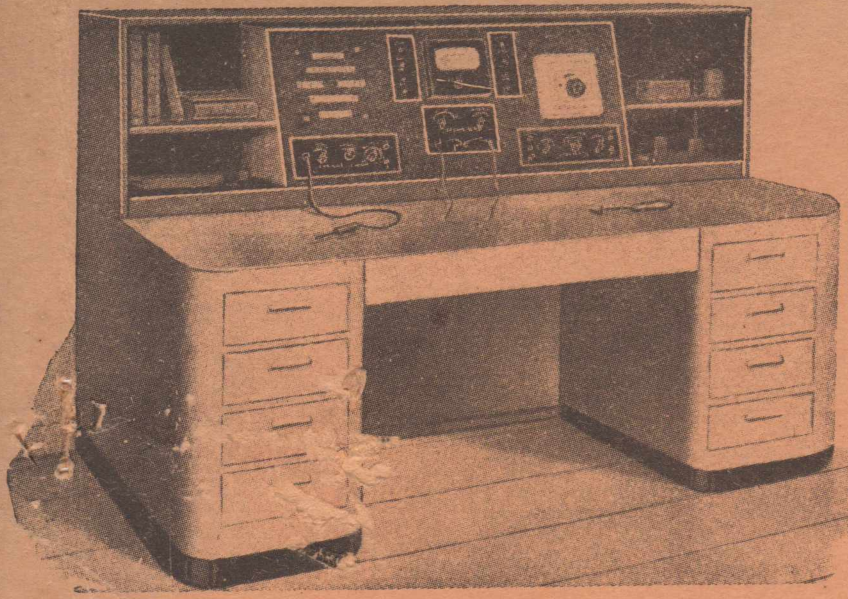

HOME PRACTICAL INSTRUCTION

LESSON No. 9

Contents . . . . .

SUPERHETERODYNE RECEIVER and TEST PANEL

This lesson will show you how to build and test—

AUSTRALIAN RADIO AND TELEVISION COLLEGE PTY. LTD.

206 BROADWAY, N.S.W., AUSTRALIA

HOME PRACTICAL INSTRUCTION

LESSON No. 9.

The principal purpose of this instruction lesson is to explain how to construct the final modulated oscillator and signal tracer and to provide instructions on the method of mounting them on the main steel panel. However, before we proceed with these units there are several other interesting experiments which may be carried out and which are explained below.

As usual, the first procedure is to carefully check the contents of your kit and to see that everything is present. The materials contained in this kit are as follows:-

1 Switch, single bank 2 pole 5 position
1 Moulded Signal Tracer Probe
1 yd.each 3 colours, hook-up wire
5 yds. hook-up wire
1 Small round knob
1 Pointer knob
1 yd. shielded wire
2 Split plugs for test leads
2 Alligator clips for test leads
1 47 ohm $\frac{1}{2}$ Watt Resistor
1 length $1\frac{1}{2}$"dia. trolitul coil former
1 length $\frac{3}{4}$"dia. coil former

1 coil mounting bracket(small)
7 tip jack sockets with nuts
7 moulded insulating bushings
7 solder lugs with $\frac{1}{4}$"dia. holes
7 5/8"x$\frac{1}{4}$"x1/16th" bakelite washers
1 metal switch collar,or washer
2 yds. $1\frac{1}{2}$ or 2mm.Spag.
1 rubber grommet
1 5/32" Whit round head bolt
1 .1mfd.200V tubular condenser
1 .001 400V condenser
1 coil mounting bracket for three coils (large)

EXPERIMENT 1. GRAMOPHONE OR MICROPHONE MODULATED OSCILLATOR.

It is quite a simple operation to modulate the carrier wave, produced by an R.F. oscillator, with audio frequency signals if a source of audio frequency voltage, such as a gramophone pick-up or carbon type microphone is available. This type of equipment illustrates very simply and crudely the principles upon which broadcasting stations operate and if you have a source of audio frequency signals available you can transmit the modulated carrier wave over a distance of a few feet and pick up the signals in your receiver. If you do not have a gramophone pickup or carbon type of microphone available, it will not be possible for you to carry out this experiment because the carrier wave alone would not produce any audible sound from the receiver. Consequently if you do not have this equipment you should proceed straight on with Experiment 2.

For those who have either a gramophone pickup or carbon microphone,with microphone transformer available, the circuit diagram of the modulated oscillator is indicated in Figure 1. In this you will notice that we use the 1R5 valve to produce the radio frequency carrier wave and also to provide modulation of the carrier when an audio frequency signal is applied to grid No. 1.

