whether visual or audible indication of a timed interval is required. With enlargements or contact prints, the enlarger or printing frame bulb can be connected in series with Output 1 where the bulb consumption does not exceed 50 watts. Where a bulb of more than 50 watts is to be switched, a slave relay must be employed to handle the heavier load. The timer should be positioned in such a way that press-button S_3 can be easily located in the dark or in dim light. Better still, the external trigger socket could be wired to a remote push-button, which is adjacent to the apparatus being timed.

The oscillator will act as a clock, or as a timer for sports events. A resettable magnetic counter should be used, connected in series with a battery, timer Output 1, and a bathroom type cord-pull switch. The oscillator is set to give precisely 10 c/s. When the cord-pull switch is tripped to its closed position, the counter will commence to record elapsed time in intervals of $\frac{1}{10}$ second. At the end of the event, the cord-pull switch is made to open, and the counter will then show the total time occupied by the event. Alternatively, for longer events, the oscillator clock pulse could be set to 1 c/s. At 1 c/s a four digit counter will record up to 2 hours 46 minutes, and at 10 c/s the duration will be 16 minutes 40 seconds.

Apart from the applications mentioned above, the timer can be adapted for a number of other uses. By connecting the primary winding of a speaker

transformer to Output 2, with a speaker wired to the transformer secondary, the oscillator can function as a metronome. If the bistable is triggered by an external pulse, injected via C_8 , the timer will then serve as an electronic "gate". On receipt of a positive-going control pulse, the gate (Output 1) will remain open for a period dependent on timer control settings.

The unit could be "borrowed" at Christmas time, to stand-in as a Christmas tree fairy light winker, with variable wink rate, or as a slow speed stroboscope, for visual experiments. By adding an extra oscillator range, with $0.1\mu\text{F}$ timing capacitor, the stroboscope speed will be extended to 100 c/s. The reed switch should be capable of handling frequencies up to some 500 c/s without excessive contact bounce.

A PP9 9-volt battery is specified in the Components List. This size of battery should offer better than 350 hours use.

Editor's Note

The term 60-80 AT, following the type number DRT-5 for the Flight Refuelling reed switch in the components list, refers to nominal ampere-turns rating in a standard test coil. In normal use, dry reed switches are operated at some 50% above their nominal ampere-turns figure. The coil used by the writer offers 63 ampere-turns at 9mA but no trouble was experienced with the prototype due to non-operation of the switch, and the coil was also used successfully with a Radiospares 2-RSR reed switch (15 watt maximum switching load) rated at 75-90 ampere-turns. The coil construction employed by the

writer enables the winding to very closely approach the reed switch. If desired, an increase in ampere-turns could be given by slightly lengthening the coil and winding it with a slightly thicker gauge of wire. This will cause TR₃

collector current to rise somewhat above the 10mA maximum rating for an OC71, whereupon an alternative transistor (e.g. ACY17 to ACY22) should be employed in its place. *

TRADE REVIEW . . .

HEATHKIT PORTABLE STEREO/MONO RECORD PLAYER MODEL SRP-1



This record player provides a compact and economical stereo/mono unit which may be enjoyed by the whole family. Using British components and the well-known B.S.R. UA15SS record deck, the SRP-1 may be constructed from a kit of parts or purchased completely assembled.

The circuit consists of 8 transistors and one diode using the printed circuit board technique, thus ensuring instant operation from the moment of switching on. Automatic playing of 16, 33, 45 and 78 r.p.m. records using a dual sapphire stylus for LP's and 78's—mono or stereo—and two 8 x 5in speakers are features of this design. One speaker enclosure can be detached from the main cabinet and positioned to obtain the best stereo separation.

The soundly constructed wood cabinet is covered with two-tone blue and grey Rexine with Vynair covered speaker grilles and the control spindles are fitted with black knobs having spun metal inserts, this attractive presentation being most pleasing to the eye.

The record changer and the cabinet is supplied pre-assembled, the constructor only being required to wire up one small circuit board, mount into position the two 8in speakers and complete the interconnecting wiring—this process taking only a few hours to complete.

The SRP-1 is fitted with a suitcase-type handle and one speaker enclosure clips neatly to the main cabinet, thus providing a easy-to-carry and portable unit.

SPECIFICATION

AMPLIFIER

Frequency Response3dB, 50 c/s to 12 kc/s.

Power Output r.m.s.
per channel1.5 watts.

Music power output
(total)4.5 watts.

ControlsVolume, Balance, Tone.

Speakers8 x 5in permanent magnet, 15 ohm.

Transistor & Diode

Complement2-BC108; 4-AC128; 2-AC176;
1 silicon diode.

RECORD CHANGER

TypeModel UA15 SS.

ControlsMODE: OFF, MANual ON,
REject. SPEED: 16, 33, 45 or
78 r.p.m.

Record Size12, 10 and 7in.

CartridgeStereophonic crystal, LP & 78
turnover sapphire stylus.

GENERAL

Power Requirements220-250 volts, 50 c/s a.c., 30
watts.

FinishWooden cabinet covered with
blue and grey Rexine. Vynair
covered speaker grilles.
Black knobs with spun metal
insets. Satin anodized control
panel.

Dimensions, overall,
with separate speaker
enclosure in place27 wide x 14 $\frac{3}{8}$ high x 7 $\frac{1}{2}$ in deep.

Net Weight28 $\frac{3}{4}$ lb.

Shipping Weight35 $\frac{1}{2}$ lb.

The SRP-1 kit of parts is priced at £27.15.0 (inc. purchase tax) and is delivered free to any address in the U.K.

RADIO CONTROL FIELD MONITOR

Continued from page 415

adhesive and, when dry, bolt the Veroboard to the bracket, interposing three grommets between the bracket and the panel to act as spacer-insulators. Now bolt the resulting Veroboard and battery assembly to the main case, using the two holes provided (E), then fix the 25Ω speaker in place with the aid of Bostik. (Suitable clamps bolted as required with countersunk screws to the case could alternatively be employed for mounting the speaker, but it was found that the use of adhesive was perfectly satisfactory with the prototype.) Bolt the slide switch, S_1 , in place. Now make up the simple antenna bracket, as shown in Fig. 5, and bolt the screw-on antenna socket to it. Insert a grommet in the antenna opening in the case, screw the antenna to its socket, pass the free end of the antenna through the grommet, and bolt the antenna bracket to the side of the case. Finally, complete the circuit wiring by taking the antenna lead to the antenna bracket, the negative battery lead to the negative battery terminal, and the positive battery lead to the positive battery terminal via S_1 . Switch on to check that the unit is functioning correctly.

The unit can be finished off by making a simple back-plate, as shown in Fig. 6, and securing it to the rear of the case by means of four self-tapping screws. Note that a group of holes is provided in the area of the speaker, so as not to restrict the audio volume, and that a hole is also provided to give access to the core of L_4 . Holes A in the back-plate take self-tapping screws which fit into holes F of the case. Hole B is the L_4 access hole, and has a diameter of $\frac{1}{4}$ in. The back-plate should be a tight fit on the case.

The Field Monitor is now complete and ready for use.

Using The Unit

Before using the unit in the field, switch on and partly erect the antenna, and then operate your own transmitter and adjust the core of L_4 for maximum volume. Reduce the antenna, if necessary, to give a sharp peak in the tuning. The Field Monitor is now centred on your own transmitter's carrier signal, and will respond well to other carriers within plus or minus 500 kc/s of that frequency.

The above setting-up procedure should be used if the unit is intended for personal use. If, on the other hand, it is intended to be used by an entire group of operators, a better procedure would be to align L_4 with a transmitter that is operating very near to the centre of the radio control band.

Transmitter types can be identified by the type of signal that they cause the Field Monitor to reproduce at its speaker, and in this respect the following notes will be of value.

If it is known that someone is operating a radio control transmitter at reasonably close range, but only a constant rushing sound is heard from the monitor, it can be assumed that the person concerned is operating illegally outside of the permitted band.

If the rushing sound is occasionally interrupted by either a fall in volume or complete silence, it can be assumed that a "carrier only" type of transmitter is being operated.

If a rushing noise, interrupted by an occasional tone signal, is heard, it can be assumed that a "carrier plus tone" transmitter is in use. Again, if the tone signal is always of the same frequency it can be assumed that the transmitter is of the single channel type while, if the tone signals are of different frequencies at different times, a multi-channel system is indicated.

If no rushing noise is heard, but only silence interrupted by an occasional tone-signal, it can be assumed that a "constant carrier" tone transmitter is in use. When the tone is always of the same

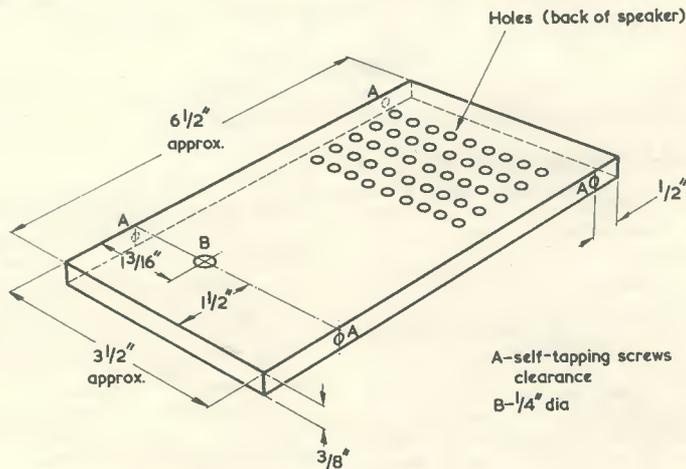


Fig. 6. Details of the back plate

frequency, single channel is indicated, while if different tones are heard the system is multi-channel.

Should a continuous tone signal be heard which sounds as if it is modulated or switched at a very low but variable frequency, it can be assumed that a multi-proportional system is in use. This may be a single channel "galloping ghost" system, or a multi-channel system, some experience being neces-

sary in differentiating between the different systems.

A transmitter, can, if required, be tracked down by reducing the length of the telescopic antenna until a reduction in signal strength is noted, and then walking around to find a position at which signal strength increases to a peak. A line-of-sight bearing can then be taken along the original and new positions to locate the transmitter visually. *

Catalogues Received . . .

Home Radio Ltd, 187 London Road, Mitcham, Surrey.

The 4th edition of this well-known and most excellent catalogue is now available for those requiring quite the most comprehensive and well-illustrated publication that this company has produced.

This new edition has been enlarged by 40 pages and now comprises a total of 250 pages, each set out in a logical and ordered sequence complete with a comprehensive index at the front of the catalogue—the latter making quick and easy reference to almost every conceivable radio component a simple matter.

A ribbon-affixed bookmark, having *Abbreviations in Common Use* printed on one side and *Abbreviations for Manufacturers used in the Catalogue* together with a useful 4in/100mm rule on the reverse side, represents a useful improvement over the old edition.

As with previous editions, five one shilling vouchers are available as a discount arrangement to offset the initial purchase price of the catalogue (7/6d. plus 2/- postage and packing), instructions for the use of these vouchers being printed alongside.

A few new features and sections have been added and all have been revised and brought up to date.

There is no doubt that this well-produced catalogue should find a place on the bookshelf of every radio constructor's workshop.

Lasky's Radio Ltd, 3-15 Cavell Street, Tower Hamlets, London, E.1.

