

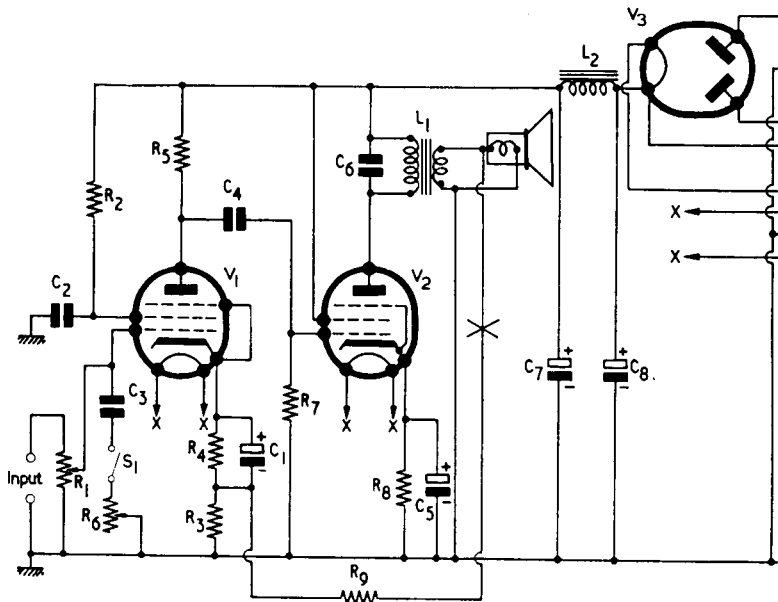
20

2 VACUUM
AMPLIFIER

SUGGESTED CIRCUITS

Nos. 1-20 of The Radio Constructor series

By
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3/6

20

Suggested Circuits

These articles

by

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were first published in

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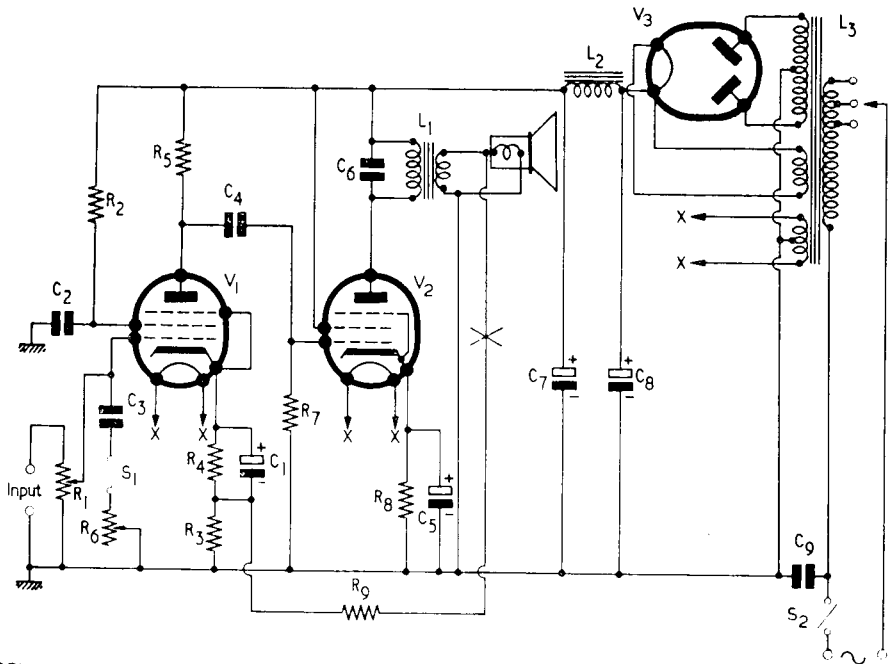


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No. 1 TWO-STAGE GRAM AMPLIFIER



SCI

Components List

Resistors

- R₁ 250 kΩ
- R₂ 1 MΩ
- R₃ 100 Ω
- R₄ 2.2 kΩ
- R₅ 250 kΩ
- R₆ 250 kΩ (with switch)
- R₇ 680 kΩ
- R₈ 250 Ω
- R₉ 2 kΩ

Capacitors:

- C₁ 25 μF, 12 WV
- C₂ 0.2 μF
- C₃ 0.005 μF
- C₄ 0.02 μF
- C₅ 25 μF, 25 WV
- C₆ 0.002 μF
- C₇ 16 μF

C₈ 8 μF

C₉ 0.01 μF, 350V AC

Valves:

- V₁ 6X4
- V₂ 6V6
- V₃ 5Y3, or any other similar rectifier.

Switches:

- S₁ Fitted to R₆ (see text).
- S₂ On-off switch (may be fitted to R₁).

Inductors:

- L₁ Output transformer (ratio depends upon impedance of speech-coil).
- L₂ Smoothing choke.
- L₃ Mains transformer (250—0—250, 5 and 6.3 volt outputs).

Characteristics

Without negative feedback the output is approximately 4 watts for 0.03 volts input.

With negative feedback the output is approximately 4 watts for 0.1 volts input.

Optimum output load (transformer primary) is 5,000 ohms.

Tone Control

A simple top-cut tone control (R_6 and S_1) is fitted to the amplifier. A potentiometer fitted with an on-off switch should be employed here, in order that, when the control is adjusted for minimum cut (total potentiometer resistance in circuit), the switch disconnects the circuit completely.

Supplies

Any mains transformer capable of supplying 250 - 0 - 250 volts at 60 mA may be employed. The 6.3 volt winding could be earthed at one end, although it is preferable to earth it at the centre tap as shown in the diagram.

Type of Pick-up

The amplifier will function with any high-impedance moving-iron pick-up. If a low-impedance pick-up is used, the manufacturers will advise as to the type of matching transformer and input impedance required.

The gain of the amplifier will almost certainly be too great for a crystal pick-up. If such a pick-up is employed the EF86, (V_1), may be replaced by a 6J5 or similar triode. In this case R_2 and C_2 will not be required, R_3 should be replaced by a 150k Ω resistor, and the value of the bias resistor, R_1 , should be altered to 1,000 Ω . The feedback circuit may remain as it is.

Valves

The output valve need not necessarily be a 6V6, and most other pentode or beam power output valves, (6F6, EL36, etc., etc.) can be used in its place without disturbing the characteristics to a great extent. It will be necessary to change the value of R_4 for some valves.

Construction and Testing

After completion, the amplifier should be tested with the negative feedback loop disconnected (i.e. broken at the point marked with a cross in the diagram). In this state it should be completely stable, although reproduction may be a little shrill, particularly if a small-diameter loudspeaker is used.

After this test the negative feedback loop can be connected up. It will be necessary to experiment with the connections to the speaker transformer secondary when this is being done. If the secondary is connected the wrong way round positive feedback and probable oscillation will be caused. The correct connection will, of course, result in lowered volume and increased fidelity.

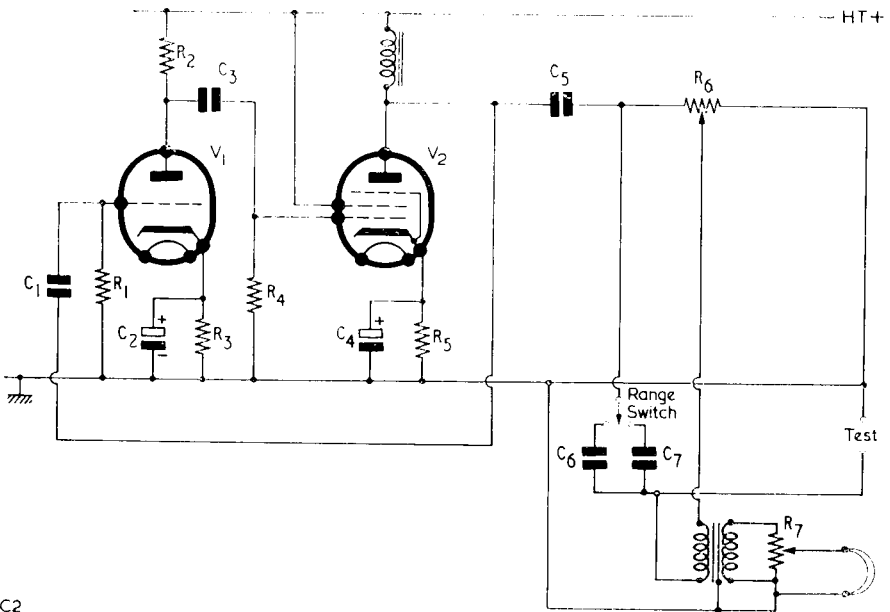
Should it be found that more than adequate gain is obtained from the amplifier, the negative feedback can be increased by reducing the value of R_9 . (If negative

feedback is increased by a large extent the output impedance may be sufficiently lowered to necessitate a smaller ratio output transformer.)

With some types of output transformer it might be found that the introduction of negative feedback will cause a small amount of supersonic oscillation, sometimes noticeable as a hiss. This condition may be checked by connecting a milliammeter in series with the positive HT supply; whereupon a change in reading when the output transformer secondary is short-circuited at its terminals will indicate that oscillations are present. The oscillations can usually be stopped by connecting a capacitor between the anode of V_1 and chassis, its value lying between 50 and 500pF.

Finally, results may be improved if the value of C_1 is reduced or if it is removed altogether. This point should be checked experimentally.

No. 2 USEFUL CAPACITANCE BRIDGE



SC2

Components List

C_1	see text	C_5	0.1 μF	R_1	250 $\text{k}\Omega$
C_2	25 μF	C_7	500 pF	R_3	400 Ω
C_3	0.01 μF	R_1	250 $\text{k}\Omega$	R_6	50 $\text{k}\Omega$ pot.
C_4	25 μF	R_2	100 $\text{k}\Omega$	R_7	10 $\text{k}\Omega$ pot.
C_6	0.1 μF	R_3	1 $\text{k}\Omega$		

Range

Range: --50 pF (or less) to greater than 2 μ F in two ranges. With careful design, values of capacitance down to 10 or 15 pF can be measured.

The Oscillator

The oscillator is intended to function mainly as a multivibrator, in order that it may deliver a rich band of audio frequencies to the bridge. The capacitor C_1 should be experimentally chosen to give the output a large proportion of high audio frequencies, these being audible as a "hiss". (The "hiss" may be drowned by the lower audio frequencies present until it is used for testing purposes). The value of C_1 will lie between 100 pF and 0.01 μ F.

The purpose of having such a strong "hiss" content is to enable capacitors below 200 pF or so to be tested, a facility not always available with an audio bridge. Whereas such low value capacitors offer a very high impedance to the usual audio frequencies, they allow sufficient "hiss" to be passed to enable the bridge to be balanced for values down to and below 50 pF.

Any two reasonably chosen valves may be employed in the oscillator. V_1 should be a triode, (6J5, etc.), and V_2 an output pentode or tetrode, (6V6, EL32, etc.). If desired, V_1 and V_2 may be combined together in a single triode-pentode, such as the ECL82 or ECL83.

The output choke in the anode circuit of V_2 may consist of any choke available which can carry the appropriate anode current. The primary of a speaker transformer would do quite well.

The Bridge

It may be found convenient to make the bridge a separate unit. Care should be taken to ensure that the earthy lead of the oscillator output corresponds to the appropriate terminal on the bridge unit.

The wiring in the bridge unit should be well-secured and short. If a metal panel or chassis is used this should be earthed to the earthy lead from the oscillator.

The transformer coupling the bridge proper to the headphones may consist of any "inter-valve" transformer whose ratio is smaller than 4:1. It should be connected as shown in the diagram.

The 10 k Ω potentiometer, R_1 , acts as a volume control. High impedance headphones should be used.

The 50 k Ω potentiometer, R_2 , should be a high-grade, wire-wound component, its spindle being fitted with a pointer and scale. For maximum accuracy, the indicating part of the pointer should trace an arc whose diameter is at least four inches.

Calibration

Calibration is carried out by checking the position of the potentiometer for various known values of capacitance: then completing the scale to cover all values which may be encountered. (Point of balance will correspond to minimum AF in the headphones).

The bridge should be used with its own oscillator only, as the use of other oscillators, after original calibration, may cause slight discrepancies.

No. 3 SUGGESTED MUTING OR CODAN CIRCUIT

This circuit is intended for use with receivers of relatively high sensitivity (such as a well-designed broadcast superhet with an RF stage) where it is found that tuning the receiver from one station to another (either manually or by a motor) causes a large amount of disagreeable noise to be heard from the loud-speaker. The circuit ensures that the receiver output is muted unless a carrier is actually being received.

The usual form of codan* employs a switching valve which varies the bias on one of the AF amplifying valves. This has the disadvantages that the amplifying valve is worked at a lower HT voltage than would normally be the case, and that a fault or maladjustment in the switching valve circuit may cause the amplifying valve to operate at an incorrect value of bias, thus introducing distortion.

In this circuit, a sensitive relay is used to mute the receiver. These relays may nowadays be fairly easily obtained in the form of surplus equipment. They have a normal construction, but the bobbin is wound with fine wire giving a resistance of 1,000 to 5,000 ohms, the relay closing between 1 and 10 mA according to its make and type.

In Fig. 1 an additional triode is used to operate the relay, its grid being connected to the AGC line of the receiver. The current drawn by the triode anode is sufficient to close the relay. On reception of a signal the AGC line goes negative, the valve draws less current, and the relay opens.

The cathode resistor, R_1 , is fitted to ensure that the triode is not operated with zero bias. Its value should be kept low (below 300 ohms) as it reduces the effect of the valve. With many receivers it will be found that (apart from such things as oscillator failure, etc.) the AGC line always has a small negative voltage, owing to the rectification of noise or contact potential in the AGC diode, and the cathode resistor may therefore be reduced in value, or even omitted. Alternatively, the cathode may be given a relatively fixed value of bias by employing a potentiometer circuit across the HT supply (R_2 and R_3), but this draws current and should not really be necessary.

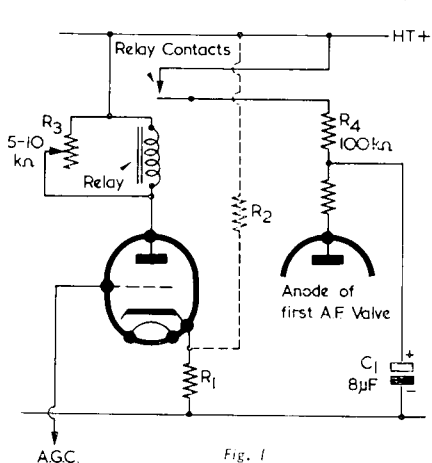


Fig. 1

SC3

R_3 is used to vary the sensitivity of the relay. In some cases it may be found that this also can be omitted.

Switching

The muting circuit would be fairly effective if the relay contacts were used simply to short-circuit the grid of the output valve to chassis when the relay was closed, but this would have the disadvantage that the action would be too abrupt and "ploppy".

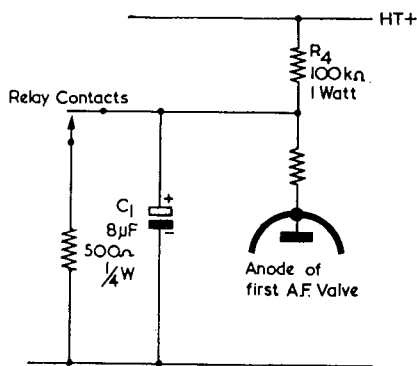
A better scheme is shown in Fig. 1 where the relay contacts complete the HT circuit to the anode of the 1st AF amplifier when the relay opens. A time delay

*Short for "carrier-operated device anti-noise".

is offered by R_1 and C_1 . Switching the anode instead of the bias circuit eradicates any possible distortion which may occur due to incorrect values of bias.