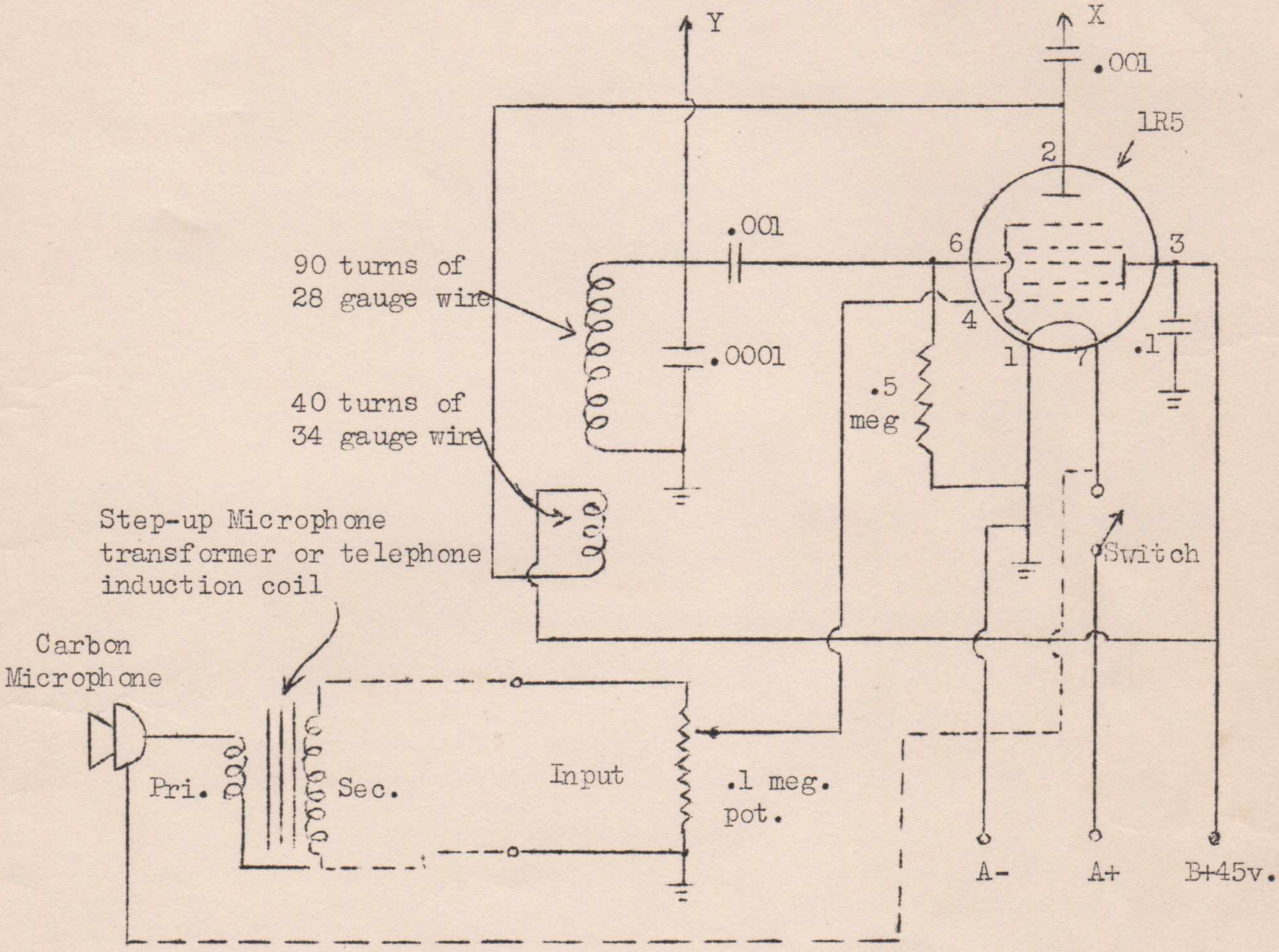

FIGURE 1.

The carrier wave is produced by oscillation caused through energy feeding back from the plate circuit, through the 40 turn plate winding and inducing a voltage into the 90 turn winding which is tuned by a .0001 mfd. condenser. The carrier frequency will be determined by the resonant frequency of the 90 turn coil and .0001 mfd. condenser and will be at approximately the centre of the broadcast band. Voltage fed back into the tuned circuit, from the plate circuit will be applied to grid No. 3 in the 1R5 valve and will result in oscillation. The strength of oscillation can be varied by any voltages applied to grid No. 1 in the valve. The audio frequency signal voltages provided by the gramophone pickup or microphone should be applied to the terminals marked "Input" and the strength of the signals can be varied by the setting of the .1 megohm potentiometer.

CONSTRUCTION.

The oscillator indicated in Figure 1 should be constructed on the smaller of the two chassis, the valve socket being mounted in any convenient hole. The .1 meg. potentiometer and filament switch can be mounted in two of the holes on the front flange of the chassis.

The coil should be wound on the coil former contained in Kit No. 6 and originally used for the short-wave coil.

Commence the 90 turn winding at the top pair of small holes, furthest away from the mounting screws. By winding the 90 turns of 28 gauge wire side by side you will find that they end fairly close to one of the other pairs of holes and the lower end should be secured through those. Near the holes for the mounting bracket you should wind 40 turns of 34 gauge wire which becomes the plate winding. This coil is wound in the position occupied by the 20 turn coil in Figure 9 of Lesson No. 6.

TESTING.

On completing the wiring, check over your work carefully to see that you have carried it out accurately. You may then connect the leads marked A-, A+, and B+ to the A and B batteries and turn on the switch on the front panel of the instrument. Connect the negative lead of your voltmeter to the chassis and with the positive lead plugged into the 50 volt socket you should experience a reading of about $1\frac{1}{2}$ graduations at pin 7, no reading at pins 4 or 6 and a reading of full B battery voltage at pins 2 and 3. If this appears to be correct, connect the phonograph pickup to the input terminals, switch on both oscillator and receiver and place a wire from the receiver's aerial terminal very close to the tuning coil on the oscillator chassis. If you now rotate the tuning condenser on the receiver near the centre of its travel you should hear the music from the record coming from the receiver's loudspeaker.

