# Building a Superhet Receiver

**Here is an ideal project to build up in order to reinforce the knowledge you have gained in the previous chapters. It is a simple superhet radio receiver of modern design, battery operated and with its own loudspeaker. The circuit uses six bipolar transistors and a FET, and is built on a printed wiring board to give you experience with this widely-used construction technique.**

Having studied various aspects of electronics as applied to radio receivers in previous chapters, together with the construction of simple receivers in Chapter 12, you are now in a position to tackle a more involved type of receiver using the superheterodyne principle. Perhaps it may be wise to refresh your theory of operation of the superheterodyne before proceeding, by referring back to chapter 13.

Although superheterodyne receivers can often be very complex affairs, nevertheless it is possible to design quite a simple version. With this in mind, we will discuss details of a simple superhet (for short) and show how it may be built quite easily. It must be pointed out here that although the receiver to be described is simple, it embodies all the basic superhet principles.

As you may well have gathered by now, the superhet principle applies only to the sections or stages of a receiver up to and including the detector. The signal emerging from the detector is the wanted audio in the form of speech or music at low level. So that the audio signal may be used to drive a loudspeaker, it is necessary to amplify the signal and this is done in the audio amplifier, which is another essential part of a complete receiver. A modern audio amplifier is incorporated into this receiver and it is sufficient to drive a loudspeaker to a level adequate for normal listening purposes.

The other essential part to complete the receiver is a power supply. In its simplest form, this can be a suitable battery and this is the type of supply which we have used here. By taking this approach, we are able to avoid the use of a mains power supply, which has the advantages of reduced initial cost and the avoidance of any hazards which may attend the use of mains power by a novice. Hum problems are reduced to vanishing point, and the receiver may also be operated where no mains supply is available.

Having dispensed with the preliminaries, we shall now take a look at the complete circuit and discuss it in some detail. It will be seen that there are seven transistors in all, with only three of them in the "tuner" and the other four in the audio amplifier system.

The first stage which the signals meet after entering from the aerial is an RF amplifier and it uses an N-channel junction FET, either a Motorola 2N5485 or a Fairchild FE5485. A FET was chosen in preference to a bipolar transistor for this stage, on grounds of circuit simplicity.

In the gate circuit is a conventional type of miniature aerial coil. This coil is type No S203, made by Aegis Pty Ltd. It may also be seen that there is a 220pF capacitor from the top of the primary winding of the coil, to the tap on the secondary winding. This has been added to increase the coupling, more particularly at the high frequency end of the RF band.

In many receivers which have an RF amplifier, the output as well as the input of this stage is tuned. However, on the score of simplicity, we have not tuned the output. Instead, the drain of the FET is fed via a 2.5mH RF choke. The output of the RF amplifier, at the drain of the FET, is a high impedance and the input to the next stage is a relatively low impedance. To meet this situation, we must devise some sort of matching arrangement.

This problem has been solved by connecting two capacitors in series, across the RF choke. By arranging the correct ratio between the two capacitor values, an impedance transformation is achieved at the junction of the two capacitors. From this point, the signal is fed directly to the base of the next stage.

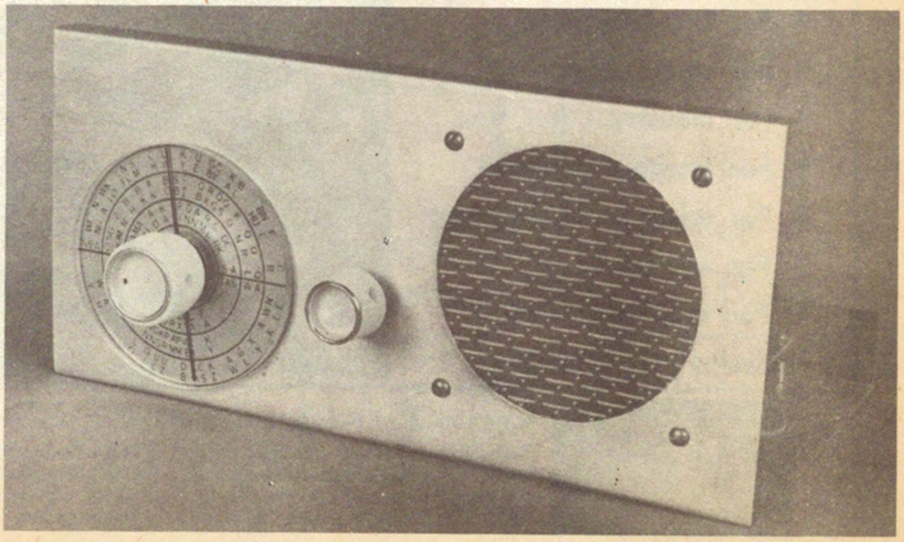
In order to provide a standing negative bias for the gate of the FET, with respect to the source, a resistor is placed between the source and earth and the voltage drop across this resistor is effectively the bias for the stage. Generally, there is a capacitor across such a resistor, to provide a low impedance path for the signal. However, in this case, the capacitor has been omitted so that negative feedback or degeneration is introduced. Also, the value of the resistor is larger than the optimum value for maximum gain. Again, this has been done to increase the amount of degeneration.

