JAN 1962

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THE **Radio Constructor**

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CONTRIBUTIONS on constructional matters are invited, especially when they describe the construction of particular items of equipment. Articles should be written on one side of the sheet only and should preferably be typewritten, diagrams being on separate sheets. Whether hand-written or typewritten, lines should be double spaced. Diagrams need not be large or perfectly drawn, as our draughtsmen will redraw in most cases, but all relevant information should be included. Photographs should be clear and accompanied by negatives. Details of topical ideas and techniques are also welcomed and, if the contributor so wishes, will be re-written by our staff into article form. All contributions must be accompanied by a stamped addressed envelope for reply or return, and should bear the sender's name and address. Payment is made for all material published.

OPINIONS expressed by contributors are not necessarily those of the Editor or the proprietors.

TRADE NEWS. Manufacturers, publishers, etc., are invited to submit samples or information of new products for review in this section.

TECHNICAL QUERIES must be submitted in writing. We regret that we are unable to answer queries, other than those arising from articles appearing in this magazine; nor can we advise on modifications to the equipment described in these articles.

CORRESPONDENCE should be addressed to the Editor, Advertising Manager, Subscription Manager or the Publishers, as appropriate.

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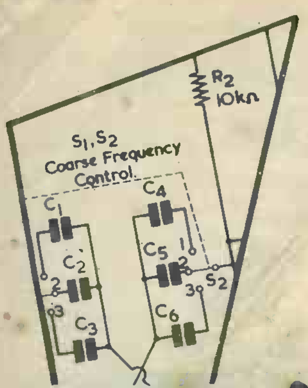
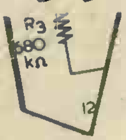


suggested circuits



The circuits presented in this series have been designed by G. A. FRENCH, specially for the enthusiast who needs only the circuit and essential data

No. 134
A TEMPERATURE-OPERATED SWITCH

THE CIRCUIT DESCRIBED THIS month employs a simple two-transistor amplifier to operate a relay when a heat sensitive device is raised or lowered to a pre-determined temperature. The heat sensitive device is a small and inexpensive thermistor whose resistance variations with temperature change cause corresponding changes in input current to the amplifier. The writer visualises the most useful application of the switching unit as that of providing a warning of overheating in any equipment to which the thermistor is coupled. Such equipment could consist of electronic apparatus, engine cooling systems, and the like; and it would, in many cases, also be possible for the unit to switch off the equipment if temperature reached an undesirable level. A further application would be that of employing the switch to give warning of fire, in which case the warning system could be tested from time to time by momentarily holding a lighted match below the thermistor.[1] The switching unit could also be used for the temperature control of ovens, but it must be pointed out that change of thermistor resistance with temperature is too low to permit a very close degree of control to be obtained.

The switching unit, as described in this article, allows relay operation to occur at temperatures within the range of some 40° to 120° C. It can, in consequence, provide warning or protection for most types of overheating. A method of enabling the switching unit to operate outside this range is suggested, but it must be pointed out that maximum operating temperature for the thermistor is of the order of 200° C. Since the thermistor is a filament protection device, a minimum operating temperature is not quoted in the manufacturer's literature, but there seems little reason why it could not be employed below 0° C.

A meter capable of measuring the current flowing through the relay coil (or the voltage dropped across it) is required during the setting-up of the unit.

The Circuit

The circuit of the switching unit appears in Fig. 1. The CZ10 thermistor is connected between a

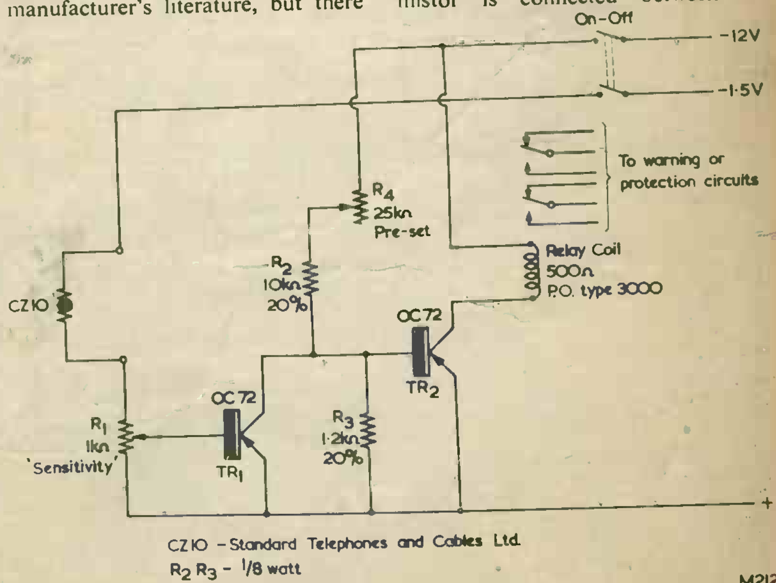


Fig. 1. The circuit of the temperature operated switch

[1] The match should be applied for a short time only, as is discussed later.

negative source of 1.5 volts and the 1kΩ potentiometer, R_1. Since the thermistor has a negative temperature coefficient its resistance drops as temperature increases. In consequence, an increase in temperature in the thermistor causes increased current to flow through it and, also, through the base-emitter circuit of TR_1.

TR_1 collector current passes through R_2 and R_4 in series and is normally of a low level, thereby allowing a relatively high base-emitter current to flow in TR_2. The base-emitter current in TR_2 is sufficiently high to enable the collector current of this transistor to energise the relay.

When the resistance of the thermistor falls, due to increasing temperature, the increased base-emitter current in TR_1 causes a corresponding increase in its collector current. This, flowing through R_2 and R_4, causes a reduced base-emitter current in TR_2, and a consequent reduction in TR_2 collector current. The relay then de-energises.

If the switching unit is intended to detect a *fall* in temperature to a pre-determined level the relay normally remains de-energised. When the temperature is sufficiently low, the increase in thermistor resistance causes a decrease in TR_1 current, a corresponding increase in TR_2 current, and the energising of the relay.

The relay specified may be fitted with two sets of contacts, these being used to operate warning circuits or to switch the equipment whose temperature is being monitored.

The "sensitivity" control, R_1, functions in an extremely simple manner, since it merely regulates the change in TR_1 base-emitter current brought about by changes in thermistor resistance. Adjusting R_1 varies the temperature at which the relay operates. The variable resistor R_4 is used to bring TR_2 on to its correct operating point.

Design Features

A CZ10 was employed as the temperature sensitive device in the switching unit because it has a high initial resistance (i.e. resistance at ambient temperature). Most thermistors exhibit approximately the same *ratio* of resistance change with change in temperature, and a high initial resistance enables this change in ratio to be sensed by the first transistor in the amplifier without the necessity of drawing a heavy energising current from the power supply. The CZ10 has the further advantage of being small in physical size, its dimensions being $\frac{5}{16}$in long by $\frac{3}{32}$in in diameter. The thermistor may, therefore, be readily fitted in equipment where space is limited.

The potentiometer R_1 offers an extremely simple means of controlling sensitivity, but its use incurs the disadvantage that the rate of change of relay current for temperature change reduces as the slider moves towards the lower end of the track, whereupon variations in relay performance become more liable to vary the temperature at which external circuits are switched. However, results with the prototype indicated that the simple sensitivity circuit given by R_1 was adequate in practice, especially if the device was merely intended to give protection against excessive temperatures.

No tests were made for repeatability of operation, and this point can only be ascertained by experience. One of the performance curves obtained with the prototype was determined from two sets of readings, and these tallied with each other satisfactorily. If the device is to be used to check a temperature having a fixed maximum level (such as a water cooling system, whose maximum level would be 100° C.) it might be advisable, until repeatability had been reliably ascertained, to set the switching device such that it operated at a minimum of some 10 to 15° C. below the maximum temperature. This procedure should give reasonable protection against any long-term shifts in performance which might occur.

It will be noted that a separate 1.5 volt supply is required for the thermistor. If desired, this could be obtained from a potentiometer connected across the 12 volt supply, the upper arm consisting of a 390Ω 1W resistor and the lower arm of a 56Ω ¼W resistor. Such a potentiometer would draw a standing current of some 27mA, and both resistors should preferably be ±5%. If the 1.5 volt cell is retained it will need to supply less than 1mA energising current for temperatures of up to 100° C. The resistance of the thermistor at maximum operating temperature (200–250° C.) is 148Ω, with the result that the maximum current liable to be required from the cell (assuming zero base-emitter resistance in TR_1) is 10mA. (This figure falls comfortably within the maximum base current rat... the OC72 of 20mA.)

If it is desired to ha... unit operate at te... the range 40 t... be achieved b... voltage ...ed Lower circuit mod... locking an... the coil.

ing it. Performance at such temperatures has not been checked by the writer.

The relay circuit employed with the switching unit employs a transistor and relay combination which offers extremely reliable results and which has been used in previous circuits in this series. Brief details of relay operation are given at the end of this article. It is not necessary to connect a protective diode across the relay coil (to prevent the formation of high reverse voltages on the sudden cessation of energising current) because, in this circuit, changes in relay current should take place relatively slowly.

Setting-up and Operation

After the unit has been completed it needs to be set up. For this process it is necessary to connect a milliammeter capable of reading 20mA in series with the relay coil (or a voltmeter capable of reading 10 volts across it).

Initially, R_4 should be adjusted to insert maximum resistance and the 12 volt supply only should be applied. When the unit is switched on under this condition, TR_2 should be capable of passing maximum collector current. Pre-set resistor R_4 should now be adjusted until the relay coil current is 20mA (or until 10 volts appears across the 500Ω coil). Currents in excess of 23mA should be avoided.

The 1.5 volt supply should now be applied and R_1 adjusted for maximum sensitivity. The maximum sensitivity setting of R_1 may cause a slight reduction in relay current, this effect indicating that the current in the base-emitter circuit of TR_1 at maximum sensitivity is sufficiently high to affect TR_2 current. The thermistor may now be held between thumb and forefinger, whereupon the heat imparted to it should cause a noticeable drop in relay coil current. (Some of this drop may be caused by leakage across the surface of the thumb and finger.) A more positive check is given by *momentarily* holding a lighted match... inches under the therm... should cause the relay... to drop...

...use it another in the ...s the base via a pair of ...20, in an "impedance dividing" provide the necessary feedback at low ...ance. The crystal is in series with this path ...d was found to oscillate readily on the overtone frequency. Several small plated crystals in the range 21 to 24 Mc/s were tried in this circuit, and all worked well as soon as the coil was resonated, there being no noticeable attempt to self-oscillate on detuning. Off resonance the crystal merely stops working after a very slight frequency pulling.

that its terminals are not short-circuited. If such a short-circuit were to occur, TR_1 could pass an excess base-emitter current and be irreparably damaged.

Results with the Prototype

Several temperature runs were taken with the prototype, the results obtained being illustrated in Fig. 2. Fig. 2 (*a*) shows the results given at full sensitivity and, as may be seen, the slope of the temperature/current curve about the relay operating points is comfortably steep, despite the simplicity of the switching unit circuit. Readings for the curve of Fig. 2 (*a*) were taken on two separate occasions and tallied satisfactorily.

Fig. 2 (*b*) gives the curve given for a reduced sensitivity setting. In this case the slope at the relay operating points is not as steep, but it is still adequate for the applications envisaged by the writer.

The current consumed by the prototype from the 12 volt supply was approximately 21mA when the relay was energised, and 1mA when it was de-energised.

The Relay Circuit

The circuit around TR_2 is designed to allow this transistor to control the robust relay specified in an efficient manner, and the constructor is strongly recommended to employ a relay of the same type. That specified is a Post Office type 3,000 unit with a coil resistance of 500Ω. More than two contact sets should not be used, as energising current would become excessive. Under no circumstances should a relay having a coil resistance less than 500Ω be employed.[2]

Although not essential, it would be preferable to clamp TR_2 to a heat sink, the latter having the minimum dimensions of 1½in square. The supply voltage should be reasonably well regulated, a desirable figure being better than ±2 volts on 12 volts.

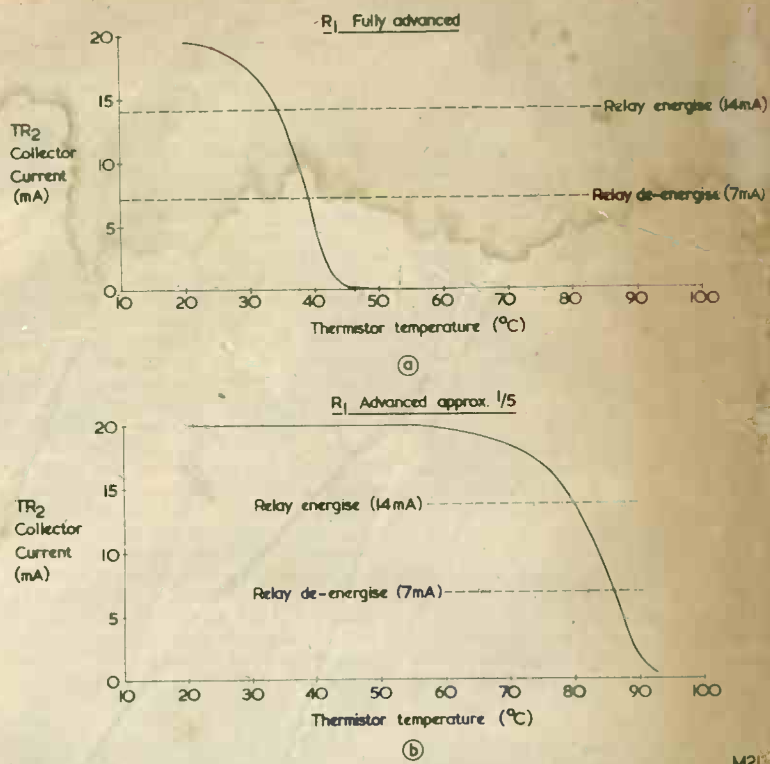


Fig. 2. Curves showing TR_2 collector current for temperatures in the range 20 to 95° C, as given by the prototype. The relay employed had two sets of changeover contacts

[2] A suitable relay, fitted with two sets of changeover contacts, is available from H. L. Smith & Co. Ltd., 287 Edgware Road, London, W.2.

Two-Tone Alarm Generator

Marconi Marine Radiotelephony Alarm Signal Generator

fire, The two-tone radiotelephony alarm signal generator now being fitted in many British fishing vessels and small
system cou... Marconi International Marine Communication Co., Ltd., has been type-approved by the British General
time by ... and fulfils all the requirements of the C.C.I.R. (International Radio Consultative Committee) recommendations.
lighted match there will be some delay before all the authorities concerned bring appropriate regulations into force,
The switching unit could ...ort has already made a strong recommendation that all United Kingdom ships carrying
used for the temperature control o... fitted with alarm generating equipment by 1st January, 1962.

ovens, but it must be pointed out that change of thermistor resistance with temperature is too low to permit a very close degree of control to be obtained.

The switching unit, as described in this article, allows relay operation to occur at temperatures within the range of some 40° to 120° C. It

...n designed for speed and simplicity in operation: the operator starts up
...al radiotelephone distress frequency of 2182 kc/s, switches on the
...o it, and pulls the alarm knob. The two-tone signal—alternating
...illiseconds—is transmitted for approximately 30 to 60 seconds
...mply disengaging the handset and speaking into it.
...stive tests designed to discover a signal which will be
...ence of intermediate frequency radiotelephony and
...supply and delivers twelve milliwatts into a 300
...set and, at the same time, enables the signal

1kΩ 'Sensitivity'
CZ10 - Standa.
R_2 R_3 - 1/8 watt

Fig. 1. The circuit of th

[1] The match should be applied for a short time only, as is discussed later.

An Experimental TRANSISTOR VHF RECEIVER for the Aircraft Bands

By D. T. Bradford, VQ4EV

There has for some time been a need for light weight v.h.f. equipment in some of the older aircraft, as are sometimes used by private flying enthusiasts. These aircraft are particularly mentioned because of their popularity, due to relatively low cost, and because there is usually a complete absence of storage battery electrical facilities and/or radio installation.

With an aged Leopard Moth in mind, the author set out to investigate the possibilities of useful transistorised equipment which could improve the safety of flying in the vicinity of crowded aerodromes. The fairly strong signals to be expected encouraged experiments using transistors alone. While the resultant receiver as it stands does not offer immediate applications for amateurs, a description is given as it is felt that the circuits used, and difficulties involved, may well prove of interest to those working in the 70 or 144 Mc/s bands.

The only transistors available at the time of these experiments which appeared to be suitable for use up to 120 Mc/s were the Ediswan type XA131 and four of these were purchased. These transistors are normally only recommended for use as amplifiers up to 100 Mc/s but it was resolved to attempt to squeeze them past this limit if at all possible. Very little other data could be found on these semiconductors and all of the results have been achieved by pure experiment without manufacturer's data. Crystal control of the oscillator was considered essential because of the possible vibration, etc., to which any final model would be subjected.

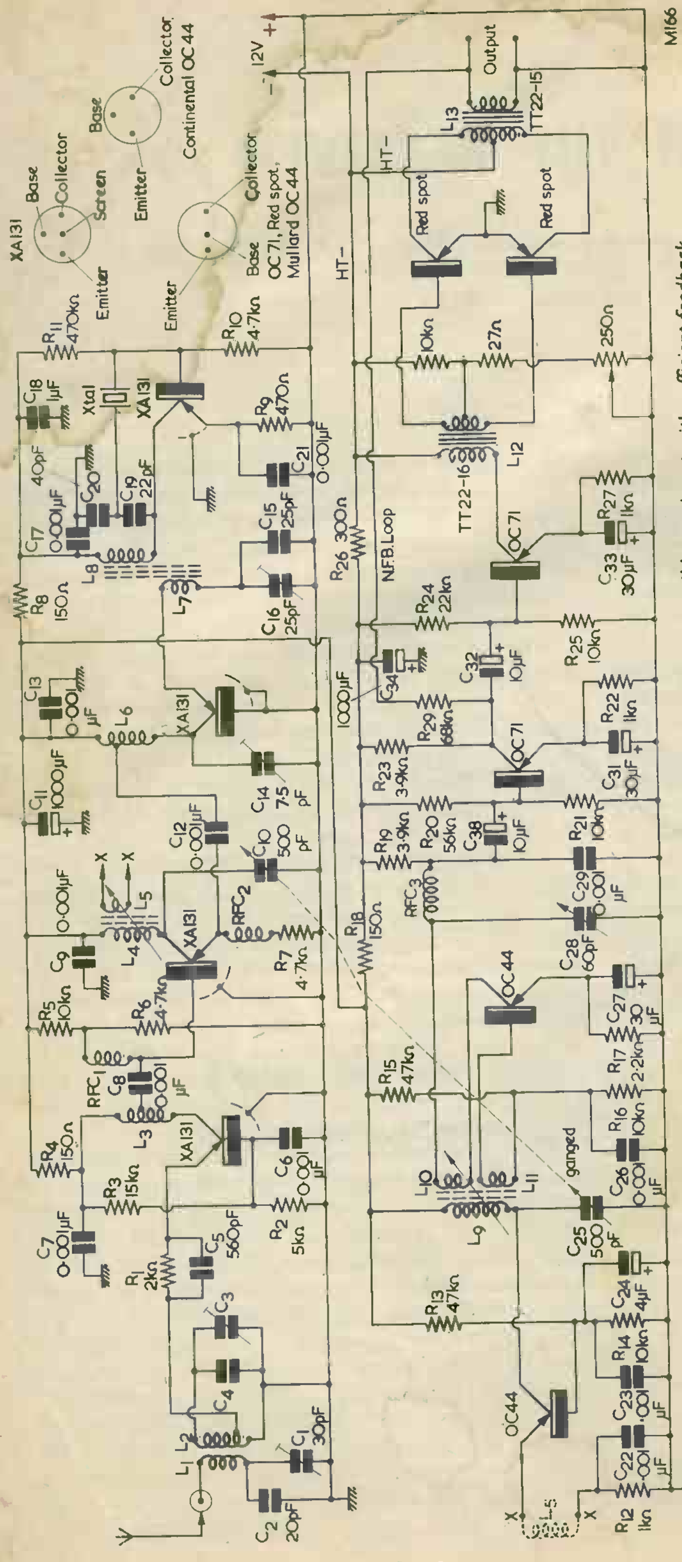
Front End Circuit

As may be seen from the circuit diagram, an XA131 is arranged in a grounded base circuit amplifying at the signal frequency. The aerial is coupled into the input tuned circuit L_2, C_3, C_4 using a series tuned link L_1, C_1, C_2, the signal frequency tuned circuit feeding the XA131 emitter via a bias-blocking capacitor C_5 from a low impedance tap in the coil. C_3 is merely a small piece of tinplate approximately $\frac{1}{4}$ by $\frac{3}{8}$in soldered to a short supporting wire from the top of C_4. The proximity of this small capacitance to chassis is sufficient to provide final adjustment to resonance of the input circuit, which in this case was required to give a reasonably broad response across the range 118.1 to 119.7 Mc/s.

The collector circuit of this first stage is also broad tuned by means of L_3 which is "squeeze tuned" to resonance in the centre of the required band. This coil feeds the following XA131 mixer via a blocking capacitor, C_8, and a low impedance tapping. Bias for the XA131 mixer is fed from the usual potential divider through a series v.h.f. choke RFC_1 to minimise losses.

Local oscillator injection is fed into the mixer emitter from the multiplier chain, again using an r.f. choke, RFC_2, in series with the resistor R_7. Care should be taken to avoid stray coupling between the two r.f. chokes in this stage. The value of the emitter resistor was found to be quite critical, and reducing this much below the stated value of 4.7kΩ was found to increase the output at i.f. considerably, amplifying breakthrough, etc., but causing a serious drop into the noise level of the wanted converted signal.

Crystal controlled oscillator injection is obtained from a 23 Mc/s overtone crystal (chosen because it happened to be available!) using yet another XA131. A conventional tuned circuit in the collector of this stage feeds the base via a pair of capacitors, C_{19} and C_{20}, in an "impedance dividing" circuit to provide the necessary feedback at low impedance. The crystal is in series with this path and was found to oscillate readily on the overtone frequency. Several small plated crystals in the range 21 to 24 Mc/s were tried in this circuit, and all worked well as soon as the coil was resonated, there being no noticeable attempt to self-oscillate on detuning. Off resonance the crystal merely stops working after a very slight frequency pulling.