Due to the unfortunate fact that we must use the same B battery for powering the oscillator and receiver there may be some tendency for the music from the pick-up to be heard through the receiver's loudspeaker, regardless of where the tuning condenser is set. This is due to the fact that the voltages from the pick-up are producing changes in plate current in the 1R5 valve which vary the voltage of the B battery slightly and this B battery voltage variation is being amplified by the receiver and so being reproduced from the speaker. This effect is unavoidable when the one B battery is used to power both receiver and oscillator and to minimise the effect the .1 megohm potentiometer should be turned back as far towards the off position as is necessary to make the sound from the receiver inaudible when the receiver tuning condenser is turned right away from the position where the modulated signals from the oscillator are picked up. If you have another radio receiver, apart from the one you have built in practical kit No. 8 then it would be preferable to use this for picking up signals from the oscillator as this will be independent of the B battery and so will avoid this undesirable coupling between the two.

Once you have been able to tune in signals from the modulated oscillator with the receiver's aerial wire placed very close to the tuning coil of the oscillator, you may then experiment with greater amounts of separation between the receiver's aerial and the oscillator to determine how far the signals will travel through space. The actual distance which can be covered will depend mainly upon the sensitivity of the receiver and also to a very large degree on whether or not a transmitting aerial is attached to the oscillator.

The more sensitive the receiver the further you will be able to move the receiver's aerial wire from the oscillator coil and still have signals reproduced from the receiver. Naturally, the further away the aerial is placed - the weaker the signals will become but you will probably be able to hear signals over a distance of several feet if the receiver is tuned exactly to the transmitter's frequency.

To increase the distance, it is necessary to provide a transmitting aerial for the oscillator. This can consist of about 8 or 10 feet of wire with one end attached, through a .001 mfd. condenser, to the plate of the valve at point "X" in Figure 1 or alternatively, you can experiment with the end connected instead to point "Y". If you are using the modulated oscillator in conjunction with a receiver other than the one you constructed in accordance with Practical Lesson 8 then it would also be a good idea to attach an earth wire to the metal chassis of the oscillator. The other end of the transmitter's aerial can be attached to any elevated point in the room but on no account should it be connected directly to the aerial terminal of a receiver.

The two .001 mfd. condensers shown in Figure 1 may be obtained by removing all three .001 mfd. condensers from the plate of the 1S5 valve in the receiver and connecting in place of them the .01 mfd. condenser shown in dotted lines at the right of Figure 23 of Lesson 8. That is, one end of the .01 mfd. condenser should connect to pin 5 on the 1S5 valve socket and the other end to the chassis.

With about a 10 foot length of aerial wire attached to point "X" or "Y" you should be able to establish a transfer of signals from the oscillator to the receiver over a distance of quite a few feet.

On no account should you attach a large outdoor aerial to the oscillator or the signals may interfere with neighbouring receivers and this is strictly contrary to regulations which forbid the illegal operation of radio transmitters without a licence.

If you are using a separate receiver then you will be able to turn up the .1 megohm potentiometer to a point where the signals are comparatively clear and distinct and not unpleasantly distorted. Of course, if you are using the battery operated receiver described in Practical Lesson 8, as mentioned previously, you can only turn up the potentiometer to a point where the signals do not "play through" the receiver even when it is not tuned to the oscillator.

If you have a carbon microphone available, such as a telephone type microphone and also a step-up transformer or telephone induction coil to suit it, you can connect these two units together as shown at the left of Figure 1. The secondary winding of the transformer should connect as shown by the dotted line to the input terminals and one wire from the microphone should connect to the valve side of the switch or to one of the clips on the "C" battery.

When the microphone is in use it should not be placed near the receiver's loudspeaker, otherwise sounds from the loudspeaker will enter the microphone, modulate the oscillator, be transmitted through to the receiver, reproduced from the receiver's loudspeaker and so set up a ringing howl which is nearly always evident when a microphone and speaker are used in the same room as one another.

EXPERIMENT No. 2. 5-VALVE SUPERHETERODYNE RECEIVER.

The majority of commercial radio receivers employ a superheterodyne circuit and consequently our practical experiments would not be complete without constructing equipment to illustrate the superheterodyne principle of reception.

In a superheterodyne receiver, signals picked up by the aerial and earth system are changed, usually in the first valve, to a new frequency, lower than their original carrier frequency and the bulk of the amplification and selectivity is carried out at this new low frequency. The new frequency is called the intermediate frequency and the valves amplifying this frequency are known as intermediate frequency amplifiers.

(See A.R.T.C. Service Engineering Course Lessons 21, 47-50.)

The circuit arrangement of the superheterodyne receiver we will construct is illustrated in Figures 2 and 3. Figure 2 shows the 1R5 valve employed as a frequency changer or frequency converter. This valve is used to change the frequency of signals picked up from the aerial and earth circuit and passed through the first tuning circuit, illustrated at the left of Figure 2 and applied to grid 3 in the 1R5 valve. Grids 1 and 2 in this valve are connected to the oscillator tuning circuit, shown at the lower right hand side of Figure 2 and this section produces an unmodulated signal known as the "oscillator frequency". The two signals combine in the 1R5 valve so that, emerging from the plate, we have signals at the original frequency, signals at the oscillating frequency and also the combined effect of the two frequencies which is equal to the value of the oscillator frequency and signal frequency added together and also a fourth signal equal to the difference between the oscillator and signal frequency. It is this fourth frequency we are particularly concerned with and which becomes our intermediate frequency signal. Due to the fact that this intermediate frequency signal is made up out of the original signal frequency it will carry the same programme as was present on the original signal.