At this stage, it may well be asked, why all the degeneration in the RF amplifier, which reduces the gain? The answer is that a compromise must be reached between conflicting requirements. While maximum gain is desirable, there is another consideration which must also be met.

It will be explained later that automatic gain control (AGC) voltage is applied to the gate of the RF amplifier and the RF amplifier is followed by a self-oscillating mixer. Now the varying AGC voltage causes a change in capacitance at the output of the RF amplifier and this change is seen by the following mixer stage. The capacitance change tends to cause corresponding mixer oscillator frequency changes, and this cannot be tolerated as it upsets the tuning of the receiver. By introducing the degeneration previously referred to, the effect is reduced to a minimum.

As mentioned earlier, the next stage is a self-oscillating mixer, also called an "autodyne". One transistor, which is a bipolar type BF115, TT1002, SE1002, etc, performs the dual task of oscillator and mixer. In order to achieve this, the circuit is rather interesting, as even a casual glance will indicate.

The transistor is biased in the usual way, with a voltage divider in the base circuit and a bypassed resistor in the emitter circuit. A special oscillator coil has been designed for this arrangement. There is the usual winding tuned by one section of the gang, together with two small windings to



provide feedback between collector and emitter. It will be seen that these windings are connected in series with the collector and emitter, respectively.

To complete the oscillator circuit, the base of the transistor should be earthed to AC, although not to DC. This can be met by placing a bypass capacitor from base to earth. However, if we use a large value of capacitance, with a very small reactance, for this purpose, the oscillator requirement will be met but the wanted signal from the RF stage would be short-circuited, preventing the stage from acting as a mixer.

Once again, we must compromise but fortunately this can be done quite easily, without detriment to performance. In order to get the oscillator to function satisfactorily, it is not necessary to bypass the base with a very large capacitor. It is possible to arrive at a capacitance value which will bypass the base sufficiently to allow proper oscillator operation and still permit the signal to be fed into the base.

If we take a careful look at the circuit, it will be seen that the base of the autodyne is bypassed by the .0022uF capacitor at the RF choke, and the 0.1uF capacitor from the +9V line to earth. These two capacitors are effectively in series for this function. It may be remembered that the .0022uF capacitor is part of the voltage divider across the RF choke, mentioned earlier. This same capacitor also performs a third function of DC blocking between the drain of the RF amplifier and the base of the autodyne.