Circuit of the transistor v.h.f receiver. The value of R_{17} should be as high as possible consistent with sufficient feedback enabling the stage to gently oscillate over the tuning range

Brief attempts to use 5 Mc/s 10X crystals on their 5th overtone and FT.243 7 Mc/s units on their 3rd overtone proved fruitless, although no very serious efforts have so far been made to press them into use owing to their clumsy size for the present purpose.

The 23 Mc/s output from the overtone oscillator circuit is taken via a series tuned winding consisting of 5 turns of plastic covered wirewound on top of the oscillator winding, and tuned to chassis with a variable capacitor C_{16} with C_{15} as a padder. The 5th harmonic generating stage is operated in the grounded base Class C condition and gives best output at 115 Mc/s with no base bias whatsoever! Attempts to bias the base of this stage only reduced the output. The latter is taken from a low impedance tapping on a conventional tuned circuit L_6, C_{14} via a blocking capacitor C_{12}, to the mixer emitter. Variable capacitance is used in this tuned circuit in order to reduce the amount of unwanted harmonics present, for to have a broad band characteristic here would only cause trouble.

The tuned circuit in the collector of the mixer is conventional and is tuned by a 500pF section of the two-gang variable capacitor, C_{10}. A low impedance winding on this coil, L_5, provides output for the next stage. All original experiments were carried out by feeding this low impedance output into the aerial terminals of an Eddystone S750 receiver, using the front-end as a crystal controlled converter only. When properly aligned, this "converter" circuit puts S9-plus signals into the S750 with the i.f. gain control set at minimum, the r.f. gain advanced by about one-third and audio gain at maximum. With these rough settings the background noise was just audible with the "converter" switched on.

The I.F./A.F. Section

Having obtained a "converter" capable of resolving signals of well below 10μV, the next step was to build some sort of receiver into which it could be fed. In the interests of low consumption, sensitivity, and above all, cheapness, a t.r.f. circuit using a regenerative detector with a fair amount of audio amplification was selected. The high audio output is a requirement peculiar to aircraft use and is possibly unnecessary for an amateur portable application.

With an injection frequency of approximately 115 Mc/s, the Nairobi Approach frequency of 119.7 Mc/s appears at 4.7 Mc/s on the receiver, while the Tower frequency of 118.1, at 3.1 Mc/s, represented the lowest channel needed. Therefore a range of say 3–5 Mc/s would conveniently cover the required i.f. when using a 23 Mc/s crystal.

This section of the overall receiver consists of an OC44 grounded base amplifier following the XA131 v.h.f. mixer, and is fed on its emitter by the coupling coil L_5 which was previously used to couple into the S750. A suitable resistor and bypass capacitor is inserted at the earthy end of this coil. The output from the amplifier stage is taken, via a conventional tuned circuit using L_9 and the other half of the two-gang capacitor, C_{25}, to an OC44 functioning as a regenerative detector. This stage is operated in the grounded-emitter condition and signals are fed to its base via a low impedance coil, L_{11}. The collector of the detector stage is connected to L_{10}, which provides feedback controlled by C_{28}, a 60pF trimmer. RFC_3 and C_{29} filter out any radio frequency signals which would otherwise reach the first OC71 audio amplifier. This feeds a second OC71 acting as a driver stage which in turn feeds a conventional transformer-coupled Class B audio amplifier using a pair of surplus red spot transistors. Negative feedback has been included from the loudspeaker output transformer winding, although for speech purposes this is probably an unnecessary embellishment.

Alignment and Adjustments

As mentioned earlier, the front-end is best tested first, on its own. Output from L_5 (X–X) is taken to the aerial terminals of a receiver covering the intermediate and oscillator frequencies. The receiver is tuned to the crystal oscillator frequency of 23 Mc/s and L_8 is adjusted for maximum stable output. This should sound S9 in the receiver with only the coupling as above.

After this the receiver is tuned to the intermediate frequency for the required channel (oscillator injection frequency being 115 Mc/s) and noise is peaked by adjusting L_4, C_{10} to resonance. A fairly strong signal should be injected into the aerial socket to L_1 at the required signal frequency, and the following trimmers adjusted for maximum signal in this order:

C_{14}, C_{16} are adjusted, followed by touching up L_8 and C_{16} again for maximum signal.

L_3 is "squeeze-tuned" to resonance, also L_2 in conjunction with C_3 and C_1. All are adjusted for maximum signal. By this time the front-end should sound lively and car ignition and/or aircraft signals should be audible when an aerial is connected in place of the signal generator.

Having ascertained that the front end is operating correctly, the i.f./a.f. section should be connected in place of the receiver. C_{25}, L_9, and regeneration control C_{28} are now all adjusted for maximum signal on the wanted channel. The regeneration control will be found to cause some frequency pulling of the detector and final adjustments are best made on noise from a fluorescent lamp or other broad band source rather than from a signal generator.

Coil Winding Data

L_1	1 Turn 22 s.w.g. plastic covered introduced into earthy end of L_2 (same dia.).
L_2	7½ Turns 22 s.w.g. tinned copper. Self supporting 1 cm. long, 8 mm. i.d. (Tapped 1T from chassis.)
L_3	12 Turns 22 s.w.g. tinned copper. Self supporting 1.5 cm. long, 8 mm. i.d.
L_4	50 Turns 32 s.w.g. enam. copper on 7 mm. miniature Aladdin D.1 cored former.
L_5	9 Turns 32 s.w.g. enam. copper wound on top of L_4.
L_6	9 Turns 22 s.w.g. tinned copper. Self supporting 2.3 cm. long, 8 mm. i.d. (Tapped 2T from h.t.)
L_7	5 Turns 22 s.w.g. plastic covered on top of L_8.
L_8*	10 Turns (approx.) on 7 mm. miniature Aladdin D.1 cored former. Close wound 32 s.w.g. enam. copper.
L_9	50 Turns on 7 mm. miniature Aladdin D.1 cored former. Close wound 32 s.w.g. enam. copper.
L_{10}	30 Turns 32 s.w.g. enam. copper on top of L_9.
L_{11}	9 Turns 32 s.w.g. enam. copper on top of L_9 and L_{10}.
R.F.C.$_{1, 2}$	27 inches 32 s.w.g. enam. copper close wound on body of any convenient resistor over 100kΩ.
R.F.C.$_3$	1.5mH single pi dust iron cored.

* The size of this coil was found to vary a few turns either way among the XA131's used. This coil will also of course depend on the crystal frequency being 23 Mc/s, and on small differences in the values of C_{19} and C_{20}. In most cases the dust iron core should compensate sufficiently for such changes.

Because of this pulling effect it is recommended that at this stage all trimmers and coils are re-adjusted for maximum signal *several* times to ensure best results.

Points to Watch

The use of a preset regeneration control was found to be unsatisfactory as the required amount of feedback varied considerably from channel to channel and a larger variable would be needed on anything other than a prototype model. Regeneration was found to be quite smooth provided that the emitter bias resistor R_{17} was not too low in value.

Insufficient bypassing of the h.t. supply to the early audio stages can cause modulation of the supply by the output transistors. This produces feedback, and a form of motor-boating can also occur. The latter seems to be due to frequency modulation effects on the detector when the h.t. voltage swings as above, and is noticeable on very strong signals. Some form of a.g.c. would perhaps help with this trouble, but increasing the values of C_{11} and C_{34} to 1,000μF each also minimised this effect. It is important to remember that transistors are, by valve comparisons, very low impedance devices, and as such require equally low impedance power supply sources. The use of old batteries whose internal resistance has risen too far can cause endless trouble and the author has used "lantern" cells or "bell" cells for all test purposes to good effect.

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

Transistorised DF Circuit.—W. N. Perioli, 22 Perch Meadow, R.A.F., Halton, Bucks, requires circuit of this loop or ferrite rod DF receiver.

* * *

Radio Altimeter, type RT-40/APN.1X.—A. L. Wakeman, 29 Islington Road, Southville, Bristol 3, has recently acquired this unit and is in need of the circuit diagram. Has any reader any conversion details for the 430 Mc/s amateur band or any other use?

* * *

R1155A Receiver.—R. Mouat, 22 Norfolk Road, Thornton Heath, Surrey, would appreciate any advice on this receiver.

* * *

Jason FM Tuner.—D. Byrne, G3KPO, Jersey House, Eye, Peterborough, Northants, would appreciate circuit and details of the Jason FM Tuner (original kit), and the T1131 VHF Transmitter.

* * *

Combination Tester Model No. 104 (?SC7051.A).—W. B. Glayzer, 126 Trenchard Avenue, R.A.F. Halton, Aylesbury, Bucks, wishes to buy, borrow or purchase any information concerning this tester and the meter, this latter being missing. The tester was manufactured by Espey Mfg. Co. Inc., of U.S.A.

* * *

The Radio Amateur's Handbook 1961.—J. Langford, 20 Eastlake Avenue, Parkstone, Dorset, would like to borrow this manual for two weeks only. Postage, carriage and hiring fee to instructions received.

* * *

Receiver type RL85.—4019253, Cpl. Peyton, W., Signals Workshop, R.A.F. Driffield, Yorks, is in need of the circuit diagram or any other information of the r.f. section of this receiver.

Bendix Receiver Unit type BC624.—J. A. Taylor, 16 Springfield Gardens, Lowestoft, Suffolk, wants to convert this unit to cover the 2 metre band and would appreciate any details from readers.

* * *

Original Senior HRO Receiver.—A. W. Mann, 62 Costa Street, Middlesbrough, wishes to purchase, or obtain on loan, the instruction manual or drawing of under-chassis showing values of components.

* * *

Ex-R.A.F. Indicator Unit Ref. AB/414.—P. J. Horn, 81 Brockley Rise, London, S.E.23, wishes to know if any reader can supply the circuit or service manual of this equipment, also any modifications to convert to general purpose oscilloscope. Willing to purchase information if necessary.

* * *

Wavemeter W1191A and AR88D Receiver.—J. Hudson, 68 Glebe Street, Great Harwood, Blackburn, Lancs, wishes to obtain any technical information on these equipments.

* * *

Ekco TU211 TV.—R. S. Waite, 17 Southdown Road, London, S.W.20, would like to borrow the service sheet or manual for this television receiver.

* * *

Philco Stereo Record Player Model 62.—J. Goodworth, 29 Chestnut Avenue, Oswestry, Salop, urgently requires the circuit diagram of this player.

* * *

R1147 Receiver.—P. W. Ellis, 354 North Road, Hull, requests tuning coil/capacitor modifications to cover any useful waveband.

* * *

R107 and R110 Receivers.—F. J. Lubbock, 12 Derwent Close, Cambridge, would like to receive the circuit diagrams and any other data concerning these two receivers.

A SIMPLE Musical Instrument

By R. C. MARSHALL, M.A.,Grad.I.E.E.

THIS ARTICLE DESCRIBES AN OSCILLATOR THAT WAS built as a child's toy, but has proved a useful musical instrument. It will play only one note at a time, but cannot produce a discord if two keys are pressed simultaneously. The keyboard covers the scale from middle B to top F. The basic instrument only consumes power from its battery when a key is pressed. If the vibrato oscillator is fitted, the consumption rises to about 10mA and an on/off switch is desirable.

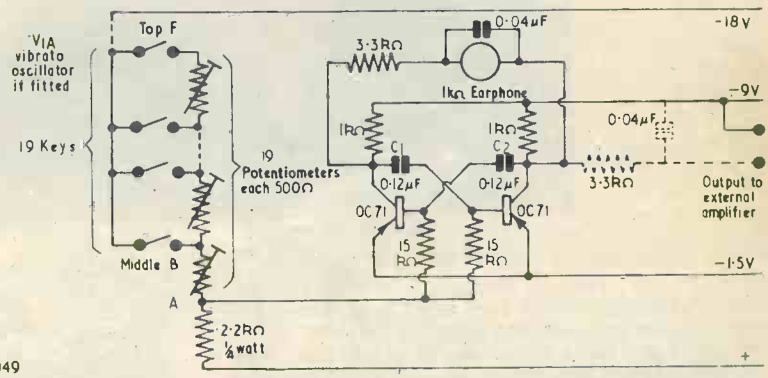


Fig. 1. Circuit of the Simple Musical Instrument described by the author. The capacitors C_1 and C_2 should be adjusted on test (see text). All resistors are rated at ¼ watt ±10%

The basic circuit, Fig. 1, is that of a multivibrator using two OC71 transistors. The output is connected to an earphone via a resistor-capacitor filter that reduces the harshness of the square waveform. To feed an external power amplifier, connection can be made between one collector and the −9 volt line as shown dotted in Fig. 1. The frequency of the oscillator is determined by the potential at point "A". Normally this is positive to the emitters and both transistors are cut off. Pressing a key connects the appropriate portion of the resistor chain, raising the potential as required, and oscillation commences.

The lowest frequency is obtained with "A" about 2½ volts negative to the emitter. At lower voltages the oscillator ceases to work as a multivibrator and produces a sinewave of higher frequency. Above this voltage, frequency is proportional to voltage, and is limited only by the battery voltage available. If it is desired to extend the keyboard beyond 19 notes a higher voltage is needed. Alternatively a switch can be arranged to double or halve the values of C_1 and C_2, to give a scale an octave lower or higher than the basic one. Frequency stability is good, as frequency depends largely on the ratio between the 9 volt and 18 volt supplies, which will not vary during the life of the battery. The use of transisitors of lower leakage current, and a higher minimum voltage at "A", would improve the stability further.

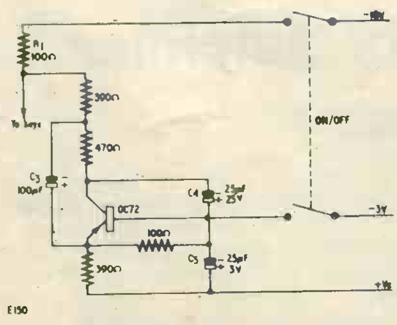


Fig. 2. Circuit of the vibrato "Twin-T" oscillator. All resistors are rated at ¼ watt ±10%

The realism of the sound can be improved by adding vibrato, that is, modulation of the frequency or amplitude at about 10 c/s. A suitable oscillator is shown in Fig. 2.[1] It is a "Twin T" oscillator using the transistor in grounded base, and frequency modulates the main oscillator by supplying a fluctuating voltage to the keyboard. The components shown give a frequency of about 12 c/s. This may be varied by changing C_3, C_4 and C_5, keeping their ratio constant. An OC72 is used as the output is

[1] "A Novel Single Transistor Oscillator" by E. T. Emms, *Electronic Engineering*, August 1960.

required at a fairly low output impedance. Variation of the 100Ω resistor R_1 will control vibrato amplitude, but as it affects pitch also, the potentiometer corresponding to the highest note must be reset.

The photograph shows the construction of the meters. Longer bolts are used for the black notes, with nuts above and below so that the heads nearly reach the upper tier of springs. The heads of the bolts need cleaning occasionally. A proper keyboard from an old piano and a pair of relay contacts

View of the simple musical instrument constructed by the author

author's instrument, which, being intended for a small boy, is "narrow gauge". The keys are dismantled springsets from post office type relays, and they are clamped between strips of paxolin in two tiers, with the black notes on the upper tier. Two strips of tinplate link all the keys together and thus to the 18 volt line or the vibrato oscillator. The baseboard is also of paxolin and carries cheese-headed bolts, with heads above, and solder tags and nuts below: These bolts act as fixed contacts for each key, and are connected to the preset potentiofor each note would be much better.

The adjustment procedure is as follows. Capacitors C_1 and C_2 are adjusted to bring the highest note within the range of its potentiometer, and then each lower note may be set in turn. This sequence is essential, as each potentiometer affects all lower notes. The vibrato oscillator can be stopped by disconnecting one of the capacitors. The frequencies can be set against an accurate oscillator, or they can be set approximately with an oscillator and adjusted into tune with a piano.

A Small High Quality Amplifier

By PETER J. L. BINNS, *M.Sc.*

THE AUDIO OUTPUT IN WATTS WHICH IS NEEDED to reproduce music realistically in a normal living room is a subject for argument. Many people will maintain that a minimum of 10-12 watts is necessary with ordinary moving coil loudspeakers, and the writer is inclined to agree with this view; but nevertheless the results which can be obtained with an output of only 4 watts are frequently surprisingly good, provided that this 4 watts is delivered with very low distortion. The present amplifier design is suggested as fulfilling this requirement and is also both sensitive and economical. A pair of these small amplifiers for stereo use, employing a common power supply, can be built for a price not much greater than that needed for a conventional 10 watt monophonic push-pull amplifier

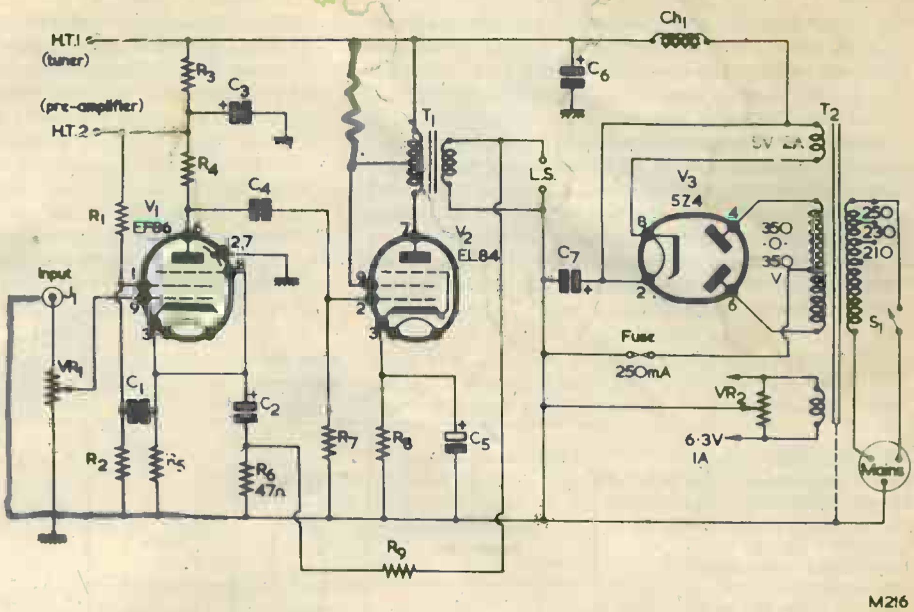


Fig. 1. The circuit of the amplifier

The Output Transformer

The one component on which the quality of the amplifier depends is, as usual, the output transformer, and it is advisable not to try to economise on this. A nominal rating of 10 watts is suggested: the prototype amplifier used a 20 watt "C core" push-pull triode transformer (still quite small), and the excellent performance is no doubt related to this. There must, however, be many readers who have good quality output transformers rated at 10 watts or more, designed for push-pull triode operation but without the tappings necessary for ultra-linear circuits. Such transformers are excellent for the amplifier here described, as the centre tapping on the primary winding approximates closely to the 43% tap preferred for the ultra-linear operation of a single-ended output stage.

The writer has used the prototype amplifier in direct comparison with a Mullard 20 watt ultra-linear design using push-pull KT66 valves and giving a distortion of 0.05% and a damping factor of 50. The tests were conducted in a room roughly 18 x 12 x 10ft (i.e. not by any means the smallest of modern living rooms), and at full realistic listening volume the small amplifier was almost indistinguishable from the larger when both were operating a large three-speaker system. On exceptionally heavy passages of organ music, the deep bass occasionally lacked the clarity provided by the 20 watt amplifier, but this only at a volume level which even an organist described as "excessive"!

A perusal of the circuit diagram (Fig. 1) shows it to be fairly conventional. A low noise pentode V_1 is RC coupled to the output stage V_2, the screen grid of the latter being fed from the centre-tap (ideally at 43% from the anode) to provide ultra-linear operation. Negative feedback is applied from

Components List

Resistors

(All ½ watt unless otherwise specified)

R_1	1MΩ
R_2	1MΩ
R_3	10kΩ 1 watt
R_4	330kΩ high stability
R_5	2.2kΩ
R_6	47Ω
R_7	470kΩ
R_8	150Ω
R_9	4.7kΩ
VR_1	500kΩ log.
VR_2	200Ω wirewound, pre-set

Fuse

Cartridge, 250mA

Capacitors

C_1	0.5μF 350 w.v. paper
C_2	50μF 12 w.v. electrolytic
C_3	16μF 450 w.v. electrolytic
C_4	0.1μF 350 w.v. paper
C_5	50μF 25 w.v. electrolytic
C_6	16μF 450 w.v. electrolytic
C_7	8μF 450 w.v. electrolytic

Valves

V_1	EF86
V_2	EL84
V_3	5Z4

Transformers

T_1	Output transformer (see text)
T_2	Mains transformer 350–0–350V, 60mA, 5V at 2A, 6.3V at 1A

Choke

CH_1	Approx. 20H at 60mA

the secondary of the output transformer to the cathode of V_1, and the cathodes of both valves are bypassed to keep the overall gain as high as possible. The power supply uses a full-wave rectifier, and a smoothing choke is employed to keep hum to a minimum without needing large values of capacitances, though no doubt RC smoothing would also prove satisfactory. Provision is made for supplying power to both a preamplifier and an f.m. tuner, though if this is not required the size of the mains transformer can be correspondingly reduced. With the values given in the components list sensitivity is approximately 200mV for 4 watts output.

fixed to a small metal sub-chassis screwed to the wooden shell adjacent to the input jack and potentiometer VR_1. The position of the remaining small components will be clear from the foregoing: small tagboards or strips are easily screwed to the wooden shell to support them as necessary.

A further unexpected virtue of this method of construction results from there being no definite metal chassis, and hence no opportunity to make indiscriminate earth connections to it! Instead, an earth bus-bar is run round the amplifier, starting at the input jack and extending finally to the mains input socket earth connection, and all other earth connections are made to this. To keep hum down to a minimum, only one earth connection is made to ancillary equipment (preamplifier, tuner, etc.) and this will normally be via the shielding of the coaxial input cable.