If the relay contacts "make" when it closes, the circuit of Fig. 2 may be employed, in which the HT supply to the AF valve is short-circuited to chassis when the receiver is muted.

In some cases the additional triode of Fig. 1 may be omitted by connecting the relay in the anode circuit of one of the AGC controlled valves, such as an IF amplifier. Unfortunately, the necessity of providing a certain amount of bias for such a valve would reduce the efficiency of the circuit.



SC4

Fig. 2

Additional Facilities

The codan circuit may be further utilised to provide several more attractive facilities.

For instance, additional contacts on the relay could be used to light or extinguish a pilot lamp, showing whether the receiver was tuned to a station. Alternatively, an arrangement could be made such that the dial would be well-illuminated when searching for a station, but would be lit only dimly after the station had been found.

A further use might be obtained by supplying the codan circuit with its own rectifier, this being fed from a highly selective IF circuit, itself energised from the normal IF amplifier stages. The circuit would then operate only when the receiver was accurately tuned; and it would be impossible to tune the receiver incorrectly.

No. 4 ALL-WAVE ALL-DRY PERSONAL RECEIVER

This circuit is that of an all-wave four valve superhet, signal pick-up being effected on all bands by the use of frame aerials. Where possible, unnecessary components have been eliminated in order to reduce bulk, but this has only been done when their exclusion would cause no falling off in performance.

The Circuit

A pentagrid frequency-changer, V_1 , is shown in the diagram, the signal-grid tuned circuits being provided by the frame aerials. S_2 selects the particular frame aerial for each band, whilst S_1 switches in a separate trimmer for the medium-wave band. This slightly unorthodox arrangement enables the medium and long-wave frames to be connected in series to obtain optimum pick-up, whilst, at the same time, eliminating the somewhat complicated parallel trimming circuits often employed in a receiver of this type. It also prevents the use of a parallel trimmer permanently connected across the medium-wave frame. The short-wave frame is switched in separately and consists of a single turn (L_2) in series with a loading coil (L_1). It is described in detail later.

A high value of grid leak, R_3 , is recommended for the double diode-triode. This provides a small amount of leaky-grid bias, and it helps to keep the AC and DC diode loads similar in value.

A tone correction capacitor, (C_{26}), is shown in dotted line connected across the speaker transformer primary. If possible, this capacitor should be omitted since it reduces the limited power available from the output stage. Adjacent channel whistles should not be too troublesome when frame aerials are used as it is possible to rotate the set such that the interfering signal is at minimum strength, and the slight shrillness which may be apparent when a small speaker is installed can be counterbalanced by having the speaker fairly heavily baffled by the cabinet (i.e. by using an almost completely enclosed cabinet). In addition, if the IF transformers are carefully aligned to a "peak" (it should be remembered that the second IF transformer secondary is only lightly loaded by the diode circuit) sufficient selectivity should be obtained in the IF stages to reduce top response and help in providing apparent AF correction.

The capacitor, C_{10} , connected across the HT supply prevents instability when the HT battery runs down, and increases its effective life. In one or two cases, a slight improvement in volume may perhaps be found if a low-voltage electrolytic capacitor is connected across R_3 , and this point can be checked by experiment.

The Frame Aerials

The number of turns required for the frame aerials is found experimentally. Before commencing on the frames, the rest of the receiver should be completed and the HT stages aligned to their correct frequency. The oscillator coils should be trimmed and padded to cover the correct frequencies, using a signal generator connected directly to the signal-grid of the frequency changer.

The medium and long-wave frames may then be wound experimentally. The best check of whether the correct number of turns has been fitted is by testing the trimming at the low-frequency end of the appropriate band. The medium-wave frame should be wound and checked first. Both medium and long-wave frames may be wound on the same former, the wires being laid side by side. As an extremely rough guide, it may be said that, if it is larger than a foot square the medium-wave frame will need about 50 feet of wire, and the long-wave frame about 150 feet. It is emphasised that this is only a rough guide.

If desired, a medium and long-wave ferrite frame may be employed instead of the two open frame aerials shown in the diagram. Provided that the medium and long-wave windings on the ferrite frame aerial may be connected in series for long-wave reception no alterations to the circuit are required.

The short-wave frame consists of a single loop of wire, (L_3), as large as the physical dimensions of the cabinet will allow, completed by a coil, (L_4), at its earthy end. To cover approximately the 15-49 metre band this coil will need about half-a-dozen turns of wire on a $\frac{3}{4}$ -inch former, the exact number of turns being found by experiment. This time the inductance of the frame and its coil is checked by trimming at the high-frequency end of the band. Using such an arrangement it will be difficult to eradicate second channel interference on the short-wave band over the lower (frequency) two-thirds of the range. Nevertheless the short-wave band is capable of good entertainment value, the presence of second channel interference being considered as an unavoidable detraction.

Squegging

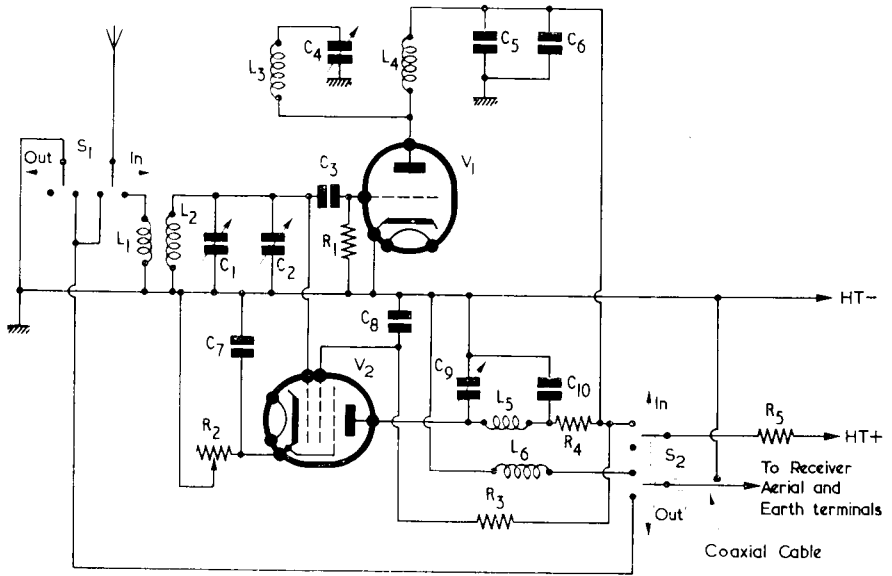
Owing to the high value of oscillator grid leak, R_1 , it is possible that the oscillator may squeg on part of one or more of the bands. Squegging will be evident as a loud, harsh hiss.

If this trouble occurs on all bands, the value of the oscillator grid leak should be reduced; but if it only occurs on one band a resistor should be connected across the feedback winding of the oscillator coil for that band. This resistor should have as high a value as possible so long as it offers sufficient damping to prevent the circuit from squegging.

Padding

If coils with adjustable iron-dust cores are employed in the medium and long-wave oscillator positions, the variable padding capacitors specified for C_{10} and C_{11} may be replaced by fixed components. In this event C_{10} requires a capacitance of 470 pF and C_{11} a capacitance of 150 pF, both values being at a tolerance of $\pm 5\%$.

No. 5 REGENERATIVE PRESELECTOR UNIT



SC6

Components List

C_1	Bandset 150 to 250 pF	C_9	150 to 250 pF (to correspond with C_1)
C_2	Bandspread 15 to 30 pF	C_{10}	0.02 μ F (mica)
C_3	100 pF	R_1	1 M Ω
C_4	200 pF	R_2	10 k Ω
C_5	0.01 μ F (mica)	R_3	100 k Ω
C_6	0.25 μ F (paper)	R_4	10 k Ω
C_7	0.02 μ F (mica)	R_5	5 k Ω
C_8	0.02 μ F (mica)		

This circuit illustrates a preselector unit with controlled regeneration which is intended for connection between the aerial and the aerial terminals of a short-wave receiver. Apart from its use as a preselector, in which function the unit is capable of removing second channel interference with a superhet, and of attenuating adjacent channel interference when used with a straight receiver, the main purpose of the circuit is to increase the sensitivity of the equipment to which it is connected. This increase in sensitivity is occasioned by the use of the regenerative tuned circuit immediately after the aerial. It will be appreciated that, when properly adjusted, the effective "Q" of such a tuned circuit may be made very high indeed, thus occasioning a signal noise ratio from the aerial stage which is higher than that afforded by the input circuits of many, if not nearly all, superhet or straight receivers.

Regeneration is provided by the valve V_1 , V_2 being a buffer whose function is to pass the aerial signals to the subsequent receiver. The connection to the receiver is made *via* coaxial cable. The HT and heater supplies for the preselector may be obtained, if desired, from the receiver.

A special switch, S_1 S_2 , is used to switch the preselector "in" or "out". When the preselector is switched "out", HT is removed from V_1 and V_2 , and the aerial is connected directly to the coaxial cable which feeds the receiver. On switching to "in", HT is applied to the preselector, and its input and output aerial circuits are completed. In addition, the lead which previously connected the aerial straight to the receiver is now connected to chassis (by S_1), this course being advisable to prevent capacitive feedback along this lead (the capacitance being present in the wiring and contacts of S_1 and S_2) when the preselector is operating.

It may be noticed that the aerial tuned coil L_2 is tuned by C_1 and C_2 , these being band-set and band-spread capacitors respectively. Unless an extremely good slow-motion drive is available bandspreading is almost essential, since the tuning of the aerial stage is very sharp. Regeneration is provided by the variable capacitor C_3 . To allow an accurate regeneration setting to be obtained, this component should also have a slow-motion drive.

The tuned circuit, L_3 C_4 , in the anode circuit of V_2 is made purposely flat (it being damped by the anode resistance of the valve) in order to remove the necessity of continually keeping it in step with C_2 when searching for stations. It will probably be found that one setting of C_4 will cope for about a third, if not more, of an amateur band. Despite the flat tuning, however, it would be advisable to fit this capacitor with a slow-motion drive as well.

The coils L_1 , L_2 and L_3 may be provided in practice by using a normal six-pin plug-in coil. L_3 and L_4 may consist of a four-pin coil, the usual aerial winding providing L_4 . For L_1 a good quality short-wave reaction choke is required.

The valves V_1 and V_2 may consist of a high- μ triode and a variable- μ RF pentode respectively. For reasons of layout the control grid of the pentode should preferably be brought out to a top cap.

Construction

As every reader who has experimented with O \cdot v \cdot O and O \cdot v \cdot I short-wave receivers will know, layout in a circuit of this type is of the utmost importance. All RF carrying leads must be kept as short as possible; and, if this can be done, ceramic insulation should be used throughout. The chassis cannot be relied upon for tuning-capacitor earth returns, and it should also be borne in mind that the capacitor C_{10} is part of the tuned circuit C_3 L_3 . The switches S_1 S_2 should preferably be ganged in some manner, although two

separate switches may be used if the layout renders ganging impossible.

The lead connecting the aerial tuned circuit to the grid of V_2 should also be kept very short. The best method of making this connection consists of entirely enclosing the V_1 circuit in a screening "box", and allowing the grid of V_2 to "probe" into the box.

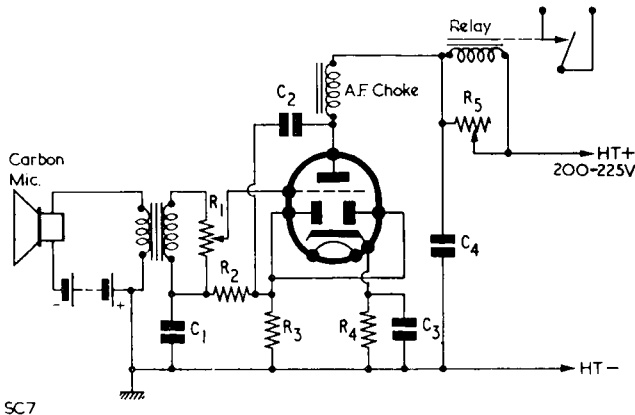
Operation

The only disadvantage with a preselector is, of course, the necessity for tuning it in step with the main receiver. In this case is added the necessity of keeping the regeneration just below oscillation point. With this particular circuit the best procedure consists of tuning the main receiver to the required frequency, keeping the preselector switched "out". The preselector may then be switched "in", C_3 set approximately to position, and C_2 and C_1 adjusted until the required station comes in free (commensurate with its strength) of background. It will be found that a small adjustment of C_1 will provide very high alterations indeed in signal strength. Regeneration should not be "ploppy" or suffer from backlash; and the oscillation point can be distinguished by a suddenly increased background and the presence of heterodynes.

A final adjustment of C_3 should then be made, whereupon the preselector is set up. If further searching is required, any small deviations in frequency may be carried out by using C_2 alone, finally "touching up" with C_1 .

The resistor R_2 should not be touched after it has been initially set. It will probably be found that, if too little bias is applied to V_2 , reaction may become "ploppy"; and so an adjustment should be made which gives the greatest RF amplification without incurring this condition. Large adjustments of C_3 will also have a slight effect upon the reaction setting.

No. 6 SPEECH-OPERATED SWITCHING CIRCUIT



Components List

C_1	0.1 μ F	R_1	250 k Ω
C_2	0.01 μ F	R_2	50 k Ω
C_3	25 μ F 25V W	R_3	2 M Ω
C_4	0.1 μ F	R_4	200 Ω
		R_5	25 k Ω

This circuit is capable of switching external circuits, it being actuated by sound picked up by the microphone. It has the advantage of requiring only one valve, this valve carrying out the functions of amplifier, rectifier and relay switching. If a sensitive microphone is used the device should be capable of acting as an efficient "baby-alarm" without any additional amplification. Other applications, such as its use for an automatic "talk-listen" switch with loud-speaking intercom installations, and so on, will also suggest themselves to the experimenter.

Components

The valve used in the circuit may consist of any double-diode-triode, such as the 6AT6 or EBC90, but it should be pointed out that battery types may not be capable of passing sufficient current to operate the relay. The relay is a high-resistance model which operates at approximately 5 mA or less.

Although, of course, the microphone need not be a "quality" component, it should nevertheless be fairly sensitive and, in addition, should cause little background noise. The two variable resistors, R_1 and R_2 , can be chassis-mounting types and will probably need little alteration once they have been set up. R_1 adjusts the sensitivity of the device, ensuring that only noises above a certain level will cause the circuit to operate. In cases where this facility is not required R_1 may be omitted, the grid of the valve being taken directly to the top of the transformer secondary.

It is important to make certain that the two capacitors C_1 and C_2 are not "leaky", as the circuit will not otherwise function correctly.