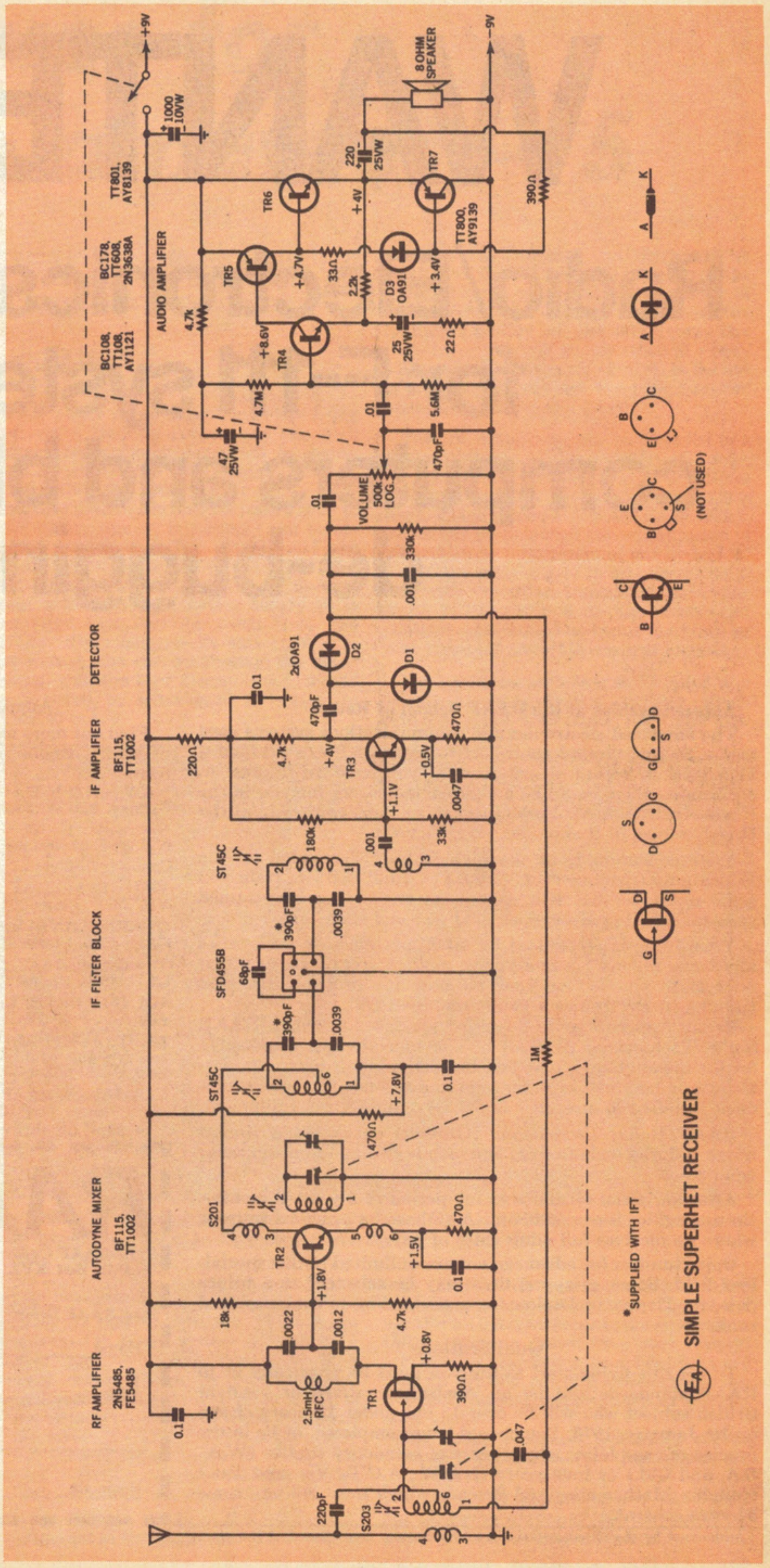
The circuit requires a 2-gang variable capacitor, with one section designed for an oscillator incorporating the padderless technique. This section has a lower maximum capacitance and consequently smaller plates. It will be noted that we have actually used a 3-gang unit, 200pF-90pF-200pF, made by Roblan. This was chosen because it was most physically suited to our purpose and the extra cost was only slight. The extra 200pF section is left unused.

So far, we have considered the function of the mixer as an oscillator, and the wanted signal at its base. You have read in an earlier chapter about the process of frequency conversion of the incoming signal, to an "intermediate frequency" (IF). The IF we are using is nominally 455KHz.

This means that as well as the oscillator and RF signals at the collector of the autodyne, there will also be a 455KHz component. So that the latter may be separated out and fed into the succeeding stages, the first IF transformer primary is connected in series with the oscillator coil winding in the collector circuit. As the IF transformer winding is tuned to the wanted 455KHz frequency, this component is accepted and the oscillator and signal components rejected.

This has brought us to a very important section of the receiver, and where most of the selectivity is realised. Two IF transformers, intercoupled with a two section ceramic filter, form a complete "filter block." We have already explained that the tuned winding of the first IF transformer is connected into the collector circuit of the autodyne stage. For reasons which should become apparent, the low impedance winding of this first IF transformer is left unused.

Now the impedance of the IF transformer is high and the input of the ceramic filter



into which the transformer feeds is a relatively low impedance. We have a very similar situation here that we had when we had to couple between the RF amplifier and the input of the oscillator-mixer, and although different values of capacitance are used, the matching system used is the same. In this case the total capacitance across the winding has a value which will allow the transformer to be tuned to 455KHz and the ratio of the two capacitances is chosen to give the right impedance transformation.

The ceramic filter consists of two sections, and it is necessary to provide coupling between the two sections. This is done with a 68pF capacitor. The value of this capacitor, within definite limits, determines the bandwidth of the ceramic filter assembly. Increasing the capacitance up to 150pF increases the bandwidth and reducing it to 27pF reduces the bandwidth. The value we have chosen is about right for our purpose.