This old-established business, which began operations 35 years ago in Harrow Road, Paddington, is celebrating the occasion by distributing a 12-page colour pictorial catalogue. This catalogue has been produced in a similar format (16½ x 11½ in approximately) and style to that of some newspapers and is therefore, so far as the writer is concerned, an innovation in the world of radio catalogues.

A feature of this production is the fact that on the front page of each copy is printed a Birthday Draw number, the winners of which will be announced in the radio press at a later date, the prizes being cash vouchers which may be used to offset the cost of purchases from the company. The winners will be allocated vouchers as follows:—10 at £5, 25 at £1 and 50 at 10/6d. Instructions for entering this draw, and the simple questions to be answered, are printed on the back page of the catalogue.

This attractively produced publication may be obtained from the above address by forwarding name, address and a 4d. stamp for postage.

Electroniques (Prop. S.T.C. Ltd), Edinburgh Way, Harlow, Essex.

Obtainable from this company are two free catalogues. The first contains full details and specifications, together with illustrations, of the currently available range of Hallicrafters equipments. This range includes a selection of four new all solid-state receivers, both stereo hi-fi and shortwave designs being featured. Available also is the new Hallicrafters SR400 Cyclone s.s.b. transceiver, together with an expanded range of useful accessories.

The second catalogue features the well-known Knightkit range of do-it-yourself quality kits, these being fully engineered to British Standards. These kits cover a wide range and include such equipments as hi-fi, car tuners, photographic exposure meter, shortwave superhet receiver, a whole range of test instruments and kits for the beginner. Additionally, this publication contains details of speakers and speaker enclosures and also a whole range of educational kits suitable for beginners, elementary students and the interested child. These educational kits would obviously make an acceptable present for many youngsters or could form the basis, on a practical level, of a school scientific project.

Other free publications available from this company are three supplements to the *Electroniques Hobbies Manual* (available at 10/6d. post free)—*Aerial Supplement* (where not contained in pages v-xix of the Manual); *Book Supplement* and *Car Radio Supplement*.

Those readers interested in quartz crystals may also obtain the second Crystal List, covering over 13,000 crystals, by forwarding the postage charge of 1/-.



IN LAST MONTH'S ISSUE WE EXAMINED THE IMPROVEMENT in performance of an a.f. amplifier which results from applying negative feedback to it. We saw that negative feedback produces a smoother frequency response, reduces harmonic distortion, hum and noise introduced in the amplifier itself and stabilises amplifier performance. These improvements are obtained at the expense of gain. In valve high quality or high fidelity amplifiers, where cost limitations are less stringent than with normal domestic entertainment equipment, the loss of gain due to negative feedback represents only a minor disadvantage, and such amplifiers may have one or more relatively inexpensive voltage amplifying stages whose gain is partly or completely nullified by negative feedback.

The application of negative feedback introduces a number of amplifier design problems and we shall next examine these in this month's article.

inter-electrode capacitances in valves, wiring capacitances and capacitances in the speaker transformer. "Stray" inductances appear mainly in the speaker transformer and are due to leakage inductance.

When an alternating voltage is applied to a circuit consisting of a capacitor and resistor in series, as in Fig. 1 (a) (which is representative of a coupling capacitor from a voltage amplifier anode to the grid resistor of a following valve), the voltage across the resistor does not have the same phase as the voltage applied to the capacitor. At frequencies where the reactance of the capacitor is small compared with the resistance the shift in phase is low and may, in general, be ignored, but at frequencies where the reactance of the capacitor is high the phase shift is high also. If the reactance is twice the resistance the phase shift is of the order of 60°. To take an example, a 0.01μF capacitor has a reactance of about 1MΩ at 15 c/s whereupon, if a

UNDERSTANDING RADIO

PROBLEMS WITH NEGATIVE FEEDBACK

$$f = \frac{1}{2\pi\sqrt{LC}}$$






by *W. G. Morley*

Amplifier Phase Shift

In our discussion of negative feedback up to the present it has been understood that the amplifier to which the negative feedback is applied does not introduce any shift in phase of the input signal. We have assumed that the output signal always maintains the same phase relationship to the input signal at all frequencies. Under such conditions the fraction of the output signal fed back to the input terminals is always in anti-phase with the input signal, whereupon true negative feedback is provided regardless of frequency.

In practice, the circuits of an a.f. amplifier include a number of reactances which are given by physical capacitors and inductors and by "stray" capacitances and inductances. These reactances will cause shifts in the phase of the input signal as it passes through the amplifier. Physical capacitive reactances are given by coupling capacitors between amplifying stages and by cathode and screen-grid bypass capacitors, whilst physical inductive reactances are given, when the speaker transformer appears inside the feedback loop, by this component and the speaker. "Stray" capacitances are the result of

0.01μF coupling capacitor were to feed into a 470kΩ grid resistor, we could expect a phase shift of around 60° at this frequency. The phase shift, regardless of capacitor or resistor values, always tends towards 90° as the alternating voltage approaches zero frequency. The voltage across the resistor leads on the voltage applied to the capacitor.

If an alternating voltage is applied to a resistor in series with a capacitor, as in Fig. 1 (b), the voltage across the capacitor is similarly out of phase with that applied to the resistor. At frequencies where the reactance of the capacitor is high compared with the resistor the phase shift is small but, at frequencies where the capacitive reactance is low compared with the resistor the phase shift is high. When the reactance is half the resistance the phase shift is around 60°, and it tends towards 90° as the alternating frequency approaches infinite frequency. A circuit of this type is representative of the case where there is "stray" capacitance between a valve anode and chassis, the series resistance being given by the r_a of the valve. To take a practical example, if the anode of an EF86 a.f. pentode ($r_a=2.5M\Omega$) fed into a "stray" capacitance to

chassis of $5\mu\text{F}$, whose reactance is approximately $1.25\text{M}\Omega$ at 25 kc/s , then we would expect a phase shift of about 60° at this frequency. In this instance, the voltage across the capacitor lags on the applied voltage.*

The two examples of phase shift just quoted show that surprisingly high degrees of phase shift can occur in what appear, at first sight, to be quite innocuous amplifier circuit elements. Phase shifts are also given in series combinations of resistance and inductance, as may appear in the speaker transformer circuit of an amplifier.

It follows from what we have just noted that, if the amplifier stages enclosed within a negative feedback loop include sufficient reactive elements, it is possible at one frequency for the individual phase shifts to add up to 180° . At such a frequency the fraction of the output signal fed back to the input is then in phase with the input signal and the feedback becomes *positive*. If the phase shifts were predominantly due to circuits of the type shown in Fig. 1 (a), the output signal would lead on the input signal by 180° . If they were predominantly due to circuits of the type shown in Fig. 1 (b) the output signal would lag on the input signal by 180° . Whether the output signal is leading or lagging by 180° the result will still, nevertheless, be *positive* feedback.

Conditions For Stability

We already know that if enough positive feedback is applied to any amplifier it becomes an oscillator. Let us now see how much positive feedback is required with an a.f. amplifier fitted with nominal negative feedback to make this an oscillator, too.

In Fig. 2 we have an amplifier which provides a gain of A before feedback is applied. Connected to its output is a potential divider which allows a fraction, n , of the amplifier output to be applied back to the input. This is the standard arrangement for negative feedback. The *loop gain*, i.e. the gain provided by any signal passing through the amplifier and then via the potential divider back to the input again, is obviously An , because it is the gain A multiplied by the fraction of the output, n , which is fed back to the input. If, at any frequency at which the phase shift in the amplifier is 180° (either leading or lagging) the product An is equal to unity (i.e. equal to one), then the amplifier will oscillate at that frequency. If the product is greater than unity, the amplifier will also oscillate, the amplitude of oscillations increasing to a level which, due to consequent changes in valve operating conditions, once more causes An to be equal to unity. Should the product An be less than unity at a frequency at which phase shift is 180° (either leading or lagging) then the amplifier will be stable and will not oscillate. Since this last condition still corresponds to positive

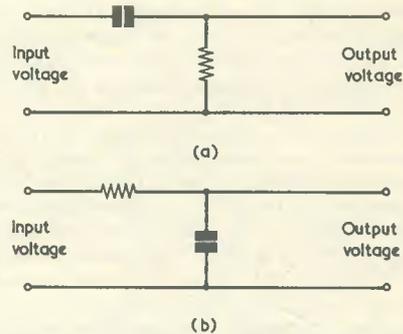


Fig. 1 (a). If an alternating voltage is applied to this simple circuit, the phase shift between input and output voltages tends towards 90° as the alternating voltage approaches zero frequency

(b). With this circuit the phase shift tends towards 90° as the alternating voltage approaches infinite frequency

feedback, the amplifier will show enhanced amplification at the frequency at which 180° phase shift takes place so that, whilst it is still inherently stable, it may exhibit an undesirable peak in its frequency response at that frequency.

We have seen that the simple phase-shifting circuits we have considered provide an increasing phase shift as frequency approaches zero frequency or infinite frequency. It follows that an amplifier whose overall phase shift cannot be more than 180° (lagging or leading) at either zero or infinite frequency will always be stable regardless of the value of n .

The frequency at which the product An is equal to or greater than unity at 180° phase shift does not need to be an audio frequency. In practice it will very probably appear above or below the audible range of frequencies, but the resultant oscillation will still upset amplifier operation. Where a large number of amplifying stages appear in the feedback loop, considerable care is needed

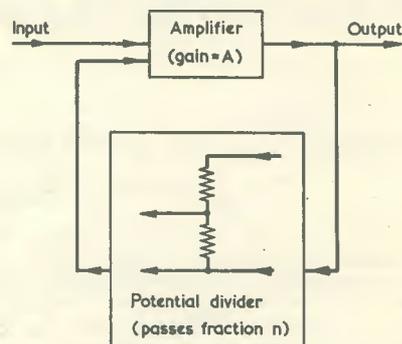


Fig. 2. The basic negative feedback arrangement. The text discusses the requirements for stability when phase shifts exist in the amplifier

* Regular readers who have retained earlier volumes will find that a short vector analysis of circuits employing resistance and capacitance in series, or resistance and inductance in series, was given in "Understanding Radio" in the December 1962 and January 1963 issues. Leakage inductance in a transformer was described in "Understanding Radio" in the July 1963 issue.

to prevent 180° phase reversal at one or more frequencies. As was shown by the example of Fig. 1 (a), resistance capacitance coupling between valves provides a prevalent cause of phase shift, a shift of 60° per coupling at some low frequency representing quite a normal state of affairs. In consequence it is desirable to keep resistance capacitance couplings in the amplifier to a minimum. A good approach here is to employ direct couplings wherever possible. In the Mullard phase-splitter circuit shown in Fig. 2 of "Understanding Radio" in the December 1967 issue, for instance, the anode of a voltage amplifier valve connects directly to the grid of the following phase-splitter without any coupling capacitor at all. Such a circuit neatly cuts out one undesirable coupling capacitor from the feedback loop.

If the speaker transformer appears in the feedback loop (and with a high fidelity amplifier it is virtually essential that it should do so) great care has to be taken in its design to keep "stray" capacitances, capacitive couplings and leakage inductances to a minimum. Speaker transformers intended for high fidelity amplifiers in which a high level of feedback is provided are specially designed and manufactured to meet these requirements. They are, in consequence, more expensive than the simple low-cost speaker transformers encountered in domestic entertainment equipment.