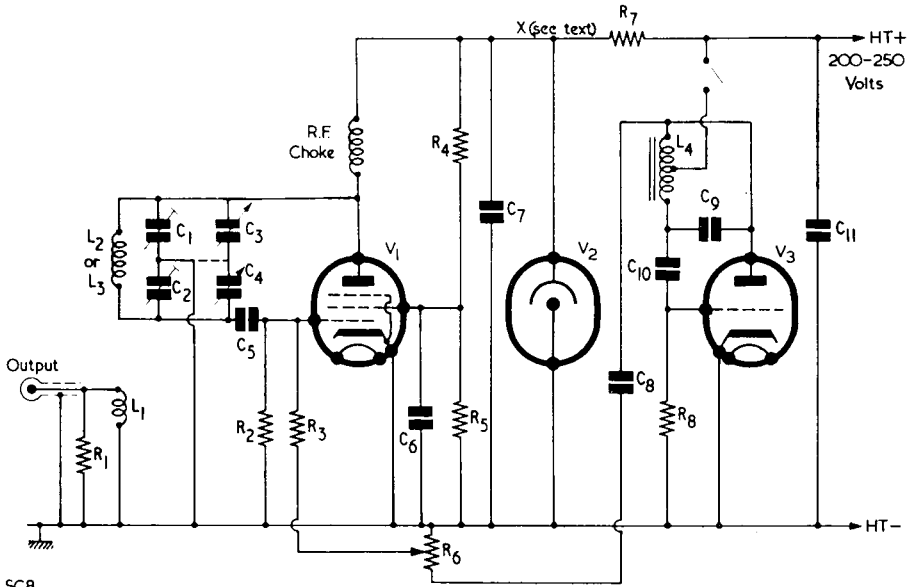
The Action of the Circuit

The working of the circuit is fairly simple. The AF voltages (formed by speech or noise at the microphone) are supplied to the grid of the triode by the transformer secondary, the earthy end of which is effectively taken to cathode by the capacitor C_1 . The triode amplifies the AF, the choke forming its anode load. The amplified AF is then passed to the diode which forms a negative voltage (with respect to chassis) across its load, R_3 . This negative voltage charges C_1 , via R_2 , thus applying a bias to the triode section. The anode current of the valve then drops, de-energising the relay and operating its contacts.

When the sound picked up by the microphone ceases, the charge on C_1 leaks away through the resistors R_2 and R_3 , bringing the circuit back to its original condition. Altering the value of C_1 (or R_3) will vary the time taken by the circuit to return to its former state.

The resistor R_3 is adjusted such that the relay just closes with the normal anode current of the valve. In this condition the circuit is in its most sensitive state.

No. 7 40-70 Mc/s SIGNAL GENERATOR



SC8

Components List

Coils

- L_1 $1\frac{1}{2}$ turns; $\frac{1}{2}$ in. diameter; $\frac{1}{2}$ in. from earth end of $L_{2,3}$.
- L_2 $0.207 \mu\text{H}$; 6.6 turns; $\frac{1}{2}$ in. diameter; 1 in. long; 16 swg enamelled—70-55 Mc/s.
- L_3 $0.335 \mu\text{H}$; 10 turns; $\frac{1}{2}$ in. diameter; $1\frac{1}{2}$ in. long; 18 swg enamelled—55-40 Mc/s.
- L_4 AF oscillator coil.
- RFC Approx. $50 \mu\text{H}$; 55 turns; 26 swg D.S.C. on $\frac{1}{4}$ in. former $1\frac{1}{4}$ in. long.

Capacitors

- C_1, C_2 Trimmers; Philips concentric; 6-30 pF.
- C_3, C_4 Tuning Capacitor (see text).
- C_5 20 pF.
- C_6, C_7 $0.001 \mu\text{F}$
- C_8 $0.01 \mu\text{F}$.

- C_9 AF oscillator tuning capacitor.
- C_{10} 500 pF
- C_{11} $0.1 \mu\text{F}$

Resistors ($\frac{1}{4}$ watt unless otherwise stated)

- R_1 See text.
- R_2 15 k Ω
- R_3 500 k Ω
- R_4 20 k Ω ; 1 watt.
- R_5 40 k Ω ; 2 watts.
- R_6 100 k Ω ; potentiometer.
- R_7 1.5-4 k Ω ; (to suit stabiliser and HT voltage).
- R_8 20 k Ω

Switches

- S_1 Modulation on-off switch.

Valves

- V_1 RF oscillator (see text).
- V_2 Any suitable stabiliser; VR 150/30, etc.
- V_3 Triode AF oscillator; 6J5, etc.

This circuit is suggested for a signal generator covering the range 40-70 Mc/s. AF modulation may be switched in or out as desired.

Circuit Details

The signal generator consists fundamentally of a pentode (or triode) valve, (V_1), functioning as a Colpitts oscillator. The anode voltage is stabilised by V_2 , whilst the screen-grid voltage is further maintained steady by the potentiometer R_1 , R_2 . AF modulation is provided by V_3 , working (in this case) as a Hartley oscillator. (Any other type of AF oscillator could be used in order to take advantage of components on hand). The modulation is injected via R_3 , the degree of modulation being adjusted by R_4 which may be either a panel or a pre-set component.

The Oscillator

As the Colpitts circuit has gained popularity amongst amateurs when used as a VHF receiver oscillator, it was decided to employ such an oscillator in this particular circuit. The tuned circuit consists of L_2 or L_3 shunted by C_1 , C_2 , C_3 and C_4 in series-parallel. C_1 and C_2 are trimmers, and are used not only to set the tuned circuit to the correct frequency but also to vary the ratio between the RF applied to the anode and to the grid for best oscillator working. (It could be said that they vary the position of the "earth tap" into the tuned circuit). They should be adjusted such that, with C_3 , C_4 set to minimum capacitance, the total capacitance across the coil (including strays and valve electrode capacitances) is approximately 25 pF. C_3 , C_4 should be a split-stator capacitor, preferably of the "butterfly" type. If it is impracticable to earth the moving vanes of the particular tuning capacitor used they may remain disconnected; C_1 , C_2 and stray capacitances suffering for the "earth tap" into the tuned circuit. A normal tuning capacitor is not recommended owing to the possible high capacitance between its frame and chassis.

It is intended that the wave range 40-70 Mc/s be covered in two steps. Using coil L_2 , the top frequency is 70 Mc/s for a total parallel capacitance of 25 pF and 55 Mc/s for a capacitance of 40.5 pF. With coil L_3 , a parallel capacitance of 25 pF will cause it to resonate at 55 Mc/s; whilst 47.3 pF will give 40 Mc/s. It may be seen that the capacitance swing needed from C_1 and C_2 in series is slightly less than 25 pF. Coil changing could be effected by using plug-in coils or by means of a turret switching device. The coils must be very rigid and must not be subject to any alterations in inductance due to the mechanical handling necessitated when using the plug-in system. The coil dimensions given in the components list are calculated and may need slight initial adjustments when put into practical use. Sufficient alterations in inductance could probably be carried out by slightly opening or closing the turns.

To obviate the necessity of changing coils, it may be found possible to use coil L_2 for the complete range. L_2 will resonate at 40 Mc/s when a total capacitance of 76.6 pF is connected across it; thus necessitating a tuning capacitance swing of slightly more than 50 pF. Whether L_2 will work satisfactorily over this range in the constructor's particular case may be discovered by experiment.

Coil L_1 is, of course, intended for coupling to the output terminal. If plug-in coils are used, L_1 could be fitted permanently so that it is in line, whichever coil is fitted. The resistor R_1 is intended to load the coil and prevent external

circuits from affecting the frequency of oscillation. R_1 should be mounted close to the coupling coil.

It will be noted that HT is present across the trimmers and the tuning capacitors. This voltage could be isolated by fitting a 0.001 μ F capacitor between the anode of V_1 and the tuned circuit, but such a precaution is hardly necessary. If desired, a fuse bulb could be inserted in the HT positive line after the stabiliser.

The oscillator valve shown in the diagram is a pentode, the writer having in mind the ubiquitous EF50. However, almost any "all-glass" pentode or triode with low inter-electrode capacitances should cope in the circuit.

Construction

It is, of course, essential to take great care over the wiring around the oscillator valve. All RF connections to V_1 and in the tuned circuit should be kept as short as possible. The resistor R_3 should be mounted close to the valve grid, even if this necessitates a long lead from its other side.

The main cause of drift will be given by temperature changes. A good method of minimising these consists of having the oscillator valve above the chassis in a well-ventilated position, the components of the tuned circuit being below and kept well away from heat-radiating components such as R_7 .

Setting Up

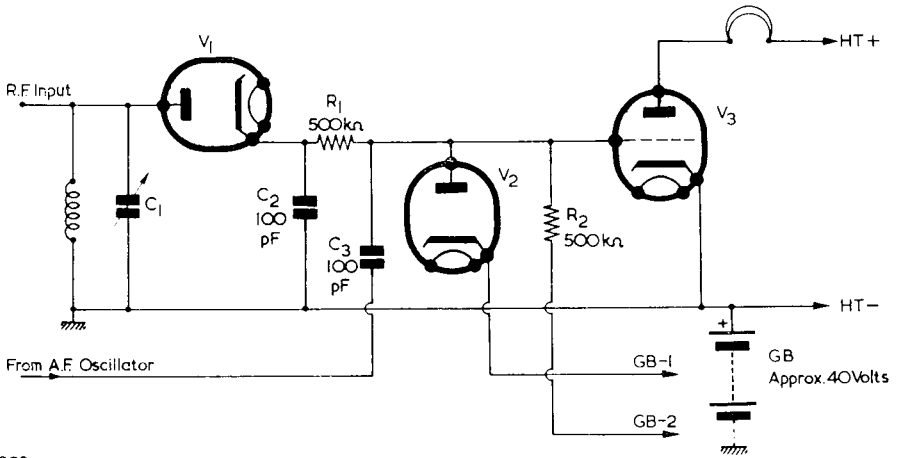
When the oscillator has been completed, the presence of oscillations may be checked by inserting a milliammeter in the HT line at the point marked with a cross in the diagram. If oscillations are stopped by touching the oscillator grid with an earthed prod the HT current will increase considerably, thus indicating that the circuit is working. Bearing in mind the fact that C_1 and C_2 are needed also to set the minimum tuning capacitance, these two trimmers may then be adjusted to the capacitance ratio which gives maximum "dip" with the tuning capacitor half-enmeshed. Trimming for this ratio will probably be very flat.

The resistor R_1 should then be experimentally reduced in value until it begins to load the tuned circuit, this state being indicated by an increase in the HT current reading. A value for R_1 which causes slight loading should be quite sufficient.

Frequency Calibration

Calibrating the signal generator for frequency may prove a little difficult without additional equipment. Spot checks may be obtained by beating the output against known frequencies (TV sound, etc.) the signal generator then being "followed" by using the harmonics of wavemeters or lower frequency generators. Such wavemeters as the BC221 give useful harmonics up to at least 100 Mc/s or so; and should prove very useful in this respect. Stronger harmonics from normal signal generators could probably be obtained by feeding their full output into an unbiased aperiodic amplifier.

No. 8 KEYING MONITOR



SC9

Although this circuit is designed mainly as a monitor for amateur built transmitters it is capable of being used for many other purposes, where the switching of AF amplification by means of an RF signal is required. It could, for instance, provide a useful method of silencing a sensitive receiver which is not tuned to an actual carrier; (in such a case the value of C_3 would have to be increased). As a monitor it has the advantage that the AF in the headphones is controlled by the transmitter output itself and not by subsidiary key circuits; thus giving a more reliable idea of what is heard at the distant receiver.

The Operation of the Circuit

In its normal state the triode is overbiased, this being done by choosing an appropriate grid bias voltage with the GB—2 tap. This negative voltage will cause the diode V_1 to conduct and so the bias actually applied to the valve will be approximately half of that chosen, the voltage drop being occasioned by the potentiometer R_1 , R_2 . The grid bias tap used should be just sufficient to ensure cut-off, thus preventing the triode from amplifying the output of the separate AF oscillator which is fed to its grid via C_3 .

The GB—1 tapping is taken to a point which corresponds to slightly more than the usual bias voltage for the particular type of triode which is being used.

When an RF input is applied to the tuned circuit, V_1 immediately rectifies, thus applying a positive voltage (relative to chassis) to R_1 . This voltage causes the negative bias on the valve to be reduced or removed, allowing it to amplify the AF oscillator, whose note is then heard in the headphones. As it would be difficult to regulate the RF voltages appearing across the tuned circuit, the input is made such that the voltage obtained from the rectified RF is too large and would cause the grid of V_3 to become positive with respect to its cathode (resulting, in practice, with "clicky" monitoring). However, when the positive voltage at the grid of V_3 rises above its usual grid bias value, V_2 conducts and provides an effective short-circuit to any increasing grid voltages.

Practical Points

Although the circuit shown here is perfectly capable of working as it stands, some experimenters may care to make a few alterations to meet different conditions. For instance, the headphones could be replaced by a transformer, the secondary of which could be permanently connected to the receiver output terminals, thus obviating any headphone switching. Similarly, the grid bias battery could be dispensed with, using instead a rectified negative supply from the mains and employing pre-set potentiometers for the tappings.

When used as a monitor, only a very loose coupling to the transmitter should be needed. This may consist of a short length of wire mounted near the aerial terminal or near the output tank circuit.

No. 9 SUB-STANDARD 200 KC/S HARMONIC GENERATOR

This circuit is intended to provide a series of checks over all the usual frequencies employed for domestic and short-wave listening and servicing, the check points being obtained from harmonics based on a 200 kc/s fundamental.

Principle of Operation

The circuit works on the principle of amplifying an RF source of known frequency and stability, and then applying the amplified signal to a stage capable of adding a rich harmonic content, the output then being used to provide heterodyne tests for checking receiver, signal generator and wavemeter calibration, etc. In this case, the RF source has a frequency of 200 kc/s and is obtained from the BBC Light Programme transmitter on 1500 metres.

The disadvantages of an arrangement such as this consist of the necessity of constructing a fairly complex circuit, and the cost of providing the parts. However, the latter can be reduced considerably by the use of surplus valves and components.

The advantages are given by the fact that the accuracy of the frequency checks obtained is as good as that employed by the BBC in maintaining transmitter frequency stability, and is therefore higher and more reliable than that given by the average crystal oscillator.

