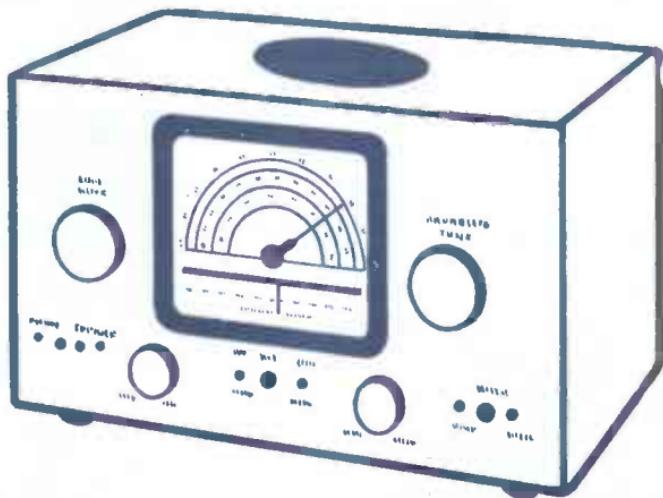


# MODERN BATTERY



# RECEIVERS' MANUAL

PUBLICATION NO 71

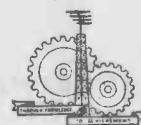
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MODERN BATTERY RECEIVERS' MANUAL

# MODERN BATTERY RECEIVERS' MANUAL

by

EDWIN N. BRADLEY



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# MODERN BATTERY RECEIVERS' MANUAL

## CHAPTER I

### MODERN BATTERY VALVES

That the days of the Battery Radio Receiver are by no means over is a self-evident fact to the country dweller, and the townsman, in these days of fuel shortage, is also discovering that the battery set is by no means a back number. At the same time, the technical Press appears to concern itself but little with publishing new designs and ideas for the battery receiver constructor, so that it is felt that there is, especially in country districts, a demand for a book of this type.

A glance through the chapter headings will show that we have placed no restrictions on the range of receivers and gear to be described. Besides dealing with the straightforward T.R.F. and the superhet, receiver for home entertainment, there are details given concerning portable receivers, small communications receivers, short-wave receivers and even Very High Frequency receivers for the amateur who wishes to specialise, whilst battery operated record players and signal generators are not forgotten.

Considerable advances have been made in valve design and manufacture, and with the present range of 1.4 volt heater valves, battery sets and apparatus can be made smaller, and more efficient, than ever before. Such valves are readily obtainable from good stores and also as Government war surplus, when they may be bought at bargain prices with suitably attached gear, such as low wattage resistors, small low voltage capacitors and even highly efficient midget I.F. transformers with adjustable powdered iron cores. At the same time, these valve types—often known as "Peanut" valves—are still not as widely known as they deserve, and no apology is needed for setting forth the working conditions in the table below of the more common 1.4 volt valves. A more detailed valve list will be found in Messrs. Bernard's publication No. 30, "The Radio Valve Manual," price 3/6.

No.	Valve	Operation.	Va.	Ia.	Vs.	Is.	Vg.	Gm.	mA/V.
	1R5.	Pentagrid.	90	0.8	45	1.8	0	Conver.	0.25
	1S5.	Diode-Pentode.						Supply the pentode, as voltage amplifier,	
								thro' 1 meg. anode resistance with up to 90	
								volts, with screen resistor of 3 megs. and	
								grid resistor of 10 megs. Volts gain, 30.	
	1T4.	Var-mu. R.F. Pentode	90	2.0	45	0.65	0		0.75
	3S4.	Power Pentode.	90	7.4	67.5	1.4	—7		1.58
								Output load, 8,000 ohms, output, 0.27 watt.	

The filaments of all the above valves require 50 mA.s. at 1.4 volts except for the 3S4, which requires either 50 mA.s. at 2.8 (say 3 volts) or

100 mAs. at 1.4 volts. The filament arrangement will be understood if reference is made to Fig. 1 where the connections to the valves are shown. It will be seen that the 3S4 has a centre tapped filament, so that either 3 volts may be applied right across the filament, or valve-holder points 1 and 7 may be connected together and 1.4 volts applied between this common connection and the filament centre tap, point 5.

The fact that dry cells may be used for filament supplies with these valves is a great saving both in space and convenience and, in the case of

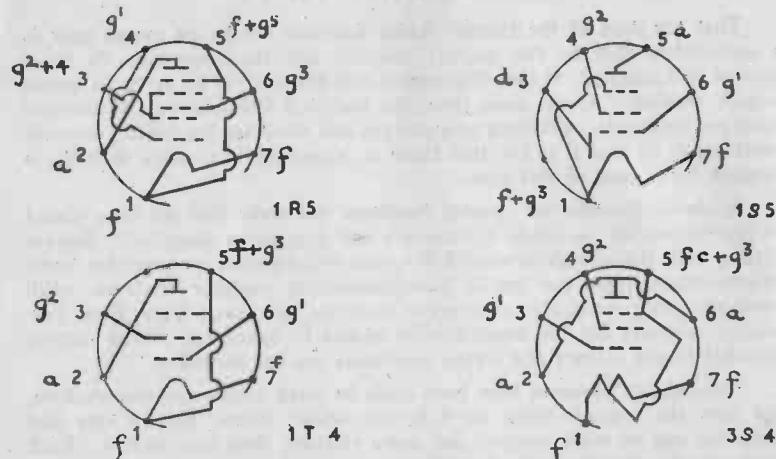


FIG. 1. Base connections, viewed from below, of B7G, based 1.4 Volt Valves.

the portable receiver, of weight, since an accumulator which is bulky, messy and which requires frequent recharging, may be replaced by a unit as small as the Ever-Ready Cell U.2. With several filaments working from such a cell, the filaments being connected in parallel of course, the cell life will not be great, but since replacements are readily available at a price of about 4d. this is no real disadvantage. On the other hand, there may be obtained filament batteries designed especially for use with 1.4 volt valves, with small two-way socket connectors into which may be fitted a small two-pin plug.

The 1S5 diode pentode is a particularly interesting valve, since it will take the place of a diode-triode in a battery superhet, and feed a strong signal into the output valve. Alternatively, this valve can be used to give good headphone reception by strapping the anode and screen leads together and running them straight to about 45 volts H.T. through a pair of high impedance headphones.

Whilst there are several types of holder available for the peanut valves, the writer favours the ceramic base with a metal screening tube type of holder. These give good insulation for D.C. and R.F., screen the valve to

some extent, grip it very firmly and also give a good measure of protection. The peanut valves are glass footed with wire leads brought straight out through the glass, the leads themselves acting as small diameter pins which are inserted into the 7-way valve holders. This method of construction means that a due care must be exercised when handling the valves and withdrawing them from their sockets.

Other 1.4 volt valves very similar in characteristics to those already listed are the 1A7G (Mullard DK32), the 1N5G (Mullard DF33), the 1H5G (Mullard DAC32) and the 1C5G (Mullard DL35), one of the chief differences being that these valves are octal based and plug into International octal holders in the usual manner. For the reader's convenience their working conditions are listed below.

Valve No.	Operation.	Va.	Ia.	Vs.	Is.	Vg.	Gm.mA/V.
1A7G	Pentagrid.	90	0.55	45	0.6	0	Conver. con. 0.25
1N5G	R.F. Pentode.	90	1.2	90	0.3	0	0.75
1H5G	Diode-Triode.	90	0.15	—	—	0	0.275
1C5G	Power-Pentode.	90	7.5	90	1.6	-7	1.55

Output load, 8,000 ohms, output, 0.24 watt.

The first three of these valves require a filament current of 50 mAs. at 1.4 volts, whilst the Output Pentode requires 100 mAs. at the same filament voltage.

The valve-holder connections are shown in Fig. 2.

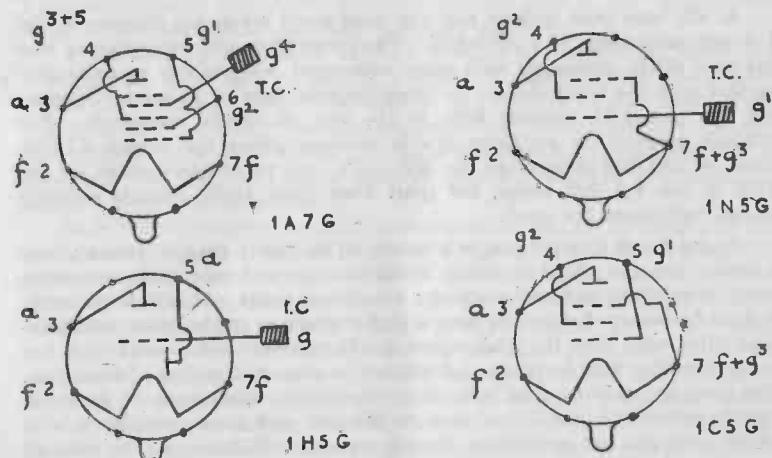


FIG. 2. Base connections, viewed from below, of Octal 1.4 Volt Valves.

The quarter watt or so output available from the 3S4 or the 1C5G is sufficient for many purposes and will operate a small moving coil speaker with good results, especially if a speaker such as the Electro-Acoustics special 5" model is obtained, which, complete with output transformer, is priced at 32/6. (Electro-Acoustic Industries, Stamford Works, Broad Lane, Tottenham, London, N.15.)

Where greater outputs are necessary, however, recourse must be made to the use of 2 volt battery valves, and if a 2 volt output valve is to be used it is only convenient to use 2 volt filament valves throughout the whole circuit. In this case an accumulator rather than a dry battery filament supply source must be used. The many 2 volt valves available are so well known that there would be no useful purpose served by selecting some types for listing here. Special attention is drawn, however, to the Mazda double-pentodes, QP230 and QP25, which are rated to give outputs of, respectively, 0.86 and 0.94 watt. The respective output loads are, anode to anode, 17,000 and 16,000 ohms.

Two volt filament double-diode valves are obtainable—for example, the Mazda DD207—but, in general, when it is desirable to use a diode detector an economy can be effected by using a double-diode triode such as the Mazda HL21/DD or HL23/DD for 2 volt operation. The HL21/DD requires a rather greater filament current, but gives slightly greater gain, giving an amplification factor of 32 with a heater current of 0.15 amp., against the amplification factor of 25 for a filament current of 0.05 amp. for the HL23/DD.

Single-diode triodes and pentodes are found in the peanut 1.4 volt range, but since detection and A.V.C. can both be obtained from a single diode this is no drawback.

It will have been noticed that the most usual frequency changer in the 1.4 volt valve range is a pentagrid. The constructor and experimenter who has been chiefly concerned with mains equipment will possibly be more conversant with the triode-hexode or triode-heptode type of frequency changer, but the pentagrid requires little in the way of special treatment. The gridleak between the oscillator grid is increased above the normal 47,000 ohms to 200,000 ohms or so, for the 1A7G, and to 100,000 ohms for the 1R5 in the 1.4 volt range, but apart from these slight changes ordinary circuit techniques are used.

In the 2-volt filament ranges a variety of frequency changer valves allows a choice between triode-pentodes, triode-hexodes and pentagrids, the valve being selected to suit the particular conditions under which it is to work. A good frequency changer will have a high conversion conductance, will introduce little noise into the final output of the receiver, will require only low power from the local oscillator and will not be subject to pulling of frequency. The pentagrid may be used as a mixer—oscillator, when some of its grids, usually numbers 1 and 2, are used as the grid and plate respectively of a triode oscillator, or oscillations from a separate oscillator may be injected into the valve through its first grid. The latter method of frequency conversion is not much used for the broadcast bands, but is found to be more

efficient for high frequency working, when the isolation of the oscillator from the mixer circuits renders frequency pulling less likely.

In both the 1.4 and 2 volt valve ranges straight and variable-mu R.F. pentodes are available. In general variable-mu valves will be used for I.F. amplification when A.V.C. is to be applied, but, broadly speaking, whether the valve is for R.F. or I.F. amplification the characteristics should include a high anode resistance and a high mutual conductance for high gain and good selectivity.

## CHAPTER II

### THE T.R.F. RECEIVER.

The simplest type of receiver for use on any frequency band is the regenerative detector, and this, extended and improved by the addition of one or more R.F. stages and an output stage, becomes the T.R.F. (Tuned Radio Frequency) receiver.

The addition of R.F. amplifying stages has several effects. In the first place the original signal is amplified in its original form, as a modulated carrier wave, so that a greater amplitude of carrier is passed on to the detector valve for demodulation, but at the same time the selectivity of the whole receiver is enhanced simply because the single tuned circuit of an oscillating detector is preceded by at least one other tuned circuit and possibly more, and it is well known to the reader that tuning is progressively sharpened as further tuned circuits are added to a receiver.

It is possible to use untuned R.F. amplifying stages, at one time quite a common practice in portable receivers, but this type of R.F. stage is now found only in specialised very high frequency receivers.

When working with mains valves it is found that whilst the addition of a single R.F. stage to a receiver is a relatively simple matter, the addition of two R.F. stages is much more difficult, and there are often troubles with instability and feedback. The gain obtained from battery valves is less than that obtained from mains valves, and so instability is less likely, but even so a receiver with two R.F. stages must be carefully designed and made, and decoupling must be employed.

In a T.R.F. receiver, however, a considerable part of the total gain can come from the regenerative detector, and this stage may rightly be regarded as the heart of the receiver. A T.R.F. set can, of course, have a diode detector, but the very great increase in signal strength obtained from a triode with reaction is usually not only desirable, but necessary.

A reacting detector also gives a further increase in selectivity, the tuning characteristic of the detector stage itself sharpening as the reaction control is advanced towards the oscillating point, and so the quality enthusiast who is forced to work with battery gear may require a diode detector. This means that more than one R.F. stage is necessary for the quality battery receiver, although selectivity must be only sufficient for correct station separation. This brings forward the fact which the writer has stated in other of these

books—a receiver should really be designed to suit both the chief requirements of its user and also the conditions at the locality where it is to be used.

At the same time, the usual demand is for a set which will bring in as many stations as possible, all well separated, at as great a volume as possible with economical use of batteries, and since, in any case, the battery receiver user is usually located at a distance from even his local station, this is the type of set on which the writer has chiefly concentrated.

#### REGENERATIVE DETECTORS

As a single valve receiver, the regenerative detector can give extremely good results, especially for short wave operation. Short wave receivers are dealt with in a later chapter, however, and for the present these remarks must refer only to broadcast reception. One drawback of the single valve receiver is that only headphone reception is given unless a "trick" circuit is used, but even so, the one valve set can be used as a bedside or standby receiver and is also an invaluable starting point for the newcomer to radio construction.

Two types of regenerative detectors are shown in Fig. 3, the first employing a triode and the second a pentode valve. (An R.F. pentode is used, of course). The circuits are basically identical in that reaction is obtained by positive feedback from a coil in the anode circuit wound close to the grid or tuned coil, whilst grid-leak detection takes place. The grid and cathode of the valve act as a diode, thus rectifying the radio frequency signal, whilst the consequent flow of current through the grid leak,  $R_1$  in both circuits, gives the grid a negative bias. The grid capacitor maintains this bias on the grid and the time constant of the grid capacitor ( $C_1$ ), and the grid leak is so chosen that the bias remains relatively steady, when compared against the extremely rapid fluctuations of radio frequency, although the potential set up across  $R_1$  is actually varying in step with the audio modulation of the modulated carrier wave. The audio signal is thus imposed upon the grid and is amplified by the valve, the amplified output appearing at the anode.

The chief difference between the circuits is that the triode has a "throttle" reaction control,  $C_3$  in the triode circuit being a variable capacitor. As the capacitance of  $C_3$  is increased, the feedback from the anode to the grid coil is also increased until a critical point is reached and the whole circuit bursts into oscillation. The correct setting for  $C_3$  is just below this point,  $C_3$  being backed off as the required signal is tuned since this capacitor also acts as a volume control.

In the R.F. pentode circuit  $C_3$  is a fixed by-pass capacitor sufficiently large in capacitance to cause oscillation when the valve is working normally, and the degree of reaction applied is controlled in this case by the variable potentiometer through which the screening grid of the valve is supplied with H.T., the screen potential controlling the action of the anode circuit. As the screen potential is increased so the critical reaction point is approached, and this type of control is preferred by many workers on account of its smooth action.

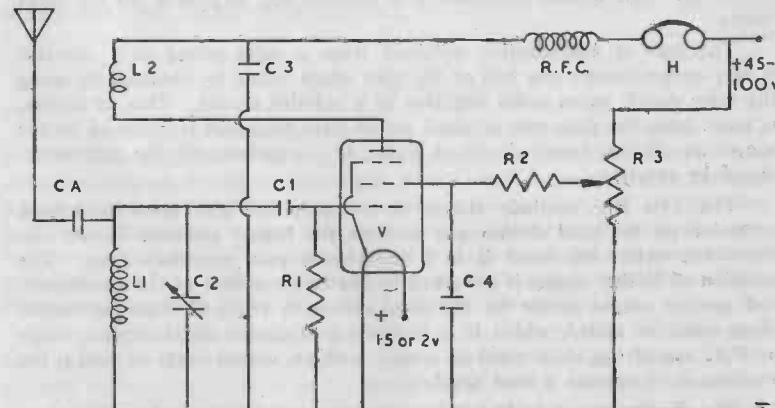
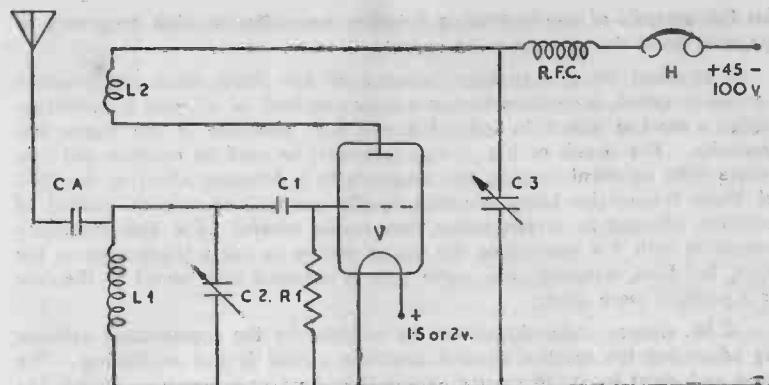


FIG. 3. Triode and R.F. Pentode Oscillating Detectors.

A good regenerative detector has smooth control right up to and past the critical point, whilst varying the degree of reaction has no effect (or very little) on the tuning of the grid circuit. A poor circuit, on the other hand, "plops" into reaction as soon as the critical point is reached, gives "threshold howl"—a squeal as reaction is advanced to the oscillating point—and shows a marked effect on the tuning in the grid circuit as the reaction control is varied. Another annoying defect is "hand capacity." As the hand is approached towards the controls either the tuning or the degree of reaction is affected. The cure for this trouble is to use a good metal panel

for the controls of any oscillating detector, no matter at what frequency or on what band the receiver is to operate.

The effect on grid tuning, detuning off the signal when the reaction control is varied, is perhaps the most annoying fault of all, and is, unfortunately, a marked defect in some 1.4 volt R.F. pentodes at the higher frequencies. The circuit of Fig. 3 can, however, be used on medium and long waves with excellent results, any tendency to a detuning effect in the 1T4 at these frequencies being obviated by the particularly smooth control of reaction afforded by screen rather than anode control. For high frequency operation with 1.4 volt valves the writer prefers to use a triode such as the 1G4, but then, naturally, less audio gain is obtained than would be the case if a pentode were used.

C.W. (Morse code) signals can be received by the regenerative detector by advancing the reaction control until the circuit is just oscillating. The long and short bursts of carrier energy then beat or heterodyne against the local oscillations generated in the circuit to give an audible note, the frequency of the note being under control within limits by tuning the grid circuit of the detector slightly to one side or the other of the central carrier frequency. This type of reception is of greatest use, of course, on the short waves.

The gain or amplification obtained from a valve acting as a detector is very approximately one half of the gain which would be obtained by using the valve purely as an audio amplifier in a suitable circuit. This, of course, is apart from the gain over original signal strength which is obtained by the use of an efficient tuned circuit of high "Q" together with the gain introduced by reaction.

The 1T4 R.F. pentode circuit as it stands will give good headphone reception on the local station and also on the higher powered distant stations—the writer has used it in a notoriously poor reception area. The addition of further stages is governed by the requirements of the constructor—if greater output power on the local station is required, then an output stage must be added, whilst if it is desired to extend the reception range an R.F. amplifying stage must be added, with an output stage as well if the receiver is to operate a loud speaker.

The circuits shown in Fig. 3 may also be used for 2 volt filament valves without any change in their component values, although a greater H.T. voltage may be used on 2 volt valves than on 1.4 volt types. So far as the regenerative detector is concerned, however, it is often found that a low H.T. voltage gives much better reaction control with very little sacrifice of audio gain. When a multi-valve set is designed the detector H.T. may be reduced in one of several ways—the H.T. line from the detector stage can be taken to a lower tapping on the battery, the valve can be fed from a fixed voltage divider or the coupling into the next stage can be designed in such a way that an anode resistance is used both to give an H.T. voltage drop at the valve's anode whilst affording the necessary coupling.

The coupling of the detector into an output stage requires some consideration, and is dealt with under the heading of The Output Stage.