An a.f. amplifier without feedback will normally exhibit its highest gain over the centre of the audio frequency range, the gain dropping off to zero at frequencies below this range and at frequencies above this range. If the circuits in the amplifier are capable of allowing 180° phase shift to occur at a frequency below the a.f. range, or at a frequency above the a.f. range, but the gain A provided at such frequencies is too low to allow A_n to be equal to or greater than unity, then the amplifier is, as already stated, stable. Sometimes, the response of an amplifier may be deliberately reduced at a frequency well above the a.f. range so that the factor A is sufficiently low to ensure that A_n is below unity at the 180° phase shift point. This is a design technique which assumes the inevitability of 180° phase shift in the amplifier and which deliberately

reduces the factor A at the frequency in question in order to retain stability.

An alternative approach where 180° phase shift is inevitable is to keep the fraction, n, of the output voltage which is fed back below the figure which allows oscillation to occur. This results in an amplifier which is stable but with reduced negative feedback at all frequencies.

Before concluding on this subject, it should be mentioned that other reactive components can also produce phase-shifts which may prove troublesome with negative feedback amplifiers. Typical amongst these are cathode bypass and screen-grid bypass capacitors. Some high fidelity designs reduce phase shifts by omitting cathode bypass capacitors from one or more of the voltage amplifiers in the loop. Apart from obviating the risk of phase shift this approach causes a reduction in gain in the amplifier before the application of feedback.

As will have been gathered from this article, the design of a negative feedback amplifier having a high performance is by no means a simple procedure. To sum up, if full advantage is to be taken of the negative feedback, there must be a high level of gain without feedback, a high level of feedback should be applied, and the speaker transformer should appear in the loop. The first two requirements mean that the initial high gain amplifier will require an output stage plus at least one voltage amplifying stage, whereupon phase shifts have to be kept to a minimum. Also, output transformer design has to be very carefully carried out to minimise phase shifts in this component.

As a final point it should be mentioned that it is possible to apply more than one feedback path to an amplifier. Some amplifiers have been produced in which additional negative feedback loops are applied to stages which appear within the main feedback loop.

Next Month

In next month's issue, we shall conclude on the subject of negative feedback. In the succeeding article we will commence to examine the superhet receiver.



Institution of Electrical Engineers Second Microwave Summer School

The professional group on microwave techniques and quantum electronics of the IEE Electronics Division has announced that the second summer school organised under its aegis will be held at Bodington Hall, University of Leeds from 8 to 19 July 1968. The subject of the school will be microwave solid state devices.

The Organising Committee under the Chairmanship of Professor P. J. B. Clarricoats, includes Professor E. A. Ash (University College), I. B. Bott (Royal Radar Establishment), J. R. A. Beale (Mullard Research Laboratories), J. H. Collins (University of Glasgow), Dr. C. D. Hannaford (University of Leeds), Dr. L. Lewin (Standard Telecommunication Laboratories), Dr. P. N. Robson (University College).

Those who would like to receive further details, which will be announced in due course, should apply in writing to the Secretary, IEE, Savoy Place, W.C.2.

In your workshop-shop

Smithy can, at times, assume the mantle of a man of mystery, and our episode this month commences with some particularly unusual behaviour on his part. But the enigma is solved when Dick discovers that the Serviceman is merely carrying out experiments with a fascinating new integrated circuit—the R.C.A. CA3020

I'M GETTING WORRIED ABOUT Jim.

The more senior among we citizens will at once recognise this *cri de coeur* as belonging to an era when we never had it so good, when the general practitioner held a position of esteem in the community, and when the B.B.C. could reflect this state of affairs by the popular "Mrs. Dale's Diary" in which wifely concern for Jim, as expressed in our first sentence, marked the opening of very many of the episodes.

Nowadays, of course, it is another good lady whose Diary has been made open to the public, and our doctor hero has slipped down amongst the plebs to reappear in

a far more egalitarian series under the title of "The Dales".

Such changes are inevitable in a continually evolving society but it is heartening to be able to record, as we follow Dick's hurried progress towards the Workshop one sharp February morning, that the solicitude which can be aroused in one human being for his fellow still prevails unaltered.

Dick was getting worried about Smithy.

Integrated Circuit

The expression of anxiety on Dick's face deepened as he approached the Workshop and the sound of "Family Choice" filtered through the closed windows. He opened the door, to be met by the same scene that had greeted him for the last two mornings.

As on the previous occasions, Smithy was hunched over a small chassis on his bench. Two leads ran to his right and terminated at a test speaker in its cabinet. A further, screened, lead travelled to his left, to disappear into the entrails of a small medium and long wave transistor radio. As Dick watched, Smithy reached out a hand to adjust the tuning of this radio, and the effect was at once apparent from the speaker at his right.

"Don't tell me," remarked Dick, as he hung his overcoat behind the Workshop door, "that you're at it again?"

The preoccupied Smithy turned a mild glance of enquiry at his assistant.

"At what?"

"At whatever it is," replied Dick irritably, "that you are at. For the last two mornings you've been coming into the Workshop ages before me, and whenever I ask you what you're up to you refuse to tell me. All you do is pack it up and get on with your ordinary work.

It's a state of affairs," concluded Dick in an aggrieved tone, "which I find extremely unsettling."

Smithy chuckled.

"All that's unsettling you," he remarked unkindly, "is that your curiosity is aroused and I haven't satisfied it for you."

"You must admit," protested Dick, "that you've never done anything like this before. Dash it all, Smithy, eccentricities of this order can be quite disturbing for a young lad of my sensitivity."

"Well, from now on you can stop being disturbed," replied Smithy shortly. "Because I'm going to show you what I've been up to. Just take a shufti at this little lot."

Dick walked over to Smithy's bench and peered inquisitively at the assembly on which Smithy had been working. On a neat little chassis bearing several tagstrips Smithy had wired up a potentiometer, a transformer, four capacitors, two resistors and what appeared at first sight to be a transistor fitted with a small corrugated heat sink. Two leads, previously hidden from Dick's gaze, passed from this chassis to a PP9 battery, one via a testmeter switched to a current range. The testmeter needle jumped spasmodically in time to the music which was reproduced, at a comfortable listening level, by the loudspeaker.

"There doesn't," pronounced Dick suspiciously, "seem to be much to look at here. Only a transistor and a few odd parts."

"Just you count the leads," ordered Smithy severely, "which poke out of what you so casually dismiss as a transistor."

Dick looked closer.

"Hell's teeth, what's this?" he exclaimed. "There must be at least ten leads coming out of that can!"

"As a matter of fact," said Smithy, "there are twelve. And what you're looking at is not a transistor at all.

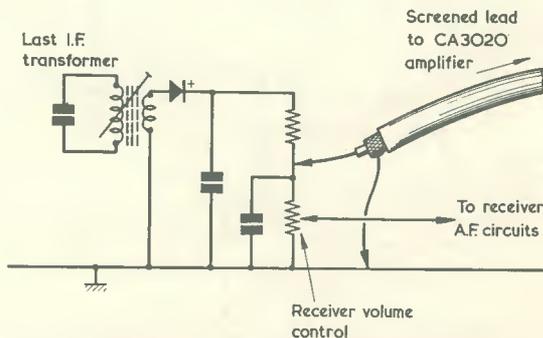


Fig. 1. Smithy obtained an a.f. drive for his integrated circuit amplifier from the volume control of a standard transistor a.m. superhet

Instead, it's a silicon integrated circuit which not only includes a Class B output pair of transistors, but which also contains an emitter-follower, an amplifying phase-splitter, two driver transistors and three stabilising diodes. To say nothing of eleven resistors!"

"In that little can?" spluttered Dick incredulously. "Why, it's no bigger than an ordinary transistor."

"It's smaller than an ordinary transistor," corrected Smithy, pulling a manufacturer's leaflet towards him and consulting its contents. "This integrated circuit is in a can whose diameter is 0.305 to 0.335 inches, which is about the same as that of a normal TO-5 transistor can. But the height of the can is only 0.180 inch maximum as opposed to the 0.257 inch of a standard TO-5 can."

"Blimey," said Dick, impressed. "That's what I call a micro-circuit."

He turned his attention to the other equipment on Smithy's bench.

"Where," he asked, "does that screened lead connect to inside the transistor radio?"

"It connects across the track of the volume control," replied Smithy, "which forms the diode load. The set is just an ordinary superhet having one transistor as mixer-oscillator and two transistors as i.f. amplifiers, and it provides a very useful signal source for my

experiments. You can't hear any sound from its own speaker because I've turned its volume control back." (Fig. 1).

"I see," commented Dick. "Then what we're hearing from that bench speaker will be the amplified output given by the integrated circuit."

He bent his head down and listened critically to the sound from the test speaker.

"The output from that integrated circuit," he remarked, after some moments, "seems to be nice and undistorted. But it's not very loud, is it?"

"That," replied Smithy, "is merely because I've kept the wick down while we were talking. Just listen to this!"

Smithy put out his hand and adjusted the potentiometer on his chassis. At once the sound from the bench speaker rose to the same high level as is given by a conventional transistor portable operating at full output. Simultaneously, the needle of the meter in series with the PP9 battery swung over to the right. The music from the speaker changed to a continually sustained note, and Dick gazed incredulously at the reading indicated by the meter.

"That just can't be true," he called out, over the sound from the speaker. "That meter's reading all of 140mA!"

"That's right," grinned Smithy cheerfully as he returned the volume to its former low level. "And what is more, that tiny little integrated circuit was bashing out no less than half a watt! Which, considering its size, is a pretty staggering performance by any standards. You can now see why I've been devoting my spare time over the last few days to this integrated circuit. In the light of the transistor circuitry we've got used to over the last few years, its performance is so fantastic that I just couldn't resist coming in early over the last two mornings to play around with it."

Complete A.F. System

"I can certainly understand that, now," said Dick warmly. "What really shatters me is that not only does that integrated circuit give you a really high output but it also provides all the previous a.f. amplification which is needed as well. In other words, you can build a transistor superhet using standard circuits up to the diode, after which this single integrated circuit provides the complete a.f. circuitry up to the speaker. It replaces pretty nearly all the separate a.f. transistors and components which have been used in transistor radios up to now."

"Exactly."

"Blimey," breathed Dick, as he pondered on this wonder. "This means that, if you wanted to make up a really miniature home-constructed transistor superhet you can save about a third of the components at one fell swoop!"

"Precisely," agreed Smithy. "So far as amateur set-makers are concerned, this integrated circuit is the most attractive thing I've heard of yet. It offers you the entire a.f. system for a radio in one single can."

A thought suddenly occurred to Dick.

"Why," he asked, "have you suddenly decided to start doing experiments with integrated circuits?"

"As opposed," queried Smithy in return, "to my normal servicing work?"

"Well, yes. After all is said and done, we're supposed to be servicing current sets in the Workshop, not designing new ones!"