Coupling from the output of the ceramic filter into the tuned winding of the second IF transformer is done in the same way as before. This brings us to the point where we have to couple from the filter block into the base of the IF amplifier, which again is a relatively low impedance. As menioned before, there is a low impedance winding provided on the IF transformer for this purpose. A look at the circuit will show just how this is done.

The two IF transformers (type ST45C) and the oscillator coil (type S201), like the aerial coil mentioned earlier, are made by Aegis Pty Ltd. The ceramic filter is type SFD455B, made by the Japanese firm Murata and imported by IRH Components Pty Ltd.

The IF amplifier is a conventional bipolar transistor amplifier and there are only a couple of points of interest as far as we are concerned. Although it is used as an IF amplifier, the collector circuit is not tuned and consists simply of a 4.7k resistive load. It will also be noted that the collector circuit is decoupled with a 220 ohm resistor and a 0.1uF capacitor. This is done to prevent any possibility of IF signals being fed back into earlier stages via the power supply line, which would cause instability.

The detector follows, and is quite an interesting circuit. Two germanium diodes are used and they are connected in a half-wave voltage-doubler rectifier circuit. The IF amplifier transistor takes the place of the usual transformer and the 470pF and .001uF capacitors perform the functions of doubling and filtering. The 330k resistor forms a load for the circuit and the rectified 455KHz signal appears across the 330k load. This takes the form of a DC voltage, together with the audio signal recovered from the modulation. The advantage of using the voltage doubler type of detector is that we get almost twice the recovered audio compared with a single diode detector.

The DC voltage which accompanies the audio is also greater than that from a single diode detector. As this voltage varies in level according to the signal strength, it is possible to use it for automatic gain control (AGC). The gain of the FET in the RF amplifier may be controlled by feeding a negative voltage to its gate. By connecting the two diodes in the detector the right way around, we can make them produce a negative DC voltage across the 330k resistor.

As mentioned before, this DC voltage has the audio superimposed on it. Before the DC voltage can be used for AGC purposes, the audio component must be removed and this is done with a simple filter consisting of a series 1M resistor and a .047uF capacitor. This capacitor performs the dual role of filter and a low impedance path to earth for the secondary winding of the aerial coil. Thus, the DC control voltage for AGC action is fed from the detector output to the gate of the FET, via the 1M resistor and the secondary of the aerial coil.

As the audio output from the detector is not sufficient to drive a loudspeaker, it must be amplified in an audio amplifier system. So the audio from the detector is fed through a volume control into an audio amplifier consisting of three stages. The battery On / Off switch is mounted on the back of the volume control.

The audio amplifier circuit is quite straightforward and in line with modern design. It is transformerless and uses a complementary-symmetry PNP-NPN pair of silicon transistors in the output stage. Two more silicon transistors, and NPN and PNP, are direct coupled and form a high gain system to drive the output pair. DC feedback of 100 per cent is achieved through the 2.2k resistor, to stabilise the operating current. AC negative feedback is also applied via the same resistor, but can be controlled over a wide range by varying the value of the resistor in series with the 25uF capacitor. The input impedance of the stage following the volume control is high, in the order of a megohm or so, and is largely dependent upon the degree of negative feedback adopted.

The output transistors are operated in class B, with a consequent low value of quiescent current. In its simplest form, the bases of the transistors of this type of output stage are tied together. This can lead to some "crossover" distortion, particularly at low levels. To avoid this, we have introduced a 33 ohm resistor and an OA91 germanium diode in series, between the transistor bases. This sets up the bias such that crossover distortion is avoided and is well worth the slight increase in cost.

The voltage at the emitters of the output transistors should be as close as possible to half the supply voltage, to ensure that the amplifier can deliver full output without premature clipping. As the three stages in the main amplifier are DC coupled, this voltage is determined mainly by the voltage divider at the base of the stage following the volume control. It may be necessary to adjust the value of the resistor shown as 4.7M if the voltage at the output emitters is not approximately +4.5V when the set is first switched on.

The loudspeaker is fed from the output transistor emitters via a DC blocking capacitor — a 220uF electrolytic. For our requirements, this value is sufficient as we are only driving a small speaker. If we had to consider a much larger speaker in a system where good bass response would be expected, then the capacitor would have to be larger, up to 1000uF or so.