### Components Lists for the Circuits of Fig. 3.

L1, L2, Ca,	Tuning and reaction coils. Aerial coupling condenser. Use value between 0.0001 mfd. and 0.001 mfd. depending on aerial size and local conditions.
C1,	0.0005 mfd. Mica.
C2,	0.0005 mfd. variable tuner.
C3, (Triode) (Pentode)	0.0005 mfd. variable condenser.
C4,	0.0005 mfd. fixed Mica.
R1,	1 mfd. Non-inductive.
R2,	2.2 megohms, $\frac{1}{2}$ watt.
R3,	47,000 ohms, $\frac{1}{2}$ watt.
R.F.C.	0.5 megohm, variable.
H,	Broadcast R.F. choke.
	High Impedance Headphones.

#### Valves :—

Battery triode detectors, 1.4 or 2 volt, or R.F. Pentodes, 1.4 or 2 volt, such as the 1T4, 1N5G, SP2, etc., etc.

### THE OUTPUT STAGE

For use with the regenerative detector, two types of output stage are available. The first type is a further voltage amplifier to give better headphone reception without providing the output power which is necessary to operate a loudspeaker, when a triode, or a pentode of the R.F. variety, can be used in a stage which will require very little extra H.T. current over the detector valve's requirements. The second type of output stage is that where a power pentode is used to provide sufficient power for loudspeaker operation, with a consequent relatively heavy extra H.T. current consumption.

The "super-power" triode type of valve is now little used. The current consumption is heavy and a further audio amplifying stage is needed to provide sufficient grid input to the large triode. It is more economical to use a driver valve feeding into a double pentode in a push-pull circuit, using one of the QP double pentode types.

The coupling between the detector and the output or driver stage must be arranged to suit the detector valve, the chief factor being the internal resistance or anode impedance of the detector. A valve with a relatively low anode impedance requires also a relatively low optimum load in the anode circuit—a usual figure for the anode load, so far as a triode is concerned, is four times the internal impedance—so that for a triode valve audio transformer coupling is quite suitable. The transformer primary, connected in series with the H.T. supply and the detector anode has a fairly low D.C. resistance, so that current is passed to the detector without a high voltage drop across the transformer, the transformer presenting a correct order of load impedance so far as the audio modulation frequencies are concerned.

Where a high impedance triode or an R.F. pentode is being used as the detector, however, the anode load will require to be much higher, and so an audio transformer will not load the circuit correctly, with the results that the detector will operate inefficiently and there will be a loss in the transfer of signal voltages from detector anode to the following grid. Choke coupling or resistance-capacitance coupling must be used for pentodes and high impedance triodes. If the detector valve requires a fairly high current choke coupling is to be preferred, for then the choke can have a low D.C. resistance to pass the current to the valve whilst the impedance to audio frequencies can be very high. If, on the other hand, the valve can operate with a low current, or, alternatively, the receiver is operating from a battery with a total voltage higher than is necessary for straight operation of the detector, then the anode load can be a high resistance, the detector H.T. line being taken to the full battery voltage instead of to a tapping down the battery.

A high impedance triode (also, generally, this will mean that the triode has quite a high amplification factor) is usually found not as the detector itself, but as part of a diode-triode valve, where the diode acts as the detector and the triode forms the stage of audio amplification immediately following the diode. One such valve is the IH5G, where the triode can be fed from the H.T. line at 90 volts through a 330,000 ohms resistance. A similar example is the 1S5 diode pentode, where the anode load is formed by a 1 megohm resistance. Where a valve such as the 1T4 is used as an oscillating detector, however, choke coupling may be used if the battery voltage is low—with a 22½ volt battery, for example—whilst if a 90 volt battery is used, then a resistance may be included in series with the anode. A simple measurement shows that the 1T4 will still operate satisfactorily as an oscillating detector with a total anode and screen current consumption of only 0.25 mA., so that a resistance of the order of 220,000, or even 330,000, ohms can be used as the anode load for such a detector, providing that the stage is supplied from a 90 volt battery.

A voltage amplifier and a power amplifier are essentially similar, even though the first will supply only headphones and the second will operate a loudspeaker. An R.F. pentode will make a satisfactory voltage amplifier; the 1T4, for example, might again be used, but a power pentode such as the 3S4 must be used for the power output stage.

In both cases the stage must be correctly loaded. The voltage amplifier stage should have a choke or resistance load with the headphones parallel fed through a capacitor, whilst the power output stage will obviously be coupled to the loudspeaker through the correct transformer ratio.

It may be as well at this point to repeat the formula used to calculate the ratio output transformer. Neglecting D.C. resistances of each of the transformer windings and transformer losses, the required ratio is given by

$$\text{Ratio} = \sqrt{\frac{\text{Optimum anode load}}{\text{Voice coil impedance}}}$$

Both the 3S4 and the 1C5G require output loads of 8,000 ohms. To couple such a valve to a loudspeaker with a 3 ohm voice coil, a transformer must be used with the ratio

$$\text{Ratio} = \sqrt{\frac{8,000}{3}}$$

$$= \sqrt{2,666.6}$$

= 51.64 so that a transformer with the ratio of 51: 1 or, say, 50: 1 would be suitable.

Different output stages with different couplings to the detector valve are shown in Figs. 4, 5 and 6, where transformer, choke and R.C. couplings are shown. The circuits are shown in full with complete components lists and may be used as small two valve receivers as they stand, although for really good loudspeaker operation the circuit of Fig. 6 should be used in a good reception area. Figs. 4 and 5 show couplings that may also be used with a power pentode rather than an R.F. pentode or voltage amplifier. Simply replace the R.F. pentode, in Figs. 4 and 5 by a power pentode, coupling the loudspeaker into circuit as in Fig. 6.

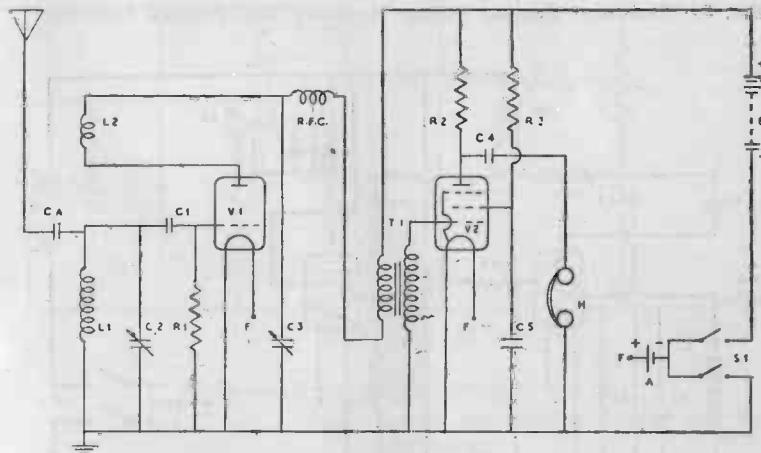


FIG. 4. Transformer Coupled Voltage Amplifier with Triode Detector.

In areas where signals are all generally weak a voltage amplifier will be needed between the detector and the output pentode stage for loudspeaker operation. A circuit such as that of Fig. 5 may then have an output pentode connected in to follow the audio amplifier, connecting the output pentode grid, together with its grid leak, in place of the headphones. Resistance-capacitance coupling should be used for preference, although choke coupling might also be employed. It is bad practice to use two inductive couplings when three stages are being coupled together, since there is a chance of audio feedback through stray transformer or choke fields, so that when

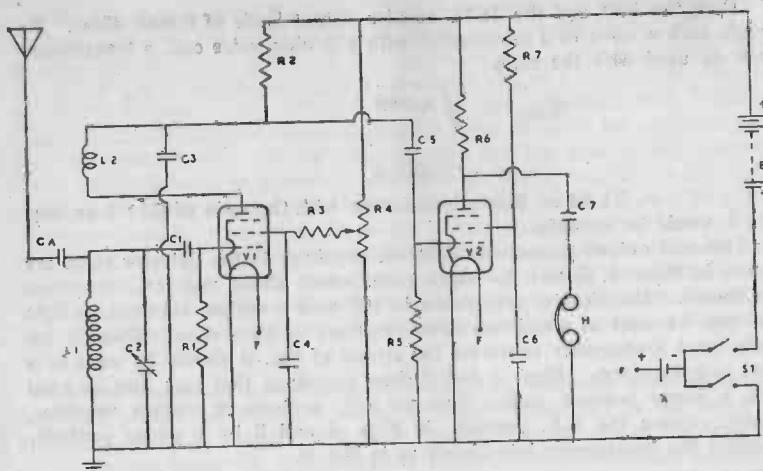


FIG. 5. Resistance Coupled Voltage Amplifier with Pentode Detector.

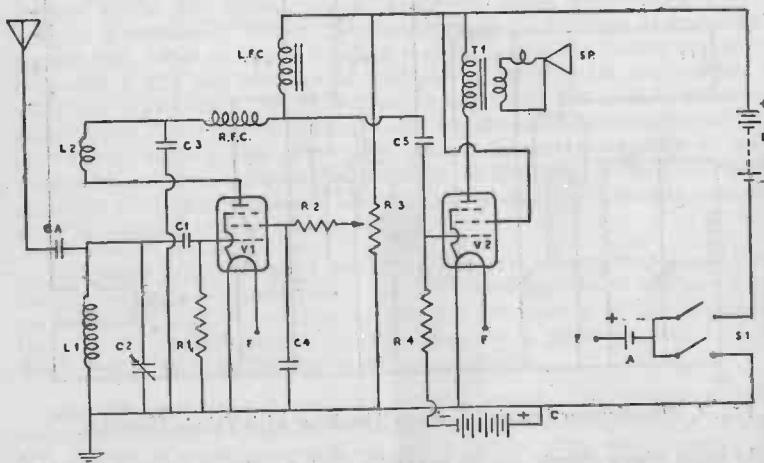


FIG. 6. Choke Coupled Output Pentode with Pentode Detector.

a transformer or choke coupling is used between the detector and audio amplifier it is best to use R.C. coupling between the audio amplifier and power output stage.

No decoupling is needed when only two audio stages are in use—counting the detector as the first audio stage—but where three stages are working together it is wise to decouple the first, i.e., the detector, stage. Whatever

anode load is used, resistance, transformer or choke, disconnect this, on the H.T. side, from the H.T. line inserting a resistance such as 22,000 ohms in the break. From the junction of this resistance and the anode load take a 2 mfd. paper condenser to earth. The method is pictured in Fig. 7.

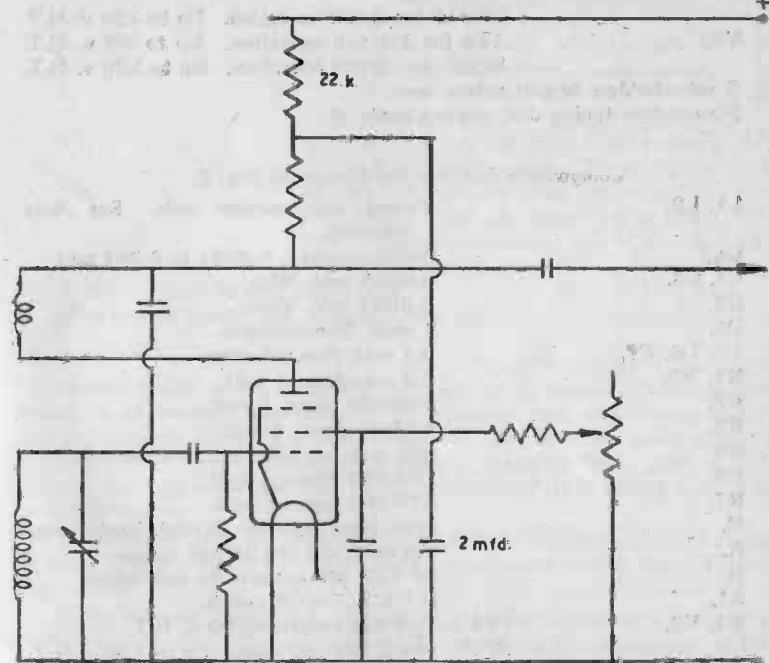


FIG. 7. Decoupling the Detector.

#### Components List for the Circuit of Fig. 4.

L1, L2,	Tuning and reaction coils. See Note following.
C <sub>a</sub> ,	Aerial coupling, 0.0001 to 0.001 mfd.
C <sub>1</sub> ,	0.0005 mfd. Mica.
C <sub>2</sub> ,	0.0005 mfd. Tuner.
C <sub>3</sub> ,	0.0005 mfd. variable, reaction control.
C <sub>4</sub> , C <sub>5</sub> ,	0.1 mfd. Non-inductive.
R <sub>1</sub> ,	2.2 meg. $\frac{1}{2}$ watt.
R <sub>2</sub> ,	220,000 ohms, $\frac{1}{2}$ watt.
R <sub>3</sub> ,	470,000 ohms, $\frac{1}{2}$ watt.
R.F.C.	Broadcast R.F. choke, Bulgin H.F. 8.
T <sub>1</sub> ,	3.1 Inter-valve midget transformer.
H,	High Impedance (or Crystal) headphones.

A,	1.5 or 2 volt cell, to suit valves.
B,	45.100 volt battery, to suit valves.
S1,	D.P.S.T. On-Off switch.
V1,	1G4 (Octal) for 1.4 volt operation. Up to 90 v. H.T.
V2,	HR210 for 2 volt operation. Up to 120 v. H.T.
	1T4 for 1.4 volt operation. Up to 90 v. H.T.
	SP2Bs for 2 volt operation. Up to 120 v. H.T.
	2 valve-holders to suit valves used.
	Slow-motion tuning dial, control knob, etc.

Components List for the Circuit of Fig. 5.

L1, L2,	Tuning and reaction coils. See Note following.
Ca,	Aerial coupling, 0.0001 to 0.001 mfd.
C1, C3,	0.0005 mfd. Mica.
C2,	0.0005 mfd. Tuner.
C4,	1 mfd. Non-inductive.
C5, C6, C7,	0.1 mfd. Non-inductive.
R1, R5,	2.2 megohms, $\frac{1}{2}$ watt.
R2,	100,000 ohms, $\frac{1}{2}$ watt.
R3,	47,000 ohms, $\frac{1}{2}$ watt.
R4,	0.5 meg. variable, reaction control.
R6,	220,000 ohms, $\frac{1}{2}$ watt.
R7,	470,000 ohms, $\frac{1}{2}$ watt.
H,	High Impedance (or Crystal) headphones.
A,	1.5 or 2 volt cell, to suit valves.
B,	90-120 volt battery, to suit valves.
S1,	D.P.S.T. On-Off switch.
V1, V2;	1T4 for 1.4 volt operation, 90 v. H.T.
	SP2Bs for 2 volt operation. Up to 120 v. H.T.

2 valve-holders to suit valves used.

Slow-motion tuning dial, control knob, etc.

Components List for the Circuit of Fig. 6.

L1, L2,	Tuning and reaction coils. See Note following.
Ca,	Aerial coupling 0.0001 to 0.001 mfd.
C1, C3,	0.0005 mfd. Mica.
C2,	0.0005 mfd. Tuner.
C4,	1 mfd. Non-inductive.
C5,	0.1 mfd. Non-inductive.
R1,	2.2 meg., $\frac{1}{2}$ watt.
R2,	47,000 ohms, $\frac{1}{2}$ watt.
R3,	0.5 meg. variable, reaction control.
R4,	1 megohm, $\frac{1}{2}$ watt.
R.F.C.	Broadcast R.F. choke.

L.F.C	L.F. Choke, Bulgin L.F.34.
Sp. with T1,	Electro-Acoustic Industries 5" speaker with output transformer, match to 8,000 ohms anode load for 3S4 or 14,000 ohms anode load for Pen. 25.
S1,	D.P.S.T. On-Off switch.
A,	1.5 or 2 volt cell, to suit valves.
B,	90-120 volt battery, to suit valves.
C,	7.5 v. G.B. for 3S4 or 3 v. G.B. for Pen. 25.
V1,	1T4 for 1.4 volt operation. 45 to 90 v H.T.
V2,	SP2Bs for 2 volt operaton. Up to 120 v. H.T.
	3S4 for 1.4 volt operation. 90 v. H.T.
	Pen. 25 for 2 volt operation. Up to 150 v. H.T. (Increase G.B. to 4.5 v. for over 100 v. H.T.)
	2 valve-holders to suit valves used.
	Slow-motion tuning dial, control knob, etc.

NOTES :—

In each circuit only a single-range tuning coil is shown, but double-band tuning is, of course, easily provided by using two coils and a band switch, the arrangement being as shown in Fig. 8. For medium wave tuning a Wearite PHF2 is very suitable, covering a range of from 200 to 557 metres, the long-wave coil then being a Wearite PHF1, tuning from 700 to 2,000 metres.

If iron-cored coils are preferred H. C. Atkins Laboratories coils should be used, a yellow No. 2 for the medium waves and a Yellow No. 1 for the long waves.

If the detector circuit fails to oscillate the cause is probably connection of the reaction coil in the wrong sense, and reversing the connections to this coil will correct the fault. Remember that if both the tuned and reaction coils are wound in the same direction and the top lead of the tuned winding is taken to the grid, then the sense will be correct if the top lead of the reaction winding is taken to the anode.

The longer the aerial the less must be the capacitance of Ca, the aerial coupling capacitor. An earth connection can be used with any battery receiver, and may or may not improve reception. The aerial-earth system, coupled to the tuned circuit as shown in the figures, loads the tuned circuit, and it is possible for the loading to be sufficiently great to stop reaction. In this case, Ca must again be reduced in capacitance.

It will be seen, from Fig. 5, that an R.F. choke need not be used in the anode circuit of the detector valve when the load in the circuit is a resistance providing the coupling into the following stage. The resistance acts as a choke in that it prevents R.F. from flowing into the rest of the receiver's circuits via the H.T. line. When the load in the detector anode line is an L.F. choke or an inter-valve transformer, however, it is wise to use an R.F. choke.

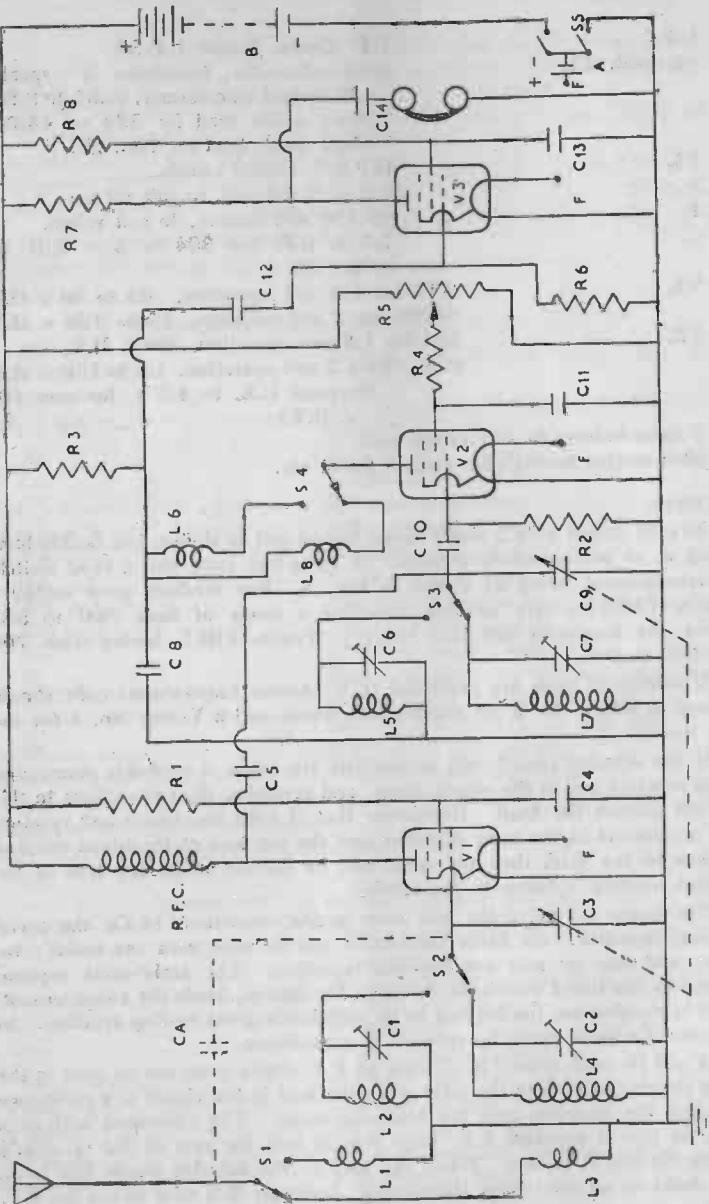


FIG. 8. A low consumption TRF Receiver for Headphones.

### THE H.F. STAGE

It has already been said that the H.F. stage not only extends the range of the receiver by amplifying the weak signals before detection or demodulation, but that the use of such a stage also enhances the selectivity of the receiver. When reaction is incorporated in the detector circuit this latter point becomes of little importance, since an oscillating detector worked near the critical condition is quite sufficiently selective for any ordinary purpose. The gain on weak signals is worthwhile, however.

