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RADIO CONSTRUCTOR

Vol. 22 No. 11 JUNE 1969 THREE SHILLINGS

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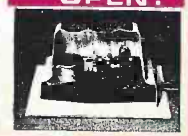

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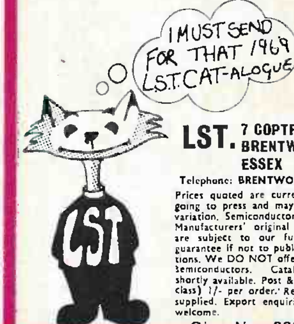

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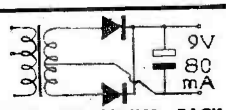

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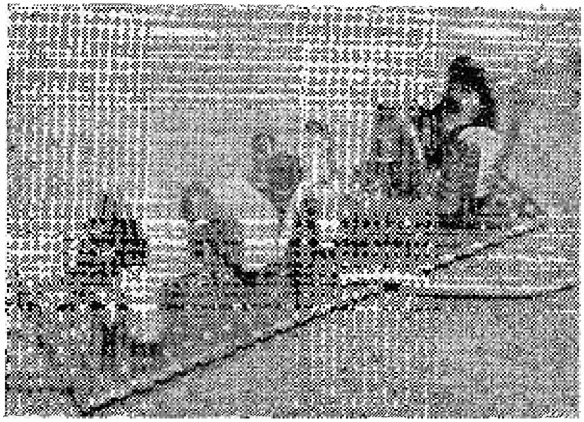
CONTENTS



SEMICONDUCTOR SOUND-OPERATED SWITCH

by

W. KEMP

The components of this versatile sound-operated electronic switch may be neatly assembled on a small piece of Veroboard. The circuit operates from a low to medium impedance moving-coil microphone (or loudspeaker) and offers a wide range of applications

THIS SOUND OPERATED ELECTRONIC SWITCH REQUIRES an input signal of only 0.3mV r.m.s. to give operation of its output relay, and is mainly intended for such applications as the automatic switching of a tape recorder or amateur transmitter. It could also be used as a burglar alarm, but a simple pre-amplifier might, in this case, be necessary. Although the unit is described as being "sound-operated" it is in fact activated by the a.c. signal generated by a microphone at its input terminals, and the device can therefore be made to operate by *any* quantity that can be converted to a.c. simply by using a suitable transducer. It can, for example, be made to operate from air pressure, velocity, light intensity, heat, humidity, etc.,

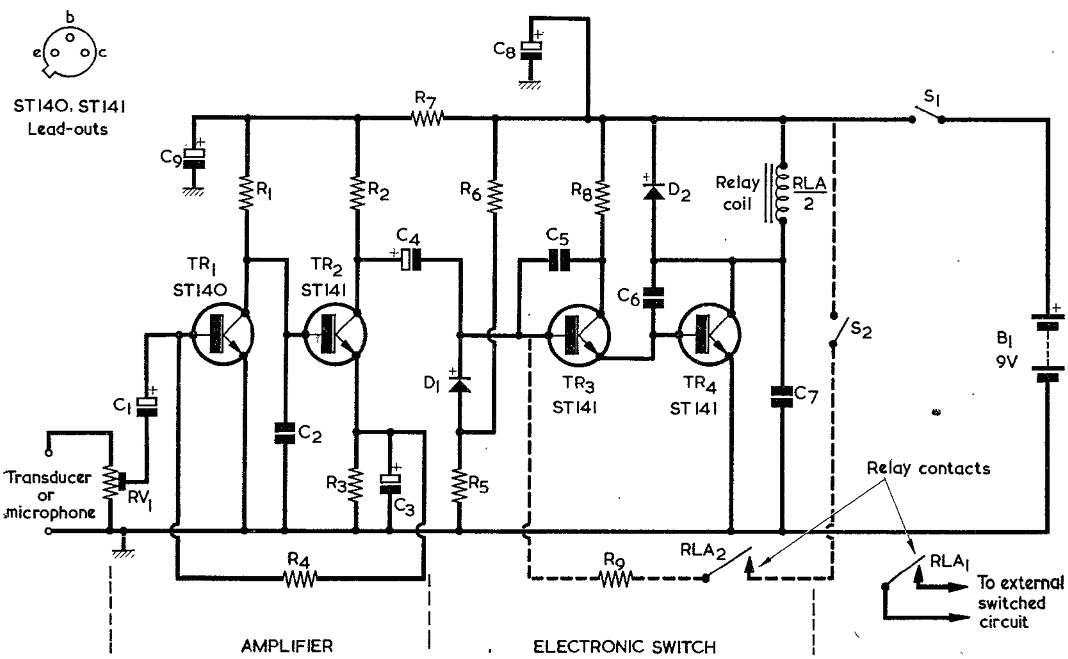


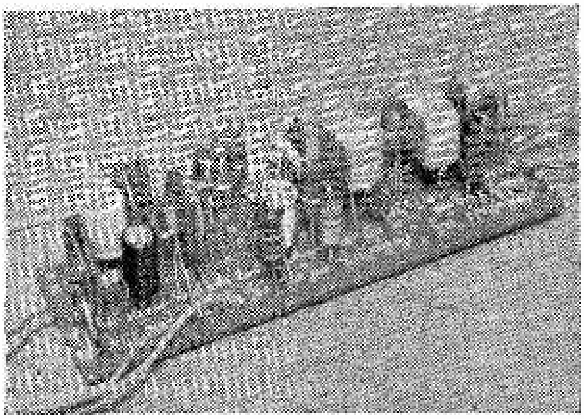
Fig. 1. The circuit of the sound-operated electronic switch

if the correct type of transducer or converter is employed.

The circuit employs four transistors and one relay, operates from a 9 volt supply and, excluding the relay and battery, measures approximately 3¾ by 1¼ by 1 in.

CIRCUIT OPERATION

The full circuit diagram of the unit is shown in Fig. 1. The input transducer or microphone is connected across the 5kΩ variable resistor, RV1, which acts as a sensitivity control, a portion of the input signal being taken from RV1 slider and fed to the base of TR1 via C1. TR1 and TR2 are both wired as common emitter amplifiers, using direct coupling between TR1 collector and TR2 base. A standing d.c. bias voltage is provided at TR2 emitter via R3, which is decoupled to a.c. by C3, and this bias voltage also provides the base bias for TR1 by way of R4. A d.c. negative feedback link is thus provided via the bias network, TR1 and TR2, and the d.c. levels of the circuit are thus well stabilised against variations in transistor characteristics and in the potential of the positive supply line.



Side view of the components mounted on the Veroboard, with VR1 to the left

C2 decouples TR1 for very high frequency signals, and thus restricts the bandwidth of the amplifier to the audio frequency range. TR1 and TR2 provide a high degree of amplification, and the output signal of the amplifier is taken from TR2 collector and fed to the "electronic switch" part of the unit via C4.

The operation of the TR3-TR4 electronic switch circuit is fairly involved, and explanations are best made by first ignoring TR4 and assuming that TR3 emitter is connected directly to the negative chassis line. In this case, the values of R5 and R6 (the TR3 base bias resistors) are chosen so that TR3 draws only a negligible collector current, but is not entirely cut off. The base of TR3 is connected to the junction of R5 and R6 via D1.

The amplified input signal from TR2 collector is fed to TR3 base via C4 and, since TR3 is wired in the common emitter mode with collector load R8, an amplified version of this signal appears at TR3 collector. This is then fed back to D1 and TR3 base via C5, where it is rectified by D1. The rectifying action causes an increase in the positive bias to TR3 base, drives the transistor forward and gives an increase in its mean collector current. Under the present conditions, the gain in this transistor increases as collector current increases. This increase in gain results in an increase in the magnitude of the feedback signal from TR3 collector and a consequent further increase in the base-bias current from D1. What is virtually a regenerative action takes place, causing TR3 to switch hard on once a signal of sufficient amplitude is made available from TR2 collector.

Returning now to the actual circuit of the "electronic switch" section, TR3 operates in the manner already outlined above, with the exception that its emitter is connected to the negative chassis line via TR4 base. In this case, both TR3 and TR4 are normally biased to near cut-off, but when TR3 is switched on by an input signal the resulting increase in its emitter current is fed directly to TR4 base and so drives TR4 on as well. TR4 is wired in the common emitter mode with the relay coil as its collector load. Any a.c. signal that

COMPONENTS

Resistors
(All fixed values ¼ watt 10%)

R1	5.6kΩ
R2	2.2kΩ
R3	680Ω
R4	12kΩ
R5	2.2kΩ
R6	18kΩ
R7	470Ω
R8	5.6kΩ
R9	18kΩ (optional—see text)
RV1	5kΩ skeleton preset

Capacitors
(All capacitors sub-miniature types)

C1	16μF electrolytic, 12V wkg.
C2	0.01μF
C3	30μF electrolytic, 6V wkg.
C4	16μF electrolytic, 12V wkg.
C5	0.1μF
C6	0.1μF
C7	0.05μF
C8	50μF electrolytic, 12V wkg.
C9	50μF electrolytic, 12V wkg.

Semiconductors

TR1	ST140 (Sinclair)
TR2, 3, 4	ST141 (Sinclair)
D1, 2	OA200

Switches

S1	s.p.s.t., on-off
S2	s.p.s.t. (optional—see text)

Battery

B1 9-volt battery

Miscellaneous

Relay (see text)
Low or medium impedance microphone (see text)
Veroboard, 0.15 in. matrix, 3¾ by 1 1/16 in. (see Fig. 2)
Wire, sleeving, etc.
(N.B. A crystal earphone is required for circuit testing)

A= mounting holes drill 6BA clear

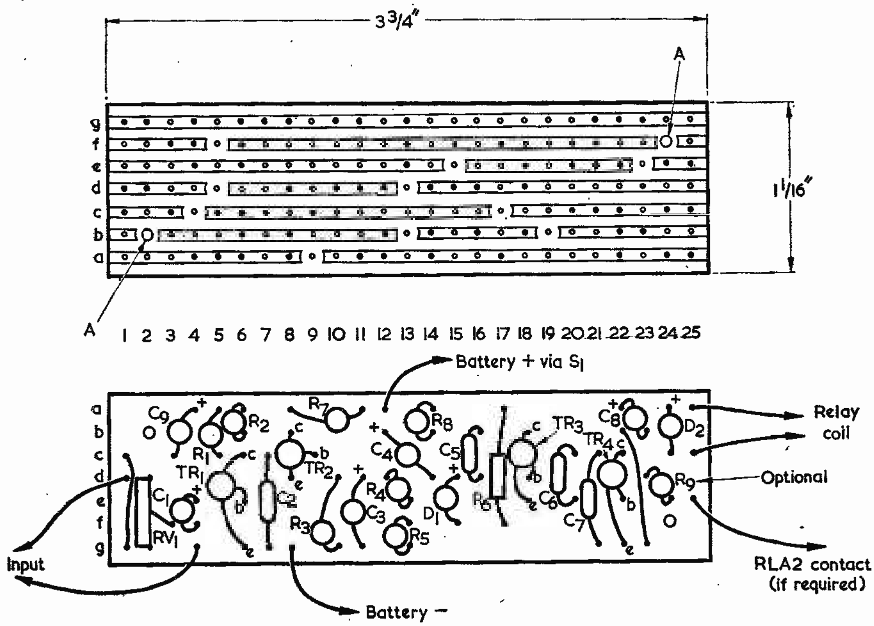


Fig. 2. Illustrating the copper and component sides of the Veroboard panel

breaks through from TR3 emitter then appears in amplified form at TR4 collector, this being then fed back to the junction of TR3 emitter and TR4 base via C6. This second feedback signal is next rectified by the emitter-base junction of TR3 in such a way that it gives an even further increase in the positive bias to TR3 base. The result is that the transistors are driven on even harder, and the regenerative effect in TR3 on its own is further enhanced. Thus, both TR3 and TR4 switch on very sharply when driven by a signal of sufficient amplitude from TR2 collector.

D2 is wired across the relay coil and C7 is wired across TR4 in such a way that any transients resulting from the sharp switching action of the relay will be damped, thereby preventing possible damage to the transistors which might otherwise occur. An on-off switch (S1) can be wired in series with the positive supply line as shown, if required.

The circuit is basically designed so that the relay switches *on* (i.e. energises) when an output signal is applied, and switches *off* again when the signal is removed. In some applications, however, it may be desirable that the relay should *lock* on once it has been initially switched. In this case one of its contacts should be wired in series with switch S2 between the positive supply line and R9, as shown in the diagram.

If, now, S2 is closed, R9 will be connected to the positive supply line when the relay operates, and will then provide sufficient positive bias to TR3 base to hold the relay on even though the a.c. input signal to the unit may be completely removed. This type of operation will be required if the unit is to be used as, say, a burglar alarm.

CONSTRUCTION

The unit is wired up on a small piece of Veroboard panel with 0.15in. hole spacing as shown in Fig. 2. Construction should be started by cutting this panel to size and drilling the two small mounting holes to clear 6BA screws. Next, break the copper strips, with the aid of a small drill or the special cutting tool that is available, in the positions shown.

The components and leads can now be soldered to the panel, as shown in the lower view. Note that all resistors and capacitors other than R6 are mounted vertically on the panel, and that insulated sleeving should be used where there is any danger of component leads short-circuiting against one another. It should be remembered, here, that the collector of an ST140 or ST141 transistor is common to its metal case.

Start assembly by wiring the following components in place; RV1, C1, TR1, TR2, R1, R2, R3, R4, C2, C3, C4, C8, C9, R7, the input leads, and the positive and negative supply leads. Ensure that electrolytic capacitors are connected into circuit with correct polarity, and note that the legs of RV1 will need to be filed down slightly so as to fit the Veroboard holes.

This part of the unit can now be given a functional check by wiring a crystal earpiece between TR2 collector and emitter. An input signal is applied across the input leads and the unit is connected to a 9 volt supply, whereupon a strong signal should be heard in the earpiece. TR2 collector should be at approximately half the supply potential above the negative supply line.

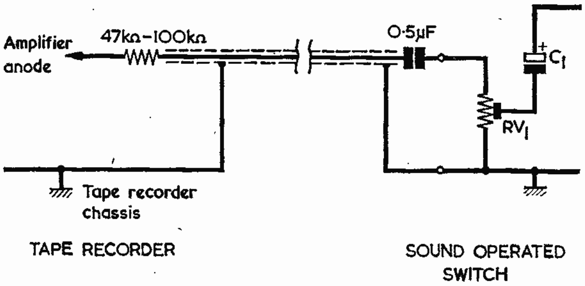


Fig. 3. Coupling the switch to an anode in a tape recorder amplifier

If the above tests are satisfactory, the rest of the components and leads should now be wired in position and a suitable relay connected in place at the output. The unit can now be given a final functional check by connecting a low or medium impedance microphone at the input terminals, connecting the 9 volt supply to the unit, and checking that the relay operates when a noise is made at the microphone. Note that the relay may energise at the moment that the supply is connected, even though no input is applied from the microphone. It will de-energise again after a delay of a second or so and then operate only when a sound input is applied.

USING THE UNIT

The unit, complete with relay and battery, etc., may be mounted in a small container or case, the Veroboard panel being secured in position via the two small mounting holes that are provided. If the board is secured to a metal surface, small rubber or p.v.c. grommets should be fitted over the 6BA mounting screws at the underside of the board, these functioning both as spacers and insulators. Ensure that the inside copper strips at the two 6BA clear holes in the board are cleaned well away from the hole edges to prevent possible short-circuits to the mounting screws.

Under no-signal conditions the circuit draws a current of a few milliamps. When the relay is energised the battery current is several milliamps greater than the current drawn by the relay.

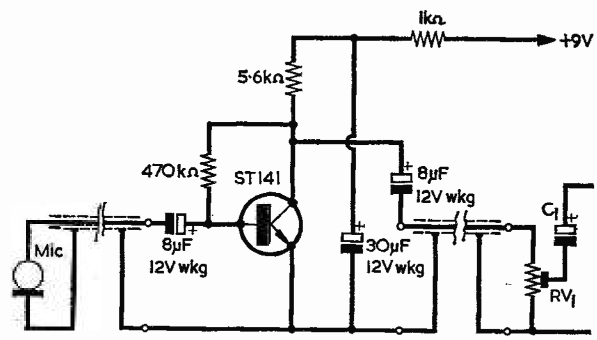
When used for automatically switching a tape recorder on and off during speech recording, the recording microphone can be jointly connected to the input of both the recorder and the sound switch, or, alternatively, separate microphones may be used for both units. In either case, RV1 should be pre-set to the required sensitivity level. The relay output connections of the unit should be wired in series with the tape drive circuit. (Some further notes concerning the relay are given at the end of this article.)

If it is required that the unit be operated by very weak signals, such as bird calls, etc., the input signal to the sound switch should be applied via some form of pre-amplifier, and the amplifier circuit of the actual tape recorder may in many cases be used for this purpose. In this instance, the input terminals of the sound switch should be connected, via a $5\mu F$ capacitor with transistorised recorders, to a point in the tape amplifier at which the very weak sound signals have been amplified to a degree at which they will give positive operation of the sound switch.

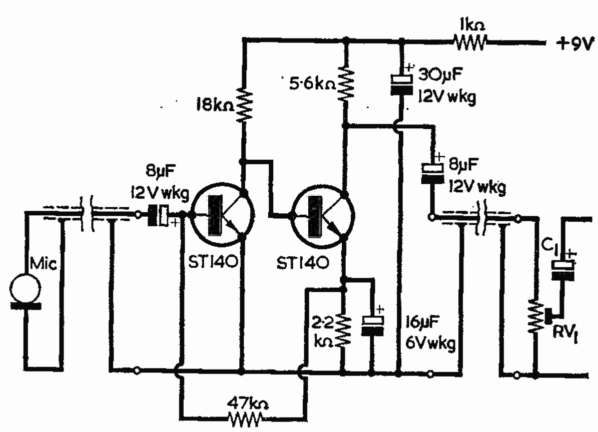
If the tape recorder employs valves (as opposed to transistors) it will be necessary to insert a series resistor of some 47kΩ to 100kΩ and take the drive from a suitable anode in the recorder amplifier. The series resistor is mounted inside the tape recorder and connections should be made via screened lead, as in Fig. 3. In this case the coupling capacitance may be reduced to $0.5\mu F$ (The $5\mu F$ value mentioned previously is applicable to the low impedance a.f. circuits encountered in transistorised recorders). It must be emphasised that this particular method of operation requires some experiment and that it should not be undertaken if the constructor is not familiar with tape recorder circuitry.

Rather the same techniques apply if the switch is employed with an amateur transmitter. When the latter has a high impedance microphone, a suitable signal could similarly be taken off at a convenient point in the modulation amplifier.

If the switch is to be used to activate a burglar alarm, the circuit should be wired to give self latching of the relay, as shown by the dotted connections of Fig. 1. In such applications, the input microphone should either be placed close to probable points of burglar entry, such as doors or windows, or close to probable points of violation, such as safes or cabinets,



(a)



(b)

Fig. 4(a). A simple pre-amplifier, which offers increased sensitivity

(b). A high gain pre-amplifier. Both these pre-amplifiers obtain their supply from the battery which powers the electronic switch

etc. For this application an increase in sensitivity may be desirable, whereupon a simple pre-amplifier such as that shown in Fig. 4(a) can be used. An alternative pre-amplifier circuit is illustrated in Fig. 4(b). This second circuit gives a very high degree of gain, probably more than will normally be required. Screened lead input and output connections are required with both the circuits of Figs 4(a) and (b), and both may employ the same type of microphone as is normally used for the Fig. 2 circuit on its own.

SENSITIVITY AND RELAY DETAILS

The unit has an overall sensitivity of 0.3mV, but has been so designed that sensitivity falls rapidly at frequencies of less than 100c/s, thus preventing unwanted operation due to mains hum pick-up or tape motor noise. If required, however, the frequency response can be extended downwards by simply increasing the values of C3, C5, and C6.

The microphone may be any moving-coil speaker or microphone with an impedance in the range 3Ω to 5kΩ. Sensitivity will tend to increase as the impedance presented to RV1 is increased, and it may prove helpful to use a step-up transformer here, remembering that the impedance presented to the input of the switch is multiplied by the square of its secondary-to-primary turns ratio. Thus, a 1:10 transformer will effectively multiply impedance 100 times.

As an example of circuit performance when employing a microphone near the low impedance end of the range just mentioned, checks with a 25Ω 3in. speaker showed that the circuit could be activated by normal speech up to a range of 2ft. and by a loud whistle up to about 15ft.

The primary requirements of the relay are that it should be capable of energising at 6 volts and that its coil resistance should, preferably, be 500Ω or more. If the coil resistance is less than 500Ω (to a minimum limit of 250Ω) the value of R8 should be reduced so that it is approximately 8 to 10 times the coil resistance. Incidentally, a P.O. 600 relay with a 500Ω coil and two contact sets will be just sensitive enough for use in the circuit. Contact insulation and rating must, of course, be suitable for the external circuits which are to be switched. (P.O. 600 relays made up to customer's specification are available from L. Wilkinson (Croydon) Ltd., Longley House, Longley Road, West Croydon, Surrey. A relay having an energising voltage slightly in excess of 6 volts could also be employed if the battery voltage were increased from 9 to 12 volts.—Editor.)

OTHER APPLICATIONS

As mentioned in the introduction, the unit may be activated by any quantity that can be represented by an a.c. signal, provided that a suitable transducer is used at the input terminals. In this context a d.c. sensor such as, for example, a thermistor (for temperature operation) may be wired in a Wheatstone bridge circuit which is energised by an a.c. signal. When the bridge is balanced no output signal will be available from the bridge, but when the bridge goes out of balance (due to a temperature shift), an a.c. signal will be made available at the bridge output terminals, and this signal can then be used to activate the switch unit. The same technique may be used to give operation from a number of other sensor types. A typical example would be given by employing a cadmium sulphide photocell to indicate changes in light intensity. ■

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

52 Sets.—R. Brown, 15 Daleview Road, Carlton Hill, Nottingham—loan of manual or other circuit information on this receiver.

Dynaport Receiver Model AG50.—L. C. Oxlade, 25 Bradley Close, Thundersley, Benfleet, Essex — purchase of circuit or wiring diagram.

Philco Radiogram Model 245.—P. Bolger, 11 South Road, Hanworth, Middx.— purchase of circuit diagram or any data.

Vintage Receiver Data.—D. M. Field, 116 Tanhouse Lane, Malvern Link, Worcs.— handbook, circuit diagram, photograph of BTH VR3 Form 8A receiver (circa 1926). Also range blocks and regeneration units for Marconi V2A (circa 1923).

Elliott Multiversal Test Set.—L. O. Tully, 120 Victoria Street, Fairfield 4103, Brisbane, Australia—manual or circuit wanted.

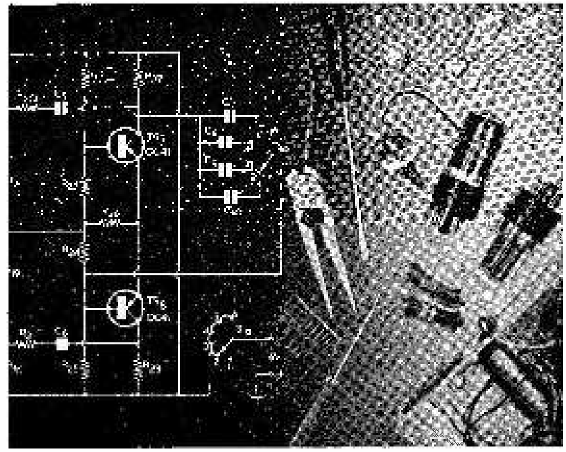
Solartron Monitor Oscilloscope Type 101.—P. Hitchens, The Villa, Church Hill, Ludgvan, Penzance, Cornwall—loan or purchase of circuit, manual or any other information.

WS 19 MkIII.—M. Catterall, 80 John Street, Chadsmoor, Cannock, Staffs—loan or purchase of handbook or complete circuit with component values.

Electronics World.—J. Partington, 30 Ings Way, Fairweather Green, Bradford, 8—loan or purchase of a copy of this American magazine containing an article describing an electronic percussion unit—believed February 1967 or thereabouts.

SUGGESTED CIRCUIT No. 223

POCKET CONTINUITY-LEAKAGE TESTER



by G. A. FRENCH

SIMPLE AND INEXPENSIVE ITEMS of test gear are always popular subjects for constructional articles, and they appear to be particularly appreciated by beginners. In consequence, the writer includes circuits for such items from time to time in the "Suggested Circuit" series.

A typical instance appeared some four years ago,[1] and the article published at that time described a simple two-transistor design which was capable of indicating leakage resistances up to 500kΩ. The existence of leakage resistance was shown by the glowing of a bulb and, since the device comprised only this bulb, a 6 volt battery and two small transistors, it could carry out the secondary function of acting as a torch during servicing. Those who have probed around the shadowy recesses of ill-lit TV receiver cabinets will certify how useful a torch can be for such work.

THE CIRCUIT

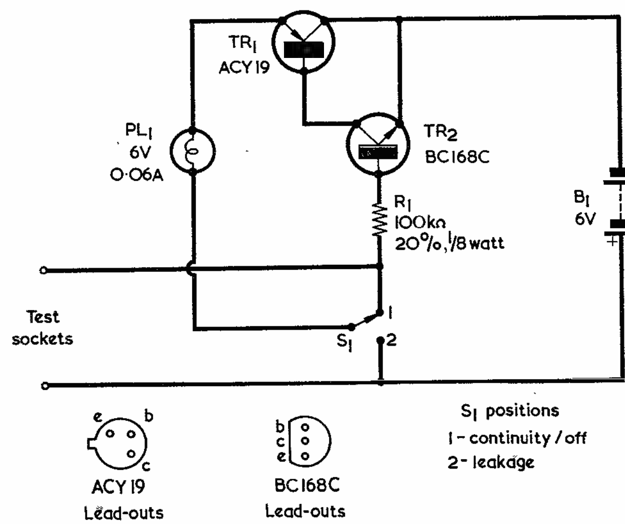
This month's "Suggested Circuit" is for a unit offering the same facilities. However, due to the use of a more modern silicon transistor having very high gain, the present design gives considerably enhanced sensitivity (greater than 10MΩ with the prototype) for the leakage test. There is, also, a different circuit approach. The new tester requires a 6 volt battery, a bulb, two test sockets, two small transistors, an $\frac{1}{8}$ watt resistor and a single-pole 2-way switch. As the components other than the bulb and battery take up very little space the tester can, as with the earlier design, be made up in the form of a torch.