"True enough," admitted Smithy. "But this integrated circuit business represents rather a special case. To start off with, I'm extremely interested in integrated circuits because I'm convinced that, over the next ten years or so, they're going to alter the world of electronics very considerably indeed. At the same

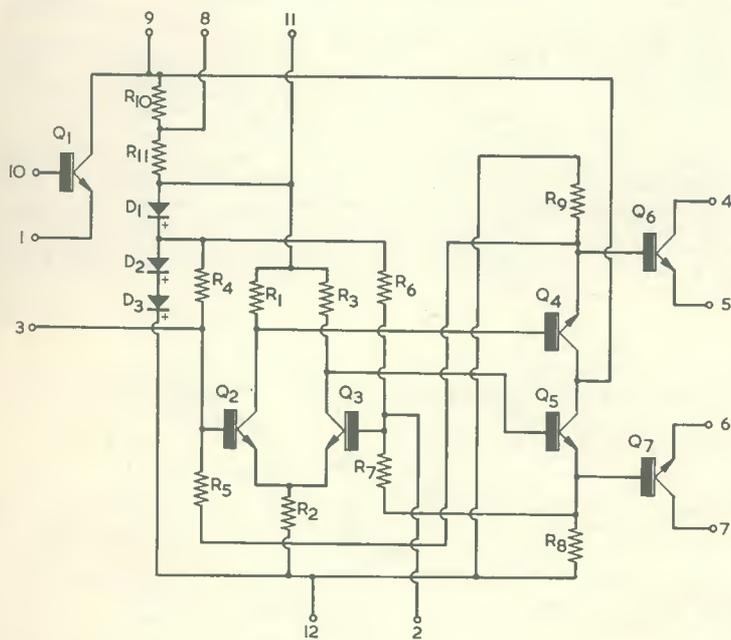


Fig. 2. The internal circuitry of the R.C.A. integrated circuit type CA3020

time, it will be quite a little while before I see any integrated circuits in the commercially made receivers which I service. So, if I'm going to get any experience with these new devices, I've got to do the next best thing and go out and buy one or two of them for myself. Funnily enough, at the present moment we have the rather unique situation where quite sophisticated integrated circuits are readily available from do-it-yourself retail suppliers, and yet they aren't finding their way into current British entertainment equipment. In consequence, the home-constructor is in the happy position of being able to take advantage of the devices well before the commercial set-maker does."

"You know, Smithy," commented Dick thoughtfully, "you've got rather a good point there."

"It's one which is worth making at any rate," said Smithy. "Anyway, that's enough nattering about the general subject of integrated circuits. Let's get down to some facts and figures concerning the particular integrated circuit whose performance I've just been demonstrating to you."

Smithy reached across his bench and picked up a sheet of paper on which he had scribbled some notes.

"Now," he added, "the integrated circuit I'm using here is the R.C.A. type CA3020. This is described as an audio power amplifier, and it's available from Amatronic Ltd., 396 Selsdon Road, Croydon, Surrey. The heat sink I'm employing with it is a type H2 from Henry's Radio. And the output transformer is an Ardenite D.3035. This is available from Home Radio under Cat. No. TRC25E, and it has the nice small dimensions of $1 \times \frac{3}{4} \times \frac{1}{8}$ inches. The few remaining components external to the integrated circuit are just normal standard parts."

"What sort of circuitry is there inside the integrated circuit?"

Smithy turned to the manufacturer's publication from which he had previously quoted the dimensions of the integrated circuit.

"Here we are," he remarked. "This gives the full R.C.A. gen on this particular device, including the internal circuitry. (Fig. 2). Incidentally, don't bother about the fact that the transistors are called Q₁ to Q₇ in the circuit diagram instead of TR₁ to TR₇. That's just because it's common American practice to identify transistors with the letter 'Q'. Now, let's first go through the external connections which are made to the integrated circuit. In normal use, terminal 12 goes to chassis, which is the negative supply. Terminal 9 goes to the positive supply. So,

also, does terminal 8 for most a.f. applications. For a reason which I'll explain in a moment, terminal 2 goes to chassis via a 1 μ F capacitor. And that's enough about the external connections to enable me to explain how the circuitry works."

"Transistor Q₁," interrupted Dick, "doesn't seem to be connected to any other part of the internal circuit. All that happens is that its collector goes to terminal 9."

"That's right," agreed Smithy. "This transistor represents an optional emitter-follower which you can use, or ignore, as required. The input to the amplifier section proper is at terminal 3 and the input resistance here is, typically, 700 Ω . If you want a higher input resistance you can apply the input to terminal 10, which connects to the base of Q₁, whereupon you get an input resistance of the order of 50k Ω . The emitter of Q₁ is then coupled by means of external components to terminal 3. Thus, Q₁ provides no gain, but it offers an a.f. input terminal having a high input resistance."

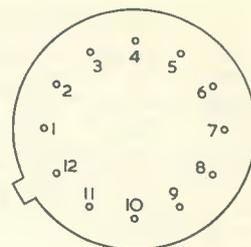
Smithy shifted himself to a more comfortable position on his stool.

"That," he resumed, "disposes of why Q₁ is in the circuit, so let's next proceed to the amplifier proper. Terminal 9, the positive supply point, connects via R₁₀ and R₁₁ to the three diodes D₁, D₂ and D₃. These diodes are silicon p.n. junctions and about 0.7 volts stabilised appears across each. In consequence, about 2.1 volts relative to terminal 12 is applied to the upper ends of R₁ and R₃, and about 1.4 volts relative to terminal 12 to the upper ends of R₄ and R₆. Transistors Q₂ and Q₃ are the next parts of the circuit to consider and, if you look carefully at the diagram, you'll see that these form a Schmitt phase inverter. As I told you just now, terminal 2 goes to chassis via a 1 μ F capacitor, so the base of Q₃ is held firmly at chassis potential so far as a.f. is concerned. Both Q₂ and Q₃ share the common emitter resistor, R₂, which is needed to enable them to function as a Schmitt phase inverter."

Dick gazed at the circuit and grimaced.

"I'm not entirely clear," he confessed, "just exactly how this bit works."

"It's quite simple," replied Smithy. "Let's assume that the input signal causes the base of Q₂ to go positive. This transistor will in consequence pass more current and its collector will go negative. The negative-going signal at the collector of Q₂ is one of the outputs of the phase inverter. Since the base of Q₂



CA 3020
lead-outs

Fig. 3. The lead-outs of the CA3020

goes positive its emitter will go positive as well. This causes the emitter of Q₃ to go positive also."

"That," said Dick, frowning portentously, "would be the same as the base of Q₃ going negative, wouldn't it?"

"Exactly," confirmed Smithy. "So, the positive-going signal applied to Q₃ emitter causes Q₃ to pass less current, whereupon its collector goes positive. The signal at Q₃ collector is the second output of the phase inverter and it is 180° out of phase with that at Q₂ collector. The output voltages will, of course, be of opposite polarity if the input signal caused Q₂ base to go negative. Provided that R₂ has a sufficiently high value, the two anti-phase outputs will have pretty well the same amplitude."

"Those outputs," remarked Dick, "go to the bases of Q₄ and Q₅. Are Q₄ and Q₅ the two drivers you mentioned earlier?"

"They are," confirmed Smithy. "Q₄ and Q₅ are emitter-followers, and they function as drivers for the two output transistors, Q₆ and Q₇. Please observe, at this stage, that there's a very crafty bit of d.c. feed-back incorporated between the emitters of Q₄ and Q₅ and the bases of Q₂ and Q₃. This is given by way of resistors R₅ and R₇. These resistors correct for any unbalance in Q₂ and Q₃. If, for any reason, Q₂ tried to pass too high a current, its collector would go negative. So also would the base and emitter of Q₄, whereupon a negative-going voltage would be fed back to the base of Q₂ via R₅, and this would counteract the original tendency in Q₂ to pass increased current. The same sort of thing takes place in the Q₃, Q₅ network."

"Blimey," commented Dick. "D'you know, Smithy, it takes all the imagination I can drum up just to conceive that all these components

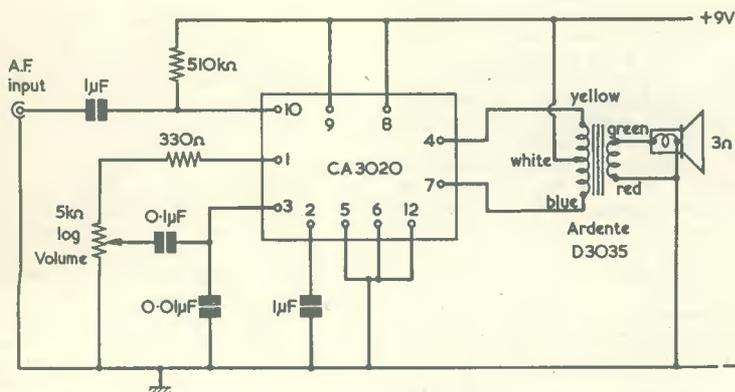


Fig. 4. A practical a.f. amplifier incorporating the integrated circuit. Terminal 11 is connected

exist inside that tiny little integrated circuit can!"

"It is pretty miraculous," agreed Smithy. "Anyway, let's press on next to the output transistors. These are Q₆ and Q₇, and the anti-phase output signals from Q₄ and Q₅ are passed to their bases, with the result that they work as a Class B output pair. Terminals 4 and 7 go to the load and terminals 5 and 6 to the negative supply, so they both operate in the common emitter configuration."

Base Layout

Smithy pointed to another diagram on the sheet in front of him. (Fig. 3).

"This," he remarked, "is the lead-out diagram for the CA3020. There are twelve lead-outs, and these proceed in a clockwise direction from 1 to 12, with lead number 12 being in line with the projection. This diagram is drawn with the leads pointing towards you."

Dick's eyes wandered from the layout diagram to Smithy's experimental rig.

"How did you connect up the integrated circuit in that set-up of yours?"

Smithy pulled a note-pad towards him, on the top sheet of which he had sketched out a circuit. (Fig. 4).

"This is the circuit I used," he stated, "and it's almost identical to the one recommended by R.C.A. for a 310mW output. The a.f. input passes to terminal 10 via a 1µF capacitor. Terminal 10 connects to the base of the optional emitter-follower, Q₁, and this base is biased by way of the external 510kΩ resistor connecting between terminal 10 and the positive supply. The emitter of Q₁ appears at terminal 1 and goes to the negative supply,

which is common to chassis, via a 330Ω resistor and a 5kΩ log pot. The 5kΩ pot is the volume control, its slider coupling to terminal 3, which is the input to the amplifier proper, via a 0.1µF capacitor. The 0.01µF capacitor from terminal 3 to chassis provides some top-cut and, presumably, also cuts down amplification at frequencies above the a.f. range. The CA3020 integrated circuit has a relatively flat response up to some 6 Mc/s or so, and there could be trouble due to amplification at these high frequencies if they weren't attenuated at the input. The 0.01µF capacitor will also prevent the d.c. feedback via R₅ from being a.c. feedback as well, thus balancing up with the situation at the base of Q₃. Terminal 2, the base of Q₃, goes down to deck via a 1µF capacitor, as I mentioned earlier, thereby enabling the Schmitt phase-splitter section to work properly. The emitters of Q₆ and Q₇, at terminals 5 and 6, also go directly down to deck."

"Well, all that seems clear enough," remarked Dick. "I see also

that the collectors of Q₆ and Q₇ go to the output transformer primary via terminals 4 and 7."