There is little point in using an H.F. stage if there is no amplification after the detector valve, since the apparent gain on signals which are already sufficiently strong for good listening is not great, whilst the weaker signals will still not be sufficiently strong for comfortable listening. A receiver which has an H.F. stage therefore usually has some type of output stage as well, and the practical circuits of Figs. 8 and 9 show complete T.R.F. receivers capable of giving good headphone and loudspeaker reception, respectively, on a considerable number of stations, depending on location, conditions and the aerial.

Headphone receivers have been shown since when these sets are built up using the 1.4 volt valve types their H.T. and filament current consumption is so small that they may easily be fed from the small layer-built type of battery with a single U2 cell, or two such cells in parallel, as the filament supply. The use of the layer-built battery means that the receiver can be fitted into a very small case and, with a throw-out aerial, can be carried about for outdoor reception.

The receiver shown in Fig. 8 requires only 4 mAs. or less in the way of H.T. current, the filament consumption being 150 mAs. or 0.15 amp.

Coupling the H.F. stage into the detector circuit needs some consideration if the best results are to be obtained. The two stages must be tuned together, using a two-gang tuning capacitor, so that coupling between stages, and the aerial to H.F. stage coupling, must not be so tight that one stage is loaded more than the other with the result that ganging will suffer. The aerial may be coupled either capacitively or inductively to the H.F. stage, and both methods should be tested to discover which gives the better results. The H.F. stage may also be inductively coupled into the detector stage, but since the majority of commercially made coils have only two windings, and both of these are needed for the detector circuit, one as the tuned and the other as the reaction winding, this method is ruled out. The H.F. stage must therefore be capacitively coupled to the detector, an 0.0003 or 0.0005 mfd. capacitor generally being suitable.

The anode load of the H.F. stage may be either a resistance or H.F. choke, and in this case the R.F. choke gives good results. The valve is allowed to draw full current, since the D.C. resistance of an R.F. choke is low and there is in consequence an unimportant potential drop, whilst the choke impedance to R.F. is high, so that there is good transference of signal energy from the H.F. to the detector stage.

The screen of the H.F. valve is fed through a resistance and decoupled by a capacitor in order that it may have the correct potential. This is chiefly of importance when 1.4 volt valves, such as the 1T4, are to be used, the screen of the 1T4 requiring 45 volts, compared with the anode's 90 volts maximum, but it is generally good practice with any R.F. pentode. The dropping resistances used in the screen lines of the 2 volt valves are, however, shown as of lower values.

receivers with more than one H.F. stage are not shown in this chapter. The gain is hardly needed, using an oscillating detector, and two stages together are generally difficult to handle, both as regards ganging and instability.

#### Components List for the Low Consumption Receiver, Fig. 8.

L1, L2,	Wearite PA2.
L3, L4,	Wearite PA1.
L5, L6,	Wearite PHF2.
L7, L8,	Wearite PHF1.
Ca,	0.0001-0.0003 mfd. if used.
C1, C2, C6, C7,	75 mmfd. max. variable trimmers.
C3, C9,	0.0005 mfd. Two gang tuner.
C4, C12, C13, C14,	0.1 mfd. Non-inductive.
C5,	0.0003 mfd. Mica.
C8, C10,	0.0005 mfd. Mica.
C11,	1 mfd. Non-inductive.
R1, (for 1T4) (for SP2Bs)	68,000 ohms, $\frac{1}{2}$ watt. 33,000 ohms, $\frac{1}{2}$ watt.
R2, R6,	2.2 meg., $\frac{1}{2}$ watt.
R3,	150,000 ohms, $\frac{1}{2}$ watt.
R4,	47,000 ohms, $\frac{1}{2}$ watt.
R5,	0.5 meg. variable, reaction control.
R7,	220,000 ohms, $\frac{1}{2}$ watt.
R8,	470,000 ohms, $\frac{1}{2}$ watt.
R.F.C.,	Broadcast R.F. choke.
S1, 2, 3, 4,	4 pole 2 way range switch.
S5,	D.P.S.T. On-Off switch.
H,	High Impedance (or Crystal) headphones.
A,	1.5 or 2 volt cell to suit valves.
B,	100 volt battery. Or for 1.4 volt operation, use 45 volt layer-built battery and drop R3 to 100,000 ohms.
V1, V2, V3,	1T4 for 1.4 volt operation. SP2Bs for 2 volt operation.

3-valve-holders to suit valves used.

Slow-motion tuning dial, control knob, etc.

The receiver may be built on any suitable chassis and made to any layout, providing that the H.F. stage coils are shielded from the detector stage coils. One method of obtaining the shielding is to mount one pair of coils above and one below the chassis, providing that this does not cause long switch leads. These leads must be short and well separated.

Circuit alignment is dealt with on a later page.

#### Components List for the Loudspeaker T.R.F. Receiver, Fig. 9.

L1, L2,	Wearite PA2.
L3, L4,	Wearite PA1.
L5, L6,	Wearite PHF 2.
L7, L8,	Wearite PHF1.
Ca,	0.0001-0.0003 mfd. if used.
C1, C2, C6, C7,	75 mmfd. max. variable trimmers.
C3, C8,	0.0005 mfd. two-gang tuner.
C4, C12,	0.1 mfd. Non-inductive.
C5,	0.0003 mfd. Mica.
C9, C11,	0.0005 mfd. Mica.
C10,	1 mfd. Non-inductive.
C13,	4 mfd. 250 v.w. Electrolytic or Paper.
R1, (for 1T4) (for SP2Bs)	68,000 ohms, $\frac{1}{2}$ watt. 33,000 ohms, $\frac{1}{2}$ watt.
R2, R6,	2.2 megohms.
R3,	150,000 ohms, $\frac{1}{2}$ watt.
R4,	47,000 ohms, $\frac{1}{2}$ watt.
R5,	0.5 meg. variable, reaction control.
R7, (for 3S4) (for Pen. 25)	680 ohms, $\frac{1}{2}$ watt. 330 ohms, $\frac{1}{2}$ watt.
R.F.C.	Broadcast R.F. choke.
S1, 2, 3, 4,	4 pole 2-way range switch.
S5,	D.P.S.T. On-Off switch.
Sp. with T1,	Electro-Acoustic Industries 5" speaker with output transformer, match to 8,000 ohms anode load for 3S4 or 14,000 ohms anode load for Pen. 25.
A,	1.5 or 2 volt cell to suit valves.
B,	100 volt battery.
V1, V2,	1T4 for 1.4 volt operation. SP2Bs for 2 volt operation.
V3,	3S4 for 1.4 volt operation. Pen. 25 for 2 volt operation.

3 valve-holders to suit valves used.

Slow-motion tuning dial, control knob, etc.

NOTE:—The screen of the 3S4 must be taken to 67.5 volts on the H.T. battery, or the nearest tapping. If the Pen. 25 2 volt output valve is used, the screen should then be taken directly to the main H.T. line.

In this receiver self-bias is used to render a grid bias battery unnecessary. Self-bias is obtained by connecting the H.T. battery into circuit, on the negative side, through a suitable resistance, R7 in Fig. 9. The total current required for the operation of the receiver then must flow through R7, with a corresponding voltage drop, which leaves the "top" of the resistance more negative than the "bottom," to which the main negative, or earth line,

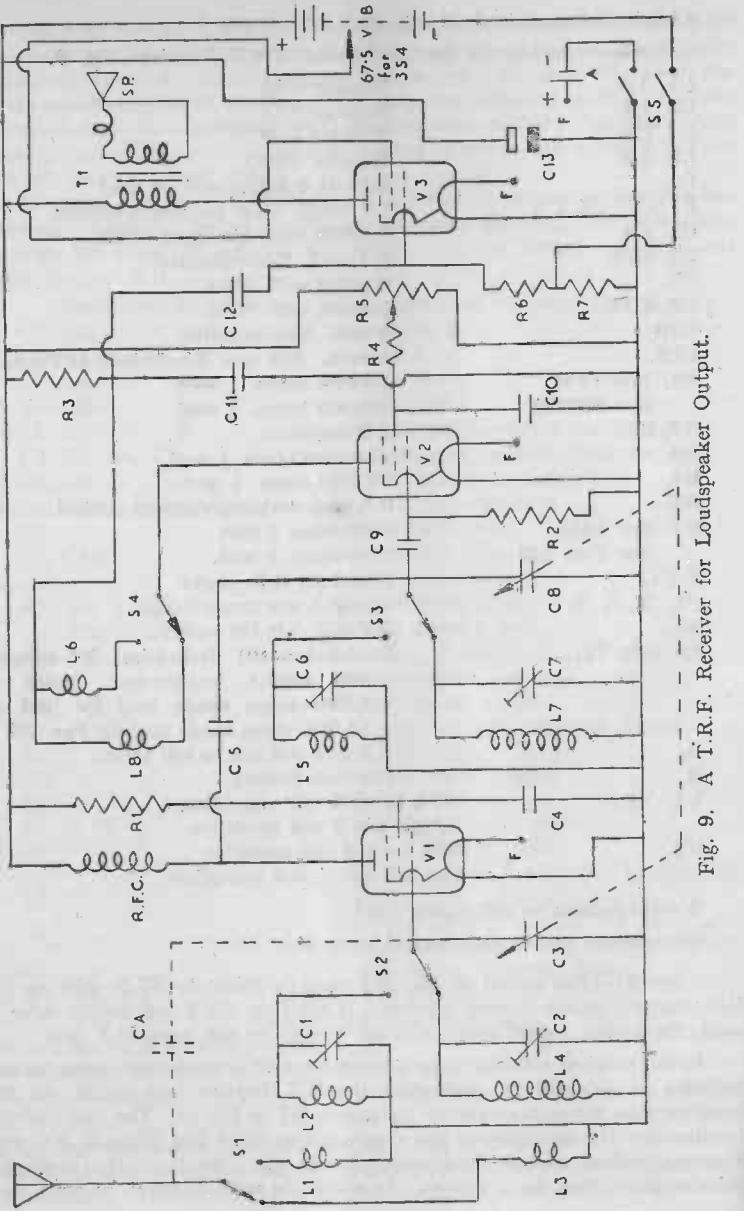


Fig. 9. A T.R.F. Receiver for Loudspeaker Output.

of the receiver is connected. To prevent negative feedback or interstage coupling across this resistance the high capacitance, C13, is connected across the H.T. positive line and the earth line to provide a low impedance path for the audio frequencies. Alternatively, a large bias capacitor could be connected across R7, observing polarity, but the position of C13 is better. As batteries age their internal resistance rises, and in many cases a battery set will give better volume and quality if a 4 or 8 mfd. capacitor is connected across the H.T. battery as it begins to show signs of age, whilst instability in a battery receiver can often be cured by the same treatment. The capacitor, if fitted to an existing receiver, should be connected after the switch, as in Fig. 9, rather than directly across the H.T. battery, since there is always a slight current leakage through electrolytic capacitors.

The receiver shown in Fig. 9 takes approximately 10 mAs. in both the 1.4 volt and 2 volt versions. The resistance R7 must therefore be calculated, using Ohm's Law, to give the correct bias on the output valve with this current flowing. For example, the 3S4 needs 7 volts bias, so that the potential drop across R7 must be 7 volts, with 10 mAs. or so passing, and the nearest standard value is 680 ohms.

Using the 3S4 means a rather heavier filament current, the total being for this receiver 200 mAs., or 0.2 amp. A high capacity L.T. cell should be used, therefore, such as the Drydex H1158.

Aligning receivers with two stages of tuning is a simple matter and may be carried out using the signal from a broadcasting station on about 250 metres or a little lower, or, preferably, a signal generator may be used. The signal in either case should be weak. If a dial is supplied with the two-gang capacitor tune the receiver to the wavelength, as shown on the dial, of the station or signal to be used. If a dial is not fitted one must be made up and calibrated, either in metres or in terms of frequency in kcs. with, perhaps, the main station names shown as well. In either case, the dial must, of course, cover the frequencies or wavelengths given by the tuning coils, the ranges being 200-557 and 700-2,000 metres using coils as specified.

If the tuning capacitor is fitted with trimmers, unscrew these as far as possible to reduce their capacitance, since they are not used in the trimming, each coil having been provided with its own trimmer which, in the case of the Wearite coils, can be mounted right on top of the coil former across the two main connecting tags.

With the receiver switched on, it may be necessary to "hunt" for the test signal on either side of 250 metres, or whatever the exact tuning point may be, but once the signal is located adjust C6 in either Fig. 8 or 9, so that the tuning dial may be turned towards the correct wavelength or frequency with the signal still coming in. With the detector trimmed on the medium waveband, trim the H.F. stage to bring the signal up to maximum volume. Throughout the trimming keep the reaction control backed off as much as possible.

Repeat the procedure on the long wave band, choosing or supplying a signal somewhere near 750 or 800 metres, and trim the long wave trimmers, C2 and C7.

With the trimmers set for both bands on the high frequency ends of the tuning ranges, tune over each band to test for correct ganging through the whole of the tuning capacitor excursion. A fall-off in reception towards the low frequency-high wavelength end of either band most probably means that one coil or other has been mounted too near to earthed screening or metal—there should be at least a clear half-inch round each coil between it and the chassis or other conducting material. If this is the case, and the cause is not easily corrected, the trimming must be reset to give a compromise so that stations are received with as great efficiency as possible over the whole tuning range.

It is possible, although very unlikely, that oscillating detectors using resistance-capacitance coupling into the following stage will fail to oscillate. This will probably be due to some slight variation in valve or coil manufacture, or, possibly, to the use of an H.T. battery with low voltage. If the batteries are found to be in good condition, reduce the anode resistance in the detector circuit so that the potential drop is lower and the detector valve has a slightly higher anode potential.

### CHAPTER III

#### THE SUPERHET. RECEIVER

The T.R.F. receiver in the last chapter was described sectionally, since the detector of such a receiver can be used either alone or in conjunction with other stages. The superhet, however, must be considered as a whole.

The incoming signal is tuned and fed to the first stage, the frequency changer, where the signal is detected and mixed with a signal from the local oscillator, usually a part of the first stage valve. Beating, or heterodyning, one frequency with another within the valve means that at the valve's anode a number of frequencies appear, including the sum and difference of the two frequencies which have been mixed. One of these resultant frequencies, usually the difference frequency, is selected for passing on to the following stages.

Imagine that the required signal is situated at 300 metres, 1,000 kcs. Then, if the local oscillator is tuned to, say, 1,465 kcs., the difference frequency will be  $1,465 - 1,000 = 465$  kcs., the usual Intermediate Frequency chosen for broadcast receivers.

This particular frequency is chosen from amongst the other frequencies appearing at the frequency changer valve's anode by making the coupling between this valve and the next stage a tuned transformer. The impedance of such a device to other frequencies will be low, although to the chosen frequency it will be high. The chosen frequency will therefore energise the tuned transformer's primary, there will be good signal energy transference to the transformer's secondary and the signal will be amplified, not only by the following valve, but also by the transformer itself.

(It will be as well at this point to say that of several frequencies appearing at the frequency changer's anode, the strongest are the sum and differ-

ence frequencies of the two signals, the original signal frequency and the local oscillator frequency. The transformer, therefore, must be sharply tuned in order to select and pass on the required difference frequency.)

The difference frequency is always maintained constant at 465 kcs., or whatever frequency is chosen by tuning the local oscillator in step with the main or aerial tuning. When a signal at, say, 500 metres, 600 kcs. is tuned the local oscillator must then automatically be tuned to 1,065 kcs. to give once again a difference frequency of 465 kcs. It is found that an oscillator frequency higher than the signal frequency gives the best results, although, of course, the required 465 kcs. resultant frequency could be obtained by tuning the local oscillator to a figure lower than the signal frequency.

It will be seen that to tune the local oscillator so that it remains properly in step with the signal tuning is no simple matter. The frequency range is different—for example, tuning the signal frequency from 300 to 500 metres means a frequency range of from 1,000 to 600 kcs., whilst at the same time the oscillator range is from 1,465 to 1,065, a different percentage of frequency change, altogether. Accordingly, the local oscillator is fitted with special coils wound to suit the conditions obtaining, and the tuning range of the oscillator tuning capacitor is corrected by the use of a padding capacitor. The tracking of the oscillator—by tracking is meant the oscillator's keeping in step with the signal tuning—is adjusted by adjusting the usual trimmer across the oscillator coil for the high frequency end of the coil's range and the padder for the low frequency end of the coil's range, balancing one adjustment against the other until the best possible compromise has been obtained.

The transformer between the frequency changer and the following valve passes the signal to the I.F. amplifier. This valve acts rather in the manner of an H.F. stage, but the efficiency obtained is high. This is the reason for using a superhet, rather than a T.R.F. circuit. Practically all the tuned circuits are fixed at 465 kcs., so that they can be made very stable, and at the same time the frequency is relatively low, so that the I.F. amplifier can have good gain. The tuned circuits themselves can also be highly efficient simply because the tune is fixed and not variable, apart from the permissible variations made to adjust the circuits to the correct working frequency, and so the selectivity of the receiver as a whole is very high, each fixed tune circuit contributing to the selectivity.

From the I.F. amplifier the signal may be passed to a further I.F. amplifying stage, but it is usually passed direct to the detector or demodulator stage. Diode detection is most commonly used in superhets.; an oscillating detector could be arranged, but neither the selectivity nor the gain that this would give is now required, since both have been contributed by the I.F. circuits.

The rectified I.F. signal from the diode is fed to the first audio amplifying stage, part of the detector output also being smoothed, so that the audio signal disappears and the remaining potential level corresponds to the strength of the carrier wave of the station being received. This voltage is then fed back to the control grids of the frequency changer and the I.F.

amplifying valve, to give Automatic Volume Control. The weaker the station carrier is so the A.V.C. voltage falls, and since the A.V.C. voltage is applied in the negative sense, as is ordinary grid bias, the weaker the A.V.C. voltage becomes the less is the bias on the controlled valve and the greater is the amplification given by that valve. In this way a weak carrier is given greater amplification than a strong carrier, and the differences in signal strength are to some extent cancelled.

The audio output from the diode detector should, for the best results, be fed to the next stage in such a way that the diode is shunted by a high rather than a low impedance, and with battery valves this is easily arranged. The feed from the diode to the next stage can also be via the volume control. In the majority of battery receivers the diode detector and the first stage of audio amplification are combined in one valve using a diode-triode or a diode-pentode. This first audio stage then feeds the amplified audio signal into the output stage and the loudspeaker.

In the circuits of Figs. 10 and 12 are shown two battery superhets., essentially similar in outline, although the first is for 1.4 volt and the second for 2 volt operation. The 1.4 volt circuit uses a pentagrid frequency changer and a diode-pentode detector—first audio stage whilst the second circuit utilises a triode-pentode frequency changer and a double-diode triode detector and first audio stage, but these variations in no way affect the basic operation of the receivers which are as already described. Using the double-diode as a detector means that A.V.C. can be taken from one diode whilst the other diode deals solely with demodulation.

Once again the aerial and oscillator tuning coils should be separated, although coil-switch leads must always be as short and direct as possible. The I.F. valve must also be close to the I.F. transformers, so that the leads are short between them, and by mounting the valve actually between the transformers, the wiring is direct whilst the valve is given extra screening by the transformer cans.

#### Components List for the 1.4 volt Superhet., Fig. 10.

L1, L2,	Wearite PA2.
L3, L4,	Wearite PA1.
L5, L6,	Wearite PO2.
L7, L8,	Wearite PO1.
C1, C2, C8,	75 mmfds. max. trimmers.
C3, C13, C16, C17,	0.01 mfd. Non-inductive.
C4, C7,	0.0005 mfd. two-gang tuner.
C5, C14, C18,	0.1 mfd. Non-inductive.
C6, C15,	0.0002 mfd. Mica.
C9,	500 mmfds. max. padder.
C10,	100 mmfds. max. trimmer.
C11,	200 mmfds. max. padder.
C12,	4 mfd., 200 v.w. Electrolytic or Paper.
C19,	0.0001 mfd. Mica.
R1,	220,000 ohms, $\frac{1}{2}$ watt.
R2, R4, R8,	1 meg., $\frac{1}{2}$ watt.

