PRACTICAL RADIO FOR BEGINNERS (Book 2)

V1 V2 V3

BERNARDS RADIO MANUALS—No. 139

PRACTICAL RADIO FOR BEGINNERS. BOOK II

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CONTENTS

CONTENTS

LIST OF ILLUSTRATIONS

PRACTICAL RADIO FOR BEGINNERS.
BOOK II.

CHAPTER I

ADDING THE RADIO FREQUENCY
AMPLIFIER STAGE

The introduction to Book 1 told the beginner a " Progressive " receiver was being discussed and finally built.

After a few chapters on the various aspects to radio theory and components, the first of the simple receivers was then given, firstly as a theoretical diagram and then as a schematic layout to be built on the chassis described.

Having built the two simple receivers, a more ambitious type follows, where this time another stage is added in front of the existing layout, to amplify the incoming Radio Frequency signals and make the receiver capable of receiving some of the more powerful Continental Stations.

A Mullard EF 36 valve acts as the R.F. amplifier. It was chosen as it conforms to the current rating through the heater with the other valves. This valve is rated at 0.2 amperes and when this current is flowing the cathode is raised to its correct working temperature. If another type of valve with, say a 0.3 ampere heater was used here, the cathode temperature would not be sufficiently high due to the current control exercised by the barretter.

As this type of valve, and all R.F. amplifying valves, has a very high anode " impedance "; to make the valve operate at its best a high anode load must be used.

Here a problem arises on how best to achieve this. If a high value resistor is connected between the H.T. positive line and the anode of the valve, the current which flows through the valve, must also flow through the anode resistor, a large voltage is therefore developed across the anode load, and, as this voltage must be subtracted from the main H.T. voltage, very little appears at the actual anode of the valve; under this condition the valve cannot operate at its correct working point.

Fortunately there is another way; for use can be made of the property which exists between a coil and capacitor when at resonance. " Resonance " is that property which exists between an inductor and capacitor when tuned to a particular frequency. This property is measured in ohms and is given the term " Impedance," but this should not be confused with the valve's " impedance " as this is actually the " Anode A.C. Resistance " of the valve.

At radio frequencies, and as a variable capacitor is being used in conjunction with a coil of fixed inductance, by varying the amount of capacity several resonant points can be obtained.

The E.F. 36 has an Anode A.C. resistance of something between 2 and 2.5 megohms, the coil and capacitor (C1L2) present, at resonance, something to this order, so by connecting the anode in series with the coil to the H.T. line, and tuning by the capacitor the correct anode load can be offered to the valve, while at the same time the full anode voltage appears at the anode because of the low D.C. resistance of the windings of the coil.

Construction.

A slight re-arrangement of some of the components will be necessary before including the R.F. stage. R5, the volume control must be moved from hole A.F. to hole A.E., to make room for the aerial coil and its bracket. This will mean lengthening some of the leads already connected.

Unsolder the lead on the switch contact A which feeds V4 and the one at contact B which goes to chassis. Remove all leads from the volume control tags. Unscrew the volume control and move to hole A.E. The mains lead has now become slackened, the spare can be pulled back through the grometted hole A.I. and made tidy.

The wire on contact A of the switch can now be shortened a trifle, and resoldered, while the earthing wire at contact B will have to be lengthened and resoldered.

A longer wire is required from the junction of R1 C5 to the left hand tag of the volume control, also from R4 to centre tag on the volume control. Make sure that the wire earthing the right-hand tag of the volume control is also connected to chassis.

Unsolder carefully all connections on L1 L2, take whole coil out and place aside for the time being.

Fit a new International octal valveholder in hole A, to be known as V5 during construction, with solder tags under each nut.

Remove wire connecting Pin 2 on V2 and Pin 7 on V1.

Replace with longer wire connecting Pin 2, V2 and Pin 7 V5.

Connect Pin 2 V5 to Pin 2 V1.

Now that there are two sets of coils in the receiver, care must be taken that interaction does not take place due to the rapidly changing magnetic field associated with them. If these coils were to be placed vertically on the chassis near to one another the magnetic fields would be in the same plane, therefore cutting each others windings, and causing instability.

A way to counter this is to make a bracket from a strip of aluminium to carry the original L1 L2. The aluminium can be 18 S.W.G. and a strip $2\frac{3}{8}''$ long by $\frac{3}{4}''$ wide will be sufficient. Scribe a line half an inch from one end, this will give the bending mark. A 6BA clearing hole is now drilled centrally, half an inch from the end of the long section, another is drilled in the short section a quarter of an inch from the end.

Interaction now is not so prevalent between the two coils when mounted at right angles to one another.

Fix the bracket by the short leg to hole Q, which already has a long bolt through it holding the ganged capacitor in position. Bolt on to the longer side the coil L1 L2. This is now the aerial coil.

The wire from C14 which originally made contact with Tag 1 of the coil must be removed, and a fresh piece now joins C14 and Tag 3. Tags 2 and 4 are connected to chassis on the solder tag nearest V5.

Tag 1 is connected to C1 through the hole T.

The heater wiring to the valves having been completed earlier, attention can now be turned to wiring V5. Firstly join Pin 5 and Pin 8 (the Suppressor Grid to the Cathode). R13 (330Ω) together with C18 (.1 μF) are soldered to Pin 8 V5, the other ends being connected to the soldering tag nearest the Keyway of V5 valveholder. Tag 1 is taken to chassis

From Pin 4 V2 R11 (1Kr) connects to the unused positive tag of C5, at this point R12 (100KΩ) is joined to Pin 4 V5, from Pin 4 also C17 (.1 μF) is connected to chassis at the solder tag under V1 Valveholder.

Coils L3 and L4 (Wearite PHF2) can now be fitted into place. These replace L1 L2 and can be bolted to hole R.

The circuit changes a trifle here, the reaction capacitor R13 is no longer connected to the anode of V1, but is in the earthy end of L3. This enables the earthed movable section to be varied without the risk of shock or making the receiver unstable while adjusting. Pin 3 V5 is connected to Tag 1 of L3 L4 while from Tag 2 C19 (.1μF) is connected to chassis. From Tag 2 also, R14 (1KΩ) connects to the main H.T. line Pin 4 V2. Pin 3 V1 connects to Tag 3 on L3 L4 and Tag 4 to inner plates of C13. The outer plates being connected to chassis. Tag 3 L3 L4 connects to C2 through hole U in the chassis. The Top Cap connections to V1 and the connections to R9 should not have been disturbed. Connection to the Top Cap of V5 is made in a similar manner as to V1.

To increase the performance of the receiver still further two small trimmers can be connected across L2 and L4; these help to straighten out the tuning curve at the high frequency end of the tuning range.

The theoretical circuit is shown on the facing page, while overleaf on page 14 is the practical layout diagram.
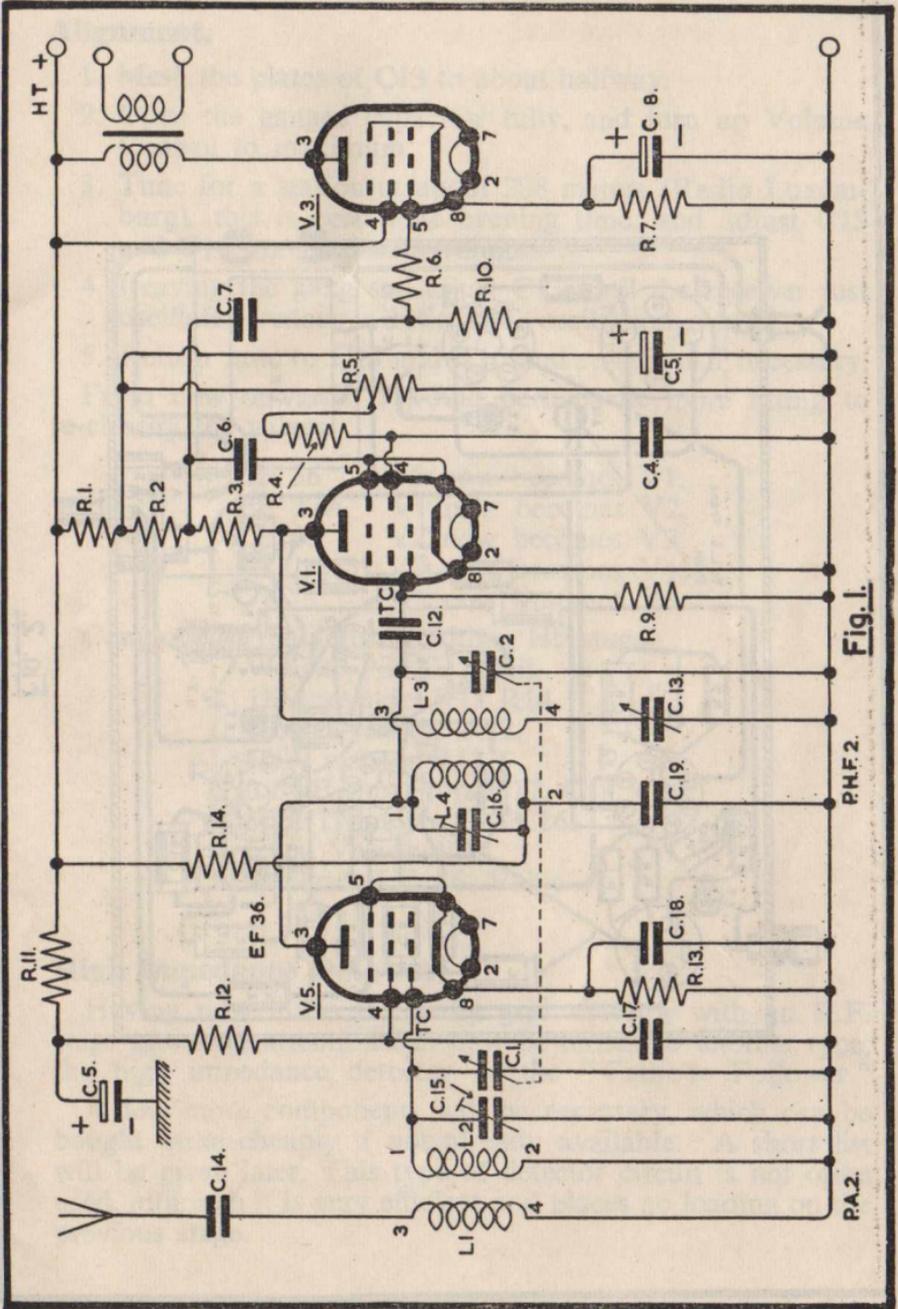
H.F. stage added to Leaky Grid Detector.
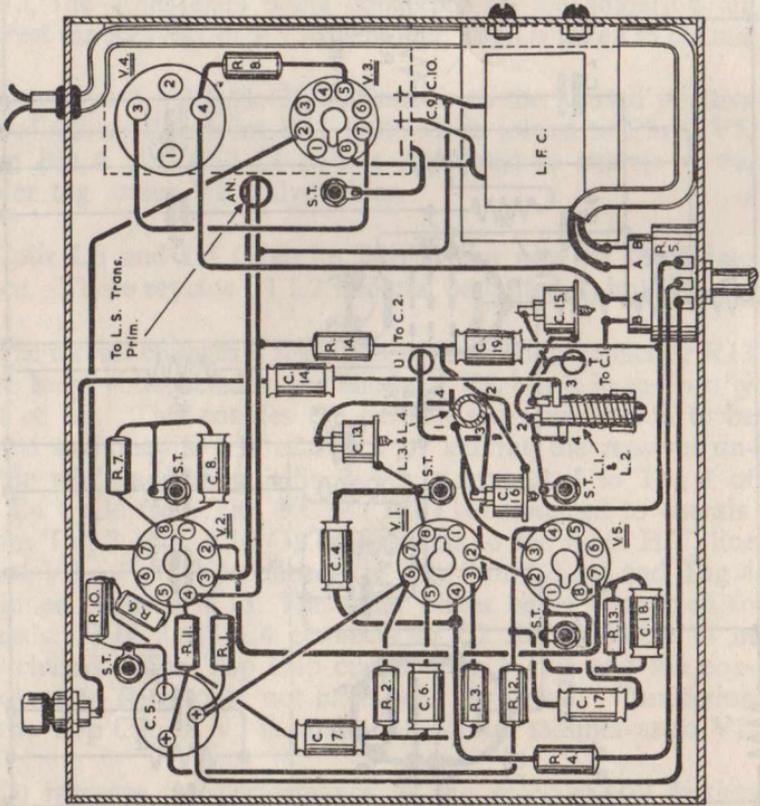
Fig. 2.

Practical layout for Detector and H.F. Stage.

Alignment.

1. Mesh the plates of C13 to about halfway.

2. Open the ganged capacitor fully, and turn up Volume Control to maximum.

3. Tune for a station at about 208 meters (Radio Luxemburg), this is best done evening time, and adjust C15 and C16 for maximum volume.

4. Leaving the gang set adjust C13 until the receiver just oscillates, reduce a little until oscillation ceases.

5. Return now to C15 and C16 and re-adjust if necessary.

From now onwards it would perhaps be more fitting to re-classify the valves.

EF 36	V5	now becomes V1.
EF 37A	V1	now becomes V2.
CL 33	V2	now becomes V3.
CY1	V3	now becomes V4.
C1C	V4	now becomes V5.

Components required for adding HF stage.

1. Wearite P.H.F. 2 coil.
2. 1KΩ resistors R11 R14.
1. 100KΩ resistor R12.
1. 560Ω resistor R13.
3. 0.1 μF capacitors C17. C18. C19.
2. 50pf Trimmers C15 C16.
1. Octal Valveholder.
1. Mullard E.F. 36. Valve.

High Impedance Detector.

Having now made the leaky grid detector with an R.F. stage attached, attention can now be turned to another type, the high impedance detector or the " Cathode Follower."