The intermediate frequency signal is passed through the tuning circuit

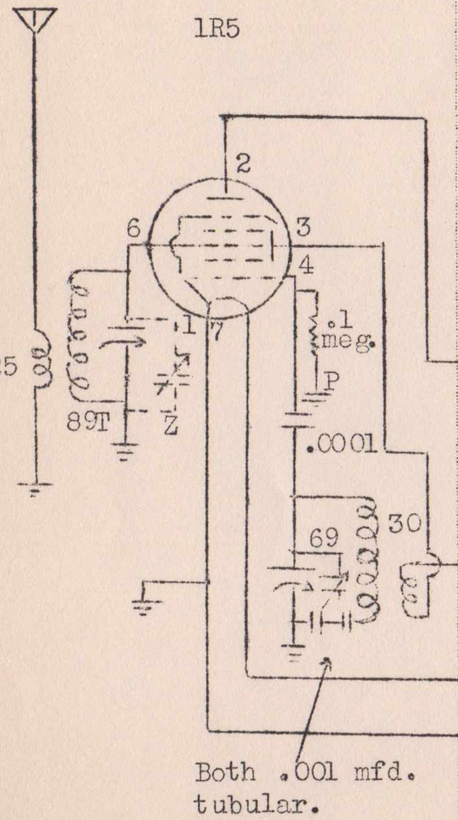

FIGURE 2.

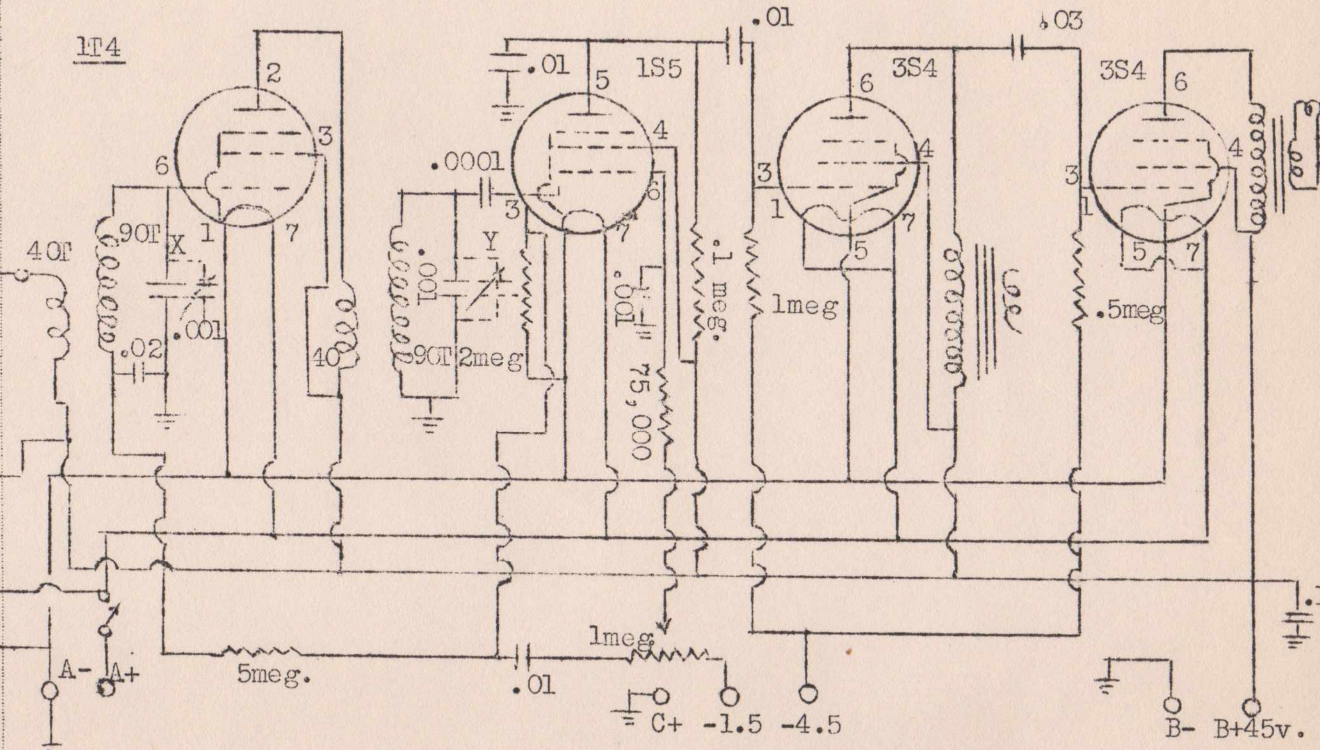

FIGURE 3.

shown at the left hand side of Figure 3 and on to the 1T4 valve which acts as the intermediate frequency amplifier. The signals from this valve are then fed through the second tuning circuit shown in Figure 3 and applied to the diode detector contained in the 1S5 valve. After detection the audio frequency programme is passed through the pentode section of the 1S5 and through both 3S4 valves in a similar fashion to that applying to Figure 23 in Practical Lesson 8.

Selection of the required station is achieved by tuning in the desired carrier frequency by means of the aerial tuning circuit shown at the left of Figure 2 and also by arranging for the second section of the tuning condenser to tune the oscillator coil to an appropriate oscillator frequency so that the original carrier frequency is changed to the value of the intermediate frequency.

The intermediate frequency we will use will be approximately 350 KC although the majority of commercial receivers employ an intermediate frequency of 455 KC. In our case, we do not have conventional intermediate frequency transformers available and it becomes a simple matter to employ the 90 turn tuning coils we have already constructed in conjunction with the .001 mfd. mica condensers to act as intermediate frequency transformers. The rather large capacity of the .001 mfd. condensers will tune the coils to a frequency of approximately 350 kilocycles so that this will become our intermediate frequency.