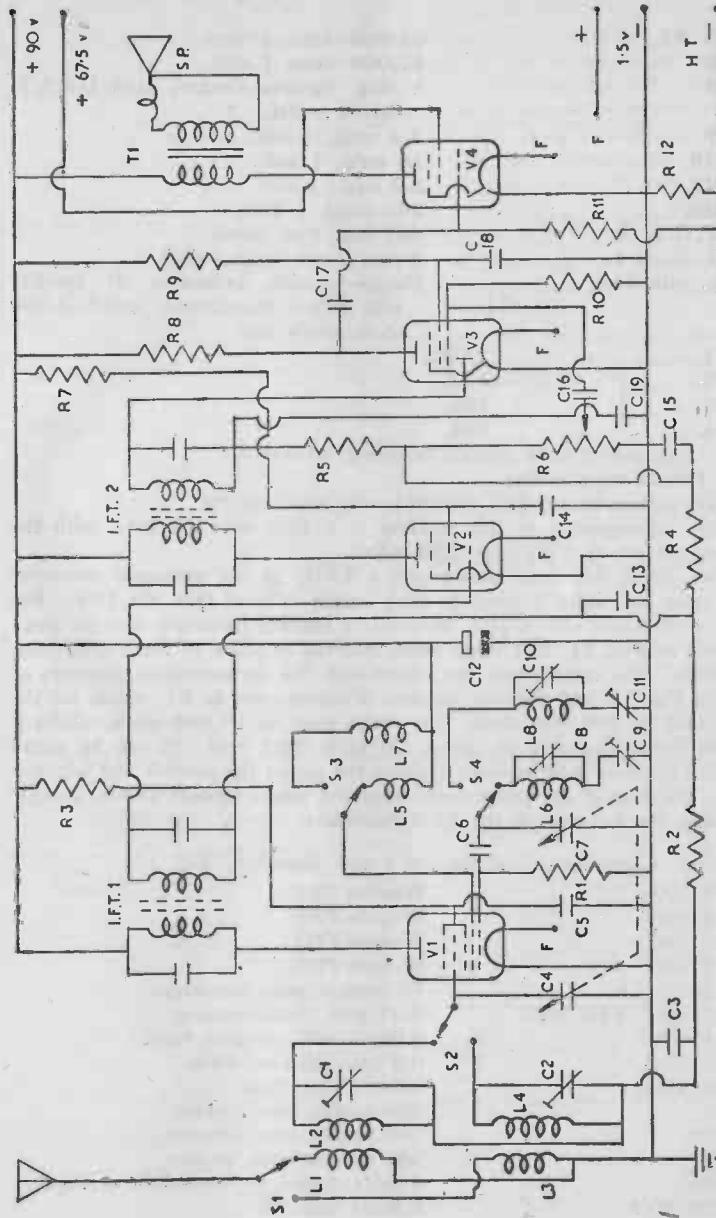


FIG. 10. A 1.4 Volt Superhet Receiver

R3, R7,

R5,

R6,

R9,

R10,

R11,

F12,

I.F.T: 1, 2,

S1, 2, 3, 4,

Sp. with T1.

68,000 ohms,  $\frac{1}{2}$  watt.

47,000 ohms,  $\frac{1}{2}$  watt.

1 meg. Volume Control, with D.P.S.T

On-Off switch.

3.3 meg.,  $\frac{1}{2}$  watt.

10 meg.,  $\frac{1}{2}$  watt.

2.2 meg.,  $\frac{1}{2}$  watt.

560 ohms,  $\frac{1}{2}$  watt.

465 kcs. Iron cored.

4 pole 2-way range switch.

Electro-Acoustic Industries 5" speaker  
with output transformer, match 8,000  
ohms anode load.

V1,

V2,

V3,

V4,

1A7G.

1T4.

1S5.

3S4.

1 International octal chassis mounting valve-holder.

3 Peanut valve-holders.

Slow-motion tuning dial, control knobs, grid clip, etc.

H.T. consumption of this receiver is a little over 12 mAs. with the  
filament current at 0.25 amp (250 mAs.).

This circuit has been shown with a 1A7G as the pentagrid converter  
stage since this valve is possibly more easily obtained than the 1R5. For  
those constructors with a 1R5, however, a suitable frequency changer stage  
is shown in Fig. 11, this stage being inserted in place of the 1A7G stage  
if desired. The components are coded with the corresponding numbers of  
those in Fig. 10, and the only changes in values refer to R1, which, for the  
1R5, must be 100,000 ohms, R3, which must be 24,000 ohms, whilst it  
may be found desirable to reduce C6 to 0.0001 mfd. It will be noted  
that C12 has now to be separately connected across the positive and negative  
lines. The rest of the components keep the values already shown, except,  
obviously, for a change of the V1 valve-holder.

#### Components List for the 2 volt Superhet., Fig. 12.

L1, L2,

L3, L4,

L5, L6,

L7, L8,

C1, C2, C8,

C3, C13, C16, C17,

C4, C7,

C5, C12,

C6, C18,

C9,

C10,

C11,

C14,

C15, C19,

Wearite PA2.

Wearite PA1.

Wearite PO2.

Wearite PO1.

75 mmfds. max. trimmers.

0.01 mfd. Non-inductive.

0.0005 mfd. two-gang tuner.

0.1 mfd. Non-inductive.

0.0002 mfd. Mica.

500 mmfds. max. padder.

100 mmfds. max. trimmer.

200 mmfds. max. padder.

4 mfd. 200 v.w. Electrolytic or Paper.

0.0001 mfd. Mica.

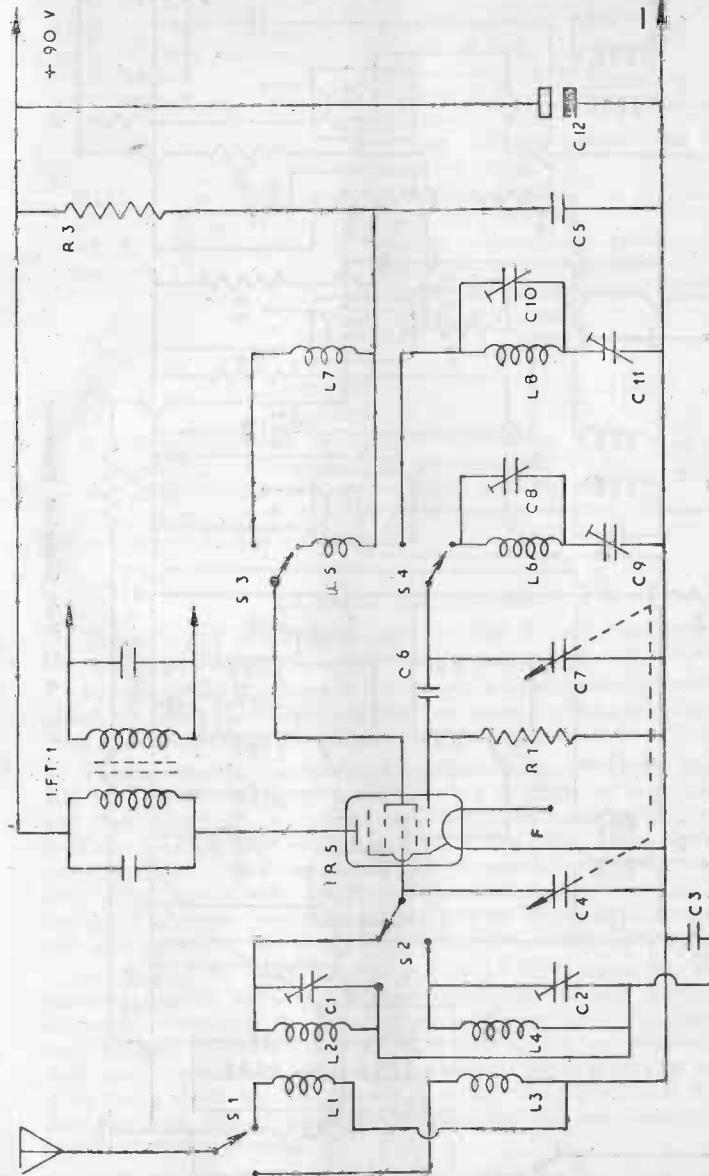


FIG. 11. Using the 1R5 in place of the 1A7G.

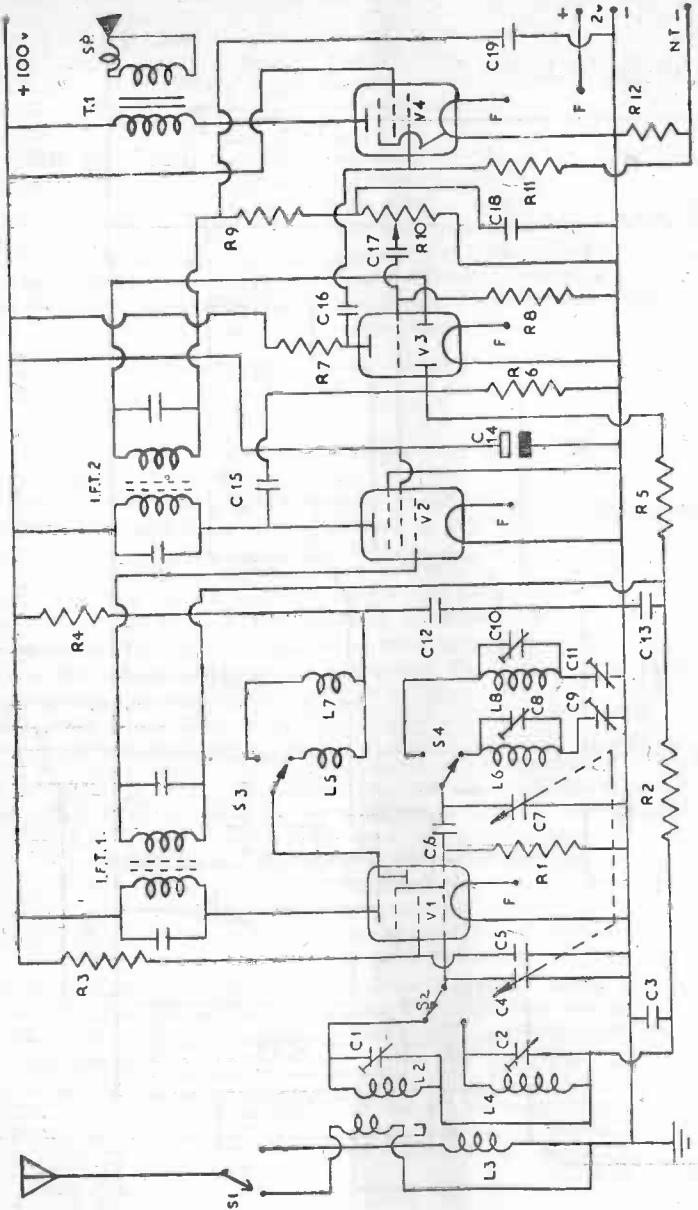


FIG. 12. A .2 Volt Superhet Receiver.

R1, 100,000 ohms,  $\frac{1}{2}$  watt.  
 R2, R5, R6, R11, 1 meg.,  $\frac{1}{2}$  watt.  
 R3, R4, 33,000 ohms,  $\frac{1}{2}$  watt.  
 R7, R9, 47,000 ohms,  $\frac{1}{2}$  watt.  
 R8, 2.2 meg.,  $\frac{1}{2}$  watt.  
 R10, 1 meg. Volume control with D.P.S.T. On-Off switch.

R12, 330 ohms,  $\frac{1}{2}$  watt.  
 I.F.T. 1, 2, 465 kcs. Iron cord.  
 S1, 2, 3, 4, 4 pole two-way range switch.  
 Sp. with T1, Electro-Acoustic Industries 5" speaker with output transformer, match 14,000 ohms anode load.

V1, TP26.  
 V2, VP23.  
 V3, HL21DD.  
 V4, Pen. 25.

3 Mazda octal chassis mounting valve-holders.  
 1 British 5-pin chassis mounting valve-holder.  
 Slow-motion tuning dial, control knobs, grid clip, etc.  
 H.T. consumption of this receiver is between 10 and 12 mAs. with the filament current at 0.55a (550 mAs.).

#### ALIGNING THE SUPERHET.

The following instructions apply equally to both superhet. receivers shown, since corresponding components have the same code numbers.

For the correct alignment of the receiver a signal generator must be used. Switch on both generator and receiver for some minutes before commencing work. Set all trimmers to minimum capacity and padders to half capacity.

The first step is to align the I.F. transformers. Tune the generator to 465 kcs. and put the receiver oscillator out of action by shunting R1 with a 0.1 mfd. capacitor. Where the control grid connection to V1 is made by a grid clip to a top cap connection, remove this clip. When the IR5 frequency changer is used the control grid connection cannot be removed without trouble, and so must be allowed to remain for this operation. Connect the signal generator across the control grid of V1, in place of the removed grid clip where this has been possible, and the receiver chassis.

Starting at the diode detector side of I.F.T.2., adjust the transformer trimming controls until the signal generator note is heard in the receiver's loudspeaker, reducing the signal generator output as volume rises. Work back towards the primary of I.F.T.1., obtaining the best response possible from each transformer. The signal generator must always be maintained at as low a signal level as possible in order that the receiver A.V.C. line does not come into action, which would render the resonant point of each tuned circuit less obvious.

With the I.F. transformers tuned to 465 kcs. throughout, remove the generator connection from the grid of V1 and transfer it to the aerial socket,

leaving the other generator lead still earthed. Remove the capacitor shorted across R1 and replace the grid clip on V1. Switch the receiver to the medium waveband and tune to 200 metres (1,500 kcs.), tuning the signal generator to the same frequency.

Without altering the setting of the tuning capacitor trim C8 until the generator signal is heard in the receiver loudspeaker, adjusting C8 to give maximum volume. Then trim C1 to improve the volume, reducing the signal generator output if necessary.

Tune both the receiver and the signal generator to 500 metres (600 kcs.) and adjust the padder, C9, to give maximum volume. The signal will probably need "hunting" with the main tuning control, but when it is found C9 should be adjusted and the main tuning brought to 500 metres simultaneously, the main tuning capacitor being "rocked" through the signal until the adjustment is complete.

Retune both receiver and generator to 200 metres. C8 will probably need a further adjustment to obtain maximum volume, and C1 will also probably require a fresh adjustment.

Retune to 500 metres. The fresh adjustments to C8 will require a slight readjustment to C9, in order that maximum volume at 500 metres may be obtained.

These last two adjustments should be continued, one after another, until the readjustments of C8 have no effect on the setting of C9, and vice versa. The trimming and padding of the medium wave oscillator circuit is then complete and a final trim should be given to C1.

The receiver is then switched to the long-wave band and the whole procedure repeated, using tuning points of 750 metres (400 kcs.) and 1,500 metres (200 kcs.), trimming C10 and C2 and padding with C11.

## CHAPTER IV

### THE PORTABLE RECEIVER

With advances in radio design the term "Portable Receiver" becomes increasingly difficult to define. The American "Personal Set" has set a new fashion in ultra-small, ultra-lightweight receivers, and in this country extremely efficient little radio sets are now manufactured along the same lines. The old portable of the suitcase type is now far too bulky and heavy to suit the average user, and the advent of valves of the peanut type or of the midget variety have made such a method of construction quite unnecessary. It must not be forgotten, however, that the old style large portable receiver at least gave the framework upon which a fairly efficient frame aerial could be wound. The small receiver gives no such facility—a "pocket" or "personal" receiver could have an internal frame aerial, but the signal pick-up would be very poor.

It must be remembered that the frame aerial proper is a closed circuit, which acts both as an aerial and as the first tuned circuit of a receiver. A loop aerial may also act as the first tuned circuit, but the term "loop aerial," at least so far as ordinary receiving equipment is concerned, is coming more and more to mean that a folded wire is included in the receiver as an open circuit, acting purely as an aerial suitable for use either under good reception conditions or near to a broadcasting station. The loop aerial does not form part of a tuned circuit when used in an ordinary portable set. This, however, should not be confused with radio direction finding gear or with the American use of the term "loop aerial," the American "loop aerial" usually having the same meaning as our own "frame aerial."

To design and build a receiver which has a frame aerial as the first tuned circuit followed by normal tuned circuits with small coils, all the tuning being carried out on a normal ganged capacitor, is, in the writer's opinion, a very difficult matter. The commercial manufacturer can solve the ganging problem by designing special coils, but the home constructor's only real solution lies in the use of separate tuning capacitors with separate drives or dials, when a single gang capacitor is used for the frame aerial with the second tuning capacitor having as many sections as there are further tuned circuits. Incorporating the frame aerial as the first tuned circuit of a superhet, is even more difficult, and once again the circuit alignment is most easily brought about by the use of two tuning capacitors, one for the frame and one for the oscillator circuit.

Unfortunately, the use of two capacitors adds considerably to the bulk of the receiver, and it is far simpler to build either a small receiver fitted with a "throw-out" aerial or as simple a frame aerial receiver as possible, the frame feeding directly into an oscillating detector, the frame tuned winding having a reaction winding added to it. The necessary gain must then be provided by audio amplifying stages.

The receiver using a throw-out aerial can also have a loop aerial fitted to the back of its cabinet if the size permits, although neither a loop nor a frame aerial can be very efficient if they are smaller than, say, a foot square.

The open circuit loop aerial can be wound in the form of a square spiral, whilst the tuned frame aerial should be wound with the turns side by side, the two types of winding being shown in Fig. 13. With one end of the loop aerial left free, this provides a terminal to which an ordinary or throw-out aerial may be attached to give a wider reception range or greater pickup. The throw-out aerial is, as its name implies, simply a length of wire carried with the receiver, this wire being thrown out over a tree or fence or similar support to act as a temporary aerial. The best wire for the purpose is a good grade, fairly light rubber covered flex.

The two superhetrodyne receivers described in the previous chapter will operate well on either a loop or throw-out aerial, or, given separate tuning arrangements, will also work with the first tuned circuit made up of a frame aerial, the oscillator then being tuned on its own capacitor. With such a method of tuning the two capacitors must be marked with station names or scaled in some similar manner, so that they can be set together to the required frequency without hunting, the receiver being calibrated when first built and tested, using the signal generator.

TO EXTERNAL AERIAL SOCKET

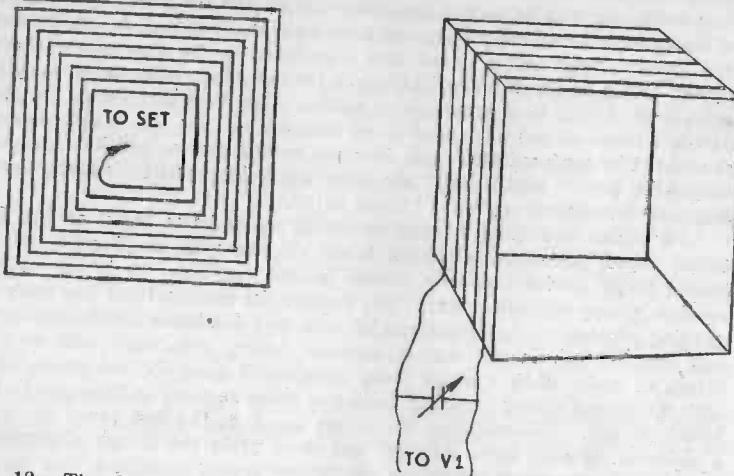


FIG. 13. The Open Circuit Loop Aerial. The Closed Circuit Frame Aerial

The circuit of a true frame aerial receiver is shown in Fig. 14, using 1.4 volt valves. This receiver has also been tested in the poor reception area already mentioned, and has given good reception, both of the local Regional station and the Light programme on the long-wave band, whilst,

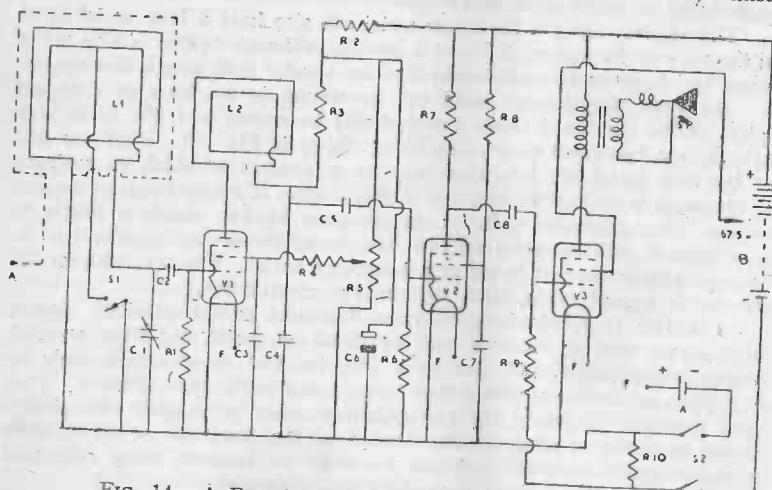


FIG. 14. A Portable Receiver for 1.4 Volt Operation.

under reasonable conditions, a number of foreign stations have also been received at good strength.

The original frame aerial was wound on a square box-shaped structure, each side being a foot long. The medium wave winding consists of 12 turns of 28 S.W.G. enamelled copper wire, the turns being laid side by side, with the reaction winding for the medium waveband consisting of 5 turns of the same wire wound on directly after the tuned winding. In series with the tuned medium wave winding is the long-wave tuned winding, a further 25 turns of the same wire wound in the same direction. A further reaction winding of 7 turns follows the long-wave winding, also wound in the same direction.

If desired, a 5-turn coil can be wound on over the medium wave winding to act as an aerial coupling coil when the set is to be used with an ordinary aerial.

The four or five windings, whichever are used, can be wound on to a 1" former length, and the frame connections and switching are shown in detail in Fig. 15. For medium wave reception the long-wave winding is shortened down to earth in the usual manner, the two tuned windings being connected in series for long-wave reception.

The 1T4 is used as the regenerative detector, since this valve gives excellent results with the small aerial described. A 2 volt triode was also tested and found to give relatively poor reception compared with the 1T4. At the same time, the use of 1.4 volt valves enables a small chassis to be used with a small battery compartment, whilst the receiver is lightened by using a dry filament cell rather than an accumulator.