A few more components will be necessary, which can be bought quite cheaply if not already available. A short list will be given later. This type of detector circuit is not often used, although it is very efficient and places no loading on the previous stage.

Fig. 3 shows the circuit diagram.

The A.F. signal is developed across the cathode resistor, which is in value comparable with the anode resistor of a normal triode valve, and is handed on to the output stage through a resistor capacity filter network. The filter network is similar to that used for smoothing the H.T. line in modern midget mains receivers, except that the resistor is much higher in value and the capacitors much smaller.

C7 blocks the D.C. component from reaching the grid of V3, but allows the audio signal to pass and the magnitude of that signal is controlled by R5 the volume control.

Construction.

The R.F. stage can be left as it stands, but quite a number of alterations will have to be made to the second stage, with minor ones to the output.

Working through from the anode of the EF 36 (V1) disconnect the lead from Pin 3 (the anode) from Tag 1 on the P.H.F. 2 coil. Disconnect Tag 2 from C19 (.1μF) and R14 also disconnect from C2.

The lead from Pin 3 V2 is disconnected from Tag 3 and removed altogether. Tag 4 is unsoldered from C13, C13 is not being used in this circuit so it can be removed completely. This now leaves coils L3 and L4 free for re-wiring. Remove C12 and R9, also R1 R2 and R3 together with C4 and C6. Disconnect all wires from R5 except the earthing wire and switch wiring.

Strap together Pin 3, 4, and 5 of the EF37A (V2) and connect direct to H.T. line at Pin 4 of the CL 33 (V3).

Connect R14 with C19 to Tag 4 on P.H.F.2. Tag 3 take to anode of V1 (Pin 3). Tag 2 is connected direct to a convenient solder tag while Tag 1 connects to C2 through hole R.

Pin 8, cathode of V2 has a 47KΩ (R8) resistor to chassis.

At Pin 8 again is another 47KΩ (R9) resistor. This resistor is connected to C7 (0.1μF) the free end of the capacitor being soldered to the left-hand tag of R5.
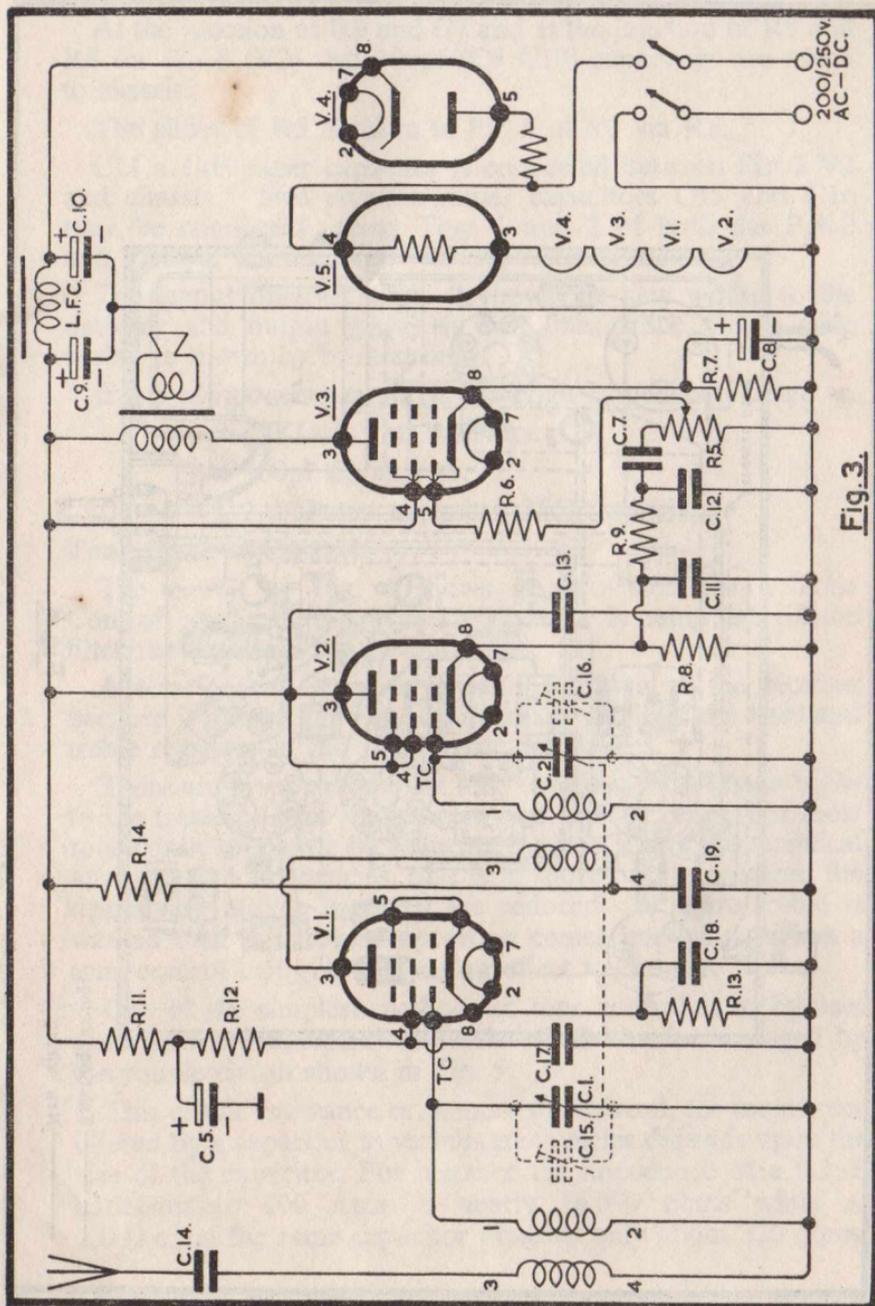
T.R.F. circuit using High Impedance Detector.

Fig. 3.

*Practical layout for High Impedance Detector.*
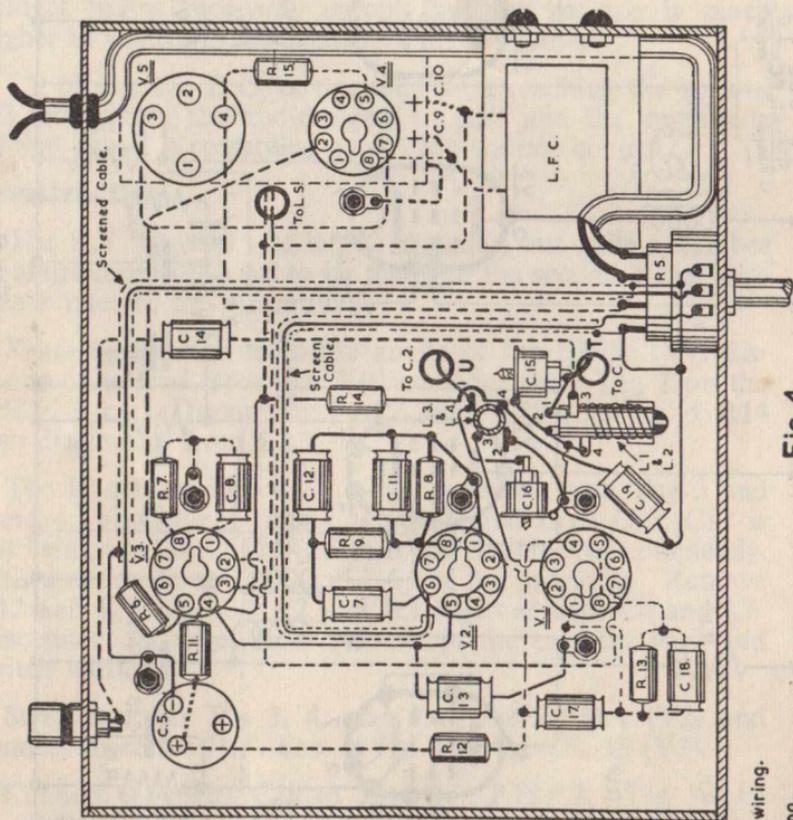
Fig. 4.

- - - - Existing wiring.
———— New wiring.

At the junction of R9 and C7 and at the junction of R9 and R8 on Pin 8 (V2) two 100pf (C9 C10) capacitors are taken to chassis.

The slider of R5 is taken to Pin 5 of V3 via R6.

C11 a 1μF paper capacitor is connected between Pin 3 V2 and chassis. Two small trimmer capacitors C15 and C16 may be connected across Tags 1 and 2 of both the P.A.2 and P.H.F.2 tuning coils.

The layout diagram (Fig. 4) shows the new wiring to the detector and output stages in full lines while the existing wiring is shown by broken lines.

Extra components required for High Impedance Detector.

2 47KΩ 1 watt resistors.

2 100pf Capacitors.

1 1μF Paper capacitor 350V working.

Tone Control Circuit.

The circuit of Fig. 4 shows no provision for a Tone Control, as the output from the detector is being fed via the filter network into the output valve.

A tone control is quite a useful addition to the receiver because it allows the user to adjust the levels of the bass and treble registers to suit their particular desires.

There are many designs for tone controls, some give a boost to the treble or bass frequencies over a short range, but most tone controls operate by reducing the range, or to be technical attenuate the frequencies, that is, if more bass is required the upper and middle registers are reduced. If more treble is wanted then the reverse operation comes into play. Thus a tone control can give a pleasing effect to the ear.

One of the simplest methods of tone control is to by-pass some of the frequencies to earth, which can be arranged by the simple circuit shown in Fig. 5.

This ohmic resistance or, a more usual word, the impedance offered by a capacitor to various frequencies depends upon the size of the capacitor. For instance the impedance of a 0.1μF capacitor to 100 c.p.s. is nearly 16,000 ohms while at 5,000 c.p.s. the same capacitor presents only about 320 ohms.
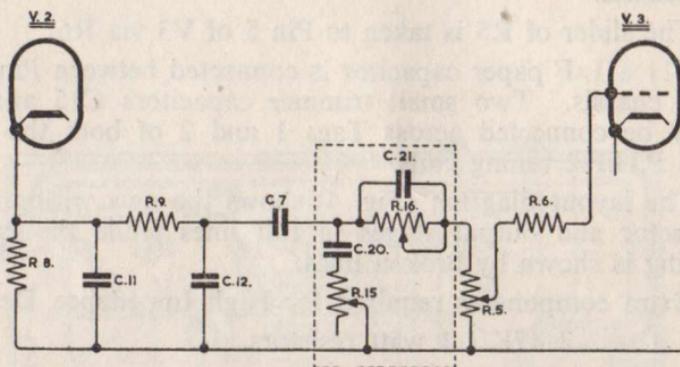
Fig. 5.

Simple Tone Control Network.

By choosing suitable capacitors the attenuation of certain frequencies is automatic, and the amount of attenuation being under manual control by a variable resistance.

In Fig. 5, C20 and R15 act as the treble attenuator and by-pass a proportion of the upper frequencies to earth, while C21 and R16 by-pass some of the lower frequencies.

The capacitance of C21 is kept small so that its impedance to the higher frequencies is not large, although its impedance rises as the frequency falls.

Therefore the capacitor blocks the passage of the bass frequencies, which are allowed to reach the volume control through R16. As the resistance of R16 is increased a small proportion of these lower frequencies is passed on to the output stage.

An advantage of this type of tone control is that it causes very little loss of gain. Some types cause rather serious loss in the overall amplification of the stages in which they are placed, but by keeping the attenuation to the upper and lower

frequencies the middle frequencies suffer very little loss. Since these are the frequencies which have most to do with the apparent volume level, tone compensation is satisfactory whilst the apparent volume loss is small.

The tone control can easily be inserted into the circuit by a few simple connections.

Fit into holes A.F. and A.G. the two .25MΩ potentiometers. Disconnect C7 from R5 left-hand tag.

Connect to R15 one end of C20, the other end of C20 to R16 left-hand tag.

One end of C21 connect to junction of C20, R16, the other end to centre tag R16.

The centre tag of R16 and the free end of C21 connect to left-hand tag R5.

R15 centre tag connect to convenient solder tag.

Connect C7 to junction of C20, C21, R16.
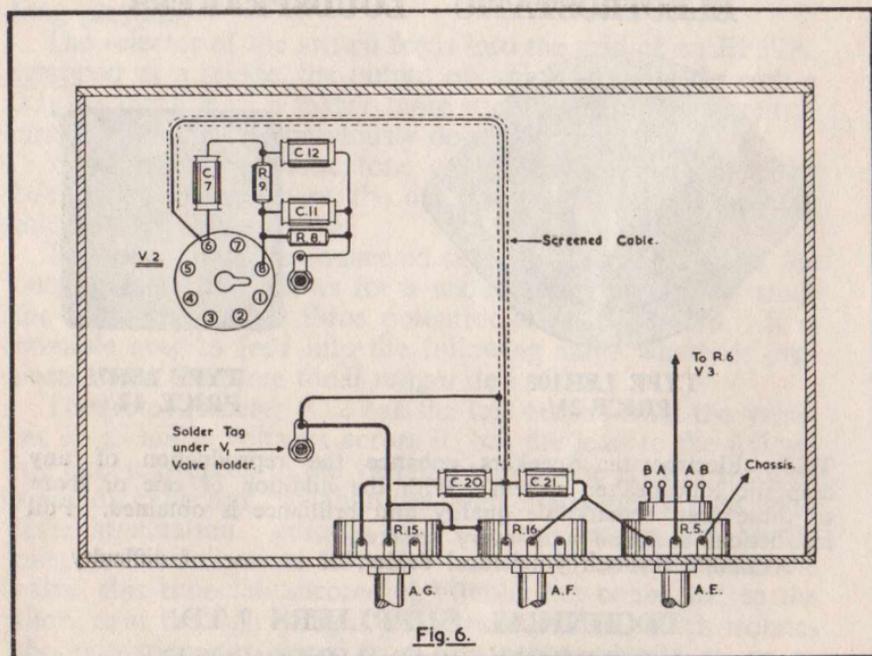
Fig. 6.