"That's right," confirmed Smithy. "The centre-tap of the output tranny primary then connects to the 9 volts positive line to complete the collector circuit. Now, the optimum collector-to-collector output load for the CA3020 is 130Ω, and the appropriate R.C.A. circuit specifies a centre-tapped 130Ω speaker voice coil, or equivalent, as the load. Since I couldn't get hold of a speaker of this type, I decided to use an output transformer to step the 130Ω impedance down to 3Ω instead. The nearest I could find to the ratio I required is the Ardenite type D.3035 which I've used here. This has a primary-to-secondary ratio of 7.3 to 1, with a centre-tap in the primary. The square of 7.3 is 53, which means that the actual collector-to-collector impedance I'm getting is 3 times 53, or 159Ω. I'd have preferred to have used a transformer which offered a load somewhat closer to 130Ω, but the Ardenite transformer works very well in practice. Also, it's a physically small component, which is just what is required for any application using the CA3020. According to R.C.A. curves, the loss in power with the higher load impedance is, in any case, very small. And that, Dick, is the circuit which I've just demonstrated to you."

"Did you have any trouble in getting it to work?"

"None at all," replied Smithy. "Apart from one very minor snag it went like a bomb as soon as I connected up the battery!"

"What was the snag?"

"Initially," replied Smithy. "I wired terminal 1 direct to the top end of the 5kΩ volume control track, instead of via the 330Ω resistor I've included in my sketch. This is the method of connection given in the amplifier circuit recommended by R.C.A., but I found that

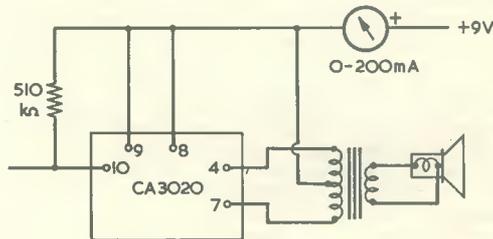


Fig. 5. When connecting the CA3020 into a new circuit, it is advisable to initially check current consumption from the 9-volt supply

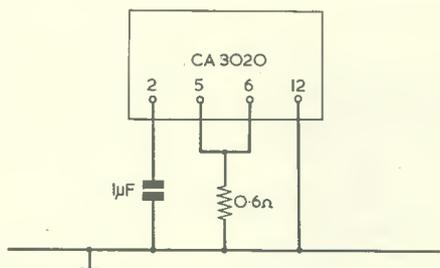


Fig. 6. A modification to the circuit of Fig. 4 for 545mW output. This causes a measure of negative feedback and thermal stabilising to be applied to the output transistors

to the same value when I turned the gain down after a run at high power which, again, would appear to indicate that no excessive changes in internal operation due to high temperature were taking place. Incidentally, the voltage regulation provided by D₁, D₂ and D₃ counteracts changes due to temperature variations."

"What is the quiescent current?"

"Approximately 24mA," replied Smithy. "This, so far as I can see, represents the only snag presented by the integrated circuit. Its quiescent current is higher than the figure given by a conventional Class B output stage using separate transistors. But the disadvantage becomes less important, of course, if the integrated circuit offers an output which causes an average of about 50mA or so to be drawn from the battery. Proportionately, this will be only marginally higher than the current drawn by a standard Class B output stage for the same output power."

"There's something I've just remembered," said Dick. "You said at the beginning that you were getting half a watt out of that CA3020, but you've since been referring to the circuit as being intended for 310mW."

"I was getting about half a watt out of the circuit in actual practice," replied Smithy, "although I must hasten to add that I was using a rather rough and ready method of measuring the output power. I merely connected a testmeter switched to a.c. volts across the transformer primary, and found I was getting readings of 9 volts r.m.s. on music

I ran into instability when the slider of the volume control was right at the top end of its track. I'm pretty certain that this instability was due to the fact that the leads in my experimental assembly were rather long, and I should imagine that it wouldn't occur when the integrated circuit is connected into circuit with short wiring."

"Is this instability," asked Dick, "something to guard against?"

"It is, rather," said Smithy, "because it's possible for Q₆ and Q₇ to draw a heavy current when the circuit goes unstable, and this might cause damage. Anyone using the CA3020 for the first time in a new circuit should insert a meter capable of reading 200mA in series with the positive supply. (Fig. 5). If the instability occurs when the slider of the volume control is at the top end of the track, the current consumption may shoot up, and this will be indicated by the meter. The instability may not be evident on audio listening tests and I would suggest that the initial test with the meter is quite essential."

"You seem to have cleared the trouble quite easily yourself."

"That 330Ω resistor," replied Smithy, "removed the instability completely, and with negligible loss of overall gain. It's almost certain, of course, that the instability is occurring at r.f. If any constructor runs into this instability trouble, he should find the lowest value of resistor, in series between terminal 1 and the 5kΩ pot, which clears the oscillation. And, as I said just now, the instability probably won't be present if short wiring to the external components is employed. An incidental point, by the way, is that the input feed to terminal 10 is a wee bit 'hot', and that it needs to be kept away from the output wiring."

"Would it help," asked Dick, "if the metal can of the integrated circuit was earthed?"

"It's earthed already," replied Smithy. "With the integrated circuit I had, the can was internally connected to terminal 12."

Heat Sink

"I still," said Dick, returning to his previous theme, "find it almost incredible that that little integrated circuit can push out so much power. You'd think it would tend to over-heat."

"Well," replied Smithy, "the manufacturers recommend a heat sink if the device is to be employed at a high power level, and the little H2 sink I've used myself seems to cope very nicely. I don't know what thermal coupling there is between the output transistors and the case but, at any event, I couldn't detect any increase in temperature even after I'd had the integrated circuit offering full output on speech and music for over an hour. Also, the quiescent current always returned

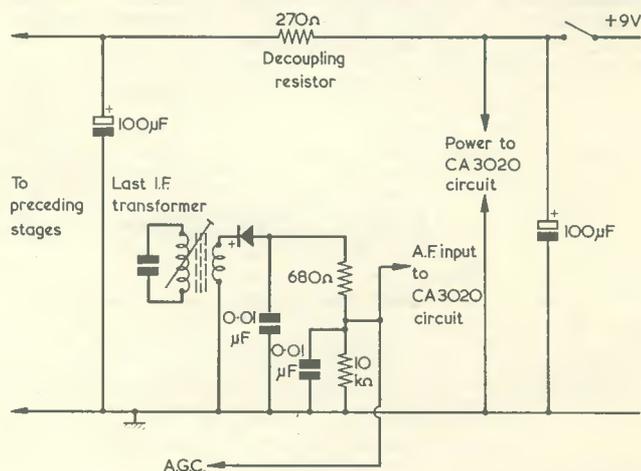


Fig. 7. A suggested method of incorporating the CA3020 integrated circuit in a home-constructed superhet. The component values shown are intended to be representative only

peaks. From $\frac{V_2}{R}$ this corresponds to an output around half a watt. Incidentally, there is an alternative circuit arrangement which is specified by R.C.A. for a 545mW output. It's exactly the same as the circuit I've just shown you, with the exception that a 0.6Ω resistor is inserted between terminals 5 and 6 and chassis (Fig. 6). This introduces a small amount of negative feedback in the output transistor stage and gives added thermal stability. If you intended to operate the integrated circuit at high power over long periods of time, it would be a sensible precaution to insert this resistor. When I tried it myself I found it caused a slight drop in gain together with a small reduction in distortion. But even without this resistor, distortion is quite low and R.C.A. quote 1% distortion at an output power of 135mW."

"I see that two of the capacitors in your circuit," said Dick, "have values of $1\mu\text{F}$. Could these be electrolytic types?"

"Preferably not," replied Smithy. "I used paper capacitors in my rig and did a little experimenting to see what would happen if there was leakage resistance across them. Terminal 2 is at a fairly high impedance and circuit conditions alter quite noticeably if there is any leakage resistance between this terminal and chassis. I found, for instance, that quiescent current increased by 2mA if I temporarily added a resistor as high as $1\text{m}\Omega$ between terminal 2 and chassis. Since this part of the circuit is sensitive to leakage resistance it would definitely be best to avoid using an electrolytic component here. Rather the same applies to the $1\mu\text{F}$ input capacitor connecting to terminal 10. The bias resistor to this

terminal is pretty high, at $510\text{k}\Omega$ and leakage in an electrolytic capacitor could easily upset the biasing conditions for Q_1 ."

"Still," objected Dick, "a value of $1\mu\text{F}$ means that a non-electrolytic capacitor will be a fairly large component, won't it?"

"It shouldn't be too enormous, with modern capacitors," replied Smithy. "Incidentally, my circuit worked just as well with $0.5\mu\text{F}$ between terminal 2 and chassis, so it would be O.K. to use the lower value for this position if you wanted to. And you don't have to use $1\mu\text{F}$ in the input circuit to pin 10. A value of $0.5\mu\text{F}$ here, or even lower, would merely cause a small drop in gain at the lower frequencies."

"Well, that," said Dick, "seems to clear up all the questions that I can think of!"

"There are several points I haven't referred to yet," said Smithy. "If, for instance, you're going to use the integrated circuit in a home-constructed superhet it would be best to look upon the negative supply line as being the chassis line, and to return the diode load to this line. The transistor or transistors which are controlled by the a.g.c. voltage from the diode load would then have to be n.p.n. types. The decoupling resistor to the preceding stages should, preferably, be in the positive line. (Fig. 7). Oh, and I've forgotten to mention that the input signal voltage for both the 310 and 545mW versions of the circuit is approximately 45mV for full output, which should be readily available at the diode of any normal a.m. superhet. Also, the supply potential shouldn't be higher than 9 volts."

Earning A Living

Smithy looked down at his watch. "Well, I'm dashed," he exclaimed.

"I've spent nearly half an hour rabbiting on about that integrated circuit, when we should have been hard at work earning a living!"

"Not to worry, Smithy," replied Dick comfortingly, "It's been time well spent. Let's just spend a few more minutes listening to that integrated circuit working at full blast again!"

"Okey-doke," said Smithy obligingly, reaching his hand out to the $5\text{k}\Omega$ volume control. "Listening to it fascinates me just as much as it seems to fascinate you!"

Once more the bench speaker at Smithy's side reproduced the full volume of which the integrated circuit was capable and the pair listened entranced whilst they gazed at the diminutive device which not only provided this output but all the preceding a.f. amplification and phase inversion as well.

"In my younger days," said Smithy as, eventually, he reluctantly disconnected the leads to the PP9 battery and cleared his bench ready for work, "we'd have considered ourselves lucky if we'd got as much output as that from a dirty great clumsy PM2."

"What," asked Dick innocently, "is a PM2?"

"The PM2," replied Smithy, "was an old triode output valve with a 2-volt filament."

He paused for a moment.

"I suppose," he added reflectively, "we thought the PM2 was pretty marvellous at the time, too."

Editor's Note

Technical information, in this article, on amplifiers incorporating the CA3020 is taken from "R.C.A. Integrated Circuits Application Note—Application of the R.C.A. CA3020 Multi-Purpose Integrated-Circuit Audio Power Amplifier."



UNIVERSITY TV ORDER

EMI Electronics have received an order from Glasgow University for the largest and first fully professional University television installation in the U.K.

The University has made available and is converting Southpark House into a programme origination studio which will employ four EMI Type 201 cameras, capable of producing broadcast-quality signals on either 405 or 625 line standards. Two cameras will be equipped with zoom lens systems, one with a turret lens. The fourth camera will be used in a telecine channel based on the professional EMI Type 404 telecine.