The speaker we have chosen is a type 3U made by Magnavox, with an 8 ohm voice coil. A similar speaker with a 15 ohm voice coil may be used but somewhat less volume will be available. Other brands of speaker with similar characteristics to the one we used would be quite suitable.

The 9V battery is an Eveready type 2364.

## You will need these parts

*1 Chassis-panel, 9in long x 4¼in high x 5in deep*
*2 Terminals, 1-red, 1-black*
*1 Dial, Roblan 6 / 1, with knob*
*1 Knob to match, for volume control*
*6 Spacers, ½in long x ¼in dia, tapped ⅛in Whitworth*
*1 Speaker, 3in, 8 ohms*
*1 Battery, 9V type 2364 or similar*
*1 Battery plug*
*1 Printed board, 72 / R9, 7in x 3in*
*1 Jabel flexible coupling, ¼in x ¼in*
*1 Aerial coil, Aegis S203*
*1 Oscillator coil, Aegis S201*
*2 IF transformers, Aegis ST45C*
*1 Murata filter, SFD455B*
*1 2.5mH RF choke*
*1 Transistor, 2N5485, FE5485*
*2 Transistors, BF115, TT1002, SE1002*
*1 Transistor, BC108, TT108, AY1121*
*1 Transistor, BC178, TT608, 2N3638A*
*1 Transistor with heat sink, TT801, AY8139*
*1 Transistor with heat sink, TT800, AY9139*
*3 Diodes, OA91*
*Screws, nuts, hookup wire, solder, etc.*

*RESISTORS (½ watt)*
*1 22 ohms*
*1 33 ohms*
*1 220 ohms*
*2 390 ohms*
*3 470 ohms*
*1 2.2k*
*3 4.7k*
*1 18k*
*1 33k*
*1 180k*
*1 330k*
*1 Potentiometer, 500k with switch*
*1 1M*
*1 4.7M*
*1 5.6M*

*CAPACITORS*
*1 220pF 630V polystyrene*
*1 3-gang, 200pF-90pF-200pF, Roblan*
*2 470pF 630V polystyrene*
*2 .001uF 630V polystyrene*
*1 .0012uF 400V polyester*
*1 .0022uF 400V polyester*
*2 .0039uF 400V polyester*
*1 .0047uF 25V ceramic*
*2 .01uF 25V ceramic*
*1 .047uF 25V ceramic*
*3 0.1uF 25V ceramic*
*1 25uF 25VW electrolytic single ended*
*1 47uF 25VW electrolytic single ended*
*1 220uF 25VW electrolytic single ended*
*1 1000uF 10VW electrolytic single ended*

*Note: Resistor wattage ratings and capacitor voltage ratings are those used with our prototype. Components with higher ratings may generally be used providing they are physically compatible. Components with lower ratings may also be used in some cases, providing the ratings are not exceeded.*

This is the most suitable type for our purpose, being compact in size and still an economical proposition. However, it should be pointed out that if you wish to use a larger 9V battery and either make the metalwork larger to take it, or leave it external to the receiver, a longer life would be possible for only a little extra outlay. Just as a broad example, supposing that the type 2364 battery lasted for 60 hours of operation, a type 276P may be expected to last for about 130 hours. The cost of the larger battery is only marginally greater than the small one.

The above figures are only given as a guide and a very important point to watch with regard to battery life is the volume at which the set is used. The class B output stage draws current from the battery to a degree roughly proportional to the volume. Clearly, if the set is operated at a modest volume, the battery will last correspondingly longer. The choice is up to you.

The dial is quite a simple unit but adequate for the job. Many of the Australian broadcast stations are marked in groups for the six States, around the circular scale. A planetary drive is incorporated and the movement is very smooth, with a reduction of about 6:1. This makes tuning pleasant and easy. The complete dial assembly is marketed under the name of Jabel by Watkin Wynne Pty Ltd, and should be available from most radio components suppliers.

Construction of this little set has been made about as easy as it could be, as most of the components are contained on one printed board 7in x 3in. The only components external to the board are the louspeaker, battery and volume control. The latter has a 470pF capacitor mounted between the earthed and rotor lugs.

Mounting and soldering of the components on the board may best be done by following the coded picture which we have provided. Alternatively, some board manufacturers, such as RCS Radio Pty Ltd, actually print the code directly on the board. This makes assembly doubly easy.

Before proceeding with the assembly, it must again be emphasised that care should be taken not to overheat the components. This applies particularly to transistors and the point has been covered in more detail in Chapter 12.

A systematic approach to construction will make the job easier and here are some suggestions as to how it may be done.