Practical layout for Tone Control Circuit.

The tone control section should now operate efficiently. The circuit diagram is shown in Fig. 5 and the layout wiring in Fig. 6.

Additional Components required for Tone Control:—

C.20 0.005μF Mica capacitor.
C.21 0.001μF Mica capacitor.
R.15 0.25MΩ Potentiometer.
R.16 0.25MΩ Potentiometer.
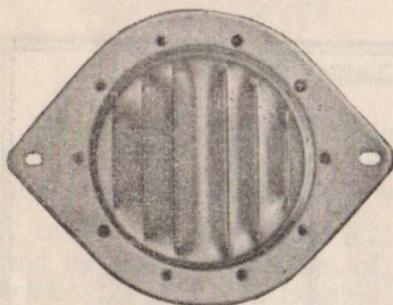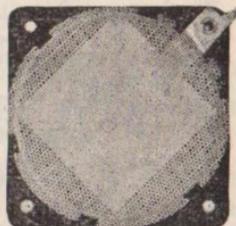
CHAPTER II

INTRODUCING THE RADIO GRAMOPHONE

Quite often gramophone reproduction is required, when one reaches this stage and can be operated by a simple switching arrangement, at the same time bringing into operation correction circuits for the more popular crystal pick-ups.

In the circuit shown at Fig. 7 a two pole three position wafer type-switch switches from Radio to two gramophone positions. one for standard 78 r.p.m. recordings and the other for long playing.

The selector of the switch feeds into the grid of an EF37A, strapped as a triode, the output of which is taken through a $0.1\mu F$ capacitor to a rather more useful type of tone control circuit than the one previously described.

Whereas the previous tone control catered only for the bass and treble registers, the one described here controls the middle frequencies as well.

The tone control is connected between the detector and the output stages and allows for a wide variety of settings since the output is fed to three potentiometers in parallel. It is possible now to feed into the following stage whatever proportions of the three tonal ranges desirable.

The potentiometer R12 has the full output from the valve, set up as audio voltages across it, but the lead to the following circuit is taken to the variable arm of the control through a small capacitor, so that the high frequencies pass with little attenuation. Middle and low frequencies are hardly present. Potentiometer R13 also has the full output from the valve, this time the succeeding circuits are connected to the slider arm through a high value resistor R13, which isolates the potentiometer away from the other circuits so as to minimise its effect on the other controls.
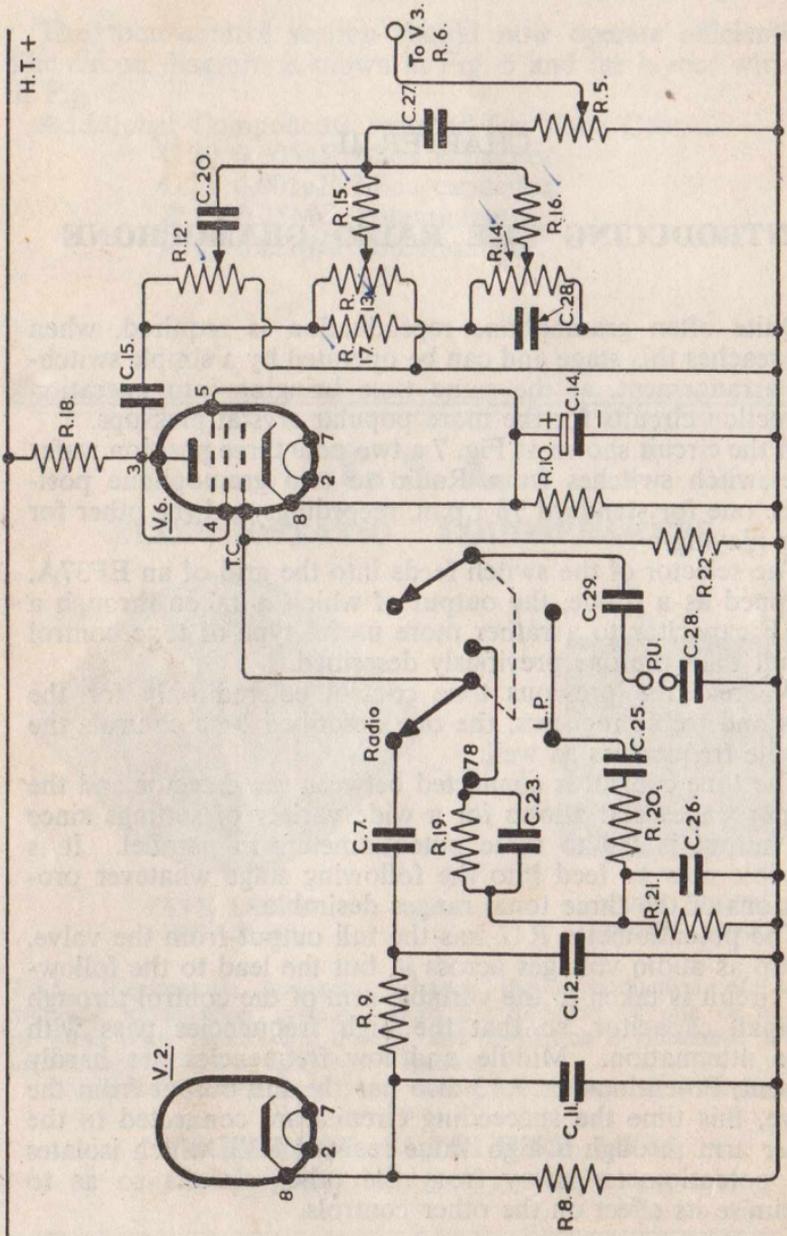
Fig. 7.

Gramophone Pre-Amplifier and Tone Control Circuit.

Finally the remaining potentiometer R14 is fed through a treble attenuating circuit. Since R17 is in series with it, and R14 is shunted by a relatively large capacitor C21 therefore by-passing all the high frequencies. Another isolating resistor R16 feeds the succeeding circuits from the slider contact.

This type of control circuit should be fed from a triode valve or as in this case an EF37A strapped as a triode, but this time with the Suppressor Grid (G3) connected to cathode instead of to the anode.

Equalising circuits are incorporated in the switching to compensate for the various losses which occur in 78 r.p.m. and L.P. recordings.

Crystal type pick-ups require compensation above 250 c.p.s. and a suitable network is shown for 78 r.p.m. recordings.

With L.P. recordings the characteristic rises steadily with increasing frequency, therefore calling for a bass lifting and top cutting circuit for compensation purposes.

One of the chief drawbacks comparing the old heavy head with the modern lightweight is the output voltage, whereas the old type produced from between 1 volt and 2 volts, the modern pick-up produced between 0.2 volts and 0.5 volts, therefore a pre-amplification stage must be included in the circuit, and is provided by the E.F.37A.

Coming back to the tone control again, it can be made as a remote control unit, by fitting the three potentiometers in a metal box, the input and output circuits being carried to the control box by twin screened cable, with the screening acting as the earth return and the inner cables as the input and output leads.

The length of cable which is permissible between the receiver and the control box is limited by the hum pick-up, and also by the self capacity of the cable which causes a loss at high frequencies. A cable of about 9 feet in length was found to cause very little noticeable effect.

Separate volume control is provided by the output leads of the three controls to C27 and R5.

Extra Components for Pre-Amplifier and
Tone Control Unit.

R9	470KΩ	½ watt.
R10...................	470Ω	½ watt.
R12, 13, 14	470KΩ	Potentiometers.
R15, 16	330KΩ	½ watt.
R17...................	150KΩ	½ watt.
R18...................	47KΩ	½ watt.
R19..................2.2MΩ		¼ watt.
R20..................1.5MΩ		¼ watt.
R27..................1.5MΩ		¼ watt.
C14..................25μF	25V.D.C.W.	
C15...................0.1μF	350V.D.C.W.	
C20................... 200pf.		
C23.................. 250pf.		
C25..................1000pf.		
C26.................. 100pf.		
C27...................0.1μF.		
C28...................0.005μF.		
S1 ....2 pole 3 position wafer switch.		

Construction.

Disconnect completely the previous tone control circuit and remove the two 0.25 MΩ potentiometers.

Move R5 from hole AE to hole AD, pull back slackened mains leads and disconnect C7 from left-hand tag.

Fit R14 into hole AE.

R13 into hole AF.

R12 into hole AG.

S1 into hole AH.

Join together tag C and tag G also tag D and tag H on S.1 (Key to contact positions shown in Fig. 8).
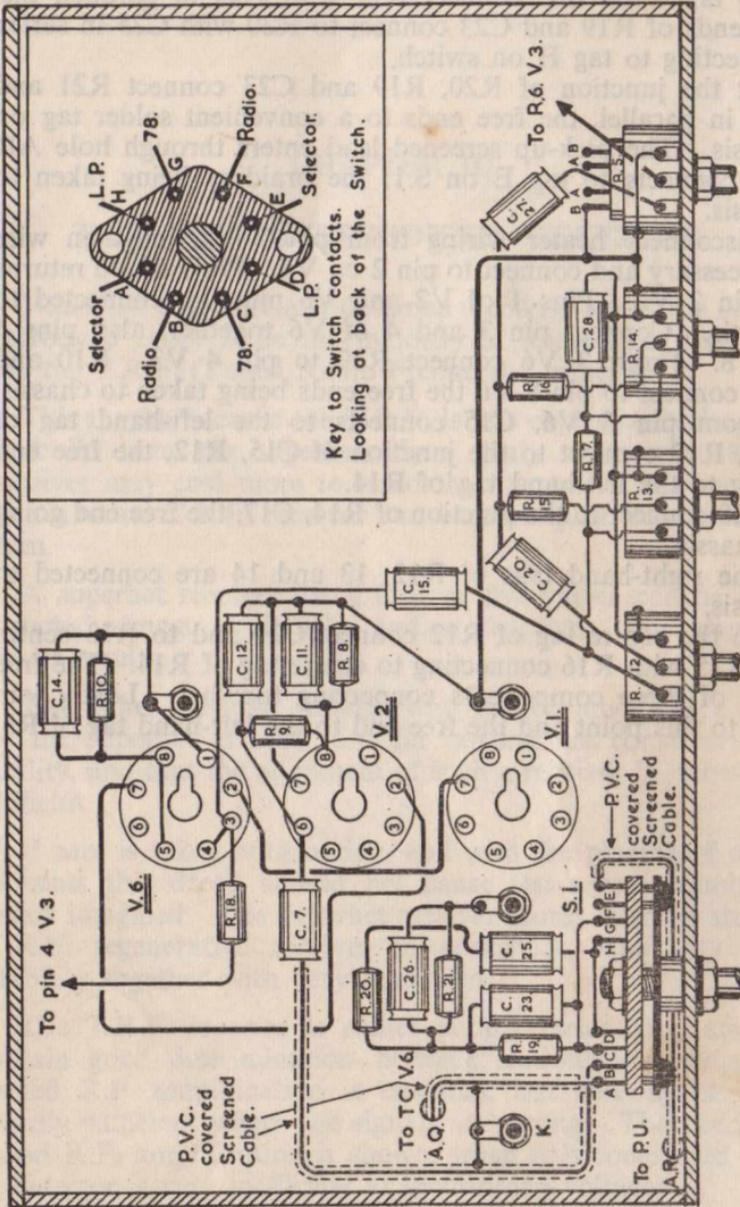
Practical layout for Gramophone Pre-Amplifier.

Fig. 8.

Selector 78.
Radio

L.P. Radio.
L.P. Selector.

Key to Switch contacts.
Looking at back of the Switch.

To R.6. V.3.

To pin 4 V.3.

To R.6. V.3.

P.V.C. covered Screened Cable.

P.V.C. covered Screened Cable.

To pin 4 V.3.

To TC V.6.

To P.U.

To tag C on S.1. connect R19 with C23 in parallel, the free ends of R19 and C23 connect to R20 with C25 in series connecting to tag H on switch.

At the junction of R20, R19 and C23 connect R21 and C26 in parallel, the free ends to a convenient solder tag on chassis. The pick-up screened lead enters through hole AR and connects to tag E on S.1; the braiding being taken to chassis.

Disconnect heater wiring from pin 2 V2, lengthen wire if necessary and connect to pin 2 on V6. Pin 7 of V6 returns to pin 2 V2. Pins 1 of V2 and V6 must be connected to chassis. Connect pin 3 and 4 of V6 together, also pins 5 and 8. From 3 V6 connect R10 to pin 4 V3. R10 and C14 connect to pin 8 V6 the free ends being taken to chassis.

From pin 3 V6, C15 connects to the left-hand tag of R12, R17 connect to the junction of C15, R12, the free end going to the left-hand tag of R14.

C28 connect to the junction of R14, C17, the free end going to chassis.

The right-hand tags of R12, 13 and 14 are connected to chassis.

To the centre tag of R12 connect C20 and to R13 centre tag R15 with R16 connecting to centre tag of R14. The free ends of these components connecting together. Lastly join C27 to this point and the free end to the left-hand tag of R5.

CHAPTER III

THE SUPERHETRODYNE RECEIVER.

Nearly all commercially designed receivers are of the super-hetrodyne class, while the majority of home built receivers use the T.R.F. (Tuned Radio Frequency) principle.

This maybe because the T.R.F. is less expensive and easier to build than the superhetrodyne, truly a superhetrodyne receiver may cost more to build than superhet, but even so an elaborate T.R.F. receiver can become quite an expensive item.

A superhet receiver using four or five valves can be constructed almost as cheaply, and at the same time give far better results.

Two other possible reasons why the beginner has a fear of the superhet is that, it is far beyond his constructional ability, and that the alignment of such a receiver is somewhat difficult.

If care is taken with wiring, and with the placing of components this dread should not cause the severe stumbling block imagined. The superhet receiver scores over the simple T.R.F. regenerative receiver in selectivity, sensitivity and stability together with easy operation.