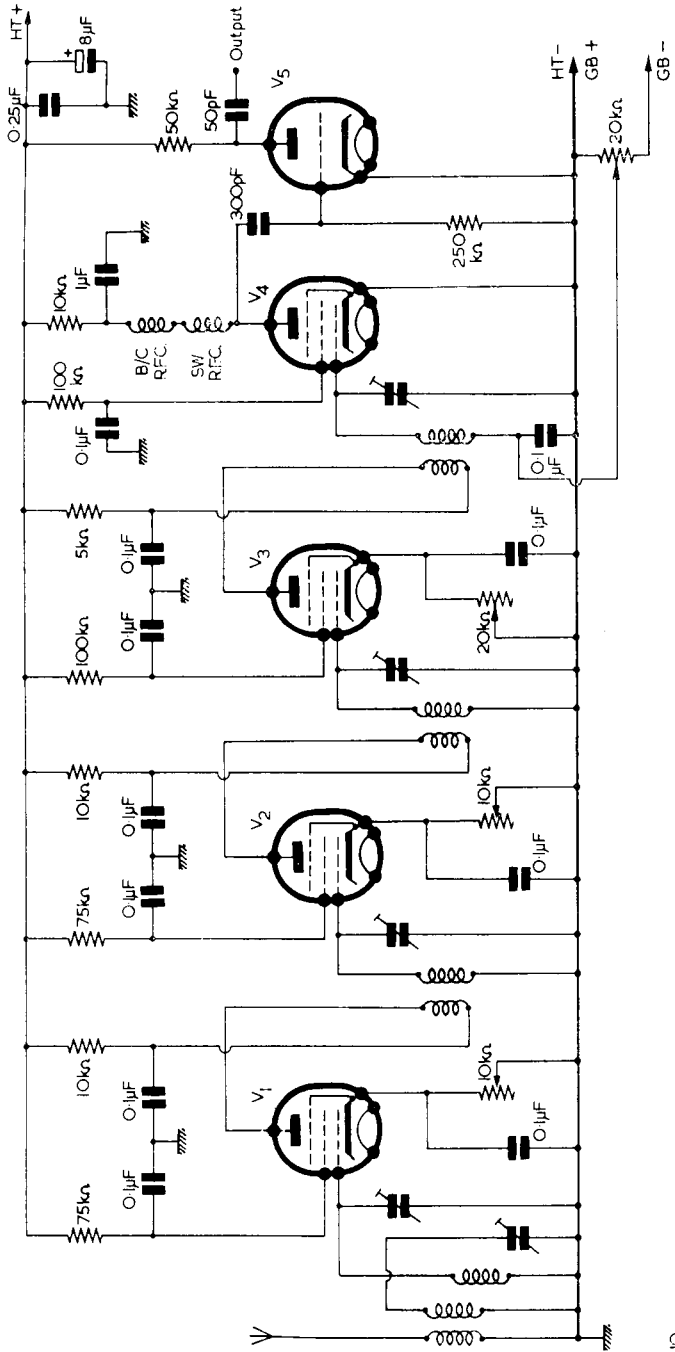
The Circuit

In the circuit shown here, V_1 , V_2 and V_3 are variable- μ RF pentodes, and they are employed to amplify the 200 kc/s signal in the usual manner. Their gain is controlled by variable cathode resistors, which are set to obtain the greatest amplification from each stage without running into grid current.

The amplified signal should then be sufficiently strong to permit of harmonic generation. It is applied to the grid of V_4 , a "straight" RF pentode, whose bias can be altered by a grid bias potentiometer. This valve is made to distort the signal either by the application of excessive bias or none at all, it being found experimentally which procedure offers the greater amount of harmonics. The anode circuit of V_4 is completed by a short-wave choke in series with a medium and long-wave choke. The signal is then applied to the triode detector which will again increase the harmonic content.

Practical Points

Owing to the comparatively low frequency of the fundamental RF, the layout of the harmonic generator should not prove very difficult. Efficient screening of each stage should remove any tendency to instability. Normal



long-wave coils can be used for the first three stages and the input aerial coupling could be obtained by mounting two coils side by side. A good aerial and earth system is advisable.

Really good components should be chosen for the two chokes connected in the anode circuit of V_4 . If one of the old-fashioned "binocular" chokes can be obtained, this would do excellently for the medium and long-wave section. It might also be worth-while to keep the RF wiring around V_1 and V_2 reasonably short.

Modulation

It is appreciated, of course, that the original 200 kc/s signal will be modulated whilst it is being used for test purposes, and that the sidebands obtained will also be multiplied with the carrier. In addition to this, the multiplying stages are almost certain to introduce cross-modulation between sidebands and harmonics, etc. As, however, these unwanted frequencies will be constantly changing they could hardly be confused with the steady, stronger note which would be obtained from the original carrier and its harmonics.

No. 10 MIDGET 2-VALVE AC/DC RECEIVER

The circuit is suitable for a two-valve "midget" receiver and takes advantage of the small size of the 117L7 or 117L7GT to give a compact layout.

As the 117L7 takes a heater current of 0.09 amps, it would be necessary to use a parallel resistor to enable it to work in an AC/DC receiver with other mains valves. In this particular circuit, this problem is overcome by using the cathode current of the 117L7 to heat a separate 1.4 volt valve.

Circuit Details

The circuit is very straightforward, the aerial feeding into a leaky-grid triode detector with reaction, the latter being controlled by the potentiometer R_1 . The aerial coils are conventional medium and long-wave interstage coupling components, the coupling winding being employed for feedback. A midget "interval" transformer is shunt-fed by the triode, its secondary being connected to the output valve, which is part of the 117L7. The transformer should have a ratio of between 1:3 and 1:6 inclusive.

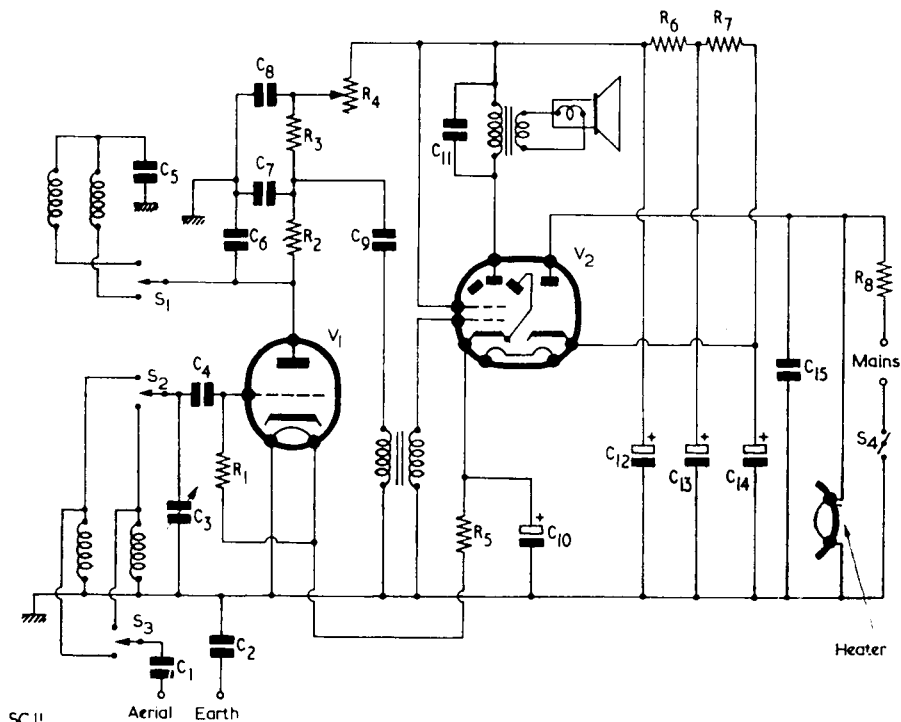
To prevent the loss of too much HT voltage and to avoid using a bulky choke, a slightly unorthodox smoothing circuit is shown in the diagram, this consisting of three capacitors connected together by low value resistors. No rectifier limiting is needed here as the input impedance offered to the rectifier anode is fairly high. It will probably be found, after the 117L7 has warmed up, that the additional HT current will cause too great a voltage drop in the line-cord, R_2 , to enable the requisite 117 volts to be obtained across the heater. When the output stage has been completed, the value of R_3 should be experimentally reduced until correct working is obtained.

With 5.2 volts grid bias the cathode current of the 117L7 should be approximately 47 mA. As different valves will present slight variations on this figure, a 28 ohm resistor should be connected up temporarily in place of the filament of V_1 to ascertain that the correct current is flowing, and thus prevent any accidental burn-outs. A voltage of 1.4 (or very slightly less) should be built up across this resistor. The cathode current of the 117L7 may be increased by reducing the value of R_5 and *vice versa*. (V_1 should not be connected until both R_4 and R_5 have been correctly adjusted).

Construction

The circuit may be built up in very compact form and, apart from the usual requirements of using short connecting leads, etc, needs little attention to layout. However, it should be remembered that the 117L7 dissipates a large amount of heat and good air circulation is needed around this valve. The intervalve transformer should not be mounted close to the aerial coils or to the speaker transformer. To prevent interaction, the axes of the transformers and the aerial coils should all be at right angles to each other.

The aerial coils are conventional medium and long-wave interstage coupling components, the coupling winding being employed for feedback.



Components List

C ₁	20 pF, 500 WV	C ₁₅	0.01 μF, 350V. A.C.
C ₂	0.01 μF, 500 WV	R ₁	500 kΩ
C ₃	500 pF, solid dielectric;	R ₂	10 kΩ
C ₄	200 pF	R ₃	100 kΩ
C ₅	300 pF	R ₄	100 kΩ
C ₆	200 pF	R ₅	76 Ω
C ₇	200 pF	R ₆	200 Ω
C ₈	0.01 μF	R ₇	200 Ω
C ₉	0.01 μF	R ₈	1,340 Ω line cord (see text)
C ₁₀	100 μF, 12 WV	V ₁	1G4 (or 1L4 with screen-grid and anode strapped)
C ₁₁	0.002 μF	V ₂	117L7 or 117L7GT
C _{12, 13, 14}	16 μF, 250 WV		

No. 11 TRANSFORMER RATIO ANALYSER

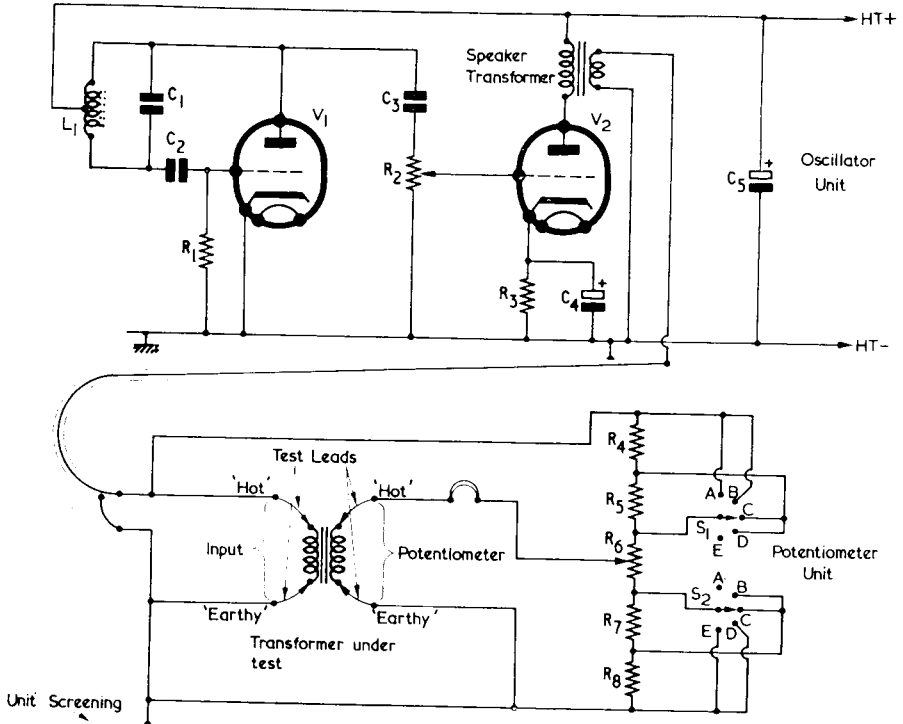


Fig. 1

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Components List

Capacitors

- C₁ Experimental. (Chosen to give 1,000 c/s tone).
- C₂ 500 pF
- C₃ 0.001 μF
- C₄ 25 μF, 25 WV (May be omitted if sufficient gain is available without).
- C₅ 4 μF (or larger)

Resistors

- R₁ 10 kΩ to 100 kΩ (Experimental).
- R₂ 250 kΩ
- R₃ Value according to particular valve chosen for V₂.
- R₄ 10 kΩ
- R₅ 500 kΩ
- R₆ 10 kΩ wirewound (see text).
- R₇ 500 kΩ
- R₈ 10kΩ

AF Choke

- L₁ Experimental—suggest tapped output transformer primary, P/P inter-valve transformer, or ordinary inter-valve transformer with windings connected in series.

Valves

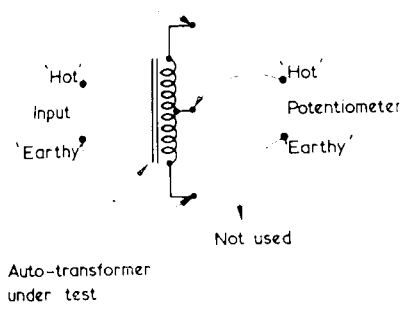
- V₁, V₂—See text.

Switches

- S₁, S₂—Single pole, five way. Ganged.

Range Switch Positions

- A Ratios closely approaching unity.
- B Ratios between unity and 2:1.
- C Ratios between 3:2 and 3:1.
- D Ratios between 2:1 and 8:1.
- E Ratios closely approaching 8:1.



SC 12 Fig. 2

This circuit (Fig. 1) has been developed at the request of readers, and represents an item of test equipment which will have many uses in the amateur workshop. The purpose of the analyser is to determine the ratios existing between windings mounted on a common iron core; such as would be provided by mains or audio transformers, etc., or by auto-transformers. The analyser may also be utilised occasionally to find the ratio of RF transformers; this being feasible if an iron core of some sort can be temporarily inserted inside the former of such a coil.

The analyser has three important advantages. First of all, it allows readings to be obtained quickly and simply. Secondly, the transformer under test is not subjected to any harmful voltages or currents. Thirdly, the ratio figures obtained are those for no-load conditions; and are, therefore, not only accurate in themselves, but are also useful for working out anticipated performance figures.

Principle of operation

The principle on which the circuit functions is quite simple. An AF tone is fed from an oscillator to one of the windings of the transformer under test, and also to the outside ends of a potentiometer network. A second winding on the transformer has one end connected also to an end of the potentiometer network, its other end being connected, via a pair of phones, to the potentiometer slider. To find the ratio between the two windings of the transformer, the slider is adjusted until the tone heard in the phones is at a minimum, whereupon the ratio between the windings corresponds to that existing in the potentiometer network. If the potentiometer has been fitted beforehand with a calibrated scale, this ratio may be read directly. The process is, of course, similar to that of balancing a bridge.

It will be seen that, to obtain a "minimum", it is necessary for the second winding to have fewer turns than the first, and for it to be connected the correct way round to the analyser test leads. These requirements can be satisfied by using experimental connections at first; although in most cases, the proper connections may be easily ascertained from a preliminary examination of the transformer before it is connected to the tester.

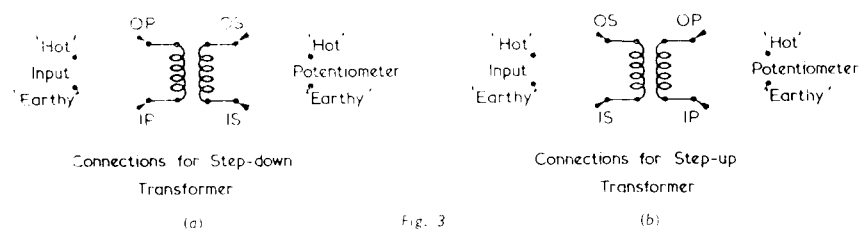


Fig. 3

When an auto-transformer is being investigated it should be connected up to the test leads as illustrated in Fig. 2. A transformer whose tags are marked "I.P.", "O.P.", etc., can be connected in the manner shown in Figs. 3 (a) and (b).

The writer has chosen the terms "Input" and "Potentiometer", "Hot" and "Earthy", to designate the test leads shown in the diagrams. This was done mainly because these expressions are self-explanatory and clearly denote the function of each lead. Any other suitable identifying terms could, of course, be used in their place.