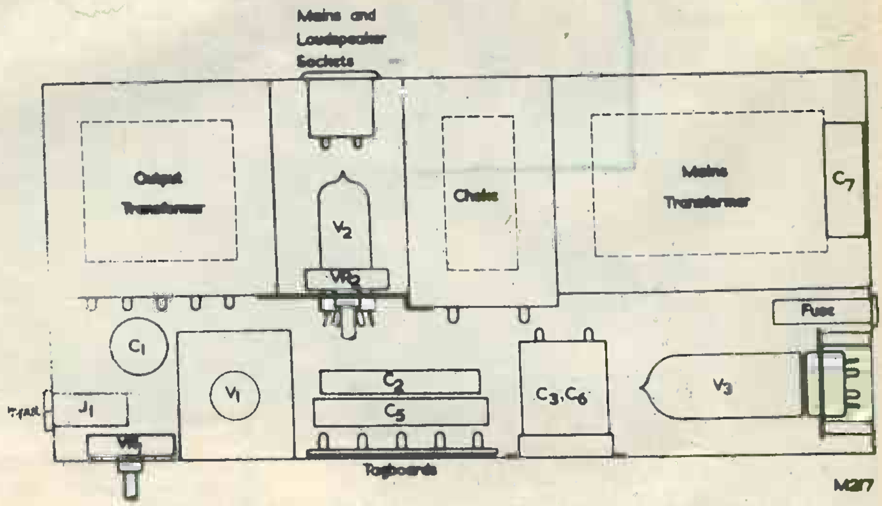


Fig. 2. Diagram showing layout and position of the larger components. (See also text.) V_1 is mounted vertically on a small aluminium bracket, which also supports C_1. V_2 is mounted below VR_2 on an aluminium bracket held between the output transformer and the choke. C_4 is not shown, being below C_2 and C_5

Layout

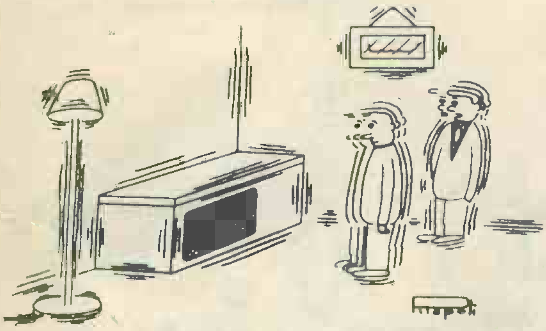
The layout of the prototype amplifier is somewhat unusual but has proved very satisfactory, being surprisingly compact and well protected. A conventional metal chassis is not used: instead, a rectangular wooden shell, open top and bottom, is used as the main framework (Fig. 2). On the rear wall are placed the three heavy components—mains transformer, smoothing choke, and output transformer, with a small gap between the latter two for the mains input and loudspeaker sockets. Also in this space are mounted horizontally the output valve and the "humdinger" potentiometer, VR_1. The valveholder and potentiometer are fixed to a small metal subchassis, which is in turn secured to the "top" of the choke and output transformer.

The rectifier valve is also mounted horizontally, with the valveholder fixed to the shell with wood screws but spaced from it by means of spacers. There can be sufficient room to employ a large rectifier of the international octal class as is used in the prototype. A miniature of the EZ80 type could alternatively be used. It is advisable to solder the leads to the valveholder before mounting it in position. Above the valveholder is the reservoir capacitor C_7 (unless mounted as shown in Fig. 2). The EF86 (V_1) is mounted vertically, its base being

One word of repetition. To realise the full potentiality of this small amplifier, it is essential to use an output transformer of the highest quality, preferably rated at a minimum of 10 watts. After all, the design is still considerably simpler and cheaper than a genuine 10 watt amplifier! And it provides an admirable use for any available "push-pull triode" transformer without the ultra-linear tappings.

Stereo Version

The design of a stereo version calls for no special comment: the circuitry of V_1 and V_2 will be duplicated, and the ratings of the power supply components increased accordingly. It is important that the output transformers are similar, and also that critical components such as anode load and bias resistors are closely matched. It is suggested that the input potentiometers be made concentric, but with separate operating spindles: in this way, an additional balance control becomes unnecessary. Other refinements such as channel reverse and speaker phasing switches can be added if required, though it seems to the author that these things should be settled once and for all at the time of initial setting up, and then left alone!



"That's some amplifier you've got there!"

In conclusion, do not be misled by the simplicity of the circuit. If you still think that 10 watts of undistorted sound are essential for real "hi-fi" reproduction, build this amplifier and see for yourself. You may be surprised!

NOTE: *It should be pointed out that a single-ended output transformer normally has butt-jointed laminations (e.g. all the E's on one side and all the I's on the other) with spacing at the joint to prevent the formation of a complete magnetic circuit. The iron is thus less driven towards saturation by the constant d.c. in the primary. Push-pull transformers, on the other hand, normally have interleaved laminations (e.g. alternate E's and I's down the stack) because the steady d.c. currents in the primary cancel each other out. This fact also necessitates the use of a relatively large push-pull transformer in the single-ended circuit discussed here.*

The output transformer ratio is experimental, but we would suggest a reflected anode load of some 4 to 5kΩ. The value of R_9 may, also, require adjustmen according to speaker impedance.—Editor.

TRADE REVIEW . . .

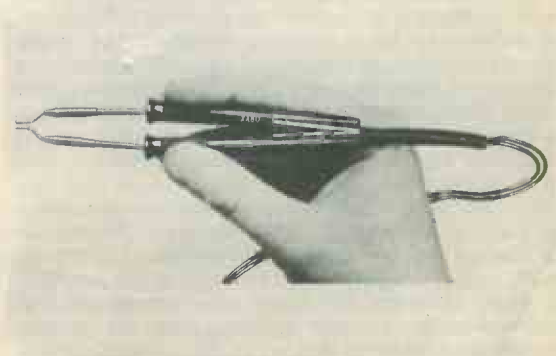
New Oryx Micro-miniature Soldering Tweezers

A revolutionary type of soldering instrument has been developed to meet the need for precision soldering in laboratories and on production lines with micro-miniature circuit modules, diodes, transistors, other semi-conductors, relays, etc.

Designed, developed and manufactured in the U.K. by Oryx Electrical Laboratories Ltd., the instrument is in the form of a pair of tweezers having $\frac{1}{32}$in tips and separate heating elements to both tips. The quality long-life elements are as provided for the popular range of Oryx standard miniature soldering instruments and operate at up to 554° F. tip temperature from a 6 volt supply.

Incredibly light to handle and requiring only minimum finger pressure, these tweezers provide unobstructed view at all times for close precision soldering. An operator can hold work and give simultaneous heating on both sides of a circuit module with only one hand. It is claimed that heating times are considerably reduced and cold joints are virtually eliminated.

World-wide patents have been applied for and the introduction of these instruments in America has been well received by the electronic, radio and television, electrical, jewellery and fancy goods industries where precision soldering of miniature and micro-miniature components is carried out.



These soldering tweezers are being added to the standard Oryx range and are marketed in the U.K. by W. Greenwood Electronic Ltd., 677 Finchley Road, London, N.W.2.

The sixth in a series of articles which, starting from first principles, describes the basic theory and practice of radio

part 6

understanding radio

By W. G. MORLEY

IN LAST MONTH'S ISSUE, WE DISCUSSED THE RESISTOR colour code and introduced the subject of variable resistors. We shall now carry on to a further discussion of these components.

Mounting Arrangements

It is normally necessary for a variable resistor to be securely mounted on a chassis, a means being provided for rotating the shaft. The most frequently encountered mounting method employs a threaded bush and nut, as in Fig. 17 (*a*). The threaded bush is passed through a hole in a panel and is secured by a nut and shake-proof washer, as shown, or by a specially designed nut which has shake-proof properties of its own. A locating lug on the variable resistor fits into a second hole in the panel and prevents the whole assembly from being rotated out of position if excessive torque is applied to the shaft after it has reached the end of its travel.

An alternative method of mounting is shown in Fig. 17 (*b*). In this case the variable resistor is secured by two screws on either side of the shaft, these fitting into tapped holes in the housing. In some instances the holes may not be tapped, whereupon the housing is secured by self-tapping screws, or by normal BA (or similar) screws cutting their own thread in the material. Untapped holes of this type are encountered in plastic housings and normally have square sections, the corners of which offer space for the material cut away by the screw.

The bush mounting method shown in Fig. 17 (*a*) is employed generally with carbon-track variable resistors and with some wirewound variable resistors, whilst that of Fig. 17 (*b*) is employed most commonly with wirewound components.

Variable resistors of the type shown in Figs. 17 (*a*) and (*b*) usually have shaft diameters with a nominal dimension of 0.25 in. A knob may be fitted to such shafts with the aid of a grub screw, as in Fig. 17 (*c*). To ensure a more positive mechanical coupling between knob and shaft, it is normal to provide a *flat* on the shaft, as illustrated in Fig. 17 (*d*). The grub screw then tightens down on to this flat. When a flat is provided the knob may be affixed to the shaft by an inexpensive spring device instead of by a grub screw. Many present-day variable resistors are miniaturised (for use in transistor radios and the like) whereupon shaft diameters tend to be smaller than the nominal 0.25 in. just mentioned.

Some variable resistors need occasional adjustment only, and they may then be fitted with a slotted shaft, as in Fig. 17 (*e*). No knob is fitted, and the shaft is rotated by a screwdriver. Such components are described as *pre-set* variable resistors, (or *pre-set* potentiometers). Another variation is shown in Fig. 17 (*f*), in which a variable resistor having two-screw mounting is fitted with an integral knob. The latter may also have a screwdriver slot at the end, whereupon adjustments can be carried out either with the fingers or by screwdriver. Integral knob designs are normally

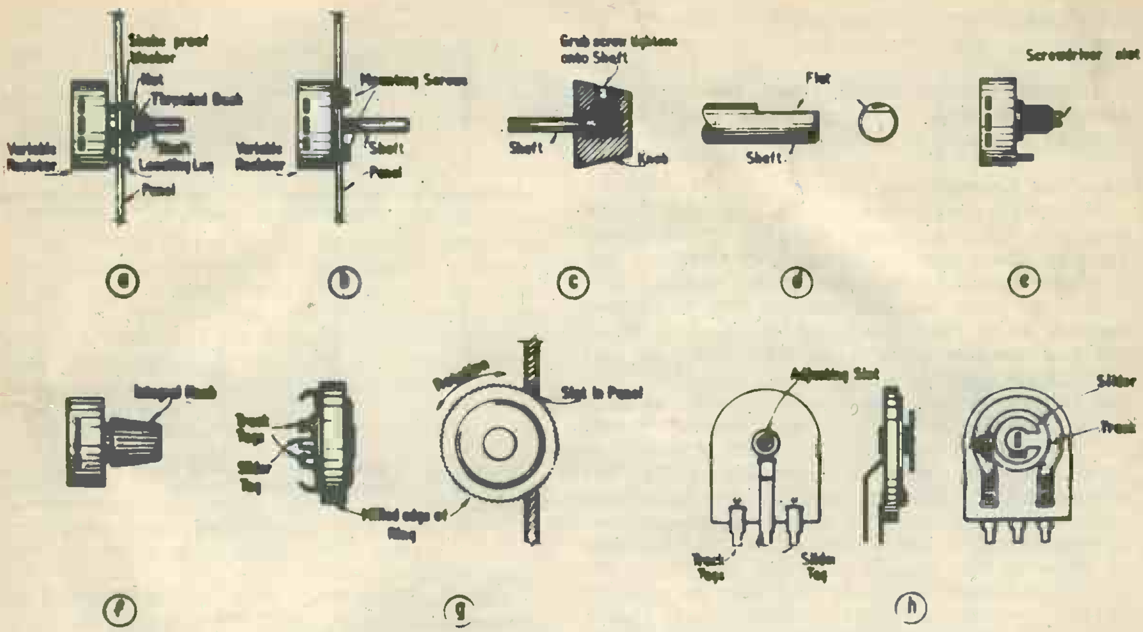


Fig. 17 (a). Variable resistors are commonly mounted by means of a threaded bush and nut
(b). An alternative method using two screws
(c). A knob may be secured to the shaft with a grub screw
(d). Normally, the shaft is provided with a flat (e). A preset variable resistor
(f). Some variable resistors have integral knobs, which may also have a screwdriver slot
(g). A miniature variable resistor, which is adjusted through a slot in the front panel of the associated equipment. The whole ring, which forms the housing, rotates
(h). A miniature variable resistor of the pre-set type

encountered with wirewound resistors only.

A miniature variable resistor of a type commonly fitted to transistor radios is shown in Fig. 17 (*g*). This component is mounted by its tags, these being soldered into position on a printed circuit board. The milled edge of the assembly protrudes through a slot in the case of the radio to enable adjustments to be made.

Another miniaturised variable resistor commonly encountered in this country and on the Continent is illustrated in basic form in Fig. 17 (*h*). This is again mounted by its tags, and it is a pre-set component.

The Slide-Wire

Some circuits need a variable resistor having an extremely low value of resistance. This requirement may be met by employing a track which consists, quite simply, of a length of resistance wire. Such a component is known as a *slide-wire*. Slide-wires are not used in conventional radio receivers, but are employed in measuring equipment.[1]

[1] Apart from its low resistance, the slide-wire has the important advantage of having a low *inductance* (especially when compared with wirewound components), and this latter point may furnish the major reason for its being used in some equipment. We have not discussed inductance yet, but when we do so the reason for the low inductance of the slide-wire will become self-evident.

Tapered Tracks

A variable resistor may be manufactured such that the resistance between the slider and one end of the resistance element varies in direct proportion to the rotation of the shaft. Such a component is described as being a *linear* variable resistor, or *linear* potentiometer, or (in the case of carbon-track components) as having a *linear* track.

However, a large number of radio applications require that the resistance between the slider and one end of the element does not vary in direct proportion with shaft rotation. A typical instance would be given if the resistance between the slider and the starting end varied as the *logarithm* of rotation as the shaft was turned clockwise. Variable resistors in which resistance does not vary in direct proportion with shaft rotation are described as being *tapered*, or as having *tapered* tracks. The relationship between resistance and rotation is then referred to as the *law*, or *taper*, of the variable resistor. In practice, a large number of different laws are available, these having been designed for particular applications. That most frequently encountered in elementary radio work in this country is the *logarithmic* law which, in practical variable resistors, corresponds approximately to the logarithmic relationship just referred to. Frequently, the abbreviation "log" would be used.

Tapered variable resistors are usually of the carbon-track type. Tapered wirewound variable resistors may also be encountered.[2]

Taps and Combinations

For certain circuit requirements, a variable resistor may have one or more taps made into the resistance element. Such taps are brought out to solder tags to enable external connection to be made.

Two (or more) variable resistors may be coupled together as in Fig. 18 (*a*) and (*b*). In Fig. 18 (*a*) the two resistors share a common shaft, so that both sliders rotate in unison as this is turned. The two variable resistors can then be described as being *ganged*. In Fig. 18 (*b*) the two variable resistors are not ganged because the sliders operate independently by means of concentric shafts. The outside shaft controls the forward variable resistor, and the centre shaft the rear variable resistor. Combinations of this nature have the advantage of allowing two variable resistors to occupy the same panel space as would normally be required by one. A very common combination is shown in Fig. 18 (*c*), in which a switch is fitted at the rear of a variable resistor. The switch is operated when the slider is at one end of the track.

[2] The word "linear", as applied to a variable resistor, defines a different characteristic than in the case of a "linear resistor" which follows Ohm's Law. See "Understanding Radio", part 3, October 1961 issue. The two usages are, of course, quite separate and would be obvious from their context.

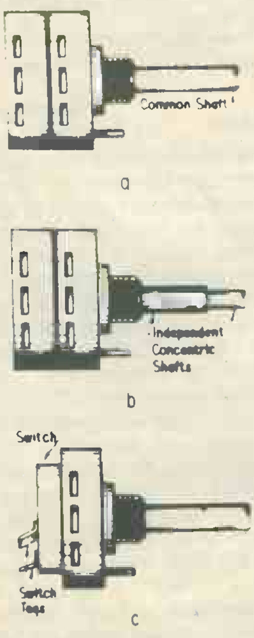


Fig. 18. Common variable resistor combinations. A ganged double variable resistor is shown at (a), and a dual combination with independent shafts in (b). In (c) a switch is combined with the variable resistor

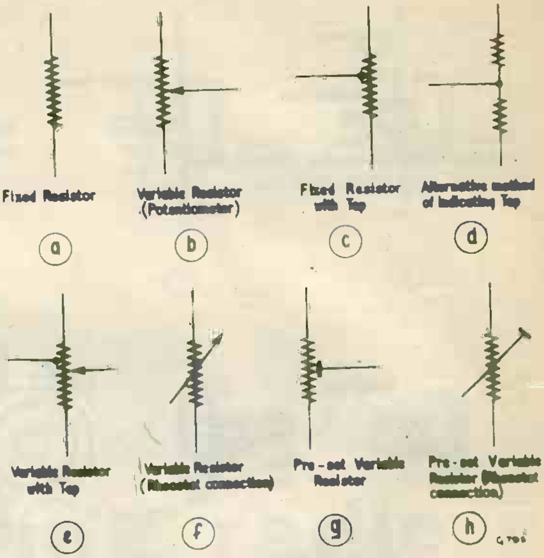


Fig. 19. Resistor circuit symbols. These are discussed in the text

Resistor Symbols

As we already know, a cell is shown in a circuit diagram by means of a symbol. So, also, are resistors. A fixed resistor is represented by the symbol shown in Fig. 19 (*a*), and a variable resistor by the symbol illustrated in Fig. 19 (*b*). In the latter diagram the arrow in the centre represents the slider, which could then move up and down the resistance element. If a fixed resistor has a tap this may be represented as in Fig. 19 (*c*). Alternatively, if the tap is fixed, two separate resistors may be drawn about the tapping point, as in Fig. 19 (*d*). A tap into the resistance element in a variable resistor is illustrated as shown in Fig. 19 (*e*). If a variable resistor is employed as a rheostat (i.e. with the slider and one end of the resistance element only in circuit) it may sometimes be presented as in Fig. 19 (*f*), the arrow drawn through the component indicating "variable". Pre-set variable resistors may be drawn as in Figs. 19 (*b*), (*e*) or (*f*), the fact that they are pre-set being indicated on the drawing or in the accompanying text; or they can be illustrated as in Fig. 19 (g). Occasionally, the symbol of Fig. 19 (*h*) for a pre-set variable resistor employed as a rheostat may be encountered.

It will be noted from Figs. 19 (*g*) and (*h*) that a change of function from "variable" to "pre-set" is indicated by replacing the arrow which indicates "variable" with a T-shaped symbol. As we shall see later when we come to consider other components, this is a general practice in circuit diagram presentation.

Individual resistors in a circuit diagram are normally identified by the letter R with a number suffix. A circuit with three resistors would, therefore, identify these as R_1, R_2 and R_3. The letter R may be applied to fixed and variable resistors alike, although the latter are sometimes identified by the letters VR, also with a number suffix. Occasionally, variable resistors are identified by the letter P (for potentiometer).

Resistor Circuits

We have seen[3] that when we connect two wires of equal resistance in series, the total resistance is doubled. In other words, the total resistance is equal to the sum of the two individual resistances. If we were to add another wire of equal resistance in series we would obtain three times the initial resistance, because the total resistance is now equal to the sum of the three individual resistances. This rule applies to all resistors connected in series: the total resistance is the sum of the individual resistances.

Fig. 20 (*a*) illustrates a 10Ω resistor in series with a 22Ω resistor. The total resistance is 32Ω. Fig. 20 (*b*) shows three resistors in series, these having values of 100kΩ, 220kΩ and 820kΩ. Once more, the total resistance is the sum of these, and it is equal to 1,140kΩ, or 1.14MΩ.

At the same time that we examined the effect of connecting two wires of equal resistance in series we also looked at the result of connecting them in parallel. In this case the total resistance is one half the resistance of each wire. It we connect a third wire of equal resistance in parallel, the total resistance becomes one third. This relationship is easy to understand if we consider it in terms of the expression $R = \frac{E}{I}$. Obviously, three wires of equal resistance in parallel allow three times as much current to flow as does a single wire. If E in the expression remains constant, multiplying I by three reduces R to one third of its initial value.

The formula for determining the total resistance of resistors in parallel is:

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots\ldots$$

where R represents the total resistance, and R_1, R_2, R_3, etc., the individual resistors.

[3] In "Understanding Radio", part 2, September 1961 issue.

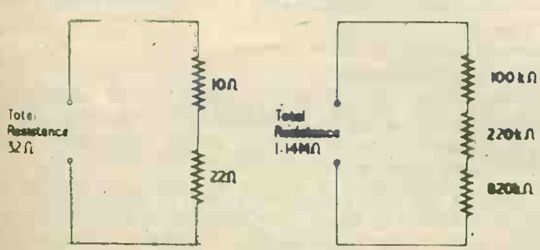


Fig. 20. Two series resistor combinations, showing also the total resistance

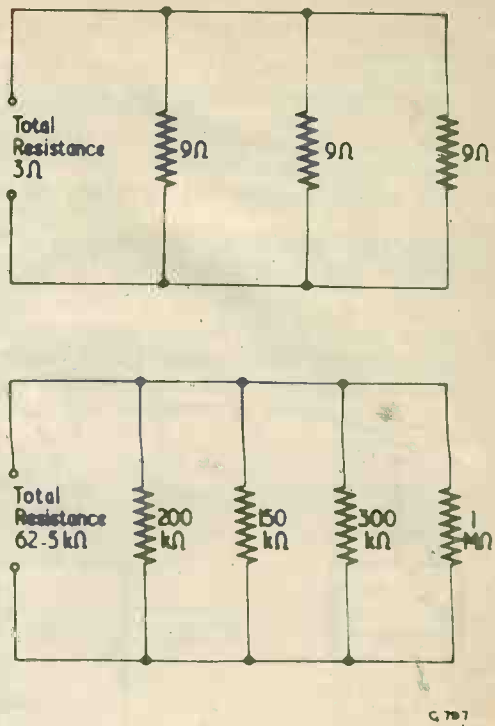


Fig. 21 (*a*) illustrates three 9Ω resistors in parallel. From our formula:

$$\frac{1}{R} = \frac{1}{9} + \frac{1}{9} + \frac{1}{9}$$

$$= \frac{3}{9}$$

$$\therefore R = \frac{9}{3}$$

$$= 3\Omega.$$

As we would expect, the total resistance is a third of the individual equal resistances.

In Fig. 21 (*b*) we have four resistors in parallel, these having unequal values. In this case, and working in units of kΩ, we have:

$$\frac{1}{R} = \frac{1}{200} + \frac{1}{150} + \frac{1}{300} + \frac{1}{1000}$$

$$= \frac{15+20+10+3}{3000}$$

$$= \frac{48}{3000}$$

$$\therefore R = \frac{3000}{48}$$

$$= 62.5k\Omega.$$

The total resistance is 62.5kΩ.

The formula we have just considered may also be expressed as:

$$R = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \cdots}$$

which is merely another way of saying the same thing.