With an intermediate frequency of 350 KC it will be necessary to have the oscillator tuning circuit tuning always to a frequency 350 KC higher than that of the aerial circuit of Figure 2. This means that the oscillator tuning range will have to be from 550 plus 350 KC or 900 KC, when the tuning condenser plates are fully in mesh to 1500 KC plus 350 KC or 1850 KC, when the tuning condenser plates are fully out of mesh. The higher frequency range covered by the oscillator tuning circuit is achieved by winding fewer turns on the oscillator tuning winding and also by reducing the effective capacity of one section of the tuning condenser by inserting the two .001 mfd. tubular condensers, connected in series, to provide a capacity of .0005 mfd., so that current oscillating around the circuit consisting of the tuned winding of the oscillator coil, the tuning condenser section and the two .001 mfd. condensers means that the .001 mfd. condensers, which act as a "padding condenser", are in effect in series with the tuning condenser gang and this reduces its maximum capacity and so helps to tune the oscillator circuit to a frequency higher than that of the aerial tuning circuit.

In order to adjust the receiver to the best possible standard of performance after it is completed, one of the trimmer condensers should be connected across the oscillator section of the tuning condenser gang and the other trimmer condenser will be connected across one of the intermediate frequency transformers in either the position "X" or "Y" as shown in Figure 3.

CONSTRUCTION.

Due to the fact that there is insufficient room for the whole of the receiver indicated in the combination of Figures 2 and 3, to be built on the one chassis we will split the receiver into two sections, building the frequency changer valve and tuning circuit on the small chassis and leaving the intermediate frequency amplifying, detector and audio amplifying stages on the larger chassis. In other words, the parts indicated in Figure 2 will be mounted on the small chassis and those indicated in Figure 3 will be mounted on the larger chassis.

You will notice that it is necessary for you to remove the tuning condenser gang from the larger chassis and mount it on the small chassis. The location of the tuning condenser gang, aerial and oscillator coils and 1R5 valve on this chassis is shown in Figure 4. It will be found that two of the holes in the tuning condenser mounting brackets will fit over two of the holes in the small chassis near the front right hand corner and the tuning condenser can be secured in position by bolts passed through these two holes.

COIL DETAILS.

The aerial coil shown at the left of Figure 2 and also at the left of Figure 4 consists of the aerial coil previously mounted on the large chassis. It is necessary to remove this coil from the large chassis and to replace the aerial primary winding, which previously consisted of 15 turns of 34 gauge wire with a winding of 25 turns of the same wire. It is impossible to fit in 25 turns in exactly the same position occupied by the 15 turn winding because of insufficient space between the small sets of holes in this coil former. In winding the 25 turn coil you should commence by threading one end of the 34 gauge wire through the same small holes used for terminat-

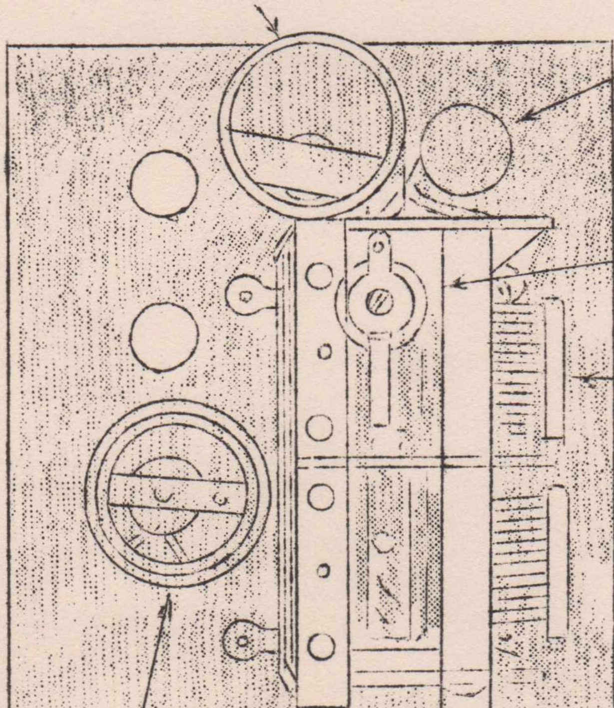

FIGURE 4.

ing the lower end of the 89 turn winding. In other words the 25 turn primary winding commences almost immediately below the finish of the 89 turn winding. There will probably be a small space of about 1/32nd of an inch or 1/16th of an inch between these two coils. After completing the 25 turns, the lower end will be found to finish approximately level with the second set of small holes from the bottom end of the former and the end of the primary can be terminated by being passed to and fro through these small holes once or twice and then taken down inside the coil former and through the large hole in the chassis. We will not bother to move the aerial and earth terminals from the large chassis and consequently as no aerial terminal is available for terminating this wire it is suggested that you mount one of the tip-jack sockets, bushes and insulating washers in the hole near the left hand end of the front flange of the chassis and attach the end of the aerial coil primary to this. You can then simply push the lead-in wire from your aerial into the hole in this tip-jack socket and it will make a satisfactory connection with the end of the aerial coil winding.

When wiring up the coil, the upper end of the 89 turn winding can pass directly to either the upper or lower lug protruding from the stator plates of the front section of the tuning condenser gang. Another wire, soldered to the lower stator plate lug on the front section of the gang passes through the hole near the right hand end of the chassis and across to pin No.6 on the socket of the 1R5 valve.

It will be necessary to completely wind the oscillator coil on the larger coil former supplied with this kit of parts.