The T.R.F. receiver is rather poor in selectivity, and to obtain good discrimination between stations, one stage of tuned R.F. amplification is essential, but here again it is hardly sufficient where the signals are strong. The need for good R.F. amplification is shown, when it is considered that a detector is very inefficient at low driving voltages.

29

With T.R.F. receivers it is usual to use either a triode or pentode detector which not only rectifies but amplifies as well. This will lead to instability and distortion, while the introduction of three or more tuned R.F. stages, although improving selectivity, causes a large number of practical difficulties.

Each stage including the detector stage would have to be individually tuned to get rid of unwanted signals, and the whole thing becomes bulky, costly, and difficult to handle.

As an example, the R.F. stages would be prone to feed back energy to the preceding stage, not only through the self capacitances of the valves but also through the small capacities between the wiring and give rise to undesirable effects.

The signal is amplified at carrier frequencies in the case of T.R.F. receivers, and as the frequency rises the difficulty of obtaining satisfactory amplification also increases. A further shortcoming of the T.R.F. receiver is that the R.F. stages have to handle signals of all frequencies, and although component values may be carefully selected amplification cannot be maintained uniform over the whole band.

With the use of a superhet receiver these deficiencies can be overcome. Fig. 9 shows the basic operation of a superhet in block diagram form.

The **R.F. amplifier** follows the usual lines. It amplifies the incoming signal at its carrier frequency, and gives a degree of selectivity, thus unwanted signals are prevented from passing into the receiver. This amplified signal is then passed on to the **mixer stage.** Here another signal, an unmodulated R.F. signal, developed by a **local oscillator,** is injected into the mixer stage. These two signals are mixed together and a third signal is produced, which is called a **beat** or **heterodyne** signal. The frequency will be the difference between the incoming and the locally generated signals. For instance if the carrier frequency was 1500 Kc/s, and the local oscillator produced 1030 Kc/s, the resultant and the beat frequency would be 470 Kc/s.

The important thing to note here is that this new signal, although of a different frequency, will have all the modulation characteristics of the original signal amplified by the R.F. stage.
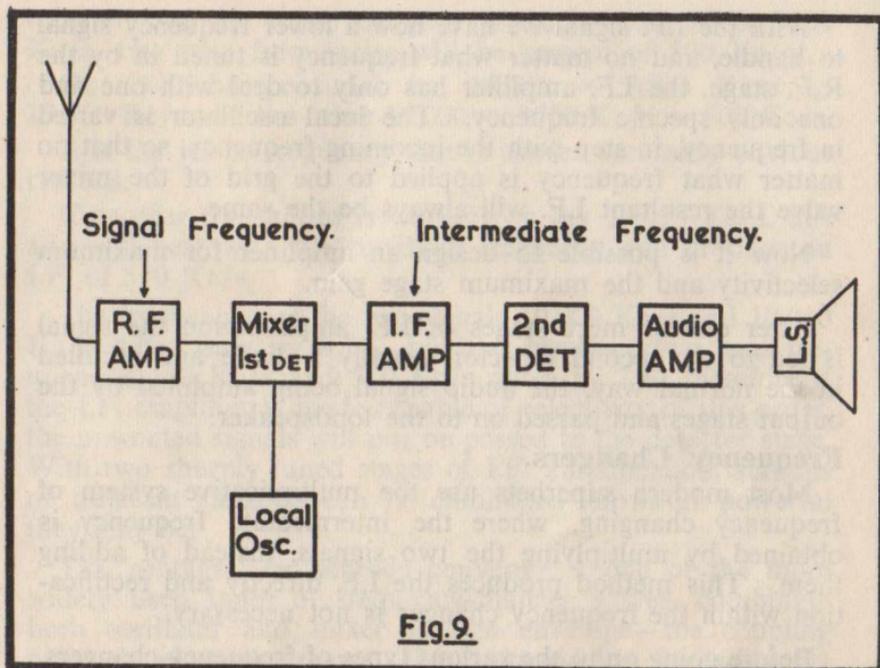
Block diagram of Superheterodyne Receiver.

This conversion from one frequency to another is the basic function of the receiver, and takes on rather a lengthy title of "supersonic-heterodyne" receiver. The "heterodyne" is already explained, while "supersonic" means that the beat frequency is above the audible range.

The production of the new frequency is called **frequency conversion,** and this part of the circuit is shown as the **frequency changer.** In the early types, the applied signals were also detected and the term first detector is synonymous with the frequency changer.

Nowadays the signal is converted to the lower frequency, but still retains the original modulation, and is fed to the **I.F. amplifier** It must now be becoming obvious why the superhet is more beneficial. Although it is an easy matter to amplify signals of a low frequency it becomes a different matter with the high frequencies.

With the I.F. signal we have now a lower frequency signal to handle, and no matter what frequency is tuned in by the R.F. stage, the I.F. amplifier has only to deal with one and one only specific frequency. The local oscillator is varied in frequency, in step with the incoming frequency, so that no matter what frequency is applied to the grid of the mixer valve the resultant I.F. will always be the same.

Now it is possible to design an amplifier for maximum selectivity and the maximum stage gain.

After one or more stages of I.F. amplification the signal is fed to the second detector, usually a diode and rectified in the normal way, the audio signal being amplified by the output stages and passed on to the loudspeaker.

Frequency Changers.

Most modern superhets use the multiplicative system of frequency changing, where the intermediate frequency is obtained by multiplying the two signals, instead of adding them. This method produces the I.F. directly and rectification within the frequency changer is not necessary.

Before going on to the various types of frequency changers, perhaps a few words on how the superhet performs the degree of selectivity, which is the greatest advantage of the circuit.

The full name for the high selectivity of a superhet is **adjacent channel selectivity** and it is the ability of the receiver to reject unwanted signals close to those which it is desired to be received. When an R.F. signal is mixed with a local oscillator signal, various oscillations will appear in the mixer valve. Those most prominent are, the R.F. signal, the beat frequency equal to the **difference** of the incoming and the local oscillator signal and another beat frequency equal to the **sum** of the incoming signal and the local oscillator; the most prominent ones of course being the beat frequencies.

Therefore there is a choice of I.F. frequencies either the one comprising the sum of the frequencies or the one of the difference between the two frequencies.

Let us assume that a signal of 10,000 Kc/s is being

received and the local oscillator produces a signal of 9500 Kc/s, two beat frequencies will be present of 500 Kc/s.

One will be produced by 10,000 + 9500 Kc/s = 19,500 Kc/s and the other 10,000 − 9500 Kc/s = 500 Kc/s.

It is the lower frequency that is chosen for fairly obvious reasons.

If another transmitter is working on say 10,010 Kc/s, this also will beat with the oscillator frequency and produce an I.F. of 510 Kc/s.

The frequencies of the two signals 10,000 Kc/s and 10,010 Kc/s differ only by 0.1%, but the resultant two beat frequencies 500 Kc/s and 510 Kc/s differ by 2%; therefore if the I.F. amplifier is made capable of selectivity of this order, the unwanted signals will not be passed to the detector stage. With two sharply tuned stages of I.F. amplification, stations on adjacent channels can be eliminated—however powerful they may be.

The pentagrid or heptode converter is one of the more widely used types of frequency-changer valves, combining both oscillator and mixer in one envelope—the coupling being the electron stream. The Pentagrid has five grids, G1 and G2 form the oscillator grid and " anode " respective. With the cathode, these two grids form virtually a composite cathode which will emit an electron stream which will vary with the oscillator frequency set by the tuned circuit. G3 speeds or accelerates the electron stream towards G4 which is the signal grid of the mixer section. It will be seen that G4 and G5 form the grid and screen grid of a tetrode. G3 not only accelerates the electron stream but also prevents electrostatic coupling between G2 and G4; being maintained at a positive potential and as it is internally connected to G5, screens the anode from the signal grid. Due to G4 being bombarded by electrons, the two grids forming the shield actually emit secondary electrons directed towards the oscillator " anode " G2. The oscillator " anode current " being largely dependent upon this secondary emission from G3 G5.

As the signal grid G4 is negatively biased and repels electrons a space charge is built up between G3 and G4 and this cloud of electrons form an effective cathode. This grid controls the main electron stream and those derived from the

space charge, the current arriving at the anode carries both the sum and difference frequencies.

The octode is very similar to the pentagrid or heptode but has an additional grid G6 between G5 and the anode, acting as a suppressor to prevent secondary emission.

Most widely used of all frequency changers is the triode-hexode, being very efficient at high frequencies. It is a triode oscillator and a hexode mixer, each section having its own electron stream, thereby reducing the capacitance between the two sections and also being shielded by screening grid, interaction between the two is greatly lessened.

The oscillator voltage is injected into the mixer section at the grid nearest the oscillator anode, which minimises space charge coupling. Owing to this low interaction the oscillator grid can be tuned. Fig. 10 shows the pentagrid and triode hexode frequency changers.

Local oscillators are usually of the leaky grid detector type, except that the reaction windings are made sufficiently tight that the valve is in a continuous state of oscillation.

The most popular methods are the series fed oscillator with the grid circuit tuned, or the parallel fed, in which either the anode or the grid is tuned. Fig. 11 shows the various methods of using the triode-hexode. Fig. 12 shows the valve element positions for (a) Pentagrid, (b) Octode, and (c) Triode-Hexode.

Parallel fed tuned anode is used to provide maximum isolation between the injector grid and the oscillator tuned circuit. L1 is the oscillator primary winding which, with C1 tunes to a different frequency by an equal amount to the I.F. frequency. L2 is the reaction or feed-back winding closely coupled to L1 to maintain continuous oscillation. C2 is the grid blocking capacitor, R1 is the grid leak, and R3 provides the bias for the mixer section by-passed in the usual manner by C3. R2 is to prevent parasitic oscillation, and R5 decoupled by C4 is the voltage dropping resistor for the triode section, shown in diagram (a), while in diagrams (b) and (c) it is used for the anode load resistor.

The small trimmer C5 across the primary is used for the alignment of the stage at the high frequency end of the band and C6 in series with the primary is used at the low frequency end. C1 is one section of a ganged capacitor—the
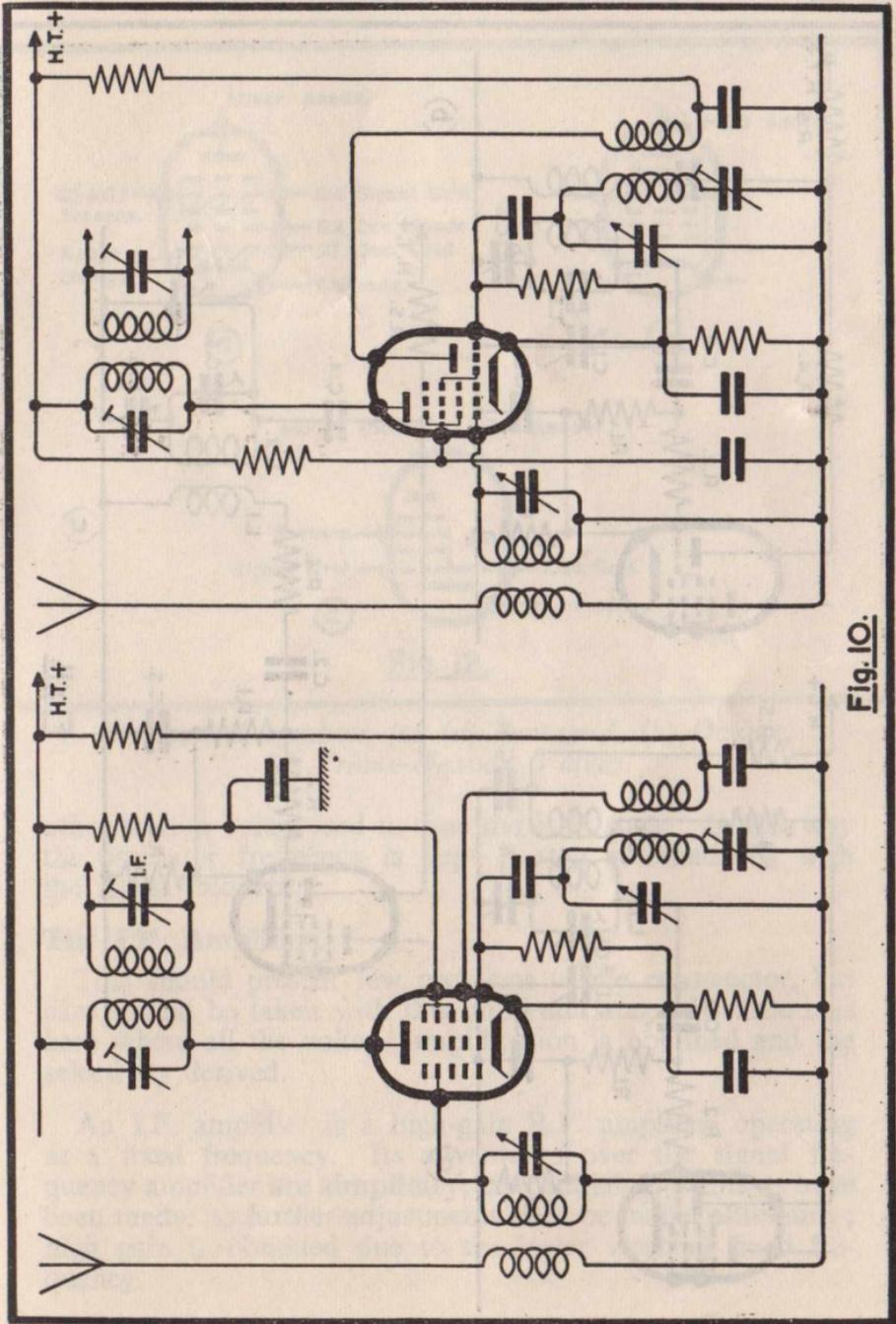
Pentagrid and Triode-Hexode Frequency Changers.