If only two resistors are connected in parallel, the formula may be simplified to:

$$R = \frac{R_1 \quad R_2}{R_1 + R_2}$$

Most beginners will probably find it convenient to work to the formula for parallel resistors given first, as this is easiest to remember and covers all cases.

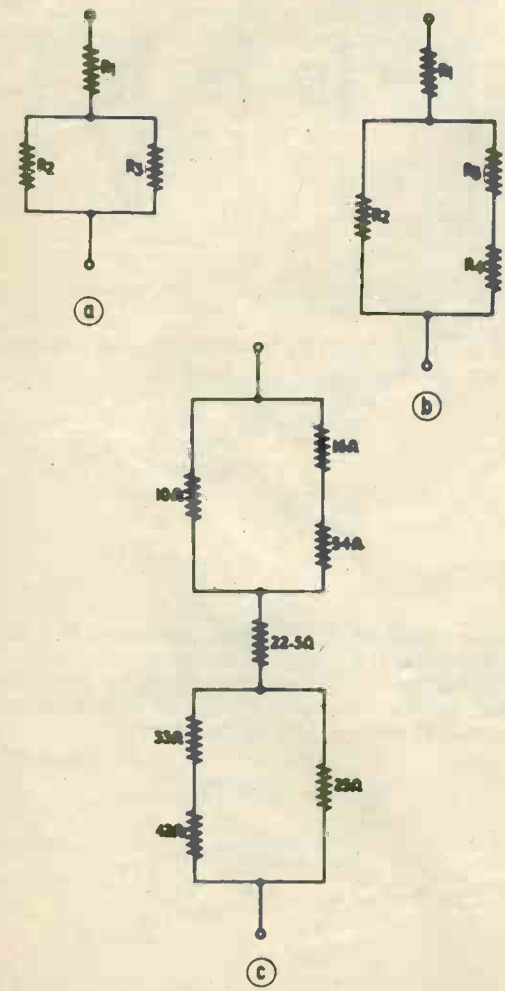


Fig. 22 (a) and (b). Two series-parallel resistor combinations

(c). A series-parallel combination, the total resistance of which is 50Ω

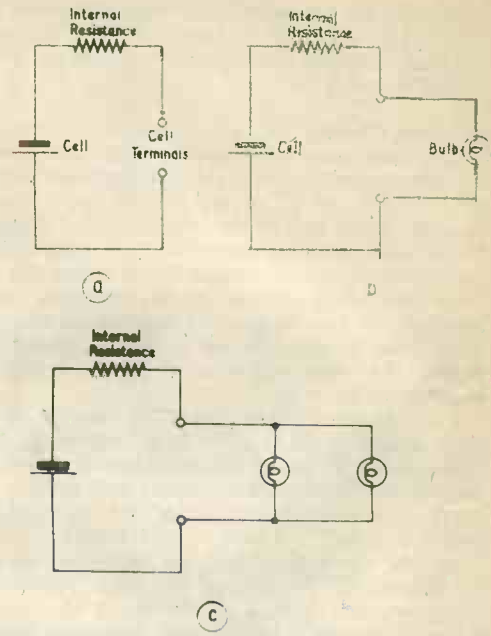


Fig. 23 (a). The internal resistance of a cell may be shown as a separate resistor

(b) and (c). Showing the effect of increasing the current flowing through the internal resistance of a cell

Series-Parallel Combinations

Combinations of resistors in series and parallel are frequently encountered in radio work, typical examples being given in Figs. 22 (*a*) and (*b*). To find the total resistance of such combinations it is necessary to work in separate steps. Thus, in Fig. 22 (*a*), the total resistance of R_2 and R_3 in parallel must first be determined, this then being added to the resistance of R_1. In Fig. 22 (*b*) there are three steps. First, the total resistance of R_3 and R_4 in series must be calculated. This total resistance is then considered as a single resistance in parallel with R_2, whereupon the combined resistance of the parallel combination is determined. This last figure is then added to the resistance of R_1 to give the total resistance.

Fig. 22 (*c*) gives a series-parallel combination of resistors, with values, the total resistance of which readers may care to calculate on their own. This total resistance is 50Ω.

Internal Resistance

We have up to now looked upon cells, and batteries made up of cells, simply as devices which are capable of providing an e.m.f. This does not, however, provide a full picture.

When we apply a source of electromotive force to a conductor there is a flow of electric current. Electrons leave the negative terminal of the source of electromotive force and a similar quantity enter at its positive terminal. Thus there is a flow of current through the source itself. In practice, we might employ a cell as the source of electromotive force, whereupon we would find that this cell offered a resistance to the flow of electric current. Resistance is present in just the same manner as it is present in any conductor: it is impossible to have a perfect conductor of electricity.

The resistance in a cell is known as its *internal resistance*, and it may be represented in a circuit diagram as a separate resistor in series with the cell as in Fig. 23 (*a*), the cell itself now being assumed perfect. Because of the presence of internal resistance, the e.m.f. on the terminals of a cell drops as the current which flows increases. This is an effect which can be easily verified. If we connect a flash-light bulb to the terminals of a small partly exhausted flash-light battery (dry Leclanché) the bulb will light up in normal manner. See Fig. 23 (*b*). If we add a second similar bulb in parallel to the first, as in Fig. 23 (*c*), the brightness of the first bulb will noticeably drop. This is because the additional current flowing through the internal resistance of the battery causes a larger e.m.f. to appear across it, and a smaller e.m.f. to be available for the bulb. This particular effect is especially noticeable with a small partly exhaused dry Leclanché battery because, in general, the internal resistance of such a battery increases as its size decreases; also the internal resistance of a dry battery of this type tends to increase as it becomes exhausted.

It was stated earlier[4] that cells are not normally connected in parallel to increase current capability unless they are identical, or nearly identical, in electrical performance. The reason for this now becomes apparent. Fig. 24 (*a*) illustrates three cells in parallel, each having its own internal resistance. If all the internal resistances are equal each cell is capable of providing its fair share of current to an external circuit. If, however, the internal resistance of one cell is higher than the others it will not be capable of providing the same current, and an unfair burden of the total current is carried by the remaining two cells. When cells are connected in series, as in Fig. 24 (*b*), the situation is somewhat different. In this case all the individual internal resistances add up to a single overall resistance (Fig. 24 (*c*)), which can then be described as the internal resistance of the battery. In this case all cells must provide the same current and dissimilarities in internal resistance (provided they are not exceptionally great) do not detract from the overall performance of the battery.

Sources of e.m.f. other than cells and batteries also have unavoidable internal resistances, and these may similarly be expressed in the form of series resistors.

Two new points of terminology may now be introduced. Fig. 23 (*a*) shows a cell with its internal resistance in series with the terminals. The e.m.f. at these points is known as the *terminal e.m.f.* Obviously, terminal e.m.f. falls as current increases.

It was stated just now with reference to Fig. 23

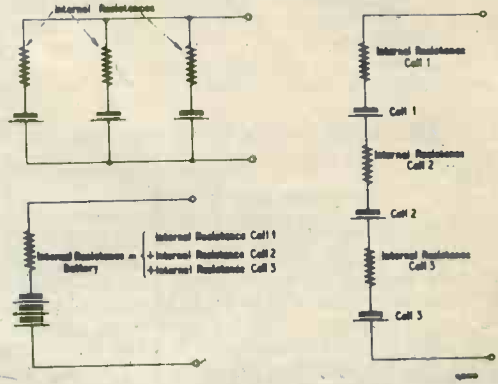


Fig. 24. Illustrating individual internal resistances when cells are connected in series or parallel. The effect of the internal resistances is discussed in the text

that increased current flowing through the internal resistance caused a larger e.m.f. to appear across it, and a smaller e.m.f. to be available for the external circuit (in this case a bulb). This statement could have been condensed by saying that the increased current caused a larger *voltage drop* across the series internal resistance, the fact that less voltage was available for the external circuit being then understood. The term "voltage drop" may be applied to any form of resistance which performs the same function.

Next Month

In next month's issue we shall deal briefly with a few remaining aspects of resistance, and shall then carry on to capacitance.

[4] In "Understanding Radio", part 2.

THIRD PYE I.L.S. FOR CZECHOSLOVAKIA

Pye Telecommunications Limited of Cambridge, England, announce that a Pye Instrument Landing System has been ordered by the Czechoslovakian Government for installation at Bratislava International Airport.

The Instrument Landing System will be the third supplied by Pye to Czechoslovakia, the previous two installations being at Prague International Airport.

This Pye contract brings the value of I.L.S. and ancillary equipment supplied by the Company to Czechoslovakia to over £100,000.

The latest contract covers additionally the supply of transistorised radiotelephones for use on Czechoslovak airfields.

IN YOUR WORKSHOP

This month Smithy the Serviceman and his able assistant Dick tackle their first job for 1962. They also experience their first taste of the rigours of winter!

"A HAPPY," CALLED OUT DICK, as he entered the Workshop, "and preposterous New Year to you, Smithy!"

Smithy the Serviceman looked up, and Dick was surprised to see that he was sporting a full day's stubble on his normally immaculate chin.

"Blimey," remarked Dick, regarding the Serviceman closely. "*You* must have had a session last night!"

"Nothing of the sort," replied Smithy indignantly. "I had a very quiet and sedate New Year's Eve."

"Well, why the beard?" persisted Dick. "Are you trying to wangle a staff job on the Committee of 100?"

"The reasons why I haven't shaved this morning," said Smithy, with dignity, "are twofold. If I were superstitious, I might add that they augur ill for the coming year. When I woke up this morning I found, firstly, that my electric razor had broken down. Secondly, when I got the old cut-throat out, I found that our pipes had frozen!"

"Already?"

"Our pipes, Dick," said Smithy wearily, "are the most sensitive pipes in the British Isles. It only needs a touch of frost and they freeze up solid."

"Yours doesn't sound a very desirable residence to me," commented Dick.

"It isn't a bad old dump, really," conceded Smithy, "but it just wasn't meant to be left out in the open. If, for instance, we have what other people would look upon as a gentle breeze, our roof is immediately denuded of slates. They come off one after the other, just like peas out of the pod."

"There *have* been some gales recently," commented Dick, suspecting this statement. "How many slates did you actually lose?"

Smithy chuckled.

"Perhaps I'm exaggerating a little," he said. "But we did find one in the gutter and another one ready to go. Anyway, we'd better get on with a little work right now, and I'll have a shave later on over at the sink. Perhaps you could put the kettle on."

Dick looked a little hurt.

Haven't you forgotten something?"

"Forgotten something?" questioned Smithy, frowning. "I don't think so. Oh yes, I have too! A happy New Year to you as well, Dick."

F.M. Receiver

Satisfied, Dick walked over and filled the kettle whilst Smithy started work on his first receiver for 1962. The Workshop soon settled into its normal industrious rhythm, with Smithy and Dick quietly occupied with their respective tasks.

But not for long.

"Well, that's queer."

Smithy, wise with the years, let Dick's remark go unheeded.

"Yes, that's a very queer thing."

Smithy ignored this further comment, and concentrated on his own receiver.

"This is a *most* queer effect."

Smithy sighed and looked at his watch. If matters pursued their normal course, Dick should be finally calling out for assistance within five seconds.

"Smithy!"

"Four seconds," muttered Smithy to himself with sombre satisfaction. He liked his predictions to come out accurately.

"What did you say?" called out Dick suspiciously.

"Oh nothing," said Smithy, hastily. "What do you want, anyway?"

"There's something queer happening with this f.m. receiver I've got here" replied Dick. "Could you come and have a look at it?"

"What's the trouble?" asked Smithy, as he wandered over to Dick's bench.

"It's an f.m. set, and it's responding to a.m!"

"More details please."

"Well, I'm pumping an amplitude modulated signal into the i.f. strip at 10.7 Mc/s," stated Dick, "and it's coming out of the speaker!"

Smithy glanced at the signal generator Dick had coupled to his receiver.

"Even if the receiver were in perfect order," he remarked, "I wouldn't be too surprised at an effect like that. You happen to be using a relatively inexpensive a.m.-only signal generator, and quite a few of these give a small amount of frequency modulation as well. So you might well hear a weak tone from the speaker."

Dick looked disappointed.

"Then that particular effect won't have anything to do with the trouble I'm experiencing," he remarked moodily. "I suppose I'll have to look somewhere else now!"

"What *is* the trouble anyway?"

"This set came in as 'weak reception'," replied Dick. "And, when I tried it out I could only just get our two local stations with the volume turned fully up. Even so, there was quite a lot of background hiss behind them. I then thought that the set wasn't limiting properly, and that my experience with the a.m. signal genny had confirmed this."

"I shouldn't be too sure about diagnoses like that," commented Smithy. "When the signal is as weak as that, it may well mean that the only circuit which can do any effective limiting is the ratio detector itself. If there is a limiting i.f. amplifier it probably wouldn't have enough signal to limit on."

Dick looked puzzled.

"Why do you refer to the presence of a ratio detector so confidently? This set could just as easily have a phase detector or any other f.m. detector."

"Not in this country, it couldn't," replied Smithy firmly. "Ratio detectors are just about standard equipment in domestic f.m. receivers."

"I suppose you're right," conceded Dick. "At any rate there's an electrolytic capacitor sitting in the detector wiring, and ratio detectors need electrolytics if they're going to work."

"We'll go into that at a later date," said Smithy. "What have you done up to now?"

"One of the first things I did," said Dick, "was to insert my finger into the works, applying it, therein, to the a.f. triode grid. I was rewarded with a good loud 'um from the speaker."

"And then?"

"I next followed," said Dick, "some advice which has been given much publicity recently. I pulled my finger out!"

"Which is," approved Smithy, "a good servicing gambit. So we can now say that the a.f. stages seem to be in pretty reasonable shape."

"That's right," said Dick. "I next turned my attention to the i.f. stages, whereupon I encountered the queer business with the a.m. and f.m. we've just been talking about."

Smithy frowned.

"Have you checked the valves?" he asked. "It would be foolish to start serious work without swapping bottles."

"Oh I've done that," said Dick. "None of the new valves gave any improvement, and so I've left all the old ones in."

"Good show," approved Smithy. "It's always a sensible thing to do the easy tests first, even if it's unlikely that they'll reveal the cause of the trouble. What about voltage tests?"

"I haven't done any yet."

"Well," said Smithy, "I think that these are the next thing to do, rather than start playing around with the signal genny. Have you got the service manual out?"

Dick looked uncomfortable.

"I was just getting around to that."

Smithy frowned.

I.F. Stages

Dick quickly obtained the manual and passed it over to the Serviceman. As usually occurred, the latter had become completely absorbed in Dick's fault; and he was now firmly seated on Dick's stool with test prods at the ready. Smithy opened up the manual and laid it on the bench so that they could both look at the circuit of the receiver.

"Ah," he said, "it seems nice and straightforward. A double triode r.f. amplifier and mixer in a separate tuner unit to handle the signal frequencies; after which we get a two-pentode i.f. amplifier and a triple diode triode ratio detector and a.f. amplifier (Fig. 1). Nothing much to be scared of here."

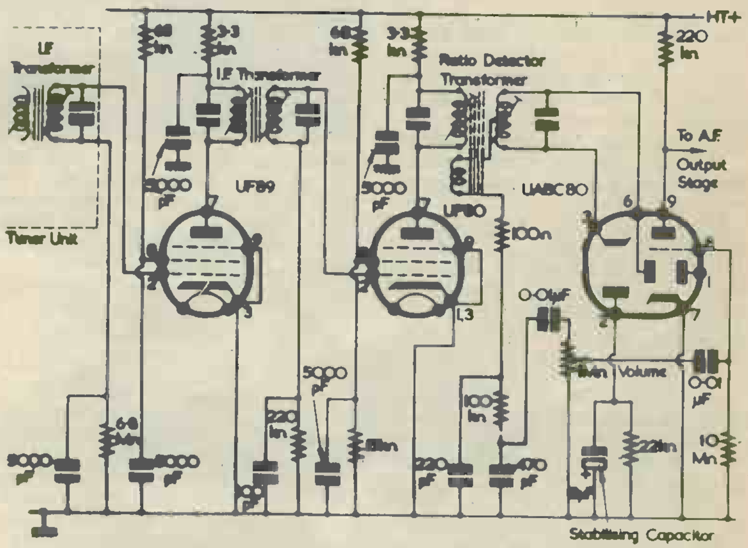


Fig. 1. The i.f. and detector circuits in the f.m.-only receiver serviced by Dick and Smithy. Component values are representative of commercial practice

"I can appreciate," he remarked, "your pressing on with a.f. grid tests and valve changing without the manual, but I can't see much sense in proceeding further. You've already been guessing about the ratio detector, and without the manual you'll be guessing also about any other tests you carry out."

"We don't have manuals for *all* the sets we service," protested Dick.

"I know we don't," replied Smithy, "and that often means that we have to spend longer on them. Anyway, I'm certain we've got a manual for *this* set, so let's have a look at it."

Smithy applied his test prods.

"Tuner unit anode voltage seem to be O.K.," he remarked, "so let's tackle the i.f. amplifier. The h.t. rail voltage is around 180, and the first i.f. anode is reading 155 volts. There's a 3.3kΩ anode decoupling resistor, so this means that the anode's drawing some 7 or 8mA. Which is quite a reasonable figure."

"That's a pretty quick mental calculation for the current, isn't it?" commented Dick. "Dash it all, I have to start with $R = \frac{E}{I}$ before I can even *think* of current. And even then I need a bit of paper to get the I over to the left-hand side!"

Smithy looked surprised.

"Oh, I never bother with that sort of thing when working out currents from voltage and resistance," he said. "All you have to remember is that 1 volt across 1kΩ gives you 1mA. Here we have 25 volts dropped across an anode decoupling resistor of 3.3kΩ. Now, 25 volts across 1kΩ is obviously 25mA; and across 3.3kΩ it would be slightly less than a third of this figure. My guess was some 7 to 8mA. And that's near enough for the present job."

"What's the anode voltage on the second i.f. pentode?"

Smithy applied his test prods.

"It's 165 volts," he announced.

"That's 15 volts dropped across another 3.3kΩ resistor," announced Dick. "Let's see now! 1 volt across 1kΩ is 1mA, 15 volts across 1kΩ is 15mA, so 15 volts across 3.3kΩ would be slightly less than a third of 15mA. Would the anode current be around 4mA?"

"Near enough," confirmed Smithy.

Dick thought for a moment and then a sudden gleam came into his eye.

"Well, there it is," he exclaimed.

"What?"

"Why, the fault of course," said Dick excitedly. "We have two pentodes, and one draws only half the anode current of the other."

"So?"

"They've both got 3.3kΩ anode dropping resistors," continued Dick impatiently, "and if you look at the circuit you'll see that both cathodes go straight down to deck."

"Go on."

"Well, it's obvious!" rushed on Dick. "Something in the circuit is causing the second pentode to draw less anode current."

"You're perfectly right there."

Dick examined the circuit in greater detail.

"Both grids go to chassis via parallel resistors and capacitors," he continued, "so *they're* the same. Both suppressors are tied to cathode. And," concluded Dick triumphantly, "both screen-grids go up to h.t. plus via 68kΩ droppers."

"You have forgotten to point out," concluded Smithy gently, "that the screen-grid of the second pentode goes to chassis via a 15kΩ resistor."

Dick looked more closely at the circuit, and his finger traced the connections from the screen-grids down to the chassis line. There was silence for a moment.

"Well," he said eventually, "I suppose you *could* say that the screen-grid voltage on the second pentode must be lower than that on the first, and I suppose you *could* say that this would make the second pentode anode current less."

"I like the way you say you *could* say these things," protested Smithy. "You jolly well *should* say them, because they happen to be true! I'll measure the screen-grid voltages right now just to see what they really are. The first one is 80 volts and the second one is 30 volts. Does that satisfy you?"

"O.K. Smithy," said Dick. looking slightly abashed. "I *was* rather jumping the gun, I suppose."

"I'll say you were," confirmed Smithy.

He stroked his chin absent-mindedly, and suddenly realised that it was covered with stubble.

"Dash it all," he remarked, "I haven't had my shave. Is that kettle boiling yet?"

"I'd forgotten all about it," confessed Dick.

He walked over to the battered Workshop kettle, which was now giving off steam furiously and picked it up. Its weight caused him to open the led and look inside, whereupon he turned a somewhat doleful face to the Serviceman.

"Sorry Smithy," he remarked. "But it's nearly boiled dry. I'll have to fill it up again."

Limiting

Smithy shrugged.

"Not to worry, lad," he remarked. "It's just in the nature of things today. My main hope is that our pipes at home will have got unfrozen by the time I get back tonight. It's most inconvenient being without water. Particularly on a Monday."

"What's so special about Monday?"

"Monday's my bath-night."

"Do you only have one bath a week, then?" asked Dick, interestedly.

"Of course not," said Smithy defensively. "I have another one on Thursdays as well."

"I suppose that's all right," commented Dick critically.

"Of course it's all right," said Smithy irritatedly, "What's wrong with having two baths a week?"

"Nothing really," said Dick. "After all you don't do a *dirty* job, do you?"

"I wish you'd stop discussing my personal hygiene in this way," said Smithy, vexedly. "I have two baths a week and that's that."

"O.K. Smithy."

"But I will admit it's a darned nuisance if I have to go without one tonight."

"You can always," suggested Dick, "dust yourself down with D.D.T."

Smithy turned a furious glance on his assistant.

"I shall dust *you* down in a minute," he glowered. "Now let's change the conversation."

"Fair enough, Smithy," said Dick equably.

There was quiet for a long moment whilst Smithy's ire slowly evaporated. Dick maintained his innocent expression throughout this period. But only just.

"Where were we?" growled Smithy.

"We'd realised that the second pentode anode current was lower than the first because it had a lower screen-grid voltage."

"*You'd* realised, you mean," grunted Smithy. "Oh well, I suppose I might as well get on and finish off this job. I'll check the voltages on the control grids next. This is not because I have much certainty that there's anything wrong there but because I've got the test prods handy."

Smithy applied the test prods and noted the meter readings.

"As I thought," he nodded. "They're both reading slightly negative of chassis, which is to be expected because they are both connected to chassis via high resistances. The negative voltage is, of course, contact potential."

"*Might* there have been some other voltage on those grids?"