The plate winding consists of 30 turns of 34 gauge wire and connects to grid 2 of the 1R5 valve by means of socket pin No.3. This winding should be commenced approximately 3/16th of an inch from the top end of the former, away from the mounting bolts and when wound, will be found to end about $\frac{5}{8}$ of an inch from the top edge of the former. Suitable holes will be found already in position on the former for the ends of this coil. A space of approximately $\frac{1}{8}$ of an inch separates the 30 turn winding from the tuned winding which consists of 69 turns of 28 gauge wire. The upper end of the 69 turn coil should be passed through insulating tubing and soldered either to the upper or lower lug protruding from the stator plates of the rear section of the tuning condenser. The other end of the 69 turn coil and both ends of the 30 turn coil should be threaded through insulating tubing and passed down through the centre of the coil former and through the large hole, over which the coil former is mounted, to the respective points to which they connect. The lower end of the 69 turn coil will connect to one end of one of the .001 mfd. tubular condensers, and the lower end of the 30 turn coil will connect to valve socket lug No. 3. In winding the oscillator coil care should be taken to see that the 30 turn winding and 69 turn winding are wound in the same direction as one another.

The top end of the 30 turn winding is to be connected to the positive terminal of the B battery. To prevent the long B battery wire from snapping the fine coil wire it is not satisfactory to merely solder a length of hook-up wire onto the end of this coil wire but rather to mount another one of the tip-jack sockets, insulated by means of a bushing and insulating washer in one of the holes at the rear of the chassis and to use this as an insulated supporting point to which the top end of the 30 turn winding can be soldered and from which a length of hook-up wire can be extended to the positive terminal of the B battery. The fine coil wire and hook-up wire can both be soldered to one of the solder lugs mounted under the nut of the insulated tipjack socket. To prevent the socket from turning, place the metal washer or switch collar against the chassis so that the ridge on the bushing passes through both chassis and washer.

The .1 meg resistor connected between socket lug No.4 and chassis will have to be removed from the grid circuit of the 3S4 output valve on the larger chassis. This can be replaced on the larger chassis by the .5 megohm resistor which will complete the grid circuit of the 3S4 valve again.

The .0001 mfd. condenser can have one end directly soldered to socket lug No.4 for the 1R5 valve and the other end can be soldered to a length of hook-up wire which will pass through a hole approximately in the centre of the small chassis and up to the lug protruding downwards from the stator plates of the rear section of the tuning condenser gang.

The filament plus wire extending from socket Lug No.7 on the small chassis should be made long enough to reach to the on-off switch mounted on the larger chassis. It should be connected to the same lug as that which furnishes filament voltage for the valves in the larger chassis so that when the switch is turned "on", filament voltage will be applied not only to the valves on the large chassis but also to the 1R5 as well. The coil at the left hand side of Figure 3, which acts as the first I.F. transformer and couples signals from the plate circuit of the 1R5 to the grid of the 1T4 is mounted on the large chassis beside the valve socket for the 1T4 valve. This coil, which has a 90 turn winding and a 40 turn winding, is the one which was wound for the oscillator described in Experiment 1 in this lesson. It was wound on the former previously used for the short wave coil as described in Practical Lesson 6. If you did not conduct the first experiment described in this lesson then it will be necessary for you to wind the coil at this stage. The coil coupling the plate of the 1T4 valve to the diode detector in the 1S5 is not changed in any way and remains in the same position on the larger chassis.

From the diode plate of the 1S5 valve to the loudspeaker, the circuit is not changed in any way with the exception of the value of grid load resistor for the 3S4 output valve which should be changed to a value of .5 megohm as mentioned above.

The two 90 turn windings, which become the I.F. transformers, are tuned to the intermediate frequency by means of the .001 mfd. mica condensers. It is important that you use the mica condensers and not the tubular type in this position.

One of the trimmer condensers should be connected across the oscillator section of the tuning condenser gang, that is the rear section, and the second trimmer condenser can be tried across each of the .001 mfd. mica condensers in turn later, when we are testing the receiver.

It should not be necessary to remind you that before making any alterations whatsoever, to the receiver mounted on the larger chassis, it is important that you disconnect the wires from the batteries and remove the valves from their sockets. After you have built up the tuning section on the smaller chassis and completed the alterations to the larger chassis, you should check the battery leads for short circuits as explained previously and if no short circuits exist, the leads may be connected to the battery terminals. You should next check the voltages by means of the 50 volt range of your multimeter before inserting any of the valves.

Starting with the socket for the 1R5 valve, and with the negative test lead of the multimeter clipped onto the metal chassis, you should obtain a reading of $1\frac{1}{2}$ graduations at pin 7, no reading at pins 6 or 4, and full B battery voltage at pins 3 and 2. You will not obtain a reading of full voltage at pin 2 until you have connected the output wire, emerging from the plate of the 1R5 at socket pin 2, to the terminal on the rear of the larger chassis connecting to the end of the 40 turn winding.

On the 4 valve sockets fitted on the larger chassis, the voltages should be exactly the same as those set out on page 42 of Practical Lesson 8 and you should turn back to this lesson in order to check the voltages and see that they agree with those listed.

If all the voltage readings are correct you may plug in the valves, being careful to see that they are inserted in the sockets intended for them. Inserting a valve in the wrong socket may possibly damage it.

TESTING.

With the valves inserted, an aerial plugged into the tip jack socket on the front corner of the small chassis and the earth wire attached to any part of the smaller chassis, such as for instance the tuning condenser frame, you should be in a position to receive signals when the tuning dial is rotated.