Range Switching

To enable the analyser to work with greater accuracy, a five-position range switch (S_1 and S_2) is included in the potentiometer unit. The ranges covered by this switch are given in the table accompanying this article. It will be noticed that ratios approaching unity and infinity can be accurately determined, this being made possible by the inclusion of the 500 k Ω resistors R_5 and R_7 in the potentiometer network. Although readings at the infinity end of the scale are obviously limited by the physical capabilities of the variable resistor itself, it should be possible to obtain accurate readings to the order of 5,000:1. Higher-ratio reading could be obtained by increasing the value of R_5 .

There will be a certain amount of overlap between ranges but this point is not, of course, a disadvantage. Calibration can be carried out over the common parts of overlap; although there is little point in calibrating to the extreme end of a particular range if the readings given there are adequately covered elsewhere.

The Oscillator Unit

The oscillator unit needs little description, it consisting simply of an AF oscillator (V_1) followed by a triode amplifier (V_2). The AF output to the potentiometer unit is provided at low impedance by connecting a conventional speaker transformer in the anode circuit of V_2 .

The diagram shows a Hartley oscillator; although any other oscillator circuit can be used so long as it gives a reliable source of AF at approximately 1,000 c/s with good power. (1,000 c/s will be found an easier tone to work with than 400 c/s). The volume control is essential and will need to be turned down in most cases. However, a high level of volume will probably be needed for checking transformers with high ratios.

Any two triodes (6J5, 6C5, etc.) can be used in the oscillator unit. Alternatively a double-triode, such as a 6SN7 or 12AU7, could be employed instead. (If battery types are used, V_2 should be an "output" valve. An alternative bias supply for V_2 will, of course, be needed as well). HT could consist of any voltage higher than, say, 100 volts.

Construction

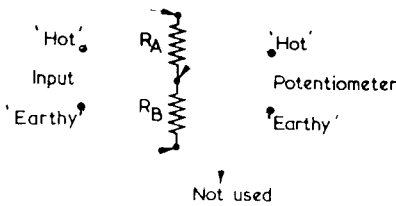
It will probably be found most convenient to build the analyser in two parts. Although the oscillator unit need not necessarily be screened it will be helpful, in some cases, to have it so. It is essential, however, to use screened wire for the lead from the oscillator to the potentiometer unit. The potentiometer unit must also be screened. The chassis connection to this unit can be taken from the screening of the interconnecting screened wire. The oscillator unit should, in addition, be connected to a good earth.

The test leads from the potentiometer unit could consist of four eight-inch lengths of wire terminated by crocodile clips, these leads being taken through the side of the unit some distance away from the knob of the variable resistor, R_6 . Longer test leads should not be necessary. The internal wiring inside the

potentiometer unit (particularly that in the range-switch circuit) should be kept separated and as short as possible in order to reduce capacitances between leads, and between leads and chassis.

The above precautions are advised in order to prevent poor minima being obtained due to stray capacitances when very high-ratio transformers are being measured. It might further prove helpful to keep the phone leads away from the transformer under test.

It will be necessary to use high-resistance phones (2,000Ω); and it is important to note that, for reliable results, the variable resistor R_A should be a well-made, high grade component.



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Fig. 4

Calibration

Initial calibrations should be carried out by checking transformers of known ratios. Mains transformers (particularly those made by reputable manufacturers) are the most useful in this respect as, apart from the many alternative ratio figures which can be obtained by taking advantage of the tapped windings, etc., such transformers are wound, in so far as the number of turns is concerned, very accurately. Further calibrations may then be made by using resistors connected as shown in Fig. 4. Using this circuit the ratios obtained will be

$$\text{equal to } \frac{R_A \cdot R_B}{R_B}$$

Before calibration is commenced, a check should be made at several "spot" points to make certain that readings obtained from resistor ratios correspond with those given by similar transformer ratios. Discrepancies are unlikely; but should any occur, they will most probably be caused by excessive stray capacitances in the potentiometer unit.

HIGH FIDELITY TRF TUNER UNIT

(continued from Page 32)

To set up the indicator circuit, the resistor R_{23} should be adjusted until the shadow on the target of the indicator just "closes". When a station is tuned in the shadow will then "open." It will be seen that the potentiometer network R_{22} and R_{23} prevents the indicator from making use of the full HT voltage. It might, therefore, possibly not be worth while including the tuning indicator if the available HT voltage were less than, say, 200 volts.

Current Consumption

With the RF volume control fully advanced, the total HT current taken by the unit will be approximately 20 to 30 mA for an HT voltage of 250.

No. 12 HIGH FIDELITY TRF TUNER UNIT

The circuit shown in Fig. 1 gives details of a TRF tuner unit intended for connection to a high-fidelity AF amplifier. The tuner unit covers both medium and long-waves, a comprehensive control of variable selectivity being provided by a switching circuit which, as it is advanced, progressively loads each tuned circuit in turn. Detection is carried out by an infinite impedance detector. A "magic eye" tuning indicator can be included, if desired, this being used to show the state of tuning and also give an indication of the magnitude of the RF voltages fed to the detector.

The RF Circuits

As may be seen from the diagram, the RF circuits are quite simple and straightforward. Wave-change switching is effected by S_1 to S_4 inclusive. RF amplification is carried out by V_1 and V_2 , both of which are vari-mu RF pentodes. V_2 feeds into V_3 , the infinite impedance detector, the demodulated output from this valve being built up across R_{17} .

Variable selectivity is provided by the 3-wafer, 7-way switch S_5 , S_6 and S_{10} . When the arm of this switch is fully to the left (anti-clockwise in Fig. 1), the tuned circuits are unaffected and the unit is capable of giving its sharpest degree of selectivity. As the switch is turned clock-wise through one contact, a $100\text{ k}\Omega$ resistor, R_{18} , is connected across the aerial tuned circuits (L_3 or L_4 and C_4), causing these circuits to be slightly flattened. At the next contact a $10\text{ k}\Omega$ resistor, R_1 , is connected across the tuned circuits, causing them therefore to be flattened still further. R_1 remains connected across the aerial tuned circuits for the remainder of the variable selectivity switch positions; additional flattening being obtained by loading the tuned circuits L_2 , L_1 and C_{10} in the same way, and, in the final two positions, the detector tuned circuits as well.

RF volume control is provided by R_{11} , which varies the cathode bias of V_1 and V_2 . This control may be ineffective when receiving very strong signals, whereupon it will be necessary to close switch S_7 . This switch causes the screen-grid voltage of V_1 to be considerably reduced.

An AF volume control (R_{19}) is also provided. This component may not be necessary in some installations, and it could be replaced by a fixed resistor of the same value. To prevent attenuation of the higher AF frequencies, it is essential that the output be fed to the subsequent AF amplifier through a screened lead whose self-capacitance is very small. If the use of a long screened lead (whose self-capacitance would therefore be high) cannot be avoided, it would be advisable to insert a cathode follower between the output of the detector and the screened lead. A suitable circuit is shown in Fig. 2. In cases where the self-capacitance in the connecting lead to the amplifier would not be higher than 100 pF or so, an easier course would consist of omitting R_{19} altogether and taking the output directly from C_{21} and chassis. However, should this course be adopted it will be necessary to have a volume control at the amplifier input. When R_{19} is retained the input impedance of the subsequent amplifier should be $1\text{ M}\Omega$ or greater. If R_{19} is omitted, and connection is made direct to C_{21} , the input impedance should be $500\text{ k}\Omega$ or greater. Any input impedance above $50\text{ k}\Omega$ or so will be acceptable when the cathode follower output is employed.

Stability

In order to prevent instability, careful attention has been paid in the design of the circuit to the inclusion of adequate decoupling. The provision of effective.

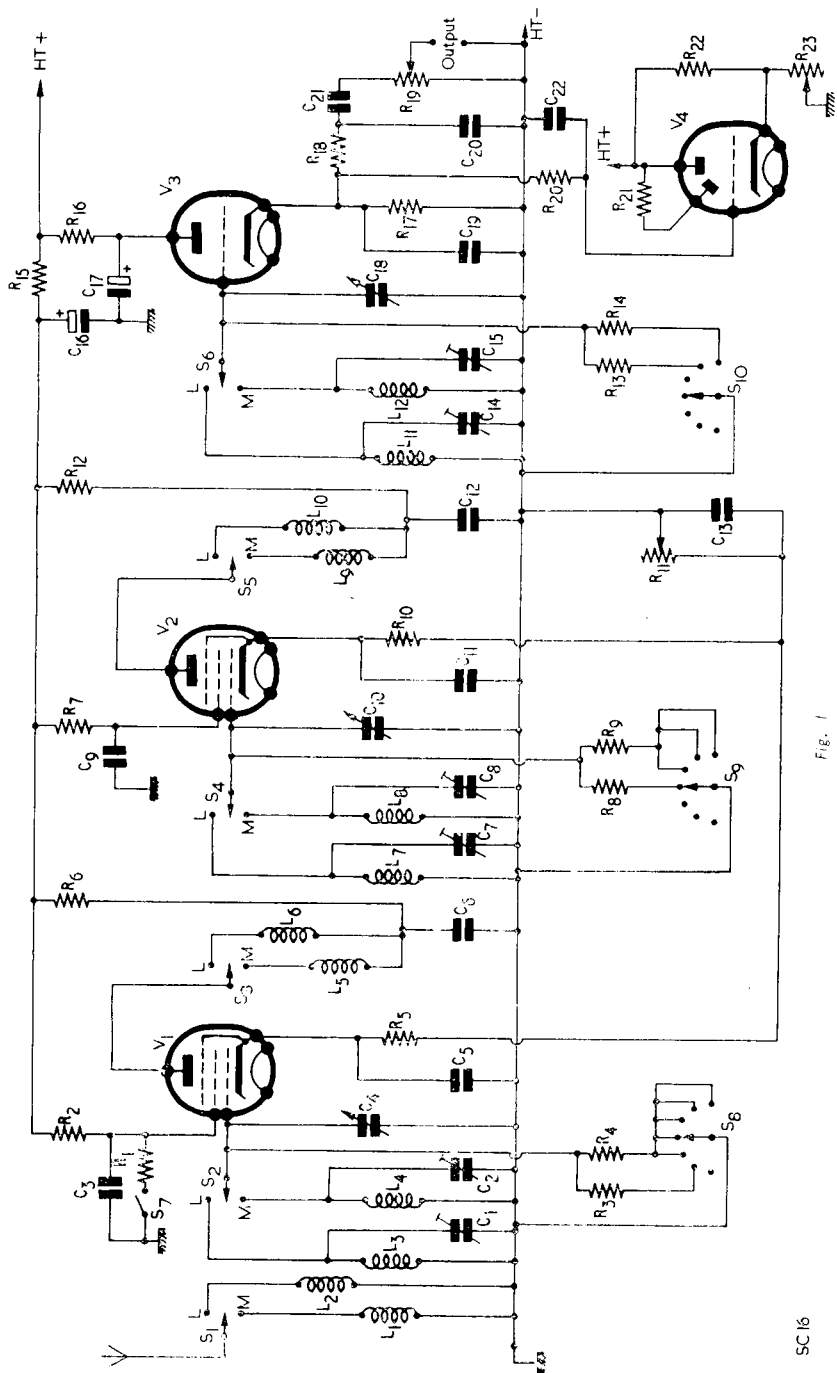


Fig. 1

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Components List

Resistors (All $\frac{1}{4}$ watt unless otherwise stated)	Inductors	Coupling: medium-waves
R ₁ 5 k Ω	L ₁ , L ₅ , L ₉	Coupling: long-waves
R ₂ 75 k Ω ; 1 watt	L ₂ , L ₆ , L ₁₀	Grid: long-waves
R ₃ 100 k Ω	L ₃ , L ₇ , L ₁₁	Grid: medium-waves
R ₄ 10 k Ω	L ₄ , L ₈ , L ₁₂	
R ₅ 300 Ω		
R ₆ 10 k Ω		Trimmers: 60 pF max.
R ₇ 75 k Ω		0.1 μ F
R ₈ 100 k Ω		500 pF; part of 3-gang
R ₉ 10 k Ω		0.1 μ F
R ₁₀ 600 Ω		Trimmers: 60 pF max.
R ₁₁ 25 k Ω ; 1 watt		0.1 μ F
R ₁₂ 5 k Ω		500 pF; part of 3-gang
R ₁₃ 100 k Ω		C ₁₁ , C ₁₂ , C ₁₃ , 0.1 μ F
R ₁₄ 10 k Ω		Trimmers: 60 pF max.
R ₁₅ 1 k Ω ; 1 watt		8 μ F
R ₁₆ 50 k Ω		500 pF; part of 3-gang
R ₁₇ 100 k Ω		200 pF
R ₁₈ 10 k Ω		0.01 μ F
R ₁₉ 500 k Ω		

Valves

- V₁, V₂ Vari-Mu RF Pentodes
- V₃ Amplifier triode (6L5, $\frac{1}{2}$ 12AU7, etc.)

Switches

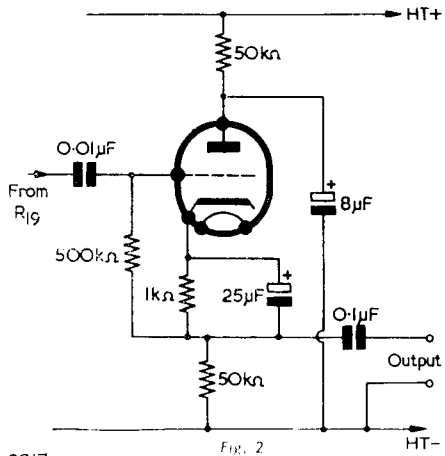
- S₁ to S₆ Wave-change (Ganged)
- S₇ Local station attenuating switch
- S₈, S₉, S₁₀ Variable selectivity (Ganged)

When tuning indicator is used

- R₂₀ 4 M Ω ; $\frac{1}{4}$ watt
- R₂₁ 1 M Ω ; $\frac{1}{4}$ watt
- R₂₂ 50 k Ω ; 2 watts
- R₂₃ 50 k Ω ; 2 watts. Pre-set
- C₂₂ 0.01 μ F
- V₁ Tuning Indicator (6U5G, etc.)

screening is also of considerable importance and the layout should be planned with this point always in mind. The best policy consists of screening the three sets of tuned circuits (and their immediate wiring) away from each other as effectively as possible. The dashed lines in the diagram give a good idea of the points at which screening should be applied. (If instability should be persistent, it might help to have the anode leads from V₁ and V₂ to their respective switch contacts screened also).

It should be remembered that the individual wafers of both the wave-



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FIG. 2

change and the variable selectivity switches must be connected to their respective tuned circuits by means of short wiring.

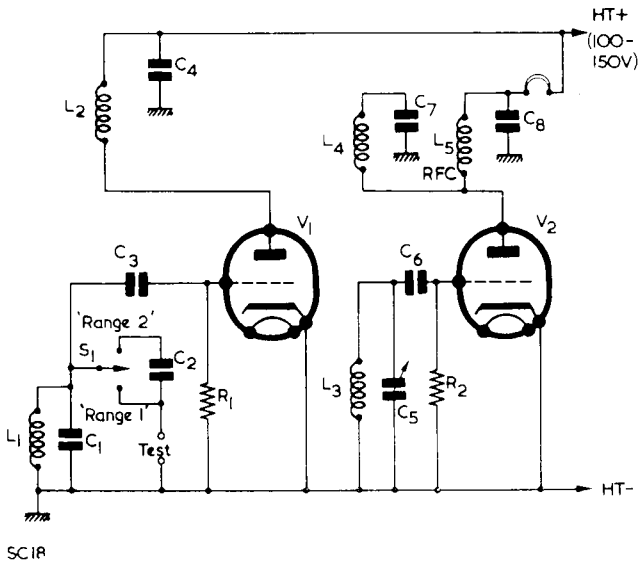
The Tuning Indicator

The tuning indicator shown in the circuit need not necessarily be fitted to the tuner unit, as its inclusion is entirely optional. It is used here in a different manner to that normally encountered. This is due to the fact that the DC voltage built up across the infinite impedance detector load is positive (with respect to chassis) instead of negative.