"It's conceivable," said Smithy, "zero volts would have indicated a possible short between grid and chassis, and a positive voltage might have indicated a leak to h.t. via, say, the previous i.f. transformer. If there'd been a high negative voltage it could mean that a high level of r.f. was getting to the grid because of oscillation somewhere, whereupon the grid would bias itself back by leaky-grid action. All these possibilities are a bit far-fetched but they could happen nevertheless. And it only took a second to measure the grid voltages anyway."

"Where do you get the leaky-grid action from?" asked Dick. "There are no grid leaks or grid capacitors."

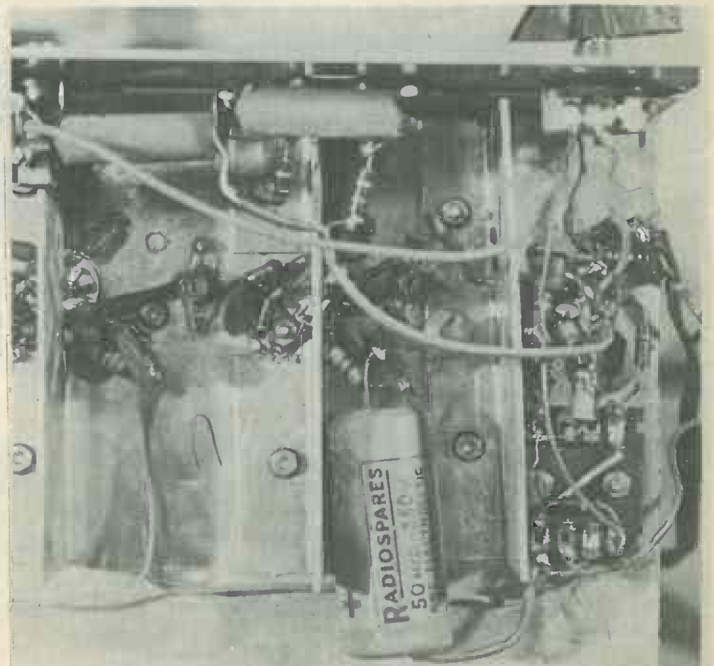
"Yes, there are," replied Smithy. "They're the ones on the other side of the i.f. secondaries."

He scribbled a circuit on Dick's pad.

"Now the normal leaky-grid circuit," said Smithy, "is like this (Fig. 2 (*a*)), whilst the pentode grid circuits in our receiver are like this (Fig. 2 (*b*)). If you re-draw

View of the receiver with power unit (below) and recorder. The receiver controls are—extreme bottom, left to right, r.f. gain; tuning; a.f. output; pen recorder or meter output sockets and, extreme right, the zero adjustment

The author has arranged with Denco (Clacton) Ltd., of 357/9 Old Road, Clacton-on-Sea, Essex, that the coils specified for the units featured in this issue be manufactured and supplied direct to interested readers. Those readers who would prefer to obtain the coils ready made should therefore contact Denco (Clacton) Ltd. direct.—Editor.



The detector and recording section layout

Components List
(Translator)

Resistors

R_1	1MΩ
R_2	500Ω pot.
R_3	25kΩ pot.
R_4	100kΩ

Capacitors

C_1	0.1μF
C_2	1.0μF
C_3	0.25μF

Switch

S_1	Single pole, 2 way

Valve

V_1	12AX7/ECC83

The next contributor to the noise in the first part of the circuit is the valve itself. This valve is important and there are a number of low noise valves available on the market at the present time. A good deal has been written on this subject and a number of manufacturers issue pamphlets dealing with it very comprehensively. Calculations of the total input noise are referred to the grid of the first valve. Each of the sources of noise must be calculated and referred to this reference point. As has already been stated, noise is a random effect and is calculated on a power basis.

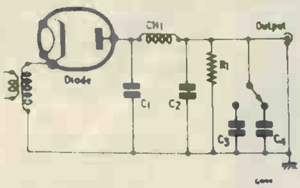


Fig. 24. Modification of Pye i.f. strip for use with the pen recorder d.c. amplifier

Components List
(Detector modification of Pye Strip)

Resistor

R_1 1MΩ

Capacitors

C_1 50pF
C_2 50pF
C_3 1.0μF
C_4 0.1μF

To sum up the various noise voltages that must be referred to the first grid are, (*i*) thermal agitation noise of the tuned grid circuit, (*ii*) shot noise of the input valve, (*iii*) induced grid noise of the input valve, and (*iv*) the following stages of grid circuit noise referred back to the first grid.

R.F. units are available in the surplus market, some of these are single tuned and others, such as the many turret tuners available, cover a wide range of frequencies in the television bands. As was stated in an earlier article, one of the principal receivers used by the writer consists of first, a modified turret tuner, second, an i.f. strip (the familiar Pye strip), and finally an audio output and recorder section. The intermediate amplifier can be, as just stated, an i.f. strip or it can be a communications receiver set to a particular frequency. Among the receivers that would be suitable are the R1155, the AR88, the CR100, the R208, the S27, the CR150, and the National HRO. Each of the communication receivers will, of course, have its own audio output. We may use this directly to record on tape for subsequent analysis by a translator described herewith, or we may use the translator direct for instantaneous observations. This is the simple method which can be put into immediate operation. The tape recorder can make a permanent record but, even at the slowest speed of say 1⅞in per second, observations would be limited by the length of tape available. However, at this slow speed it would be possible to cover the whole period of the passage of the Sun through the aerial, or of the Milky Way containing the constellation Cygnus where one of the most powerful radio sources is located.

Pen Recorder

The most desirable part of the equipment is, of course, the pen recorder. Such a piece of apparatus enables us to make permanent records of everything received at the aerial. The speed at which the records are made depends largely upon the observation to be carried out, and all

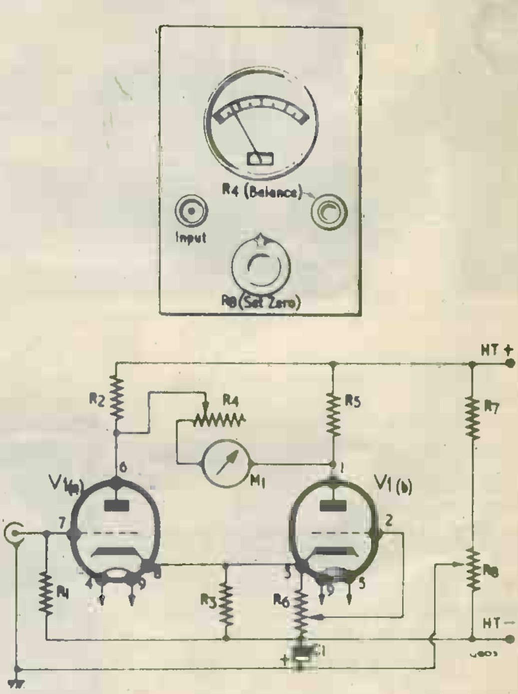


Fig. 25. Layout and circuit of the pen recorder d.c. amplifier

Components List
(D.C. Amplifier for Pen Recorder)

Resistors

R_1 20MΩ
R_2 5kΩ
R_3 500Ω
R_4 20kΩ pot.
R_5 5kΩ
R_6 25kΩ pot.
R_7 47kΩ
R_8 5kΩ pot.

Meter

M_1 1mA f.s.d.
$V_1(a)$, (b) 12AX7/ECC83

Capacitor

C_1 12μF 50wV

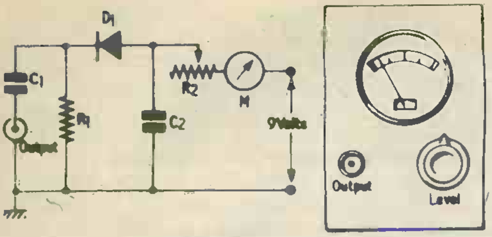


Fig. 26. Front panel layout and circuit of the noise generator

speeds are available from, say, ½in per hour to 24in per hour. For special observations very much higher speeds are sometimes used. From the amateur's point of view the two most useful speeds are 1in and 6in per hour. At 1in per hour a steady examination of the whole of the galactic system may be made. This is accomplished by setting the angle of the aerial at a different position for each sweep. Such a process would mean that a complete map of the radio sky could be built up in, say, seven or eight successive runs of 24 hours each. This, of course, represents the ideal, but it should not be thought that the lack of a pen recorder will preclude any work of a useful nature being done. The use of the tape recorder and subsequently the translator, or the translator direct (though somewhat slow and laborious), will still enable the observer to complete quite useful records. If the translator is used direct the presence of the observer is, of course, required at the time that observations are made. As previously mentioned, the cost of the equipment including the pen recorder is no more expensive than that of many other hobbies such as ciné or even amateur radio. Indeed, the purpose of these articles is to enable any amateur with the available equipment to enter into and enjoy this fascinating section of electronics combined with astronomy. The translator will be described next since it becomes the only additional apparatus to that already discussed.

Components List
(Noise Generator)

Resistors
- R_1 75Ω
- R_2 25kΩ pot.

Capacitors
- C_1 1000pF
- C_2 1000pF

Diode
- D_1 Silicon

Components List
(Receiver RF Section)

Resistors
- R_1 4.7kΩ
- R_2 47kΩ
- R_3 1kΩ
- R_4 47Ω
- R_5 5kΩ pot. (linear)
- R_6 150kΩ 5%
- R_7 150kΩ 5%
- R_8 100kΩ
- R_9 2.7kΩ
- R_{10} 3.3kΩ Hi-Stab
- R_{11} 3.3kΩ Hi-Stab
- R_{12} 10kΩ

Valves
- V_1 PCC89
- V_2 ECC81

Capacitors
- C_1 3.3pF
- C_2 2pF
- C_3 2pF
- C_4 1000pF
- C_5 4.7pF
- C_6 1000pF
- C_7 5pF
- C_8 1000pF
- C_9 3pF (or suitable value to tune L_5)
- C_{10} 1000pF
- C_{11} 25pF
- C_{12} 2000pF
- C_{13} 10pF
- C_{14} 10pF
- C_{15} 5pF
- C_{16} 3–30pF variable

Translator Unit

The circuit of the translator unit is shown in Fig. 23. It will be seen that this is quite straightforward, receiving its audio via the 0.25μF capacitor C_3 to an adjustable input. The first section of the double-triode is strapped as a diode and feeds into the other triode. The grid circuit of this second triode has a time constant which can be set to different values. This is necessary because

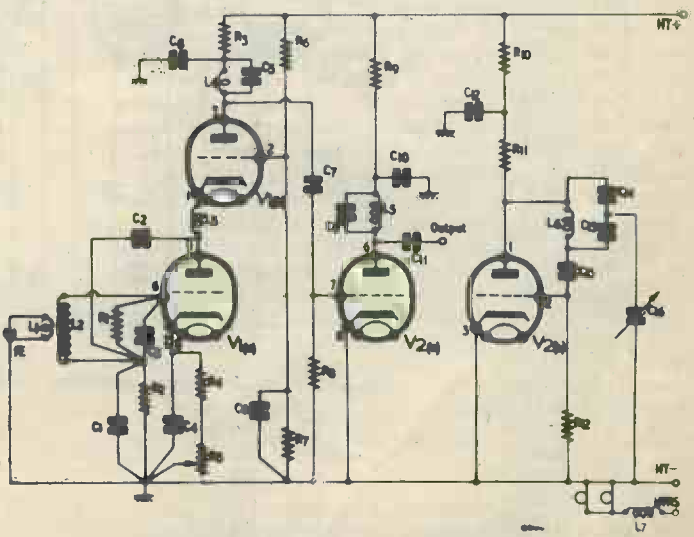


Fig. 27. Circuit of the r.f. section of the receiver. Note that V_1 has 6.3V applied to the heater and not 7.5V, this assisting in the reduction of receiver noise. For coil winding details see Table 1. All coils are dust-core tuned.

TABLE 1

L_1	$1\frac{3}{4}$ turns 22 s.w.g. (p.v.c.)
L_2	$3\frac{1}{2}$ turns 22 s.w.g. (p.v.c.)
L_3	4 turns 18 s.w.g. (p.v.c.)
L_4	1 turn 14 s.w.g. (p.v.c.)
L_5	7 turns 26 s.w.g.
L_6	2 turns 14 s.w.g.
L_7	4 turns 18 s.w.g. (p.v.c.)

if observations are being made of rapidly fluctuating sources a short time constant may be useful in order to record these sudden fluctuations. On the other hand, when observing long period variations a longer time constant is more satisfactory. The values shown in Fig. 23 are arbitrary and will in fact give time constants of one-tenth of a second and of one second. For some work which will be described later it may be necessary to use a time constant of several seconds. When using communications receivers, this unit can obviously be incorporated in the receiver using the existing power supply. A suitable meter would be one having a full scale deflection of 1mA, although this is not absolutely necessary. The requirements are that the meter shall be sufficiently sensitive to enable accurate measurements to be recorded in action by direct observation. It would, or course, be used as a guide point when plotting a graph with readings taken say every half or one second, or even longer. This will enable a graph to be plotted against time. If the translator is used with a tape recorder it will be necessary to arrange for the output of the recorder to be at a sufficiently high level to be fed into the unit. Where long periods of observations have been made with the tape recorder, much of the time may show little variation in level. The time taken to reduce this to graph form can be reduced by speeding up the tape on replay, the record given will be quite valid provided the time shown on the graph is corrected. The amplitude of the variations will not, of course, be affected by the change of speed.

Those who propose to use a turret tuner and the Pye i.f. strip will find that modification of the output at the detector is required. The circuit for feeding a pen recorder from the Pye strip is shown in Fig. 24, this also having the variable time constant. For use with the translator, the Pye strip could

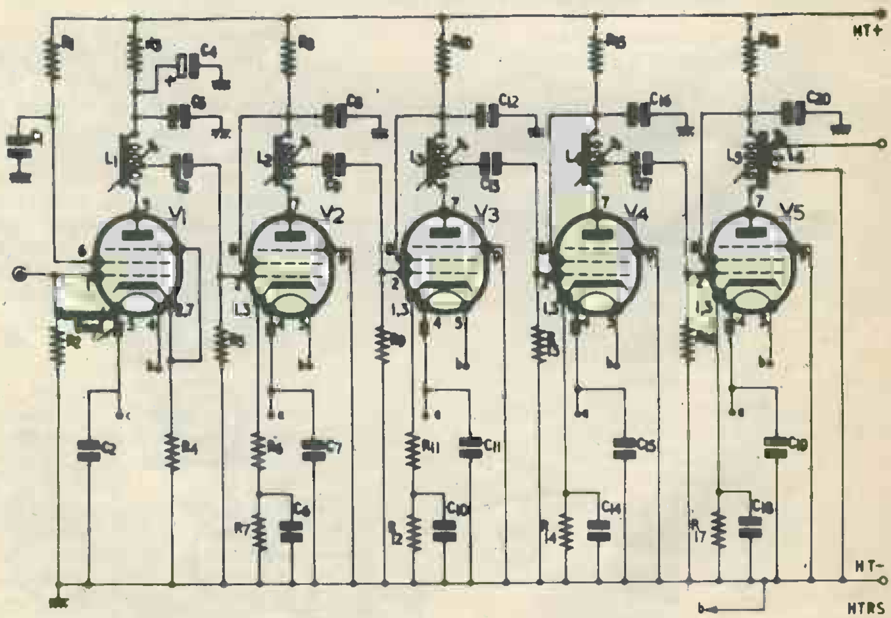


Fig. 28. I.F. section of the receiver; see Table 2 for coil winding details

Components List
(Receiver IF Section)

Resistors

R_1	33kΩ
R_2	47kΩ
R_3	2.2kΩ
R_4	180Ω
R_5	22kΩ
R_6	33Ω
R_7	68Ω
R_8	2.2kΩ
R_9	22kΩ
R_{10}	2.2kΩ
R_{11}	33Ω
R_{12}	68Ω
R_{13}	22kΩ
R_{14}	100Ω
R_{15}	2.2kΩ
R_{16}	22kΩ
R_{17}	150Ω
R_{18}	470Ω

Valves

V_1	6AK5
V_2	6BW7
V_3	6BW7
V_4	6BW7
V_5	6BW7

Capacitors

C_1	1000pF
C_2	1000pF
C_3	1000pF
C_4	8μF 350wV
C_5	2000pF
C_6	2000pF
C_7	1000pF
C_8	2000pF
C_9	1000pF
C_{10}	2000pF
C_{11}	1000pF
C_{12}	2000pF
C_{13}	1000pF
C_{14}	2000pF
C_{15}	1000pF
C_{16}	3000pF
C_{17}	1000pF
C_{18}	2000pF
C_{19}	1000pF
C_{20}	3000pF

TABLE 2

L_1	9 turns tapped at 3 turns 26 s.w.g.
L_2	,, ,,
L_3	,, ,,
L_4	,, ,,
L_5	12 turns 26 s.w.g.
L_6	7 turns 26 s.w.g.

have the conventional audio frequency stage after the diode, this then being followed by the translator. It is important to have an audio stage to which a loudspeaker is connected, thus enabling the observer to listen to the various changes in level. Indeed, when working in the workshop with the loudspeaker switched on, any sudden change or special phenomena which takes place will be immediately apparent. Attention can then be turned to the apparatus directly and, if necessary, plots made from the translator while the phenomena is in progress. This is particularly interesting in the case of the active Sun, for sometimes the sudden increase in noise is of such an amplitude that the audio stages may even become overloaded.

Pen Recorder D.C. Amplifier

For the sake of completeness in dealing with existing apparatus a d.c. amplifier for the pen recorder is included. This is shown in Fig. 25. The amplifier is again quite a straightforward piece of apparatus and may be used by the more ambitious in place of the translator. In this case, of course, it will have to follow a circuit containing a time constant. Referring back to Fig. 24 it will be seen that it may be either added to the Pye strip or the diode section of the communications receiver, (the latter being then modified). This unit requires a stable source of h.t. supply and it should perhaps be noted that stability of the supply is very important. Should there be any doubt about this aspect of the apparatus, steps must be taken to ensure that reasonable voltage stability is obtained.

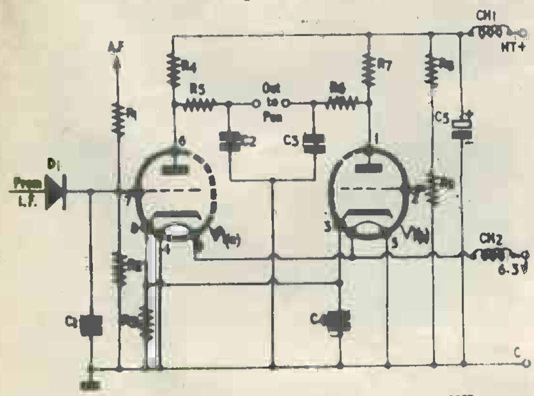


Fig. 29. Circuit of the pen recorder unit

Components List
(Pen Recorder Unit)

Resistors

R_1	220kΩ
R_2	1MΩ
R_3	500Ω
R_4	22kΩ
R_5	3.3kΩ
R_6	3.3kΩ
R_7	22kΩ
R_8	100kΩ
R_9	25kΩ pot.

Valve

$V_1(_a), (_b)$ 12AU7/ECC82

Capacitors

C_1	50pF
C_2	0.02μF
C_3	0.02μF
C_4	5000pF
C_5	50μF 350wV

Chokes

CH_1	Interference suppressor choke (1A)
CH_2	4 turns 18 s.w.g. insulated

Diode

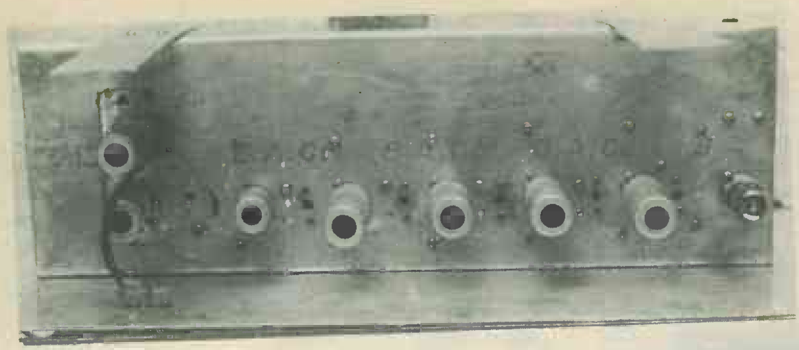
D_1 Germanium Diode

Noise Generator

The apparatus so far described forms now, with the aerial, the complete radio telescope. It is however necessary to make a calibration of the noise level and this can best be done with the use of a noise generator. Fig. 26 shows the circuit of a simple piece of apparatus containing a silicon diode and a meter. The control R_2 sets the level. The noise generator is used as a comparator. The noise input is fed into the aerial terminal of the receiver and the level of output noted. The generator is then disconnected and the aerial itself connected to the receiver, this should produce a rise in reading. The position of the control on the noise generator should be noted, for this will now become the reference point. In cases where the extra-terrestrial radiations are near to, or possibly even less than, that of the noise generator, comparison of the two inputs will show whether or not there has been a change in the level for, having established the setting on the noise generator, comparison of the two positions will show to what extent it has been changed. It is advisable to check the receiver once at the beginning and once at the end of the period of observation if these are short, or once a day if long-term observations are being made. The noise generator will be found to be an extremely useful piece of apparatus for it provides an immediate check on the condition of the receiving system. It is of more value for our purpose than the standard type of signal generator which deals with a particular frequency only. It must be remembered that, although our receiver is set to the middle of the band, it was noted earlier that noise voltages receiver by the aerial cover an infinite band of frequencies. The output of a noise generator corresponds more nearly to the energy received by the aerial than does the ordinary signal generator modulated with an audio frequency source.