The circuit of the unit appears in the accompanying diagram. TR1 is a germanium p.n.p. transistor type ACY19 offering a medium degree of current gain, whilst TR2 is a silicon n.p.n. transistor type BC168C offering a very high current gain of the order of 450 to 900. The two transistors are coupled together in such a manner that the overall gain is approximately equal to the product of their individual gains. The manner in which the two transistors operate was described in detail in last month's "Suggested Circuit",[2] where the combination was used for the same purpose as is required here, that of providing an extremely high level of current gain.

Also appearing in the circuit are two test sockets. These should be of the insulated type, and it is intended that two external test leads terminated in test prods or clips be plugged into them. The bulb, PL1, is a 6 volt 0.06 amp pilot lamp.

When S1 in the diagram is set to position 2 it selects the "Leakage" function. The positive terminal of the battery connects via S1 to the lower side of PL1, whilst its negative terminal connects to the upper side of PL1 via TR1. TR1 can be made conductive by passing a small current from the positive terminal of the battery to the base of TR2. Thus, if a short-circuit or resistance of suitable value is connected across the test sockets, the resulting base current in TR2 will cause TR1 to become conductive and PL1 to light up. The presence of leakage resistance across the test sockets is, in consequence, indicated by illumination in PL1.

Setting S1 to position 1 selects the "Continuity" function. In this instance both the lower ends of PL1 and R1 connect to the upper test socket,



The circuit diagram of the pocket continuity-leakage tester. As may be seen, very few components are required

1 Suggested Circuit No. 176, "Combined Torch and Leakage-Continuity Tester", 'The Radio Constructor', July 1965.

2 Suggested Circuit No. 222, "Light-Operated Radio Switch", 'The Radio Constructor', May 1969.

with the positive terminal of the battery connecting to the lower test socket. Only a very small current is required to flow to the base of TR2 to make TR1 fully conductive, whereupon the combination of PL1, TR1, TR2 and R1 gives the same results as if TR1 were short-circuited and the upper side of PL1 connected direct to the negative terminal of the battery. The device then functions as a continuity indicator in the same manner as any battery and bulb in series.

Putting S1 to position 1 also switches the device off. No current then flows from the battery until an external circuit is connected to the test sockets. It is for this reason that it is recommended that the sockets be of the insulated type. Otherwise, accidental short-circuits might appear across them as could happen if, for example, the device were carried in a tool-bag, and the battery would run down prematurely.

Resistor R1 is merely a limiter resistor. It prevents excessive current flow to TR2 base when the test sockets are short-circuited.

RESULTS WITH THE PROTOTYPE

The current gain offered by TR1 and TR2 in combination depends upon the individual gains of the actual transistors employed. The transistors used in the prototype offered a gain which enabled TR1 to be hard on at an emitter current of 60mA (that required for full illumination of the bulb) when TR2 base current was slightly in excess of 1μA.

The prototype was checked with S1 at position 2, and it was found that the bulb was fully lit for all resistances across the test sockets from zero to 5.5MΩ. Brilliance dropped to about half for a test resistance of 10MΩ, and there was still a perceptible glow in the filament for a test resistance of 14MΩ. The bulb gave no indication for higher test resistances. Other units made up to the circuit may offer increases or decreases in sensitivity according to the individual gains of the actual transistors employed, but it would seem reasonable to expect that sensitivity should always be well in excess of 5MΩ.

The prototype was also used to check capacitors, whereupon it indicated any leakage of the order of 14MΩ or less. As an incidental note, the bulb flashed momentarily when capacitors of 0.03μF or more were connected across the test sockets, just as occurs when such capacitors are checked with a neon bulb tester! The device cannot be used for checking electrolytic capacitors as their leakage resistance is too low.

With S1 at position 1 the bulb was, of course, fully illuminated when a short-circuit was put across the test sockets. It lit at about half brillance for a test resistance of 50Ω, and gave a perceptible glow with a test resistance of 100Ω.

When TR1 was fully conductive, the voltage drop across its collector and emitter was 0.3 volts only. This transistor is used well within its power rating and does not require a heat sink.

COMPONENTS

The transistors employed in the circuit should be as specified. The BC168C used in the TR2 position was obtained from Amatronix Ltd. The bulb must be a 6 volt 0.06 amp type, and it is available from Home Radio under Cat. No. PL7. It has a standard M.E.S. base. A bulb drawing a current greater than 0.06 amp must *not* be used. The two test sockets can be Home Radio Cat. No. PK4 or similar. The battery may be of small size, because the current it provides is only 60mA even when the bulb is fully illuminated. It could consist, conveniently, of four "penlight" cells in series.

The whole unit may be assembled in a small case, with the bulb at one end. The light given by the bulb specified is somewhat less than that offered by a standard torch, but it should be adequate for normal purposes. A stronger light will be provided if the bulb is fitted with a reflector. When the unit is used as a torch the two test sockets are short-circuited, and S1 can be in either position for this application. ■

THE GEC ELECTRONIC TUBE COMPANY LIMITED

An important move bringing together the M-O Valve Company Ltd. and English Electric Valve Company Ltd. was announced recently with the formation of a new management company, the GEC Electronic Tube Co. Ltd. With a turnover of some £11,000,000, representing about 50% of the total U.K. manufacture, main factories at Hammersmith, Chelmsford and Lincoln, and with a total of 4,000 employees, the GEC Electronic Tube Co. Ltd. is Britain's largest manufacturer of professional and industrial electronic tubes, and probably the largest manufacturer in its specialised field in the world outside the United States.

The comprehensive product range of the new company comprises microwave tubes and devices and ferrite components; high power vacuum and gas-filled valves; special lower power valves; instrument, radar and TV monitor cathode ray tubes; TV camera tubes; gas lasers; flash tubes; vacuum capacitors; reed switches and telephone line protectors.

MOV is already Europe's largest manufacturer of instrument and radar cathode ray tubes, while EEV has the same distinction in its TV camera tube business, supplying these tubes to sixty-five countries. The new grouping will enhance the strength of the individual companies, particularly overseas, in supplying components to makers and users of airborne, land-based and marine radar and military systems; television, radio and communications transmitters; television cameras and studio monitors; electronic instruments; heating and welding equipment; and equipment used in nuclear research, medicine and electro-optics.

Both MOV and EEV will continue to manufacture and market under their existing trade names in order to secure the maximum advantage from their established trading connections in world markets.

The Chairman of the GEC Electronic Tube Co. Limited is Mr. A. J. Young, managing director of English Electric Valve Co. Limited; and Mr V. A. Cheeseman, managing director of the M-O Valve Co. Limited will be managing director. Both Mr. Young and Mr. Cheeseman will continue as managing directors of their respective companies.

THE POSISTOR

by

J. B. DANCE, M.Sc.

The posistor represents yet a further weapon in the armoury of the electronic or electrical engineer. This new device offers very high change in resistance over a narrow range of temperature and lends itself, in particular, to temperature monitoring applications

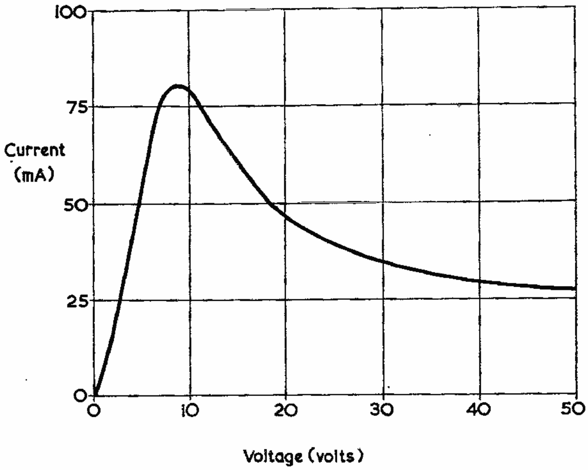


Fig. 2. Typical voltage-current characteristic of a 3mm diameter posistor

THE POSISTOR IS A SPECIAL TYPE OF RESISTOR WHICH has a very high positive temperature coefficient of resistance over a relatively narrow range of temperature. The particular temperature range over which this rapid increase of resistance occurs can be controlled by a suitable choice of the ceramic material used in manufacture. The variation of the resistance with temperature for a range of 3 mm diameter posistors is shown in Fig. 1.

CONSTRUCTION

The posistor is normally produced in the form of a small disc of a few mm. diameter. The leads of the device are usually covered with p.t.f.e. heat resistant insulation which may be colour coded to indicate the "characteristic temperature" at which the resistance of the device changes most rapidly.

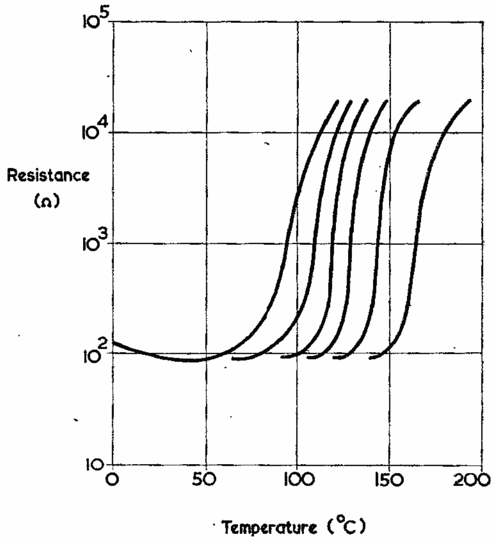


Fig. 1. Typical resistance-temperature characteristics for a range of 3mm diameter posistors

The resistance of the posistor is dependent on the size of the piece of ceramic material used in its construction. In many devices the resistance is about 1kΩ at the characteristic temperature, as in Fig. 1. Increasing the diameter of the material or reducing its thickness will produce a posistor of lower resistance.

The variation of resistance with applied voltage is small when the latter is below 10 volts. The current—voltage characteristic of a typical 3 mm diameter posistor is shown in Fig. 2.

APPLICATIONS

Posistors can be used to measure temperatures and may, for example, be used as the temperature sensing elements in thermostats. Their thermal capacity is low (owing to their small size) and therefore the temperature of a posistor rapidly follows that of the surroundings.

Several posistors may be employed if it is desired to monitor a range of temperatures. Each posistor may be used to actuate its own warning device when the temperature rises above (or falls below) the characteristic temperature of that device. Currently available materials enable posistors to be manufactured with a large positive temperature coefficient anywhere in the range of 95°C to 170°C.

Other applications include water cooled engine overheat warning systems and a.c. induction motor overheat protection (where each phase winding of the motor is monitored).

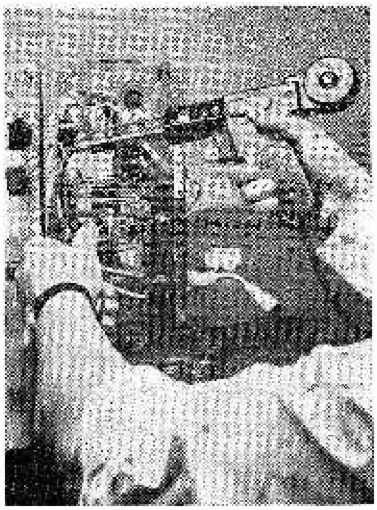
In another type of application the posistor is deliberately heated (either indirectly or directly by an electric current) to a temperature above that of the environment. As the heat transfer properties of the surroundings change, so does the temperature of the device—and hence its resistance. A liquid level monitor may be made in this way, the heated posistor being kept cooler when the liquid level is high enough to submerge the device.

Further details about the posistor can be obtained from the manufacturers, Thorn Parsons Company Ltd., 40 Broadway, London, S.W.1.

■

NEWS . . . AND .

SELF-FEEDING SOLDERING GUN



An entirely new electric soldering gun has just been introduced by SKIL. This new tool features automatic trigger feed control which enables the operator to feed solder directly on to the work. The tool has been so designed that control is very simple. At the end of the high impact plastic housing there is a built-in spool which carries up to 10in. x $\frac{1}{16}$in. solder. The solder is fed through a tube and when the operator presses the trigger, a length of solder is fed on to the hot soldering tip. This length of solder can be adjusted up to $\frac{3}{16}$in. with a simple control knob.

One hand guides the tool and controls the solder feed and the other hand is free to hold the work in place. Problems of the work moving away, or a blob of solder landing on the wrong spot, are overcome.

This new soldering gun has an element of 0.2 amps. Standard equipment includes a spool of 10in. x $\frac{1}{16}$in. solder and a medium size soldering tip. Small and large size soldering tips are available. The tool is packed in a polystyrene display pack and sells in the U.K. for £4 2s. 0d.

Enquiries to: Skil (Great Britain) Ltd., 59 High Street, Hounslow, Middlesex.

AN INTERNATIONAL CONGRESS OF AMATEUR TELEVISION

An International Congress of Amateur Television organised by the Club Français de Télévision d'Amateur was held on Saturday 19th and Sunday 20th April in the Salle des Sportes at Armentiéres in Northern France. This highly successful event was attended by over 300 amateurs from France, Belgium, West Germany, Switzerland, the United Kingdom and other countries.

The programme comprised:

(1) A technical conference in which the state of amateur TV activity in various countries was described, and papers read on a number of technical aspects.

(2) An exhibition of amateur television equipment and photographs from several countries.

(3) An exhibition of historic radio and television equipment.

A working amateur television station under the call F9MF/T maintained a two-way vision and sound QSO on 70 cm with ON4RT/T, a station specially set up by the Belgian ATA at Mont Rouge in that country.

On the Saturday evening the proceedings were enlivened by a dance at which was held an election for "Miss Amateur Television", and on the Sunday the delegates were received by the Mayor and civic leaders in the Town Hall.

The programme closed with a banquet and a draw for prizes.

Talk-in for mobiles was provided during the period of the Congress by stations on 3.5 and 144 MHz operated under the call signs F8REF and FØTV.

Congratulations are due to F3DD, the President of the C.F.T.A., for organising this first venture in such an excellent manner.

NEW EAGLE PRODUCT

All-Silicon 10-Transistor Stereo Headphone Amplifier

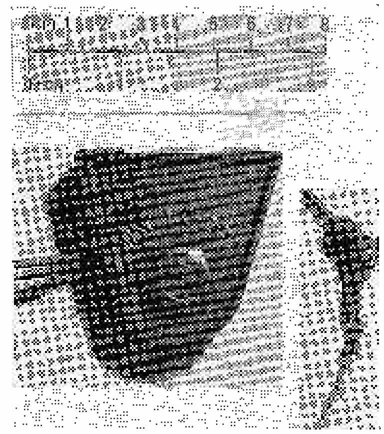
Powered by a single 9V. battery, this all-silicon 10-transistor stereo headphone amplifier can be used with any record deck and cartridge to give high fidelity results at headphone level.

Specification:

Outputs:	2 x 2 @ 50mW per channel
Inputs:	Magnetic 5mV (Equalised)
	Ceramic 100mV (Flat)
	Tuner 100mV (Flat)
List Price:	£11. 0s. 6d.

. . . COMMENT

RADIATOR WATER LEVEL ALARM TO BE NATIONALLY PROMOTED



With today's high performance engines, it is of paramount importance that the correct level of cooling water is maintained. Yet how many drivers take the trouble to check water level regularly? Now this all-important function may be carried out automatically with the unique "Watercheck" instrument. "Watercheck" is an all solid-state liquid level indicator which maintains a constant surveillance within your radiator.

Although many vehicles are fitted with a temperature gauge, this instrument is slow to react and does not usually give an alarm or sufficiently early warning of loss of water. "Watercheck", however, has a small probe which is easily fitted into the radiator header tank at a predetermined level. Whenever the water level falls to the level of the probe, the latter passes a signal to the "Watercheck" instrument at the dashboard and an amber lamp flashes.

The instrument could be fitted by the average driver within 20 minutes, there being only three electrical connections.

Two models are available – one for positive and one for negative earth vehicles; 12V. systems only.

Retail Price: £3. 15s. 0d.

Manufactured by Automets Ltd., New Street, Oadby, Leicester.

BETTER AND CHEAPER TELEVISION

In many parts of the world, if you watch on television a relay from studios a long distance away, you may notice that, whilst the picture is of good quality, the sound has a noisy background and seems almost telephonic. As Richard Oliver pointed out in a BBC broadcast, this is not surprising, because an ordinary telephone circuit sometimes has to be used for the sound channel. BBC engineers have now found a way round the problem. They convert the sound signal into an electronic code—called pulse code modulation—and then transmit this on the picture circuit together with the picture. How does it fit in? Well, between each line of the television picture there is a slight gap—just a mere 3.8 millionths of a second—and the sound, as a burst of electronic code, goes in here. At the transmitters, this code is re-converted to ordinary sound.

The new system gives a clean, live, sparkling quality of sound indistinguishable from the original. And it is cheaper, too. The extra equipment for the BBC's extensive networks will pay for itself, by saving rented sound lines, in two or three years. It will probably be manufactured commercially under BBC patent licence, so broadcasters—and viewers—everywhere may benefit.

WAVEMASTER VARIABLE CAPACITORS

Jackson Brothers (London) Ltd., have recently purchased the Trade Mark and manufacturing rights of "Wavemaster" variable capacitor range from the Webb Condenser Company.

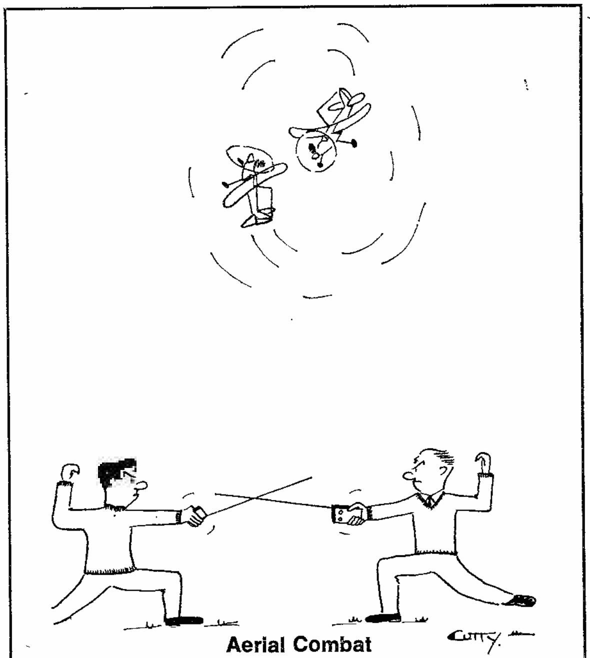
Most of the "Wavemaster" range will continue to be produced by Jackson Brothers (London) Ltd., and new lines will be added as opportunity offers.

NEW B.A.T.C. CHAIRMAN

The British Amateur Television Club recently announced the election of Mr. Gordon Sharpley, G6LEE/T to the post of Chairman.

The retiring Chairman, Mr. Ian Waters, G6KKD/T, to whom the club expressed appreciation for his wise and efficient guidance, will continue his support by serving on the Committee.

Incidentally, we are indebted to the P.R.O. of the B.A.T.C. for the information on the International Congress.



Aerial Combat

CASCODE RECORD-PLAYER AMPLIFIER

by

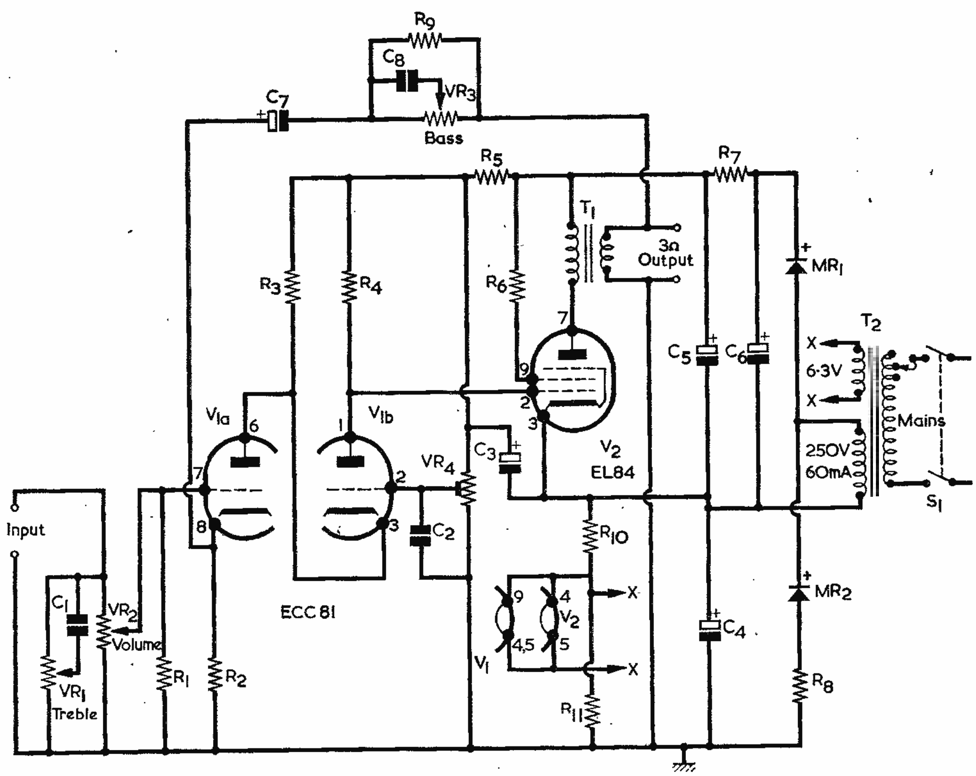
D. G. HUGHES

This unusual 5-watt a.f. amplifier design incorporates a cascode input stage, heavy negative feedback, and separate bass and treble controls. A voltage doubling power supply enables an inexpensive mains transformer to provide 500 volts h.t. for the cascode valve

One of the contributing factors to the unremarkable reproduction of many record-players is a poorly damped loudspeaker. This results in lack of 'crispness' in the reproduced sound, and a general muddling of the individual themes of the music.

For a speaker to be effectively damped, the output impedance of the amplifier must be low compared with that of the speaker. This can be achieved by the application of large amounts of negative feedback taken from the secondary of the output transformers.[1]

1 See, for instance, "Understanding Radio" in 'The Radio Constructor' for December 1967, January, February and March 1968.



The circuit of the cascode record-player amplifier. Note the unusual power supply circuit, which provides a doubled h.t. voltage for the cascode

Two main drawbacks can result from this, however, these being:
1. Instability due to phase shifts in the amplifier and feedback loop,
2. Serious loss of gain, resulting in the need for an uneconomical number of amplifying stages.

The circuit to be described has considerable negative feedback applied, and attempts to overcome both the drawbacks just mentioned by providing direct couplings where possible and a high level of gain within the loop. At the same time, it is very sparing of components.

DESCRIPTION OF CIRCUIT

A quick glance at the accompanying diagram shows that the circuit consists of a cascode[2] voltage amplifier stage V1 (ECC81), followed by a pentode output stage V2 (EL84). A closer look reveals that the cathode of V2 is supplied from the centre-tap of a voltage doubling rectifier circuit. The h.t. supply for this valve is thus 250V. On the other hand the cascode stage, V1, is supplied from the full 500V of the voltage doubler, thereby enhancing its inherently high gain with a high h.t. voltage.

It will be noted that the cathode of V1(a) is 250V more negative than the cathode of V2, and it is therefore an easy matter to arrange for the anode of V1(b) to be sufficiently negative of V2 cathode to provide the negative grid bias for the latter valve. The anode of V1(b) can hence be directly coupled to the control grid of V2. This has the advantages that the anode load of the cascode is not shunted by the grid leak of V2, which could result in a slight loss of gain, and that no phase shift is introduced, as would occur with a coupling capacitor and grid leak.

R6 has been included as a safety measure. Also, and to ensure that V2 is not operated without bias, V1 should not be removed whilst the amplifier is switched on.

A simple, but efficient, treble cut control has been included, and is provided by VR1. The circuit for this control presented no difficulty, but it is a more complicated matter to design a bass control operating on fairly similar principles which does not introduce serious loss of gain, because bass boost can then only be realised by cutting down the treble and middle frequencies.

It was finally decided to place the bass boost control in the feedback loop. When the slider of VR3 is fully to the end of the track which connects to C7, all frequencies are fed back equally. As the slider is moved towards the output transformer secondary, treble and middle frequencies are fed through C8, but bass frequencies are not fed back in the same proportion. Thus, bass boost is achieved.

The 50μF capacitor, C7, is included in the loop to block direct current. If it were not in circuit the varying value of VR3 would alter the bias on V1(a) and this, with the present direct coupling between V1 and V2, could cause the grid of V2 to run positive. If a bass control is not required, R2 may be replaced by a 2.2kΩ resistor, and all the components in the feedback network (C7, C8, R9 and VR3) replaced by a single 2.2kΩ resistor.

It will be noted that the heaters of the valves are maintained at about 150V positive of chassis by means of the fixed potential divider given by R10 and R11 in series. This is done in order to keep the heaters close to the maximum heater-cathode voltage ratings for the valves concerned. In practice these ratings are liable to be slightly exceeded, and this point, together with the consequent small risk of cathode-heater breakdown, has to be accepted by the constructor building up the amplifier. The writer would add that, during initial experimental work, he has had the heaters tied direct to the central power supply line and has had no trouble due to breakdown even with voltages exceeding 700 across the complete voltage doubler output.