Start with the smaller components and more specifically, all resistors may be mounted and soldered in. To make a neat job, the resistors should have their pigtails bent at right angles and at points equidistant from the body of the resistor. The pigtails are then dropped through the appropriate holes and with the body of the resistor against the surface of the board. Turn the board over and bend the two pigtails outwards by about 45 degrees. This stops the resistor from falling out during the soldering process. Cut the two leads off, leaving about 1/16in protruding and then carefully solder.

Having done all the resistors, the small capacitors are next. Treat them in a similar way to the resistors. It will be seen that some of the holes on the board are too close together to allow capacitors to be mounted against the board. There are six capacitors so affected and these are the two each across the IF transformers and the .0022uF and the .0012uF across the RF choke. These should be stood on end, with one end hard against the board and the other pigtail bent over and down so that it goes through the other hole.

Perhaps it should be noted that we have specified 630V rating types for many of the small value polystyrene capacitors. This has been done simply because in these capacitors, most suppliers stock only the 630V types. Needless to say lower voltage capacitors may certainly be used if your supplier has them.

The four electrolytic capacitors are next and should present no problems. However, care should be taken to make sure that they are mounted with due regard to polarity. If you should have any difficulty in getting "single ended" electrolytics, as we did with the 1000uF unit, then an ordinary one may be used and mounted in the same way as we have described for the other capacitors which were mounted on end. In some cases, it may be necessary to lengthen one pigtail by soldering another pigtail offcut to it.

The RF choke is mounted in a similar way to the resistors and with the coil resting against the board. The little ceramic filter must be given careful attention, as it is quite small and perhaps a little delicate. Make very sure that it it mounted with the dot on the case facing the 68pF capacitor. Press the filter hard against the board and the four corner tags may be bent over so that they lie against the copper to which each has to be soldered. Start with the unbent centre tag and carefully solder it, then follow with the other four. Be very careful not to allow any solder to run across and so bridge the gaps between the lugs and adjacent copper on the board.

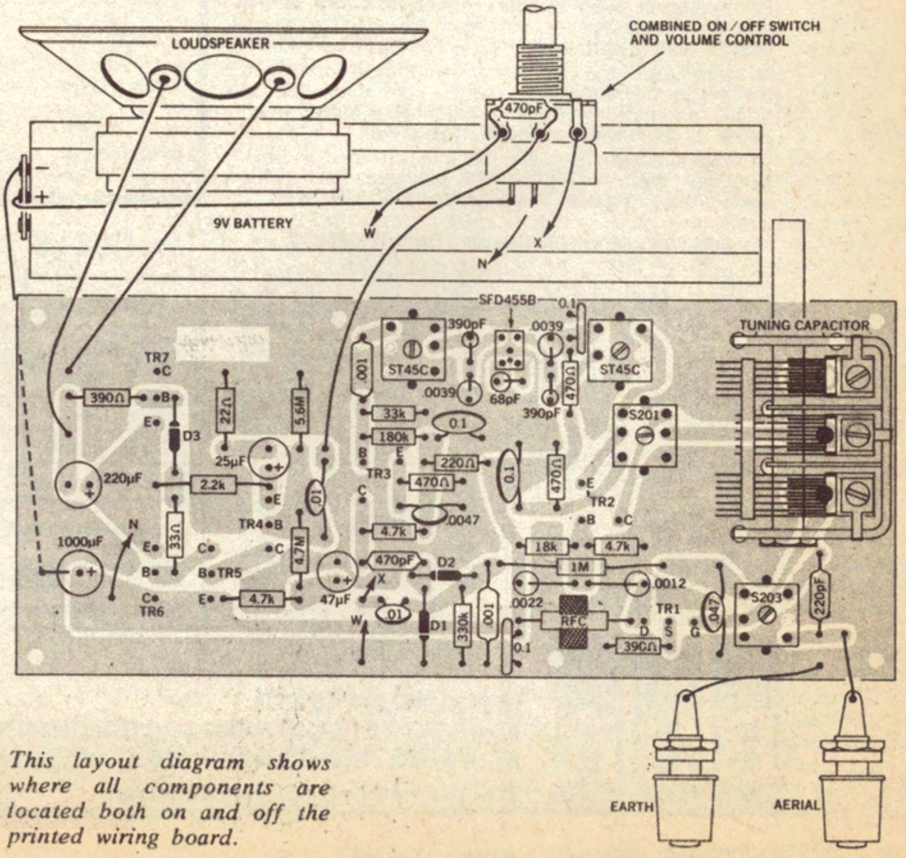
The four coils may be done next. Although it is not possible to put the coils into the board the wrong way around, care must be taken to see that each coil is placed in its correct position on the board. Push the lugs of the coil through the holes on the board and press the can hard against the board. Do not bend the lugs over, but first solder the two lugs of the can. Then solder all other lugs which connect to copper conductors. It will be noted that in some cases, lugs are left insolated and no attempt should be made to solder them.