The Receiver

We next discuss a particular receiver which was developed for the purpose of these articles. It is a modification of a receiver originally designed for use between 200 and 240 Mc/s and the first prototype was in fact demonstrated to the Duke



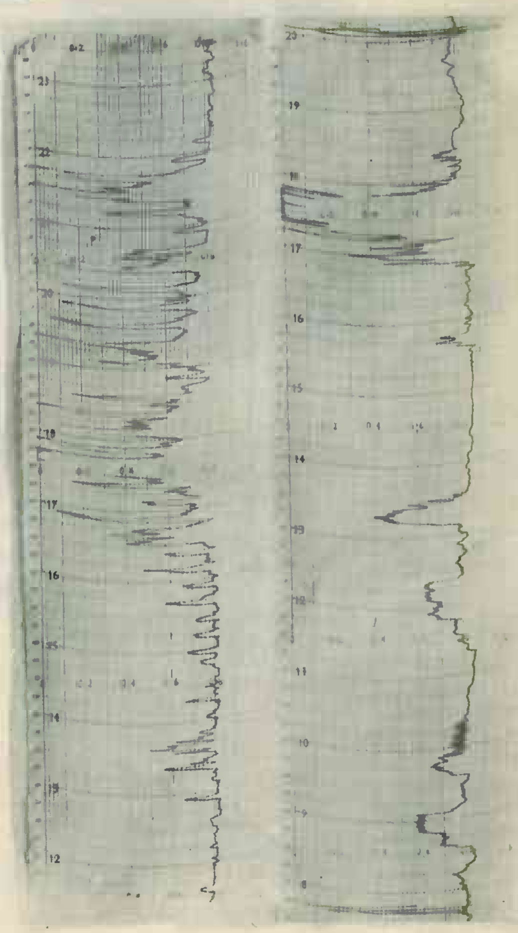
View of the top of the receiver chassis showing the valve line-up

of Edinburgh on the occasion of the opening of Crawley Technical College, where there had been installed a portable radio telescope of the author's design. The majority of the development work on this receiver has been directed to making it simple in design and easy to build. The circuit has been broken down into three sections for the sake of clarity. These three sections are shown in Figs. 27, 28 and 29. The input from the aerial is fed into the transformer, L_1, L_2, and from thence to the grid of one-half of V_1 (a) which is cascode coupled to the other half, V_1 (b). From there it is fed to the double-triode frequency changer. It will be observed that this follows conventional practice. The layout is important and details of this can be seen in the accompanying illustration[1]. The output from the r.f. section is fed into the i.f. stages, which again are conventional although considerable development work was necessary to provide stability with high gain. The layout will be apparent from the photograph. The output section includes the diode and the pen recorder unit with provision for a.f. monitoring.

This receiver has been designed nominally for operation for 210 to 220 Mc/s but modification of the r.f. section is all that is required to make it suitable for the other frequencies for which the aerial was designed. Within the limits of space available the individual amateur can choose his own frequency at any point between 60 and 240 Mc/s. The power supply chosen for this receiver is one of the many which are available on the surplus market at a reasonable price. That employed by the writer is the ex-R.A.F. unit type 234A

The complete receiver with pen recorder and power unit is shown in the illustrations. For the sake of completeness in this part of the series, it is necessary to show what the receiver actually does and a further illustration shows two of the recordings made during tests in the past seven weeks.[2] One trace shows the Sun passing through the beam of the aerial and the other shows a section of the Milky Way. The difference between the types of radiation received are clearly visible on these charts and the amplitude of the variations can be readily seen. Those amateurs who enter this field will find that the interpretation of these results is, indeed, a fascinating pursuit.

(To be continued)



Pen recordings showing (at top) passage of the Sun through the aerial beam and (below) part of the Milky Way (Sagittarius-Area) passing through the beam

[1] In the photograph L_1, L_2 are farthest away from the variable capacitor. L_4 is between the valveholders and L_6 is below the variable capacitor. L_5 is close to the screen, through which the output lead to the i.f. section passes. Oscillator coupling to the mixer is by way of stray capacitive and inductive couplings.—EDITOR

[2] Up to November 10th 1961.—EDITOR

The JR1/JTL Stereo Tape Recorder Unit

PART 4. By G. BLUNDELL

The JR1 JTL Stereo Tape Recording Unit offers stereophonic record and playback facilities, together with instantaneous tape monitoring. It is employed with a stereo amplifier. The unit can also allow all tape tracks to be recorded and played back in conjunction with a monaural amplifier or amplifiers, the instantaneous monitoring facilities still being retained for this application

THE JTL TAPE LINK HAS BEEN PRIMARILY DESIGNED to use with the Jason J2–10 Stereo Amplifier, but equally successful results have been obtained with other amplifiers, after a few minor modifications have been made. Notes on converting a Leak Varislope Stereo pre-amplifier were made in conjunction with Teleradio (1943) Ltd., of 189 Edgware Road, London, W.1., who have co-operated throughout and who would carry out these modifications for a nominal fee. While these modifications to the Varislope Stereo have been discussed with Messrs H. J. Leak & Co. Ltd., it can be readily understood that they can in no way be responsible for any modifications so made or the results obtained.

The object of these modifications is to separate the first stage of the pre-amplifier from the final stages, so that, as explained elsewhere, the first stage can correct the signal which is being applied to the tape, whilst the tone controls are being used on playback. Switching off the JTL then leaves the amplifier operating as though the tape unit were not connected.

Varislope Stereo

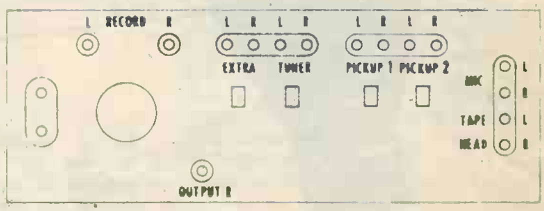
(1) Remove top and bottom covers.

(2) Remove two leads connecting the "Extra" sockets to the gain switch, which is mounted immediately below.

(3) Remove two leads connecting the "Record" L and R sockets to the volume control (P_{41} and P_{42}) at the extreme right of the front panel.

(4) Refer to the layout diagram on page 5 and the circuit diagram page 6 (of the Varislope manual) and locate the junction of C_{14R} and C_{15R}. Trace the lead from this junction to C_{17R} and R_{30R} on top of the tagboard. Disconnect this lead at the junction of C_{17R} and $R30_R$ and reconnect to the "Record R" socket. If the lead is re-routed it may be long enough, otherwise replace with a longer wire.

(5) Again, refer to diagrams and locate C_{14L} and C_{15L}. Disconnect C_{17L} from the tagstrip. Disconnect R_{30L} from the tagstrip. Reposition R_{30L} pointing towards C_{17L}. Join a length of tinned copper wire to R_{30L} and cover with 2in of sleeving. Join the other end of this wire to C_{17L} and from this joint a further length of wire is connected to the "Extra L" socket.



Rear view of the Leak Variscope Preamplifier

(6) Find the junction of R_{30R} and C_{17R} with the unit upside down and the front facing away. This junction is on the 9th tag from the left on the edge of the board nearest the controls. Connect this junction to the socket. ("Extra R".)

(7) Find the junction of C_{14L} and C_{15L}, which is on the 8th tag from the left. Connect this junction to the "Record L" socket.

(8) Find the junction of C_{14R} and C_{15R} and connect a 10MΩ resistor from this point to tag 3, which is connected to chassis.

(9) From the junction C_{14L} and C_{15L}, which is tag 8 as previously mentioned, connect a 10MΩ resistor to tag 3, from the left, on the front row. These last two resistors are required to prevent a charge building up on capacitors C_{14} and C_{15} when the monitor switch is operated. Normally the connection to the tone control circuit through R_{30} prevents this voltage appearing.

(10) If the Leak pre-amplifier is to be used before the JTL is obtained, the sockets must now be joined together externally otherwise there will be no output. Two 6in lengths of screened wire are required with the appropriate plugs at each end. With these leads, join "Extra R" to "Record R" and "Extra L" to "Record L". With these leads in position the performance of the Varislope pre-amplifier will be in no way altered from the original specification.

If the Leak pre-amplifier was manufactured before September 1960, it may be necessary to carry out a further modification. Referring again to the layout and circuit diagram, find the junction of R_{9R} and R_{8R} and see whether this is connected to C_{3R}. If C_{3R} exists, it should be short-circuited so that the above junction connects directly to R_{7R}. The same modification is required on the other channel and if C_{3L} exists, it should also be short-circuited.

This modification is required because with C_3 connected, operation of the monitor switch results in clicks being recorded on the tape, due to the discharge of C_3. It should be emphasised again that deliveries since September 1960 of the Leak pre-amplifier already have this modification included.

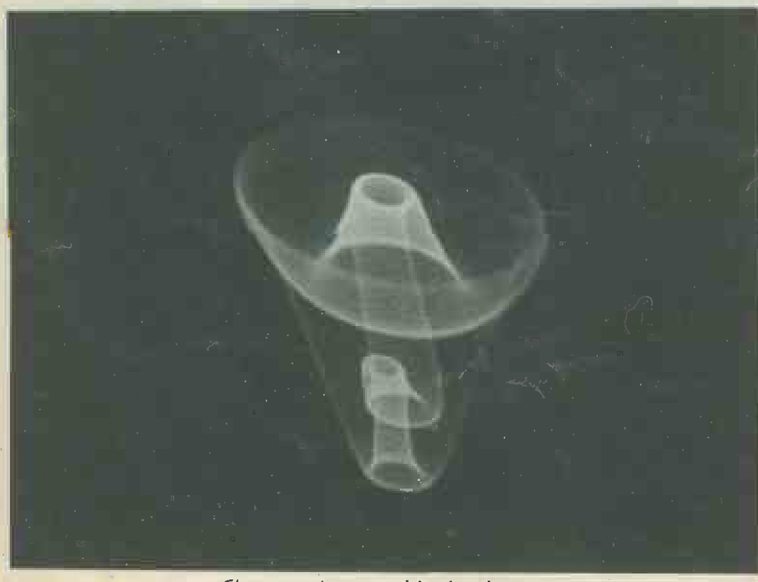
(Conclusion)

RADIO topics

By RECORDER

THE PHOTOGRAPH ON THIS PAGE is a visual presentation of sound. We have to reproduce it here in black and white, of course, but it would appear in practice in one or more colours. The pattern is obtained by electronic means on the screen of a cathode ray tube, and it represents just one of an infinite variety of figures which can depict sounds in abstract form. It is a simple example, in fact, of what is offered by very recent developments in the art of Chromasonics.[1]

[1] "Chromasonics" is a Registered Name.



Chromasonics: sound in the abstract

Chromasonics

Mr. F. C. Judd is well known in audio and home-constructor circles as a protagonist in the field of electronic music and *musique concrète*[2], and I am indebted to him for the details he has passed on to me concerning Chromasonics.

The term Chromasonics was coined to segregate abstract visual presentation of sound in colour from normal colour films having their own sound tracks. In the latter case there is complete co-ordination of aural and visual impressions because it is the primary function of the sound track to provide sound which is synchronised with the actions and speech of the film characters (live or cartoon), and which stresses the changing emotions dictated by the plot. With Chromasonics the visual display is still directly related to the sound but, in this instance, its purpose is to provide abstract aesthetic impressions to further emphasise the character of the sound reproduced. Chromasonics can enhance enjoyment by creating patterns and colours which move and change to the mood of different kinds of music; an obvious instance being given by rhythmic movements with rhythmic sound.

What could be described as a crude form of abstract visual presentation is given when displays of coloured lighting, in conjunction

[2] See for instance Mr. Judd's articles: "Electronic Music", *Wireless World*, September 1961; and "A Console Recorder For *Musique Concrète* and Electronic Music" *The Radio Constructor*, August 1960.

with music, are employed to create pleasing effects at exhibition displays or in the cinema during intervals. On a much more impressive scale are the Vortex concerts of electronic music held annually in U.S.A., these being invariably presented with coloured illumination, together with moving patterns of light and projected coloured abstract or geometric shapes.

The pattern illustrated here represents a significant breakaway from these other forms of Chromasonics, and it is made possible by sophisticated techniques which have been recently developed. These techniques are employed in two different display systems. The first of these consists of presentation on a cathode ray tube by the use of low frequency signals and mechanically scanned colour systems, recording and complete synchronisation (between sound and visual display) being given by way of magnetic tape running at slow speed. The second is direct projection on to a large screen of pulsed light controlled by sound recorded on magnetic tape, with colour and images produced by mechanical scanning.[3]

It will be interesting to watch future progress in this new and unusual off-shoot of electronics.

Absorption Effects

Despite the introduction of v.h.f. sound transmissions, home-constructors are still very interested in broadcast band receivers. A friend of mine has, indeed, just knocked up a long, medium and short-wave job and he bumped into a snag which baffled him completely. Although the cause of the fault is an "oldie", it is still not generally known. So I shall relate what happened in this case.

[3] Both these systems are the subject of patent application by Mr. F. C. Judd.

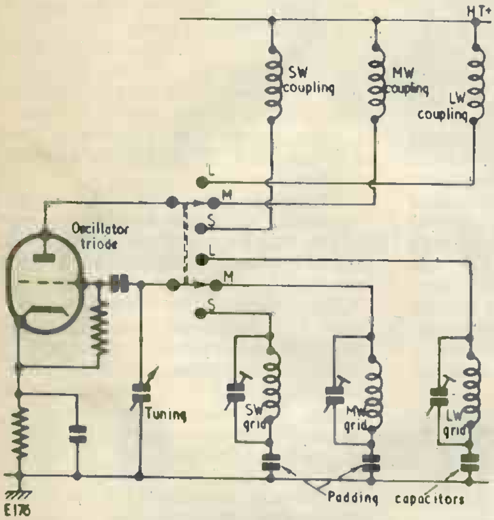


Fig. 1. A simple oscillator circuit, which gave peculiar results on the medium-wave band circuit

The receiver, which was a superhet, worked excellently on long and short waves, as well as over the high frequency end of the medium-wave band. Round about 450 metres, however, sensitivity dropped. When my friend tried the medium-wave range with a signal generator, the dial calibration held accurately enough until the mysterious 450 metre region was approached. The set tuning then hopped several kc/s at that point. Obviously, there was trouble in the oscillator circuit.

Fig. 1 shows the oscillator circuit employed, and Fig. 2 (*a*) the neat way in which my friend had laid out the coils. (Knowledgeable readers may now skip the rest and carry on at the next sub-heading!) After one look I tuned the receiver to 450 metres with the signal generator connected, and increased the capacitance of the *long-wave* trimmer. As I adjusted the trimmer medium-wave sensitivity rose at once, and after I had given the adjusting screw a turn or two the receiver worked perfectly over the entire medium-wave band, with no peculiar hops in frequency or anything like that at all.

The trouble, of course, was absorption. When it was switched out of circuit the long-wave coil still had the trimmer connected across it. This now provided the only parallel capacitance and resulted in the long-wave oscillator grid coil resonating at the oscillator frequency which corresponded to 450 metres on the dial. In consequence it formed an absorption tuned circuit which took a considerable amount of energy out of the medium-wave oscillator coil at this point, as well as causing the queer hop in frequency. The cure was to change the layout to that of Fig. 2 (*b*), whereupon the medium- and long-wave coils were spaced further apart from each other, a useful bit of screening being provided by the short-wave coil in between.

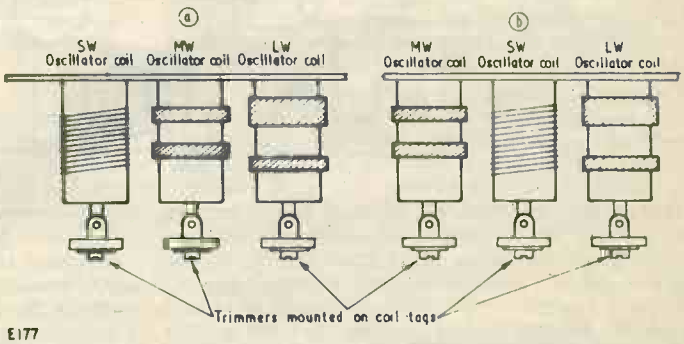


Fig. 2 (a). The coil layout originally employed for the oscillator (b). The revised coil layout

If you're surprised at the fact that a long-wave oscillator coil can ascend to the heights of the medium-wave band, a look at some typical facts and figures may be of interest. Assuming a medium-wave range of 500 to 1,500 kc/s (600 to 200 metres), the medium-wave oscillator covers (with 465 kc/s i.f. transformers) 965 to 1,965 kc/s. The corresponding long-wave oscillator frequency range (assuming a dial coverage of 2,000 to 800 metres, or 150 to 375 kc/s) is 615 to 840 kc/s. If the long-wave oscillator trimmer is set to a fairly low capacitance, it is pretty easy to imagine that switching the long-wave coil out of circuit (with the consequent disconnection of stray wiring capacitances, valve capacitances, and minimum tuning gang capacitance) can easily cause the grid coil to jump up from a top frequency of 840 kc/s to 965 kc/s or more.

In the past, this effect has been one of the main reasons why many coil-packs have the short-wave oscillator coil mounted between the medium- and long-wave oscillator coils. In the absence of a short-wave coil, the trouble can of course be avoided by adequate spacing between the two coils or by mounting them at right angles.

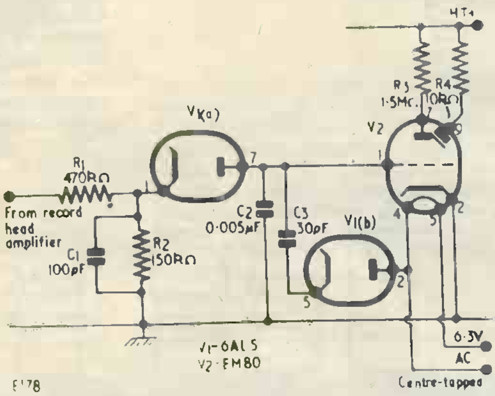


Fig. 3. A discharge circuit whose operation is discussed in the text

Hitting The Jackpot

Talking of "oldies" reminds me that this is how colleague W. Holmes referred to one of his "Gadgets For Your Christmas Party" in last month's issue. The gadget consisted of a metal ring which was moved along a bar. When the ring touched the bar a bell sounded.

Those of our readers who watch the I.T.V. programme "Sunday Night At The London Palladium" will, of course, have seen the self-same gadget employed in the Jackpot Prize contest. This particular Jackpot series commenced after W. Holmes' article was written and set up, and we note that the London Palladium version of the bar sported considerably more bends and turns than did ours!

An Interesting Discharge Circuit

Mr. D. E. Launchbury, of Leamington Spa, has sent in details of an interesting discharge circuit. The circuit appears in Fig. 3 and, as may be seen, it consists for the most part of a fairly conventional tape recording level indicator arrangement. The a.f. voltage fed to the record head is applied also, via R_1, to diode V_1 (*a*), this rectifying and causing an appropriate negative potential to be applied to the grid of the Magic-Eye, V_2. The latter then offers a display corresponding to the peak level of the applied a.f. It is normal to have a capacitor and resistor in parallel connected between the Magic-Eye control grid and chassis in order to provide a relatively slow decay in the display, and time constants here for commercial recorders are usually of the order of 0.2 to 0.3 seconds. Such time constants necessitate a relatively large value in the capacitor if the parallel resistor is not to have a value greater than the maximum Rg-k permissable with the Magic-Eye.

It was desired to obtain a long time constant without increasing the value of the storage capacitor since, to maintain the same charge time, such an increase would have necessitated a lower value of series diode resistance with the risk of loading on recording peaks. In consequence, the arrangement shown in the diagram was devised. In this a second diode, V_1(b), in series with a 30pF capacitor, C_3, is connected across C_2 which has the relatively low value of 0.005μF. And this is where the interesting part begins, because C_2 discharges more rapidly when the 30pF capacitor and V_1(b) are applied than when they are disconnected.

The following discharge times were recorded for different arrangements of the circuit. An arbitrary indication of discharge time (given by the Magic-Eye display) was used, and this was probably significantly longer than the time constant of a capacitor and parallel resistor.

Discharge time with V_1(b) and C_3 disconnected was 60 seconds. In this instance C_2 discharged via circuit leakage paths.

Discharge time with V_1(b) and C_3 in circuit as in the diagram was 15 seconds. Since V_1(b) anode was coupled to one side of a centre-tapped heater line it received an a.c. potential of 3.15 volts relative to chassis.

Discharge time with V_1(b) anode connected to chassis was 25 seconds, whilst discharge time with V_1(b) anode connected to 6.3 volts a.c. relative to chassis was 13 seconds.

From these results it would appear that C_2 discharges more rapidly when the a.c. voltage applied to V_2 anode is increased. Also, the combination of 30pF capacitor and diode (particularly with a.c. on its anode) would appear to cause a marked decrease in discharge time when they are initially applied. Incidentally, capacitor C_3 has been thoroughly checked and appears to be 100% both for capacitance and leakage.

Technical News

That well known speaker fabric "Tygan" (manufacturered by Fothergill & Harvey Ltd., Littleborough, Lancs.) has exceptionally low sound absorption because it employs polyvinylidene chloride yarn. Tests have shown that such yarns, used in speaker fabrics, can even give a 2% *increase* in sound. This is because they do not absorb the sound but reflect it back into the speaker.

Do you remember those miniature metal-cased Sprague 0.1 and 0.01μF capacitors that appeared in such large numbers after the war? You may well be seeing quite a few more Sprague products in the future, as the result of an agreement between Sprague Electric Company and the Telegraph Condenser Company. By means of the agreement, Sprague and T.C.C. now share their research facilities, manufacturing experience and know-how; also T.C.C. are the sole distributors for Sprague products in the U.K. Sprague Electric Company is the largest manufacturer of capacitors and electrical components in America.

Seen at the recent Engineering Materials and Design Exhibition at Earls Court—knitted "armour" suits for protection against injury from micro-waves in radar stations.

The suits are very flexible and light in weight, and are made of a mesh of silver-copper material.

The largest International exhibition ever to be staged in Britain is planned for April 23rd to May 2nd, 1963. This will be known as The London International Engineering Exhibition, it will occupy *both* Olympia and Earls Court, and it will cater for every type of engineering product from the largest items of capital equipment to the smallest component.

Rechargeable portable TV batteries are now available in this country from G. A. Stanley Palmer and Co. Ltd., Maxwell House, Arundel Street, W.C.2. These are DEAC units, 6 volt versions of which are available in either 4 amp-hour or 6 amp-hour capacity. The batteries can provide 2 and 3 amp outputs respectively for five hours of continuous use, recharging being accomplished via inbuilt circuitry when the associated TV receiver is plugged into the mains. The DEAC batteries can be operated in any position, and they are entirely free from gassing, swelling, fumes and corrosion. They are guaranteed for a year or 300 recharges, whichever is the less.

Signing Off

And, now, let me end this month with the wish that all readers have a truly happy and prosperous New Year, with all equipment working immediately after the last solder joint has been made and with television tubes and transistors down to a tanner each.

All the best for 1962!

A Constructor's Wife . . .

a warning to constructors and to any girls considering marrying one

By MRS. J. ANDERSON

Mr. J. A. Anderson, who is one of our regular contributors, tells us that he has been more or less ordered to send this article on to us. (And asks us to make the cheque payable to him.)

—Editor.

AT THIS TIME OF YEAR MANY GIRLS ARE THINKING of getting married, and I am sure that quite a high percentage of them have no idea what they are in for if their future husband is keen on electronics, especially as this is sometimes concealed from them.