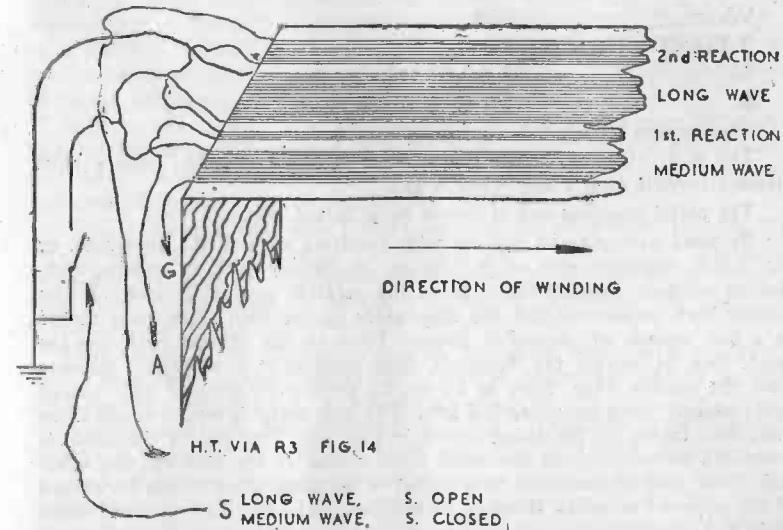


FIG. 15. Frame Aerial Connections.

Components List for the Portable Receiver, Fig. 14.

L1,	Tuned frame winding.
L2,	Reaction frame winding.
C1,	0.0005 mfd. Tuner.
C2, C4,	0.0005 mfd. Mica.
C3,	1 mfd. Non-inductive.
C5, C8,	0.01 mfd. Non-inductive.
C6,	4 mfd. 200 v.w. Electrolytic or Paper.
C7,	0.1 mfd. Non-inductive.
R1, R6, R9,	2.2 meg., $\frac{1}{2}$ watt.
R2,	33,000 ohms, $\frac{1}{2}$ watt.
R3,	150,000 ohms, $\frac{1}{2}$ watt.
R4,	47,000 ohms, $\frac{1}{2}$ watt.
R5,	0.5 meg. variable reaction control.
R7,	220,000 ohms, $\frac{1}{2}$ watt.
R8,	470,000 ohms, $\frac{1}{2}$ watt.
R10,	910 ohms, $\frac{1}{2}$ watt.
S1,	S.P.S.T. range switch.
S2,	D.P.S.T. On-Off switch.
Sp.	Electro-Acoustic Industries 5" speaker, with output transformer, match to 8,000 ohms anode load.
V1, V2,	1T4.
V3,	3S4.
3 Peanut holders,	
A,	1.5 volt cell.
B,	90 or 100 volt battery.
Slow-motion tuning dial, control knob, etc.	

The H.T. consumption of the receiver is about 8 mA.s., with a total filament current of 0.2 amp (200 mA.s.).

The aerial coupling coil is shown by a dotted line.

To wind a loop aerial for use with receivers such as the superhets. or the T.R.F. receivers with an H.F. stage, or for use with an existing commercial receiver, remove the back of the receiver case or cabinet. It has already been mentioned that the dimensions of the loop aerial base should be a foot square, or preferably larger. Draw on the cabinet back (on the inside face, of course), the diagonals, then, starting at a convenient distance from the outside edge, drive in 12 or 15 small brass pins or nails spaced equi-distantly along each diagonal line. The loop aerial is wound round these pins, thus taking up the shape shown in Fig. 13. One end of the aerial is connected permanently to the aerial input socket of the receiver, the other end of the loop is connected to a socket or terminal fitted to the backboard of the receiver, to which terminal an external aerial may be connected when desired.

Other types of portable aerial, such as the telescopic aerial, are not of great use with battery receivers, at least so far as broadcast reception is concerned, since the signal pick-up is very small and a high gain receiver must be used. Probably the most satisfactory portable receiver is a super-heterodyne fitted either with a loop aerial or a throw-out aerial, or possibly with both.

## CHAPTER V

### SHORT WAVE RECEPTION

The battery receiver has always been a favourite for short-wave reception, and even in these days of commercially-produced, highly-complicated and highly-efficient communications receivers, many amateur transmitting stations have standby battery receivers. This is especially the case in America, where radio amateurs are grouped into emergency networks to deal with communications in time of floods and other catastrophes of nature.

The newcomer to short-wave reception cannot do better than build a one-valve receiver which, with a good aerial, will give worldwide radio reception at full headphone strength. A regenerative detector is used, of course, and for short-wave operation a triode often gives smoother working than an R.F. pentode.

1.4 volt valves seem more suited to medium and long wave reception. The 1T4, for example, when used as a short-wave oscillating detector, shows serious de-tuning effects as reaction is applied, a fault which is far more troublesome on the high frequencies. A stable detector circuit is essential, as is perfectly smooth reaction up to the critical point, the elimination of hand capacity effects, the elimination of threshold howl and the elimination of tuning variations through swinging headphone leads, etc.

Battery operation of the short-wave receiver is advantageous for many reasons, but foremost among them is the complete lack of background noise and hum. A weak station can be copied on a battery receiver when the same signal would be lost on any but the best mains receiver.

The commonest one-valve battery receiver for short wave work is the triode, with throttle controlled reaction, as shown in Fig. 16. The chief difference between this and a broadcast frequency receiving circuit is a reduction in the values of the tuning and reaction capacitors, together with a reduction in the number of turns in the tuning coil.

The layout of any short-wave receiver is of great importance, and tuned circuit leads must be short and direct. Low-loss components should be used whenever possible, and R.F. wiring should always be well spaced, both from other wiring and from metal panels and chassis. Aluminium or, better still, copper, is preferable to steel for short and ultra short wave chassis.

In a simple receiver the tuning ranges are usually provided by plug-in coils, since coil switching can so easily cause serious losses, not only in the switch itself, but in the necessary wiring and the extra necessary lead lengths between coil, switch and tuning capacitor.

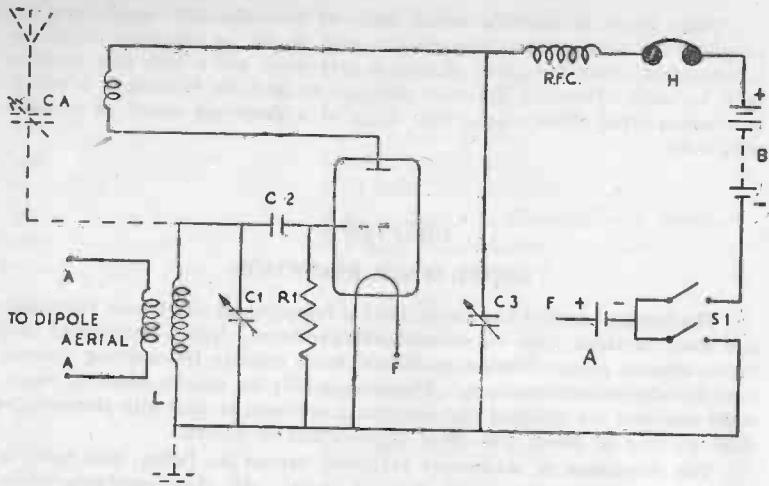


FIG. 16. A One-valve Short Wave Receiver.

Coils for the short-wave receiver can be wound by the constructor, although it is advisable to use commercially made coil-forms. The Eddystone ribbed former, No. 538, used with the Eddystone coil holder No. 964, is highly recommended, and the coils sizes given below relate to coils wound on this type of former or on a similar  $1\frac{1}{2}$ " diameter former.

The coil sizes given here are suitable for use with 0.00016 mfd. tuning capacitors, such as the Eddystone No. 1131 or Raymart VC160X, and cover the range from 33 to 1.5 mcs., that is, from 9 to 200 metres.

#### COIL TABLE

##### L1

Range 33-13 mcs.	5 turns 18 S.W.G. wound alternate slots in former. Reaction: 3 turns 22 S.W.G. enam. wound between bottom 3 turns of tuned winding. Aerial: 4 turns 22 S.W.G. enam. closewound, 2 slots above tuned winding.
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##### L2

15-5 mcs.	14 turns 18 S.W.G. wound in former slots. Reaction: 5 turns 22 S.W.G. enam. closewound, 2 slots below tuned winding. Aerial: 8 turns 22 S.W.G. enam. closewound, 2 slots above tuned winding.
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#### L3

(Wound on Eddystone former 537, unslotted)

5-1.5 mcs.

50 turns 26 S.W.G. enam. closewound (1" in length).

Reaction: 15 turns 28 S.W.G. enam. closewound,  $\frac{1}{8}$ " below tuned winding.

Aerial: 12 turns 28 S.W.G. enam. closewound,  $\frac{1}{8}$ " above tuned winding.

These coil windings and the tuning capacitance have been chosen to cover the whole short-wave band with a few coils as possible. The minimum allowance has therefore been made for stray capacitances, and a poorly laid out or wired receiver will fail to give the actual coverages indicated.

The aerial coupling winding suitable to each coil is shown, but these windings need not be made if it is intended that capacitive coupling be used in the receiver. Since capacitive coupling is variable and can thus be adjusted to suit any aerial, it is perhaps rather more satisfactory than inductive coupling, although variations in the coupling capacitance will cause tuning variations by a slight degree and a close capacitive coupling between the aerial and the tuned circuit may cause a divergence from the indicated tuning range of the coils.

Close coupling between the aerial and receiver may also cause "dead-spots," where the receiver suddenly goes out of oscillation and will not respond to an advancement of the reaction control. Tuning through the dead-spot causes reaction to be obtained once again. The dead-spot is caused by the aerial's direct or harmonic resonance at the frequency where the dead-spot occurs, the aerial thus absorbing energy from the oscillating detector circuit to such a degree that the circuit fails to oscillate. When dead-spots occur the aerial-receiver coupling is too tight and must be reduced.

Hand capacity effects are avoided by using a thick panel of the same material from which the chassis is built, the tuning and reaction capacitors being mounted directly on the panel. A good earth connection often prevents hand capacity effects, which cannot be cured by other methods. Headphone lead capacity effects can be cured by inserting an R.F. choke into each headphone lead or into the receiver wiring immediately before the headphone sockets, but this is not often required and the chokes should not be placed in circuit unless they are needed.

R.F. chokes can be home made, but it is better to purchase a good, reliable component. The normal short-wave band is adequately covered by the Eddystone R.F. choke No. 1010, whose working range is from 60 to 1.5 mcs.

Short-wave tuning is highly selective and a really good slow-motion drive must be fitted to the receiver no matter how simple a circuit is used. The high selectivity and sharp tuning of a short-wave receiver is understood when the tuning range is compared with the average tuning range of a broadcast receiver. For example, the coil L1 of the coil table covers from 31-13 mcs., a range of 20 mcs., whilst the normal medium wave range coverage of a broadcast receiver is from 1,500 kcs. to 545 kcs., a range of 955 kcs. Allowing a station bandwidth of 10 kcs, this means that whilst

in the medium-wave range there is room for only 95.5 stations to operate without interference, in the 33-13 mcs. range there is room for 2,000 stations!

A specimen layout of the single valve receiver is shown in Fig. 17, and it will be seen that a very small chassis is all that is required.

#### Components List for the 1 Valve Short-Wave Receiver, Fig. 16.

L,	L1, L2, L3, as Coil Table.
C1,	0.00016 mfd. tuner, Raymart or Eddystone.
C2,	0.0001 mfd. Silver-mica.
C3,	0.00025 mfd. reaction control, Raymart VC250X.
Ca (if used),	20 mmmfd. variable coupling, Raymart VC20D.
R1,	4.7 meg., $\frac{1}{2}$ watt.
R.F.C.,	R.F. Choke, Eddystone No. 1010.
H,	High Impedance headphones.
V1,	Detector triode as HR210, HL23, etc.
1 4-pin ceramic valve-holder.	
1 coil holder, Eddystone No. 964.	
S1,	D.P.S.T. On-Off switch.
A,	2 volt cell.
B,	100 volt battery.

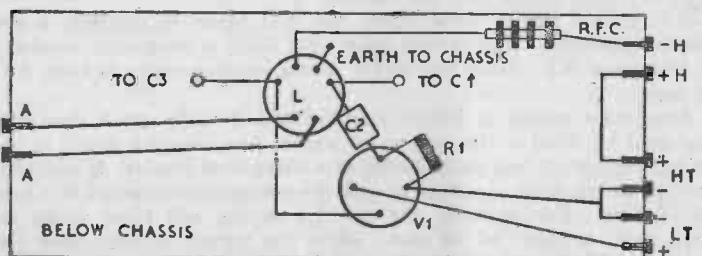
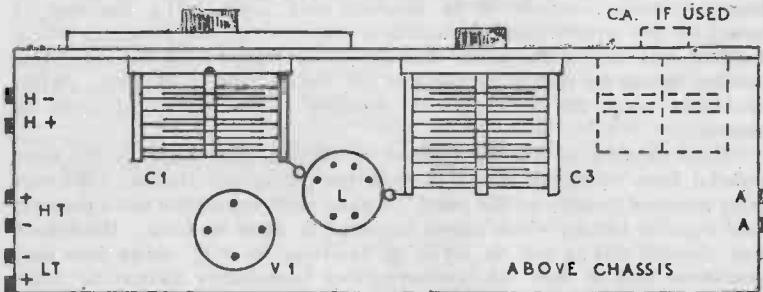


FIG. 17. Specimen Layout for the One-valve Receiver.

The optimum anode voltage on the valve should be found by experiment, using as high a voltage, for the sake of amplification, as will allow smooth reaction without threshold howl or "plopping." It may be found advantageous to test out various resistances in place of R1, a suitable range being from 1 megohm to the 4.7 megohms shown in the components list.

When Ca is used, set this to maximum capacitance, reducing the setting as necessary to eliminate dead-spots, or other tight coupling effects. For example, a tightly coupled aerial which is swaying with the breeze will cause a flutter on a station, or a wavering note if the detector is allowed to oscillate to make a C.W. signal audible. Reduction of the coupling will help to minimise the effect.

Test the receiver and ensure that oscillation is obtained—if the circuit fails to oscillate the reaction winding will be connected in the wrong sense and the leads must be reversed, or the anode voltage on the valve is too low—and then tune round the range given by coil L2 with C3 advanced to just beyond the critical oscillation point, so that a low hiss is heard. Stations will then be tuned as beat notes or heterodynes, the beat frequency reducing as the signal comes into tune, when the reaction control is backed off to allow the signal properly to be heard.

When winding the coils for this or any other oscillating receiver the tuned and reaction coils must always be wound on in the same direction so that any of the coils may be plugged into the holder with the reaction winding connected in the correct sense.

As in the case of the T.R.F. broadcast receiver, further stages may be added to the short-wave one-valve receiver, and the additions may be either H.F. or L.F. stages, or both. Since the selectivity of the short-wave receiver is in any case high, the H.F. stage is not necessary to give greater selectivity. At the same time, it is not easy to obtain really high H.F. stage gain when using battery valves, and at the shorter wave lengths, or higher frequencies, the H.F. gain can fall to a low figure. At the same time an H.F. stage does isolate the detector from the aerial, thus eliminating the chance of dead spots, aerial sway effects, and so on, and also the regenerative detector no longer supplies energy to the aerial and thus does not cause interference.

An L.F. stage added to the regenerative detector is often transformer coupled, since the detector is usually a triode, and although one stage of L.F. amplification is seldom sufficient to give loudspeaker reception of short-wave stations, it does give a worthwhile increase in the headphone strength of the received signals. If desired a loudspeaker output stage can follow the L.F. amplifier.

In Fig. 18 is shown a typical three-stage battery short-wave receiver, the detector being transformer coupled to the H.F. stage. Since both the first stages are tuned two coils for each range will be required.

The tuning coils for the H.F. stage must be made with the tuned winding exactly similar to the main winding of the detector stage coil. The reaction winding is obviously not needed and should not be put on the former, but the aerial coil can now be wound since variable aerial coupling is no longer necessary.

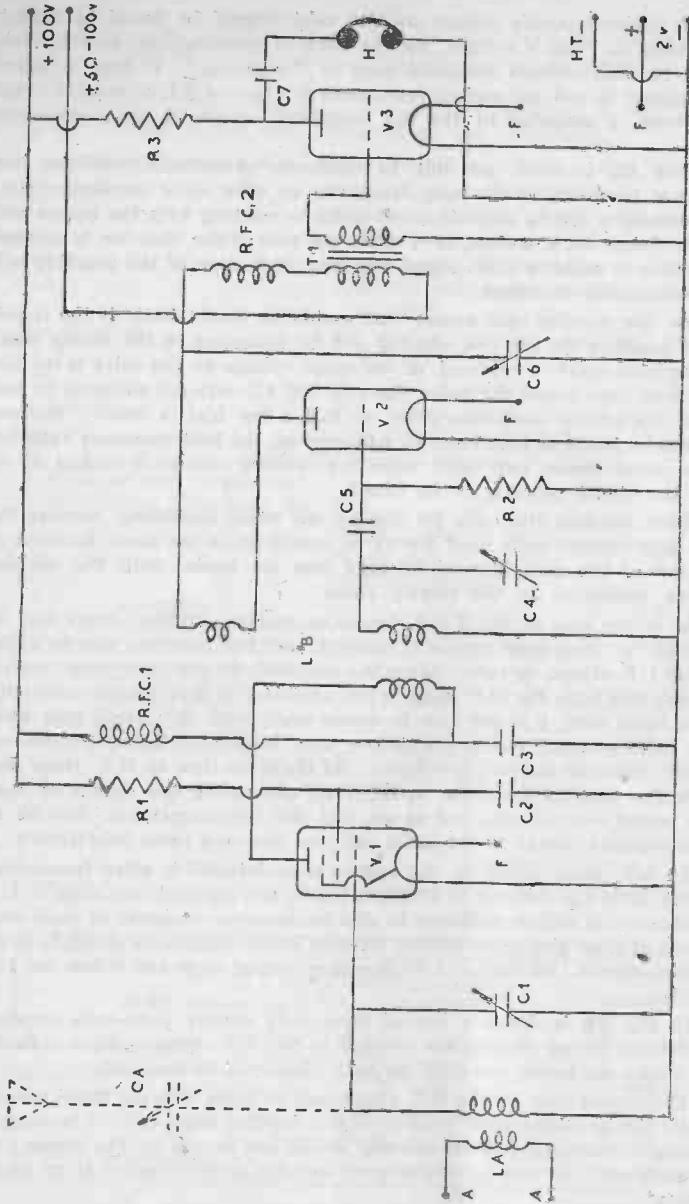


FIG. 18. A Three-stage Short Wave Receiver.

The detector coil now has to act both as a tuning and reaction coil and also as the secondary of an H.F. transformer, the primary winding of this transformer being in the anode circuit of the H.F. stage. This primary winding takes the place of the aerial winding, and in coils L1 and L2 this winding may be made in just the same way as is the aerial winding—in L1 it has 4 turns of 22 S.W.G. and in coil L2 it has 8 turns of 22 S.W.G. close-wound and spaced two former slots from the top end of the tuned winding in each case. For coil L3, however, the winding must be rather larger than is the aerial winding, and in place of the 12 turns of 28 S.W.G., as shown in the table, the primary winding must consist of 35 turns of 28 S.W.G. enamelled wire, closewound and spaced  $\frac{1}{8}$ " from the top of the main winding. L3 will now have to be wound with care in order that the three windings, coupling, tuning and reaction, all fit on to the former.

A ganged tuning capacitor is made up by using two Raymart VC160X tuning capacitors and coupling their spindles together by means of a flexible coupling. An aluminium or copper bracket is necessary to support the second capacitor in line with the first. A coupling such as the Eddystone No. 529 is used, and since the mesh of one capacitor can be varied against the mesh of the other when this form of coupling is used between them, aligning the circuit is simple. It is only necessary to tune in a fairly strong and steady signal, slacken off the coupling screws, readjust the H.F. tuning to give maximum volume and then to tighten the coupling again. If the circuits are to remain in alignment, and each pair of coils suited by the one capacitor alignment, it is obvious that the coils must be made with great care to have exactly the same characteristics in each pair. The two tuning capacitors may be separately driven if desired instead of being coupled. In that case two identical slow-motion drives will be needed, one for each tuned circuit, and the receiver must be tuned by keeping both dials in step.

#### Components List for the Three Stage Short-Wave Receiver, Fig. 18.

La,	As Coil Table, omitting reaction windings.
Lb,	As Coil Table, with larger primary windings on L3. See text.
Ca (if used),	20 mmfds. variable Raymart VC20D.
C1, C4,	0.00016 mfd. Raymart VC160X.
C2, C3,	0.01 mfd. Non-inductive.
C5,	0.0001 mfd. Silver-mica.
C6,	0.00025 mfd. Raymart VC250X.
C7,	1 mfd. Non-inductive.
R1, R3,	47,000 ohms, $\frac{1}{2}$ watt.
R2,	4.7 meg., $\frac{1}{2}$ watt.
H,	High Impedance headphones.
R.F.C. 1, 2,	R.F. chokes, Eddystone No. 1010.
T1,	3 : 1 Inter-valve transformer.
V1,	210 SPT or SP2.
V2,	HR210
V3,	HL23

- 1 British 7-pin ceramic valve-holder.
- 1 British 4-pin ceramic valve-holder.
- 1 Mazda octal chassis mounting valve-holder.
- 2 coil-holders, Eddystone No. 964.
- 1 coupler, for ganging, C1, C4, Eddystone No. 529.
- 1 aluminium or copper bracket, for C4.

Slow-motion drive, knob for C6, chassis, etc.