COMPONENTS

Resistors
(All fixed resistors ½ watt 5% unless otherwise stated)

R1	4.7MΩ
R2	1kΩ
R3	220kΩ
R4	220kΩ
R5	27kΩ
R6	100Ω
R7	330Ω 2 watt
R8	2.2kΩ
R9	2.2kΩ
R10	100kΩ
R11	150kΩ
VR1	2MΩ variable, log
VR2	2MΩ variable, log
VR3	25kΩ variable, log
VR4	2MΩ or 2.5MΩ preset, linear

Capacitors

C1	0.003μF paper or plastic foil
C2	0.2μF paper or plastic foil, 350V wkg
C3	32μF electrolytic, 350V wkg.
C4	32μF electrolytic, 350V wkg.
C5	16μF electrolytic, 350V wkg.
C6	16μF electrolytic, 350V wkg.
C7	50μF electrolytic, 6V wkg.
C8	0.25μF paper or plastic foil

Valves

V1	ECC81
V2	EL84

Rectifiers
MR1, MR2 selenium or silicon rectifiers (see text)

Transformers

T1	Speaker transformer, approx 5,000Ω to 3Ω (see text)
T2	Mains transformer. Secondaries: 250V 60mA, 6.3V 1.06A minimum (see text)

Switch
S1 d.p.s.t. on-off, toggle

Miscellaneous
2 B9A valveholders
Input and output sockets
Chassis, knobs, etc.

2 G. A. Stevens, "A.F. Amplification With The Cascode", 'Wireless World, May 1966.

COMPONENTS

The use of a voltage doubler circuit enables a low-cost mains transformer with a half-wave h.t. secondary to be employed. The potential difference between the transformer h.t. secondary and its laminations and mounting clamp are greater than in normal service, and it is recommended that its metal frame be insulated from chassis. This can be achieved by means of a simple mounting incorporating Paxolin sheet, or a similar material. The heater consumption of the two valves is 1.06A at 6.3V, and this can be readily supplied by any conventional mains transformer. (A suitable transformer is available from R.S.C. Hi-Fi Centres, Ltd., 102-106 Henconner Lane, Bramley, Leeds 13.—Editor.)

Output transformer T1 should be capable of operating with a primary current of 40mA or more, and should match 5kΩ to the 3Ω output impedance. It requires a ratio of the order of 40:1. Like the mains transformer, its mounting clamp and laminations can be insulated from chassis. (An inexpensive 5 watt transformer offering 5,000 to 3.75Ω is available from Home Radio (Components) Ltd., Under Cat. No. TO44.—Editor.)

The author used finned selenium rectifiers for MR1 and MR2. A contact-cooled selenium rectifier is suitable for MR2, but should not be used for MR1 if it is to be bolted to the chassis. Silicon rectifiers having a p.i.v. of 800 or more, such as the BY100, can also be used. It is possible that the low forward resistance of a silicon rectifier may cause the h.t. voltage in the upper section to exceed 250V. If this occurs, a resistor, whose value is found experimentally, should be inserted between the positive terminal of MR1 and the junction of R7 and C6.

Due to the unusual power supply circuit, the negative terminals of C3, C5 and C6 are not at chassis potential. If capacitors in metal cans are used for these components, the cans must be reliably insulated from chassis.

If desired, R7 could be replaced by an l.f. choke of 5 Henrys or more. However, such a choke adds considerable bulk to the amplifier.

The resistive components at the input are given high values and the circuit is suitable for use with a crystal pick-up. R1 ensures that the grid of V1(a) remains at chassis potential if, due to a worn track, there are momentary disconnections between the slider of VR2 and its track. It was found in practice, incidentally, that operation of VR2, even with a new control, tended to be "scratchy" if R1 was omitted from circuit.

CONSTRUCTION

The construction of the amplifier should raise few problems, since the layout is not at all critical. As in all amplifiers, control grid wiring must be kept reasonably short, whereupon it is desirable to have V1 and V2 mounted fairly close together, and to have V1 close to the treble and volume controls. The components in the feedback loop couple into low impedance points in the circuit, and lead length here is less important.

Due to the high h.t. voltages provided, care should be taken to prevent accidental shock both when checking the amplifier and using it later.

SETTING UP

After the amplifier has been constructed and the wiring carefully checked it is necessary for the phasing of the negative feedback connection to T1 secondary to be checked, and for VR4 to be set up.

Insert a 0—100mA meter in series between R7 and its connection to C5 and the amplifier circuits, then set VR4 to approximately central position and VR2 to the minimum volume position. Connect up a loudspeaker and switch on. If the amplifier oscillates, reverse the connections to T1 secondary.

If nothing happens after warming up and the meter indicates either a very low or a very high current, adjust VR4 *by moving its slider towards the chassis end of its track* until the meter reads 35 to 40mA. If this process causes the amplifier to oscillate, reverse the connections to T1 secondary. Then, finally set up VR4 to a reading of 35 to 40mA. Take the meter out of circuit, and the amplifier is ready for use.

If, however, a silicon rectifier has been employed for MR2, next check the h.t. voltage across C5. Should this be in excess of 250V, insert a resistor in series with the rectifier as described earlier until a 250V reading is obtained. After this, VR4 may be adjusted for the final current of 35 to 40mA.

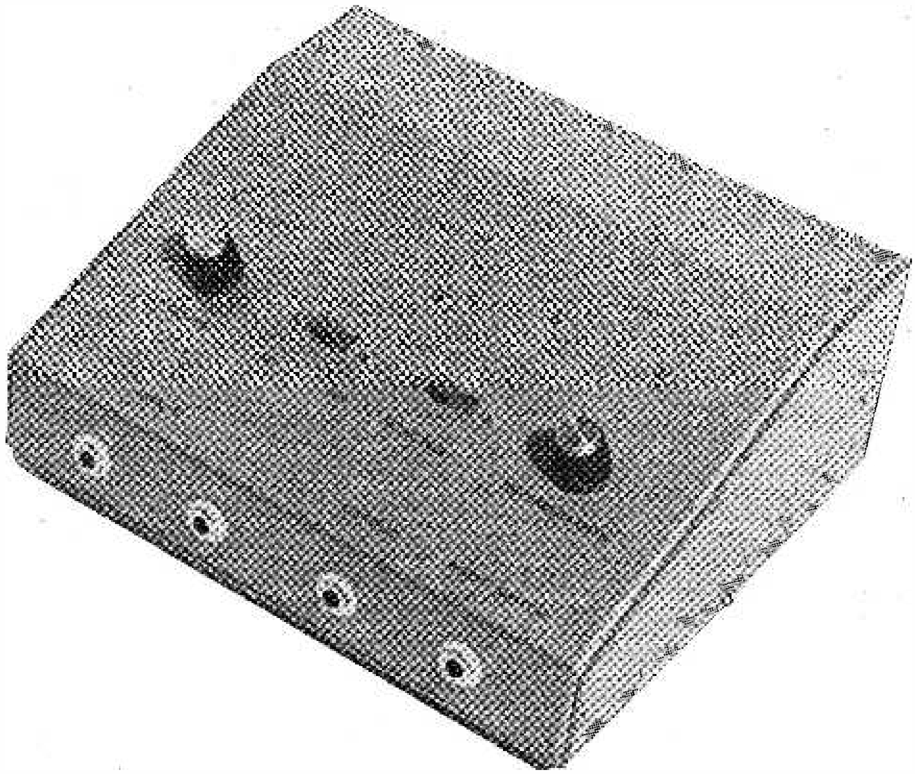
The reason for the apparently anomalous statement that VR4 slider should be adjusted towards the chassis end of its track when the initial current is either low *or* high is that V1 operates in a cascode circuit. With VR4 at the centre of its track V1(b) should, normally, be drawing a relatively heavy anode current, thereby causing V2 control grid to be well negative of its cathode, possibly beyond cut-off. As the slider of VR4 approaches chassis, V1(b) draws less anode current until a point is reached where the bias on V2 grid enables this valve to pass the requisite 35 to 40mA current. This is the correct operating point for VR4.

If, on the other hand, the slider of VR4 is moved towards the h.t. positive end of its track, the grid of V1(b) becomes more and more positive, whereupon this grid starts to pass an increasing amount of the cathode current available from V1(a). V1(b) anode current then falls and, again, a point can be reached where V2 draws 35 to 40mA. This is a *false* operating point since, although V2 is correctly biased, V1(b) is not. The situation is misleading because some amplification is still provided (accompanied, in the prototype, by a loud hum) and it might be assumed that a fault lies elsewhere.

To sum up ,VR4 offers two settings at which current in V2 is 35 to 40mA. The correct setting is that where the slider of VR4 is nearer the chassis end of its track. The incorrect setting should, if possible, be avoided.

(To ensure that the bias on V2 grid does not vary excessively due to aging in V1, it would be desirable to re-check the setting of VR4 from time to time after the amplifier has been put into use. These later checks could be facilitated if, when carrying out the initial setting up process, a note were made of the measured voltage across R7 which corresponds to the desired current of 35 to 40mA. This will be of the order of 12V, varying according to the actual value, within its tolerance, of the resistor. These subsequent checks would then merely require the connection of a voltmeter across R7 instead of the insertion into circuit or a current-reading meter.—Editor.) ■

RADIO CONSTRUCTOR — Next Month



TRANSISTORISED REVERBERATION UNIT

Add a "third dimension" to reproduced music with the aid of this simple-to-build reverberation unit, which can take its input from electric guitars, medium or high impedance microphones, or any other normal sound source. The output of this unit can feed into a standard amplifier or tape recorder, and results are particularly impressive when it is employed with an electronic organ. Construction time is considerably reduced by taking advantage of a ready-assembled transistor amplifier.

ALSO:

★ **COIL COVERAGE TEST UNIT**

★ **TRANSISTOR SUPERHET FOR TOP BAND**

★ **SIMPLE VOLTAGE AND FREQUENCY CONVERTER**

ON SALE JULY 2nd

THE "SPONTAFLEX" F.M. PORTABLE RECEIVER

by

SIR DOUGLAS HALL, K.C.M.G., M.A.(Oxon)

By combining a synchronous oscillator method of detection with the author's "Spontaflex" circuit, this 4-transistor receiver offers loudspeaker reception of all three local f.m. transmissions

DURING THE COURSE OF SOME recent experiments the author found that certain silicon transistors would oscillate happily at 100 Mc/s, or over, in the "Spontaflex" configuration. This clearly led the way to a new f.m. design, and the present article is concerned with the result—a result which is very satisfactory as it enables an f.m. tuner to be built with the use of only two inexpensive transistors and a handful of cheap, easily obtainable components. What is more, the two transistors also provide two stages of audio frequency amplification and the sensitivity of the tuner is such that it gives excellent results on a telescopic aerial in a somewhat shielded position about 18 miles from North Hessary Tor. Furthermore, the tuner is stable. Assuming constant battery voltage, there is virtually no frequency drift.

CIRCUIT OPERATION

The circuit is shown in Fig 1, and for the time being only that part to the left of the dashed line will be considered. The part to the right of the line is merely a simple audio frequency amplifier to enable the tuner to be heard at reasonable room strength on a speaker. It will be seen that the tuner shows a close resemblance to the author's short wave receiver described in the January 1968 issue, though it functions in rather a different manner.*

The signal is applied by a 36in. telescopic aerial to the emitter of TR1 which works as a common base radio frequency amplifier. It then appears, in amplified form, across the choke L1 which has the high value, for an f.m. design, of 2.5mH. If a more usual v.h.f. choke is substituted the receiver may fail to function.

TR2 is the "Spontaflex" amplifier and it is adjusted to oscillate gently at the central frequency of the incoming signal. This signal, being frequency modulated, has a varying frequency depending on the modulation. The local oscillation will lock to this signal and the amplitude of the local oscillation will therefore vary, becoming less as the incoming signal becomes out of tune with the fixed tuned circuit. The frequency modulation is therefore changed to amplitude modulation, and from this point onwards TR2 functions as a normal "Spontaflex" amplifier. That is to say, it amplifies the now amplitude modulated signal as a common collector radio frequency amplifier, the amplified signal being applied to D1 which demodulates it. TR2 then performs yet another function and offers audio frequency amplification in the common base mode, the result appearing across R4 and passing back to TR1 again, which now amplifies as a common collector audio frequency amplifier. This finally amplified signal appears across the volume control, VR3, where it is available for such further amplification as may seem desirable. Good phone signals will be heard in a pair of sensitive, fairly low impedance phones across C9. The easily obtainable DLR5 headset

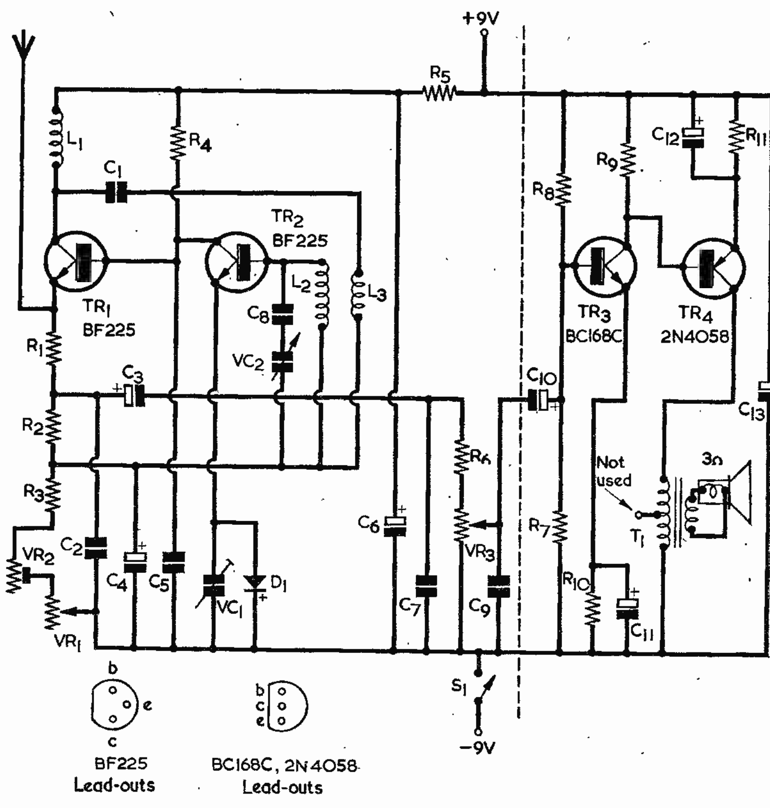


Fig. 1. The circuit of the "Spontaflex" f.m. portable receiver. The components to the left of the dashed line constitute a complete f.m. tuner

* Sir Douglas Hall, "The 'Spontaflex' Transistor Short Wave Receiver", 'The Radio Constructor, January 1968.

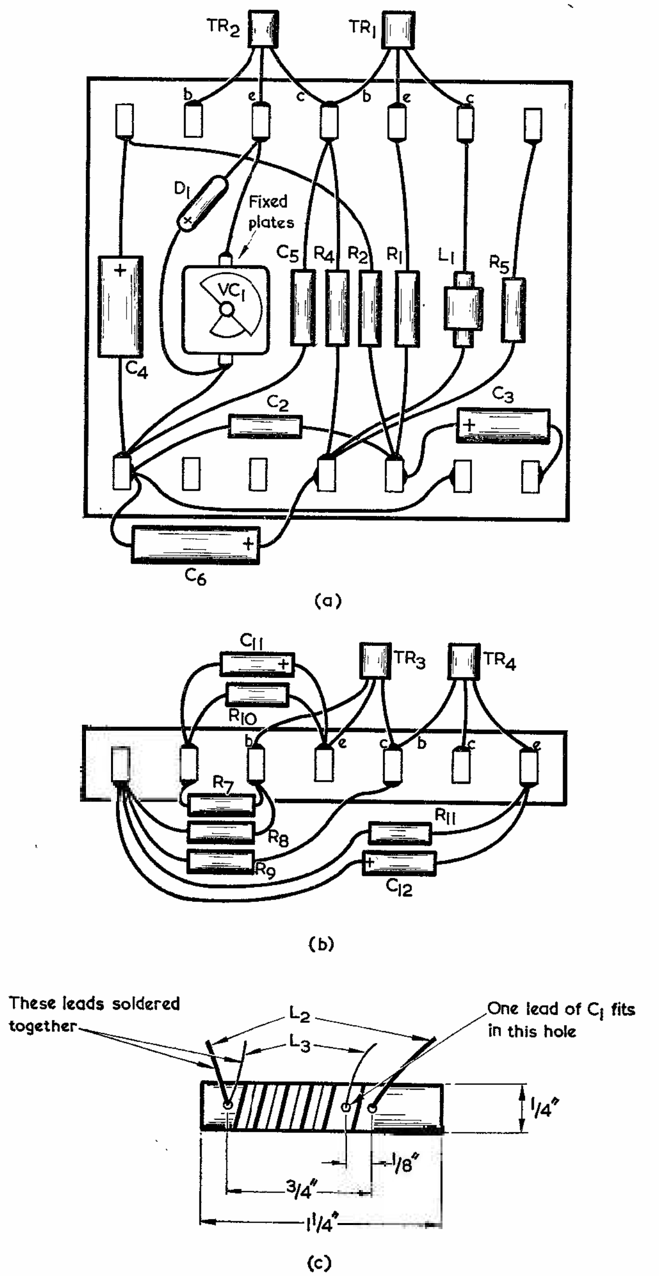


Fig. 2(a). Most of the tuner section is accommodated on this 7-pair groupboard

(b). The a.f. amplifier section is mounted on a 7-way tagstrip

(c). Details of the coil unit

(available from Henry's Radio Ltd.) is ideal.

This basic means of changing the frequency modulated signal to amplitude modulation is not new, and is known as the synchronous method.

The functions of TR2 in the author's circuit bear repetition. First, TR2 amplifies the frequency modulated signal by regeneration. Next, it changes the frequency modulation to amplitude modulation. Third, it amplifies this amplitude modulated radio frequency signal and finally it amplifies the audio signal produced across D1. TR1 also provides two stages of amplification.

Oscillation is produced by the capacitance tap (Colpitts) method, but whereas in the earlier short wave receiver reaction was controlled by varying the capacitance across D1, and the base bias of TR2 was preset, in the present design the amplitude of oscillation is controlled by varying the base bias of TR2, the capacitance across D1 being preset.

When the receiver is first wired up, C8 should be omitted and replaced by a direct connection. In most instances, it can later be introduced to reduce the range offered by the 15pF tuning capacitor, VC2, and consequently make tuning easier. C8 also reduces the chance of microphonic howling which can be caused by the sound waves from the speaker causing the vanes of VC2 to vibrate, since it reduces the effect which that component has on resonant frequency.

It will be seen that there is elaborate filtering of the radio frequency signal by means of R1, C2, C7, R6 and C9. This may seem excessive, and the presence of C7 and C2, virtually in parallel with each other, particularly so. But the lead between C3 and the volume control is quite long, at v.h.f., and if C7 is omitted the volume control may have an r.f. voltage across it.

It should be noted that the electrolytic capacitor, C4, needs to bypass v.h.f. as well as audio frequency signals. The author found that modern electrolytic capacitors were satisfactory for this function but that some older components offered quite a high impedance at these frequencies. If any difficulty is experienced in persuading TR2 to oscillate it is advisable to place a silver-mica capacitor of about 2,000pF across C4.

So much for the theoretical description of the tuner section which is, as has been said, a complete headphone receiver in itself.

The a.f. amplifier section, to the right of the dashed line, is a simple affair which needs little comment. Two high gain transistors are used in the common emitter mode, the first being n.p.n. and the output p.n.p. It will give good loudspeaker results at ample volume for a normal room. If a more powerful amplifier is substituted for the one specified, it may well prove necessary to screen the leads to VR3 and there is a strong possibility of microphonic howling due to feedback to the vanes of VC2. In fact, if a powerful amplifier is to be used it would be wise to employ a separate speaker.

The volume control, VR3, is part of the tuner section and should remain so if separate units are constructed. Any tone control required may be incorporated with the amplifier section. The complete circuit, as shown in Fig. 1, draws about 16mA from the battery, and the design will only remain free from frequency drift so long as the battery voltage remains constant. In consequence a fairly large battery should be used. The tuner section passes only about 1mA or less.

CONSTRUCTION

When the reader is ready to start construction, Fig. 2 should be examined and the tagboard and tagstrip assemblies made first. A section with 7 tag pairs cut from a standard (not miniature) 18-pair Radiospares tagboard is suitable for the tuner unit components, and a simple single-line 7-way tagstrip for the amplifier components. The tuner unit tagboard should have a piece of Paxolin cemented to its underside so that the bottoms of the tags do not come into contact with the plywood panel to which it is later fitted. Component layouts on the tagboard and tagstrip are illustrated in Figs. 2(a) and (b) respectively. The components are shown parallel to each other in these diagrams for clarity, but there is no need for this example to be followed, and components may cross each other in the interests of short wiring provided that there are no possibilities of short-circuits.

Fig. 2(c) illustrates the coil unit, L2 L3. A piece of ¼in. diameter Perspex rod about 1¼in. long is used. Two 1/16th inch holes are drilled, ⅜in. apart, and a third hole about ⅛in. on the inside of one of these holes. Six turns of 24 s.w.g. enamelled wire are wound, starting through one outside hole and finishing through the other. The turns are spaced out as evenly as possible, and about 1in. of wire is left protruding through each hole for connections. A length of 32 s.w.g. enamelled wire is then soldered to one of the thicker wire ends as shown, and passed through the appropriate hole. Five turns are then wound, in between the turns of the other winding. The end of the 32 s.w.g. wire is passed through the intermediate hole and the wire end of a 2pF capacitor (C1) is also passed through this hole and wedged into place with a sharpened matchstick. The end of the five turn winding is then soldered to the lead of the capacitor which had been wedged into position. The coil unit is now complete.

Next, a piece of ½in. plywood measuring 12in. by 12in. is cut out and a suitable hole made in it at one end to take the 10in. by 6in. speaker. This rather large speaker is recommended because of the good quality it provides. Also, it will make maximum use of the rather small a.f. output. The speaker should be fitted so that one long edge is flush with one edge of the board. Flush with the opposite edge of the board is a piece of wood, 7in. by 1¾in. and not less than ⅜in. thick. See Figs. 3 and 4. Next a piece of Paxolin or Perspex is cut, 7in. by 4in. by about ⅛ to ¼in. and three holes are drilled in it to take the three controls. The hole for VC2 should be in the exact centre and the other two holes 2½in. on either side. VC2, VR1 and VR3 are now fitted in place, and the bottom edge of the panel is screwed to the appropriate edge of the 7in. by 1¾in. piece of wood.

A plywood top panel is next cut, 12in. by 4½in., and holes are drilled in it to coincide with the three holes in the Paxolin or Perspex panel, and a fourth hole for the aerial socket as shown in Fig. 3. Note that the top panel is fitted such that its front edge covers the edge of the 12in. by 12in. panel, so that its holes for the controls will need to be 2¼in. rather than 2in. from the front edge. An epicyclic ball drive is fitted to the hole for VC2 and its spindle is linked up by means of a flexible coupler and a short length of Perspex rod. The spindles of VR1 and VR3 should be long enough not to require any extension. The top panel may now be screwed to the 7in. by 1¾in. piece of wood, and the grub screws of the flexible coupler tightened up. The aerial socket should also be fitted.

Finally, a piece of plywood having the same dimensions as the top panel may be fitted at the lower end of the 12in. by 12in. panel with the aid of suitable brackets. This forms a base and enables the assembly, in its present condition, to be set up with the controls at the top.

The tagboard and tagstrip should

COMPONENTS

Resistors

(All fixed values ¼ watt 10%)

R1	390Ω
R2	3.9kΩ
R3	390Ω
R4	22kΩ
R5	1kΩ
R6	330Ω
R7	3.9kΩ
R8	18kΩ
R9	2.7kΩ
R10	1.2kΩ
R11	100Ω
VR1	500Ω pot., wirewound
VR2	1kΩ preset pot., standard size (not miniature)
VR3	5kΩ pot., log track, with switch S1

Capacitors

C1	2pF ceramic
C2	0.05μF ceramic
C3	100μF electrolytic, 6V wkg.
C4	100μF electrolytic, 2.5V wkg.
C5	1,000pF ceramic
C6	100μF electrolytic, 9V wkg.
C7	0.01μF ceramic
C8	30 or 33pF (see text) silver-mica
C9	0.01μF ceramic
C10	100μF electrolytic, 2.5V wkg.
C11	100μF electrolytic, 2.5V wkg.
C12	100μF electrolytic, 2.5V wkg.
C13	640 to 1,000μF electrolytic, 9V wkg.
VC1	20pF trimmer, air-spaced
VC2	15pF variable, air-spaced (see text)

Inductors

L1	2.5mH r.f. choke type CH1 (Repanco)
L2,3	See text
T1	15:1 (approx) output transformer type TT5 (Repanco) or similar. (Type TT5 is available from Home Radio)

Semiconductors

TR1	BF225 (Texas)
TR2	BF225 (Texas)
TR3	BC168C
TR4	2N4058
D1	OA81 (Mullard)

Switch

S1 Part of VR3

Aerial

Panorama type TR6 (Panorama Radio Ltd., 73 Wadham Road, London, S.W.15.)

Speaker

3Ω elliptical, 10in. by 6in.

Battery

2-off No. 126, or single PP9 (Ever Ready)

Miscellaneous

18-way tagboard (from which a 7-tag section is cut) Cat. No. BTS10 (Home Radio)
7-way tagstrip
2-way tagstrip
Epicyclic tuning drive
Flexible spindle coupler
Car aerial socket
¼in. Perspex rod
3 knobs
Paxolin, plywood, etc.