If you can hear any signal at all, set the tuning condenser as accurately as possible to give the loudest signals from this station and then try connecting one of the trimmer condensers firstly across the grid circuit of the 1T4 valve as shown in dotted lines at "X" on Figure 3. Note carefully the loudness of the station before you solder the condenser on and then, switch off, solder the condenser in place as quickly as you can and switch on again. Observe whether the volume has increased or not. You should then experiment with different settings of the condenser to determine whether you can find a point at which the volume of signals increases to a maximum.

If adjustment of the condenser only seems to make the signals weaker than before, instead of stronger or, if the screw on the condenser needs to be turned out as far as possible for best results then you probably have the trimmer condenser on the tuned circuit which already has more inductance or capacity than the other one. In this case unsolder the trimmer condenser and solder it across the second I.F. transformer as shown at "Y" on Figure 3. Again, carefully notice the loudness of signals before adding the trimmer and after and again experiment with different settings to see where the best results are obtained.

The trimmer can be left either at point "X" or "Y", wherever it is most beneficial in increasing the sensitivity of the receiver.

ALIGNMENT.

The operation of trying a trimmer condenser at points "X" or "Y" and leaving it in the position where it increases the sensitivity to the greatest degree, as already explained will have had the effect of tuning the two "I.F. Transformers" to the same frequency as one another. We do not know exactly what this frequency will be but it will be very close to 350 kc. The next step is to arrange the correct relationship between the aerial tuning circuit and oscillator tuning circuit in figure 2 to assure that any incoming station is changed to the correct frequency to receive the utmost amplification in passing through the "I.F. amplifier". In other words, we must arrange the tuning of the oscillator circuit to be approximately 350 kc higher than that of the aerial circuit regardless of where the tuning condenser is set.

Firstly turn the trimmer condenser, soldered onto the oscillator section of the tuning condenser, almost fully out and then tune in a station as near as possible to the low frequency end of the tuning range, that is with the tuning condenser plates turned almost fully into mesh.

The only ready way of altering the relationship between the tuned circuits at the low frequency end is by spacing out the lower turn or two on the 69 turn winding of the oscillator coil and spreading these turns a little further away from the remaining turns. Probably 69 turns is one or two turns more than is needed on the oscillator coil and by spacing the last turn or two about an eighth of an inch away from the rest of the winding their effect can be largely removed and this is a quicker and easier way than actually unwinding the two turns. Further, if it is found that the performance suffers when these turns are moved down below the rest then they can be easily moved back again to their close-up position without the inconvenience of joining on extra wire and rewinding an extra turn or two.

Before attempting to slide the turns along the former notice carefully the loudness of the signals and also adjust the volume control so that the signals are not overloading the final valves but are just a comfortable level for listening. If you live very close to a powerful station it will probably be better to carry out the adjustments when using only a few feet of wire attached to the aerial terminal so that the signals provided by the aerial are not too strong for the set and consequently overload any of the valves. Carefully notice the loudness of the signals before you make any alteration and also make sure that the condenser is accurately set in the first place. Then commence by sliding the last turn of the 69 turn winding down about an eight of an inch from the rest of the turns. On doing this you will find that at first the signals decrease in loudness. Before you judge whether you have effected an improvement or reduced the set's sensitivity, it will be necessary to retune the condenser because you will now find that the signals are received with the tuning condenser plates turned a little further into mesh. After readjusting the tuning condenser you should endeavour to compare the loudness with the previous loudness and see whether there is any improvement. If the signals are getting louder then try spacing the second last turn also about an eighth of an inch away from the remainder, that is, move it down adjacent to the 69th turn. Again, you will have to turn the tuning condenser plates slightly further into mesh to retune the signal and again you should endeavour to judge whether the loudness is greater or worse than before. If you are continuing to make an improvement then carry on by moving an extra turn or two downwards, away from the main body of the winding, in the same fashion.

On the other hand, if you find that moving the turns downward decreases the loudness in each case, then obviously the coil needs more inductance instead of less and you should push all the turns back up close to one another again as they were in the first place.

After having carried out the adjustment of the oscillator coil inductance at the low frequency end of the tuning range, you should next tune in a station with the tuning condenser plates turned about three quarters of the way out of mesh and align the two tuned circuits at the high frequency end of the tuning range. This is accomplished by means of the trimmer condenser connected to the oscillator section of the tuning condenser gang. Before making any alteration in the trimmer setting carefully note the loudness of signals with the receiver accurately tuned to a station. Next, try screwing the condenser in further and retune the dial, by turning the tuning condenser plates a little further out of mesh until the signals again reach their loudest point before judging whether you are affecting an improvement or not. Each time you alter the setting of the trimmer condenser it will be necessary to retune the main tuning condenser before judging the results, becauseeach time the trimmer is altered it will cause the station to come in at a slightly different setting of the tuning condenser plates.

If the use of one of the trimmer condensers at point "X" or "Y" in Figure 3 produced no material improvement in performance and the sensitivity seemed as great without using the trimmer, then you can use it to better advantage by connecting it across the aerial coil at the position marked "Z" in Figure 2. This will considerably simplify alignment at the high frequency end of the tuning range. If the trimmer is used at "Z", you should screw the oscillator trimmer about two thirds of the way in and leave it at that setting. Carefully tune in a station with the condenser plates about three quarters of the way out of mesh and simply adjust the trimmer at point "Z" for loudest signals without resetting the tuning condenser.

The process of establishing the right relationship between the various tuned circuits is called "alignment" and is normally done in practice with the aid of signals from a test oscillator rather than those from a broadcast station which are not always available at convenient frequencies.