The circuits so far shown have the detector grid leak return taken in the usual manner to the negative side of the filament. It may be found advantageous, however, to return the grid leak to the positive side of the filament, especially if reaction is not as smooth as might be desired.

An R.F. Pentode may, of course, be used as a short-wave detector, and a valve with not too high an internal resistance should be chosen, such as the 210 SPT or the SP2. Using a pentode as a regenerative detector gives a choice of several reaction controls—the screen control, as shown in the broadcast receiver circuits may be used or the reaction circuit may be connected to the screen, which then acts as the reaction "anode," whilst the audio output is then tapped from the anode proper. Screen reaction may be controlled either by a variable capacitor or variable resistance.

A typical R.F. pentode oscillating detector is shown in the circuit of Fig. 19, a four-stage receiver with loudspeaker output capable of giving excellent results if carefully built and adjusted. The coil details are exactly as for the receiver of Fig. 18, since an H.F. stage is again transformer-coupled into the detector, the detector now being resistance-capacitance coupled into the first A.F. stage for a transformer cannot successfully be used in the pentode anode circuit.

#### Components List for the Four Stage Short-Wave Receiver, Fig. 19.

L <sub>a</sub> , L <sub>b</sub> ,	As for the previous circuit.
C <sub>a</sub> (if used),	20 mmfds. variable, Raymart VC20D.
C1, C4,	0.00016 mfd. tuners, Raymart VC160X.
C2, C3, C9,	0.01 mfd. No1. inductive.
C5,	0.0001 mfd. Silver-mica.
C6,	0.0005 mfd. Silver-mica.
C7,	0.5 mfd. Non-inductive.
C8,	2 mfd. 200 v.w. Paper.
C10,	0.1 mfd. Non-inductive.
C11,	4 mfd. 200 v.w. Electrolytic or Paper.
R1, R4, R6,	47,000 ohms, $\frac{1}{2}$ watt.
R2,	3.3 meg., $\frac{1}{2}$ watt.
R3,	22,000 ohms, $\frac{1}{2}$ watt.
R5,	0.25 meg., variable, reaction control.
R7,	1 meg., $\frac{1}{2}$ watt.
R8,	1 meg., variable, volume control.
R9,	330 ohms, $\frac{1}{2}$ watt.
R.F.C. 1, 2, 3,	R.F. Chokes, Eddystone No. 1010.
Sp,	Electro-Acoustic Industries 5" speaker, with output transformer, match 14,000 ohms anode load.

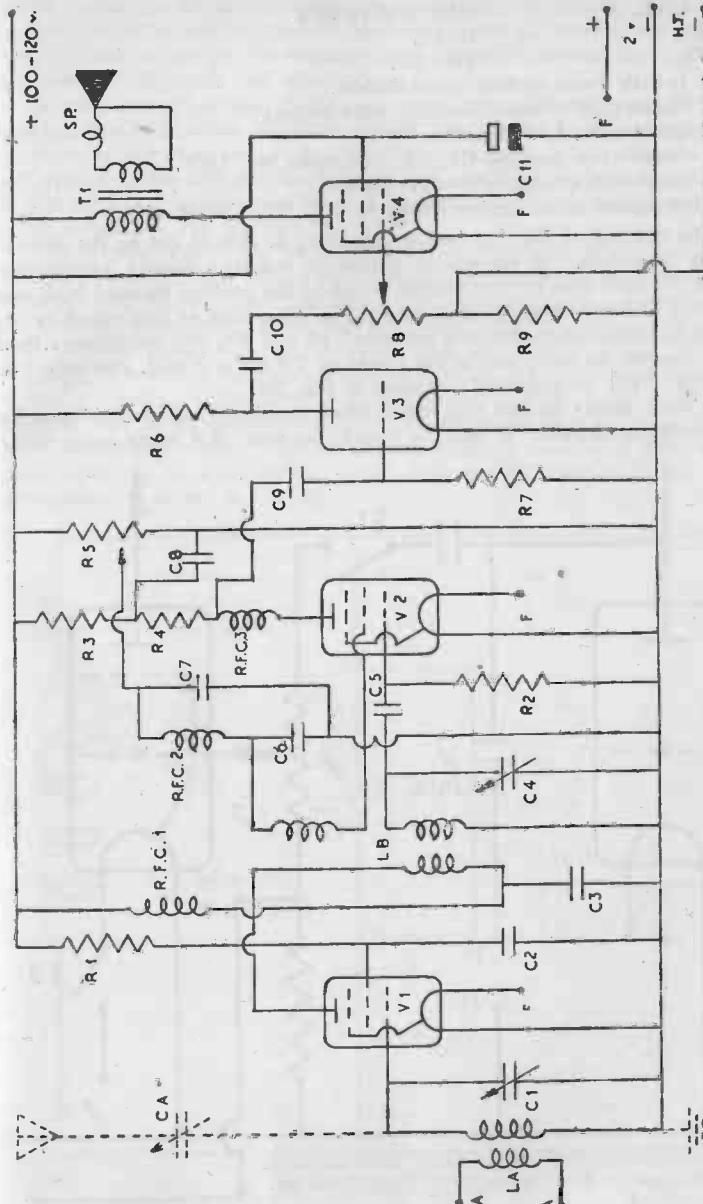


FIG. 19. A Four-stage Short Wave Receiver

V1, V2, 210 SPT or SP2.  
 V3, HL23.  
 V4, Pen. 25.  
 2 British 7-pin ceramic valve-holders.  
 2 Mazda octal chassis mounting valve-holders.  
 2 coil-holders, Eddystone No. 964.  
 1 coupler, for ganging C1, C4, Eddystone N<sup>o</sup>. 529.  
 1 aluminium or copper bracket for C4.  
 Slow-motion drive, control knobs for R5, R8, chassis, etc.

The ganging of the two tuning capacitors is carried out in the manner already described. If headphone output is required besides loudspeaker output, V4 may have its own On-Off switch in the positive filament lead, one half of a D.P.S.T. switch being used. The other half of this switch is arranged to break the connection between C10 and R8, the headphones then being coupled to earth and to the anode of V3 via a 1 mfd. non-inductive capacitor. The arrangement is shown in Fig. 20.

It need hardly be said that other valves besides those specified may be used in these circuits. It may be found, however, that when using other

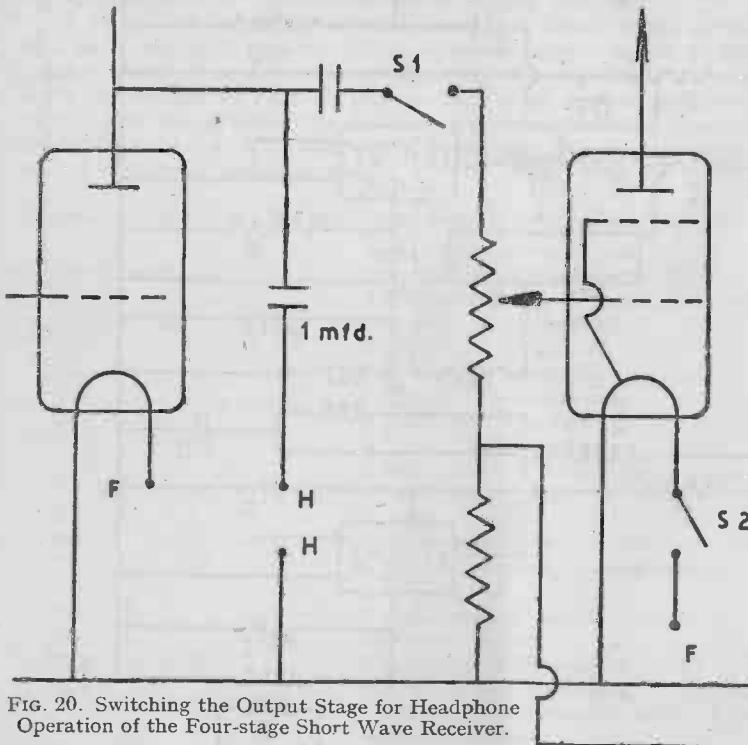


FIG. 20. Switching the Output Stage for Headphone Operation of the Four-stage Short Wave Receiver.

valves reaction is difficult to obtain or, conversely, the detector circuit may oscillate rather too readily. In this case the number of turns on the reaction winding may be varied, an increase in the number causing the circuit to oscillate more strongly, and vice versa.

It may also be beneficial to experiment with different sizes of aerial coupling windings, since different aerials will require differing degrees of coupling to the receiver. It is almost impossible to give coil data which will suit all valves and circuits, the best that can be done is to indicate the size of the tuned winding and to give reaction and aerial coupling windings which should suit the majority of cases.

When reception of the amateur bands is the main interest of short-wave operation, very fine tuning will be necessary in order to separate out the stations which lie very close together in the amateur bands. To obtain the finest tuning possible the main tuning capacitor may be shunted with a very small variable capacitance driven by its own slow-motion dial. This type of tuning, known as band-spread tuning, enables the receiver to be tuned to the proximity of the desired signal or on to a required band. The signal is then finally tuned or the band thoroughly explored by tuning on the small capacitance alone. For all general purposes this small band-spread capacitance may be a 20 mmfds. tuner, such as the Raymart VC20D. The arrangement is shown in Fig. 21.

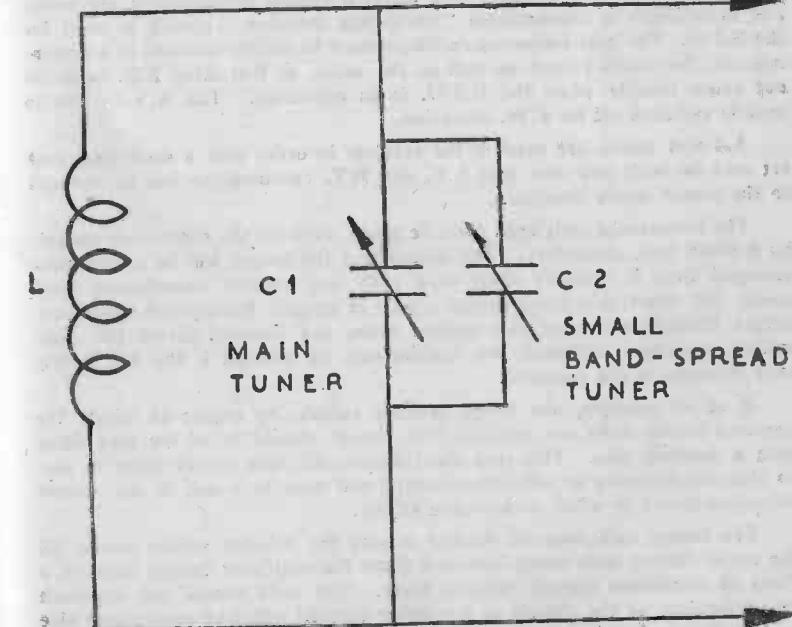


FIG. 21. Band-spread Tuning.

## CHAPTER VI

## THE "SEMI-COMMUNICATIONS" RECEIVER

The true communications receiver can hardly be copied in a battery version—features such as the crystal gate, regenerative I.F. stages, S-meters and the like cannot easily be introduced into a battery valve receiver. What may be termed a "semi" communications receiver can, however, be built with a tuning range covering both the short and medium wave bands, and the circuit of Fig. 22 shows a quite ambitious receiver. Two stages of I.F. amplification are provided, with switched A.V.C. and a beat frequency oscillator for C.W. reception.

To ensure correct alignment commercial coils are used, the P type coils of Messrs. Wearite enabling the tuning range to run from 12 to 750 metres without a break in 4 ranges. If desired a fifth range, for long-wave reception, can be added.

The beat frequency oscillator in an ordinary communications receiver is usually built up round a Hartley circuit using a tapped coil. A tapped coil can only be used with filament type valves if special arrangements are made, and accordingly a conventional "oscillating detector" circuit is used for the B.F.O. The beat frequency oscillator must be totally enclosed in a screening can, the whole circuit as well as the valve, so that stray R.F. fields do not cause trouble when the B.F.O. is in operation. The A.V.C. line is usually switched off for C.W. reception.

1.4 volt valves are used in the receiver in order that a small and neat set may be built and also that L.T. and H.T. consumption can be reduced to the lowest figure possible.

The commercial coils used must be tuned, even on the short-wave ranges, by 0.0005 mfd. capacitors. This means that the tuning will be rather more cramped than if ordinary short-wave coils and smaller capacitances were used. To offset this disadvantage a pair of ganged bandspread capacitors, driven through a second slow-motion drive, are shunted across the main tuning capacitors, although this feature may be omitted if the fine tuning thus obtained is not required.

If at all possible, the range selector switch, by means of which the required tuning coils are switched into circuit, should be of the type fitted with a shorting ring. This ring short-circuits all coils except those in use, so that the presence of an open-circuited coil near to a coil in use cannot introduce losses or other undesirable effects.

The tuning coils may be banked around the selector switch leaves, all the aerial tuning coils being screened from the oscillator tuning coils by a sheet of aluminium placed between them. The coils should not approach this screening, or the chassis or any other earthed metal of appreciable size by less than a half-inch, preferably more, otherwise the coil characteristics may be changed so far as ganging and circuit alignment are concerned.

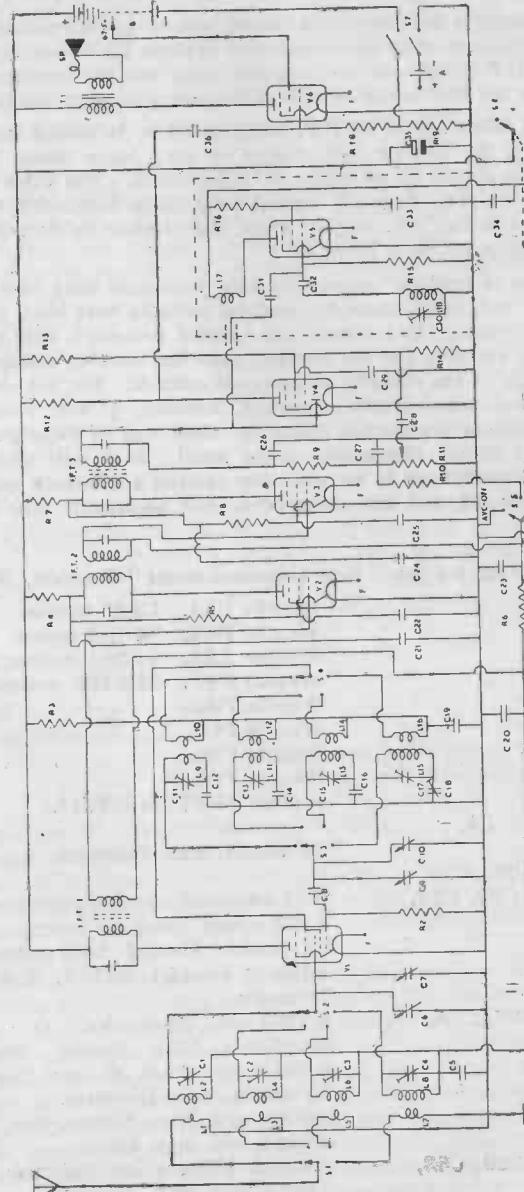


Fig. 22 A "Semi-communications" Receiver.

An R.F. stage is not shown, but can be built on to the receiver if desired by using the existing set of aerial coils (the Wearite PA series) as the tuning coils for the H.F. stage, and coupling this stage into the frequency changer stage by using the PHF series of coils as frequency changer tuning coils.

The main advantage of an H.F. stage would be to reduce image reception, but since the receiver will seldom be used below about 20 metres image reception should by no means be troublesome. The extra selectivity obtained from an H.F. stage (as distinct from image selectivity) will hardly be necessary with two I.F. stages, whilst the receiver in its present form has sufficient gain for most purposes.

In the case of previous components lists resistances have been shown as of the  $\frac{1}{2}$  watt type, whilst capacitor working voltages have been stated only for the larger values. This course was adopted because  $\frac{1}{2}$  watt resistances are universally available and the smallest capacitor working voltage rating—about 150 volts in the majority of cases—is suitable. For the components list of the semi-communications receiver, however,  $\frac{1}{4}$  watt resistors and 150 v.w. capacitors are quoted, since the small size of these components enable the set overall dimensions to be small. If  $\frac{1}{2}$  watt resistors and 350 v.w. capacitors have to be used the receiver's efficiency will not, of course, be impaired, but the components will necessarily take up more chassis space.

#### Components List for the "Semi-Communications" Receiver, Fig. 22.

L1, L2,	Wearite PA4. 12-35 metres.
L3, L4,	Wearite PA5. 34-100 metres.
L5, L6,	Wearite PA6. 91-261 metres.
L7, L8,	Wearite PA7. 250-750 metres.
L9, L10,	Wearite PO4.
L11, L12,	Wearite PO5.
L13, L14,	Wearite PO6.
L15, L16,	Wearite PO7.
L17, L18,	Wearite PHF7 (as B.F.O.).
C1, C2, C3, C4,	60 mmfds. max. Trimmers.
C11, C13,	0.01 mfd. 150 v.w. Non-inductive.
C5, C19, C20, C22,	0.0005 mfd. two-gang tuner.
C23, C25, C28, C36,	15 mmfds. Ganged band-spread tuner Use 2 Raymart MC15X, ganged with coupler.
C6, C9,	0.0001 mfd. Silver-mica.
C7, C10,	0.005 mfd. Mica. Padder. See Notes.
C8, C26, C27, C32,	0.0024 mfd. Mica. Padder. See Notes.
C12,	75 mmfds. max. Trimmers.
C14,	0.0009 mfd. Mica. Padder. See Notes.
C15, C17,	0.0004 mfd. max. Padder.
C16,	0.1 mfd. 150 v.w. Non-inductive.
C18,	0.0004 mfd. max. Trimmer.
C21, C24, C29, C33,	
C30,	

C31,	Small capacitance. See Notes.
C34,	0.001 mfd. Mica.
C35,	8 mfd. 250 v.w. Electrolytic.
R1, R6,	220,000 ohms, $\frac{1}{4}$ watt.
R2,	100,000 ohms, $\frac{1}{4}$ watt.
R3,	27,000 ohms, $\frac{1}{4}$ watt.
R4, R7,	4,700 ohms, $\frac{1}{4}$ watt.
R5, R8, R15, R16,	68,000 ohms, $\frac{1}{4}$ watt.
R9,	47,000 ohms, $\frac{1}{4}$ watt.
R10,	470,000 ohms, $\frac{1}{4}$ watt.
R11,	1 meg., variable, Volume control.
R12,	1 meg., $\frac{1}{4}$ watt.
R13,	3.3 meg., $\frac{1}{4}$ watt.
R14,	10 meg., $\frac{1}{4}$ watt.
R17,	22,000 ohms, $\frac{1}{4}$ watt.
R18,	2.2 meg., $\frac{1}{4}$ watt.
R19,	430 ohms, $\frac{1}{2}$ watt.
S1, 2, 3, 4,	4 pole 4-way wave-change switch (with shorting rings if possible).
S5, S6,	2 pole 3-way A.V.C.-B.F.O. switch.
S7,	D.P.S.T. On-Off switch, ganged with R11.
I.F.T. 1, 2, 3,	Midget 465 kcs. Iron cored.
Sp,	Electro-Acoustic Industries 5" speaker, with output transformer, match 8,000 ohms anode load.
V1,	1R5.
V2, V3, V5,	1T4.
V4,	1S5.
V6,	3S4.
6 peanut valve-holders.	1.5 volt cell (High capacity).
A,	100 volt battery (High capacity or "super power").
B,	1 coupler for C7, C10, Eddystone, No. 529.
	1 aluminium bracket for C10.
	2 slow-motion drives, 3 knobs, chassis, etc.
	Screening can for B.F.O. (aluminium or copper).
H.T. consumption, 16 mAs. approx.	L.T. consumption, 0.35 amp.

NOTES.—The final values of the padders shown in the circuit by C12, C14, C16, must be determined by trial, when the receiver is under test and alignment. The odd capacitances such as 0.0024 and 0.0009 mfd. must be built up from standard values. If it is thought desirable the total capacitance in each case may be built up by using both a fixed and a variable capacitance, so that by adjustment of the latter the final capacitance may be arrived at in as simple a manner as possible. The 0.0024 mfd. padder might, for example, be made up of an 0.002 mfd. mica capacitor with a 500 mmfds. maximum variable trimmer connected in parallel with it. The range of the combination would then be approximately 0.0022 to 0.0025

mfd., covering the 0.0024 mfd. required with ample room for exact adjustment. The 0.0009 mfd. padder might in the same way be made up of an 0.0005 mfd. mica capacitor paralleled by a 500 mmfds. maximum variable trimmer, when the range of the combination would be approximately 0.0007 to 0.001 mfd., again providing more than sufficient adjustment for exact tracking.

It is probable that the 0.005 mfd. padder on the first range oscillator tuned circuit will not require adjustment, but, here again, an 0.0047 mfd. capacitor, if available, could be shunted by a 500 mmfds. maximum variable trimmer to give a total capacitance range of approximately 0.0049 to 0.0052 mfd., which should be sufficient to overcome any slight change needed in the value of C12.