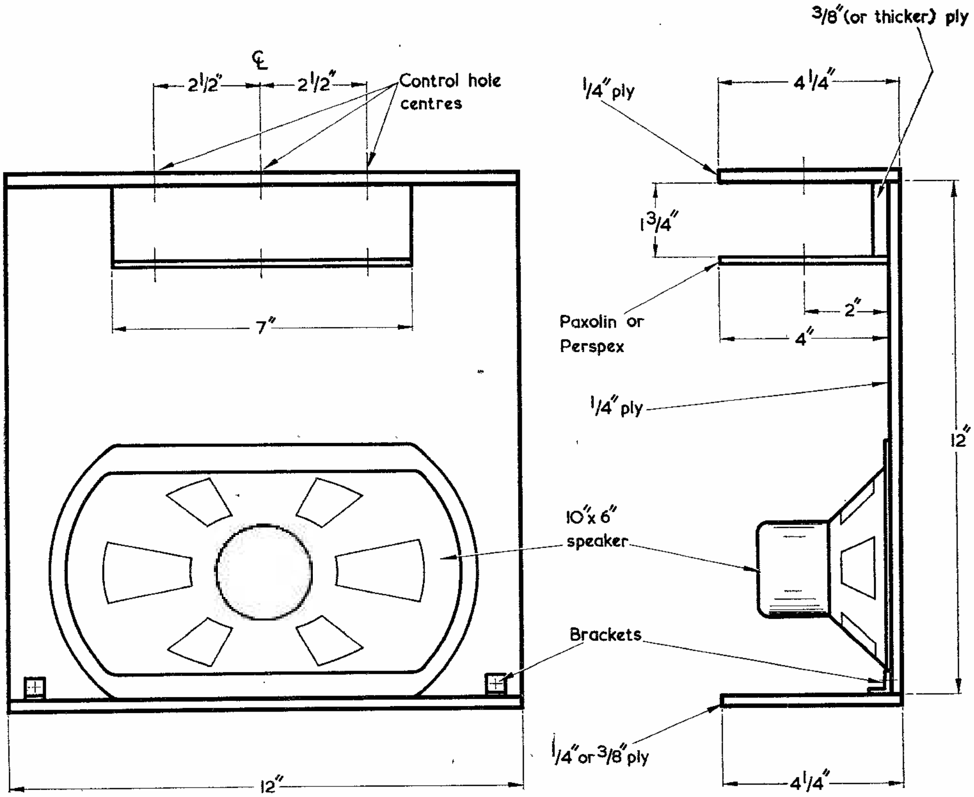


Fig. 3. Illustrating the assembly of the panels on which the receiver is built

be screwed to the main panel such that C8 leads, when this component is later fitted, will be as short as possible. As was mentioned earlier, this capacitor is replaced by a direct connection during initial testing. The components and leads shown in Fig. 4 should be connected up. Finally, the speaker can be mounted in place over a suitable piece of speaker fabric. It is convenient to connect the secondary leads of T1 to a small 2-way tagstrip.

TESTING

To test the receiver, the aerial should be fitted such that it lies horizontally and can therefore be swivelled broadside on to the direction of the station to be received. The aerial specified is very suitable, but any other can be substituted provided it is jointed, can be plugged in, and can offer a length of about 36in. Variation in aerial length alters the load on the input of TR1 and consequently its output impedance, and the load offered to TR2, is also altered. A variation of the length of the aerial will therefore require a different setting for VR1 or VR2. However, it is permissible, and indeed sensible, to try different lengths for best results on the three B.B.C. stations, and then mark the aerial so that it can be extended to the same point each time the receiver is used. In the author's locality, a fully extended aerial gave good results on all stations.

Adjust VC1 so that its vanes are about one-quarter to one-third closed, and VC2 so that its vanes are about two-thirds to three-quarters closed. Set VR1 to a central position and leave it alone for the time being. VR2 should be set with its slider at the end connected to R3. This is fully anti-clockwise as shown in Fig. 4. Switch on with VR3 and turn this control fully clockwise. Make sure a 9-volt battery has been connected up!

There should now be a gentle hiss from the speaker. If there is not, something is wrong and the wiring, etc., should be inspected again. Assuming the hiss to be present, turn VR2 clockwise and at a point which may be half-way, or before, a louder hiss should start. This denotes oscillation. Now turn VC2, first one way and then the other, keeping VR2 adjusted so that the louder hiss is just starting. The three B.B.C. stations should then be received. If the louder hiss has not come in, try different settings for VC1 and repeat the process described. Once the stations have been initially received, various combinations of settings of VC1 and VR2 can be tried for best results. It should be possible to find a setting which is just right for all three stations, without the necessity of altering the setting of VR1 when tuning from one to another. Nevertheless, VR1 is still there to be used, as required, during normal reception. When the best combination of settings for VC1 and VR2 have been found, they should be left alone.

The proper use of VR1 will soon be found in practice. Set too far in a clockwise direction will cause distortion, or violent oscillation. Set too far anti-clockwise will result in weak signals, or a complete disappearance of signals if the setting is badly out. The use of VR1 is no more critical than the use of a reaction control with a simple short wave receiver.

It will probably be found that stations are received with VC2 about half closed. In this case, C8 should be wired into position in-

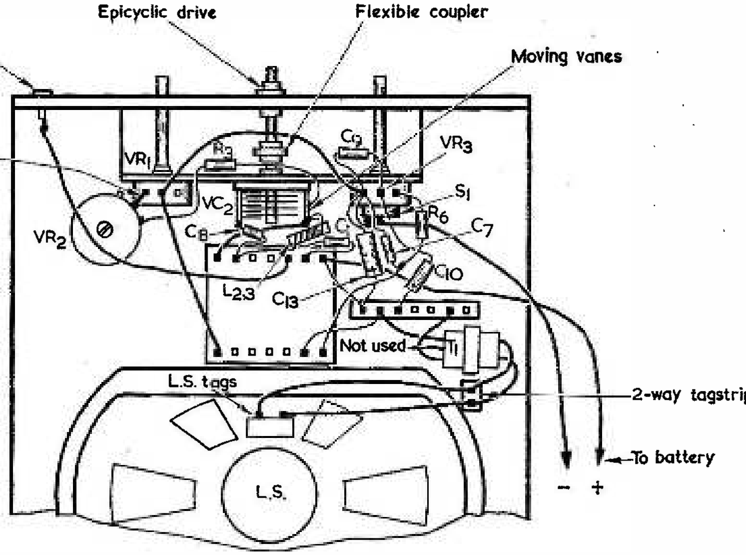


Fig. 4. Final details of the wiring

stead of the direct connection. If the stations can now no longer be received with C8 in circuit a higher value of, say, 47pF may be tried. Do not use two capacitors in parallel.

The author leaves the reader to design his own cabinet.

TRANSISTORS

A final but important word about components. Many transistors were tried for TR2, but a large number would not oscillate in the rather stringent conditions imposed by common collector configuration, together with a collector current of only about 100μA. Some others worked well but are not easily available. The one specified worked very well and is easily available. It is also the transistor most suitable for TR1. Do not be tempted to buy a substitute unless it has been tested in this actual circuit and found to be satisfactory. Many transistors which are said to oscillate, at, say, 700Mc/s, or higher, will only do so when passing about 10mA current —and only one-hundredth of that current is available in this circuit. TR3 and TR4 are not critical, but the ones selected give good results. The author obtained all his transistors from Amatronix Ltd.

D1 is very important. Use the easily obtainable OA81, and not a substitute. As a matter of interest the author tried many surplus diodes, but only one type would allow the receiver to function, and even then not very well.

VC1 should be air spaced. Although a mica dielectric component will work in this position, it is less satisfactory.

VC2 must be a good v.h.f component, with widely spaced vanes, first class insulation, and a good quiet contact to the moving vanes. Closely spaced vanes will result in a horrid howl. TR2 gets all the frequency modulation it wants from the aerial, without any unwelcome addition from the speaker! The prototype uses an ex-Government capacitor, many of which are beautifully made and reasonably priced. A Jackson type C804 would be a very suitable alternative. (This would be available from Home Radio under Cat. No. VC26D. —Editor.)

The prototype has been built with three different layouts, and with different components including several specimens of the transistors specified. It has proved perfectly reliable in all cases. In addition, a friend and fellow reader who lives close to the author has made up a receiver working from the draft of this article. This receiver gives equally good results from the B.B.C. stations, and in addition he has received the French f.m. transmissions, all on a short length of flex as an aerial. Incidentally, this reader demonstrated to the author the use of a pair of Hi-Fi moving coil headphones, with an overall impedance of 800Ω, connected in series with an isolating electrolytic capacitor across R9. TR4 was removed from the circuit. Reception can only be described as superb.

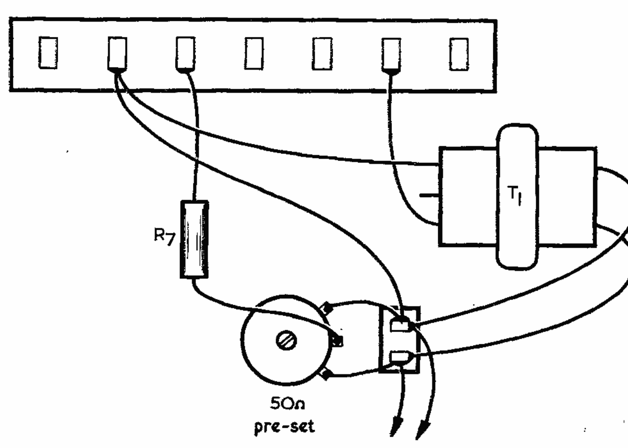


Fig. 5. A simple method of adding negative feedback to the a.f. amplifier section

NEGATIVE FEEDBACK

As a non-essential refinement, some readers may like to add negative feedback to the amplifier section. This can be done by connecting the outside tags of a 50Ω preset potentiometer across the secondary of T1, one side being also connected to the negative supply line of the amplifier. The lead from R7 which at present goes to the negative supply line is taken instead to the slider of the potentiometer. See Fig. 5. Only a small movement of the slider away from the negative end of its track is needed to provide sufficient feedback to give a useful improvement in quality. Too large a movement will cause excessive attenuation. If a different transformer is employed, and oscillation instead of attenuation results, reverse the secondary leads of T1.

RESONANT GATE TRANSISTORS

by

J. B. DANCE, M.Sc.

The phenomenon of mechanical resonance can be employed in the provision of tuning elements for integrated circuits

Mechanical resonance in an electronic component (such as microphony in a thermionic valve) is usually a very undesirable phenomenon. In a few special cases it can, however, have useful applications, such as in mechanical filters and in quartz crystal resonators. Both of these employ mechanical resonance to produce oscillating systems of very high Q factors. A new device which utilises mechanical resonance for frequency selectivity is the Westinghouse resonant gate transistor. It can be employed as part of an integrated circuit.

The resonant gate transistor uses a minute metal cantilever as a mechanical resonator which normally operates in the range of 500 c/s to 50kc/s. The device is essentially a fixed tuned one, the resonant frequency being determined by the mechanical dimensions of the cantilever. However, it is possible to make some slight adjustment to the resonant frequency by a suitable variation of the applied voltage. The uppermost frequency for a device of this type is determined by the smallest size of the cantilever which can be made by the photoresist technique, although frequencies higher than the normal maximum can be obtained by operating the device in an overtone mode. The lower frequency limit is determined by the sensitivity of the device to vibration, this sensitivity increasing in inverse proportion to the square of the frequency.

The construction of the device is similar to that of a metal-oxide-silicon transistor (MOST), except that the normal gate electrode is replaced by the cantilever—hence the name, resonant gate transistor. An input signal will produce an electrostatic force on the cantilever. For linear operation, however, the input signal must be superimposed on a polarising voltage, since the electrostatic force is proportional to the square of the applied voltage.

When using the device, care must be taken to ensure that a suitable current limiting resistor is employed in series with the polarising supply voltage, or the device will probably be destroyed.

The Q of the resonant gate transistor is typically in the range 30-150 at atmospheric pressure, but may increase to over 1,000 at very low pressures. The damping effect of the atmosphere on the moving cantilever causes a considerable reduction in the Q factor.

The resonant gate transistor can be employed to increase the range of applications of integrated circuits. The mechanical oscillator has a relatively good stability and this results in the device showing less drift than that obtained from integrated circuits using conventional tuning techniques.

SPECIAL AMATEUR RADIO STATION

A special amateur radio station (GB3SUA) will be operated by the Stratford Radio Club from July 11th to 13th, 1969, to celebrate the 700th Anniversary of the Guild of the Holy Cross in the town. This Guild was the start of local government in Stratford, whose Charter was granted in 1553.

The station will operate on the 10, 15, 20 and 80 metre bands in the s.s.b./a.m./c.w. modes and a special QSL card will be issued via the RSGB Bureau. The station will be situated opposite the Royal Shakespeare Theatre and will be open to the public.

Other attractions in the town during the above period will include a boat rally, a midnight water carnival and public dancing in the streets.

ELECTRICAL ENGINEERS EXHIBITION

A massive campaign to attract a record overseas participation and attendance at the 15th International Electrical Engineers Exhibition, to be held at Earls Court, London, from 8th to 15th April, 1970, has been launched by the organisers.

The Exhibition is sponsored by the Association of Supervising Electrical Engineers.

A mailing of invitations and brochures to 37,500 addresses in 164 countries has just been completed. Already, nearly 1,000 replies have been received from prospective overseas exhibitors and visitors.

The mailing covered manufacturers in the electrical industries, Chambers of Commerce, Trade Associations and the technical press.

Arrangements have been made for parties of visitors from Europe to have combined travel and hotel accommodation facilities at special rates. This is being organised through Thomas Cook and B.E.A.

"This is designed to encourage educational bodies and professional and trade associations to send parties of delegates," said Mr. P. A. Thorogood, General Manager of the Exhibition. "It will give them the opportunity of obtaining technical information about products and equipment shown at the Exhibition, such as the new metric standards now being introduced by British manufacturers."

Later this year there will be a follow-up publicity campaign in 164 countries, directed mainly through technical and industrial journals. The organisers are in contact with more than 4,000 such journals throughout the world.

During the 1970 Exhibition the British Electrical and Allied Manufacturers' Association is sponsoring a three-day international conference on electrical insulation. This will cover developments in and evaluations of insulation materials for a wide range of applications in power supply and in industry.

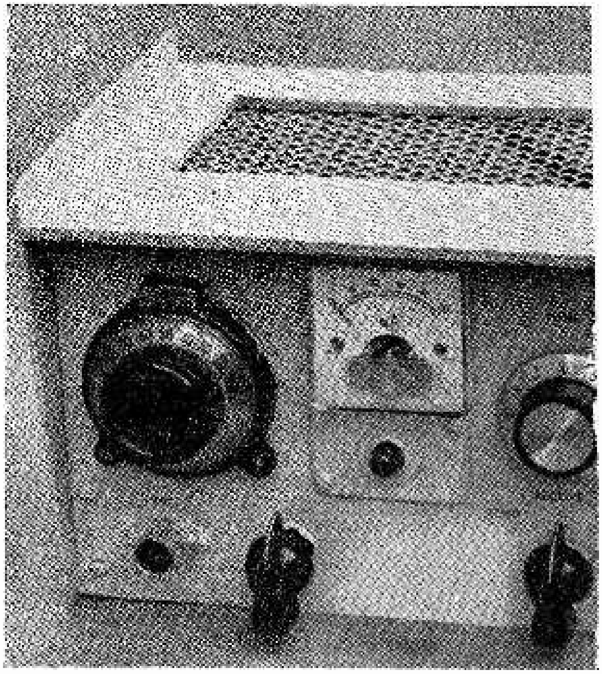
To date, more than 200 companies and governmental bodies have provisionally booked space totalling 120,000 square feet.

Cover Feature

TOP BAND "QUARTET" TRANSMITTER

by

A. S. CARPENTER, G3TYJ



An easily built little transmitter using reliable circuitry which can be operated fixed or mobile on either Phone or CW. This transmitter must not, of course, be used without the appropriate Post Office licence. A companion receiver, similarly designed for Top Band, will be described in next month's issue

SEMI-MINIATURE TRANSMITTERS SUITABLE FOR TOP Band/M working are usually of interest to the licensed Amateur fraternity, this being particularly true when 'sure-fire' circuitry is employed. Fixed station operators may also find the neat pocket-handkerchief-sized rig of interest— at least it is hoped so. Optional phone/c.w. facilities are a worthwhile inclusion and are incorporated in the little rig to be described. Using valves in the transmitter simplifies a design which cannot yet be made less expensively 'sure-fire' with transistors as the r.f. active components.

CIRCUITRY

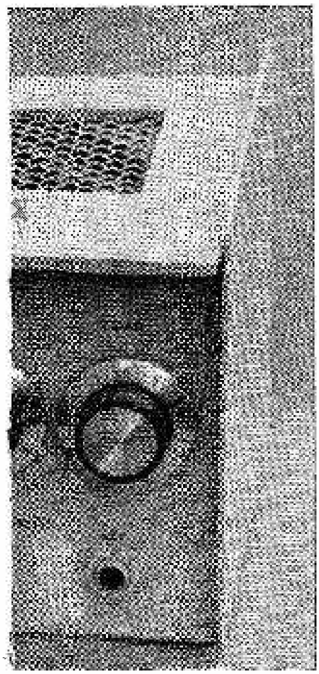
The complete transmitter circuit, which can be powered either by an external mains power supply unit or by a transistorised d.c.—d.c. inverter delivering 100mA at 300V, is given in Fig. 1.

Only four valves (plus a stabiliser tube) are used, with V1, operating as v.f.o. and multiplier, feeding V2, the final r.f. amplifier. The remainder of the circuit consists of a 2-stage speech amplifier feeding V4 which effectively anode/screen modulates the r.f. stage when Function switch S2 is in the 'Phone' position. When S2 is at the 'CW' position any charge left on the modulator h.t. line is leaked away via resistor R20.

RF STAGES

The v.f.o. circuitry around V1(a) is reliable, and in the interests of obtaining a good c.w. note operates at a division frequency. This may be either over the range 600-666 kc/s, or 900-1,000 kc/s to give final output in the Amateur frequency band of 1,800-2,000 kc/s. Frequency multiplication is taken care of by V1(b) and coil L2 is pre-tuned to afford maximum output at approximately 1,900 kc/s; v.f.o. tuning is panel-controlled via a small vernier reduction drive scaled 0 to 100. In the prototype, the v.f.o. ran at 600-666 kc/s, but the range 900-1,000 kc/s is equally satisfactory in practice.

The stabiliser tube, V5, provides stabilised h.t. for V1, The ECF80 triode chosen as oscillator is able to work satisfactorily from an applied d.c. potential of 150V, as supplied by the stabiliser. Stabilising the triode section of the valve alone seems less effective than when both sections are similarly treated. Additionally, both sections of V1 are allowed to run continuously when the transmitter is 'On' and drift is thus virtually eliminated once the rig has reached its normal operating temperature. On 'Receive' the v.f.o. does not interfere with reception in any way provided the value assigned to the detuning capacitor, C21, is so chosen that harmonics do not fall in the frequency range of 1,800-2,000 kc/s. It will be appreciated that the associated power supply unit will 'see' differing load currents as the transmitter is operated. The lightest load is presented to the supply during 'Receive' when only V1 and V5 are operating but to prevent the applied h.t. potential from rising excessively a swamping resistor, R19, is included as a dummy bleeder.



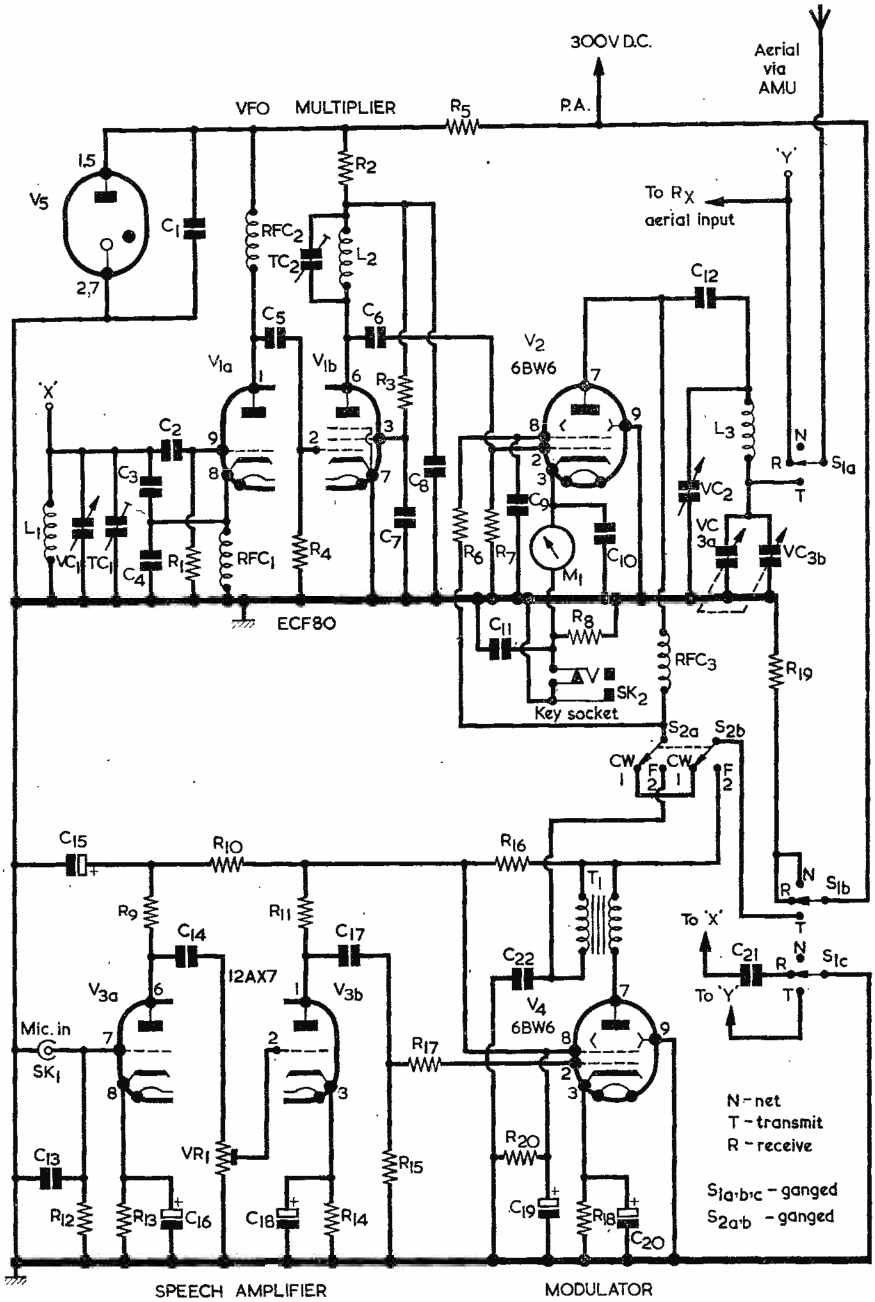
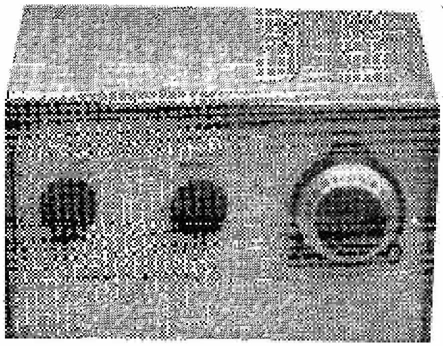


Fig. 1. Complete circuit of the Top Band "Quartet" transmitter

The p.a. stage is conventional pi-tank output with cathode keying. The meter is also included in the cathode circuit of V2 and thus enables the user to check that drive is present prior to going over to 'Transmit'. To check for drive, S1 is placed at 'Net' and in this position some 1.5 to 2mA should be just detectable in the meter.

AUDIO STAGES

Use of a crystal microphone is assumed, this being connected to socket SK1. The modulator looks simple enough but care is needed during construction if the full potential gain is to be realised. To adequately modulate the transmitter at least 5 watts of audio



Front view of the completed receiver – see next issue

must be developed and this is not over-easy using a single 6BW6 valve for the output stage. This means that the whole modulator must operate at maximum efficiency and to this end high value anode and grid return resistors are fitted. The speech amplifier valve, V3, is an excellent choice for the work, but it does tend in common with all high gain devices to become unstable when pressed hard. All grid leads *must* therefore be short, carefully oriented and run in screened cabling whilst unwanted capacitive positive feedback must be eliminated by keeping anode and grid circuits well apart.

A variable modulator gain control is unnecessary and the preset control VR1 may be fitted to the rear chassis apron. An anti-parasitic 'stopper' resistor, R17, was also found essential in the prototype, one end of this component being soldered direct to V4 valveholder at pin 2.

Audio modulation of the p.a. stage is achieved via T1 which, in the prototype, is a half-wave mains transformer. This is of the type having a mains voltage primary and an h.t. secondary offering 230 to 250 volts at a current of 25mA or more, a typical example being the Elstone MT11. The primary is in the V4 anode circuit. The heater windings are ignored and their connecting lead-outs are merely taped up and placed safely out of the way. It is appreciated that a proper modulation transformer might perform slightly better but, in the present instance, operation is only at 10 watts maximum d.c. input and the mains transformer works, in practice, very well. (Since a mains transformer has interleaved laminations instead of the butt-jointed laminations normally associated with modulation transformers, it might be worth-while checking whether modulation is improved if the leads to either the primary or secondary are experimentally transposed. If the magnetising force due to V2 opposes that due to V4, there is less risk of approaching core saturation.—Editor.)

SWITCHING

The Phone/c.w. switch S2 simply removes or connects h.t. to the modulator as required, the T1 secondary being bypassed when c.w. is the desired operating mode.

The main operating switch is S1 and is a 3-pole 3-way rotary Yaxley type, the central position being assigned to 'Receive'. In this position, the modulator and p.a. are inoperative whilst the v.f.o. and multiplier are running but thrown off-tune due to capacitor C21. The aerial is also connected through to the associated receiver. At the 'Net' position, to right of centre, capacitor C21 is disconnected and the v.f.o. signal may be sought on the receiver or may be tuned to the receiver as required, anywhere in Top Band. Moving the operating switch to its remaining position, 'Transmit', brings the p.a. to life and also the modulator provided S2 is at the Phone position; normal tuning and loading of the p.a. using the meter as a guide is then possible.