If they are used, R_{20} and C_{22} should be mounted close to the cathode of V_3 . The lead to the tuning indicator grid can then be made as long as is required by the layout. The positions of R_{22} and R_{23} are unimportant. R_{21} will, of course, be fitted directly to the indicator's valveholder tags.

(Concluded on Page 28)

No. 13 HETERODYNE CAPACITANCE METER



Components List

Capacitors

- C_1 10 pF; Mica.
- C_2 400 pF; Mica.
- C_3 50 pF; Mica.
- C_4 0.1 μ F; Paper.
- C_5 500 pF.
- C_6 50 pF; Mica.
- C_7 0.001 μ F; Mica.

- C_8 0.001 μ F; Mica.

Resistors

- R_1, R_2 —20 Ω

Valves

- V_1, V_2 6J5 or equivalent, or combined as 6SN7 or 12AU7.

This circuit is that of a heterodyne capacitance meter capable of measuring values of capacitance from less than 10 pF to greater than 0.01 μ F. Accuracy is good, but the scale is liable to become cramped for readings above 0.001 μ F.

Principle of Operation

The principle of operation is very simple. V_1 is an RF oscillator, across the grid coil of which (L_1) various values of unknown capacitance may be connected. V_2 is also an RF oscillator, being tuned by a variable capacitor, C_3 . It is loosely coupled to the circuit of V_1 by suitable positioning of the coils. To find the value of an unknown capacitor, it is first of all connected across L_1 , whereupon C_3 is adjusted until a zero beat is heard in the phones. The two oscillators are then working on the same frequency and the value of the unknown capacitor may be read from a previously-calibrated scale fitted to C_3 .

To expand the range of the meter a two-way switch, S_1 , is included in the circuit. When this switch is set to Range 1, the unknown capacitor is connected directly across L_1 . When Range 2 is selected, the unknown capacitor is connected in series with a fixed capacitor, C_2 , and acts more or less as a padder. Assuming that C_3 has a value of 500 pF, Range 1 then measures capacitances nearly up to this figure, whilst Range 2 allows readings to be taken to the probable maximum (with accuracy) of 0.01 μ F. There will be a certain amount of overlap between the two ranges, but there is little point in calibrating Range 2 below 300 pF.

A small fixed capacitor, C_1 , is connected permanently across L_1 , this helping to reduce the effects of varying stray capacitances. It also allows C_3 to swing over the zero test capacitance position when its vanes are unmeshed.

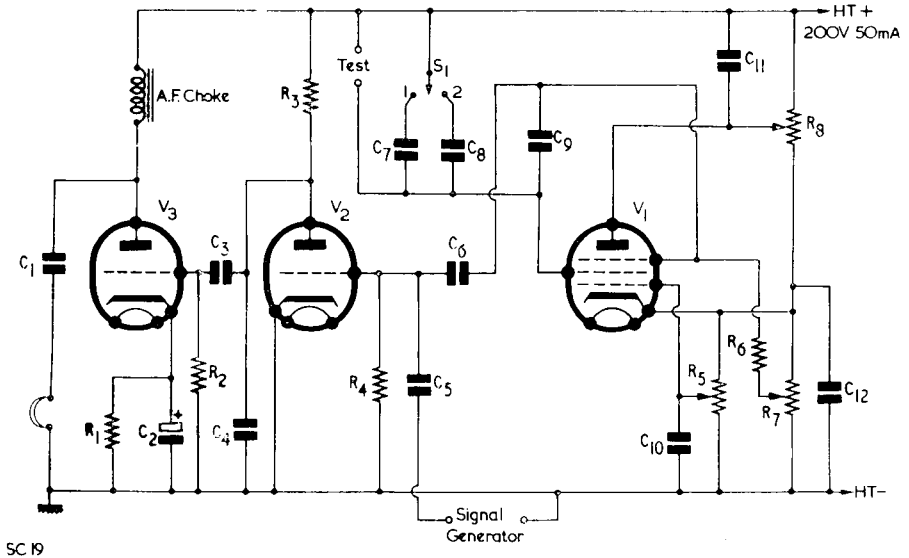
Both L_1 , L_2 and L_3 , L_1 are similar coils, and it is recommended that medium-wave superhet oscillator coils be used in these positions. With such coils, stable oscillations should be obtained without too much self-capacitance. L_3 , the RF choke, need not be elaborate. A single-bobbin "reaction-type" component would probably cope quite well.

Practical Details

The construction of the meter should present little difficulty. It will probably not be necessary to screen the coils L_1 , L_2 and L_3 , L_1 away from each other; but it would be advisable to have them some distance apart, with their axes at right angles. If this does not give sufficient coupling, their positions may be altered so that their axes are brought more in line. On the other hand, should coupling be too tight (and this may result in "pulling") it may be necessary to fit a small screen between the two coils.

When the meter has been completed, calibration may be carried out by measuring the values of known capacitors, and completing the scale with the aid of a graph.

No. 14 TRANSITRON INDUCTANCE METER



SC 19

Components List

Resistors

- R₁ 1 k Ω
- R₂ 250 k Ω
- R₃ 50 k Ω
- R₄ 1 M Ω
- R₅ 250 k Ω (Panel-mounted)
- R₆ 100 k Ω
- R₇ 2 k Ω ; 3 watts. (Pre-set)
- R₈ 6 k Ω ; 5 watts. (Pre-set)

Capacitors

- C₁ 0.1 μ F
- C₂ 25 μ F; 25V WV.
- C₃ 0.01 μ F
- C₄ 500 pF
- C₅ 50 pF

- C₆ 10 pF
- C₇ 100 pF; Silver-mica
 $\pm 2\%$, or better
- C₈ 500 pF; Silver-mica
 $\pm 2\%$, or better
- C₉ 200 pF
- C_{10, 11, 12} 0.1 μ F

Valves

- V₁ 6K7, 6J7 are recommended, but most other RF pentodes with separate suppressor-grid connections should cope.
- V_{2, 3} 6J5, etc., or combined as 6SN7 or 12AU7.

Suggested Circuit No. 13 gave details of a capacitance meter in which the unknown capacitance was used to tune an inductor, a reading then being taken of the frequency of resonance. In this circuit something of the same principle is used to find unknown values of inductance. The inductor under test is connected to a transatron oscillator and, when paralleled by a known value of capacitance, its resonant frequency read with the aid of an external signal generator. By the use of two different parallel capacitors it is also possible to obtain a measure of the self-capacitance across the inductor.

The Circuit

The most important part of the circuit centres around the transitron oscillator, V_1 . This is a conventional RF pentode whose suppressor-grid is made negative with respect to its cathode, and whose screen-grid is given a higher positive voltage than its anode. The oscillator works on a portion of its screen-grid current-voltage curve which produces negative resistance. Due to this negative resistance no feedback coil is necessary for the inductor under test, and it may be made to oscillate by the use of a simple two-terminal connection.

To maintain the necessary voltages on the electrodes, two pre-set potentiometers, R_7 and R_8 , are connected across the HT line. The values of resistance given in the circuit for these two components are a little low but, in the interests of stability of operation, such low values can be relied upon to err on the "safe side" for the different practical models which may be built.

The range of the transitron oscillator varies from low audio frequencies up to approximately 50 Mc's.

The oscillator voltages obtained from the test inductor are applied to a leaky-grid detector, V_2 , via the 10 pF capacitor, C_6 . The output of an attenuated signal generator is also applied to the same valve. A further valve, V_3 , then amplifies the AF output from V_2 and passes it to the headphones. The AF amplifier is necessary as the output from both the transitron and the signal generator will be low.

Once the frequency of oscillation given by the unknown inductor has been obtained, the value of its inductance will be given by the following formula:

$$L = \frac{1}{(2\pi f)^2 C}$$

where L is in henrys, C in farads, and f in cycles per second.

If the meter is to be used consistently a graph of inductance against frequency can be plotted, using the capacitance values already installed in the meter.

Practical Details

The construction of the meter should not present a great deal of difficulty. The wiring to the oscillator valve must be kept short in order to reduce self-capacitance and to give efficient working at high frequencies. The resistor, R_9 , is panel-mounted and its leads may be of any convenient length so long as C_{10} is mounted close to the valve. The same applies to R_8 and C_{11} .

When the meter has been completed, the pre-set resistors R_7 and R_8 may be set up for optimum results. To do this, R_8 should primarily be set about a third of the way up and R_7 set to apply a slight negative voltage to the suppressor grid (with relation to cathode). R_7 should be set to maximum. An inductor may then be connected across the test terminals and the switch S_1 set to position 1.

The oscillator will probably function straightaway, a beat-note being obtained from the external signal generator when it is set to the correct frequency. If oscillations do not commence immediately, R_7 should be adjusted. In extreme cases it will be necessary to adjust R_8 as well. Once a satisfactory beat-note has been obtained, R_7 and R_8 should be adjusted to give the strongest oscillations. (The adjustments to these two potentiometers will probably be inter-dependent). R_7 should then be turned down until the beat-note is just audible; whereupon the process can be repeated. Once they are set up, R_7 and R_8 will need no further alteration. Indeed, they can be replaced by fixed resistors, if this is desired.

For very accurate readings, it will be necessary to take into account the internal stray capacitances in the meter itself. These could be measured across the test terminals, with one of the paralleling capacitors temporarily unsoldered and with V_1 plugged in (the power supply being switched off); and should be later added to the value of capacitance switched in by S_1 . The effect of the stray capacitances will not be so great when S_1 is switched to position 2.

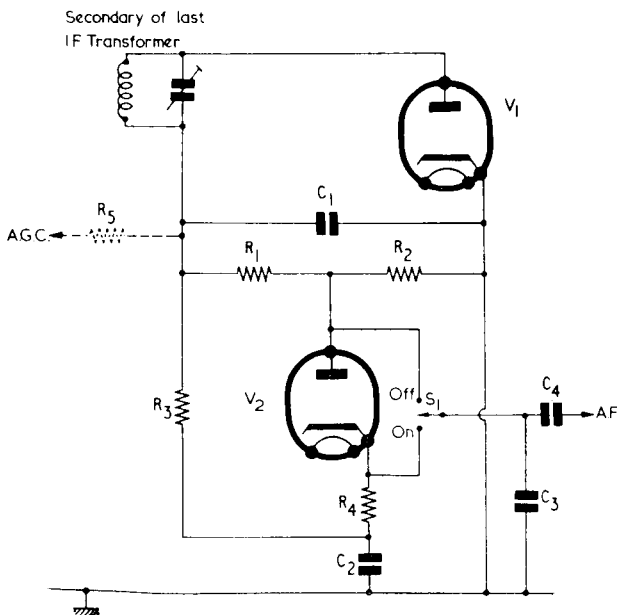
Self-Capacitance

Assuming that the self-capacitance in the inductor under test may be considered as an additional capacitor connected across it, a measure of this self-capacitance can be obtained from the frequency readings given on positions 1 and 2 of S_1 ; these readings being used to form a quadratic equation.

Harmonics

It may sometimes be possible to obtain false readings from the meter due to the presence of harmonics given either by the signal generator or by the transitron oscillator. These harmonics will, however, be very much weaker than the fundamentals; particularly so when both the signal generator and the oscillator are set to give low outputs. Once a beat-note has been obtained, the output of the transitron should be reduced (by adjusting R_3) until it is approaching the "just audible" stage. The signal generator should then be attenuated until this stage is actually reached. Should no other beat-notes be obtainable, then it will be certain that the indications obtained are given by the fundamentals.

No. 15 SERIES NOISE LIMITER



Components List

Resistors

$R_{1,2}$	250 k Ω
$R_{3,4}$	1 M Ω
R_5	2 M Ω

Capacitors

C_1	200 pF
C_2	0.01 μ F
C_3	100 pF
C_4	0.01 μ F

This circuit is that of a series-diode noise limiter which is very effective in reducing pulse-type interference, such as ignition noise. It is intended for connection at the second detector stage of a superhet. In addition to the limiter circuit, the diagram illustrates also the necessary subsidiary components needed for detection; and for undelayed AGC as well, should this be desired. The circuit may be fitted as it stands into any superhet, to provide both limiting and detection.

Circuit Action

The action of the circuit is fairly simple. On reception of a carrier, the diode V_1 rectifies, causing a negative voltage (relative to chassis) to be built up across R_1 and R_2 , appearing in full at the junction of R_1 and R_3 . This full voltage is applied, via R_3 and R_1 , to the cathode of V_2 . Half the voltage (split by R_1 and R_2 in series) appears at the anode of V_2 . This anode is therefore positive with respect to its cathode, and V_2 correspondingly conducts.

Also appearing across R_1 and R_2 is the AF modulation voltage obtained by the detecting action of V_1 . As V_2 is conducting, that part of the AF voltage built up across R_2 is passed to its cathode and, when the switch S_1 is set to "On," to the subsequent AF amplifier via C_1 .

When a pulse of interference is received, it is immediately detected by V_1 , causing a correspondingly high negative voltage to be built up across R_1 and R_2 . Half of this high voltage is applied immediately to the anode of V_2 . The cathode of this valve, however, rises only slowly to the negative voltage; this delay being due to the relatively long time constant given by R_3 and C_2 . The anode of the diode therefore becomes more negative than its cathode and it ceases to conduct; thereby cutting off altogether the AF output to the subsequent amplifier. The time constant of R_3 and C_2 is such that the interference pulse will have ceased to exist well before the cathode approaches the voltage at the anode. Thus, after the pulse has finished, the circuit settles down to normal working again.

Detection

Apart from its limiting action, this circuit also offers the correct facilities for second detection. RF decoupling of the AF output is given by the filter C_1 , R_1 and C_3 . The subsequent circuit, (probably a leak or volume control) which follows C_1 should present an input impedance of at least 1 M Ω . (A lower value would reduce fidelity). It is possible that hum may be picked up by the noise limiter components and care should be taken to see that AC leads are kept well away. If necessary, the limiter circuit could be fitted in a screened compartment. The limiter should work just as efficiently if V_2 were replaced by a germanium crystal.

Undelayed AGC can be obtained from the point indicated by the dashed line. Using the recommended value of 2 M Ω for R_3 , the subsequent AGC by-pass capacitor to earth could conveniently be 0.05 or 0.1 μ F.

No. 16 REMOTE MAINS ON-OFF CONTROL

Suggested Circuit No. 16 is designed for switching a mains receiver on and off from a remote position. It uses only two connecting leads, and drain on the energising battery is almost negligible. The two leads could, if desired, be used also for driving an extension loudspeaker.

The Circuit

The basic circuit is shown in Fig. 1. To explain its action, let us assume that the receiver is an AC mains type, using a metal HT rectifier; and that the "remote-local" switch installed in the receiver is set to "remote." The relay used is of the type having a high resistance coil.