Fig. 10.
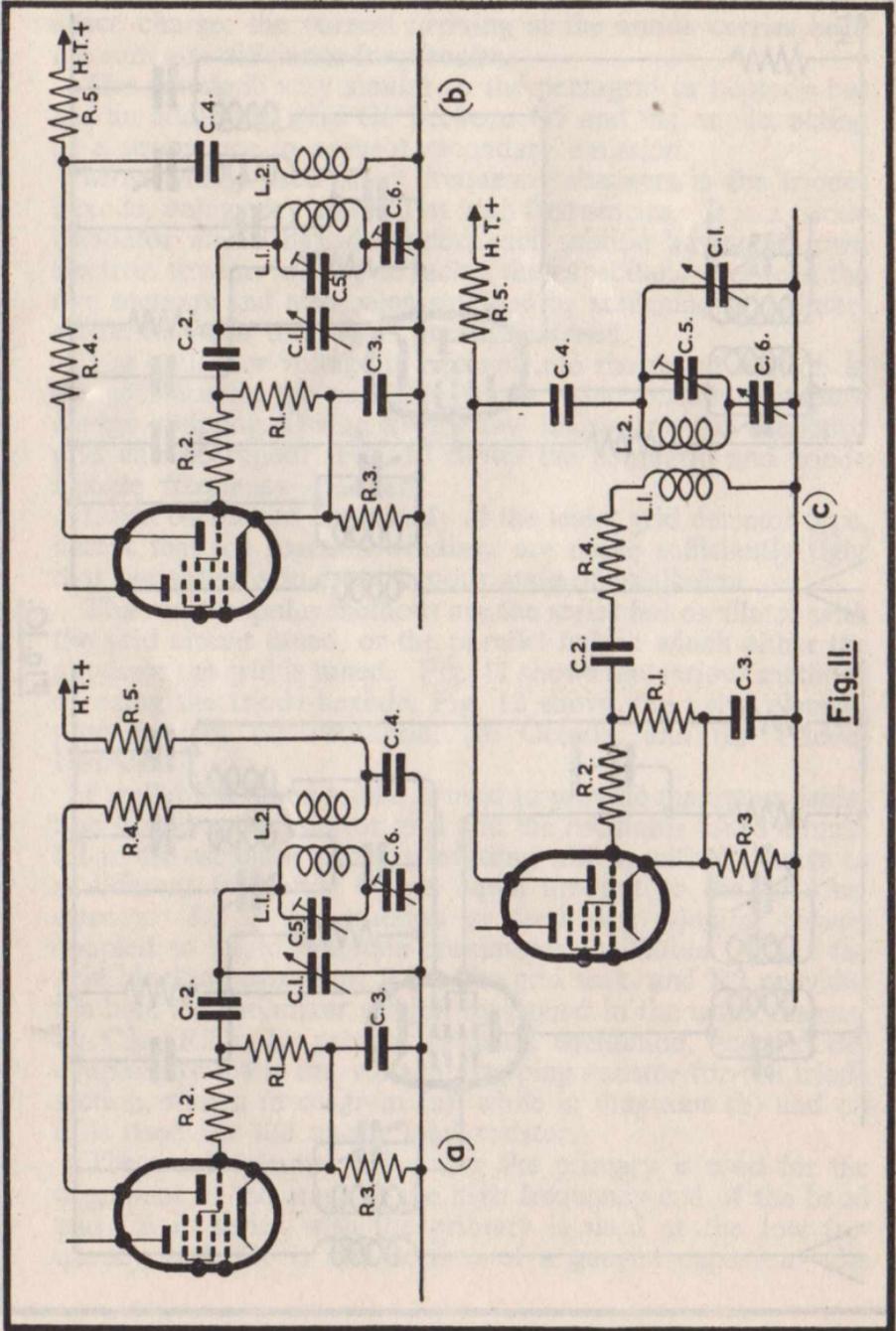
Fig.II.

Oscillator circuits using Triode Hexode.

Mixer Anode.

G3 & G5 Screens.
Space charge

G4 Signal Grid.
G2 Osc. Anode.
G1 Osc. Grid.
Cathode.

(a)

G6 Added.

(b)

Mixer Anode.   Osc. Anode.

Screens.
Signal Grid.   Osc. Grid.
Cathode.

(c)

Fig. 12.
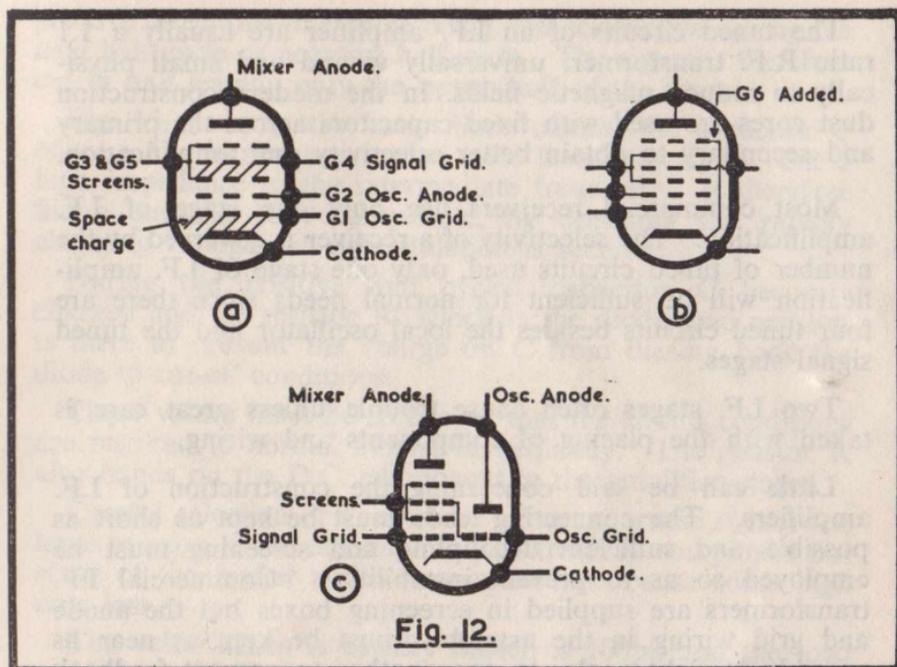
*Theoretical symbols for (a) Pentagrid, (b) Octode,
(c) Triode-Hexode Valves.*

other section being used to tune the R.F. stage. In this way
the oscillator frequency is kept in step automatically with
the signal frequency.

The I.F. Amplifier.

This should present few problems to the constructor, but
care should be taken with this important stage, because it is
here where all the voltage amplification is obtained and the
selectivity derived.

An I.F. amplifier is a high-gain R.F. amplifier operating
at a fixed frequency. Its advantages over the signal fre-
quency amplifier are **simplicity,** after initial adjustments have
been made, no further adjustments need be made, **efficiency;**
high gain is obtained due to the lower working fixed fre-
quency.

The tuned circuits of an I.F. amplifier are usually a 1.1 ratio R.F. transformer, universally wound and small physically to reduce magnetic fields. In the modern construction dust cores are used with fixed capacitors across the primary and secondary to obtain better selectivity and amplification.

Most commercial receivers use only one stage of I.F. amplification. The selectivity of a receiver is governed by the number of tuned circuits used, only one stage of I.F. amplification will be sufficient for normal needs since there are four tuned circuits besides the local oscillator and the tuned signal stages.

Two I.F. stages often cause trouble unless great care is taken with the placing of components and wiring.

Little can be said concerning the construction of I.F. amplifiers. The connecting leads must be kept as short as possible and sufficient decoupling and screening must be employed so as to prevent instability.   Commercial I.F. transformers are supplied in screening boxes but the anode and grid wiring in the assembly must be kept as near as possible at right angles to one another to prevent feedback through the small coupling which exists between the wiring.

Detection and Automatic Gain Control.

Instead of using a leaky grid detector the superhet has a diode. The diode does not amplify the signal as in the case of the leaky grid, but as it presents a low resistance in the direction in which current flows it is not liable to produce distortion on large signals as does the leaky grid. As amplification is not required, having been taken care of by the I.F. amplifier, it is better to have the minimum of distortion to hand on to later stages.

Many readers may not be altogether familiar with the diode detector. Here then some notes on how it works may be useful.

The valve will only pass current when the anode is positive in respect to its cathode, so that when a signal is applied the current will only flow when the signal swings the anode in a

positive direction—the valve being non-conductive during the next half cycle or negative half cycle. The signal is therefore cut in half leaving only the upper half of the signal.

Fig. 13(a) shows the basic diode circuit, the capacitor C offers a low impedance to the radio frequency signal, but a high impedance to the intermediate frequency. It therefore filters out the R.F. component, by opposing the rapidly changing voltage and demodulation is secured.

During the positive half cycles, capacitor C becomes charged and the resistor R, which is the diode load resistor, is there to prevent the charge on C from biasing back the diode to cut-off conditions.

These values must be so chosen that the circuit conditions are restored to normal almost immediately. The resistor R also hands on the D.C. component to the amplifier stages.

Careful selection of C must be taken otherwise if it is too large in value it will not only by-pass the R.F. component but some of the higher audio frequencies and cause some high note loss.

The value which is usually chosen is 100pf, and the load resistor can be between 0.47MΩ and 1MΩ to allow the charge on C to leak away thereby avoiding distortion.

A diode detector is practically linear in response except at low signal voltages, but its greatest disadvantage is that it tends to damp the circuit thereby flattening out the response curve and reducing the output.

Automatic Gain Control.

Most superhetrodyne circuits nowadays have some method of Automatic Gain Control, in an attempt to level out all received signals to an equal strength, so that both the weak and the strong signals are reproduced at more or less the same volume, depending of course on the setting on manual volume control.

In Fig. 13b a basic A.G.C. circuit is shown with R1 and C1, but this time R1 has been made variable so that a portion of the A.F. voltage can be tapped off, this of course is the manual volume control. It is necessary to put the volume

control here, because due to the relatively large voltage developed across R1, a control over the magnitude of the signal fed to the output stage can be operated to prevent overloading and distortion.

A steady current will flow through R1 resulting from the detection of the signal, producing a voltage drop across the resistor. At the same time there is a D.C. negative voltage, which can be fed back to the preceding R.F. and I.F. stages to increase the grid bias on the valves, thus automatically moving the signal up or down the characteristic curve of the valves.

Valves used in this circuit have what is known as a variable mu characteristic. The curve has a very long tail before it reaches cut-off conditions, going back perhaps twenty or thirty volts negative.   The negative component which is developed by R1 is fed back to the early stages, its value being dependent upon the strength of the received signal, controls the position where the signal is operated on the valve's curve. If a weak signal is being received a low voltage will be developed and the signal will operate over the steeper portion of the curve thereby giving greater amplification. On the other hand where a strong signal is being received a large voltage will be developed and the valves will operate on the long tail of the curve and reduce the amplification considerably, giving an automatic control to the incoming signals and producing a fairly constant volume level for all signal strength.

The A.G.C. can be operated on the valve grid in one of two ways, usually an isolating capacitor (Fig. 13c) is inserted in the low potential end of the tuning coil, thus preventing the A.G.C. voltage from being shorted to chassis. This capacitor must have low impedance to R.F. so that the coil is still earthed as far as the oscillatory circuit is concerned. A.G.C. can be fed back to the grid by placing a small capacitor at the grid end of the coil.

A.G.C. is usually fed back to the mixer valve and the I.F. amplifier valve.   These voltages are usually separate with individual decoupling, to prevent distortion which might arise if certain valves were overbiased.   Normally full voltage is applied to the R.F. stages and a lower voltage to the mixer and I.F. stages.
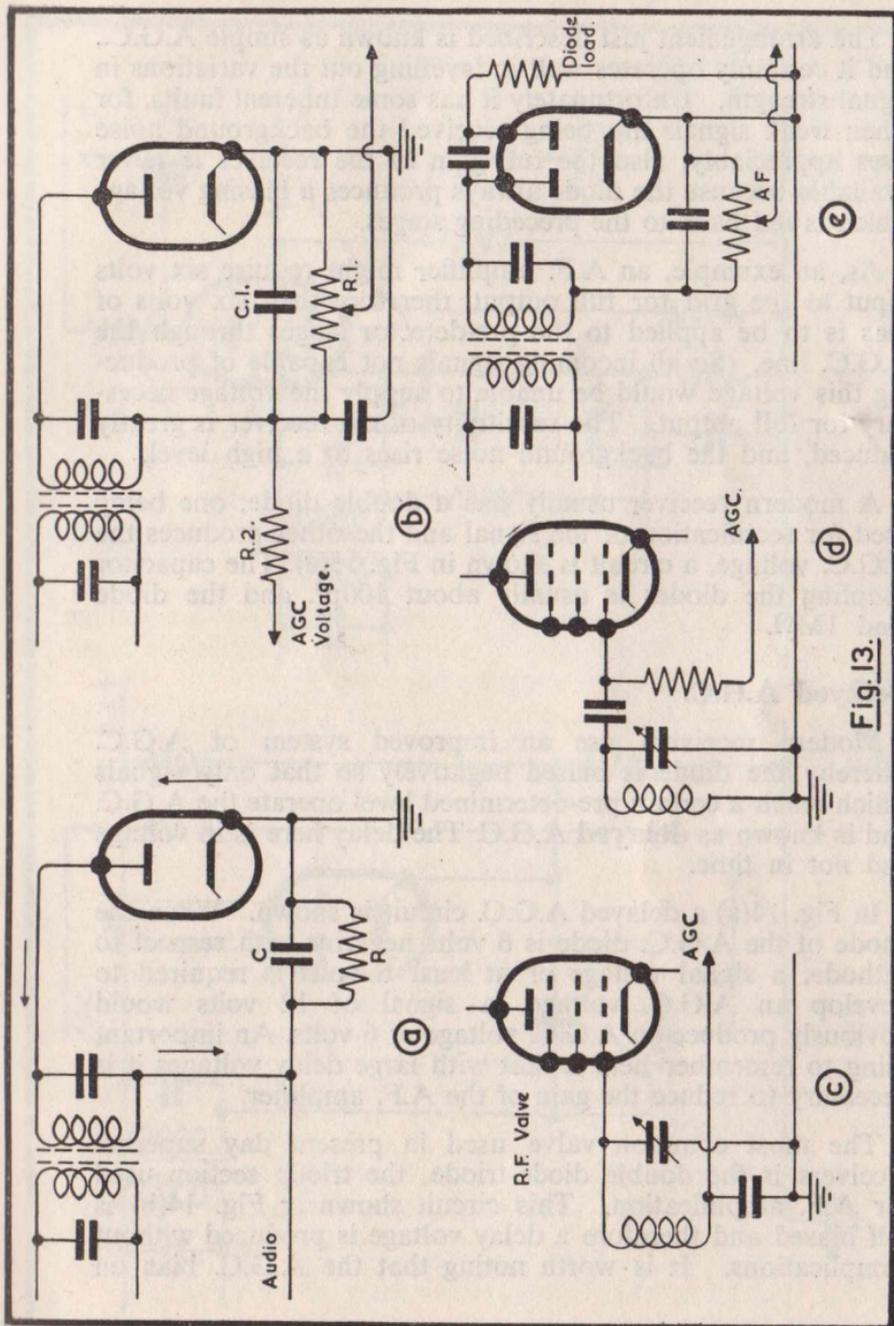
Fig. 13.