(A 3-pole 3-way switch is specified for S1. If, however, the transmitter is to be used with the receiver which will be described next month and if no external aerial switching or receiver disabling facilities are provided, it would be preferable to use a 4-pole 3-way switch. The spare pole may then be used to switch off the receiver when transmitting.—Editor.)

COILS

L1 may be a small medium wave coil provided that it is a robust and well-made component. If the coil has an r.f. coupling winding (i.e. a coupling winding which is intended for connection to the anode of a preceding r.f. amplifier) this coupling winding may be ignored. It is best to avoid using a medium wave coil with a coupling winding intended for connection to an aerial, as such coupling windings sometimes resonate with their own self-capacitance at a point in the medium wave band and cause unwanted absorption effects. Although an air cored coil may be preferred, an iron-dust cored coil has the advantage that it can simplify initial setting up, since its core may be adjusted to permit Top Band to be spread over the whole length of the v.f.o. tuning scale. For L2 another

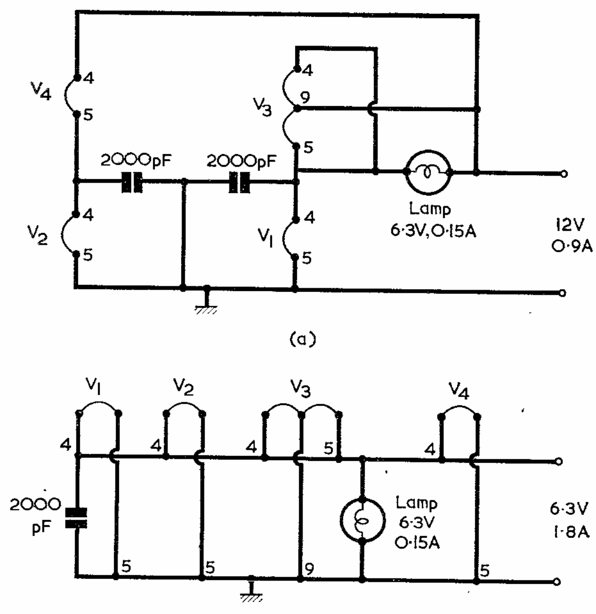


Fig. 2(a). How the heaters and panel lamp are connected for 12 volt operation
(b). The heaters and lamp are wired in parallel for 6.3 volt operation

COMPONENTS

Resistors
(All fixed values ½ watt 10% unless otherwise stated)

R1	47kΩ
R2	470Ω
R3	6.8kΩ
R4	47kΩ
R5	6.8kΩ 10 watts
R6	6.8kΩ 1 watt
R7	22kΩ
R8	100kΩ
R9	470kΩ
R10	18kΩ
R11	330kΩ
R12	3.3MΩ
R13	3.3kΩ
R14	2.2kΩ
R15	1MΩ
R16	1.5kΩ
R17	10kΩ
R18	330Ω
R19	27kΩ 5 watts
R20	470kΩ
VR1	2MΩ potentiometer, log, pre-set

Capacitors
(All fixed capacitors 350V wkg. unless otherwise stated)

C1	0.01μF ceramic
C2	100pF silver mica
C3	1,000pF silver mica
C4	1,000pF silver mica
C5	100pF silver mica
C6	330pF silver mica
C7	0.01μF ceramic
C8	0.01μF ceramic
C9	2,000pF ceramic
C10	2,000pF ceramic, 100V wkg.
C11	2,000pF ceramic, 100V wkg.
C12	1,000pF paper, 1,000V wkg.
C13	100pF ceramic, 100V wkg.
C14	1,000pF ceramic
C15	8μF electrolytic
C16	50μF electrolytic, 6V wkg.
C17	2,000pF ceramic
C18	50μF electrolytic, 6V wkg.
C19	32μF electrolytic
C20	50μF electrolytic, 25V wkg.
C21	200pF silver mica
C22	1,000pF paper, 1,000V wkg.
VC1	100pF variable, type C804 (Jackson Bros.)
VC2	250pF variable (see text)
VC3	410+410pF twin-gang variable (see text)
TC1	56pF trimmer, Mullard concentric
TC2	56pF trimmer, Mullard concentric

(N.B. Also required are ceramic capacitors, 2,000pF 100V wkg., as shown in Fig. 2.)

Inductors

L1, L2, L3	see text
RFC1	R.F. choke, 2.5mH
RFC2	R.F. choke, 1.5mH
RFC3	R.F. choke, 2.5mH
T1	Modulation transformer, see text

Valves

V1	ECF80
V2	6BW6
V3	12AX7
V4	6BW6
V5	OA2

Switches

S1	3-pole, 3-way, Yaxley (see text)
S2	2-pole, 2-way, Yaxley or toggle

Meter

M1	0-50mA type MR38P (SEW)

Sockets and Screening Cans

SK1	Coaxial socket
SK2	Closed-circuit jack socket

1 B7G valveholder
2 B9A valveholders without skirts
2B9A valveholders with skirts
2 B9A screening cans (for V1 and V3)
2 coaxial sockets (for transmitter and receiver aerial connections)

Lamp
6.3V 0.15A panel lamp and holder

Miscellaneous
1 Vernier dial drive type T502 (Eagle)
Knobs, as required
1 ¼in. insulated spindle coupler, extension shaft and panel bush (for VC1)
Material for chassis, panel and case

medium wave coil (meeting the same requirements so far as any coupling winding it may have is concerned) can be used but preferably with some 20 turns removed. The use of a grid-dip oscillator enables one to find the required resonances quickly but if such an instrument is not available a receiver may be used together with the transmitter itself. The receiver is tuned to around 1,900 kc/s and with the transmitter operation switch at the 'Net' position the VC1/L1/TC1 combination is manipulated until a beat note is heard. Coil L2 is then peaked for maximum output as shown either by the panel meter or, more clearly, by an externally connected meter set to read 0-5mA and inserted between the 'cold' end of R7 and chassis.

If no beat note can be found, a meter set to read 0-50mA should be inserted in series with the h.t. end of RFC2. At switch-on a reading should be obtained—say 5mA — whereupon L1 should be momentarily short-circuited whilst watching the meter closely. If no current change is detected the v.f.o. circuit is inoperative and must be checked; when functioning correctly the oscillator current should increase briskly when L1 is short-circuited.

Coil L3 consists of 60 turns of 28 s.w.g. enamelled

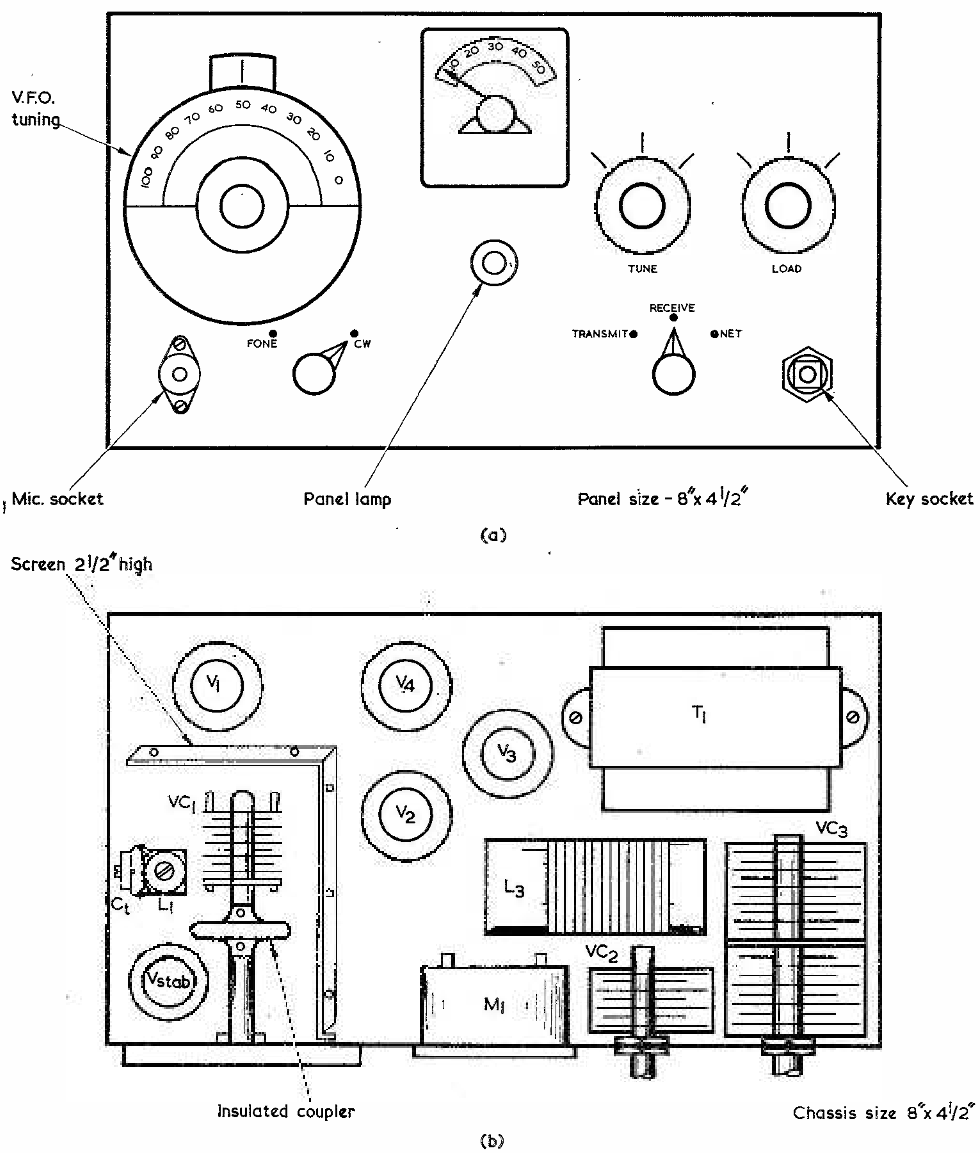


Fig. 3(a). The front panel layout employed for the prototype. Note the small overall dimensions (b). View above the chassis. VC1 is mounted on a small bracket

copper wire close-wound on a 1in. diameter former and mounted horizontally.

HEATER WIRING

This depends on the type of service required of the transmitter and for /M working a 12V heater supply will doubtless be used. Connections for both 6V and 12V heater supplies are shown in Fig. 2; a panel lamp is also included and is essential with 12V connections to act as a bypass due to dissimilar heater current ratings in V1 and V3.

LAYOUT

The layout used in the prototype is shown in Figs. 3(a) and (b). This layout need not be followed, although it is doubtful whether any significant improvement can be made. Due to possible variations in size between different components employed for T1, VC2 and VC3, all the parts should be obtained first before deciding on dimensions for the front panel and chassis. In the writer's transmitter both the panel and the chassis surface measured 8 by 4½in., these small dimensions being achieved whilst using standard components. When the transmitter is fitted in a case, adequate ventilation should be provided.

VC2 and VC3 may be of small size but should not be "miniature" types. In the prototype VC3 was 410 plus 410pF, Jackson type O2, and VC2 was of similar type.

The aerial sockets may be located, with VR1, on the rear chassis apron. The power supply cable may be fed in at the rear of the chassis also.

It should be noted that V1 and V3 are fitted with screening cans.

TESTS

Initial tests consist of the usual current and voltage measurements, checking v.f.o. coverage and so on. The stabiliser tube should glow whenever power is applied to the transmitter; should it not do so at any position of S1 or S2, R5 may require to be reduced slightly in value to obtain the required 185V striking voltage. It is important to check the current flowing through the stabilizer tube; this should not be allowed to exceed 30mA at any position of switches S1 and S2.

No aerial should be connected initially, just a 15 watt lamp as an artificial load. On 'Transmit' the lamp should glow quite brightly when tuning and loading have been carried out correctly, and speaking into the microphone on Phone should cause the lamp to brighten on peaks.

Prior to air-testing the transmitter a wavemeter must be brought into use with which to prove that radiation is taking place in the correct frequency band. viz. 1,800-2,000 kc/s. Subsequently the dummy load may be exchanged for the station or car aerial, perhaps through an aerial matching unit, and contacts sought. In next month's issue, the author will describe a companion receiver similarly intended for operation on Top Band. ■

"RADIO 2" MODIFICATION FOR M.W. TRANSISTOR RADIOS

by

B. R. HEWITT

Many of the less expensive transistor radios now in use cover medium waves only. This article describes a simple modification for the reception of Radio 2 on long waves, and continues with a practical example as carried out with a typical imported receiver

THERE MUST BE MANY OWNERS OF SMALL MEDIUM-wave-only transistor superhet radios who, with the introduction of separate programme schedules for Radios 1 and 2, are now restricted in their choice of listening—being unable to receive Radio 2 on 1,500 metres. However, with the author's set, which has a standard i.f. of 470kc/s, it was found possible to make the modification described in this article, this remedying the situation very satisfactorily. It should be possible to carry out a similar modification on most other medium-wave-only transistor receivers, provided that the associated mechanical problems can be overcome.

Some radios on the market have an integral switch on the tuning capacitor which, at one end of its travel, connects additional parallel capacitors into the aerial and oscillator tuned circuits. By suitable choice of values, 1,500 metres may then be accurately obtained.

RADIO 2 SWITCHING

It was decided to take advantage of this approach with the writer's radio. The basic switching scheme appears in Fig. 1, which shows typical ferrite aerial and oscillator tuned circuits for a medium-wave-only receiver.

Additional components introduced by the modification are switches S1(a) and S1(b), and capacitors C1

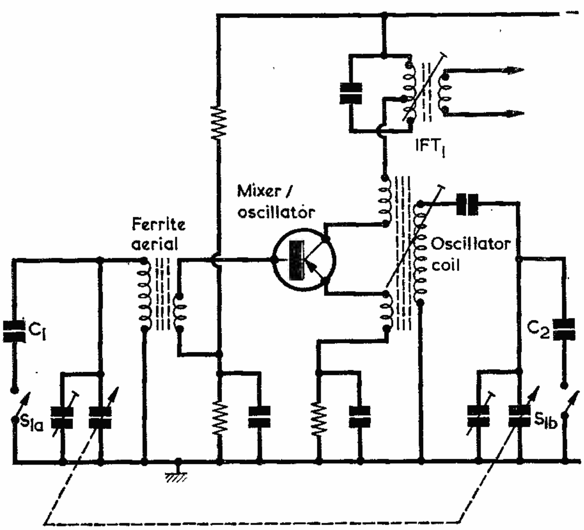


Fig. 1. Basic mixer/oscillator circuit for a medium-wave-only transistor radio, with C1, C2, S1(a) and S1(b) added. These components enable Radio 2 on 1,500 metres to be received

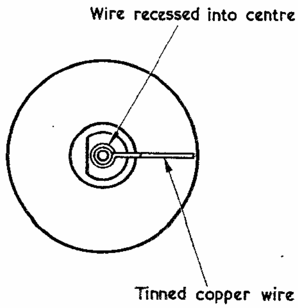


Fig. 2. Recessing the tinned copper contact wire into the underside of the tuning knob

and C2. When S1(a)(b) is closed, capacitor C1 causes the ferrite aerial to resonate at 200kc/s (1,500 metres) and the oscillator to operate at a frequency which is higher than 200kc/s by the intermediate frequency of the radio. In consequence, the oscillator now "selects" the Radio 2 transmission for amplification by the i.f. strip, whilst the ferrite aerial tuned circuit is resonant at Radio 2 signal frequency. This modification, therefore, enables Radio 2 to be received on what was previously a medium-wave-only radio.

A simple method of adding the Radio 2 components is to install a suitable panel mounted switch close to the mixer/oscillator stage, this being operated when Radio 2 is required. The values of the additional capacitors may then be found experimentally, being such that Radio 2 is tuned in with the tuning capacitor at approximately mid travel. The additional wiring must be kept short, and it may be necessary to slightly re-trim the medium wave circuits after the components have been added.

An alternative idea is to add switch contacts to the tuning capacitor itself, these bringing C1 and C2 into circuit when the capacitor is set to the low frequency end of the medium wave range. In this case the value required for C2 will probably lie between 100 and 250 pF for normal receivers having an i.f. of the order of 470kc/s, whilst the value for C1 will be approximately 1,250pF. The writer decided to employ this second method, using home-constructed contacts added to the tuning capacitor. It must be pointed out that the particular procedure he used is not applicable to all receivers, but that it should, nevertheless, give ideas for a similar approach with other radios. A few 2-gang tuning capacitors fitted with "long wave switches" are incidentally, available from home-constructor retailers, but difficulty may be experienced in obtaining one with the correct capacitance values and mechanical dimensions.

Two points need to be made before carrying on to details of the author's modification. Firstly, a check should be made that the oscillator of the receiver still continues to run satisfactorily when the requisite parallel capacitance across its tuning capacitor is added. If the additional capacitance causes it to stop oscillating, then the modification cannot be carried out. Secondly, the L/C ratio of the ferrite aerial tuned circuit is lower, with C1 in circuit, than it would be if a separate long wave winding were tuned in the normal way. The sensitivity of the receiver at 1,500 metres is therefore a little lower than would be given when a ferrite aerial with a proper long wave winding is used.

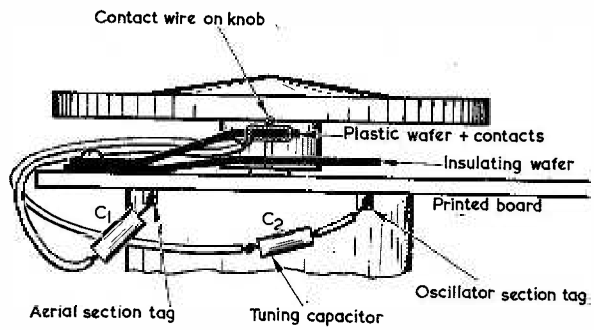


Fig. 4. Side view, showing the wire on the knob connecting to the two fixed contacts

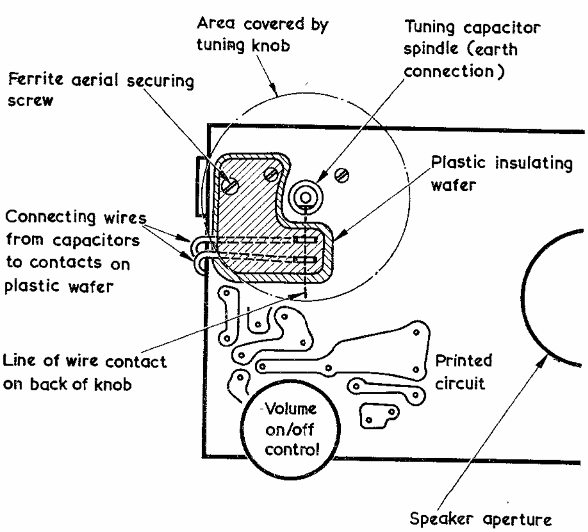


Fig. 3. Top view, with the tuning capacitor body below the board

In practice, it is doubtful whether much difficulty will be caused by either of these two points. As already mentioned, the general idea used here has been successfully employed in a large number of commercially made transistor radios.

THE MODIFICATION

The writer's transistor radio is an imported Japanese "Glaxie" receiver, model 661. The switch was improvised satisfactorily, using the reverse of the edge-operated tuning knob. Since an earth connection is common to both S1(a) and S1(b) and, also, to the centre spindle of the tuning capacitor, the method to be described is an ideal way of switching the additional capacitors into circuit.

Firstly, the set was removed from its case, and the two sections of the tuning capacitor were identified by tracing the connections from the primary winding of the ferrite aerial, and from the oscillator coil. The two additional capacitors could then be temporarily soldered to the appropriate tags on the tuning capacitor and wired across to an adjacent earth point on the circuit board. Component values were next determined experimentally.

Initially, a capacitor was added in the C2 position which allowed Radio 2 on 1,500 metres to be tuned in. It was found that a value between 100 and 180pF was necessary with the writer's receiver to bring in this signal at low strength. Tuning of the aerial circuit was accomplished by adding a 1,250pF capacitor in the C1 position, whereupon signal strength increased enormously. The correct values were then finally found for both capacitors, and close-tolerance polystyrene components selected. These, suitably sleeved, slipped in easily amongst existing components. Remember that the value of C2 must be *exactly* correct, as there is little variation in capacitance available from the tuning capacitor. The latter is at maximum capacitance when C2 is switched in.

It was next necessary to engineer the switching of both capacitors to earth. The tuning knob was removed, its securing screw being revealed by prising off a decorative centre dome. The capacitor spindle was of the tapped and threaded variety. As the knob was made of a thermoplastic material it was possible to slightly "melt" some 26 s.w.g. tinned copper wire into the back of the knob, using the heat from a soldering iron. Alternatively, a slight groove could have been cut, and the contact wire secured with epoxy resin. The wire was taken right into the centre of the knob, into the recess made to accept the fluted capacitor spindle, and was formed into a loop there as shown in Fig. 2. The wire would then make contact with the spindle when the knob was replaced.

Next, the p.v.c. insulation was stripped from $\frac{3}{4}$in. of two 4in. lengths of stranded connecting wire. The bared wires were to form the two contacts for C1 and C2, and were fitted as shown in Figs. 3 and 4 to a plastic "wafer". This was carefully shaped from part of a yoghurt carton, and pierced to receive the wire contacts by means of a hot needle. The wires were pushed through the holes and secured underneath. A second "wafer" was fitted beneath the contacts to prevent them touching the printed side of the circuit board, and epoxy resin was used to make the contact positions firm. With the writer's receiver it was found possible to secure the "wafers" using the ferrite aerial clamp bolt, which proved to be of sufficient length.

The two new capacitors had their free ends trimmed off, and were soldered to the insulated wires (shortened as necessary) leading to the contacts. The tuning knob was now replaced, secured with its screw, and checked for free movement. At the low frequency end of the tuning scale an agreeably positive "click" was felt, due no doubt to the springy characteristics of the plastic "wafers". Radio 2 was received at excellent strength. To finally complete the modification, the medium wave band was slightly re-trimmed at the high frequency end to bring it back to its previous condition. ■

CONFERENCE

EARTH STATION TECHNOLOGY

An international conference on earth station technology for satellite communication is to be held at the Institution of Electrical Engineers, Savoy Place, London WC2, during October 1970.

The effect of using higher frequencies and different modulation methods in future systems will be discussed, and it is envisaged that the conference programme will also include: the earth segment/space segment interface and the resulting earth station performance requirements; earth station configuration; electrical, mechanical and structural aspects of earth station aerials; servo control systems; aerial feed systems; tracking systems; high-power transmitters; low-noise amplifiers; frequency conversion equipment.

Further details of the conference, which will be co-sponsored by the Institution of Electronic and Radio Engineers and others, may be obtained from the Conference Department, IEE, Savoy Place, London WC2.

EXPOSITION

CURRENT CONTROL THEORY

An exposition on current control theory is to be held at the University of Warwick from the 7th to the 11th July, 1969. It is being organised by the IEE in asociation with the Institute of Mathematics and its Applications, and the Institution of Electronic and Radio Engineers.

This year the University of Warwick, with the support of the Science Research Council, the Nuffield Foundation and Shell International Petroleum, is bringing a number of distinguished workers in control theory to Britain. The object of the exposition is to enable European control engineers and mathematicians to hear state-of-the-art lectures on control theory from world authorities.

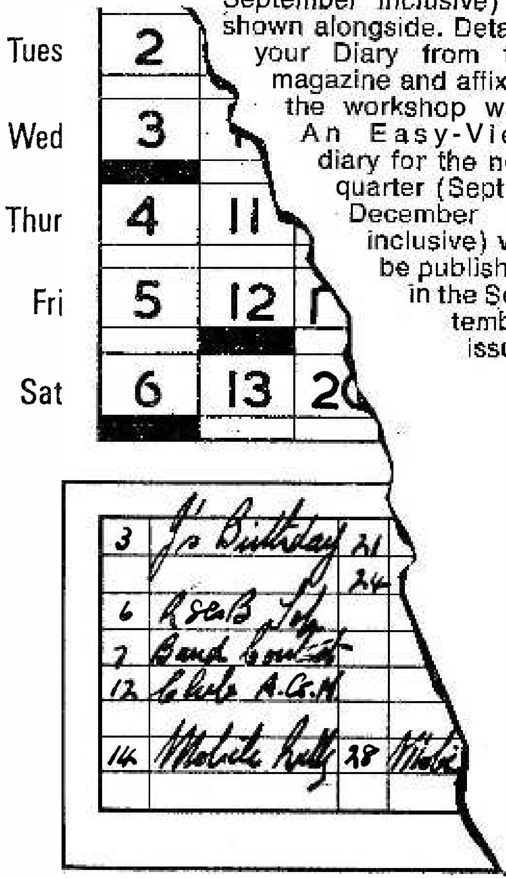
It is hoped to attract British pure and applied mathematicians and statisticians to research and teaching activities in this field. At the exposition, lectures will be arranged on: optimal control; stability; stochastic problems; multivariable systems; general systems theory.

Also there will be periods for informal seminars and discussions, one of which will be devoted to a report of the IFAC congress in Warsaw.

HOW TO MAKE FULL USE OF YOUR DIARY

Underline the dates of both personal and radio events in which you are interested or concerned, as shown in the illustration below, and enter brief details of these in the Diary Notes. A list of forthcoming events of radio interest taking place during the third quarter (July to September inclusive) is shown alongside. Detach your Diary from the magazine and affix to the workshop wall.

An Easy-View diary for the next quarter (Sept. to December '69 inclusive) will be published in the September issue.



SUGGESTIONS FOR YOUR EASY-VIEW DIARY

JULY

5–6	RSGB Summer 1.8 Mc/s Contest.
5–6	RSGB Fifth 144 Mc/s (Open) Contest.
6	South Shields Mobile Rally.
13	Worcester Mobile Rally.
12–13	RSGB High Power Field Day.
20	RSGB Second 432 Mc/s (Portable) Contest.
27	Cornish Radio Amateur Club Mobile Rally, Truro.
27	White Rose Mobile Rally, Allerton High School, Leeds.