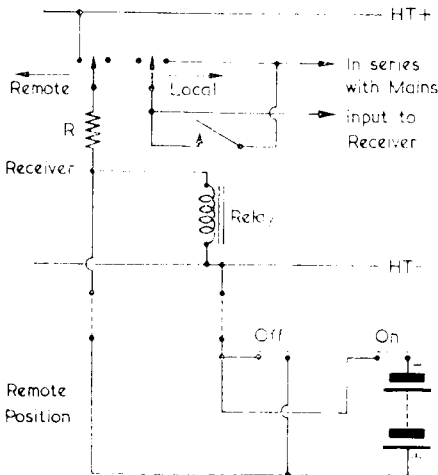
To switch on the receiver, the "On" button at the remote position is pressed. This connects a battery to the relay coil, thus energising it and completing the mains input to the receiver. Owing to the use of a metal rectifier, HT appears almost immediately. This HT voltage is applied, via R, to the relay coil. The value of R and the connections to the energising battery are so chosen that they both apply an equal voltage of the same polarity to the relay coil.

The "On" button is then released, the relay remaining energised by reason of the HT voltage. When it is desired to switch off the receiver, the "Off" button is pressed at the remote position. This short-circuits the coil of the relay, which then de-energises and switches off the receiver. (The resistor R prevents any excessive HT current when the relay coil is short-circuited).

Such is the action of the relay. It will be seen that both buttons have to be pressed for only a very short space of time; the "On" button sufficiently long for an HT voltage to be formed in the receiver, and the "Off" button long enough to allow the HT smoothing capacitors to discharge. However, should a valve instead of a metal rectifier be used in the receiver, it will be necessary to keep the "On" button pressed for a little longer in order to allow it to warm up. This is not too great a disadvantage, as most rectifiers warm up fairly

quickly. A directly-heated rectifier (such as the 5Y3) comes into operation almost immediately after the voltage has been applied to its filament. Indirectly-heated valves of the 5Z4 class (in which the cathode is internally connected to one side of the heater) do not take much longer. Even a valve like the 6X5 commences to rectify fairly quickly.

Nevertheless, in some cases and with certain particular rectifiers some considerable time can elapse before the rectifier commences to work. It would obviously be a nuisance to keep the "On" button depressed for this period, and an alternative circuit is shown in Fig. 2. In this diagram a



SC 21

Fig. 1

switch is used at the remote position and the energising battery is connected all the time that this is switched on. Otherwise the principle is the same as that used in Fig. 1. When the circuit of Fig. 2 is used care should be taken to see that the value of R is such as to apply a voltage across the relay coil as near to that of the energising battery as is possible. Under these conditions, no discharge from the battery should occur as soon as HT appears in the receiver.

5C.22

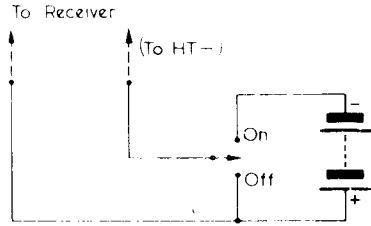


Fig. 2

Practical Points

Little needs to be said about the practical applications of the circuit as it is fairly straight forward and self-explanatory. The relay should be of the usual high-resistance type having a coil of about $2\text{ k}\Omega$ resistance. These relays usually close with a minimum energising voltage of about 20 volts or so. Three 9 volt grid bias batteries at the remote point should give an adequate voltage.

The contacts of most P.O. type relays appear usually to be rather small for mains switching; yet they seem to cope quite well in practice. It is a good plan to have two sets of contacts in parallel on the one relay, one set "making" just before the other. This set of contacts then bears the brunt of whatever arcing may occur at the moment of switching. A relay of this type could not be used for switching a receiver connected to DC mains.

The circuit should not be employed with AC DC receivers, as the remote wiring may become live.

If a high impedance extension speaker outlet is used the speaker wires themselves could be used for controlling the receiver. Should this be done, apart from fitting isolating capacitors, it will also be necessary to use a choke in series with the relay coil in the receiver. A second choke at the remote position will be needed for the circuit of Fig. 2.

AC DC BATTERY POWER SUPPLY

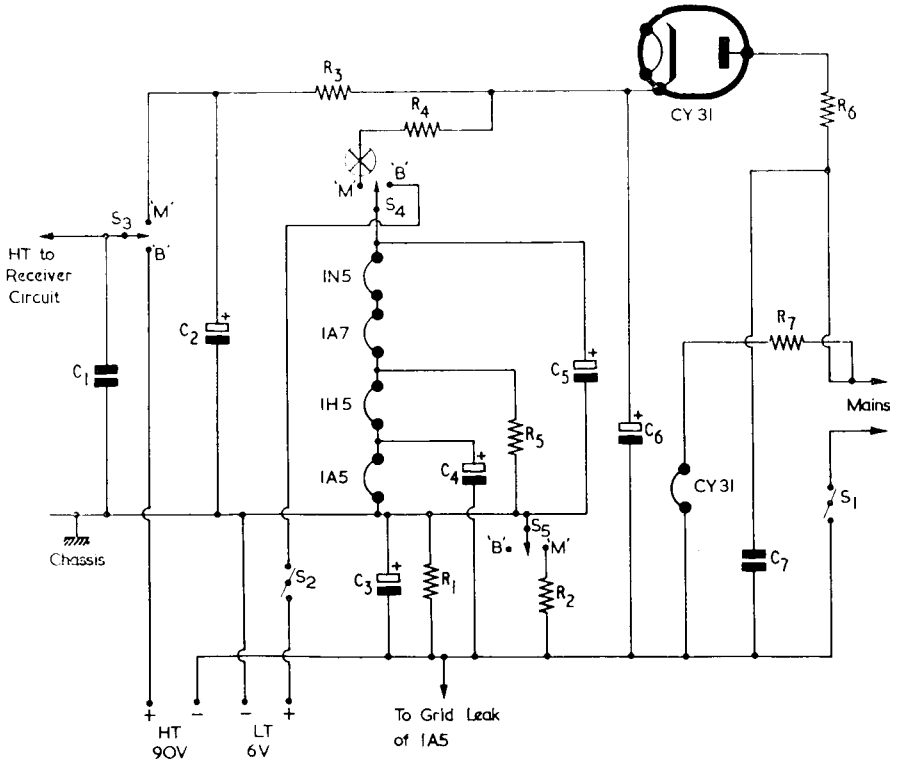
(continued from Page 42)

Only new electrolytic capacitors (or reliable paper capacitors of any reasonable age) should be used for this purpose, as otherwise they may have lower actual values than those printed on their cases. When the correct value has been found a new capacitor again should be installed. The filament current obtained may very gradually drop as this component ages and loses its capacitance; but this process will take a considerable time and is, in any case better than burning out the valves by initially using too large a capacitor.

The Second Detector

It was stated above that the position of the 1H5 in the filament chain automatically ensures correct biasing of the 1A7 and 1N5, and that its grid leak should be returned to filament. To clarify this statement a recommended second detector circuit for the 1H5 is given in Fig. 2. The diode of the 1H5 should be at the positive end of its filament.

No. 17 AC DC BATTERY POWER SUPPLY



SC23

Fig. 1

Components List

Capacitors

C_1	1 μF or more	R_3	14 k Ω ; 5 watts.
C_2	8 μF ; 250 WV.	R_4	4.5 k Ω ; 15 watts.
$C_{3, 4, 5}$	25 μF ; 12 WV.	R_5	1 k Ω ; $\frac{1}{2}$ watt.
C_6	See text.	R_6	150 Ω ; 2 watts.
C_7	0.01 μF ; 350V AC.	R_7	1,050 Ω ; 50 watts.

Resistors

R_1	400 Ω ; $\frac{1}{2}$ watt.
R_2	80 Ω ; $\frac{1}{2}$ watt.

Switches

$S_{1, 2}$	On-off switch
$S_{3, 4, 5}$	Mains/Battery switch.

Valves

1N5 (or DF33)	IF amplifier, (pentode).
1A7 (or DK32)	Frequency-changer, (heptode).
1H5 (or DAC32)	Second detector and AF amplifier, (diode-triode).
1A5 (or DL96)	Output, (pentode).

Suggested Circuit No. 17 illustrates a power supply suitable for use in an AC DC Battery receiver. This circuit allows a four-valve superhet to be operated either from 200 to 250 volt AC or DC mains, or from a 90 volt HT battery and a 6 volt LT battery (two 3 volt units in series). It is considered not worth while including the added complications needed to allow the use of a 1.5 volt LT cell, as this would necessitate both filament and bias switching when changing from mains to battery operation. It is, in any case, usually considered economical to employ a separate LT supply, and this could consist of a 6 volt battery just as easily as it could of a 1.5 volt cell.

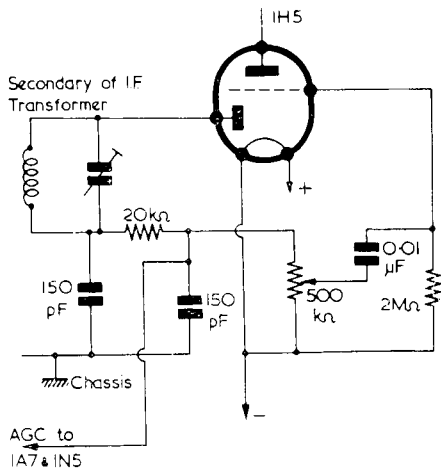
Circuit Details

The superhet circuit proper employs four valves: 1A7, 1N5, 1H5 and 1A5 output. The filaments of these valves are connected in series. Owing to the fact that the combined cathode currents of the 1A7 and the 1N5 pass through the filaments of the 1A5 and the 1H5, these latter are shunted by R_1 , which maintains their filament current at the correct value of 50 mA. The cathode current of the 1N5 by itself at the top of the chain would be too small to affect the filament current of the 1A7 overmuch, and no further filament regulating resistors are fitted.

As the 1A5 takes the greatest cathode current, this valve is connected at the negative end of the chain. The 1H5 takes the least cathode current of all the valves, but it is necessary for it to be connected immediately above the 1A5 in order that a suitable standing voltage for the 1A7 may be available on the AGC line. An AGC voltage may also be applied to the 1N5, should this be desired, with the aid of a potentiometer consisting of two 1 M Ω fixed resistors in series. The potentiometer connects between the AGC line and the positive end of the 1N5 filament, the 1N5 grid being supplied from the junction of the resistors.

The varying AF currents passed by the anode of the 1A5 are liable to build up corresponding voltages across its filament. These voltages could be passed to the filaments of the other valves and so cause audio feedback. It is recommended that the grid leak of the 1H5 be taken to its own filament to reduce this effect. In order to make doubly sure, the filament of the 1A5 is decoupled as well by C_1 . C_1 is taken to the negative end of the bias resistor R_1 instead of to chassis, in order that it may be given a higher polarising voltage. It may be found possible to omit C_1 in some receivers.

Mains Battery switching is effected by S_1 , S_2 and S_3 . This switch does not handle a great deal of current and it could consist of a miniature wave-change type, if desired. It is inadvisable to operate this switch when a mains supply is switched on. Should such an eventuality occur, however, the electrolytic capacitor connected permanently across the filaments (C_2), will prevent a



current surge here. There will, nevertheless, still be an HT surge if C_2 has an opportunity of charging up when the set is switched to battery operation; and this may cause damage to the valves. If possible, a fool-proof arrangement should be made by means of which it is only possible to switch to battery operation when the mains plug is fitted to a housing in the receiver.

When S_3 , S_4 and S_5 are switched to "Battery", the filaments are connected directly to a 6 volt LT battery, and the HT supply to a 90 volt HT battery. Automatic bias (4 volts) for the 1A5 is supplied by reason of the HT current from the negative pole of the HT battery flowing through R_1 . The receiver is switched on and off by S_2 , which breaks the LT current. It is difficult to devise a means of breaking the HT supply because the receiver on-off switch will probably be of the two-pole type fitted to the volume control: the second pole being needed for mains switching. Therefore, on battery operation, the electrolytic capacitor C_2 is disconnected from the HT circuit as it might otherwise discharge the battery whilst the set was switched off. Nevertheless, a capacitor across the HT supply is still desirable in order to prevent instability when the battery runs low. For this reason it is recommended that C_1 be connected permanently across the HT battery: this capacitor being a paper component with a value of at least 1 μ F.

When the receiver is switched to mains operation, the filaments are supplied from the cathode of the CY31 rectifier, the voltage being dropped to the correct value by R_1 . Smoothing of the filament supply is effected by C_6 and C_7 . HT is also supplied from the CY31, this being dropped by R_3 and smoothed by C_4 , C_2 and C_5 . As, now, the filament as well as the HT current would pass through the bias resistor R_1 , the value of this is effectively reduced by switching another resistor, R_2 , in parallel with it.

Mains Components

The rest of the circuit is devoted to the components needed for supplying the CY31. R_4 is a limiter resistor whose purpose consists of reducing the charging pulses passed by the rectifier. R_5 is the dropping resistor for the heater of the CY31 and could consist of one element of a 3-way line cord. C_3 is included to reduce the effect of mains modulation and to reduce mains interference.

The Reservoir Capacitor

It will be noticed that no value has been given for the reservoir capacitor C_6 . This is because the value of this component may be critical, and the writer would rather suggest a means of finding it experimentally than to state an actual value which may not be accurate in practice. The reason for this policy is that if too high a value of reservoir capacitor is used, the rectified voltage on AC may be higher than that given on DC mains, with consequent damage to the valve filaments.

To find the correct value for C_6 , the filament supply line should be broken at the point marked with a cross and a 0-100 millimeter inserted in series. Capacitor C_6 should be short-circuited and a 9 k Ω resistor connected across C_6 . The receiver should be set to mains operation, connected to a 230 or 240 volt AC supply and switched on. To ensure full emission it is worth while using a fairly new rectifier valve and to allow it to warm up for five minutes or so. C_6 should then be experimentally determined, this being done by increasing its value in 2 μ F steps until the current reading in the milliammeter is 50 mA or just below.

(Concluded on Page 39)

No. 18 AF INPUT BY CATHODE INJECTION

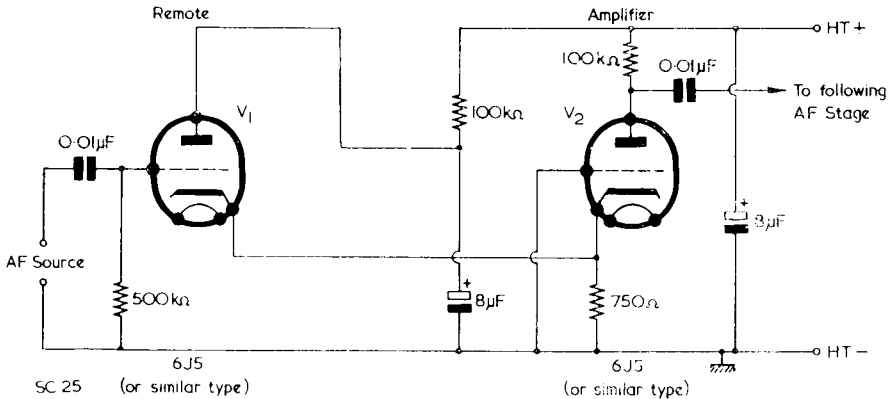


Fig. 1

It frequently happens that relatively long leads connecting one piece of equipment to another are required to carry AF at a high impedance level. This method of connection gives rise to trouble in so far that instability may occur if the leads are unscreened, attenuation of the higher frequencies may be caused by excessive capacitances in the line, and unwanted hum is liable to be picked up. These faults are considerably lessened if the impedance of the line terminations is reduced. The simplest way of doing this consists of fitting transformers at either end of the line.