(a) Basic circuit for Diode   (b) Basic A.G.C. Circuit.   (c) and (d) Showing Isolating Capacitor
(e) Double-Diode Circuit.

The arrangement just described is known as simple A.G.C., and it certainly operates well in levelling out the variations in signal strength. Unfortunately it has some inherent faults, for when weak signals are being received the background noise rises appreciably, also the full gain of the receiver is never available because the diode always produces a biasing voltage which is fed back to the preceding stages.

As, an example, an A.F. amplifier might require six volts input to the grid for full output, therefore then six volts of bias is to be applied to the pre-detector stages through the A.G.C. line. So all incoming signals not capable of producing this voltage would be unable to supply the voltage necessary for full output. The sensitivity of the receiver is greatly reduced, and the background noise rises to a high level.

A modern receiver usually has a double diode, one being used for rectification of the signal and the other produces the A.G.C. voltage, a circuit is shown in Fig. 13(e). The capacitor coupling the diodes is usually about 100pf. and the diode load 1MΩ.

Delayed A.G.C.

Modern receivers use an improved system of A.G.C. whereby the diode is biased negatively so that only signals which reach a certain pre-determined level operate the A.G.C. and is known as **delayed** A.G.C. The delay here is in voltage and not in time.

In Fig. 14(a) a delayed A.G.C. circuit is shown. When the anode of the A.G.C. diode is 6 volts negative with respect to cathode, a signal voltage of at least 6 volts is required to develop an A.G.C. voltage, a signal of 12 volts would obviously produce an A.G.C. voltage of 6 volts. An important thing to remember here is that with large delay voltages it is necessary to reduce the gain of the A.F. amplifier.

The most common valve used in present day superhet receivers is the double diode-triode, the triode section used for A.F. amplification. This circuit shown at Fig. 14(b) is self biased and therefore a delay voltage is produced without complications. It is worth noting that the A.G.C. bias on
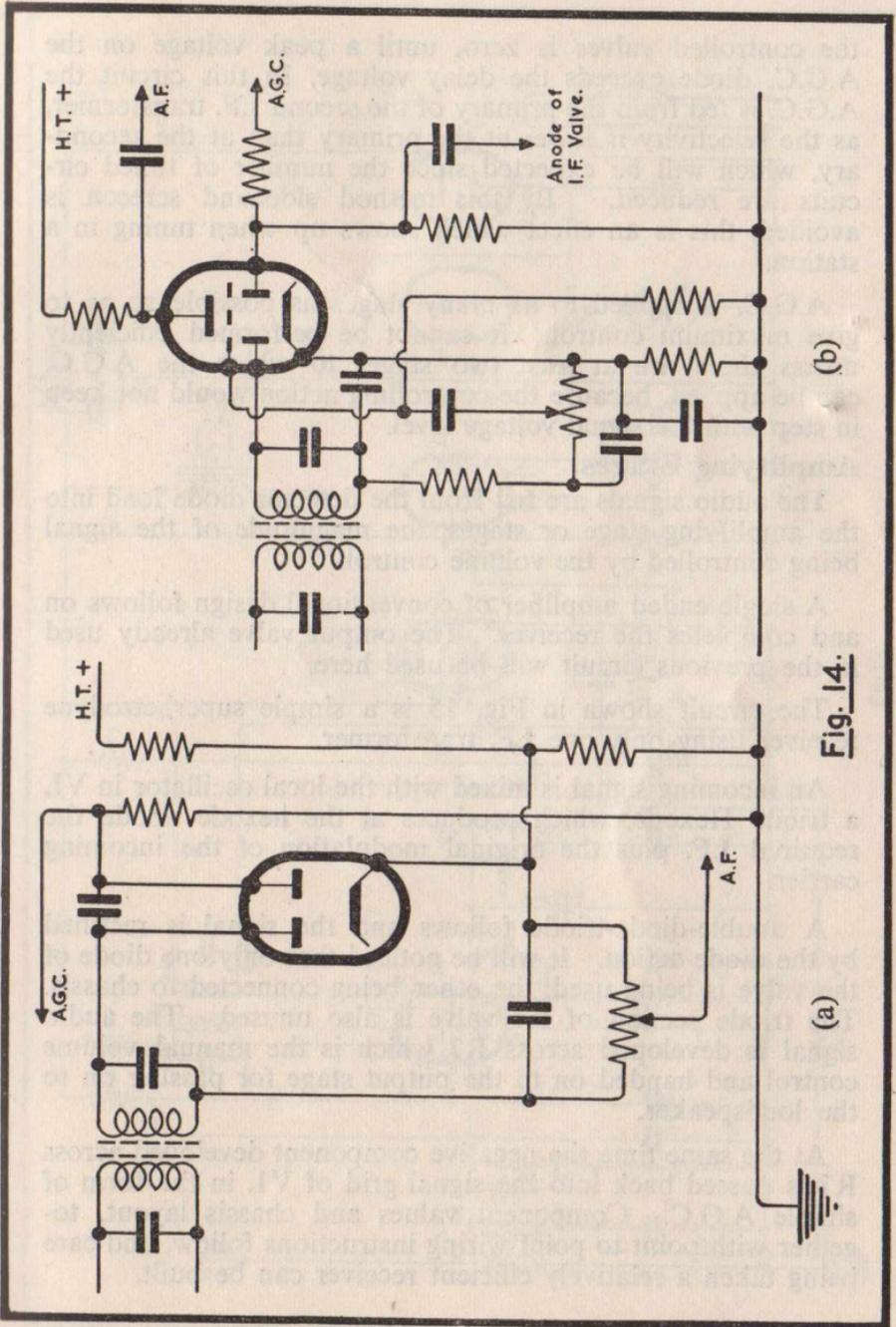
Fig. 14.

Two methods for Producing Delayed A.G.C.

the controlled valves is zero, until a peak voltage on the A.G.C. diode exceeds the delay voltage. In this circuit the A.G.C. is fed from the primary of the second I.F. transformer, as the selectivity is lower at the primary than at the secondary, which will be expected since the number of tuned circuits are reduced. By this method sideband screech is avoided, this is an effect which shows up when tuning in a station.

A.G.C. is applied to as many stages as possible so as to give maximum control. It cannot be performed efficiently unless there are at least two stages to which the A.G.C. can be applied, because the controlling action would not keep in step with the signal voltage level.

Amplifying Stages.

The audio signals are fed from the detector diode load into the amplifying stage or stages, the magnitude of the signal being controlled by the volume control.

A single ended amplifier of conventional design follows on and completes the receiver. The output valve already used in the previous circuit will be used here.

The circuit shown in Fig. 15 is a simple superhetrodyne receiver using only one I.F. transformer.

An incoming signal is mixed with the local oscillator in VI, a triode Hexode, which produces at the hexode anode the required I.F. plus the original modulation of the incoming carrier.

A double-diode-triode follows and the signal is rectified by the diode action. It will be noticed that only one diode of the valve is being used, the other being connected to chassis. The triode section of the valve is also unused. The audio signal is developed across R7 which is the manual volume control and handed on to the output stage for passing on to the loudspeaker.

At the same time the negative component developed across R7 is passed back into the signal grid of V1, in the form of simple A.G.C. Component values and chassis layout, together with point to point wiring instructions follow, and care being taken a relatively efficient receiver can be built.

Fig.15.

Superhet circuit using one I.F. Transformer.

Constructional details for a Simple Superhet Receiver.

Fit valveholders to holes B.E.F.I. and J. with soldering tags under each nut and one on top chassis under the bolt to V1 nearest hole M.

Mount the I.F. transformer without the long lead in hole " C ".

Screw the coil PA2 by the bridge supplied in the former to hole M with a 6BA x $\frac{1}{2}''$ bolt.

Make small aluminium bracket to carry C3 and fix under V/H screw nearest hole M. Wiring to top chassis will be completed later. No clips are used to hold capacitors in position as their own wires are relied upon. Wire up power supply unit as before; the smoothed H.T. going direct to pin 4 V3.

Wire up heaters and mains cable by connecting from point A left-hand side of switch to pin 4 V4, pin 3 V4 to pin 7 V5, pin 2 V5 to pin 7 V3, pin 2 V3 to pin 2 V1, pin 7 V1 to pin 7 V2, pin 2 V2 to solder tag under V2 valveholder screw.

Pin 4 V3 via R2 to Red Tag I.F. transformer.
Junction of R2 and Red tag via C4 to solder tag.
Yellow tag I.F. transformer to pin 3 V1.
Pin 4 V3 via R1 to pin 4 V1.
Pin 4 V1 via C5 to solder tag.
Pin 1 V1 to solder tag.
Pin 5 V1 via R3 to pin 8 V1.
Pin 8 V1 via R4 to solder tag.
Pin 8 V1 via C6 to solder tag.
Tag 4 PO2 via R5 to pin 4 V3.
Tag 2 PO2 via C9 to solder tag.
Tag 4 PO2 via C10 to solder tag.
Tag 1 PO2 via C7 to pin 5 V1.
Tag 1 PO2 to tag on C2 via hole S.
Tag 3 PO2 to pin 6 V1.
C8 connects across tags 1 and 2 of PO2
        non-earthy tag to tag 1.
Black tag I.F. transformer via C14 to solder tag.
Black tag I.F. transformer via C13 to solder tag.

Black tag I.F. transformer to right-hand tag of
R7 via centre core of screened cable.

Earth braiding of screened cable.

Black tag I.F. transformer via R6 to tag 2 PA2.

Tag 2 PA2 via C12 to solder tag.

Aerial terminal to tag 3 PA2.

Tag 4 PA2 to solder tag.

White tag I.F. transformer to pin 4 V2.

Pins 5 and 8 V2 strap together then to solder tag.

Centre tag R7 via core of screened cable to C15.

C15 to pin 5 V3, earth braiding.

Pin 5 V3 via R8 to solder tag.

Pin 8 V3 via R9 to solder tag.

Pin 8 V3 via C16 to solder tag.

Pin 3 V3 to one side output transformer primary.

Pin 4 V3 to other side output transformer primary.

Tag Top of C2 connect to T.C. connector V1.

T.C. connector V1 to tag 1 PA2.

Tag 4 PA2 to solder tag.

Tag 1 PA2 to non-earthy tag C3.

Earth tag C3 to bracket.

Drill hole same size as hole AA to take Belling Lee
terminal with an insulating bush, 2" from
aerial terminal hole AA. Fit and
secure terminal to chassis. Drill 6BA hole
2" from new hole and fit 6BA x ¼" bolt and
nut with solder tag under.

From new terminal via C12 to new solder tag.

NOTE:—Keep all resistors away from chassis.

Top chassis layout for Simple Superheterodyne.
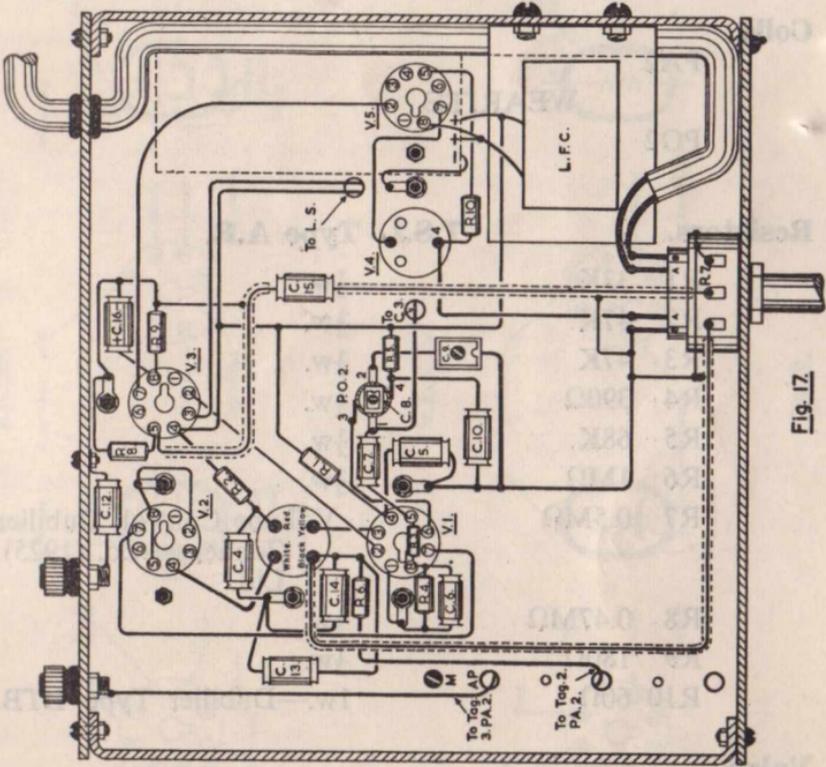
Fig. 17

Under chassis layout for Simple Superheterodyne.