AUGUST

4	RSGB Sixth 144 Mc/s (SSB) Contest.
10	RSGB National Mobile Rally, Woburn Abbey.
10	RSGB Third 432 Mc/s (Open) Contest.
17	RSGB Fourth 70 Mc/s (CW) Contest.
17	Derby & District Mobile Rally.
24	Swindon Mobile Rally.
24	ARMS/RSARS Rally, Blandford Camp, Dorset. (Members only).
24	Torbay ARS Mobile Rally.
31	Bromsgrove & District ARC Mobile Picnic.
31	Preston Amateur Radio Society Mobile Rally, Kimberley Barracks, Deepdale Road, Preston.

SEPTEMBER

6–7	RSGB VHF National Field Day.
14	RSGB 3.5 Mc/s Field Day.
21	RSGB Seventh 144 Mc/s (CW) Contest.
22	RSGB Scottish Mobile Rally, Cartland Bridge Hotel, Lanark.
29	Harlow Mobile Rally, Magdalen Laver Village Hall, Nr. Harlow. East of A11.

THE RADIO CONSTRUCTOR'S 'EASY VIEW' DIARY

THIRD QUARTER 1969

	JULY					AUGUST					SEPTEMBER				
Sun		6	13	20	27		3	10	17	24/31		7	14	21	28
Mon		7	14	21	28		4	11	18	25	1	8	15	22	29
Tues	1	8	15	22	29		5	12	19	26	2	9	16	23	30
Wed	2	9	16	23	30		6	13	20	27	3	10	17	24	
Thur	3	10	17	24	31		7	14	21	28	4	11	18	25	
Fri	4	11	18	25		1	8	15	22	29	5	12	19	26	
Sat	5	12	19	26		2	9	16	23	30	6	13	20	27	

DIARY NOTES

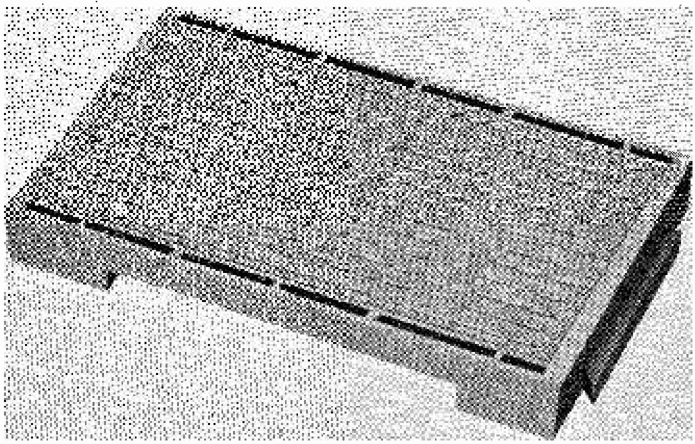
TRADE NEWS

● New Solderless Breadboards from S.D.C.

S.D.C. Products (Electronics) Limited have extended their range of modular, solderless breadboarding systems to include two new DeCs specifically designed to accommodate integrated circuits as well as discrete components and to have an increased contact capacity—208 contact points per DeC—as compared to the original S-DeC.

The new μ-DeCs, primarily for integrated circuits, can accommodate two 16 lead DIL stations or four 10 lead T05 stations. The new T-DeCs, primarily for discrete components, can also accommodate one DIL station or two T05 stations.

The layout of the contacts consists of two panels of parallel rows of electrically linked contacts spaced 5 mm apart. This spacing enables short lead devices to be inserted directly into the boards. The new DeCs may be interlocked to give a stable area of breadboard of any desired size and each DeC has slots to accommodate two control panels.



μ-DeC, a versatile new breadboard from S.D.C. Products (Electronics) Ltd., Corn Exchange, Chelmsford.

The DeCs are formed from glass filled nylon enabling temperature cycling tests to be carried out and contacts are of heavy gauge phosphor bronze in natural finish, in either silver plated or gold over nickel plated finished.

DeCs are supplied in two packs. The single pack contains one DeC, one control panel (with bushes for reducing the diameter of drilled holes in the panel) and a jig (for pre-forming components). The 6-DeC pack contains six DeCs, six control panels, sets of bushes and jigs, 50 x 1 mm plugs and 8 links for joining power rails in neighbouring DeCs.

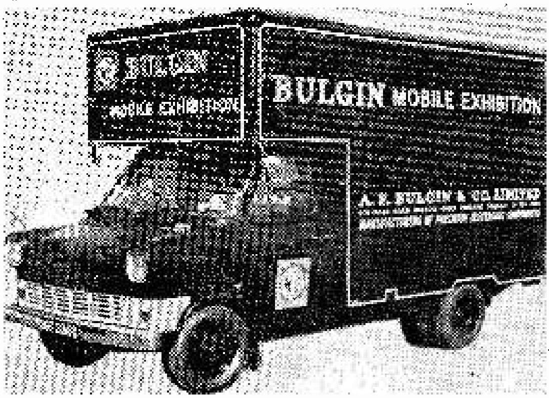
● Mobile Exhibition

A. F. Bulgin & Co. Ltd., Bye Pass Road, Barking, Essex, have recently put into commission a new Sales/Service project—see illustration.

This is in the form of a Mobile Exhibition Vehicle, staffed by Senior Technical Sales Engineers and providing excellent opportunities for Executives, Buyers, Designers, Draughtsmen and young Engineers, throughout the country, to see complete ranges of Bulgin Electrical and Electronic Components, as well as keeping abreast of the latest 'New Line' developments.

A programme of visits will be made by this Sales Team and a number of bookings have been made with various companies throughout the British Isles.

However, there are several vacant dates still available and they will be pleased to hear from other companies who may be interested in arranging set dates for this vehicle to visit their premises.



UNDERSTANDING RADIO

THE B.F.O.

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

by W. G. Morley

IN LAST MONTH'S CONTRIBUTION TO THIS SERIES WE completed our examination of tuning meters and then turned our attention to the beat frequency oscillator, as employed in a.m. superhet receivers intended for communications work. We saw that the function of the beat frequency oscillator, or b.f.o., is to produce an audible tone when a c.w. transmission is being received. The b.f.o. runs at a frequency that differs from the intermediate frequency of the receiver by an audio frequency, and its output is coupled to the signal detector of the receiver. In consequence the received transmission (converted to the intermediate frequency by the frequency changer) causes an audible tone to be passed to the a.f. stages of the receiver whenever it is present. The b.f.o. thereby enables morse transmissions to be conveniently "read" by the receiver operator.

CHOICE OF OSCILLATOR

Several conflicting requirements have to be catered for if a beat frequency oscillator is to function satisfactorily. Fortunately, these requirements do not raise any considerable difficulties in b.f.o. design, but they nevertheless have to be taken into account.

For general c.w. reception it is desirable that the b.f.o. should feed a signal to the receiver detector whose amplitude is greater than that of the strongest received signal it is anticipated will be passed to that detector from the i.f. amplifier. This method of operation ensures that the amplitude of the a.f. tone produced by the detector is very nearly directly proportional to the amplitude of the signal from the i.f. amplifier. The advantage conferred by having a strong b.f.o. signal can be more readily understood by considering the reverse situation. If a weak b.f.o. signal is applied to the detector a consequently higher overall gain is required in the preceding r.f. and i.f. amplifier stages to produce an a.f. tone of the same strength as would be given with the strong b.f.o. signal. The result is that the receiver signal-to-noise ratio then falls.[1] The fact that a strong b.f.o. signal is required infers that the coupling between the b.f.o. and the signal detector circuits needs to be relatively tight.

A conflicting factor is that if an oscillator has applied to its tuned circuit a signal whose frequency is close to that of the oscillator, the oscillator frequency tends to "pull" towards the signal frequency. This "pulling" effect becomes more noticeable as the coup-

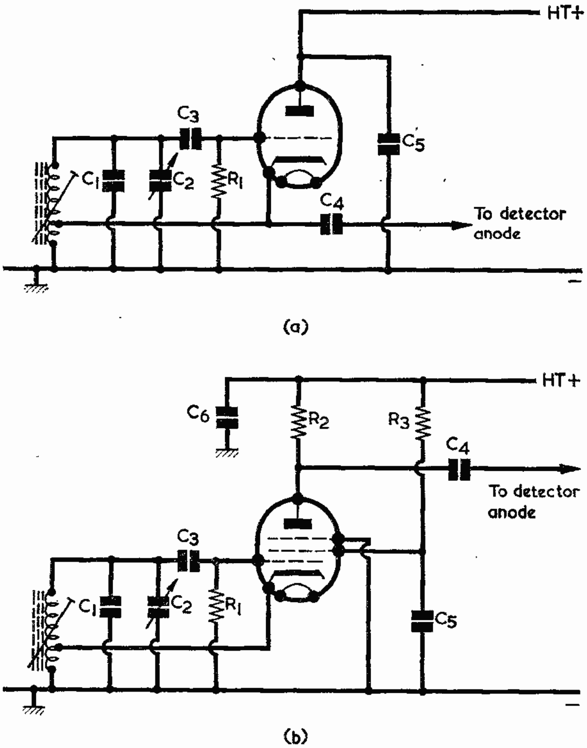


Fig. 1 (a). An oscillator circuit suitable for use as a b.f.o. in a communications receiver

(b). An alternative b.f.o. which exhibits greater freedom from frequency "pulling"

1. In this context, signal-to-noise ratio is the ratio between the amplitude of the a.f. tone and that of the noise accompanying it. The latter is noise generated in the early receiver stages (particularly the first stage) and the aerial.

ling between the signal and the oscillator tuned circuit becomes tighter (and, also, as the amplitude of the signal increases).

It follows from these two points that, if a b.f.o. is to be a simple oscillator coupling direct to the signal detector of the receiver, the coupling must be tight enough to ensure that a high amplitude b.f.o. signal is given, but not so tight that the b.f.o. is "pulled" towards the signal frequency applied to that detector. For most general receiver applications, a practicable compromise solution is provided by the Hartley oscillator circuit shown in Fig. 1(a). The cathode tap into the tuned coil has a relatively low impedance to chassis and "pulling" of tuned circuit frequency by the signal frequency is normally of a sufficiently low nature to give negligible trouble in practice. At the same time there is sufficient oscillator signal amplitude at the cathode tap to meet normal requirements for c.w. reception. The cathode tape couples direct to the signal detector anode via C4, this having a value of the order of 2 to 10pF.

Fig. 1(b) shows the Hartley oscillator of Fig. 1(a) incorporated in an *electron coupled oscillator*. The oscillator circuit functions in the same manner as does that of Fig. 1(a), the screen-grid of the pentode replacing the anode of the triode. The output is, however, taken from the pentode anode, this being coupled direct to the anode of the detector diode via C4, which may have a value of several picofarads. Since the electrodes coupling into the tuned circuit, i.e. the grid and cathode, are screened from the anode by the screen-grid, the coupling between the anode circuit and the tuned circuit is negligibly low and the "pulling" effect on oscillator frequency is very much reduced. At the same time it is possible to obtain a high amplitude output at oscillator frequency by suitable choice of anode load resistor and electrode potentials.In general, the anode resistor, R2, in Fig. 1(b) could have a value of some 5 to 20kΩ and the screen-grid resistor, R3, one of 47kΩ. The use of the term "electron coupled oscillator" for the circuit of Fig. 1(b) is apparent from its mode of operation. The output is obtained by means of coupling via the electron stream inside the valve.

A receiver b.f.o. is required to tune over a limited range only, say some 4 to 5kc/s on either side of the receiver intermediate frequency. In consequence, in both Figs. 1(a) and (b) (and assuming a b.f.o. frequency around 470 kc/s) C1 may have a large value, of the order of 300pF and C2 a maximum capacitance of some 15 to 20pF. C2 is a panel-mounted variable capacitor which is adjusted by the receiver operator to produce a beat note of the desired frequency. The oscillator tuned circuit is set up by an iron-dust core in the coil so that the b.f.o. frequency is equal to the intermediate frequency (thereby giving a "zero-beat") when C2 is set to half-capacitance. The b.f.o. frequency can then be set either above or below the intermediate frequency by adjusting C2. In both diagrams C3 and R1 may be of the order of 50pF and 47kΩ respectively. C5 is a bypass capacitor with a typical value of 0.01μF. C6 in Fig 1(b) may also have the same value.

It is desirable that the b.f.o. should have a high level of frequency stability. The use of a large value in C1 helps to maintain frequency stability because it reduces the effect of varying inter-electrode capacitance in the b.f.o. valve as it warms up. C1 should be a capacitor having a low temperature coefficient, such as a silvered mica component. It is helpful, also, to feed the b.f.o. from a stabilised h.t. supply.[2]

The b.f.o. circuit of Fig. 1(b), with its freedom from "pulling" and its ability to provide a high amplitude output, is preferable to that of Fig. 1(a), which merely offers a compromise between these two conflicting factors. Nevertheless, it is usual to find that the Fig. 1(a) circuit is employed more frequently, if only because of its simplicity and because of it offers adequate results in practice. Any other standard oscillator circuit — tuned grid, tuned anode, etc. — could be

2. Oscillators in general, including the Hartley oscillator of Fig. 1(a), were dealt with in "Understanding Radio" in the issues for May to August 1966. These earlier articles also discussed oscillator frequency stability and the design of voltage stabilised h.t. supplies.

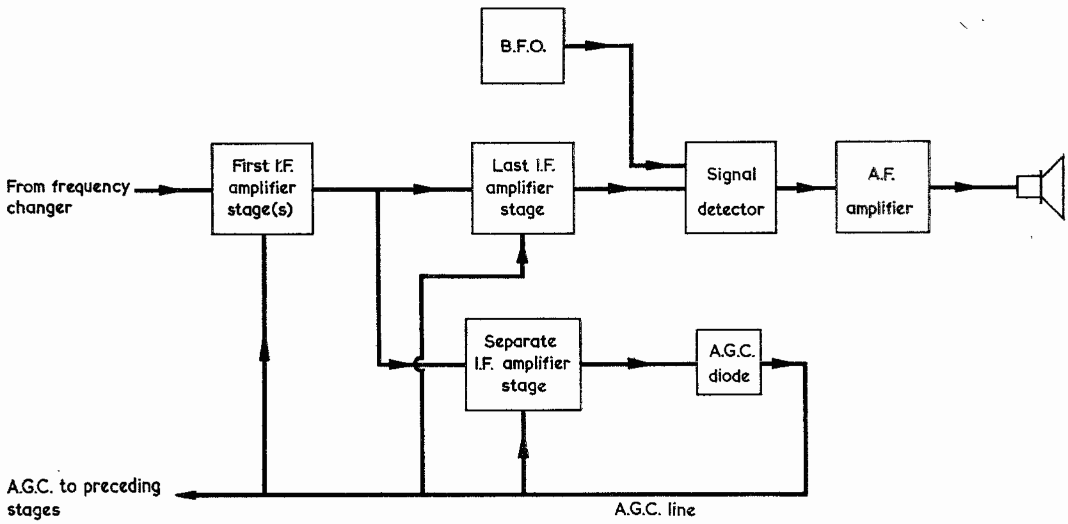


Fig. 2. A stage line-up which enables a normal a.g.c. voltage to be produced whilst the b.f.o. is switched on

employed as a b.f.o., but it would be necessary for such a circuit to offer an output at relatively low impedance, say from a tap in a tuned or coupling coil, to reduce "pulling". Alternatively, it could be coupled to the signal detector via a separate amplifier valve acting as a "buffer" between the oscillator and detector circuits. Neither of these approaches are as attractive as those illustrated in Figs. 1(a) and (b).

An interesting alternative method of injecting the b.f.o. signal consists of applying it to a point in the i.f. amplifier instead of to the signal detector. It could, for instance, be fed into the control grid of the last i.f. amplifier valve, whereupon a lower b.f.o. input amplitude is required and the risk of "pulling" is reduced since signal amplitude is smaller than at the signal detector. Despite its possible advantages, this method of b.f.o. application is not commonly employed in practical receivers.

A further point is that it is possible for the beat frequency oscillator to run at a sub-multiple of the desired frequency. To take an example, if the required b.f.o. signal needed at the signal detector were 471 kc/s (to produce a 1 kc/s a.f. tone with a 470 kc/s i.f. signal) the b.f.o. could actually run at 235.5 kc/s. The a.f. beat note would then be produced by the second harmonic of the oscillator. This alternative method of operation reduces "pulling" and can assist marginally in improving frequency stability due to the lower oscillator frequency, but it is not encountered very often in practice.

EFFECT ON A.G.C.

It is normal practice to obtain the a.g.c. voltage in an a.m. valve superhet from the signal detector diode or from a separate a.g.c. diode coupled to the last i.f. transformer. Regardless of which of these two circuits is employed the application of a b.f.o. signal will, due to rectification by the signal or a.g.c. diode, cause the appearance of a high negative voltage on the a.g.c. line. Unless precautionary steps are taken, the result will be a corresponding reduction in receiver sensitivity.

It would be possible to overcome this difficulty by incorporating a special a.g.c. circuit consisting of a separate stage of i.f. amplification following the grid of the last i.f. amplifier valve, as shown in block form in Fig. 2. Systems of this kind are not normally used, however, and the usual method of preventing the b.f.o. signal from producing a high a.g.c. voltage consists, quite simply, of short-circuiting the a.g.c. line (after its filter components) to chassis when the b.f.o. is switched on. A typical switching circuit is illustrated in Fig. 3, in which S1(a) and S1(b) are sections of a double-pole single-throw switch. When this is in the "Off" position no h.t. voltage is applied to the b.f.o. stage and the a.g.c. system functions in its normal manner. When S1(a) and S1(b) are set to "On", an h.t. supply is fed to the b.f.o. via S1(a) and the a.g.c. line is short-circuited to chassis via S1(b). The receiver now functions without a.g.c., its gain being controlled by manual gain controls in the r.f. and i.f. amplifier stages. The absence of a.g.c. does not seriously detract from the usefulness of the receiver for the reception of c.w. signals. The lack of a.g.c. can indeed be an advantage, this being particularly true for such instances as occur when the desired signal is close in frequency to a more powerful unwanted signal, which would cause receiver sensitivity to be reduced due to a.g.c. action.

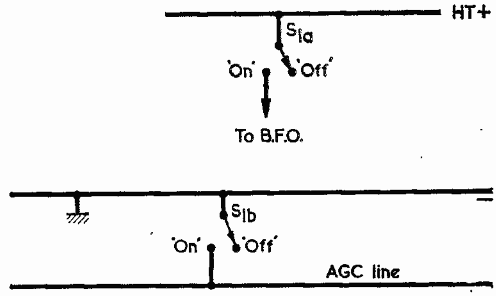


Fig. 3. A common technique consists of short-circuiting the a.g.c. line to chassis when the receiver b.f.o. is switched on

If the receiver is fitted with a tuning indicator, or S-meter which is operated from the voltage on the a.g.c. line or the signal detector load, this meter will also be affected by the high-level b.f.o. signal. To prevent this, the meter is usually taken out of circuit when the b.f.o. is switched on, this process being carried out automatically when the meter takes its control voltage from the a.g.c. line. The correct method of tuning in a c.w. signal on a receiver fitted with a tuning indicator is to initially tune for greatest deflection in the tuning indicator with the b.f.o. switched off, then switch on the b.f.o. and adjust its frequency control for the desired a.f. beat frequency. Subsequent tuning to other c.w. signals does not normally necessitate the use of the tuning indicator, as all that is then required is that a tone of the same audio frequency be produced with the tuning control turning in the correct "sense". That is, if the a.f. tone originally increased in frequency as the tuning control was turned clockwise, the tone produced by other signals, when correctly tuned in, should similarly increase in frequency as the tuning control is turned clockwise.

Whilst dealing with the question of the b.f.o. and its effect on a.g.c. systems, it should be mentioned that some circuits have been developed which enable an a.g.c. voltage to be produced from the audio frequency signal obtained after detection. The circuits employed are more complex than the simple a.g.c. system we have discussed and are designed such that an a.g.c. voltage is developed extremely quickly after the appearance of the detected a.f. signal. The a.g.c. voltage is then maintained at the same level until a short period after the cessation of the a.f. signal.

An important feature of practical b.f.o. design is that the b.f.o. stage must be reliably screened and that its h.t. supply feed should be adequately decoupled. Failure to attend to these details can result in radiation of the b.f.o. signal. The usual effect is that harmonics of the b.f.o. signal are picked up in the early stages of the receiver, where they cause interference with received signals.

INCREASING SELECTIVITY

A number of circuit devices are employed in communications receivers to provide a level of selectivity

3. A different mode of tuning is required if the receiver is fitted with a crystal or mechanical i.f. filter. These filters will be discussed in a later article.

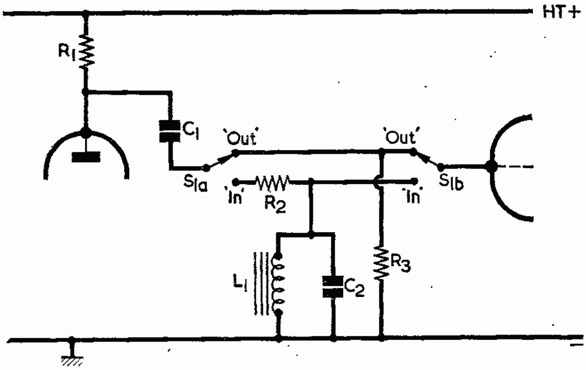


Fig. 4. A simple a.f. filter which can be employed to improve selectivity for c.w. reception. The filter is inserted between any two a.f. amplifying valves in the a.f. section of the receiver

which is greater than can be achieved by the use of i.f. transformer tuned circuits on their own. We shall discuss these in detail next month, and we now conclude the present article by describing a very simple method of improving selectivity for the reception of c.w. signals.

As we have noted, the desired c.w. signal is converted to the intermediate frequency of the receiver by the frequency changer, after which an a.f. beat note is produced at the detector, the frequency of the a.f. note being equal to the difference between the frequency of the b.f.o. and the intermediate frequency. An interfering c.w. signal close in frequency to the desired signal can also pass through the receiver i.f. amplifier, and this will reach the detector at a different converted frequency. In consequence the a.f. beat note it produces at the detector will also be different.

Fig. 4 shows a circuit which enables the desired c.w. signal to be given greater a.f. amplification after detection than the interfering signal. In this diagram L1 and C2 form a parallel tuned circuit resonant at the audio frequency produced by the desired signal, and are switched into circuit between any two a.f. amplifying valves in the a.f. section of the receiver. The tuned circuit offers maximum impedance at its resonant frequency, with the result that a.f. tones removed from that frequency suffer attenuation. The coil, L1, is an iron-cored component. To give an idea of the component values required, an inductance in the coil of 10H together with a capacitance in C2 of 0.0025μF will provide a resonant frequency of about 1 kc/s. Resistor R2 has a value sufficiently high to enable a pronounced peak in a.f. output at the resonant frequency to be obtained. Its value is found experimentally and will normally be in the range of 10 to 200kΩ. Resistor R1 is an anode load resistor, R3 a grid resistor and C1 an a.f. coupling capacitor. These components have the same values as would be employed for normal a.f. intervalve coupling. Switch S1(b) should have contacts which, as it is adjusted, complete the new circuit to be selected before breaking the old one. This ensures that the grid of the following valve always has a d.c. circuit to chassis.

To use the filter the desired c.w. signal is tuned in in the usual manner with the aid of the receiver tuning indicator. Both the b.f.o. and the filter of Fig. 4 are then switched into circuit and the b.f.o. adjusted so that the a.f. tone produced by the signal is at the resonant frequency of L1 and C2. This a.f. tone then receives greater amplification in the a.f. section of the receiver than do the beat notes produced by interfering signals of different frequency.

NEXT MONTH

In next month's issue we shall examine more sophisticated methods of improving selectivity in communications receivers.

LASKY'S RADIO "1969 AUDIO-TRONICS PICTORIAL"

The latest edition of this pictorial production has been increased in size to a total of 16 pages (11½in. x 16½in.), and in content it covers every sphere of audio and electronics for the hobbyist, enthusiast and the service engineer.

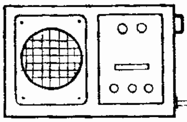
The first edition (12 pages published in 1967/8) was an immediate success, and demand soon necessitated a reprint, making a total circulation of some 55,000 copies. Of the new edition, well over 100,000 copies have already been despatched to customers all over the world.

The sections dealing with both high fidelity and communication equipments have been considerably enlarged to meet both popular request and demand for these items. To ensure the shortest possible delay in despatch, Lasky's Radio have installed a mechanised mailing system capable of sending up to 30,000 copies per day, and their mail order department has been trebled in size to cope with the increased demand for goods described and illustrated in the *Pictorial*.

The *1969 Audio-Tronics Pictorial* is available to readers by writing to Lasky's Radio, 3-15 Cavell Street, Tower Hamlets, London, E.1. There is no cover charge for the *Pictorial*, but a remittance for 1/- is requested to cover both postage and inclusion of the customers on their regular mailing list.

The *Pictorial* is both a colourful and informative publication. Well planned and designed, it provides much information on the latest equipments and components available by direct mail service from Lasky's Radio. Lavishly illustrated, it comes complete with an order form and an introductory letter from the company.

In your workshop



Like many service engineers, Smithy normally employs an oscilloscope only when its use is specifically called for. In this episode he takes advantage of the Workshop oscilloscope to set up output stage balance in a mains-driven transistor radio, after which he introduces Dick to some of the more unusual applications offered by the instrument when it is employed without its timebase

"WHERE'S THE *WHAT*?"

"The 'scope," snorted Smithy. "Dash it all, Dick, I've been searching all over the Workshop for it."

"Oh," replied Dick uneasily "it's the 'scope you want, is it?"

"Of course it is," returned Smithy irately. "I've just said so."

Dick assumed a defensive attitude. "As a matter of fact," he said, "it happens to be under my bench."