Transformers, unfortunately, are liable to give rise to trouble in themselves; particularly when they are used in the input circuit of an amplifier. Apart from the fact that they may introduce distortion, they are also, unless heavily screened, susceptible to hum pick-up obtained inductively from neighbouring mains transformers and smoothing chokes.

It is not always necessary to use transformers for impedance conversion, however; and some circuits are shown here which illustrate an alternative system, that of cathode injection.

Fig. 1 illustrates a simple method of passing high impedance AF through low impedance lines with the aid of valves. The AF source shown in the diagram may consist of a gramophone pick-up, a radio feeder unit, or any similar item of equipment whose output is at high impedance. It feeds into V_1 , a cathode follower, the lines being connected between the cathode of this valve and earth. The lines are then taken to the cathode of V_2 , across the anode load of which the AF appears at a high impedance once more. V_1 offers no voltage amplification but V_2 gives approximately as much gain as it would if used as a straightforward amplifier. In many cases, therefore, V_2 can replace the first valve in the amplifier.

It will be noticed that the 750Ω cathode resistor is common to both V_1 and V_2 . This is quite permissible when the lines have little or no resistance. The common resistor has, of course, half the value of that which would normally be employed with a single valve. In Fig. 1, the impedance at which the lines work is 750Ω . If it is desired to reduce this impedance a resistor and capacitor can be connected across the cathode resistor, as shown in Fig. 2. This circuit still allows the valve, or valves, to remain correctly biased. The new impedance is equal to the value given by the two resistors in parallel. Lowering the impedance will cause the gain of V_2 to be reduced.

splitter usually feeds the output valves directly; or the phase-splitter may be employed immediately after the detector, whereupon several AF amplifying stages in push-pull are usually required to bring the signal to loudspeaker strength.

This circuit illustrates an alternative system, by means of which phase-splitting is obtained at the detector itself. Such a system has several advantages, the most important of these being that all the following AF amplification is carried out by push-pull circuits. The circuit is at its most useful when detection occurs at a high RF voltage level. In this case the detected AF has a relatively high voltage, and subsequent AF amplification need consist only of two output valves in push-pull; almost ideal conditions being obtained when these valves are triodes (possibly with negative feedback) giving consequent harmonic cancellation in the speaker transformer.

The provision of a high RF voltage to the detector does not present many problems. Sufficient RF voltage should be obtained on local stations from a frequency-changer and IF stage alone, provided that a good aerial is used and AGC is dispensed with. Two RF stages in a TRF circuit may, if well-designed, possibly give nearly as high a voltage.

Advantages

Even when used in a normal AGC controlled superhet, the circuit still shows its advantages. These are given by the fact that the following AF amplification is in push-pull (as mentioned above), that the necessity for an additional phase-splitting valve is avoided, that the only distortion introduced is that given by a normal diode circuit (this distortion usually appearing only at very low signal levels or on the reception of heavily modulated carriers), and that hum which may be picked up by the cathode of an AF phase-splitter does not occur in this circuit.

Components

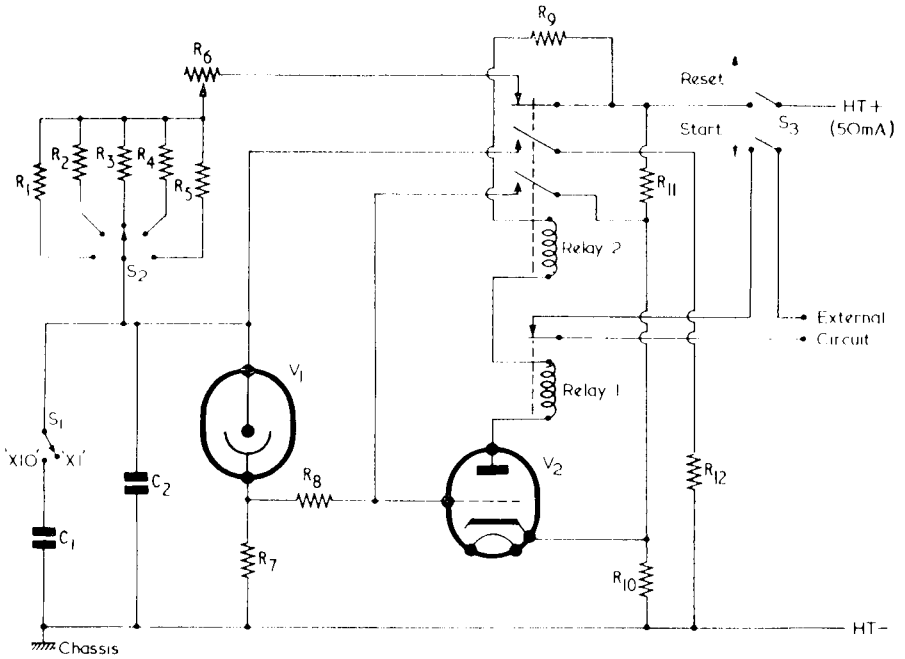
It should be noted that the detector employs a volume control, R_3 , R_4 , comprising two ganged potentiometers. Ganged volume controls of the type currently fitted to stereo amplifiers are readily available, and these will be perfectly satisfactory for the circuit discussed here.

The detector will function equally well if a germanium diode is employed in place of the thermionic diode shown in the diagram.

Functioning

The functioning of the circuit is almost self-explanatory. The diode load is made up by the two resistors R_2 and R_1 in series. By centre-tapping these resistors and arranging the other detection components symmetrically about the centre-tap, phase-splitting is automatically ensured. The tuned circuit feeding the detector should not, of course, be centre-tapped, and it should be free from chassis. If AGC is desired this may be obtained via R_7 . The high value shown for this resistor is recommended in order to prevent it upsetting the balance of the circuit. When AGC is not required, R_7 and C_2 can be omitted.

No. 20 PRODUCTION ELECTRONIC TIMER



IC 29

Components List

Capacitors

C_1 18 μF

C_2 2 μF

Resistors

R_1 250 $\text{k}\Omega$, $\frac{1}{2}$ watt

R_2 1 $\text{M}\Omega$, $\frac{1}{2}$ watt

R_3 2 $\text{M}\Omega$, $\frac{1}{2}$ watt

R_4 3 $\text{M}\Omega$, $\frac{1}{2}$ watt

R_5 4 $\text{M}\Omega$, $\frac{1}{2}$ watt

R_6 1 $\text{M}\Omega$, variable

R_7 1 $\text{M}\Omega$, $\frac{1}{2}$ watt

R_8 1 $\text{M}\Omega$, $\frac{1}{2}$ watt

R_9 25 $\text{k}\Omega$, $\frac{1}{2}$ watt

R_{10} 200 Ω , $\frac{1}{2}$ watt

R_{11} 7.5 $\text{k}\Omega$, 10 watts

R_{12} 200 Ω , 5 watts

Valves

V_1 Neon bulb (see text)

V_2 Triode: 6J5, etc.

Relays

Relay 1 High-Speed (1 Break contact)

Relay 2 Normal (1 Break, 2 Make contacts)

Switches

S_1 Scale Multiplier

S_2 Range Selector

S_3 "Start-Reset" Switch, Tumbler.

This Suggested Circuit is that of an electronic timer capable of offering a continuously variable range from 0.5 to 100 seconds. Should it be so desired, this range may be increased. It may also, on the other hand, be reduced, with consequent simplification and cheaper cost. The lower (shorter) end of the scale is limited, however, by the capabilities of the switching relay. Operation is simple, semi-automatic, and practically foolproof. An important feature of the circuit is that energising of the switching relay at the end of the timing period is achieved with an abrupt increase of current instead of a gradual rise, as occurs in many timers. In consequence, timing periods may be repeated with a higher degree of accuracy.

Operation

Before the timer can be brought into operation it must be set up. This necessitates, first of all, the provision of LT and HT supplies from a separate power supply circuit (not shown in the diagram), these being applied for sufficiently long to enable V_2 to warm up. The "Reset-Start" switch, S_3 , should be put to "Reset," and the external circuit being timed connected to the appropriate terminals. Finally, the range controls, S_1 , S_2 and R_6 , are set to the timing period required.

When the circuit is in this state, S_3 prevents the application of HT to the timer. At the same time it also keeps the "External Circuit" terminals open.

To start the timing operation, S_3 is thrown to the "Start" position, whereupon its lower contact closes the external circuit. Its upper contact simultaneously allows HT to be passed to the RC network (R_1 to R_6 and C_1 , C_2), with the result that the capacitance component of this network commences to charge. HT is also applied to the anode of V_2 (via R_4 and the coils of Relays 1 and 2). V_2 , however, has its grid taken to chassis via R_7 and R_7 whilst its cathode is connected to a positive point in the voltage divider R_{10} , R_{11} . The bias resulting from this arrangement prevents the valve from drawing sufficient anode current to energise either of the relays.

RANGE TABLE

(These ranges are selected by S_2
with S_1 set to the "X1" position)

Range 1	..	0.5 to 2.5 secs.
Range 2	..	2 to 4 secs.
Range 3	..	4 to 6 secs.
Range 4	..	6 to 8 secs.
Range 5	..	8 to 10 secs.

As mentioned above, the capacitance component of the RC network has commenced to charge. Its rate of charge is controlled by the resistor network, R_1 to R_6 . When the voltage across the capacitance component reaches the striking value of V_1 this latter conducts and correspondingly draws current. This current passes through R_2 , causing a voltage to be built up across it. The upper end of R_2 assumes therefore a positive potential (relative to chassis), this potential being applied to the grid of V_2 via R_7 . The anode current of V_2 immediately increases, energising Relays 1 and 2. Relay 1, being a high-speed component, operates at once, its break contact opening the "External Circuit" terminals. Relay 2 energises as quickly as its design allows; and its lower contact connects the grid of V_2 to its cathode, thus ensuring that this valve still continues to keep the relays energised irrespective of whatever voltage may

subsequently appear across R_7 . The upper contact of Relay 2 breaks the HT supply to the RC network: whilst its centre contact effectively short-circuits the capacitance component through the $200\ \Omega$ resistor, R_{12} , causing it to discharge.

The timing cycle is now almost complete. The circuit has reached a stable condition, the two relays remaining energised by the anode current of V_2 , whilst the capacitance component has become discharged. To bring the timing circuit back to its original state, S_1 is thrown to the "Reset" position. This breaks the HT supply to V_2 and the relays de-energise. The "External Circuit" terminals still remain open, of course, by virtue of the lower contact of S_3 .

To commence a further timing cycle, it is necessary merely to set S_1 to "start" again.

Circuit Details

It will have been noticed that the brief details of operation given do not account completely for the values chosen for, or even for the presence of, some of the circuit components. This point will now be dealt with.

The first item of importance lies in the fact that two relays are used where one might presumably be sufficient by itself. This procedure has been adopted because, for timing short periods, a high-speed relay is essential for switching the external circuit; and high-speed relays rarely possess anything more complicated than simple changeover contacts. Relay 2 is used for a different purpose, that of ensuring automatic working, and its speed of operation is comparatively unimportant. When short periods are not required from the timer, Relay 1 could conceivably be omitted, an additional break contact being fitted to Relay 2 to control the external circuit switching. When used as shown here, Relay 1 could perhaps consist of one of the sensitive model-control relays which are now being advertised at fairly cheap prices. Relay 2 may be a normal relay (with a high-resistance coil) of the type which is capable of being actuated by anode currents.

As was mentioned above, a standing cathode bias is applied to V_2 by R_{10} and R_{11} . Assuming a 250-volt HT supply, this arrangement would give a bias voltage of slightly more than 6 volts. When the neon bulb strikes, the resulting voltage built up across R_7 will almost certainly be in excess of 6 volts. Excessive grid current is, however, prevented by R_8 . The presence of this resistor also ensures correct operation of the neon bulb after striking.

It will be seen that, when the neon strikes, the bias applied to V_2 changes from 6 to zero volts. The variation in anode current resulting from this change should be more than sufficient to ensure positive operation of the relays. Nevertheless, when zero bias is applied to V_2 , it is possible that the valve may pass excessive anode current, with harmful results. This current is kept within safe bounds, however, by reason of R_9 . The value recommended here for this resistor limits the possible anode current to 10 mA. If very sensitive relays are used, the value of R_9 may be increased with a consequently longer valve life.

The neon bulb is an important component. Not all neons may strike reliably with a series resistor as high in value as $1\ M\Omega$ and a little experimental selection may be needed. Neon stabiliser valves may cope, but it is suggested that best results may possibly be given by the sensitive neons used by electricians for checking for "live" mains points. (The high value of series resistor is needed to prevent the possibility of the capacitance component discharging to below the burning value of the neon before Relay 2 has energised).

The Time Constant Components

The range periods shown in the table accompanying this article have been worked out on the assumption that the neon strikes when the capacitance component has reached the voltage which corresponds to the mathematically accepted time constant of the RC circuit. In a series RC circuit this value is equal to 0.63 of the applied charging voltage. Working to this assumption makes calculations very simple, as the charging time in seconds is then equal to the capacitance in μF multiplied by the series resistance in $\text{M}\Omega$. A further advantage is given by the fact that a relatively reliable portion of the charging curve is used. When working under these conditions it is necessary for the applied HT to be 1.58 times the striking voltage of the neon (the latter being found empirically elsewhere). In practice, such a state of affairs can hardly be obtained with any accuracy, but it would be worth while to attempt a fair approximation.

The variable resistor, R_{10} , is also an important component, and it should be well-made and robust. The maximum possible current which it will have to pass is an instantaneous one of approximately 1 mA, this occurring when the timer is set to 0.5 seconds. R_{10} is used to give a continuously variable control of timing and will need five separate scales, each calibrated in terms of the range selected by S_2 . Calibration may be obtained by measurements of resistance and capacitance and calculation; or by stop-watch. The former method will, in any case, be necessary for the shorter time periods, whilst the latter may be used for checking results. R_1 is included to limit the maximum current passed by R_{10} . The resistors R_1 to R_7 may be high-tolerance, if desired; although low-tolerance components could be used just as well, discrepancies being taken up in the calibration of R_{10} . If R_{10} has a value slightly in excess of $1 \text{ M}\Omega$ a small, but desirable, range overlap will be obtained.

The Capacitance Component

It is, of course, very important to ensure that both C_1 and C_2 have no leaks whatsoever. Paper components should be used. When long timing periods are not required the multiplying circuit may be omitted. This can be done by excluding S_1 and C_1 from the circuit.

A final important point lies in the discharging of the capacitance component through R_{12} after Relay 2 has de-energised in the timing cycle. Although this discharge will be quick it still follows an exponential law, and it would be advisable to allow a second to elapse after Relay 2 has de-energised before putting S_2 to "Reset", since this procedure would then ensure that a really adequate discharge had taken place. A longer pause than this will occur automatically in most instances, as the timed material would usually have to be handled between timing cycles.

Power Supplies

The HT power supply circuit is not shown here as it can be fairly conventional. Its voltage stability must be high. Voltage regulation during the charging period will be assisted by the presence of R_{10} and R_{11} , which take a relatively heavy current. When very accurate timing cycles are required, or when the mains supply voltage is obviously unreliable, the HT output should be stabilised.