Components List for Simple Superheterodyne Receiver.

I.F. Transformers.   DENCO (CLACTON) LTD.

    1st Type IFT6 (with flying lead).
    2nd Type IFT6.

Coils.

    PA2

           WEARITE.

    PO2

Resistors.   **T.S.L. Type A.R.**

R1	33K	$\frac{1}{2}$w.
R2	47K	$\frac{1}{2}$w.
R3	47K	$\frac{1}{2}$w.
R4	390Ω	$\frac{1}{2}$w.
R5	68K	$\frac{1}{2}$w.
R6	1MΩ	$\frac{1}{2}$w.
R7	0.5MΩ	Volume Control. Dubilier Condenser Co. (1925). Ltd.
R8	0.47MΩ	$\frac{1}{2}$w.
R9	180Ω	$\frac{1}{2}$w.
R10	60Ω	1w.—Dubilier Type BTB.

Valves.

CCH	35	Mullard.
EBC	33	Mullard.
CL	33	Mullard.
CY	31	Mullard.
C1C		Mullard.
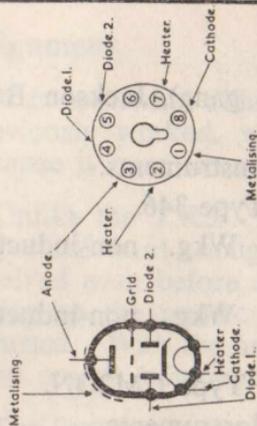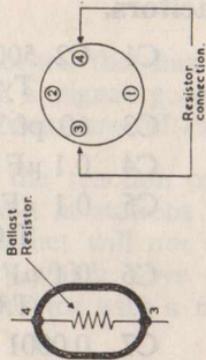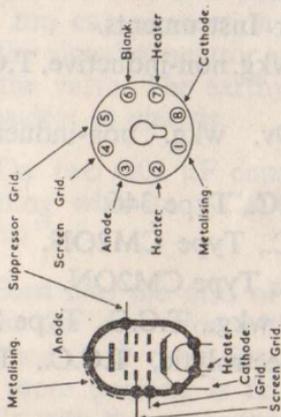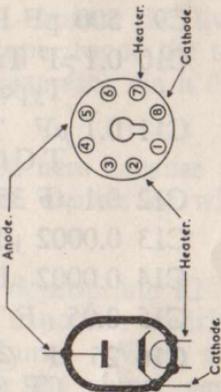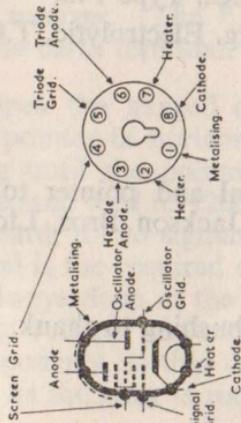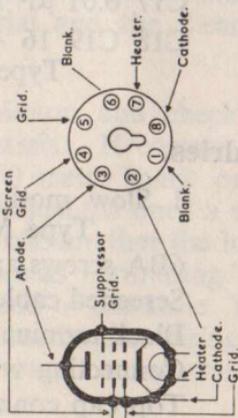
Valve Base Connections used in Receivers.

Fig. 18.

EBC 33.

Diode 2.
Heater
Cathode.
Diode 1.
Anode.
Heater
Grid
Diode 2.
Diode 1.
Cathode.
Heater
Metalising.
Metalising.

C.I.C.

Resistor connection.

Ballast Resistor.

EF 39.

Suppressor Grid.
Screen Grid.
Grid.
Blank.
Heater
Cathode.
Heater
Metalising.
Anode.
Screen Grid.
Metalising.
Heater
Cathode.
Screen Grid.

CY 31.

Heater.
Anode.
Heater.
Cathode.
Anode.

CCH 35.

Triode Anode.
Triode Grid.
Cathode.
Heater
Metalising.
Anode.
Oscillator Anode.
Hexode Anode.
Oscillator Grid.
Screen Grid.
Metalising.
Screen Grid.
Signal Grid.
Heater.

CL 33.

Screen Grid.
Blank.
Heater.
Cathode.
Blank.
Anode.
Suppressor Grid.
Screen Grid.
Heater.
Cathode.

Capacitors.

C1   C2 500 pf. (2 sections 3 gang), Jackson Bros., Type M.G.

C3   60 pf Trimmer, Walter Instruments.

C4   0.1 μF Tubular, T.C.C., Type 346.

C5   0.1 μF Tubular 350v. Wkg. non-inductive, T.C.C., Type 346.

C6   0.1 μF Tubular 350v. Wkg. non-inductive, T.C.C., Type 346.

C7   0.0001 μF Mica, T.C.C., Type CM2ON.

C8   60 pF Trimmer, Walter Instruments.

C9   500 pF Padder, Walter Instruments.

C10 0.1 μF Tubular 350v. wkg. non-inductive, T.C.C. Type 346.

C11 0.1 μF Tubular 1000v. wkg. non-inductive, T.C.C., Type 743.

C12 0.1 μF 350v. wkg., T.C.C., Type 346.

C13 0.0002 μF Mica, T.C.C., Type CM2ON.

C14 0.0002 μF Mica, T.C.C., Type CM2ON.

C15 0.05 μF Tubular 350v. wkg., T.C.C., Type 346.

C16 25 μF @ 25VDC Electrolytic, T.C.C., Type CE 32C.

C17 0.01 μF 1000v. wkg., T.C.C., Type 743.

C18 C19 16 + 8 μF 450v. wkg. Electrolytic, T.C.C., Type CE 28P.

Sundries.

1 Slow motion drive unit dial and pointer to suit Type M.G. Capacitor, Jackson Bros. Ltd.

6BA screws and nuts.

Screened cable.

Black terminal with insulated bushing to shank.

Connecting wire, sleeving, etc.

Top cap connectors.

Alignment.

It is somewhat difficult to align a superhet, that has never previously worked, without the aid of a signal generator, because it is not known how far the circuits are off tune.

Unlike the T.R.F. receiver, which if the reaction control is pressed hard enough, will usually result in stations being received even before alignment, the superhet will not do so owing to the number of tuned circuits which have to be adjusted. With the help of a signal generator with a modulated output, alignment is not difficult.

The first step is to peak the I.F. transformers. First remove the top cap connection from V1, and connect the live lead of the signal generator via a 0.01 μF capacitor to the top cap of the valve. The earthy lead of the generator via a 0.01 μF capacitor to chassis.

The two 0.01 μF capacitors are used here because we are dealing with an AC/DC receiver, the chassis of which is " live ".

Feed into the grid of the valve the appropriate I.F. signal from the generator with the ganged capacitor nearly fully meshed, and peak for maximum volume. When satisfied no more peaking is required, transfer the signal generator leads with the capacitors to the aerial and earth terminals of the receiver. The " live " to the aerial and the " earthy " to the earth terminal.

Open the ganged capacitor to minimum and check that the pointer is horizontal with the chassis. If correct close gang until the pointer is over the 250 metre mark on the scale, and feed in 1200 Kc/s signal. Adjust C8 until a signal is heard, if two signals appear near to one another the louder signal is the required one. This is known as " trimming " and is always done at the high frequency end of the scale. Trimming reduces the stray capacities between the wiring and components, so that the tuned circuits remain substantially in step as the gang is rotated.

Reduce the output from the signal generator, so as to prevent a strong signal from operating the A.G.C. and so giving misleading results. Now adjust C3 for maximum output for the same reasons as stated before. Return now to C8 without altering the frequency setting of the generator, and readjust C8 for the maximum volume again, as adjusting C3 has had a slight effect on C8. Now back to C3 and adjust there again for maximum volume. Keep returning to these capacitors alternately until satisfied no more improvement can be made.

Set the frequency of the signal generator to 600 Kc/s (500 metres) and close gang until the pointer is over the 500 metre mark. Adjust C9 for maximum output. This action is known as " padding " and is done at the low frequency end of the scale. This compensates for small discrepancies in the various components, so that the tuning curve with the " trimmer " action and the " padder " action becomes more or less of a straight line.

When satisfied with C9, return the signal generator to 1200 Kc/s and readjust C8 and C3 again for maximum volume.

With patience and careful adjustment of the trimmers and padder the receiver should now be able to respond to outside signals from an aerial.

If no signal generator is available, alignment becomes rather difficult even for an experienced person, when a set has never worked before, and adjustments have to be made to obtain maximum " hiss " from the receiver especially when aligning the I.F. Once this has been achieved and a signal received from an aerial, adjustment of C8, C3 and C9, in that order, usually results in good reception. Again patience must be shown to get good results.

Five Valve Superhet Receiver.

The following circuit takes on more conventional lines, almost akin to a commercial superhet receiver. This time an I.F. amplifier is used to amplify the I.F. signal before it is passed on to the diodes of the double-diode-triode. The triode section of the D.D.T. is also used to give amplification to the audio signals received from the rectified incoming signal, before handing them on to the grid of the output valve. Also the second diode is used for the generation of A.G.C. voltage to be handed back to the controlled valves.

To make the construction of such a receiver a worth while attempt, it would be better, perhaps, to strip the chassis completely of all the components and start afresh.

Having gained experience with the simple superhet, the construction and adjustment of the more conventional type will not seem to be so formidable. Once again care and patience must be exercised to make a good job, with good results as the reward.

Components List for 5 valve Superhet Receiver.

Capacitors.

C1 1000 pf Mica, T.C.C., Type CM2ON.

C2 0.01 μF Tubular, T.C.C., Type 743.

C3 60 pf Trimmer, Walter Instruments, Type MS20.

C4 and C12 2 sections of 3 gang., Jackson Bros.

C5 0.05 μF Tubular, T.C.C., Type 346.

C6 0.1 μF Tubular, T.C.C., Type 346.

C7 0.1 μF Tubular, T.C.C., Type 346.

C8 50 pf Silver Mica, T.C.C., Type M2U.

C9 500 pf Mica, T.C.C., Type CM2ON.

C10 480 pf Padder, Walter Instruments, Type 356.

C11 60 pf Trimmer, Walter Instruments, Type MS20.

C13 0.1 μF Tubular, T.C.C., Type 346.

C14 0.1 μF Tubular, T.C.C., Type 346.

C19 100 pf Mica, T.C.C., Type CM2ON.
C20 100 pf Mica, T.C.C., Type CM2ON.
C21 100 pf Mica, T.C.C., Type CM2ON.
C22 0.01 μF Tubular, T.C.C., Type 346.
C23 0.05 μF Tubular, T.C.C., Type 346.
C24 25 μF 12v. wkg. Electrolytic.
C25 8 μF Electrolytic.
C26 25 μF 25v. wkg. Electrolytic.
C27 0.1 μF Tubular, T.C.C., Type 346.
C28 0.01 μF Tubular, T.C.C., Type 346.
C29 and C30 16 × 8 μF Electrolytic.
C31 0.01 μF Tubular, T.C.C., Type 743.

Resistors.   T.S.L. Type A.R.

R1	22KΩ	$\frac{1}{2}$w.
R2	33KΩ	$\frac{1}{2}$w.
R3	47KΩ	$\frac{1}{2}$w.
R4	220Ω	$\frac{1}{2}$w.
R5	47KΩ	$\frac{1}{2}$w.
R6	68KΩ	$\frac{1}{2}$w.
R7	330Ω	$\frac{1}{2}$w.
R8	47KΩ	
R9	0.5KΩ	Potentiometer.
R10	1.8KΩ	$\frac{1}{2}$w.
R11	1MΩ	$\frac{1}{2}$w.
R12	270KΩ	$\frac{1}{2}$w.
R13	47KΩ	$\frac{1}{2}$w.
R14	100KΩ	$\frac{1}{2}$w.
R15	470KΩ	$\frac{1}{2}$w.
R16	180Ω	$\frac{1}{2}$w.
R17	60Ω	1w.
R18	1MΩ	$\frac{1}{2}$w.
R19	100KΩ	$\frac{1}{2}$w.

I.F. Transformers.

1st Type IFT6 (with flying lead)   **Denco**
2nd Type IFT6.   **(Clacton) Ltd.**

Valve.

Mullard EF 39.

Sundries.

Grid Top cap connectors.

Wire, Sleeving, nuts, bolts, washers, etc.

3 5-way tag strips, A. F. Bulgin and Co., Type T20.

UNDER CHASSIS WIRING

Wire up heaters.

Contact A left-hand side of switch to Pin 3 V5.

Pin 4 V5 to Pin 7 V6.

Pin 7 V6 to Pin 2 V4.

Pin 2 V4 to Pin 7 V2.

Pin 7 V2 to Pin 7 V1.

Pin 2V to Pin 7 V3.

Pin 2 V3 to solder tag under V3 fixing bolt.

Negative lead of C29 C30 to solder tag under V5 fixing bolt.

Pin 8 V5 to C30 and one side L.F. choke.

Other side L.F. choke to C29.

C29 to Pin 4 V4.

Pin 4 V4 to one side L.S. transformer primary.

Other side of primary to pin 3 V4.

Connect C28 across pins 3 and 4 of V4.

Connect R14 to Pin 5 V4 the other end to Pin 6 V4.

Pin 6 V4 via R15 to solder tag on V4 valveholder fixing bolt.

C23 from Pin 3 V3 to Pin 6 V4.

R16 from Pin 8 V4 to solder tag.

C26 from Pin 8 V4 to solder tag.

Fix tag strip 1 to chassis under V3 valveholder bolt.

Pin 4 V4 to tag 5 tag strip 1.

R13 connect between tag 5 and tag 2 on tag strip 1.

From tag 2 via R12 to Pin 3 V3.