Additional studio equipment to be supplied includes a production control desk with special effects generator, a solid-state vision mixing and switching system and an 8-channel sound mixer, video tape recorder and full sound reproduction facilities.

Television programmes originating from the studio, under the supervision of the Director of Television, Mr. R. C. MacLean, will be relayed to various parts of the University via a separate continuity switching system also provided by EMI. A scheme for relaying programmes to local schools has also been proposed.

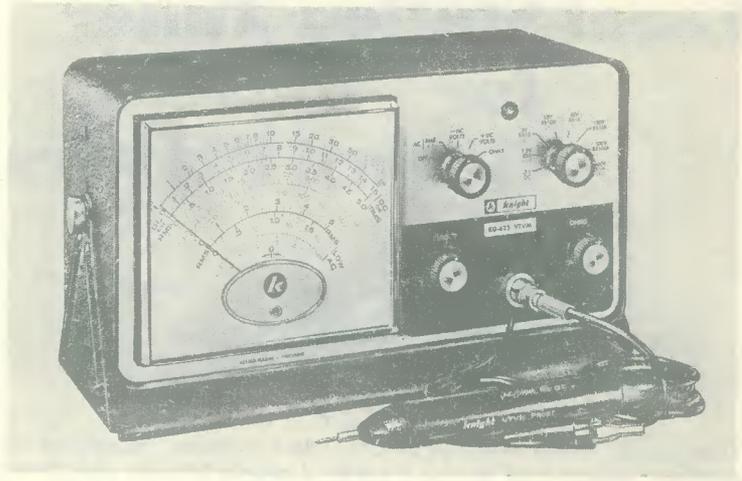
TRADE REVIEW . . .

Knightkit

KG-625

Valve

Voltmeter



The Knightkit KG-625 VTVM complete with probe and stand. This instrument has an input impedance, on d.c., of $11M\Omega$, a fluorescent knife-edge pointer and a 2-colour scale. The 100° meter arc allows easy viewing from any angle. Provided are a highly sensitive 0.5V full-scale range for transistor work and separately calibrated scales for 1.5 and 5V r.m.s., 4.2 and 14V p-p a.c. ranges. A wide range of a.c. (r.m.s. and p-p), d.c. (both negative and positive) and ohms ranges are also available. A centre zero reading facility is included. The kit of parts is moderately priced at £28 19s. 6d.

A wide range of Knightkits has recently been placed on the market, both in this country and Europe, by Electroniques (Prop. S.T.C. Ltd.). These kits are designed at the laboratories of Knight Electronics Corporation, Maywood, Illinois, U.S.A. and, at the time of writing, are being imported and anglicised by Electroniques—eventually however they will be entirely produced in this country. A well-produced and illustrated booklet of these kits may be obtained, post free, from Electroniques (Prop. S.T.C. Ltd.), Edinburgh Way, Harlow, Essex.

We were recently supplied with one of these kits—the KG-625 VTVM (Vacuum Tube Volt Meter) by Electroniques so that we could build the instrument using the Constructional Handbook in exactly the same manner as any reader purchasing this item of test equipment. In order that the sequence of events should be precisely that followed in a normal sales transaction, the kit was posted to us and not collected or specially delivered. The carton arrived in due course and was found to be completely undamaged, the packaging design being obviously well thought out with a liberal use of strong corrugated cardboard, pre-shaped and cut to size, together with soft packaging material distributed throughout the carton.

Constructing the Kit

Two publications are provided with the kit, the first being the Constructional Handbook and the second the Operator's Manual.

The Constructional Handbook is a masterpiece of lucidity, commencing with a page of construction hints and followed by a page of advice on soldering, each page including clear and precise drawings which, together with the accompanying text, make both subjects crystal clear. The following $19\frac{1}{2}$ pages deal with the construction of the kit in a logical and ordered sequence with no fewer than 21 point-to-point diagrams, all but 3 of these being full-size.

The constructional Handbook has been planned so

that when opened out, the large point-to-point diagrams are on the right-hand page with most of the relevant text on the left-hand page. Each task has alongside a small square which must be ticked off as the assembly and wiring instructions are completed. This 2 page method of presentation considerably eases the building of the voltmeter, each double-page being a section, complete in itself, of the constructional process. Works checks are advised at the end of each stage and a trouble-shooting table is included at the end of the Handbook.

Wiring-up the kit is simplicity itself, all p.v.c. covered wires being pre-cut to length and the wire ends pre-tinned for ease of assembly and soldering. All components used are of the very highest quality and ample hardware and solder are provided. The textual instructions are simple, direct and clear, and no ambiguous terms are used.

The Operator's Manual contains a description of the control functions, how to use the voltmeter, operating instructions, special applications, maintenance and calibration instructions, and a trouble-shooting guide complete with circuit diagram and description. The Manual consists of 16 pages (plus cover) and 15 diagrams.

Accompanying these two publications are (a) a sheet of photographic illustrations showing most of the components full-sized and complete with a printed 6in ruler, (b) a suggestion sheet which may be returned to the company and (c) an amendment sheet of anglicised terms.

A description of the valve voltmeter is not included here—this may be obtained, by those interested, from the free literature available from Electroniques. We did, however, accept the invitation from Electroniques to visit their service department at Harlow so that we could ascertain the service facilities available to all purchasers of Knightkits. We found that the after-sales service was first class, a completely equipped and highly developed test laboratory, staffed by qualified engineers, being available for the testing, repairing and general servicing of these quality kits. *

Local Station Tuner for Record Players

by

Sir Douglas Hall
K.C.M.G., M.A. (Oxon)

This small tuner unit provides local station reception on medium waves and is powered by a single 1.5 volt cell, from which it draws a current of approximately 1mA only. Although specifically intended for use with the author's "Pentonlector" record player, it may be employed with any other record player amplifier intended for operation from a crystal pick-up. It is important to note that, when the record player amplifier has a chassis connected to one side of the mains, full isolation must be obtained as described in the article, this process being carried out by the more experienced constructor who fully understands the principles involved

THIS LITTLE UNIT IS THE RESULT of experiments by the author to modify the "Pentonlector" record player amplifier so as to receive local stations.* This amplifier gives unusually good quality for a simple apparatus and the main object in the design of the tuning head was to ensure that quality from local stations would be equally good as that from records. Although it will probably be found that several more distant stations can be received, these will be at low volume level unless a sensitive amplifier is used, and quality will not be as good as that from local stations. The tuner is, of course, perfectly suitable for any other record player using a crystal pick-up and therefore having a high impedance input.

Circuit Operation

A short aerial, consisting of a few yards of wire along a picture

rail, is used to pick up the signal, which appears across L_1 and thence across the tuned circuit L_2/VC_1 . See the circuit diagram in Fig. 1. TR_1 is a silicon planar n.p.n. transistor and it amplifies the signal in the common emitter mode. The amplified r.f. signal appears across choke L_3 and is demodulated by D_1 and fed back directly to the base of TR_1 . The transistor then amplifies the detected audio frequency signal as a common collector amplifier. Base bias is provided by D_1 which, with 0.5 volts across it, exhibits a d.c. resistance of about 50k Ω .

The amplified audio signal appears across the primary of T_1 (an intervalve transformer giving a 1:5 step-up of voltage) its secondary feeding into the amplifier. The battery supply gives 1.5 volts, which is correct for optimum base bias and should not be changed to a higher voltage. About 1mA emitter current will be passed.

It must be emphasised that D_1 , which is a selenium rectifier and is sometimes advertised as a "meter rectifier", has very different characteristics from those of a germanium

or silicon diode, neither of which will work in this particular circuit. The rectifier specified has a high output impedance and, as has been pointed out, a high forward resistance to d.c. even when 0.5 volts d.c. appear across it. In fact, it needs something near to 0.5 volts before it will conduct at all. A germanium diode can be expected to pass several milliamps under these conditions as against about 12 μ A in the case of the M3. This characteristic of the M3 enables the very simple coupling-cum-base bias arrangements shown in Fig. 1 to be used; and this simplicity makes for efficiency since stray capacitances are kept low. The high impedance to a.c. of the M3 makes it suitable for feeding into a common collector amplifier.

The common collector configuration allows a high standard of fidelity to be maintained, first because of the inherent negative feedback, and secondly because the low output impedance is virtually immune to high note loss as a result of the necessary high frequency bypass capacitor, C_1 . Also, the low output impedance allows T_1 to provide a step up in a distortion-free manner. The primary of T_1 is heavily damped by the output impedance of TR_1 , which is of the order of 1.5k Ω so that the normal tendency of a transformer of this type to over-emphasise the higher middle frequencies is absent. Finally, the use of an aerial instead of a ferrite rod prevents high note loss resulting from the use of critically applied reaction.

The unit may be used as shown in Fig. 1 with any record player which uses a crystal pick-up and does not have a chassis which is live at mains potential. With the Pentonlector it was not found necessary to screen the output leads from the tuner, even when it was built separately and used a couple of feet from the amplifier, but screening may well prove necessary with more sensitive amplifiers. In that case, single screened wire can be used, the internal wire being used as lead A and the screening as lead B.

If it is intended to use the unit with an amplifier which has a chassis which is connected to one side of the mains, it is essential to ensure that all precautions against accidental shock are observed. Two 0.01 μ F capacitors with an a.c. working voltage of 250 or more must be connected in series with the connections to the amplifier input, as shown in Fig. 2. If the tuner unit

*"The Pentonlector Record Player Amplifier Circuit" was published in the July 1966 issue. The circuit also appears here in Fig. 3.—Editor.

COMPONENTS

Resistors

- R_1 1.5k Ω ½ watt 5% (Fig. 3 only)
 R_2 150 Ω ½ watt 5% (Fig. 3 only)
 VR_1 5k Ω potentiometer, linear, with switch S_1 (no switch for Fig. 3)

Capacitors

- C_1 0.01 μ F
 C_2 500 μ F electrolytic, 6V wkg. (Fig. 3 only)
 VC_1 500pF variable, Dilecon (Jackson Bros.)
 VC_2 750pF trimmer

Inductors

- $L_{1,2}$ See text
 L_3 R.F. choke, 2.5mH (Repanco)
 T_1 1:5 intervalve, "Midget" L.F. Transformer (Radio-spares)

Transistor

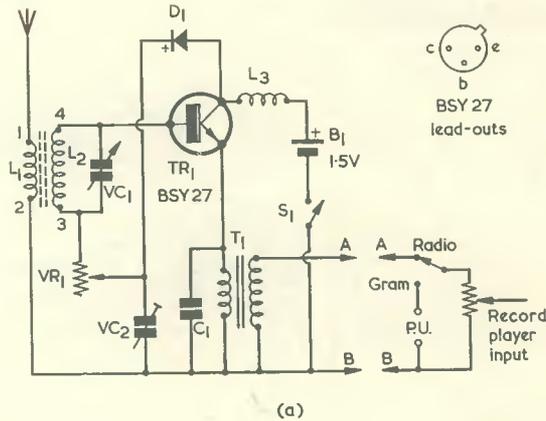
TR_1 BSY27

Diode

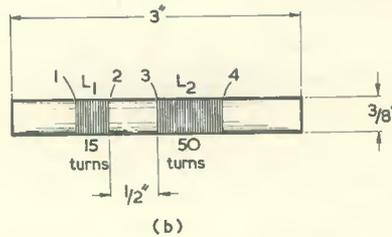
D_1 S.T.C. type M3 (Home Radio (Cat. No. MR50) or Henry's Radio.)