There are still three OA91 diodes and these may be fitted now in the same way as the resistors were done. There are seven transistors and it may be seen that there are heat sinks on the two output transistors. Before soldering these in, it may be easier to fit the heat sinks. These are stretched over the metal case of the transistors. When fitting the transistors to the board, make sure that each one is in its right place and make sure also that the connections are correct. When the leads are pushed through the holes in the board, about 1/16in should protrude for soldering.

When the transistors are fitted, the driver transistor may be touching the heat sink of the TT801 or equivalent. This is simply remedied by bending the driver transistor slightly away from the other one.

The three gang capacitor is the largest and last component to be mounted. There are three mounting lugs, two rotor earthing lugs and three stator lugs to be soldered. Push them all through the appropriate holes and push the body of the gang hard against the board. Solder the three mounting lugs first.

It will be necessary to use much more solder than for other joints and to approach the lug from all directions, until it is soldered all around. The rotor lugs are treated in a similar manner, although they are not so heavy. Bend the stator lugs over




*This layout diagram shows where all components are located both on and off the printed wiring board.*

so that they lie along the copper pad provided and then solder each one. In common with the other lugs, these also require a fair amount of solder.

To complete the board, nine leads of hook-up wire have to be soldered in. There are three for the volume control, two for the battery, two for the speaker and one each for the aerial and earth terminals. A variety of colours may be used to advantage and each lead should be long enough to reach the terminating point when the board is finally mounted on its chassis.

The completed printed board assembly, along with the other items, is mounted on a one-piece chassis-panel in the form of an "L" made from a piece of aluminium or other metal. The unit is 9in long, 4¼in high and 5in deep. Along the top of the front panel is a ½in fold, for added strength and to improve its appearance. Similarly, the base has a 1in fold up along the back, again for strength as well as to provide a mounting position for the aerial and earth terminals.

For readers who wish to make up their own metalwork, we have provided a drawing giving all the necessary details. One alternative is that ready made metalwork may be available commercially. Also, may we hasten to point out that it is not necessary to have a metal chassis and panel. Readers who feel so inclined may make up their own base and front panel from plywood, hardboard, etc.

Before attempting to mount any components on the panel and chassis, it would be wise to make a thorough check of the printed board assembly, to make sure that there are no errors or omissions. It is also a good idea to see that all joints have been properly soldered and that none has been missed.

Satisfied that all is well, we may now proceed with the final assembly. The two terminals on the back should be screwed in place, with the insulating washer provided for the aerial terminal, but without the insulating washer for the earth terminal. In each case, a solder lug is placed under the nut. When mounting the speaker on the front panel, a piece of grille cloth or perforated metal should be placed behind the panel to protect the cone of the speaker.

Before attempting to mount the dial assembly, undo the two screws and remove the circular cursor from the reduction drive and put the cursor aside for the moment. The dial movement is held in place with two countersunk head screws, each with a nut behind the panel. Another nut is run on to each screw and so placed that it provides a means of spacing the dial movement lugs from the back of the panel by the required amount. The correct spacing will be determined a little later on. With the dial movement in place, run another nut on to each screw and tighten lightly.

The dial scale is fixed to the front panel by the adhesive on the back, after the backing paper has been peeled off. Fixing the scale should be done with great care, so that it is central with the drive spindle and the line on the scale truly horizontal. When satisfied, the scale is gently rubbed in place. It is possible to lift it to change the position, by gently peeling it off and starting again.

The cursor may now be screwed back onto the drive assembly. The cursor must clear the dial scale by about 1/8in and this is adjusted by means of the spacing nuts on the screws which fix the lugs of the drive assembly to the front panel. When adjusted correctly, all nuts are finally tightened. The knob may also be fitted to the dial.

The printed board assembly is fixed to the base plate with six ½in spacers. It does not matter whether you fix the spacers to the base plate first, or the board. During the process, the dial drive is connected to the gang spindle, via a flexible coupling. It will be necessary to provide a piece of ¼in shaft, about 5/8in long. This may be obtained from the volume control shaft, which may be cut to the wanted length at this time.