From tag 2 tag strip 1 to C25 positive tag.

Negative tag C25 to solder tag.

Connect tag 5 tag strip 1 to tag 1 with sleeving over wire.

Pin 4 V3 to tag 5 via C21.

Pin 4 V3 to white tag I.F.T.2.

Pin 5 V3 to tag 3 tag strip 1.

Pin 8 via R10 to solder tag.

Pin 8 via C24 to solder tag.

Fix tag strip 2 under I.F.T.2 fixing bolt.

Mount C20 on tag strip 2 between tags 5 and 2.

R8 between tags 1 and 2.
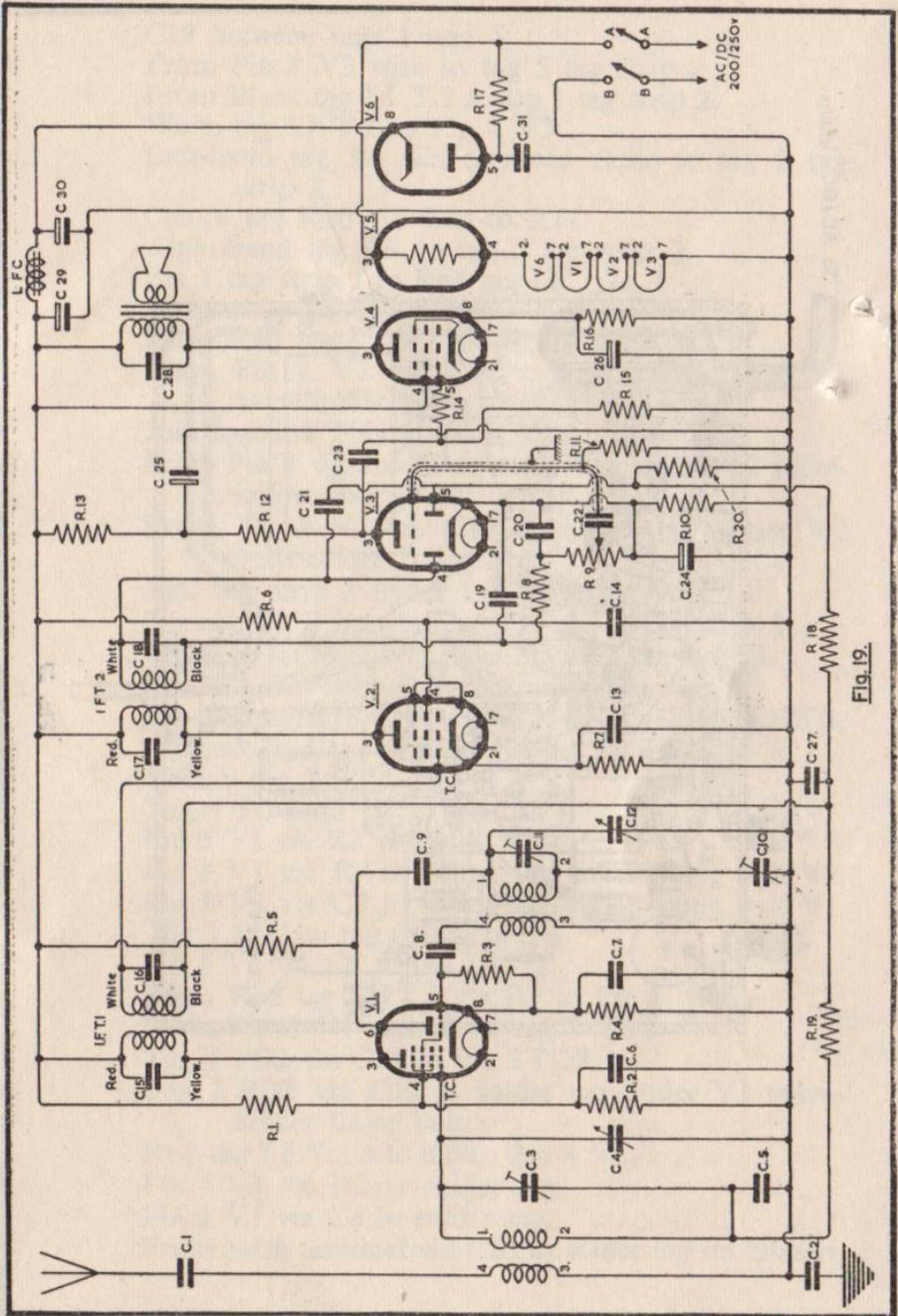
Circuit diagram of Four Valve plus Rectifier Superhet Receiver.

Fig. 19.
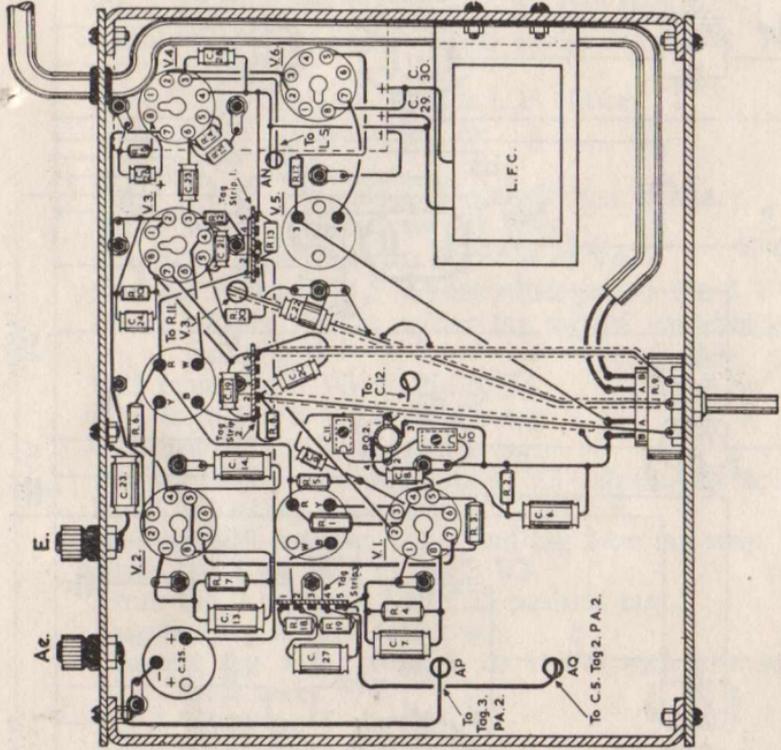
Fig. 20

Under chassis layout to Four Valve Superhet.

C19 between tags 1 and 5.

From Pin 8 V3 wire to tag 5 tag strip 2.

From Black tag I.F.T.2 to tag 1 tag strip 2.

White tag I.F.T.2 to Pin 4 V3.

Left-hand tag R9 via screened cable to tag 2 tag strip 2.

Centre tag R10 via C22 to R11.

Right-hand tag R9 to tag 5 tag strip 2.

Pin 1 tag strip 1 to Red tag I.F.T.2.

Yellow tag I.F.T.2 to pin 3 V2.

From Red tag I.F.T.2 via R6 to pin 4 V2.

From Pin 4 V2 via C14 to solder tag under V2 valveholder bolt.

Join together Pins 5 and 8 V2.

From Pin 8 V2 via R7 to solder tag under V2 valveholder fixing bolt.

From Pin 8 V2 via C13 to solder tag under V2 valveholder fixing bolt.

Bolt tag strip 3 under I.F.T.1 fixing bolt.

Connect R18 between tags 1 and 2 tag strip 3.

Connect R19 between tags 2 and 4 tag strip 3.

Connect C27 between tags 2 and 5 tag strip 3.

Junction of R18, R19 and C27 to Black tag I.F.T.1.

Connect Red tag I.F.T.1 to Red tag I.F.T.2.

Yellow tag I.F.T.1 to Pin 3 V1.

Tag 4 PO2 via C8 to Pin 5 V1.

Pin 5 V1 via R3 to Pin 8 V1.

Pin 8 V1 via R4 to solder tag under fixing bolt V1.

Pin 8 V1 via C7 to solder tag under fixing bolt V1.

Tag 1 PO2 to tag on C12.

Pin 6 V1 via C9 to tag 1 PO2.

From Red tag I.F.T.1 via R5 to Pin 6 V1.

From Pin 6 V1 via C9 to tag 1 PO2.

Tag 1 PO2 via C11 to tag 2 PO2.

Tag 2 PO2 via C10 to solder tag under V1 valveholder fixing bolt.

Red tag I.F.T.1 via R1 to Pin 4 V1.

Pin 4 V1 via R2 to solder tag.

Pin 4 V1 via C6 to solder tag.

From earth terminal via C23 to solder tag on chassis.

TOP CHASSIS WIRING

Fit PA2 coil into hole M.

Mount small bracket under V1 valveholder fixing bolt to carry C3.

Connect " live " tag C4 to top cap connector of V1.

Top cap connector V1 also to tag 1 PA2.

Tag 1 PA2 to " live " side C3.

Earthy side C3 to bracket.

Tag 3 PA2 to aerial terminal.

Tag 4 PA2 to solder tag.

Tag 2 PA2 via C5 to solder tag.

Tag 2 PA2 to R19.

Grid lead I.F.T.1 to top cap connector V2.

Grid lead from centre tag V R9 to top cap connector V3.

Top cap connector V3 via R11 to braiding.

Check and recheck all wiring.

Alignment of Five Valve Superhet Receiver.

Once again a Signal Generator with a modulated output is necessary to perform this operation properly, also if one possesses an Avometer Model 7 this will be an added advantage.

The first thing is to align the I.F. stages.

To do this connect the Signal Generator to the grid of the I.F. amplifying valve (EF39) via a 0.1 μF capacitor, the " earthy " lead of the generator via a 0.1 μF capacitor to chassis. Make sure that the ganged capacitor is almost fully meshed, and the volume control at maximum.

Set the signal generator to the required I.F. frequency (470 Kc/s) and adjust the cores or the capacitor of I.F.T.2 for maximum volume. If an Avometer No. 7 is available set the switches to A.C. 10 volts range and connect across the speaker transformer secondary terminals. This will show when maximum peak has been reached.
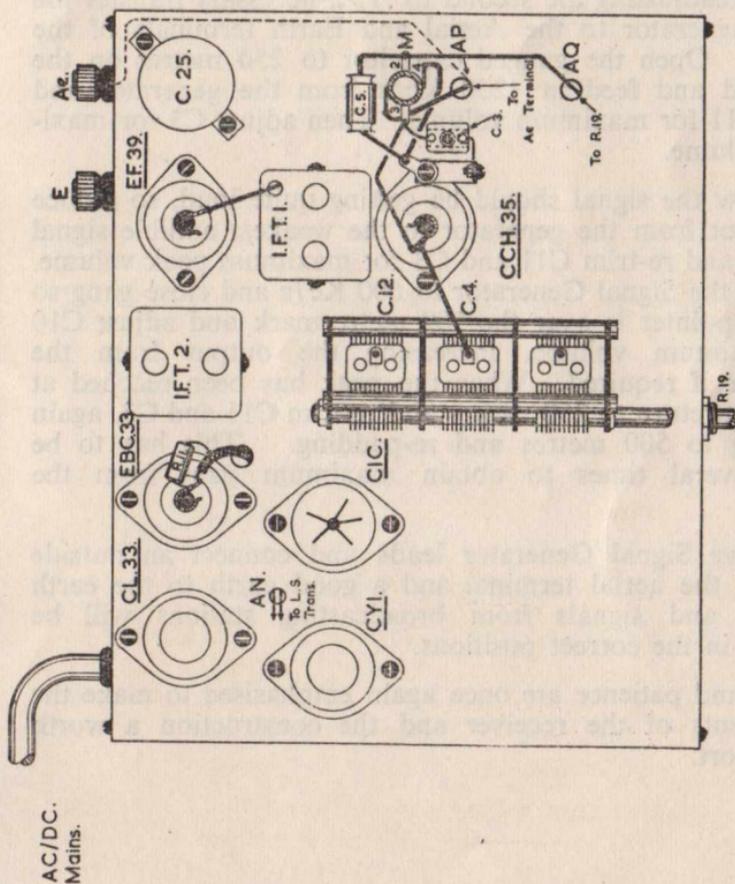
Fig. 21

Top chassis layout to Four Valve Superhet.

AC/DC.
Mains.

Ae.   E

C. 25.   EF. 39.   I.F.T.1.   CCH.35.

C.5.   M   AP   To Ae Terminal   AQ   To R.19

C.12.   C.4.

I.F.T. 2.

EBC33   C.1.C.

R.19

CL. 33   AN.   To L.S. Trans.   CY.1.

When satisfied with the adjustment, transfer generator leads, still with the isolating capactiors connected to the top grid of V1 (ECH33). Feeding in 470 Kc/s and peak I.F.T.1 for maximum volume.

Reduce the input of the generator by the attenuator control to reduce volume, and not by the manual control on the receiver.

After readjusting the second I.F.T. if necessary transfer the Signal Generator to the Aerial and Earth terminals of the receiver. Open the ganged capacitor to 250 metres on the scale and and feed in 1250 Kc/s from the generator and adjust C11 for maximum volume. Then adjust C3 for maximum volume.

By now the signal should be getting quite loud, so reduce the output from the generator to the weakest audible signal possible and re-trim C11 and C3 for maximum peak volume. Now set the Signal Generator to 600 Kc/s and close gang so that the pointer is over the 500 metre mark and adjust C10 for maximum volume, increasing the output from the generator if required. When the peak has been reached at this point return to 250 metres and re-trim C11 and C3, again returning to 500 metres and re-padding. This has to be done several times to obtain maximum gain from the receiver.

Remove Signal Generator leads and connect an outside aerial to the aerial terminal and a good earth to the earth terminal and signals from broadcasting stations will be received in the correct positions.

Care and patience are once again emphasised to make the adjustments of the receiver and the construction a worth while effort.

BERNARDS RADIO BOOKS