I thought that my husband must be very clever, being able to understand radios and things, and that he would be very useful in the house. Now, I'm not so sure about this . . .

We have a "house phone", so that I can tell my husband when a meal is ready if he is working in his workshop. A good idea? If you had only seen the floorboards that were up, the dirt that came out of them! To be quietly working in the kitchen and suddenly be startled by a loud and decidedly unmelodious buzzing, and then, perhaps having interrupted some particularly delicate cooking operation to answer it, be greeted by a request as to whether I have seen some tool or other which I've never even heard of, is not funny any more.

About once every two months, some small and inconspicuous plug appears on the skirting board. When there are more than five or six of them in several rooms, it becomes a little trying, especially when I forget which one is for the vacuum and which for the radio extension.

We had a thing for answering the front door electrically, so that from the kitchen I could ask who was there through a microphone or something: apart from the fact that I never could remember which button to press to speak, we nearly had to go to court when something went wrong and a sheet of flame blew the milkman's eyebrows into a new shape!

There was another thing for ringing a bell when it began to rain, so that I wouldn't have to keep one eye on the weather on Mondays . . . What my husband didn't say was that the bell was an ex-government alarm gong which nearly gave me a heart attack when it went off: and the first time it did so, I couldn't turn it off, it had a "locking relay" in it so that if I was upstairs it would still be on when I came down to the kitchen. I had to phone him, 300 miles away, to ask him how to stop it.

Only a week ago, I woke up at about three in the morning, and thought my husband was having an epileptic fit and wandering about the house hurting himself, there was such a strange bubbling and gurgling coming from downstairs and he wasn't in bed. On going to see what was wrong, I found him sitting with his radios, trying to "get Australia" . . . the noise was interference! Often I have been called away from the phone, or from the oven, or even from a guest, because "Old Bill in Honolulu wants to say hello." The majority of our friends seem to live in a heap of grey steel boxes; we certainly haven't got as many as we used to have locally, because even after the time when the steel poles which hold up the aerials fell down and broke some rose trees and a fence or two, the steady procession of people on a Saturday afternoon didn't stop . . . "Hello, Mrs. Anderson. Is your husband in? I was watching the Test Match and all of a sudden the television went funny, voices and things and a sort of snowstorm on the screen." Oh, dear me.

One day last year I wanted to go to a garden party, but we had to get the car out and go miles and miles, with an incredible stock of food, for a "Field Day". This wasn't much fun either . . . I sat all day in a car listening to whizzing noises from the boot and everywhere else, whilst we dashed from place to place meeting cheery men with headphones and handlebar moustaches who called my husband by an unspeakable nickname which he apparently picked up at college . . . Then when I said I was bored I was given a little dial to watch, and I had to say "UP" when the pointer got to the highest point: that gave me a headache.

About the middle of 1960, my husband advertised some gadget he had made to work off the mains, because he didn't want it any more. He *said* he had put "callers only", but I spent most of the day answering the phone; we even had two telegrams: the thing was sold by eleven in the morning to one of the innumerable men who thundered at the front door!

If you aren't discouraged yet, then buy a book on first-aid. Several years ago, when we lived in London, I was sitting enjoying a cup of coffee and reading the paper one morning, when there was a sort of scraping at the back door; I opened it, and my eldest son CRAWLED in on his hands and knees, as white as a sheet, and shaking all over. He gasped something about electricity, and collapsed. The doctor, who was one of these awful radio people as well, roared with laughter and said that a few free electrons in the body isn't as bad as people think: I don't know what that means, but I've always remembered it because it annoyed me so much! My husband has a scar on his chin, a mark which is all that is left of a hole *straight through his thumb*, and at this moment a wad of bandages conceals his right arm from wrist to elbow: and he's a dentist, that hole in his thumb could have lost him a job. . . . Although then perhaps he wouldn't have been able to afford all these radios and things!

Now, think about that lot, you girls who are being blinded with science. Our television is in pieces at the moment, there are more knobs on the radio, which *was* a beautiful wedding present, than I know what to do with, we're losing our friends, my sons have got the disease, the kitchen table has a soldering-iron burn on it, my husband is still trying to disable himself, and I can't even get a decent sleep nowadays.

And, men, take this as a warning!

Resistors and Capacitors as Mains Droppers

By J. B. DANCE, M.Sc.

In order to avoid the cost, bulk and weight of a mains transformer, it is common practice to supply valve heaters from the mains with the use of a series resistor to drop the mains voltage to the required value. It is not so well known, however, that if the mains supply is a.c., a series capacitor can be used instead of a resistor to drop the mains voltage. The advantages and disadvantages of the two methods will be discussed in this article and graphs are given which will enable the required value of the dropping resistor or capacitor to be quickly found for most practical cases.

Series Resistor Circuits

A circuit employing a series resistor, R, to drop the mains voltage for valve heaters is shown in Fig. 1. The same current passes through each of the valve heaters in the circuit shown and it is therefore necessary that they shall all have the same current rating, I.

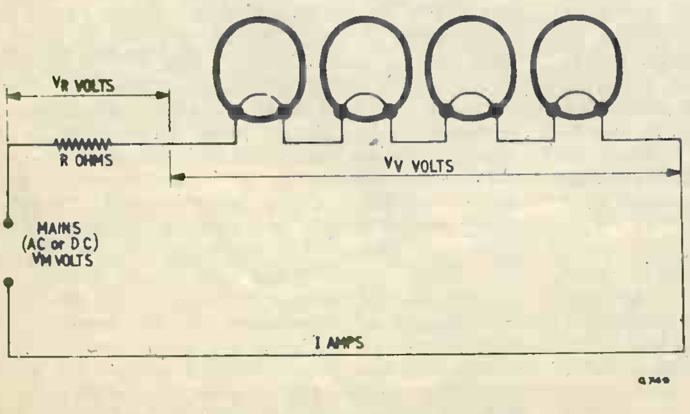


Fig. 1. A series connected resistor as a mains voltage dropper

Let the total voltage across all of the valve heaters $=V_v$, and the voltage across the series resistor $R=V_R$. The current and voltage are in phase (as the circuit is purely resistive) and therefore the mains voltage, V_M, must be equal to $R_R + V_v$. The value of the series resistor, R, which is required can be calculated from Ohm's Law:

$$R=\frac{V_R}{I}=\frac{V_M-V_v}{I}$$

If it is assumed that the mains voltage is 240, the value of R required can be found immediately from the graphs of Fig. 2 (which are based on the above equation) provided that the valves used require one of the four values of heater current shown in the graphs. Almost all modern valves require a heater current equal to one of the values shown.

Example

Suppose it was desired to construct a piece of equipment containing a PCF80, a PCC84 and a PY80 rectifier. The heaters of these valves are rated at 9, 7 and 19 volts respectively, but as they are all rated to pass 300mA heater current, they can be connected in series. Let us imagine that a 6 volt 300mA dial light is to be connected in series with the valves to indicate when the apparatus is working. The total voltage, V_v, across all the valve heaters and the dial light is 41 volts. Using the 300mA line of Fig. 2, it can be seen that the resistor value required for R is about 667Ω. The preferred value of 680Ω would be quite satisfactory, but the resistor would have to be capable of dissipating 60 watts or more.

If one of the valves in a series heater chain requires a smaller heater current than the others, this can be achieved by placing a resistor in parallel with the heater of that particular valve. The resistor must have such a value that it passes the excess current when the voltage across it is equal to the rated voltage of the valve heater.

Series Capacitors

A capacitor can be used to drop the voltage of a.c. (but not d.c.) mains in a similar way to a resistor; a typical circuit is shown in Fig. 3. A resistor of about 680kΩ should be connected across the capacitor so that it will discharge when the mains voltage is switched off, this preventing a shock from the capacitor should the mains plug pins be touched for some reason after the apparatus has been switched off and the plug withdrawn from the socket. A fuse should be incorporated in the circuit to prevent damage to the valve heaters in the event of the capacitor developing a short circuit. Under no circumstances should the use of an electrolytic capacitor be contemplated. A good quality paper capacitor rated at 250 volts a.c. working or more must be used.

Let the total voltage across all of the valve heaters be V_v as before (see Fig. 3) and the voltage across the capacitor be V_c. These voltages are not in phase with the mains voltage V_M. We can write:

$$V_c = \sqrt{V_M^2 - V_v^2}$$

$$V_c = I X_c$$

where X_c is the reactance of the capacitor. The following expression for C can be derived from these equations:

$$C = \frac{1}{2\pi f \sqrt{V_M^2 - V_v^2}}$$

where f = the mains frequency.

It is most convenient to express this equation in the form of the graphs shown in Fig. 4. This can only be done if definite values are assigned to the mains voltage and frequency. The graphs shown in Fig. 4 are for a 240 volt 50 c/s mains supply; graphs for four of the most common values of heater current are shown.

Example

Let us suppose if is required to use two ECC81 (12AT7) valves in some apparatus. The heaters of the two sections of each valve can be connected in two ways (series or parallel) in order to provide a heater rating for the whole of each valve of either 12.6 volts at 0.15 amp or 6.3 volts at 0.3 amp. For use with a series capacitor, it is usually advisable to use the method of connection requiring the lower current, a smaller value of capacitor then being used. If the two valves are connected in

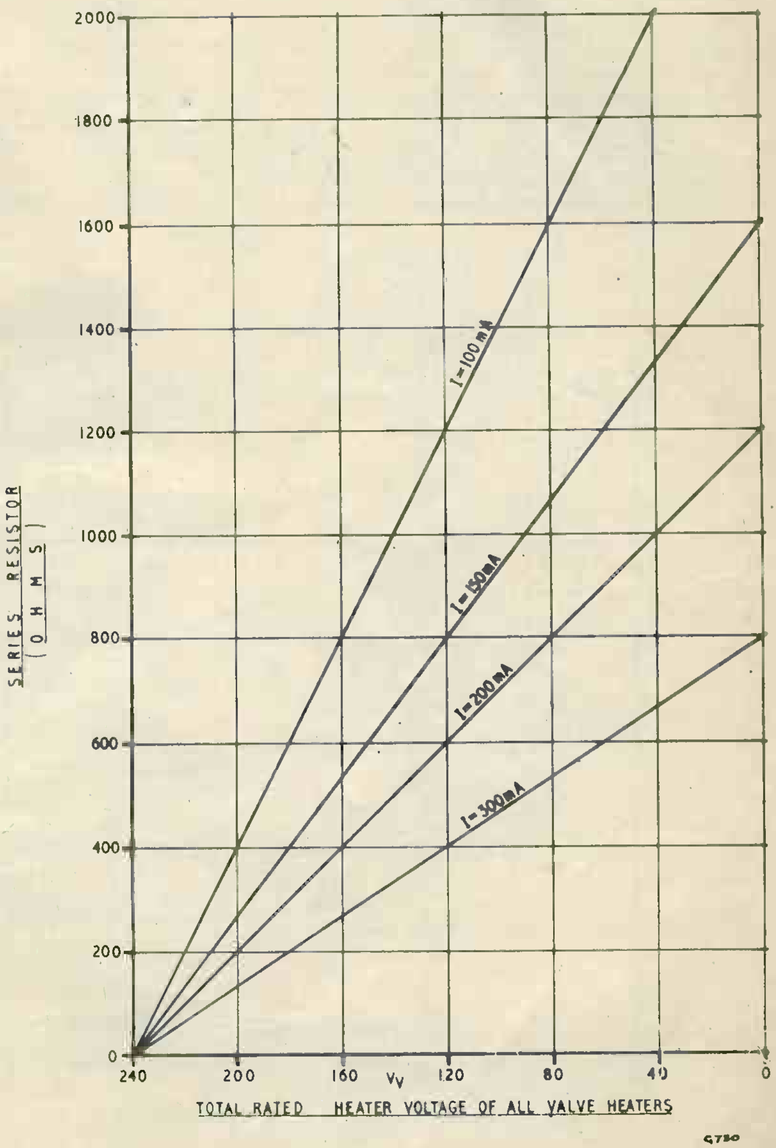


Fig. 2. These graphs enable the value of the series resistor to be found for 240V 50 c/s mains operation

series, the total heater rating will be 25.2 volts at 0.15 amp. Assuming the mains voltage is 240 volts, 50 c/s, the value of the series capacitor required can be found from the Fig. 4 graph; it is about 2μF

If the heaters of each valve had been connected so that they each required 6.3 volts at 0.3 amp, the value of the capacitor required would have been doubled.

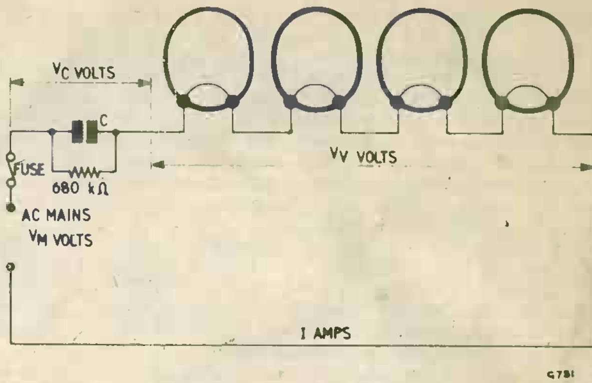


Fig. 3. A series connected capacitor may be used to drop the a.c. mains voltage

Advantages and Disadvantages

The use of a capacitor instead of a resistor enables voltage dropping to be accomplished without any wastage of power. Circuits which employ resistors may have an efficiency of less than 20%. Voltage dropping resistors must be fairly large in order to dissipate the heat evolved. This heat may help to cause frequency drift in oscillators, etc. Whilst capacitors do not radiate any heat when used as voltage droppers, it has already been mentioned that they cannot be used when the mains supply is d.c.

The use of a series capacitor enables the current during the warming up period to be kept at approximately the same value as the normal heater current. If dropping resistors are used, the low initial resistance of the valve heaters can lead to large heater currents during the warming up period. Whilst these large currents may enable the apparatus to warm up more quickly, it may result in shorter valve and dial light life.

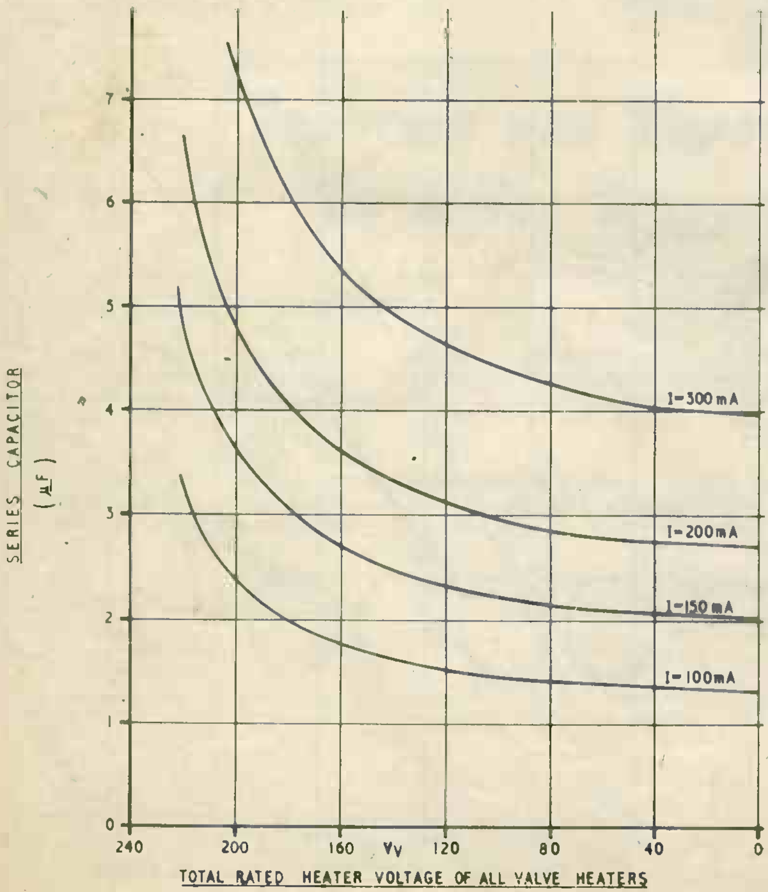


Fig. 4. Graphs showing the value of series capacitor required for 240V 50 c/s mains operation

Stability

A change of resistance of one of the valve heaters will cause a slight change in the total current passing through the heater chain. This change will be much smaller, however, if a capacitor is used as a voltage dropper instead of a resistor. This can be deduced from the fact that the slope of the graphs of Fig. 4 is much less than those of Fig. 2. A small change in the total voltage required by the valve heaters (V_v) when a capacitor is used causes a negligible change in the value of the capacitor required providing that V_v is fairly small. The use of a voltage dropping capacitor thus helps to preserve stability, especially when the total heater voltage is much smaller than the mains voltage.

Another advantage associated with the use of a series dropping capacitor is that an extra valve can be inserted in a heater chain without the necessity of changing the value of the capacitor, provided that the total heater voltage is less than half of the mains voltage. This would not be advisable in apparatus in which a series resistor is used.

Emitter Follower Circuits

Part 1

LOW IMPEDANCE MICROPHONE PREAMPLIFIER

By PETER WILLIAMS,
B.Sc.(Hons.), Grad.Inst. P., Grad.I.E.E.

This is the first of a series of four articles, each of which describes a particular application employing emitter follower transistor circuits. A special feature of the series is that a standard set of components may be employed, if desired, to construct all the devices discussed. Despite this, the circuits are extremely non-critical so far as component tolerances are concerned, and alternative values are dealt with fully.

Of particular interest are the d.c. coupling and negative feedback arrangements employed by the writer, these not only reducing the number of components required but also permitting excellent stability to be maintained, together with flexibility in component values.

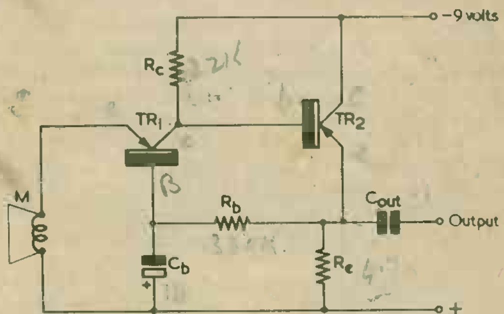
The devices described can provide a valuable introduction for the newcomer to transistor theory, and have the advantage of being somewhat more sophisticated than the "beginners' circuits" which are normally published.

BECAUSE OF THE HIGHER GAIN AVAILABLE, THE transistor is used most frequently in the common emitter configuration, i.e. with input between base and emitter, and output taken from collector to emitter. When coupling several such stages together, the loading effect on each stage of the previous one considerably reduces the gain, and this loss is further accentuated by the presence of bias and stabilising components.

[illegible] over the other configurations sensibly, match [illegible] output impedances, it is often possible to pro[illegible] results as good as those of cascaded grounded [illegible] stages and at the same time [illegible] the number of components. The designs that follow make use of direct coupling of the first stage into the high impedance of an emitter follower second stage, and by d.c. feedback eliminating several of the stabilising resistors usually required.

D.C. Stability

The d.c. stability of the circuit used (Fig. 1) can be understood when it is realised that the emitter and base of TR_2 are at the same potential as the collector of TR_1 (ignoring the small potential drop across the junction as it is a diode biassed in the forward direction). If now the collector current of TR_1 *increases*, due either to temperature rise or substitution of another transistor, then more voltage *is* lost across Rc and the base and emitter of TR_2 are brought closer to the positive supply line. Since the bias current of the first transistor is provided, through Rb, by the emitter voltage of the second transistor, this bias current will fall too, *reducing* the collector current to something near its original value. Similarly, if the collector current of the second transistor increases, the increased voltage across Re drives more bias into the first transistor, causing the collector current to rise and lowering the collector potential. This in turn returns the base and emitter of TR_2 to a lower value. Each transistor thus provides the bias for the other, and the combination can cope with more widely varying conditions than if biassed separately.



R_c = 22kΩ
R_b = 330kΩ
R_e = 4·7kΩ
C_b = 16μF
C_{out} = 0·1μF
TR_1, TR_2 = Audio Transistors (Red-spot, OC71's etc.)
M = Low Impedance Earphone

M214

Fig. 1. Circuit diagram of low impedance microphone preamplifier

A.C. Operation

When we consider the a.c. operation of the circuit, we see that the base of TR_1 is earthed via Cb. This prevents loss of gain through signal negative feedback without disturbing the d.c. feedback described above. The signal voltage across Re will be only slightly less than that across Rc because of the low junction impedance. At first sight it might seem from this that the second transistor is serving no useful purpose other than to establish the d.c. operating conditions. In fact, it also acts as a buffer and prevents much of the gain of the grounded base stage from being thrown away.

A practical example will illustrate this quite clearly. Since the emitter and collector currents of TR_1 are almost equal, the input current in this arrangement must also flow through the load resistance. This makes the voltage output directly proportional to the load and

$$\text{Voltage gain} = \frac{\text{Load resistance}}{\text{Input resistance}}$$

With the designed collector current of 0.3mA and collector resistance of 22kΩ, the input impedance is in the region of 80Ω. Inserting these values, Voltage

$$\text{gain} = \frac{22\text{k}\Omega}{80\Omega} = 275$$

If the second stage is a grounded emitter stage with an input impedance of about 1kΩ, this appears in parallel with the load and the gain is very much

$$\text{reduced, Voltage gain} = \frac{1\text{k}\Omega}{80\Omega} = 12.5$$

The action of the second stage can be described in this case as an impedance transformer since its current gain of, say, 50, enables it to provide a specified output to the emitter resistor while drawing only 1/50th of this current from the previous stage. Reducing the current at a fixed voltage implies an increased impedance, and the first stage now "sees" an impedance of 50 × Re in parallel with its collector load. This value is sufficiently high to prevent any loading, with the associated loss of gain, even when working into external loads as low as one or two kilohms.

We can summarise the working of the circuit as follows. The current injected into the emitter of TR_1 reappears in the collector load. This, being very much larger than the input impedance, has a proportionately larger voltage developed across it. Finally the voltage appears across the emitter resistor of **TR_2**, very little reduced by the slight shunting effect of the high input impedance of the second stage, and by the small loss across the emitter-base diode.

"Pick Any Resistor"

This particular circuit has been amongst the most flexible and versatile that the author has tried, and the operating conditions were varied as widely as possible to try to find its limits of operation. So wide have these proved that the following section could almost be entitled "Pick Any Resistor".