Battery

B_1 1.5 volt cell (Fig. 1 only). U12 (Ever Ready) or similar
 N.B. Radiospares components may only be obtained through retailers.



(a)



(b)

Fig. 1 (a). The circuit of the medium wave tuner. If the record player amplifier has a chassis isolated from the mains supply, the tuner is coupled to its input at points A and B, as shown

(b). Details of the coil L_1/L_2

is constructed as a separate unit, these two capacitors must be fitted

inside the record player cabinet. An insulated screened pair should be employed for connecting the tuner unit to the amplifier, as

illustrated in Fig. 2. Note that the secondary of T_1 is connected directly to this pair, and does not connect to the tuner unit negative supply line, as occurred in Fig. 1. There are, otherwise, no changes to the tuner unit circuit. As will be seen, a 3-way plug and socket are required at the record player, the socket being mounted on the cabinet of the latter. Since an earth connection has now to be available in the record player, the isolating circuit of Fig. 2 will necessitate the record player being fitted with a 3-core mains lead if a 2-core lead is currently fitted, the extra wire being needed for the earth connection. The 3-core mains lead should be correctly terminated in a 3-way plug fitting into a mains socket having a reliable earth connection. If hum results with this circuit, reverse the mains leads to the record player amplifier at the 3-way plug. The method of isolation just described must be used also if the tuner unit is fitted in the same cabinet as the record player amplifier. When separate, the tuner unit

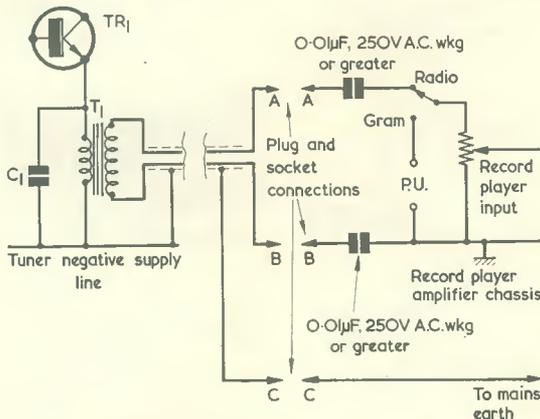


Fig. 2. When the record player amplifier has its chassis connected to one side of the mains, the isolating and earthing arrangements illustrated here must be employed

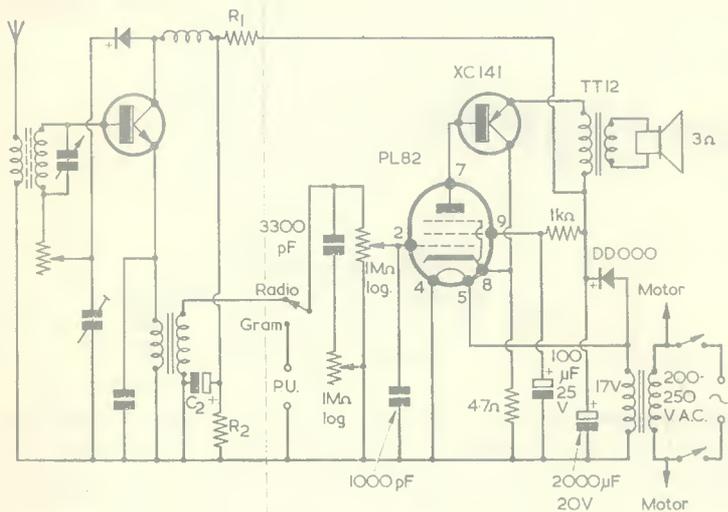


Fig. 3. The tuner can be combined with the "Pentonlector" record player amplifier to form a complete unit. The amplifier circuit is to the right of the dashed line

output can be coupled to the record player amplifier input by way of a 3-pin 2-amp mains plug and socket, the socket being mounted on the amplifier cabinet. The earth pin then carries the earth connection and the remaining pins the tuner unit a.f. output. It is important to ensure that the negative supply line of the tuner unit is always at earth potential whenever the unit is used.

Referring again to Fig. 1, it will be seen that reaction is obtained by the capacitance tap method. Part of the r.f. signal bypasses D_1 and is fed to the bottom end of the tuned circuit which, because of VC_2 and VR_1 , is not at earth potential, but at r.f. potential 180° out of phase with the signal at the top of the tuned circuit. Reaction increases as the slider moves upwards, as seen in Fig. 1. VC_2 and VR_1 also ensure that only a part of the tuned circuit is between base and emitter so that the effect of a tap in the tuned circuit is obtained and conditions are right for common emitter amplification.

Whatever record player is employed it must be fitted with a single pole changeover switch to switch from pick-up to radio and vice versa, as shown in Figs. 1 and 2. If a record player with a live chassis is used, it is essential that the operating knob, bush and spindle be reliably insulated from its con-

tacts and from any circuitry or metalwork in the cabinet of the player.

Record Player Amplifier

As was stated at the beginning of this article, the tuner was designed in the first instance for use with the "Pentonlector" amplifier, and it may well be incorporated with that amplifier rather than be built as a separate unit. Fig. 3 shows the complete circuit. It will be seen that the necessary 1.5 volts is taken from the d.c. supply for the amplifier by way of a potentiometer consisting of R_1 and R_2 with C_2 for smoothing.

No battery is required and VR_1 need not, therefore, be provided with a switch. In case any interested reader did not see the subsequent correction in the October 1966 issue, it should be pointed out that the screen grid of the PL82 is pin 9 and not pin 8 as originally shown.

In the original article describing the "Pentonlector" the author said that, with the prototype, no ventilation for the cabinet had proved necessary. Later experiments have shown that with a high amplification specimen of output transistor, and continuous use in a warm room, there can be deterioration in both volume and quality as a result of rising leakage current increasing the voltage across the resistor which is common to transistor collector and valve cathode. In such circumstances excessive grid bias can prevent the valve from handling a large input signal satisfactorily. It is wise, therefore, to arrange that the output transistor, on its heat sink, is in a position where free air can circulate round it.

Construction

Construction of the tuner is very simple and no precautions are necessary in the layout except to keep L_3 away from L_1/L_2 and with their axes at right angles. L_1 has 15 turns and L_2 50 turns of 32 s.w.g. enamelled wire, and both coils are close wound. See Fig 1 (b). About 3in of $\frac{3}{8}$ in ferrite rod is used as the former. L_1 and L_2 are wound in the same direction.

In order to set up the tuner it is only necessary to adjust VC_2 so that reaction is smooth and oscillation is available throughout the tuning range.

The "Pentonlector" amplifier has built-in tone correction, over and

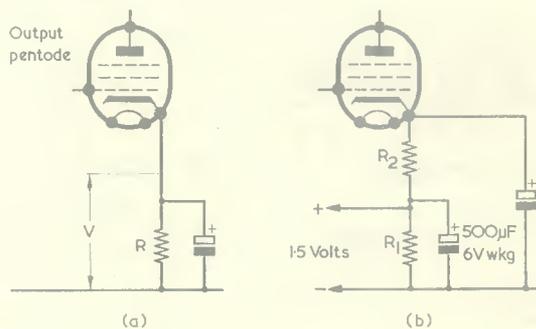


Fig. 4. When the record player amplifier has an isolated chassis, the tuner may obtain its power from the output pentode cathode bias circuit. The original amplifier circuit is shown in (a), and the modified circuit in (b)

above the variable tone control, to compensate for lack of bass from the pick-up. When used with the tuner, which has a much lower output impedance than a crystal pick-up, the fixed compensation is barely perceptible with the volume control turned fully on, but it will be found that there is a loss of treble as soon as the amplifier volume control is turned back, even quite a short way. At the same time it will be found that the variable tone control has a smaller range on radio than on records. In consequence, it is of advantage to use the "Pentonlector" with its volume control at maximum, and to employ the reaction control of the tuner as a volume control. A small movement of the amplifier volume control can then offer a measure of tone control. This has the further advantage of minimising any loss of treble due to a critical reaction setting, and in these conditions treble response will be found to be really good. If volume is too high with reaction at zero, a shorter aerial may be used. But in most areas 4 or 5 yards of wire will be needed.

The foregoing applies particularly to the "Pentonlector". Many record players offer far more amplification and have different tone control arrangements, and when these are used it will probably be necessary to control volume by means of the amplifier's control. A powerful

amplifier does not always produce its best at the full volume control setting.

Alternative Supplies

Experienced constructors will have seen that it would be possible to dispense with a battery for the tuner when it is used with any amplifier having a chassis isolated from the mains, together with a straight-forward Class A output pentode valve. The d.c. flowing through the cathode resistor of this valve can then provide a source of supply for the tuner. It is only necessary to replace the cathode resistor with two in series, and to add a capacitor of 500 μ F, 6 volt working, between the junction of these resistors and chassis. See Fig. 4. It is necessary to measure the resistance of R and the voltage V across it when the amplifier is switched on, using a voltmeter with a resistance of at least 10k Ω . Then, referring to

Fig. 4, $R_1 = \frac{1.5R}{V}$ and $R_2 = R - R_1$.

To take an example, let us suppose that R is 130 Ω and that V is 7 volts.

Then, $R_1 = \frac{1.5 \times 130}{7} = 28\Omega$, and R_2

$130 - 28 = 102\Omega$. 27 Ω for R_1 and 100 Ω for R_2 would be satisfactory. The small current passing through the reflexed transistor can be ignored in the calculations.



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Radio Topics

By Recorder

I UNDERSTAND THAT, ELSEWHERE IN this issue, Dick and Smithy of "In Your Workshop" fame carry out some fascinating experiments with the R.C.A. CA3020 integrated circuit, which is now available on the home-constructor market. The full story will be told by Smithy, and so there is little point in my adding any further

details here, apart from saying that I have heard the CA3020 in action myself and have been exceptionally impressed with the performance it offers. Together with a few external components it provides all the a.f. gain needed after the diode of a transistor superhet, and it puts out half a watt of audio power as well.

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home-constructor designs are becoming more and more commonplace as time goes by, and this represents an excellent state of affairs. When, as with the CA3020, the integrated circuit provides a practical and fully functional advantage instead of appearing merely as an interesting and instructional gimmick, then we are truly in a position to make full use of this new device.

I.C. Future

No manufacturer of integrated circuits is likely to produce a device intended specifically for the home-constructor market since the tooling costs involved would be much too great for what would inevitably represent a low sales potential. On the other hand, most manufacturers seem to be quite happy to allow sales to the home-constructor market of devices which are already in production for established commercial applications. The major call, at present, is for integrated circuits in computer manufacture; which is why most of the integrated circuits that have been presented for sale to the amateur have been computer types.

At the same time, integrated circuits intended for receivers, amplifiers and similar equipment have also been made and are being used (notably in the U.S.) in domestic equipment in quite encouraging quantities. Processes of this nature tend to mushroom: increasing sales of the devices enable more manufacturing experience to be obtained and longer production runs to be achieved, with a consequent lowering of costs. Lowering costs, in turn, make the devices more attractive and they are then ordered in greater quantities, allowing a further reduction in costs to be made.