"What on earth is it doing there?"

"Well," continued Dick hesitantly, "I think I should first explain that I'm going to a dance tonight. It's a special dance and the dress will be rather more formal than usual."

"What has the 'scope got to do with your dress?"

"I'm using it," explained Dick, "to press my trousers!"

"Our oscilloscope?" exploded Smithy incredulously. "To press your trousers?"

"Well, yes," confirmed Dick, his confidence returning now that his guilty secret was out. "Also, seeing that the oscilloscope we have in here is a pretty weighty old thing, it's just right for the job, too. I put the trousers between two pieces of hardboard on the floor, spread a load of mains trannies all over the top piece and then put the 'scope just above the knees. After a day of that I get trouser creases that are sharper than a knacker's knife, mate!"

"I've never before *heard*," stated Smithy censoriously, "of such shocking treatment for valuable test equipment. Bring out that oscilloscope immediately."

Subdued by the authoritive tone in the Serviceman's voice, Dick bent down and proceeded to remove some of the empty cardboard cartons and packing cases which always seemed to accumulate under his bench. He soon revealed the Workshop oscilloscope, positioned strategically over what was presumably the most bagginess-prone section of his trousers. He carefully hauled the oscilloscope out onto the floor in front of his bench, then proceeded to rearrange the transformers which had previously flanked it on the top sheet of hardboard.

OUTPUT BALANCE

"Never mind about those flaming pants of yours," fumed Smithy "Bring that 'scope over to my bench."

Obediently, a temporarily crushed Dick carried the oscilloscope to Smithy's bench and placed it on its surface alongside the chassis of a mains-driven transistor a.m.-f.m. radio.

"That's a bit more like it," grunted Smithy, as he blew the dust off the top of the oscilloscope, plugged it into the mains and switched it on.

"What," asked Dick, "do you want the 'scope for, anyway? You normally go for weeks or even months without using it."

"I suppose that's true enough," admitted Smithy, his irratability easing now that he was able to proceed with the job on his bench. "And perhaps that's because I'm not quite as oscilloscope-minded as some service engineers are. A testmeter and signal genny seem to be all I need for the majority of the snags that come my way. However, the particular job I'm doing here *does* require an oscilloscope."

"An ordinary table radio?"

"An ordinary table radio," confirmed Smithy. "As it happens, this radio has got two output transistors in a transformerless output stage, and I've just finished replacing one of them. In consequence I now have to re-set the d.c. balance for the output transistors and then finally set up their quiescent current. If you take a shufti at this service manual you'll see what I'm talking about."

Smithy pulled the manual over and indicated the a.f. section of the receiver circuit. (Fig. 1).

"Do you see," he continued, "that 1kΩ preset pot in the emitter circuit of the driver transistor? Well, that's the one that sets up the output stage for balance between the output transistors. When it's adjusted it causes the direct voltage at the junction of the two output emitters to vary, and its final setting is such that about half the supply voltage appears across each output transistor. In some cases where you have an output circuit of this type you can adjust the balance pot so that a specified direct voltage above chassis appears at the junction of the two output emitters under quiescent conditions, but it's usually better to balance the output transistors under signal conditions with an oscilloscope. Since the service manual for this particular set definitely states that a 'scope should be used ,that's what I'm now going to do."

"How do you use the 'scope for this job?"

"You couple it's Y input across the speaker," replied Smithy. "After which you inject an a.f. sine wave at some convenient point, such as at the volume control. Since, in this case, I'll be checking quiescent current as well, I've also slapped my test meter in series with the collector supply to the upper output transistor."

"Blimey," said Dick. "you've got your testmeter switched to the 1 *amp* range!"

"I know," chuckled Smithy. "But don't forget that this is a mains-operated receiver and not a battery job, and that these AC128-AC176 output stages take a fair old bit of current when there's a high input signal level. Right now, the 'scope seems to be all warmed up and ticking over nicely, so lets switch on the receiver and the signal generator."

After a short wait, a 400c/s tone became audible from the speaker. Simultaneously the green horizontal trace of the oscilloscope opened out to give a confused running pattern. Smithy adjusted timebase speed, whereupon four cycles of impeccable sine wave quality formed up on the screen. (Fig. 2(a)).

"Excellent," said Smithy, pleased. "All I've now got to do is to increase

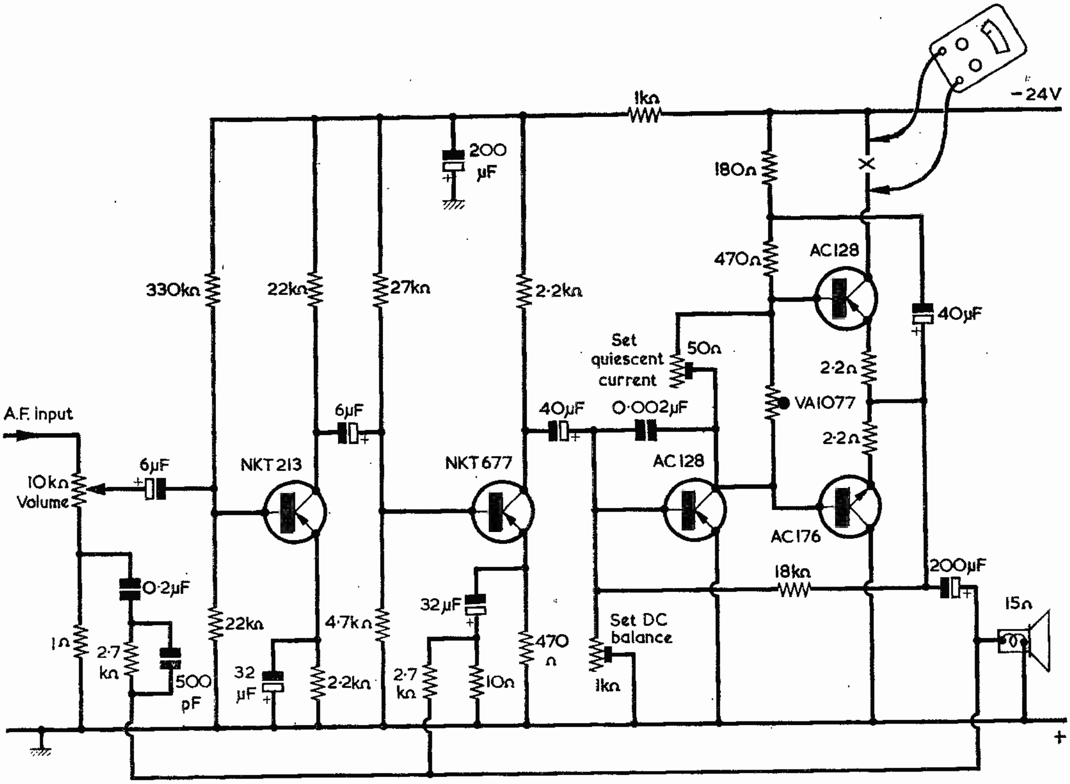


Fig. 1. The a.f. section of the radio receiver serviced by Smithy. The testmeter is inserted in series with the collector supply to the upper output transistor. The two output transistors are coupled to an ample heat sink. The component in parallel with the preset 50Ω potentiometer is a thermistor. (This is a slightly simplified version of the a.f. circuitry employed in the Ferranti Model A1143)

the a.f. sine wave input until the output stage starts to clip on output peaks. Which will, of course, mean that I'll have to reduce the Y gain of the 'scope correspondingly."

There was no reply from Dick. Smithy's assistant had suddenly become completely absorbed in the oscilloscope trace. He watched the screen with avid interest whilst Smithy increased the sine wave input to the amplifier. The Serviceman soon achieved a condition where clipping became visible on one set of half-cycles. (Fig. 2(b)).

"There we are," called out Smithy over the now very loud 400c/s note reproduced by the speaker. "What I do next is to adjust the 1kΩ pot so that the clipping is symmetrical on either side."

Smithy quickly found the desired setting in the potentiometer (Fig. 2(c)), then turned to his assistant.

"All that's now left to do," he remarked, "is to check the quiescent current."

The Serviceman switched off the signal generator, and Dick regretfully watched the output trace displayed by the oscilloscope collapse and merge into the single horizontal line produced by the timebase. Smithy set his testmeter to its 100mA range and checked its reading.

"Humph," he remarked. "The quiescent current with that new transistor I put in is 15mA. The service manual says the quiescent current should be 10mA, so let's have a stab at that 50Ω pot. Ah, here we are – no trouble at all! The output stage is now drawing a nice quiescent current of 10mA."

"Since you've readjusted the 50Ω pot," put in Dick, "shouldn't you next re-check the setting of the 1kΩ pot?"

"Not really," replied Smithy. "The adjustment to the 50Ω pot shouldn't upset the output balance setting to any significant degree. Still, no harm would be done if we *did* repeat the exercise, just to make sure."

Whilst Dick's attention again became centred on the oscilloscope screen, Smithy quickly returned his testmeter to its 1 amp range, switched on the signal generator and brought the a.f. output from the receiver up to clipping level. The same waveform, with symmetrical clipping, was displayed once more.

OSCILLOSCOPE TRACES

Transfixed, Dick watched the trace on the oscilloscope.

"Do you know, Smithy," he remarked, as the Serviceman switched off the signal generator and the receiver, and the oscilloscope display once again settled down to a horizontal line, "there's something completely fascinating about these oscilloscope traces. I wonder why it is that we don't employ that oscilloscope more in this place."

"Probably," replied Smithy, "because we've got used to doing most of our work without it. Also our 'scope is rather an old-fashioned weighty affair too, which means that we tend to think twice before lugging it around and on to the bench and connecting it up. Anyway in your case it's probably a good thing we *don't* use the 'scope too much. You'd be spending far more time fiddling around with its controls than you would fixing the sets you're supposed to be servicing."

After which statement, Smithy switched off the oscilloscope, disconnected his testmeter, and proceeded to check the receiver on broadcast signals. It produced a satisfactory response and Smithy gave a grunt of satisfaction.

"Another job done," he remarked. "Incidentally I think I'd better mention that the balancing adjustments

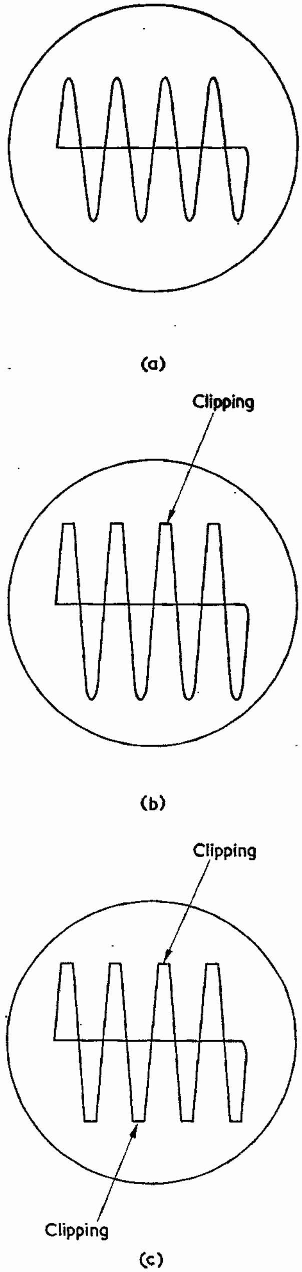


Fig. 2(a). Four sine waves, reproduced on the screen of an oscilloscope

(b). Class B transistor output stage unbalance, as indicated by asymmetric clipping on a high level signal

(c). Symmetrical clipping, as shown here, indicates a balanced output stage

we've been carrying out should always be done strictly in accordance with the service manual for the particular set."

"Why's that?" queried Dick, tearing his eyes at last from the now blank screen of the oscilloscope.

"Because mains-supplied output stages with physically small output transistors," replied Smithy, "are frequently run very close to the bone so far as dissipation with high level signals is concerned, and you can't afford to make mistakes. Also, you must never use an output load impedance lower than that for which the stage is designed and you must always ensure, when fitting replacement output transistors, that adequate coupling to the heat sink is provided."

"Fair enough," said Dick. "But let's get back to oscilloscopes! Can they be used to give you anything different from waveforms built up on a horizontal trace?"

"Of course they can," replied Smithy absently, as he fitted the back to the receiver. "If you disconnect the X timebase and couple your input signals straight into the X and Y inputs, you can get traces which, for instance, show the phase difference between two signals of the same frequency."

"Blimey," said Dick, impressed at this information. "That's something I didn't know before."

"There are lots of other things you can do with a 'scope," continued Smithy, carelessly. "You can, for example, compare frequencies as well."

"How d'you mean? With Lissajous figures?"

"That's right."

"So far as Lissajous figures are concerned," commented Dick, "I've always been able to follow how they're used, but I've never quite understood how they're formed."

Smithy put the final screw into the back of the receiver and glanced at the clock.

"It's about time," he remarked, putting down his screwdriver, "that we had a break for tea, so whilst you're putting the kettle on I'll sort out my thoughts and see if I can give you a bit of gen. on using an oscilloscope for functions other than the display of simple waveforms."

"Good show," said Dick enthusiastically. "I'll get that kettle on in next to no time!"

When Dick returned from the Workshop sink, near which the kettle was sited, Smithy had already pulled his note-pad towards him and had started scribbling out a few sketches. The Serviceman motioned to his assistant to bring his stool over.

"Right," said Smithy, after Dick had settled himself comfortably. "To start off with, I think I'm safe in saying that you should be fully aware of the way in which we normally use an oscilloscope. We have a timebase which applies a sawtooth voltage to the X plates and thereby causes the beam spot to trace out a horizontal line. If we apply a signal to the Y input terminals, the spot is deflected vertically according to the voltage amplitude of that signal. Provided we get the horizontal timebase running at the correct frequency it is then possible to reproduce one or more of the input cycles on the screen of the tube. Okay?"

"Sure," replied Dick. "That's what we did just now when we checked that a.f. output signal for clipping on cycle tips."

"Exactly," said Smithy. "And so I don't need to spend any more time on that aspect of the oscilloscope. Now let's press on to the other types of trace we can get from the oscilloscope when its horizontal timebase is switched off and out of circuit. For these we apply our input signals directly to the X and Y plates of the oscilloscope tube or to an X amplifier and a Y amplifier which precede these plates. A Y amplifier will, of course, be part and parcel of a standard oscilloscope, but an X amplifier will probably not be included unless the oscilloscope is an expensive bit of goods. Frequently, however, it is possible to couple directly into the X and Y plates of the oscilloscope c.r.t. by means of sockets provided in a convenient place, usually at the rear, these also enabling the timebase to be uncoupled. Since we're now going to examine in theoretical fashion how the traces I mentioned are formed, I'm going to assume that we have an oscilloscope which provides direct access to the X and Y plates. Also, that such commonsense requirements as coupling capacitors which isolate the input signals from the supply voltages applied to the X and Y plates are fitted, and so on. In practice, we could well employ X and Y amplifiers, but for our theoretical discussion we'll assume that the input signals go straight into the X and Y plates."

DIRECT COUPLING

"I see what you mean," said Dick. "What we're really getting down to

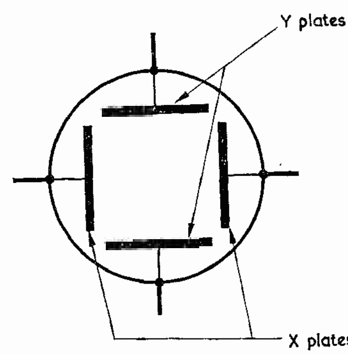


Fig. 3. The X and Y plates, of the oscilloscope tube

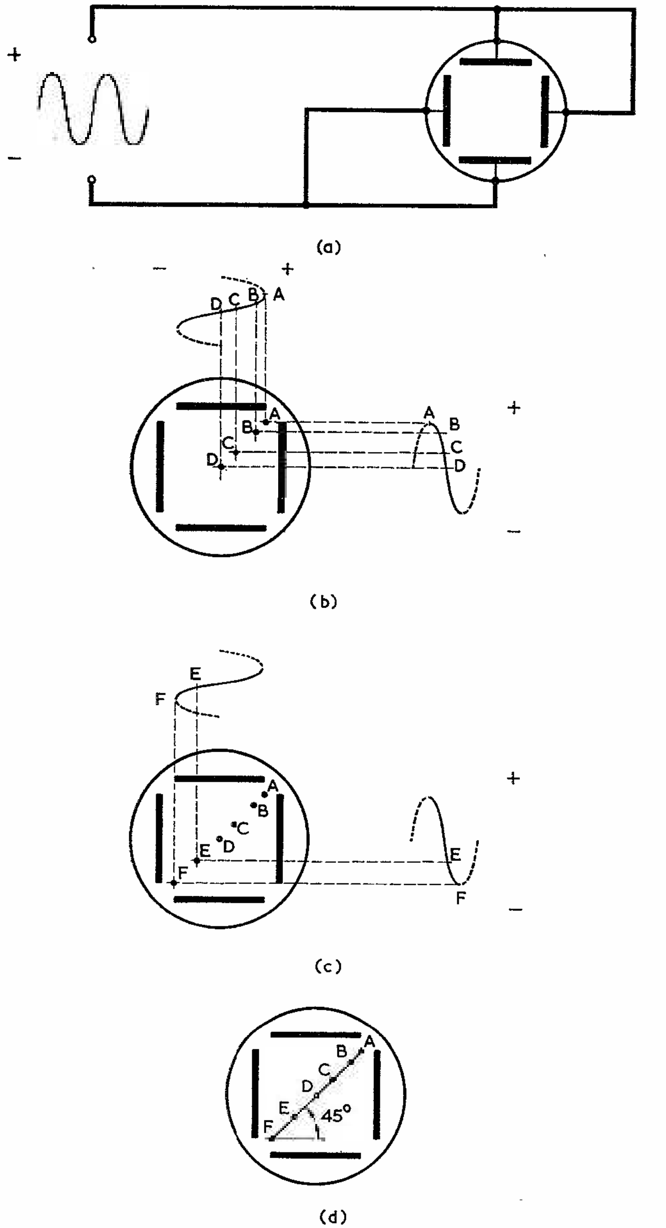


Fig. 4(a). A sine wave is applied to the X and Y plates, these being connected as shown here

(b). The deflection afforded by the X and Y plates can be shown graphically by drawing the sine waves above and alongside the c.r.t. symbol, and producing vertical and horizontal lines to the screen. The corresponding beam spot appears at the points where the produced lines cross

(c). Completing the process started in (b)

(d). The points A to F inside the c.r.t. symbol all lie on a straight line having an angle of 45° to the horizontal

now is an oscilloscope c.r.t. with all the necessary anode, grid and cathode voltages applied, and with the ability to couple directly to the X and Y plates."

"Exactly," confirmed Smithy, picking up his pen. "And we can now look upon the oscilloscope like this. (Fig. 3). All I've shown in this sketch are two X plates and two Y plates and all we need to know about these is that when any plate is positive it attracts the c.r.t. beam towards it and that, when it is negative, it repels the c.r.t. beam away from it. Without any deflection voltage on the plates the beam stays in the centre. We'll further assume that each set of plates has the same deflection sensitivity, which means that it offers equal beam deflection for the same deflection voltage."

Dick looked a little worried.

"We seem," he remarked, "to be making rather a lot of these assumptions."

"We have to," replied Smithy. "But, as you'll see soon enough, they're necessary if we are to understand how the traces are formed. Well, let's take a look at the first trace we're going to examine. We'll couple the right-hand X plate and top Y plate together, and the left-hand X plate and bottom Y plate together. After that we'll apply a sine wave to them. (Fig. 4(a)). What happens?"

"Gosh,' said Dick, shaken at this sudden question. "Don't ask me, Smithy. You're the geyser with all the answers here!"

"Well, I'll tell you," stated Smithy. "It will make things easy if we examine the deflection given during a single half-cycle, and we'll choose a half-cycle which, at its start, causes the right-hand X plate and top Y plate to be at peak positive. I'll draw the half-cycle alongside the plates both horizontally and vertically so that you can see how the beam is deflected. (Fig. 4(b)). Let's say the peak positive starting point on both the waveforms is point A. As you can see from the top waveform, this corresponds to the beam being deflected most to the right. Similarly, from the waveform at the side, we can see that point A corresponds to the beam being at its highest. So the beam spot will come out, on the c.r.t. screen, at a position which is both most to the right and highest. We can draw in point A inside the X and Y plates to illustrate this."

"That seems fair enough," commented Dick. "Let's try the same thing a bit further along the half-cycle."

"Okey-doke," said Smithy obligingly, picking up his pen again. "We'll choose a point B at random on both the waveforms which is a little further along. If we judge the effect on beam deflection, we'll see that it causes the spot to appear a little less to the right than did point A and a little lower down. So we can mark a corresponding point B on the c.r.t. screen."

"This is getting interesting," said Dick enthusiastically. "Try a few more points."

"All right" returned Smithy. "We'll take point C, which is a bit further along again. The resultant spot on the c.r.t. screen is, in its turn, a little less to the right than was point B

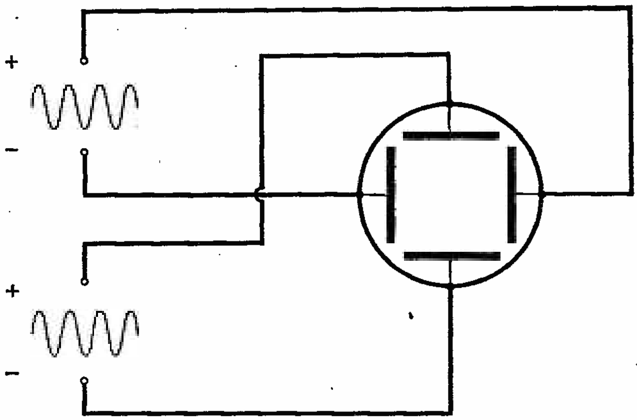


Fig. 5. When two sine waves of equal frequency, amplitude and phase are applied in the manner illustrated here, the deflecting voltages are the same as occur in Fig. 4(a), and the resulting trace is once more a straight line extending from top right to bottom left

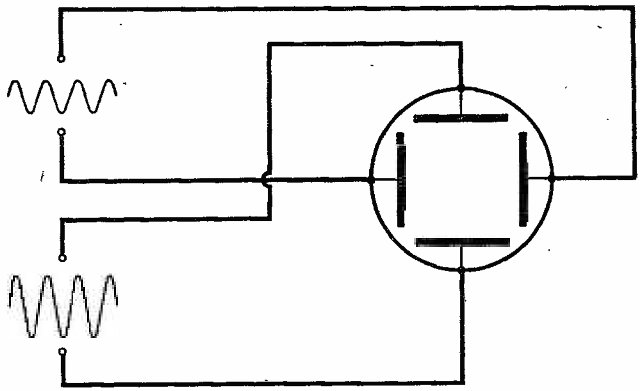
and again a little lower down. The next point is D and I'm making this the exact centre of the half-cycle, where there is zero voltage. Since there is, in consequence, no deflecting voltage on either the X or Y plates the corresponding spot from the c.r.t. beam is dead central between the plates. Two more points are enough to complete this little exercise, and these are E and F. (Fig. 4(c)). Point F, incidentally, is the most negative part of the half-cycle and it deflects the c.r.t. beam furthest to the left and furthest downwards."

With a flourish, Smithy placed his pen on the bench and turned to his assistant. That worthy was examining Smithy's sketch with an expression of enormous concentration.

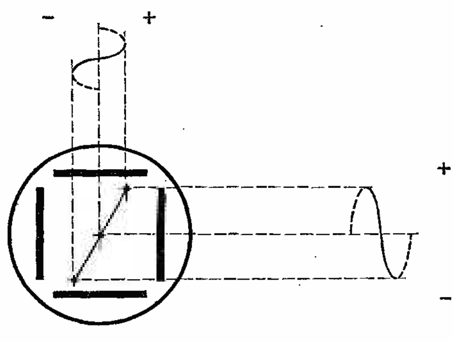
"Do you know, Smithy," Dick remarked after a moment, "those points A to F on the screen seem to be tracing out a straight line."

"I was wondering," chuckled Smithy, "how long it would take you to tumble to that fact! The line through points A to F is, indeed, a straight line, and it has an angle of 45° to the horizontal. (Fig. 4(d)). When you think about it, you'll realise that the formation of a straight line by that sine wave was bound to happen. If you took *any* corresponding points on those two half-cycles I drew in you would have the case where the c.r.t. beam suffers the same amount of deflection in the vertical sense as it does in the horizontal sense. The result *must* be a straight line with an inclination of 45°. Now, what would happen if we were to examine the deflection given over the following half-cycle?"

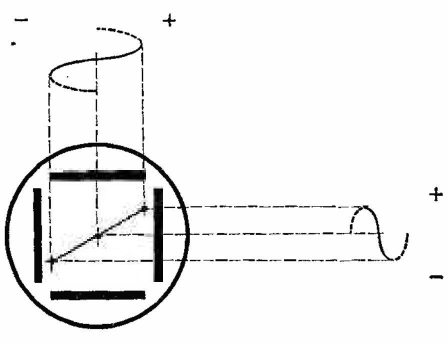
"Why, we'd get the straight line repeated," replied Dick. "Only this time it would start at the bottom left-hand corner and end up at the top right-hand corner."



(a)



(b)



(c)

Fig. 6(a). Here, the sine wave applied to the X plates is lower in amplitude than that applied to the Y plates

(b). The resultant sloping line has an angle to the horizontal which is greater than 45°

(c). The angle to the horizontal is less than 45° if the signal with smaller amplitude is applied to the Y plates

"Exactly," confirmed Smithy. "With the result that the c.r.t. beam spot would traverse exactly the same line going up as it did going down. An observer looking at the c.r.t. screen will see a single straight line sloping at 45°, and there will be no visual indication that the beam spot has traced out the line twice in both directions. Actually, of course, the spot will be tracing out the line continually, at the same frequency as that of the applied sine wave."

Smithy tore out the top sheet of his note-pad.