The B.F.O. is shown in the circuit built around V5, a 1T4. A small percentage of the output of this oscillator is fed into the diode detector, when the B.F.O. is working, via C31, which must have a small capacitance adjusted by trial. A fixed capacitor of about 10 mmfds. value might be used, or a very small variable trimmer, but it is usually sufficient to make up the value of C31 simply by winding a lead from the B.F.O. round the lead from I.F.T.3 to the diode plate. The B.F.O. lead must be as short as possible in order that stray energy may not be fed into the input side of the receiver through the tuned circuits, and the wrapping round the diode plate lead should be as near to the diode pin on the valve-holder of V4 as possible, the wrapping consisting of one or two turns. The two leads must, of course, be thoroughly insulated one from the other.

The B.F.O. is adjusted to oscillate at a frequency very close to the I.F. of the receiver. With an I.F. of 465 kcs., a B.F.O. frequency of 464 or 466 kcs. will beat with the intermediate frequency to produce an audible note of 1,000 cycles (1 kc.), this audio frequency dropping as the B.F.O. is tuned more nearly towards the I.F. or rising as the B.F.O. is tuned away from the I.F. To produce a 1,000 cycles note L18 must be tuned by a capacitance of 0.00038 mfd., so that the 0.004 mfd. trimmer specified should be advanced towards full capacitance. The B.F.O. must be tuned after the receiver I.F. amplifier is aligned and trimmed to 465 kcs. The switch S5, 6, is then turned to the B.F.O. position and, providing that the B.F.O. circuit is oscillating, an audible note will be heard when any carrier is tuned in the ordinary way. The B.F.O. should, for preference, be adjusted, using an unmodulated signal from the signal generator. Set the generator to any convenient frequency, tune in the carrier on the receiver and adjust C30 to give a pleasant note in the loudspeaker. The coupling between the B.F.O. and the diode detector afforded by C31 should also be adjusted at the same time.

#### ALIGNING THE RECEIVER

The general alignment of this receiver is similar to the superhet. alignment already described. With the whole circuit working properly, all oscillator ranges oscillating and the B.F.O. circuit oscillating, the receiver can be prepared for alignment. Switch on the signal generator and allow

it to reach operating temperature, and also allow the set to run for at least 10 minutes before the alignment. If the two-gang main tuner has trimmers fitted, unscrew them to their fullest extent. Unscrew all coil trimmers fully and leave the padder C18 at about half capacitance. The other padders, if these have been made up to have some variation, should have the variable component reduced to its minimum capacitance.

The I.F. transformers must first be adjusted. Connect an 0.1 mfd. capacitance directly across R2, so that the oscillator of V1 is put out of action. Switch the receiver to the medium-wave position. Connect the signal generator to earth and to the grid of V3 and ascertain that the A.V.C. switch is set to A.V.C. Off. Using as small an output from the generator as possible, align I.F.T.3 to 465 kcs., tuning first the diode side and then the primary or V3 side.

With this transformer tuned, transfer the generator lead to the grid of V2 and tune I.F.T.2 in the same way, first the secondary then the primary, and finally transfer the generator lead into the control grid of V1 in order to align I.F.T.1. With the I.F. transformers all tuned to 465 kcs.—sweep the generator through this frequency once or twice, after the last adjustment, to ensure that there are no stray or "off" peaks—the generator lead can now be taken to the aerial input socket, the other generator lead still being taken to the receiver earth.

Remove the shorting capacitance across R2, so that V1 can now operate in the usual manner. Leave the receiver switched to the medium-wave band, set C7, C10, the band-spread tuners, to their half-capacitance position, and tune the main tuning capacitors to 250 metres on the dial of the receiver.

C7 and C10 must, of course, be coupled so that they reach maximum and minimum capacitance together, that is, their rotors must be perfectly in line.

Tune the signal generator to 250 metres, 1,200 kcs., and trim C17 until the generator audio note is heard in the receiver's loudspeaker at maximum volume, keeping the generator output low. Then trim C4 to give an increase in volume until a new maximum is obtained.

Tune the main receiver control to 600 metres, 500 kcs., and tune the generator to the same setting. Pad the medium-wave oscillator circuit by C18, rocking the main tuning control if necessary, to bring in the generator note and then to obtain maximum volume.

Retune both receiver and generator to 250 metres and retrim C17 and C4 as necessary to obtain maximum volume.

Retune receiver and generator to 600 metres and repad C18 as necessary.

Repeat this trimming and padding until one adjustment fails to cause a change in the other. Finally, trim C4 to its final setting for maximum volume.

The other ranges of the receiver are aligned in exactly the same way, although the padding operation will probably be simpler, since the padder

values are so nearly correct at the start. On range 3, 91 to 261 metres trim at 100 metres, 3,000 kcs., and pad at 250 metres, 1,200 kcs. On range 2, 34 to 100 metres trim at 35 metres, 8,571.43 kcs. and pad at 90 metres, 3,333.33 kcs. On range 1, 12 to 35 metres trim at 15 metres, 20,000 kcs. or 20 mcs. and pad at 30 metres, 10,000 kcs. or 10 mcs.

Finally, set the B.F.O. for frequency as already described.

A typical layout for this receiver is shown in Fig. 23.

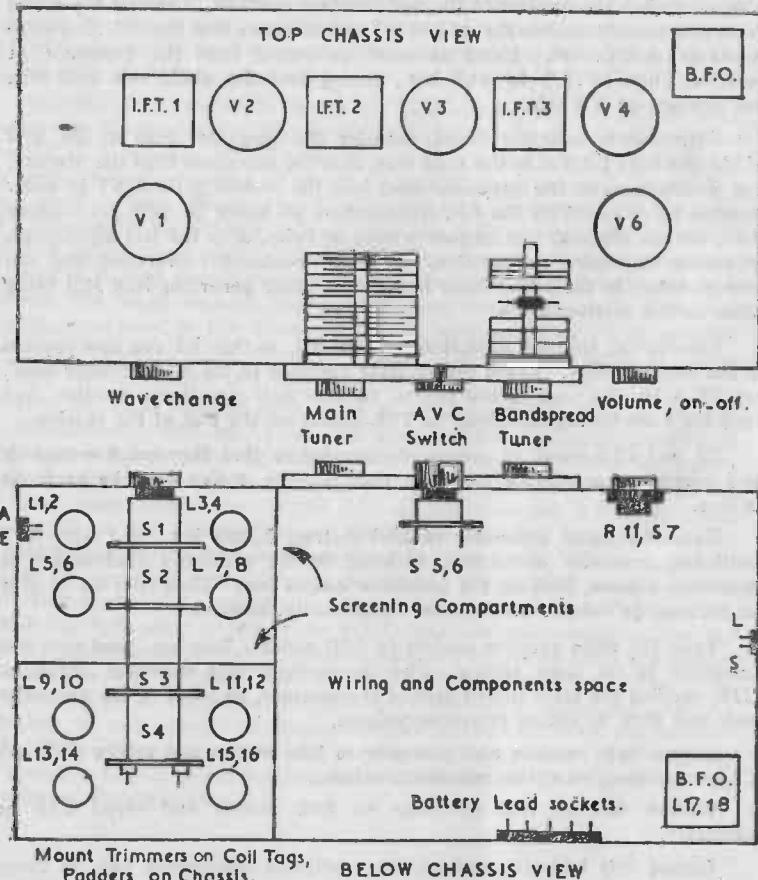


FIG. 23. Typical Layout for the "Semi-communications" Receiver.

## CHAPTER VII

### V.H.F. RECEPTION

The receivers so far described have been for the broadcast and short-wave bands, but even the "semi-communications" receiver cannot explore the wealth of interest contained within the Very High Frequency (V.H.F.) bands, which may be said to commence at the 30 mcs. amateur band.

At 30 mcs. and higher frequencies the ordinary regenerative detector circuit can be used, but with an increase in frequency the efficiency of this circuit soon begins to fall off. Tuning is exceedingly sharp, hand capacity effects become troublesome even with efficient screening, and detector stability is poor, whilst the gain given by an R.F. stage of amplification is negligible.

These defects are overcome by using either a special superheterodyne circuit, which must of necessity have a high I.F. to avoid image reception, or else by a much simpler super-regenerative circuit. The superheterodyne is gaining popularity for operation on 10 and 5 metres, and at even higher frequencies, but the constructor who wishes to build battery-operated gear will find the super-regenerative receiver of much greater value.

Experiment with a regenerative detector on any band will immediately show that the gain given by the circuit increases right up to the critical point where the valve goes into oscillation. Super-regeneration means that a second oscillatory, or alternating, voltage is introduced into the detector circuit, this second oscillatory voltage having a frequency above audibility and below the broadcast frequencies, the actual frequency being between the approximate limits of 20 and 200 kcs. This second oscillatory voltage causes the operating point of the detector circuit to vary, so that if the circuit is adjusted to the critical or oscillating point, oscillation can only take place at regular intervals, as the constantly altering operating point becomes favourable and presents the correct circuit conditions. The detector is thus swept in and out of oscillation at an inaudible rate, so that the detector can then be adjusted to what would normally be far beyond the critical point. The gain given by the detector then becomes literally enormous, and a single valve can give as great a gain as a multi-circuit superhet.

At the same time, the super-regenerative circuit gives a measure of automatic volume control, the majority of signals giving apparently the same output strength in the headphones, whilst the circuit also discriminates against noise, especially of the ignition type, which is so troublesome on the V.H.F. bands.

The super-regenerative receiver can only receive modulated signals, i.e., telephony or tone-modulated C.W., since the mode of reception is as follows. The detector works in "spurts," each spurt consisting of several cycles of oscillations which, in the absence of a received signal, are completely damped. The next spurt of oscillations commences at random, and is usually triggered off by noise voltages arising in the circuit. Thus, when no station is being

received, the characteristic output from the super-regenerator is a continuous hiss, this hiss being formed by the random spurts of oscillation.

When a signal is tuned, however, each spurt of oscillation is triggered off in accordance with the signal amplitude, so that for a weak amplitude, at a trough of modulation, the spurt is short, whilst at a peak of modulation the spurt is triggered off rapidly and is of longer duration. The characteristic hiss, therefore, disappears as a station is tuned, and the rectified output current due to the oscillatory spurts is heard in the headphones as audio corresponding to the audio modulation of the received signal. Quality, obviously, cannot be high with super-regenerative detection, but the overall gain and range of the receiver more than compensates for this one defect. The super-regenerator, moreover, is extremely inselective, so that the very fine tuning normal to the V.H.F. bands is transformed into tuning so broad that tuning can be carried out direct without the use of a slow-motion dial. Hand capacity is still present to some degree, and the super-regenerative receiver should be tuned through an extension spindle. The Eddystone 4" spindle (which can be extended to almost 7") is of adequate length. The tuning capacitor, which in the majority of circuits has neither side earthed, is then mounted in an insulating bracket, such as the Eddystone No. 1007.

Super-regeneration can be obtained in one of two ways, a separate valve or circuit can be used to supply the second oscillatory voltage (known as the "quench" voltage), or the detector can be self quenching, supplying its own quench.

The simplest self-quenching detector circuit is shown in Fig. 24. In this circuit the valve oscillates at the signal frequency and the grid capacitance and grid leak resistance are so chosen that the self-biasing negative grid voltage caused by the valve's oscillating cannot leak off sufficiently fast. The valve is thus blocked, or "squegs," so that oscillations cease momentarily and then are resumed, the squeeging action continuing at a rate which is above audible frequencies, but which is slow compared with the fundamental frequency of the oscillations.

The circuit of Fig. 24 is most suitable for use with special mains valves of the Acorn type, but battery triodes will operate in this way, although the anode voltage will require to be high as a general rule—at least 100 volts.

This circuit, like any other V.H.F. circuit, must be very neatly laid out and wired. The tuning coil is mounted directly across the tuning capacitor, and if plug-in coils are used to provide more than one tuning band the coil ends should be arranged to insert into small holders mounted on the tuning capacitor, cylindrically shanked soldering tags being suitable to hold coils wound of 18 S.W.G. wire. The coupling between the aerial and the tuning coil should be inductive, if a dipole aerial is used, but it is generally more satisfactory to use a plain half-wave aerial, cut to resonate at the preferred frequency, coupling one end of this aerial to the anode end of the tuned circuit through a very small capacitance, as shown in the diagram.

The leads from the tuned circuit to the valve-holder must be as short as possible—on the grid side there should be no leads at all, since the grid capacitor should run direct from the tuned circuit to the grid pin on the valve-holder.

The filament chokes shown in the diagram are not essential and may be omitted if desired. The operation of the circuit is smoother with the chokes included, however.

#### Components List for the One Valve Super-Regenerator, Fig. 24.

L1,

3-6 metres. 8 turns 18 S.W.G. copper wire,  $\frac{1}{2}$ " diam., spaced to 1".  
6-10 metres. 18 turns 18 S.W.G. copper wire,  $\frac{1}{2}$ " diam., spaced to  $1\frac{1}{2}$ ".

C1,

40 mmfds. Tuner. Raymart VC40X.

C2,

0.0001 mfd. Silver-mica.

C3,

3-30 mmfds. Trimmer.

C4,

0.005 mfd. Mica.

R1,

220,000 ohms,  $\frac{1}{2}$  watt.

R2,

0.25 meg., Regeneration control.

R.F.C.

60 turns 30 S.W.G. enam. closewound on a  $\frac{1}{4}$ " diam. former.

Cf,

Filament chokes. 30 turns 18 S.W.G. enam. closewound on a  $\frac{3}{8}$ " diam. former.

H,

High Impedance headphones.

S1,

D.P.S.T. On-Off switch, ganged with R2.

V1,

HR210.

1 ceramic 4-pin valve-holder.

A,

2 volt cell.

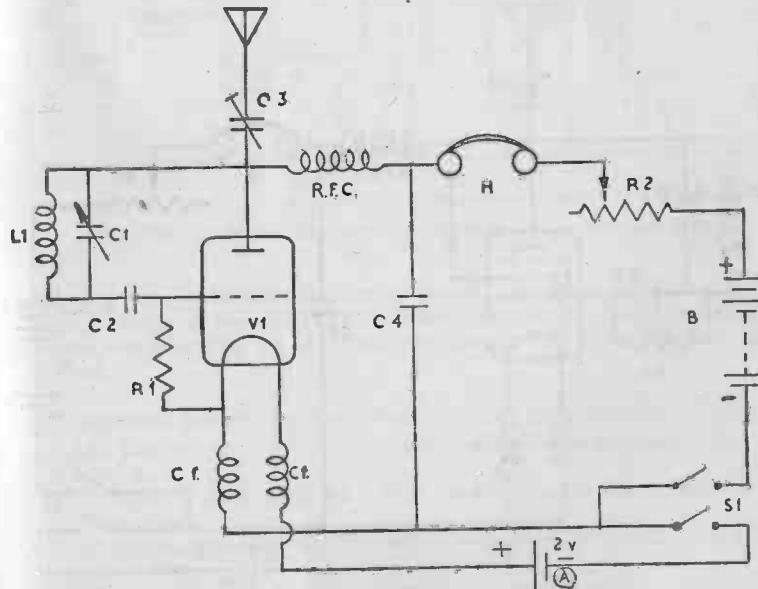


FIG. 24. A One-valve Super Regenerative Receiver.

B, 100 or 120 volt battery.

Extension spindle, Eddystone, 1008.

Insulating bracket, Eddystone 1007.

Control knobs, chassis or baseboard, etc.

Other valves than the HR210 may, of course, be tried in the circuit, and the values of R1 and C4 may be varied to vary the quenching frequency. If pentodes are tested in this circuit they should be triode connected, that is, the screen and, if a connection is brought out free from the filament, the suppressor grid also, should be connected to the anode.

A slightly different version of this circuit is shown in Fig. 25 using a 1T4 1.4 volt valve, where the screen and anode are connected together and the grid is given positive drive. In this circuit, as in Fig. 24, the R.F. choke may be taken to a tapping on L1 rather than directly to the anode of the valve, this tapping being found experimentally.

The components values for this circuit are exactly as those for the circuit of Fig. 24, except for R1. R1 must now be at least 1 megohm in value, although values between 1 and 4.7 megohms should be tried to suit the actual circuit characteristics, layout, etc. A must, of course, now be a 1.5 volt cell and the battery B may be lower in value. An anode voltage much above 45 volts should not be applied to the 1T4 valve when the screen is connected as shown, but to give control through R2 a battery voltage higher than 45 volts will be required.

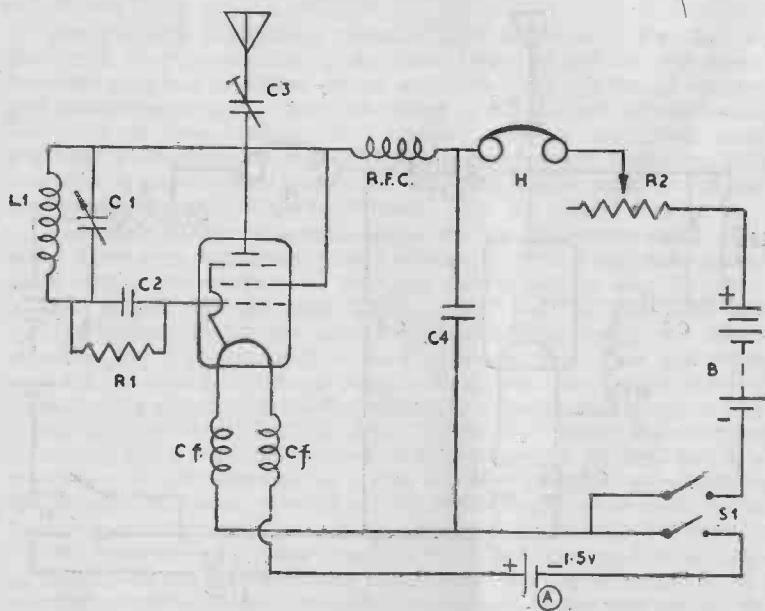


FIG. 25. The Self Quenching Receiver adapted to the IT4.

The writer has had this circuit, using the 1T4, operating with an anode voltage of only 30 volts, but even as a super-regenerator the valve displayed its rather poor high frequency qualities, the circuit proving rather unstable with shift of tuning with a variation in anode voltage, whilst hand capacity effects were bad.

It is usually more satisfactory, when using battery valves, to obtain the quench frequency from a pair of quench coils, such as the Bulgin or Eddy-stone quench coils. A pair of large "wave wound" coils on an insulating tube with fixing feet form the quench coils, and they may be tuned to a suitable frequency by fixed capacitors connected across them. These coils, connected to an oscillator, as shown in Fig. 26, so that they are in the feed lines, will supply the quench frequency by oscillating themselves, although

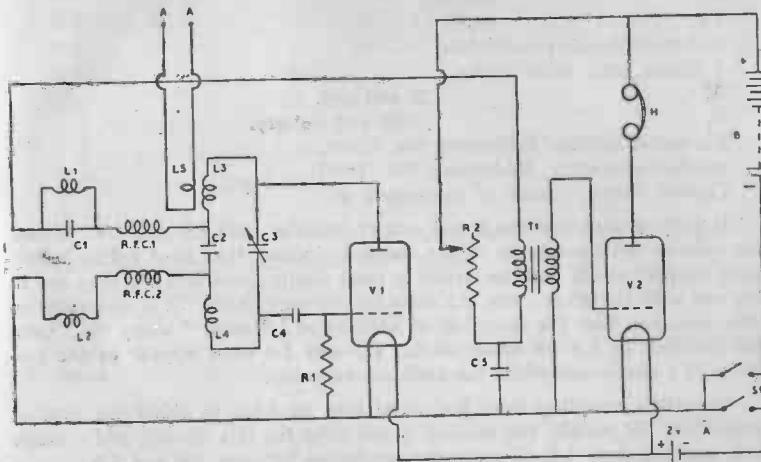


FIG. 26. A Super Regenerative Receiver using Quench Coils.

only one valve is used in the double circuit. A second valve is shown in Fig. 26 acting as an L.F. amplifier transformer coupled to the detector. A similar amplifier may be used with the detectors of Figs. 24 and 25 if desired.

#### Components List for the Super-Regenerative V.H.F. Receiver, Fig. 26.

L1, L2,

L3, L4,

For 5 metres, 3 turns each, 18 S.W.G. copper wire,  $\frac{1}{2}$ " diam., turns spaced own diam.

For 10 metres, 6 turns each, 18 S.W.G. copper wire,  $\frac{1}{2}$ " diam., turns spaced own diam.

Cf,  
Single turn aerial coupling.

0.001 to 0.005 mfd. Mica.

C2,	0.0003 mfd. Mica.
C3,	40 mmfds. Tuner. Raymart VC40X.
C4,	0.0001 mfd. Silver-Mica.
C5,	0.5 mfd. 150 v.w. Non-inductive.
R1,	220,000 ohms, $\frac{1}{2}$ watt.
R2,	0.25 megohm, variable, regeneration control.
T1,	3 : 1 Inter-valve transformer.
S1,	D.P.S.T. On-Off switch, ganged with R2.
R.F.C.1, 2,	60 turns 30 S.W.G. enam. closewound on $\frac{1}{4}$ " diameter former.
H,	High Impedance headphones.
V1,	HR210.
V2,	HL23.
1 4-pin ceramic valve-holder.	
1 Mazda octal valve-holder.	
A,	2 volt cell.
B,	100 volt battery.
Extension spindle, Eddystone No. 1008.	
Insulating bracket, Eddystone, No. 1007.	
Control knobs, chassis or baseboard, etc.	