In the amateur field we tend to be more interested in integrated circuits for receiver and amplifier applications, and it is very heartening to see that these are becoming available more readily than in the past. Prices are already, to my mind, quite reasonable and they should gradually fall as the years go by. This follows the pattern set by transistors, some of which are nowadays almost dirt-cheap.

The amateur already has two electronic arts to draw upon for his experimental and constructional work, these consisting of designs centred on the valve and designs centred on the transistor. Now coming is a third electronic art, and it consists of designs centred on the integrated circuit. This third art is, of course, allied to that of the

transistor but there are still sufficient points of difference to make the use of integrated circuits a pursuit in its own right.

And, so far as taking advantage of these new devices is concerned, we home-constructors have the considerable good fortune to be right in on the ground floor.

Hotter And Hotter

In the old days a 100-watt electric light bulb used to be a light bulb indeed, with the large and imposing glass globe which befitted its exalted wattage rating. Nowadays, however, a 100-watt bulb is a tichy little affair, having about the same dimensions as the 40-watt lamp of yore.

This reduction in size may represent an impressive saving in manufacturing and transit costs, but it also results in the bulb and its immediate surroundings becoming a great deal hotter than used to occur with the old larger bulbs. Recently, this fact was brought home forcibly to me when I tried to change the shade on the bulb in our lounge. (This used to be called the kitchen, but one has to keep up with the times.) The bulb-holder, fitted new only three years ago, was a standard pendant bayonet holder, but the threaded Bakelite ring securing the shade had, due to heat from the bulb, seized up completely solid to the body of the holder. It was quite impossible to unscrew it.

With problems of this nature it is always best to use a scientific approach, and it took me only a few seconds to break the ring away with the aid of a hammer. I then decided that I might as well replace the bulb-holder altogether, whereupon I discovered that the upper threaded section had seized up solid as well!

After a second application of the hammer and a slight shortening of the ceiling flex in order that the bits with overheated insulation near the bulb-holder terminals could be cut away, I eventually fitted a new holder. And the new shade which had originally raised all the difficulty.

If the family continues to require a change in lamp-shades from time to time, I suppose I must look forward to the purchase of a new bulb-holder per shade and the gradual ascent of the whole assembly towards the ceiling rose. The only alternative is to see if I can dig out some of those old-fashioned brass bulb-holders which had the contacts mounted in china inserts, together with little bits of wood to hold the flex. Provided, of course, that I can find some preparation

which will make those little bits of wood non-inflammable!

Fridge Repairs

Turning to the other extreme in temperature, I next pass on a true story from reader L. P. Hasler of Stroud.

"My reason for sending you this letter," writes Mr. Hasler, "is to tell you of a most unusual happening which might also be of interest to your readers. For radio in my home I use a transistor set having the normal superhet circuit, this being coupled to a push-pull 8-watt amplifier and speaker. The transistor set suddenly went silent, and a quick check of battery and circuit connections revealed no fault. After some years of service it had still been giving a good performance, so I took it to a local radio service depot. Three days later they phoned to say they could go no further as the makers were out of business and no spares were available. I next got the set back and tried one or two tests, but still without result. After very careful thought concerning the expansion and contraction of metals with changes of temperature I then picked up the set, popped it into the refrigerator, and left it there for about an hour. On taking it out and switching on it worked perfectly, and has continued to do so for two months.

"Have you heard of this before?"

No, Mr. Hasler, I haven't, and I am grateful to you for telling us about this experience.

"Radio Sentry"

My comments in the November issue concerning the use of a threemin device as a party gadget have raised a letter from another reader, Mr. R. D. A. Fraser of Eastbourne. You may recall that I suggested coupling 4 or 5ft of wire, positioned along one side of a doorway, to the "hot" end of the tuned circuit of a short-wave oscillator. This oscillator was then tuned in, to zero beat, on any short-wave receiver fitted with a b.f.o., whereupon anyone attempting to pass through the doorway would cause the short-wave receiver to give an audible tone varying in pitch as the person approached the wire. The reason for this effect is, of course, that the short-wave oscillator changes in frequency due to the altering capacitance to earth of the length of wire at the doorway.

Mr. Fraser points out that he has obtained equally good results without a short-wave receiver or oscillator. In his letter he states that "two medium-wave receivers

are required; the first, receiver 'A', being a transistor superhet, and the second, receiver 'B', being any medium-wave set. Also required is a signal generator.

"A length of wire about 3ft long is fixed to the door frame and connected to the fixed vanes on the oscillator section of the tuning capacitor in receiver 'A'. Receiver 'B' is placed close to receiver 'A', and so also is a 6-turn coil of 3in diameter connected to the signal generator by a coaxial cable. The generator is about 3ft away. Receiver 'B' is tuned to a quiet spot near the high frequency end of the medium-wave band; the generator is switched to 'mod' and then tuned so as to give maximum output from receiver 'B'. The modulation is next switched off, and receiver 'A' tuned in to approximately zero beat with the generator. This cannot be done exactly owing to hand-capacitance effects, and final fine tuning is carried out on the signal generator. The volume on receiver 'B' is next advanced and the device functions as you describe. It is advisable to keep the volume on receiver 'B' low until the zero beat position is found.

"I found the set-up worked best with about 40mV output from the generator; a loud tone was then produced even if a person was 2 to 3ft away from the wire. Receiver 'B' in my case had a ferrite frame; and receivers using capacitive aerials may require different coupling arrangements. The final volume control setting on receiver 'B' was at about mid-position."

So there you are. Two standard medium-wave receivers, a bit of wire and a signal generator, and you have a "radio sentry" which will make it impossible for anyone to pass through a doorway without giving audible warning of his presence. And I'm very much obliged to Mr. Fraser for passing on the information.

That Aintree Iron

At the time of writing these notes the current pop song starts with the words, "Thank you very much for the Aintree Iron." Nobody seems to know what an Aintree Iron is.

I can now exclusively reveal that there has been a typographical error here and that the correct term should read "Trainee Iron". This is, of course, the soldering-iron first issued to apprentice service engineers who then, very properly, express their gratitude in song.

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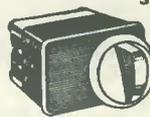
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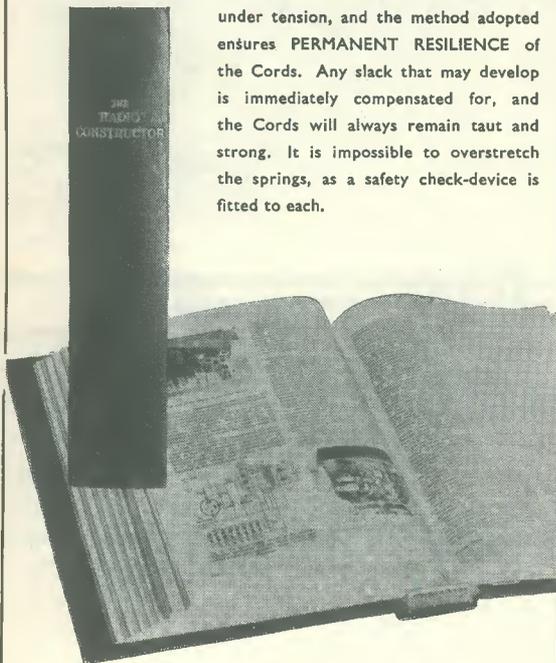
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continued from page 445

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continued on page 447

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continued from page 446

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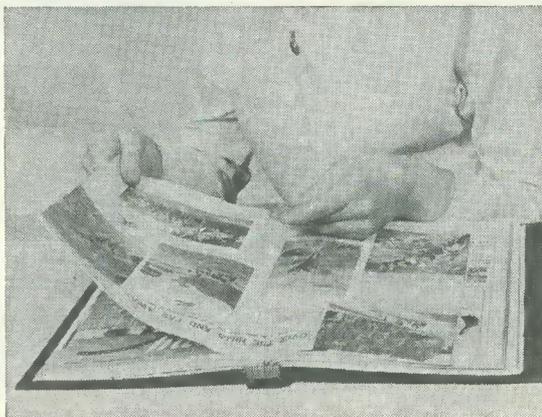
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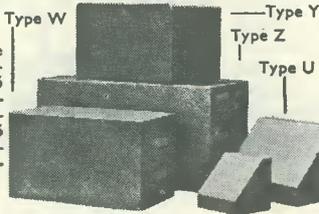
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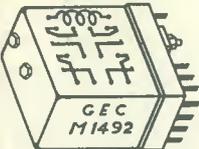
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In the Table, the two left-hand columns apply to losses, whereupon the corresponding dB figure is negative (e.g. a voltage ratio of 0.316 = -10dB). The two right hand columns apply to gains, and the corresponding dB figure is positive. To find intermediate dB figures, multiply by the nearest convenient factor. Thus, for voltage or current ratios,

$$36\text{dB} = 16\text{dB} + 20\text{dB} = 6.310 \times 10 = 63.10$$

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0.944	0.891	0.5	1.122	1.059
0.891	0.794	1.0	1.259	1.122
0.841	0.708	1.5	1.413	1.189
0.794	0.631	2.0	1.585	1.259
0.750	0.562	2.5	1.778	1.334
0.708	0.501	3.0	1.995	1.413
0.668	0.447	3.5	2.239	1.496
0.631	0.398	4.0	2.512	1.585
0.596	0.355	4.5	2.818	1.679
0.562	0.316	5.0	3.162	1.778
0.501	0.251	6.0	3.981	1.995
0.447	0.200	7.0	5.012	2.239
0.398	0.159	8.0	6.310	2.512
0.355	0.126	9.0	7.943	2.818
0.316	0.100	10	10.00	3.162
0.282	0.0794	11	12.59	3.548
0.251	0.0631	12	15.85	3.981
0.224	0.0501	13	19.95	4.467
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0.178	0.0316	15	31.62	5.623
0.159	0.0251	16	39.81	6.310
0.141	0.0200	17	50.12	7.079
0.126	0.0159	18	63.10	7.943
0.112	0.0126	19	79.43	8.913
0.100	0.0100	20	100.0	10.00
0.0316	0.00100	30	1,000	31.62
0.0100	10 ⁻⁴	40	10 ⁴	100.0
0.00316	10 ⁻⁵	50	10 ⁵	316.2
0.00100	10 ⁻⁶	60	10 ⁶	1,000
3.16 x 10 ⁻⁴	10 ⁻⁷	70	10 ⁷	3,162
10 ⁻⁴	10 ⁻⁸	80	10 ⁸	10 ⁴
3.16 x 10 ⁻⁵	10 ⁻⁹	90	10 ⁹	3.16 x 10 ⁴
10 ⁻⁵	10 ⁻¹⁰	100	10 ¹⁰	10 ⁵

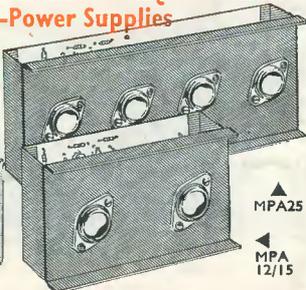
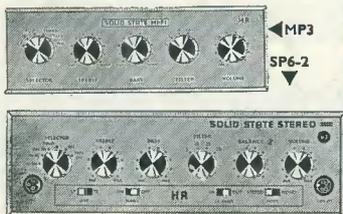
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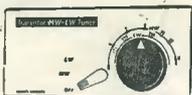
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