"That disposes," he remarked, "of the first oscilloscope trace you can get when you're coupling an input signal directly to the deflector plates. Let's next see what happens if we apply two separate sine waves to the X and Y plates. Both of these sine waves have exactly the same frequency and amplitude and they are both exactly in phase."

Dick studied the circuit condition Smithy had sketched out. (Fig. 5).

"Is there," he remarked suspiciously, "a catch here?"

"There is," confirmed Smithy sweetly.

Suddenly, Dick's frown disappeared.

"Stap me," he ejaculated. "It's obvious! Since the two sine waves are identical and are in phase, the deflection will be just the same as if you'd applied a single sine wave in the manner you described previously."

"You've got it," said Smithy. "In fact, the theoretical circuit conditions are such that if we were to put shorting links between the top Y plate and right-hand X plate, and between the bottom Y plate and left-hand X plate, no current would flow through the shorting links! This is because the top Y plate and right-hand X plate always have the same potential, as also do the bottom Y plate and left-hand X plate. In consequence, the resultant trace is a straight line sloping at 45°, exactly the same as we had before."

"This is rather a useful bit of information," remarked Dick musingly. "It means that, if you apply two sine waves to the X and Y plates in the way we have, and if you get a sloping line from top right to bottom left, those two sine waves *must* be in phase."

"You're learning," commented Smithy approvingly. "For the record, you'd get the straight line for two identical waveforms other than a sine wave if they happened to be in phase. But you don't need to bother about that, apart from just remembering the fact, because most of the other displays that are possible with an oscilloscope used in this fashion do need sine wave inputs."

DISSIMILAR INPUTS

Smithy busied himself with his pen.

"Now here," he remarked, "are two sine waves having different amplitudes, although they are still exactly in phase. The amplitude of the sine wave applied to the X plates is the smaller. (Fig. 6(a)). I'll next draw the waveforms alongside the X and Y plates in the same manner as I did for the first sine wave we considered. If we check spot deflection through a half-cycle in a similar way we will once more get a sloping straight line, as we did before. But because, in this case, there is a lower amplitude signal on the X plates there is less deflection to right and left, with the consequence that the line slopes at an angle greater than 45° to the horizontal. (Fig. 6(b)). If the signal applied to the X plates had had greater amplitude than the one applied to the Y plates, the sloping line would have had an angle to the horizontal of less than 45°." (Fig. 6(c)).

"Well, I'm blowed," gasped Dick. "Not only does the sloping line tell you that the two sine waves are in phase but its angle to the horizontal also indicates their relative amplitudes as well."

"True enough," agreed Smithy. "But, whilst it's O.K. to say that the sloping straight line indicates that the two signals are in phase, you've got to be very cautious, *in practice*, before making assumptions about their relative amplitudes according to the angle which that line makes to the horizontal. We've assumed equal deflection sensitivities in the X and Y plates for this theoretical discussion but, with a practical oscilloscope tube, they may well have slightly different deflection sensitivities."

"Then you can't," objected Dick, "rely on the angle being 45° for equal amplitudes after all."

"If *in practice* you want to ensure

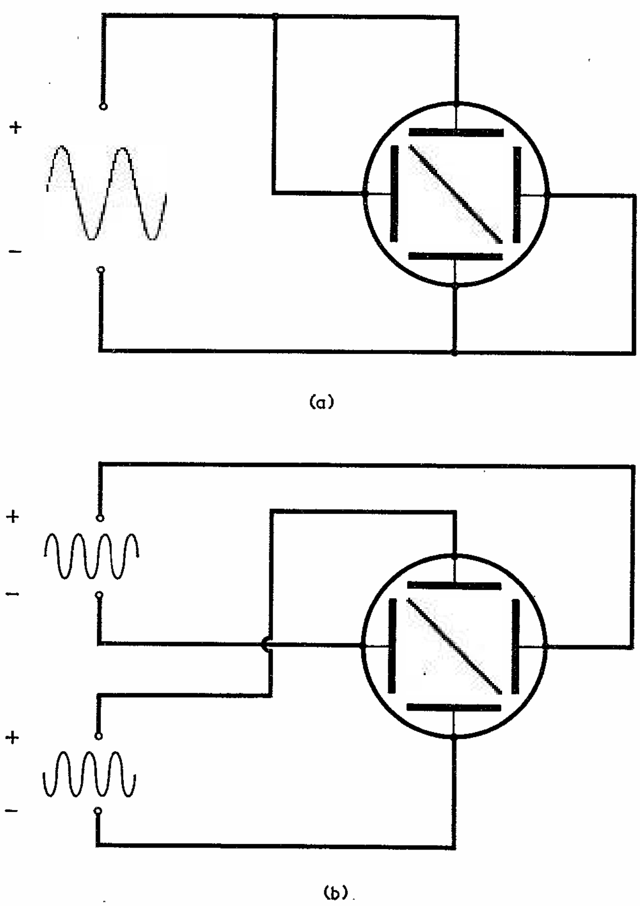


Fig. 7(a). If the X plate connections of Fig. 4(a) are reversed, the resulting line on the c.r.t. screen slopes from top left to bottom right

(b). A similar trace is given if two signals 180° out of phase are applied to the X and Y plates, using normal connections

that signals of equal amplitude give the 45° slope," replied Smithy, "you must first of all put in a single signal to the X and Y plates coupled together in the manner I first described. If it is necessary, you then *make* the angle 45° by judiciously adjusting an external attenuator circuit of some sort in either one or both of the X and Y inputs. As I said just now we may well have X and Y amplifiers between the input signals and the deflector plates. We could then alternatively adjust the gain of these amplifiers to give us the 45° angle with the single signal. After having set things up in this manner we *could* then rely on the oscilloscope to give us an indication of relative amplitude by way of slope angle."

"This setting up business," remarked Dick doubtfully, sounds a bit complicated."

"It isn't really," replied Smithy cheerfully. "We're using the simple theoretical concept of coupling direct to X and Y plates to explain how these traces we are considering are formed, but I don't want you to forget the practical side as well. Anyway, let's return to our theoretical discussion, where our input signals are going straight into X and Y plates of equal deflection sensitivity. What happens if I connect the top Y plate to the *left-hand* X plate and the bottom Y plate to the *right-hand* X plate and once more apply a single sine wave?"

"Well," said Dick, thoughtfully. "The vertical deflection remains unaltered, but the horizontal deflection is reversed. So far as I can see, you'll get the same sloping line as you had before, but this time it will go from top left to bottom right." (Fig. 7(a)).

"Correct," said Smithy. "Now, what my revised method of connection has done has been to reverse the phase of the signal applied to the X plates. It follows from this that, if I revert to my original method of connection and apply two sine waves which are *exactly* out of phase, I'll similarly get a sloping line going from top left to right bottom." (Fig. 7(b)).

"Why, so you will," remarked Dick, surprised by this sudden revelation. "You'll also get the same sort of variations in slope angle according to relative amplitudes, won't you?"

"You will," confirmed Smithy. "Well now, I reckon that we've had a short but quite useful introduction into what you can do with an oscilloscope when you couple direct to the X and Y plates. What we've learned is that, if we have two input signals which are exactly in phase, the c.r.t. displays a straight line going from top right to bottom left. And if we have two input signals which are exactly out of phase the c.r.t. displays a straight line going from top left to bottom right."

MORE TO COME

It was at that instant that the Workshop kettle informed the world that its contents had acquired their latent heat of evaporation by giving voice to an ear-splitting whistle. Dick rose quickly, and using the sketchy culinary implements available in the Workshop, measured out the tea (one and a half Denco coil can lids-full). He next poured the boiling fluid from the kettle into the tea-pot, stirring vigorously with a 12 inch steel rule. Returning, he placed Smithy's disreputable tin mug alongside him and then proceeded to sip from his own cup.

"If those two sine waves are *exactly* out of phase," he remarked, "They've got a phase difference of 180°, haven't they?"

"That's right," confirmed Smithy.

"What trace do you get if they're 90° out of phase?"

"The oscilloscope tube displays a a circle."

"It displays a *what*?"

"A circle," repeated Smithy.

"Blimey," gasped Dick. "How on earth does that happen?"

"I'll tell you all about it," said Smithy, "the next time we have a gen session together. But, just for once, I'm now going to have a tea-break which is free from technical topics. So let's change the subject. Tell me about this dance you're going to tonight."

"Will you *promise* to deal with that circular trace during our next session?"

"I promise," confirmed Smithy gravely.

"Fair enough, then," replied Dick. "Well, this dance is to be held at Joe's Caff and its going to be a really big scene. He's cleared out all the chairs and tables from the middle to give us a bit of space, and we're devoting the whole evening to Old Tyme dancing."

"Like the one-step?"

"I wouldn't." said Dick dubiously, "know about that one. The dances we'll be doing are the *real* oldies, like the Frug and the Twist. Why don't you come along, Smithy? It will be real Squaresville, man!"

But it must regretfully be recorded that the Serviceman, normally the pillar of veracity, responded to his youthful assistant with a blatant and manifest falsehood when he stated very firmly that he already had an alternative engagement. ■

LOCATING SHORT CIRCUITS QUICKLY

An ITT Short Circuit Detector now available in the United Kingdom permits rapid localisation of short circuits in telephone and signalling cables, distribution wires and power cables.

It also enables particular cables to be identified from among many others, concealed wiring to be traced, and the run of cable pairs to be followed – even buried in concrete to a depth of 30 cms.

The detector itself comprises a probe, transistorised amplifier and headphones. It operates in conjunction with a transistorised oscillator generating a fixed frequency about 1400 c/s. The short-circuited loop is energised by the oscillator. The probe is then moved along the cable – being kept as close as possible and with its axis in the direction of the magnetic field.

Initially a tone is heard in the headphones, but when the short circuit is reached it drops away practically to zero Two output voltages are available from the oscillator, for use as required by the nature of the short circuit. The loudness of the tone in the headphones is easily adjusted.

The ITT Short Circuit Detector is available through ITT Electronic Services, Edinburgh Way, Harlow, Essex.

Principles of Metal Detection

Part 2 of this article, and conclusion, will be published in our next issue (July – due to be published on the 2nd).

FOR THE SWL . . .

by L. SAXHAM

Several requests have been received from interested readers requiring advice on the necessary constant stream of information that is required to keep abreast of events in the Broadcast band listening world. It would appear that these lone operators experience the greatest difficulty in obtaining even the slightest morsel of information due to the utter lack of knowing where to gain this knowledge. To successfully operate a Broadcast band listening post, a constant stream of information is required. Such items as frequency changes, time schedules, English or other language transmission times, directional bearings of station beams, interval signals, primary language used and frequencies used in parallel are some of the details which are required. To satisfy these requirements, information is provided here on those publications easily obtainable in this country.

First things first , the prime requirement is a book providing the information outlined in the above paragraph. Such a publication is the *World Radio TV Handbook*, published annually during December. This publication is virtually the "Bible" of the Broadcast world and it contains every conceivable item of information that the enthusiast could possibly require with respect to world-wide Broadcast stations. In addition to complete short wave coverage, long and medium stations of the world are also listed — additionally TV stations are also included. A summer supplement to this handbook is published during June of each year, thus the enthusiast can acquire a complete fresh listing of short wave stations every six months. This Handbook and supplement are available from several sources, two of these being the International Short Wave League, 60 White Street, Derby, and the Modern Book Co., 19 Praed Street, London, W.2.

A further commercial publication which is of considerable interest to the operator is *Guide to Broadcasting Stations*, published annually by Iliffe Books Ltd., and is available from most bookshops at a very reasonable price. It contains long, medium and s.w. stations, listed both in order of frequency and geographically; much other information is also included.

A great deal may be culled from a good Broadcast station list if a careful perusal of the listings are made. For instance, the latest list, at the time of writing, includes the following stations, with powers, operating on 7170kHz.

250	Woofferton, U.K.
120	Moscow, U.S.S.R.
50	Algiers, Algeria
20/240	Peking, China
2	AIR Kohima, India
10	Peshawar, Pakistan
10	Singapore
4	Noumea, New Caledonia

A study of this list and the associated information published will show that the stations have broadcasting time schedules that only slightly overlap. Not only separated with respect to distance, each have differing clock times and cater for listeners in various parts of the world in which local times are of importance at the transmitting end. Radiating a programme at the wrong time would possibly result in the broadcast being receivable when the majority of the population are asleep in bed !

Radiated powers are of interest in that some stations have variable power ratings (R. Peking), these being varied according to the aerial used, the prevailing conditions and the target area, etc. Most stations, however, have fixed value radiated powers.

From the list it will be noted that Kohima, India, has the comparatively low power rating of 2 kilowatt. From this fact, it is obvious that this station is catering in the main for local listeners only, and for the enthusiast in this country to receive this transmission would be a Dx feat of a high order — particularly when a more powerful station may be operating at the same time on this or an adjacent channel. The same remarks apply, even more so, despite the 4kW rating, to Noumea, New Caledonia, bearing in mind the additional distance this signal must travel.

A station list can, however, provide traps for the unwary! Merely to hear a transmission in Arabic on 7170kHz does not automatically imply reception of Algiers — it *could* be a broadcast in that language from another station on the same channel being beamed to the Middle East! Moral — wait for the station announcement and/or interval signal prior to *positive* identification.

An additional task for the Broadcast bands operator is that of keeping the list up-to-date, and this inevitably involves some 'office work'.

An extremely useful and necessary monthly supply of information is contained in the I.S.W.L. publication *Monitor*. This is available to members of the League and, among other interesting features, includes several quarto sized pages packed with information on Broadcast stations, etc., and the section invariably contains an article of interest. Membership costs, at the time of writing, 35/- per annum — this fee including many services, Dx certificates, contests, etc. Membership is recommended.

Another organisation worthy of note is the World Dx Club, whose monthly bulletin — *Contact* — contains many items of great interest to the Broadcast bands operator, frequency listings of stations, times, schedules and news, etc., are all featured in this publication. Membership to the WDXC costs 25/- per annum (at present) and this includes receipt of the monthly *Contact*. Enquiries should be directed to the Secretary: R. Rogers, 17 Taunton Road, Bridgwater, Somerset.

With all the above publications in the shack, the operator will have readily to hand most of the information that is required for Broadcast band operation. ■

"Mains Power for Transistor Equipment"

As our regular readers will appreciate, we take the greatest care when checking both the text and circuit diagrams; but it will be noted, since it was apparent on reading the text, that the two diagrams for the article "Mains Power for Transistor Equipment", published in the May issue, were transposed. This error is regretted.

Radio Topics

By Recorder

THERE AIN'T, MAYBE, NO SUCH thing as infinity, but the Marconi Company Ltd. seems to be aspiring towards it.

What prompts my comment is that the Marconi Company has just produced an entirely new type of waveguide load whose power dissipation is virtually unlimited, to the extent that Marconi engineers have so far been unable to generate sufficient microwave power to define the upper limits of its energy dissipation curve!

WATER AS ABSORBENT

The secret of the new loading device is that water absorbs the microwave energy directly, rather than being employed as a cooling medium for a solid state energy sink.

There are no fragile parts in the new Marconi loads, and the bandwidth and power range are greater than with solid state dielectric slabs or windows where the energy absorbed is carried away by conduction, with consequent severe load limitations. The devices use either one or two tubes, made of p.t.f.e., which run through the end of a waveguide section at an angle of about 15° to the axis of the waveguide. Water is passed through the tubes, and the radio energy is absorbed directly into the water. A small percentage is dissipated in the plastic tubes, but this is rapidly transferred to the water by conduction.

In a typical application, with a dissipation of 5kW continuous wave and with 273 litres (60 gallons) per hour water flow, the temperature rise in the water passing through the load was 16°C only. No specific purity of the water is needed, and glycol can be added for low temperature applications if required.

This new device, with its limitless (for the present state of the art) upper range, can certainly be said to form a watershed in the development of microwave waveguide energy loads.

PROFESSIONAL COAX ENDS

It isn't always an easy matter to terminate coaxial cables neatly. I am, in consequence, indebted to Mr. P. A. Graves of Westcliff on Sea, Essex, who has sent us some useful information on this subject, together with the diagrams which are reproduced here as Figs. 1 and 2.

It is often a difficult job (writes Mr. Graves) to produce neat, strong connections with coaxial cable, and

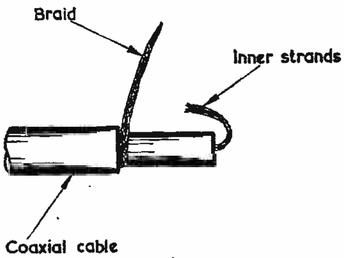


Fig. 1. First step in terminating a coaxial cable

the inner wires seem to break off with annoying frequency. A method of termination which is used in many factories, but which may not be known to the amateur enthusiast, prevents this sort of failure.

The operations required for making off the end proceed in the following sequence.

1. With a sharp knife cut round and remove the outer insulation of the cable about an inch back from the end, taking care not to score or nick the copper braid.

2. With a spike or small screwdriver tease out the braid strands and twist them together to form an earth 'tail', leaving the inner insulation revealed.

3. Strip off about ¼in. of inner insulation. One way of doing this without fear of damaging the inner strands of the wire is to run the tip of a hot soldering iron round the insulation—a rather smelly but effective method!

4. Fold the inner strands back down the insulation. The cable end should now be as in Fig. 1.

5. Take a length of tinned copper wire (20 or 22 s.w.g.) and wrap it tightly round the strands and insulation, leaving a piece projecting to provide the inner connections. See Fig. 2.

by way of an intermediate conversion to octal. The decimal number is first changed to octal by successive division by 8, taking a note of each remainder. Reading the remainders in the example from bottom to top then gives 15205 as the octal equivalent of decimal 6789. This process is carried out in Fig. 3(a).

Octal is very easily converted to binary by replacing each digit by its binary equivalent, as in the upper line in Fig. 3(b). The lower line then gives the binary equivalent of decimal 6789, as obtained via the intermediate step of converting into octal.

ALPHABETICAL ORDER

Like most people I find that mnemonics are a great help in remembering some of the facts, figures and formulae that appear so frequently in electronics. A little shamefacedly I must confess that, when dealing with Ohm's Law problems in my early days, I used to rely continually on the statement that "rain is 'eavy over India". I found that I could mentally recall this nonsensical phrase far more readily than the "R is E over I"

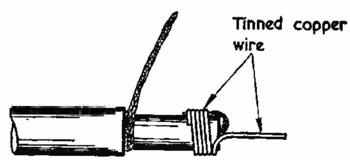


Fig. 2. The cable end before soldering the inner wire

6. With a clean *hot* iron run solder round the tinner copper wire and inner strands.

7. Leave to cool, after which it will be found that the tinned copper wire has been soldered on to the inner strands and has also melted into the inner polythene insulation.

8. For additional protection a rubber sleeve can, if desired, be put over the inner connections to prevent any danger of the braid connection short-circuiting against it.

DECIMAL, OCTAL AND BINARY

Another reader, Mr. E. W. Fothergill of Lowton, Lancs, has also sent in some useful information, this having to do with the conversion of large decimal numbers to binary. A very effective short-cut is given here by converting to octal (i.e. to numbers based on 8 instead of 10) as an intermediate step.

An example of the method appears in Fig. 3, which shows how decimal 6789 is converted to binary

which truly represented the Ohm's Law equation.

Sometimes, matters arrange themselves in such an accommodating manner that suitable mnemonics are virtually ready-made. For instance, that trusty trio of twin-triodes, the 12AT7, 12AU7 and 12AX7, have the T, U and X obviously in alphabetical order. Their direct equivalents, the ECC81, ECC82 and ECC83 respectively, conveniently appear in numerical order.

I have just now noticed another helpful choice of identifying letters, this occurring in the British PAL television specification. After weighting (i.e. being reduced in amplitude preparatory to tranmission) the B–Y signal is referred to as the U-chroma signal, and the R–Y signal as the V-chroma signal. Since B and R are in alphabetical order this useful selection of letters ensures that I, at any rate, will not ascribe the wrong colour-difference signals to the similarly alphabetically-ordered U and V.

	Remainder
6789	5
848	0
106	2
13	5
1	1
0	

6789 (DECIMAL) = 15205 (OCTAL)

(a)

15205 (OCTAL) = 001 101 010 000 101 (BINARY)

6789 (DECIMAL) = 1101010000101 (BINARY)

(b)

Fig. 3. Example illustrating a quick means of converting a large decimal number to binary. In (a) the number is changed to octal. The octal version is then directly converted, in (b), to binary notation

DRY JOINT LOCATOR

Dry soldered joints are always a problem, this being particularly true when they occur on a printed circuit flow-soldering production line. To assist technicians and engineers, Davian Instruments Ltd. have introduced a continuity measuring device which is specifically intended for the detection of dry joints. Features of the Davian Instruments Dry Joint Locator are that it applies a low voltage to its two test points (to protect in-circuit transistors) and that it operates at a high current (to persuade potential dry joints to fail). The instrument is capable of measuring from 0.005Ω to 5Ω and the maximum preset current which can be applied to the joint under test is 250mA. The test current reduces automatically if the resistance presented to the test points is greater than four times f.s.d. for the particular range of resistances being checked, thereby protecting the meter, the circuit under test and also, for the battery version of the Locator, prolonging the life of the battery. As may be inferred from this last statement, there is both a mains version and a battery-powered version. Other uses for the instrument include the checking of relay and switch contacts, and the determination of wire length for inductor re-winding services. Further details on the Davian Instruments Dry Joint Locator may be obtained from Techmation Ltd., 58 Edgware Way, Edgware, Middlesex.

An interesting note which is concerned with the operation of the Locator deals with the resistance of dry joints. A good soldered joint should have a resistance of less than 0.05Ω, whilst dry joints normally have a resistance higher than 0.5Ω. Any joint exhibiting a greater resistance than 0.1Ω is a potential source of trouble and should be re-soldered. ■

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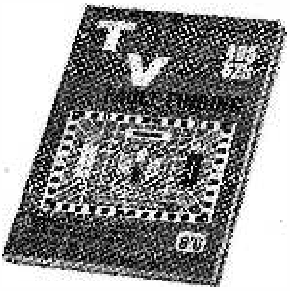

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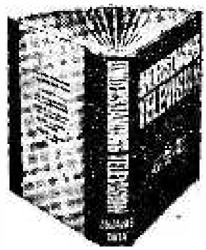

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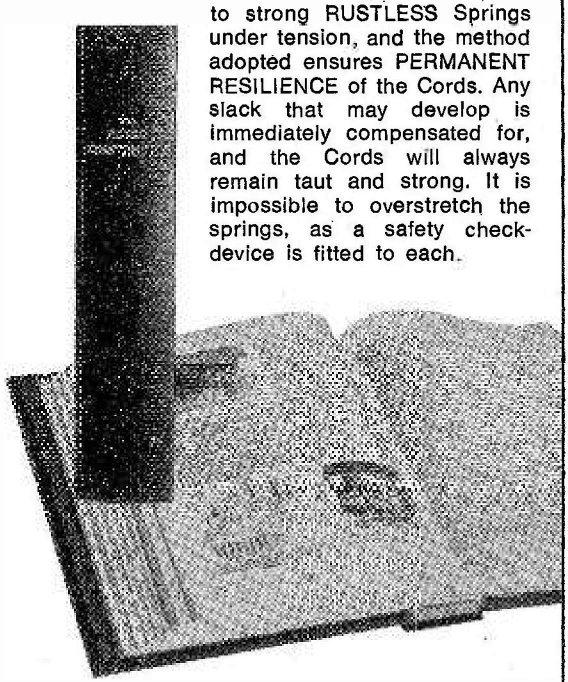

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RADIO CONSTRUCTORS DATA SHEET 27

INCH/MILLIMETRE CONVERSION TABLE

Conversions from inches to millimetres and vice versa are tedious when using the relations 1 inch = 25.4 millimetres or 1 millimetre = 0.03937 inch. Fortunately, most dimensions in electronic work are small and the Table (which lists millimetre equivalents for inches in 1/16-inch steps up to 3 inches and in ½-inch steps up to 5 inches) will enable quick approximations to be made in converting from one set of units to the other. Also given are decimal equivalents of the inch fractions.

Inches (Fractions)	Inches (Decimal)	Millimetres	Inches (Fractions)	Inches (Decimal)	Millimetres	Inches (Fractions)	Inches (Decimal)	Millimetres
1/16	0.0625	1·59	1 3/16	1.1875	30·2	2 1/4	2.25	57·2
1/8	0.125	3·18	1 1/4	1.25	31·8	2 5/16	2.3125	58·8
3/16	0.1875	4·76	1 5/16	1.3125	33·3	2 3/8	2.375	60·3
1/4	0.25	6·35	1 3/8	1.375	34·9	2 7/16	2.4375	61·9
5/16	0.3125	7·94	1 7/16	1.4375	36·5	2 1/2	2.5	63·5
3/8	0.375	9·53	1 1/2	1.5	38·1	2 9/16	2.5625	65·1
7/16	0.4375	11·1	1 9/16	1.5625	39·7	2 5/8	2.625	66·7
1/2	0.5	12·7	1 5/8	1.625	41·3	2 11/16	2.6875	68·3
9/16	0.5625	14·3	1 11/16	1.6875	42·9	2 3/4	2.75	69·9
5/8	0.625	15·9	1 3/4	1.75	44·5	2 13/16	2.8125	71·4
11/16	0.6875	17·5	1 13/16	1.8125	46·0	2 7/8	2.875	73·0
3/4	0.75	19·1	1 7/8	1.875	47·6	2 15/16	2.9375	74·6
13/16	0.8125	20·6	1 15/16	1.9375	49·2	3	3.0	76·2
7/8	0.875	22·2	2	2.0	50·8	3 1/2	3.5	88·9
15/16	0.9375	23·8	2 1/16	2.0625	52·4	4	4.0	102.0
1	1.0	25·4	2 1/8	2.125	54·0	4 1/2	4.5	114·0
1 1/16	1.0625	27·0	2 3/16	2.1875	55·6	5	5.0	127.0
1 1/8	1.125	28·6						