Satisfactory operation was in fact obtained with the following range of values, subject only to permissable dissipation at one end of the scale and bottoming due to leakage current at the other.

Supply voltage	3–20 volts
Rc	5–40kΩ
Rb	150–1,000kΩ
Re	2–5kΩ
Cb	0.5–16μF
α'_1	20–100
α'_2	20–100

At the extreme ends of the scale, of course, both gain and undistorted output will fall. Provided the constructor avoids the obvious pitfalls of high voltage together with low resistance and vice versa, he need only keep his eye on the usual limiting values specified by the manufacturer. These precautions apply only to large variations from the recommended values as these will be safe with all transistors.

To enable the constructor to select the conditions most suited to his own needs, a series of curves has been drawn up from the results, showing the gain available for various collector loads over a wide range of supply voltage. (Fig. 2.)

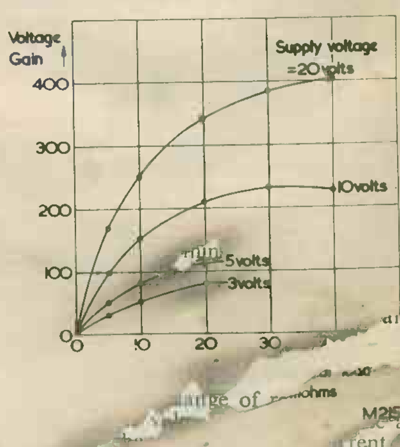


Fig. 2. Measurements taken with transistors of current gain=20, Re=4.7kΩ, Rb=330kΩ

Since one of the fundamentals laws of electronics is that "No result derived from theory or laboratory measurements works when put into practice," the final test was to insert a microphone into the emitter lead and monitor the output.

A surplus moving iron earphone of about 50Ω impedance was used and the output checked while singing and whistling at various distances from it. Singing a few inches from the "microphone" produced inputs to the preamplifier of 1 or 2mV, which after amplification gave outputs of the order of one-third of a volt. Outputs as high as 3 or 4 volts could be obtained by whistling across the microphone with it coupled to the highest gain arrangement, and this would be sufficient to drive an output valve to very nearly its full power.

Finally it is suggested that the values shown in Fig. 1 be used, since further articles in the series will make use of exactly the same components. They will include a medium impedance preamplifier and an emitter coupled multivibrator.

(To be continued)

Improving Radio Luxembourg Reception

By GORDON J. KING, *M.I.P.R.E.*

WHILST BEING ONE OF THE MOST POPULAR stations, Radio Luxembourg suffers from disconcerting fading and distortion troubles when received in most parts of Great Britain. Numerous tests have revealed that the trouble is caused essentially by random changes in the polarisation and phase of the received signal, these being due to ionospheric refraction and bending of the sky wave over the medium-distant path at the rather susceptible wavelength of 208 metres.

Luxembourg Interference Pattern

The severe fading and bad quality are caused because Radio Luxembourg is received in the main towards dusk and during the night, when the sky wave and ground wave in this country approach equal intensity. In effect, the received signals represent the vector sum of the two waves that have travelled along different paths. At some locations these waves add, while at others they subtract. This causes a Radio Luxembourg interference reception pattern over most of Great Britain, particularly at night, since it is only after dark that the sky wave really comes into play.

During the daytime the ground wave contributes most of the signal received, and it is for this reason that the daytime Luxembourg signal is relatively poor, though less disturbed by fading.

The reception pattern is rarely consistent for any length of time, since slight changes in the ionosphere result in a change in length of the sky wave path. This modifies the interference from an addition to a subtraction, and vice versa, and thereby causes the typical Luxembourg fading which alternates with progressive increases in signal strength.

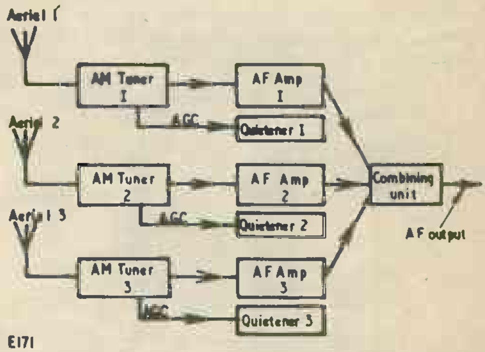
Distortion due to Selective Fading

The Luxembourg interference pattern is also somewhat sensitive to frequency because even a small alteration in frequency under these conditions is sufficient to change the relative path lengths by an appreciable fraction of a wavelength. This means, then, that the carrier and the sidebands of the Luxembourg signal are likely to occur out of phase or out of step at the receiver. For example, some frequency components will tend to cancel while others will tend to add, and the resulting distortion, which is commonly so severe as to destroy the entertainment value of the signal, is in this context known as "selective fading" or "selective distortion".

Sideband Suppression

It was required by the author to reduce this effect as inexpensively and as much as possible. Several methods were tried, including the reception of only one of the sidebands of the signal. This improved matters somewhat for it was discovered that when a fade occurred, one sideband was affected far more than the other.

This is because the worst quality distortion is invariably caused by the carrier fading, or reducing considerably in amplitude, while leaving the sideband frequencies almost unaffected. In order to receive just a single sideband, the receiver itself is called upon to supply the missing carrier, and this was accomplished by the use of a separate oscillator. This oscillator was arranged to heterodyne with the component frequencies of one of the sidebands, and the difference frequencies produced after detection corresponded to the original modulation signal. These were then amplified audio-wise in the ordinary way.



E171

Fig. 1. In this diversity arrangement only the tuner producing the strongest signal contributed to the a.f. output signal

There are several problems to this method, one of which is that to secure reasonable quality the carrier oscillator must be held within a few cycles of the correct frequency. This can be achieved by the use of a crystal oscillator or by filtering the sideband signals from the carrier and then using that to control the frequency of the locally manufactured carrier. The latter idea is sometimes called "carrier reconditioning".

Ultimately, a method was devised for switching from one sideband to the other, depending on which gave the best reception, but this made life rather difficult and by now the expense was going way up.

Diversity Reception

The exercise continued with the use of a diversity receiving system. Here three receivers were used and each was fed from its own aerial which was removed from the other two aerials by approximately 300 yards. This required a lot of room, and because there was insufficient area to space the aerials adequately the system was not wholly successful in relation to its cost. Nevertheless, it would be interesting to relate.

It was hoped to take advantage of the fact that it is unlikely for signals of the same transmission to fade simultaneously when picked up on separate aerials spaced from each other. It usually happens that when the signal fades in one aerial it fades less in another aerial and may possibly rise in a third. With this in mind the arrangement of Fig. 1 was adopted.

Basically, three a.m. tuners were used, and each of these was fed from its own aerial through 75Ω coaxial cable. The detector output of each tuner fed an associated a.f. amplifier, and the outputs of the amplifiers were mixed in a combining network, giving a single a.f. output signal.

After taking care of various phasing factors, this arrangement appeared to work adequately, apart from the introduction of noise due to those tuners which were receiving little or no signal as the result of a fade in their aerials. The effect was reduced by including at each a.f. amplifier a quieting arrangement operated by the a.g.c. systems of the tuners. The result was that the outputs of the two a.f. amplifiers with the least signal at their detectors were considerably suppressed, and the majority of the signal was supplied by the tuner receiver at any

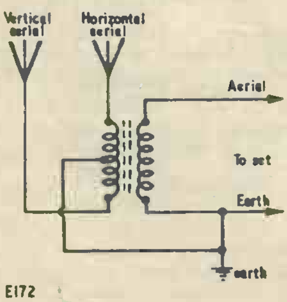


Fig. 2. A simple transformer coupling for two aerials —horizontal and vertical

time the strongest signal. In this way the signal-to-noise ratio of the system as a whole was improved.

Nevertheless, a degree of fading persisted, and this was possibly due to insufficient spacing between the aerials, for it would seem from subsequent experiments that the aerials would need to be spaced by at least ten wavelengths for optimum results. Ten wavelengths at 208 metres is over one mile, and this kind of reception can hardly be called inexpensive!

Two Aerials

Finally, the diversity reception idea just described was abandoned and two aerials were erected fairly

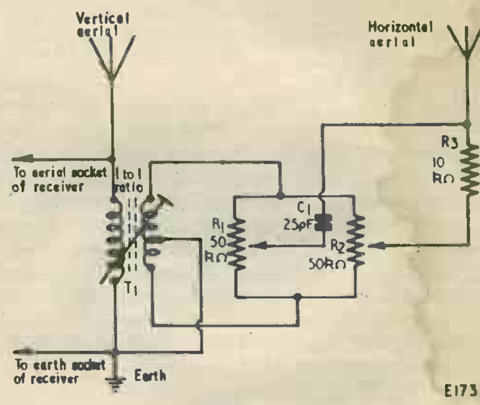


Fig. 3. A phasing circuit for the horizontal signal

close together, one vertical and the other horizontal. These were coupled to the two tuners in a semi-diversity arrangement, similar to that in Fig. 1. Surprisingly, the results were as good, if not slightly better, than the costly and complicated three-aerial system.

One Tuner—Two Aerials

It was next decided to try just one tuner and couple the horizontal and vertical aerials to it through a coupling transformer with a centre-tapped primary, as shown in Fig. 2. This was not very successful at first, but after attention was given to the aerials, mainly in terms of length, an outstanding improvement was observed.

As a test, the vertical aerial was disconnected and the signal monitored using the horizontal aerial only. At the instant of a deep fade, the vertical aerial was connected. This improved the signal strength considerably and almost eliminated the selective distortion which was present with just the horizontal aerial.

The same experiment was carried out by first using the vertical aerial only, and when the horizontal aerial was connected during a deep fade the results were almost identical to those of the first test.

These tests proved fairly conclusively that the Luxembourg fade and distortion are caused not only by the phase of the received signal altering but also by a change in the polarisation. It should be noted that the fading and distortion were not completely removed, but the improvement was well worth the small expense of an extra aerial and coupling unit. The set-up appeared to be somewhat critical in terms of aerial length, but a little over 50ft of wire for each aerial, including the down-lead of the horizontal aerial, was found to work quite well in practice.

Phasing Unit

Finally, it was decided to try to improve on the simple aerial coupling transformer. After some experimenting, the circuit shown in Fig. 3 was evolved. Here the vertical signal is connected direct to the aerial socket of the set, while the horizontal aerial is connected through the phasing network comprising R_1, R_2, R_3 and C_1, and the transformer T_1. This serves to permit adjustment of both the amplitude and phase of the horizontal signal in relation to the amplitude and phase of the vertical signal. Optimum balance may thus be achieved simply by adjusting R_1 and R_2.

How this happens is shown in Fig. 4. At (*a*) the horizontal signal is applied to the potentiometer R_2 via resistor R_3. Now since R_2 is connected across the centre-tapped primary of T_1, it follows that when R_2 is at the centre of its travel there exists, in effect, a balanced bridge arrangement and no signal appears across the secondary winding.

However, when the slider of R_2 is set towards position A signal currents circulate in the top section of the primary and a signal voltage is induced across the secondary. Similarly, when the slider is set towards position B signal currents circulate in the bottom section of the primary and a voltage, equal though of opposite phase to that in the former case, is induced across the secondary. From this description it can be realised that a horizontal signal is

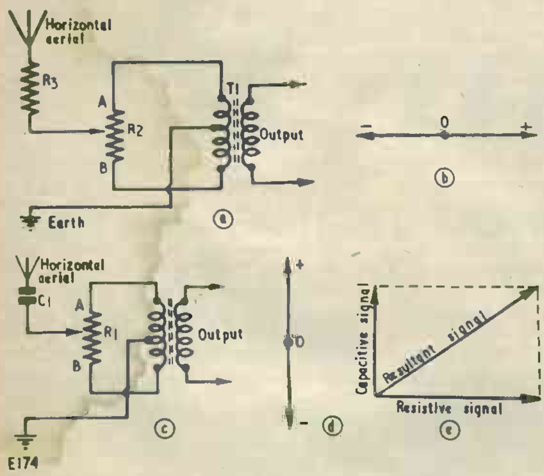


Fig. 4. The circuit producing the "resistive" component of the horizontal signal (a) and the vector representation of the signal at (b). The circuit producing the "reactive" component of the horizontal signal (c) and the vector representation of the signal at (d). At (e) is shown resultant signal due to the two signals (b) and (d). It will be seen that the amplitude and phase of the resultant signal depends on the vectorial sum of the resistive and capacitive signals

available at the secondary which can easily be adjusted from positive through zero to negative, as shown in Fig. 4 (*b*).

Adding a Reactive Component

At (*c*) is shown the other section of the circuit. This is identical to that at (*a*) except that the signal is applied through C_1 to R_1. This capacitor produces a reactive component which can also be adjusted from a positive value through zero to a negative value, but this time 90 degrees out of phase with the signal produced via the resistor, as shown at (*d*). This phase shift, of course, is attributable to the action of the capacitor.

It may now be seen how the two actions are combined in the complete circuit of Fig. 3. Clearly, the two potentiometers can be used to provide a horizontal signal which has any amplitude (being limited by the amplitude of the aerial signal itself) and any phase angle, as shown in Fig. 4 (*e*).

It is interesting to note that a circuit of a similar nature was evolved by Spencer-West some years ago as a means of eliminating pattern interference from Band III conversions.

The phasing unit almost completed the exercise, and Radio Luxembourg was received far better than hitherto with very little extra expense. The transformer was produced from an old medium-wave aerial coil to start with but, as it was found difficult to locate a good centre-tap a special coil was produced which gave improved coupling and far better balance. The transformer requires an overall 1-to-1 turns ratio and an inductance of about 150 microhenries at each winding. A suggested method of construction is shown in Fig. 5.

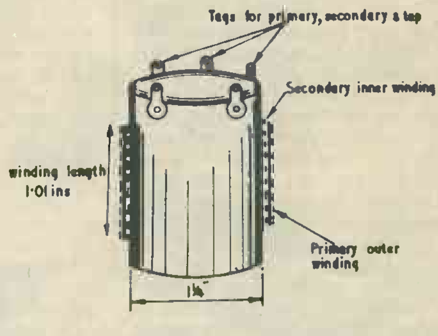


Fig. 5. Suggested transformer. Primary and secondary 84 turns, close-wound 32 s.w.g. enamelled wire on 1.25in former. Spacing between primary and secondary by thin card. Primary centre-tapped

Initial adjustment was accomplished by removing the horizontal aerial until a severe fade occurred. It was then reconnected and the potentiometers carefully adjusted to obtain the best results. It was found necessary to carry through this procedure several times for optimum results, especially during periods of fairly rapid fading.

A Constructor Visits the 1961 International Radio Hobbies Exhibition

IN HIS OPENING ADDRESS TO THE 1961 International Radio Hobbies Exhibition, held at the Royal Horticultural Hall from 22nd to 25th November, Mr. Henry Loomis, Director of "Voice of America", stressed the points of similarity between the professional and the amateur electronic communications engineer.

In an extremely informative address in which the problems involved in putting over the "Voice of America" were fully detailed, Mr. Loomis made the observation that "whereas you amateurs are experts communicating with experts, we are experts communicating with an audience possessed of only enough technical know-how, in the main, to turn a set on and off and do some tuning." Mr. Loomis concluded with the statement that "we are all of us working for mutual understanding," a sentiment with which every amateur will be in complete agreement.

After the opening ceremony, the exhibition got away to an excellent start, and the writer was pleased to observe the high attendance.

Club and Society Stands

Prominent on the R.S.G.B. stand were beautifully constructed equipments including 2 and 4 metre transmitters by G3KMD, an s.s.b. exciter unit by GM3FYB, a home-built transmitter by GM3IAA, and a transistorised receiver by G3HBW. This last item was awarded the 1961 Silver Trophy for outstanding home constructed equipment.

The British Amateur Television Club staged an impressive display of colour television, reproduction being given by monitors with shadow mask tubes. During the writer's visit reproduction from a colour bar generator was shown, whilst at other times B.B.C. pictures on the 405 line N.T.S.C. system were displayed. A further colour monitor used a rotating colour filter and was employed as a viewfinder for the B.A.T.C. colour camera, the latter having a similar filter in conjunction with a 3 in. image orthicon tube. This camera was built by J. Tanner especially for the Exhibition.

Another spectacular and imaginative presentation was evident on the Royal Air Force stand. This consisted of equipment used by the Royal Air Force Amateur Radio Society in their recent expedition to the island of Kamaran in the Red Sea, 200 miles north of Aden. The gear was mounted inside a tent on a table improvised from packing cases, and the whole floor area was covered with some six inches of very authentic-looking sand. Members of the expedition were present on the stand, and defied the rigours of London's November by being dressed in khaki drill.

Amateur radio astronomy was well to the fore, with an exhibit by G. A. Frampton, G3LRH. This consisted of a receiver, the input to which consisted of alternate bursts of noise from an aerial system and from a matched load at a known temperature. The difference in power between the two sources was then indicated on a valve voltmeter driving a pen recorder. The equipment was described as an experimental system to determine the performance likely to be obtained in an amateur system, and is the first of a series of projects undertaken for the British Astronautical Association.

Trade Stands

For the youngster or beginner, Daystrom Ltd. exhibited their newly introduced Electronic Workshops Kit, Model EW-1. This comprises an insulated board holding a number of easily recognisable and well identified components, each being coupled to spring connectors which enable wiring to be fitted quickly and without soldering. It is possible to wire up twenty different electronics set-ups with this kit, these including amplifiers, three transistor radios and voice operated relays. The kit includes a loudspeaker. Also evident on the Daystrom stand were samples from the well-known range of Heathkit equipment, including the DX-100U and DX-40U transmitters and the fully transistorised general coverage receiver type GC-1U. Announced by Daystrom Ltd. at the Exhibition was the new transistor intercom kit consisting of Model XI-1U (master) and XIR-1U (slave station). This new kit should be available in early January.

Radiostructor were well in evidence and displayed some of the equipment built up as part of their courses. These included a multi-testmeter, a signal generator, an oscilloscope, and a comprehensive a.m./f.m. receiver.

A wide range of cabinets, chassis panels and racks was shown by E. J. Philpott's Metalworks Ltd., these being available in a number of colours. Products in the Philpott's range are available in any size to meet customers' specifications and appear in a large number of basic designs. Especially attractive was this Company's well-tried and popular "S" line style of presentation, this consisting basically of "wrap around" cabinets with up to 11 ins in the front to back dimension. Ventilation is available by perforated panel or louvres according to requirements. Once again, dimensions can be to users' specification.

Copp Communications and Electroniques (Felixstowe) Ltd. displayed samples of high quality inductors. The wide range exhibited included over 100 different types of "Stabqoils", these consisting of coils with built-in adjustable capacitance trimmers, cores and temperature compensation components. Also displayed were high-Q i.f. transformers covering 85kc/s to 1.6Mc/s. These transformers feature high selectivity and give bandwidths, for 6dB down, of 2kc/s at 85kc/s and 9kc/s at 1.6Mc/s. Another interesting exhibit on the Electroniques stand was a series of "Qoilpax", these comprising a complete chassis assembly for coils, tuning capacitor, range switch and the associated valve or valves. Careful layout and clean design were very evident in these. Electroniques specialise in a wide range of components which are not generally available, and these include 6mm dust cores for varying frequency ranges, miniature ceramic trimmers, plastic fixing nuts and insulated nylon lead throughs.

Sound Vision Service (Electrical) showed a number of aerial masts having particular value for the amateur. The main exhibit was the S.V.S. 45ft. telescopic mast which is completely portable, can be erected in minutes by one person, and which carries a full rotary head. Also exhibited was the 36ft. mast incorporating a patent guy ring which enables the complete mast to be rotated regardless of strain on the guy ropes. This mast can be installed to heights up to 80ft. An innovation was the S.V.S. Automatic Rotator which offers rotation through 360 degrees for aerials up to 150lbs in weight. This device is remotely controlled, and functions from 50c/s a.c. mains. An indicator installed at the control position shows orientation relative to north on a fully calibrated circular scale.

Of interest on the stand of Avo Limited was the new model 9SX AvoMeter. This is a fully tropicalised instrument designed primarily for Service use and has sensitivities of 20,000 ohms per volt on d.c. and 1,000 ohms per volt on a.c. The meter will measure current up to 10 amp a.c. or d.c., potential up to 3,000 volt a.c. or d.c., and resistance up to 2MΩ. To meet the heavy climatic demands for which the instrument has been designed, the front panel, case and some of the internal components are moulded in a special phenolic material which not only reduces tracking and leakage but also inhibits fungus growth

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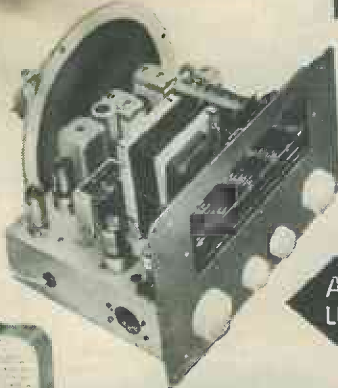

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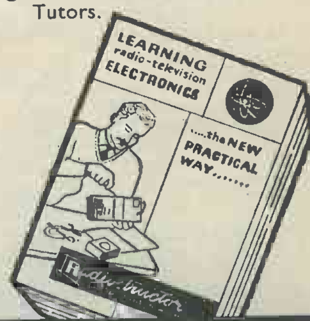

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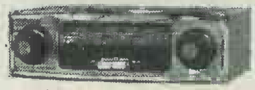

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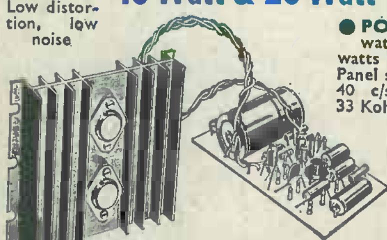

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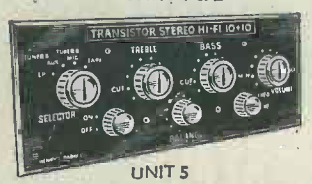

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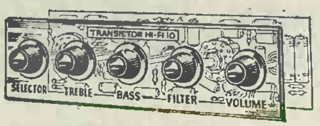

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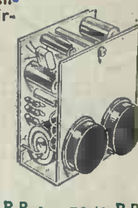

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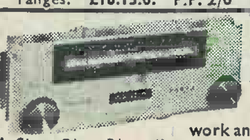

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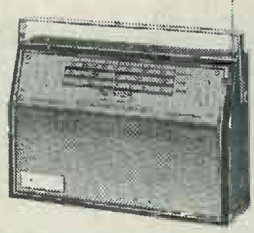

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