It will be seen that the tuned circuit includes both L3 and L4. These two coils do not have to be tightly coupled—indeed, they need not be inductively coupled at all, but the circuit is most neatly constructed if they are in line one with the other, with C2 mounted between them. It is important to note, however, that the direction of winding of L4 must "carry on" from the direction of L3—in other words, L3 and L4 must appear as the two halves of a single coil which has been cut centrally.

Capacitive coupling from the aerial may be tried to either the grid or anode coil, but usually the loading is too great for this circuit, and a single turn coupling coil, L5, is generally supported between L3 and L4.

If the circuit fails to give the characteristic super-regenerative hiss, the connections to either L1 or L2 must be reversed in order that this tuned circuit shall also oscillate.

C1 is chosen to give the best super-regenerative frequency with the coils used, and may be either in the position shown or connected across L2. Alternatively, both L1 and L2 may be tuned.

As a final example of a super-regenerative V.H.F. receiver, in Fig. 27 is shown an oscillating detector with a separate quench oscillator. The oscillating detector circuit is identical with that of Fig. 26, whilst the quench oscillator uses a commercial quench coil set. A stage of L.F. amplification is provided.

#### Components List for the Super-Regenerative Receiver, Fig. 27.

L1,	Aerial coupling.
L2, L3,	Tuning coils.
L4, L5,	Quench coils.

#### Values as for Fig. 26.

C1,	0.0003 mfd. Mica.
C2,	40 mmfds. Tuner. Raymart VC40X.
C3, C5,	0.0001 mfd. Silver-mica.
C4,	0.001 to 0.005 mfd. Mica.
C6,	0.01 mfd. 150 v.w. Non-inductive.
R1,	220,000 ohms, $\frac{1}{2}$ watt.
R2,	0.25 meg., variable, regeneration control.
R3,	47,000 ohms, $\frac{1}{2}$ watt.
T1,	3 : 1 Inter-valve transformer.
H,	High Impedance headphones.
R.F.C.1, 2,	R.F. Chokes. As for Fig 26.
S1,	D.P.S.T. On-Off switch, ganged with R2.
V1, V2,	HR210.
V3,	HL23.
1 4-pin ceramic valve-holder.	
1 4-pin paxolin valve-holder.	
1 Mazda octal valve-holder.	
A,	2 volt cell.
B,	100 volt battery
Extension spindle, Eddystone No. 1008.	
Insulating bracket, Eddystone No. 1007.	
Control knobs, chassis or baseboard, etc.	

Further details of V.H.F. circuits will be found in the "Ultra Shortwave Handbook," 2/6, No. 57 in Messrs. Bernard's List.

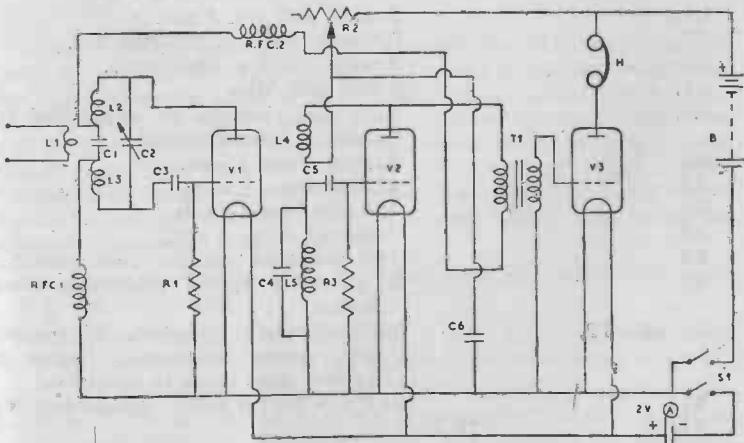


FIG. 27. A Super Regenerative Receiver with Separate Quench Valve.

## CHAPTER VIII

### THE BATTERY AMPLIFIER

The battery amplifier, for work such as record reproduction, must give the best output possible for the least battery drain. The circuit, therefore, must practically always be built round either a Q.P.P. valve or Class B valve, since in both these systems of amplification the H.T. current varies with the signal, a heavy current being drawn from the H.T. battery only when the signal amplitude is high. At the time of writing, Class B valves are in short supply, so that in Fig. 28 is shown a Q.P.P. amplifier capable of delivering a 1 watt output when fully loaded.

An advantage of Q.P.P. over Class B operation is that the input transformer to the Q.P.P. valve is not required to supply current as is the Class B input transformer. An ordinary centre tapped transformer may thus be used, as in Fig. 28, or, if this is unobtainable, an ordinary inter-valve transformer with an "artificial" centre tap, provided as shown in Fig. 29.

The grid bias for the Q.P.P. amplifier must be supplied by a bias battery, since self-biasing, due to the constantly fluctuating current, is impossible.

A tone correcting circuit is usually connected across the primary of the centre tapped output transformer used with a Q.P.P. stage, and in Fig. 28 this has been made variable to give a degree of tone control.

The resistance of the volume control potentiometer across which the input is applied must be suitable for the pickup with which the amplifier is to be used. The required input resistance is usually quoted for most good pickups, but in cases of doubt a volume control of 0.25 megohm is usually satisfactory.

Components List for the Battery Amplifier, Fig. 28.

C1,	2 mfd. 200 v.w. Paper.
C2,	0.1 mfd. 250 v.w. Non-inductive.
C3,	8 mfd. 250 v.w. Electrolytic.
C4,	0.002 mfd. Mica.
R1,	0.25 meg., variable, or as specified for pickup. Volume control.
R2,	22,000 ohms, $\frac{1}{2}$ watt.
R3,	47,000 ohms, $\frac{1}{2}$ watt.
R4,	470,000 ohms, $\frac{1}{2}$ watt.
R5,	100,000 ohms, $\frac{1}{2}$ watt.
R6,	100,000 ohms, variable, Tone control.
T1,	3 : 1 centre tapped inter-valve transformer.
Sp. with T2,	Electro-Acoustic Industries 5" speaker, with output transformer, match to 17,000 ohms anode to anode load.
S1,	D.P.S.T. On-Off switch, ganged with R1.
V1,	HL23.
V2,	LP2.
V3,	QP240.

1 4-pin valve-holder.

1 Mazda octal valve-holder.

1 British 9-pin valve-holder.

A,

B,

C,

2 volt cell.

150 volt high capacity (or "super power") battery.

9 volt grid bias battery.

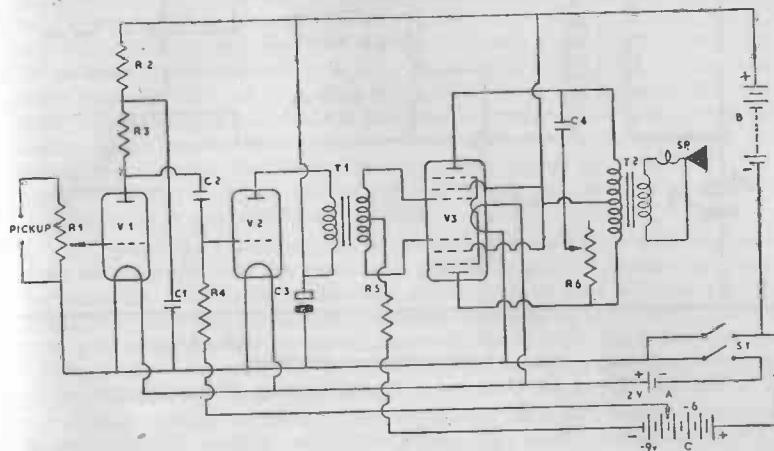


FIG. 28. The Q.P.P. One-watt Battery Amplifier.

The two pentodes comprising the QP240 valve should be ready matched but when the circuit is first built and tested it is wise to take the two screens to the H.T. battery via separate leads. Both screens should then be connected to the 150 volt battery tapping, and the anode current through each half of the valve measured in turn. If one pentode takes a slightly greater current than the other (with R1 turned down and no input signal applied) the screen of the pentode passing the greater current should be tapped at slightly lower voltages down the battery until both anodes under quiescent conditions are drawing identical currents.

The screens can then be connected permanently and the two halves of the valve will be matched.

The filament consumption of the circuit is 0.65 amp., whilst the total no-signal H.T. consumption will be approximately 14 mA. rising on peaks.

The input valve is shown unbiased. This will prove a quite suitable arrangement in the majority of cases, but if overloading should occur it is only necessary to isolate the bottom end of R1 from the earth line or chassis and take the connection instead to about 1.5 volts of negative bias.

In Fig. 29 it will be seen that the only extra components needed to provide the "artificial centre tap" on an ordinary inter-valve transformer are a pair of 10,000 ohm resistances.

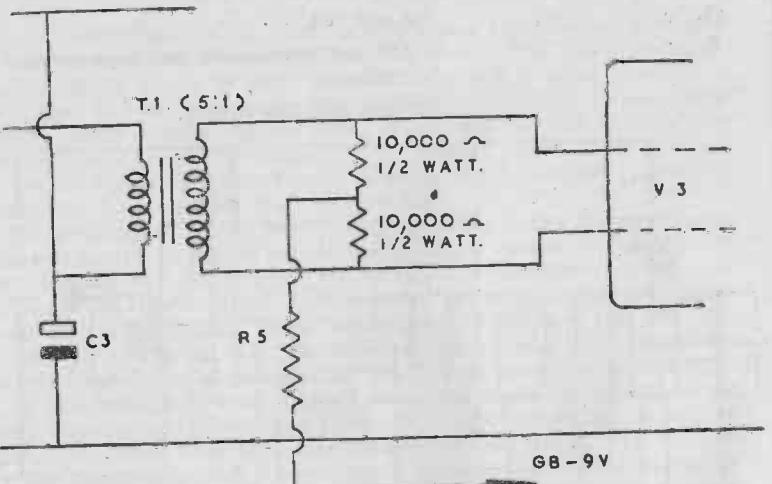


Fig. 29. Using an Untapped Transformer as T1 for Fig. 28.

## CHAPTER IX SERVICING THE BATTERY SET

So far as the actual receiving and amplifying stages are concerned, the testing and servicing of battery-operated receivers is carried out in the usual manner, faulty stages being investigated and repaired either by inspection of the circuit with a circuit analyser or multi-meter, measuring the voltages and currents associated with each stage or by the use of a signal tracer. Some defects, however, are particular to battery sets alone.

Battery valves must have the full 2 or 1.4 volts on their filaments. Filament supply wiring should be stout so that the wiring itself, together with the contacts at the valveholder between filament pins and the holder sockets, present the lowest possible resistance. One or two valves, their heaters connected in parallel, can take a current of half an ampere or more, when an undesirable and avoidable resistance in the wiring can cause an appreciable voltage drop across the filaments themselves.

When 2 volt valves are used, supplied from an accumulator, the leads should be inspected at regular intervals for corrosion, especially when a trickle charger keeps the accumulator up to voltage. The trickle charger

may cause the cell to spray, and acid spray on leads and, perhaps, a change-over switch, can cause a good deal of trouble through poor contacts, giving rise either to a fall in voltage at the receiver or to noise through intermittently changing contact resistance.

A trace of vaseline should be applied to accumulator terminals, whilst the top of the cell should be kept clean and dry.

Grid bias batteries, when used, should be changed at regular intervals. No current is drawn from them, unless they are connected across a high resistance potentiometer for the control of variable-mu valves, in which case only a very small current will be taken, but in the course of time the cell electrolyte will dry out and the internal resistance of the battery will rise. To measure the voltage across a suspect grid bias battery, use a low resistance voltmeter (the use of such a voltmeter is usually undesirable for most radio measurements), so that an appreciable current is drawn from the battery as the measurement is made. If the battery is drying out, either the voltmeter will give a low reading or else a true reading obtained as the voltmeter is connected across the battery will rapidly fall to a lower reading. In either case a new battery is required.

H.T. batteries should also be tested for voltage either with a low resistance voltmeter or with the receiver connected across the battery and working normally. H.T. batteries also dry out, and whilst they will then indicate practically full voltage on a high resistance voltmeter of the 1,000 ohms per volt type, when they are supplying current to the receiver the battery voltage will be much lower, whilst at the same time the increasing internal resistance of the battery may cause instability.

It is necessary to have a low impedance path for audio frequencies between the H.T. positive and negative lines. In a mains receiver or amplifier this path is provided by the smoothing capacitance, whilst in a battery set it is provided by the battery itself. As the battery ages, therefore, the impedance of the path rises, and may finally result in feedback and instability in the receiver. As has already been stated, this condition can be cured by connecting a suitable capacitance across H.T. positive and negative, such as an 8 mfd. electrolytic capacitor. The connections should be made after the On-Off switch.

When a receiver is self-biased, either a 4 or 8 mfd. capacitor will be found connected across the H.T. positive line and the chassis or, perhaps more commonly, a bias capacitor of about 25 mfd. capacitance will be shunted directly across the bias resistance. Should this capacitor fail, either the biasing and smoothing arrangements of the circuit before all else, output valve with a corresponding increase in H.T. consumption and distortion, or else the bias resistance will be left unshunted by a capacitance, when the output valve and the whole receiver will be subject to a percentage of feedback, causing a loss in volume and, possibly, instability and distortion.

When such troubles are encountered, therefore, it is as well to inspect the biasing and smoothing arrangements of the circuit before all else.

An ageing H.T. battery can often be improved for further useful service by making voltmeter checks across blocks of cells, taking the voltmeter connections from negative to the first tapping, from the first to the second

tapping, from the second to the third tapping, and so on. It will most likely be found that at least one group of cells between tappings are down in voltage, and have dried up to some extent, the whole battery then giving low voltage and causing noise and crackle in the receiver. This faulty block of cells is put out of circuit by connecting a wire between the two tappings on either side of the block, thus shorting out the bad cells and leaving the relatively good cells to supply the H.T. current.

For servicing battery receivers, ordinary service gear is perfectly suitable. Where there is no mains supply, however, the need may sometimes be felt for a battery-operated signal generator, and such a circuit is shown in Fig. 30. 1.4 volt valves are used, since it is then possible to make up a small instrument suitable not only for bench work but also easily portable so that it takes up but little space in the serviceman's bag.

Two 1T4's are used in the circuit, and since the oscillator is working well over the critical point and the amplitude of oscillation is not subject to variation, no trouble from detuning with reaction is experienced. The drain from the L.T. cell and the H.T. battery is small, so that the battery life is long. In order to maintain stability of calibration, the H.T. battery voltage should be kept constant.

As the H.T. battery of the prototype, four 9 volt grid bias batteries were connected in series, to give 36 volts. Thus, the battery was kept small in size but had a higher capacity than would have been the case if a layer-built type of battery had been used.

Either a modulated or unmodulated R.F. carrier is provided, or an audio signal only can be supplied by the generator. The frequency range is from 150 kcs., 2,000 metres, to 20 mcs., 15 metres, whilst higher frequencies can be obtained by using the second and even third harmonics of the signal generator, thus covering up to television frequencies if need be.

A simple attenuator only is shown, since with this type of circuit a calibrated output is practically an impossibility.

The tuning capacitor should be driven through a good slow-motion tuning dial which can be calibrated for preference in terms of wavelength or frequency. The generator must, of course, be calibrated by one of the well-known methods, such as comparison on a good receiver with a standard commercial generator or a series of station frequencies.

In Fig. 30 the coils shown as a, a, b, b, etc., refer to the tuned and reaction coils of each P type coil specified. It will be noted that across the reaction winding of coil d is shown a shunt resistance,  $R_s$ . Such a shunt may be used if a particular coil oscillates sufficiently strongly to give "squegging," immediately recognised since the signal from the generator under squegging conditions will be broadly tuned rather than sharp, whilst the audio content will sound harsh and crackly instead of the usual clear note. With the circuit values shown, squegging should not occur, but if it does a shunt across the reaction winding of the particular coil affected will cure the condition.  $R_s$  must be found experimentally, commencing with a value of about 2 or 5,000 ohms, and so is not shown in the components list.

The audio oscillator V2 uses an ordinary inter-valve transformer as the low frequency oscillating coils, and since the amplitude of oscillation is low

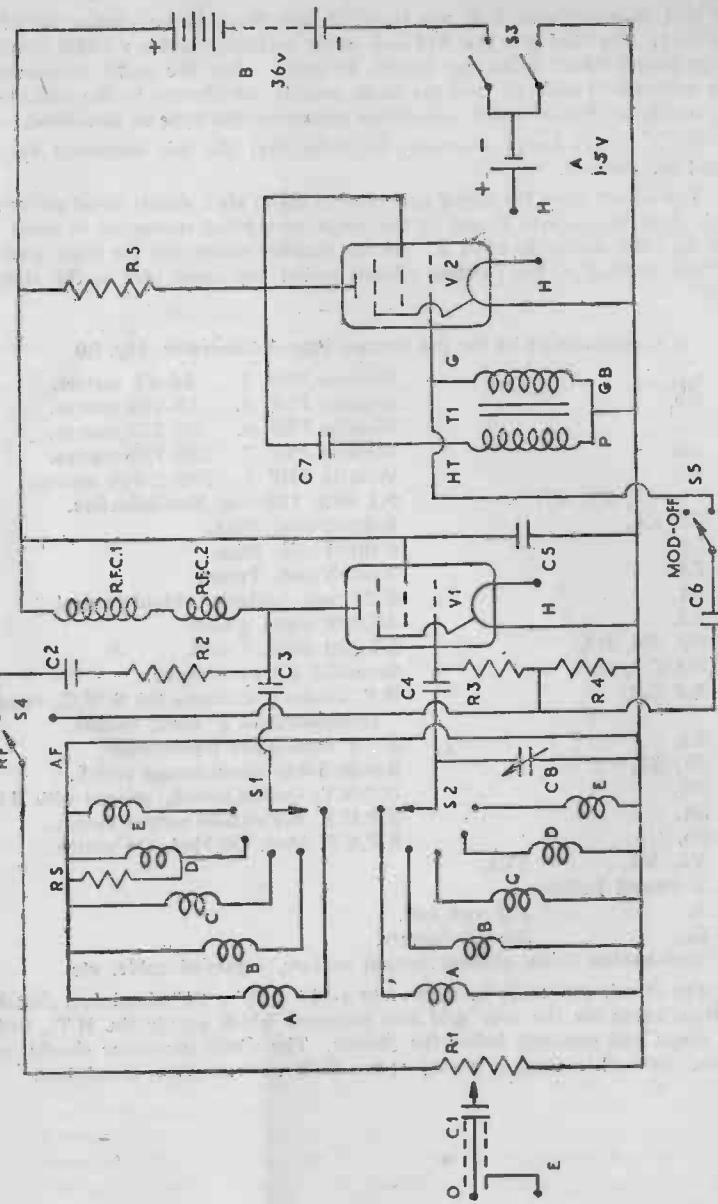


FIG. 30. A Battery-operated Signal Generator.

no grid capacitor and leak are required and there is no chance of V2's blocking. The feed into the grid leak of the oscillator avoids a slight change of frequency which otherwise tended to occur when the audio modulation was switched in and out, and the audio note is not affected by the tuning of the oscillator circuits which sometimes occurs on this type of generator.

R.F.C.2 was found necessary in order that the full frequency range might be covered.

The output from the signal generator is taken via a simple cored screened cable from the sockets O and E, the single core being connected to point O and the cable screen to point E. At the receiver under test the cable screen is then earthed to the receiver chassis whilst the cable core is the signal lead.

Components List for the Battery Signal Generator, Fig. 30.

a,a,	Wearite PHF 3. 16-47 metres.
b,b,	Wearite PHF 5. 35-100 metres.
c,c,	Wearite PHF 6. 95-255 metres.
d,d,	Wearite PHF 7. 250-750 metres.
e,e,	Wearite PHF 1. 700-2,000 metres.
C1, C3, C5, C7,	0.1 mfd. 150 v.w. Non-inductive.
C2, C6,	0.0003 mfd. Mica.
C4,	0.0001 mfd. Mica.
C8,	0.0005 mfd. Tuner.
R1,	0.25 meg. variable, output control.
R2,	47,000 ohms, $\frac{1}{2}$ watt.
R3, R4, R5,	33,000 ohms, $\frac{1}{2}$ watt.
R.F.C.1,	Screened All-wave choke.
R.F.C.2,	R.F. Choke. 40 turns 30 S.W.G. enam. closewound on $\frac{1}{4}$ " diam. former.
T1,	3 : 1 Inter-valve transformer.
S1, S2,	2-pole 5-way wave-change switch.
S3,	D.P.S.T. On-Off switch, ganged with R1.
S4,	S.P.D.T. R.F.-Audio output switch.
S5,	S.P.S.T. Mod. Off-Mod. On switch.
V1, V2,	1T4.
2 Peanut holders.	
A,	1.5 volt cell.
B,	36 volt battery.
	Slow-motion drive, chassis, output sockets, screened cable, etc.

The circuit can easily be built on to a  $9\frac{1}{2}" \times 4\frac{1}{2}" \times 2\frac{1}{2}"$  aluminium chassis to leave room for the four grid bias batteries which supply the H.T., with the single cell strapped below the chassis. The whole generator should, of course, be well shielded in a case or box built up from sheet aluminium.

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