The battery and volume control are the only items left. Slide the battery in just behind the front panel, from the speaker side and locating it laterally so that it does not foul the flexible coupling. When mounting the volume control, fix the crescent shaped clamp at the same time, so that it presses down on the battery and holds it in place.

All the wires from the board are now cut to length and terminated at the appropriate points. The two battery leads will be terminated in the battery plug and care must be taken to ensure that the correct polarity is observed. The positive lead will go via the switch on the back of the volume control.

Before attempting to align the receiver, it is important to have a good aerial and earth system. The earth wire should be run to a clamp on a water pipe, or to a metal plate buried in moist ground. For best results, the aerial wire should be as long and as high above ground level as possible. However, many readers in metropolitan areas may find that they will obtain adequate performance with just a few feet of wire.

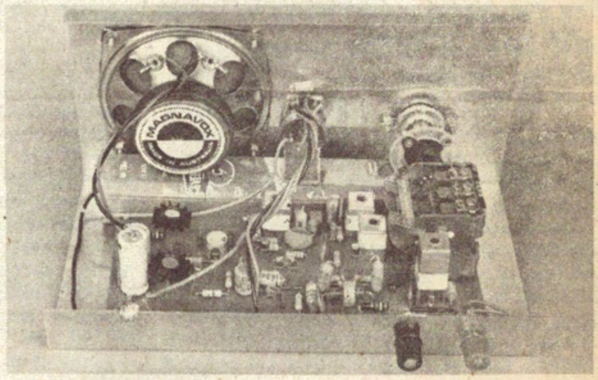
As a preliminary to alignment, set the gang rotor plates fully in and see that the dial cursor is in line with the horizontal line on the dial scale. All grub screws in the drive between the dial and gang should be firmly tightened in this position.

With aerial and earth connected, switch on the receiver and advance the volume control. Then tune in the first station nearest the low frequency end of the dial. This will vary according to the location and will be 2FC in Sydney, 3AR in Melbourne, etc. With a proper aligning tool, proceed to adjust the slug in the second IF transformer for maximum response. Then similarly adjust the slug in the first IF transformer. Rock the dial about the station to make sure that the station is correctly tuned and proceed to touch up the previous adjustments.

The station already tuned in may not coincide with its marked position on the dial. If it does, then all is well. If not, then turn the dial pointer to the correct position and proceed to adjust the slug in the oscillator coil until the station reappears. Then adjust the slug in the aerial coil for maximum response. If by now, the station is so strong that it is difficult to determine the correct adjustments, remove the aerial and substitute a shorter one, at least for the time being.

Now tune in the local station which is nearest the high frequency end of the dial. Check its position on the dial scale and more than likely, it will not be in its correct place. Reset the pointer to the correct position and proceed to retune the station as before, using this time the trimmer on the oscillator section of the gang. The trimmer on the aerial coil section of the gang should then be adjusted for maximum response.

In common with all superhet receiver alignment, it is now necessary to go back to the station near the low frequency end of the dial, as it is almost certain that the pointer will no longer correspond exactly with the station. This must be corrected with the slug in the oscillator coil, after which the slug in the aerial coil is readjusted. Then return to the other station once again and go through a similar procedure, using the two trimmers. This procedure must be repeated for as many times as are necessary to bring the stations to their correct position on the dial scale, always remembering to use the coil slugs at the low end and the trimmers at the high end. With this, alignment is complete.



*This back view of our prototype shows how your receiver should look when completed. Note the 470pF capacitor on the volume control potentiometer.*

If you live in a metropolitan area and consider that you are in a fairly strong signal location, then you may wish to consider the use of a ferrite rod aerial coil (Aegis type S211) in place of the aerial coil shown in the circuit. Only the two end leads of the rod coil are used, being soldered to the points on the printed board corresponding to pins 1 and 2 of the aerial coil. The lead from the tap on the coil may be neatly taped to the body of the coil, out of the way.

If you intend to try both coils, then to avoid the problem of removing the aerial coil after it has been firmly soldered to the board it is a good idea to just push the coil pins through the board, so that there is even less than 1/32in for soldering. This will make unsoldering easy when you wish to remove this coil and try the rod coil.

With your new receiver complete, you may expect many hours of enjoyment from it. It may be left as it is, or you may even make a cabinet of wood or other material for it. The cabinet may be so made that the receiver slides in from the front. Two cleats may be provided, one at each end of the cabinet so that a screw at each end of the panel will hold the whole assembly together.