LOCATING FAULTS.

If all the voltage measurements have checked correctly but you are unable to obtain any response from the receiver, then firstly see that the valves are plugged in the right sockets and that they are firmly seated. Secondly, with the volume control turned fairly well on, touch pin No.6 on the 1S5 valve socket with your finger or with a piece of metal held in your hand. If a loud buzzing or humming or howling sound occurs when you do this it indicates that the 1S5 and the following 3S4 valves are functioning. If there is no noise when you do this it suggests that the fault is in the latter portion of the receiver and you should then touch pin No.3 on the first 3S4 socket in a similar fashion. Again, there should be a noise audible from the speaker if this valve and the following one are working. If there is no noise then the fault is in one of the 3S4 valve stages.

If everything appears to be in order with the last three stages remove the aerial from the socket on the small chassis and touch it to pin No.6 on the 1T4 valve socket. If you hear a click each time the aerial wire is touched to the valve socket this suggests that the wiring on the larger chassis is correct. You may not actually hear any stations when you touch the aerial to this point but the mere presence of a click each time it is connected suggests that the equipment is working properly.

Next touch the aerial wire to pin No.6 on the 1R5 valve socket. Here again, you should hear some sort of click or live sound just as the aerial wire touches the socket contact. If you heard a click at pin 6 of the 1T4 valve and no click at pin 6 on the 1R5 then this suggests that the fault is in the parts shown in Figures 2 and 3 between the grid circuits of these valves and you should check over that portion of the circuit to locate the trouble. Of course, examine to see that the wire from the plate of the 1R5 valve is connected on to the terminal at the back of the chassis to which the 40 turn winding on the first I.F. transformer connects.

If you obtain a clicking noise at pin 6 on the 1R5 valve socket but can still tune no signals this suggests that the oscillator circuit is not functioning and this can be confirmed by disconnecting the end of the .1 megohm resistor at point "P" on the diagram and inserting your multimeter set to the .1 milliamp range. There should be a very slight movement, of the pointer, of about 1 graduation when the equipment is switched on if the valve is operating. If there is no movement whatsoever of the meter's pointer at position "P" then the fault is in the oscillator section and you should carefully check over the connections to the coil, tuning condenser etc. Also check to see that you have wound the 30 turn winding and 69 turn winding on the oscillator coil in the same direction as one another. If by any chance you find that you have wound one in a clockwise direction and the other in an anti-clockwise direction when looking from the same end of the coil former then you may be able to make the set function correctly by reversing the connections to the end of the 30 turn winding, that is, connect the bottom to B+ and the top end to pin 3 on the 1R5 valve socket. Of course, normally, the bottom connects to pin 3 on the valve socket and the top to B+.

If the oscillator is functioning correctly and provides a small movement of the meter's pointer when the meter is inserted at position "P" then restoring the aerial to the aerial terminal should provide reception if there are any stations operating within range at the time.

The I.F. transformers you have wound will not be as efficient as commercial I.F. transformers which have both primaries and secondaries tuned to the intermediate frequency and consequently the sensitivity of your receiver will not be as great as that of a commercial five valve set however, it does illustrate the principle of operation of superheterodyne receivers.

EXPERIMENT 3. CONSTRUCTING A SIGNAL TRACER.

We now come to the construction of the signal tracer which is to be built on the left hand end of your main steel panel.

The circuit arrangement of the signal tracer is shown in Figure 5.

The purpose of a signal tracer is to enable the speedy location of the faulty stage in a receiver which has ceased to operate or which is operating incorrectly. For example, if a fault exists in the detector stage of a radio receiver then the signals would be amplified quite normally through the early valves, preceding the detector and would be progressively stronger at each point until they are applied to the diode detector valve in the receiver. At this point however the signals would not go on in a normal fashion because of the fault existing in the detector stage and there would either be no signal output from this stage or else the signals would be weak, distorted, accompanied by hum or defective in some other way. With the aid of a signal tracer, it is possible to detect signals applied to the grid of the first valve, in the set and follow them through progressively from the grid of this valve, to its plate, where they should of course be much stronger, then to the grid of the next valve where they may be a little weaker than at the plate of the preceding valve, then to the plate of the second valve where they should be again stronger and so on to the part in the receiver where the fault exists. Once this point is reached, instead of the signals progressing in a normal fashion and becoming stronger at each stage, you will find a point where there are no signals or where they are weak or marred in some other fashion. The fault in the receiver then obviously lies between the last point at which the signals have their normal strength and the first point at which they are defective. The signal tracer will help you to locate this position in a receiver in a matter of a few seconds and consequently it is then a simple matter to check the various parts comprising the faulty stage to determine just what the fault is.

The signal tracer is able to follow the signals from point to point throughout the set by being, in effect, a small receiver in itself. The 1T4 valve drawn at the left of Figure 5 is enclosed in a small plastic moulding, with a metal tip protruding from one end, so that the tip can be touched to various points in the receiver at which it is desired to determine the signal's strength. The 1T4 valve operates as a grid leak detector, by means of the .0001 condenser and 5 meg. resistor connected to its grid. This means that when the metal tip is touched to parts of a radio receiver in which radio frequency or intermediate frequency signals are present, the 1T4 valve detects these signals and sends the audio frequency modulation on from its plate circuit, through the .5 meg and .01 mfd. condenser and also the volume control to the 1S5 valve and then on through the 3S4 to the loudspeaker. By means of the amplification provided by these valves you will be able to hear any signals which reach the metal tip of the housing enclosing the 1T4.

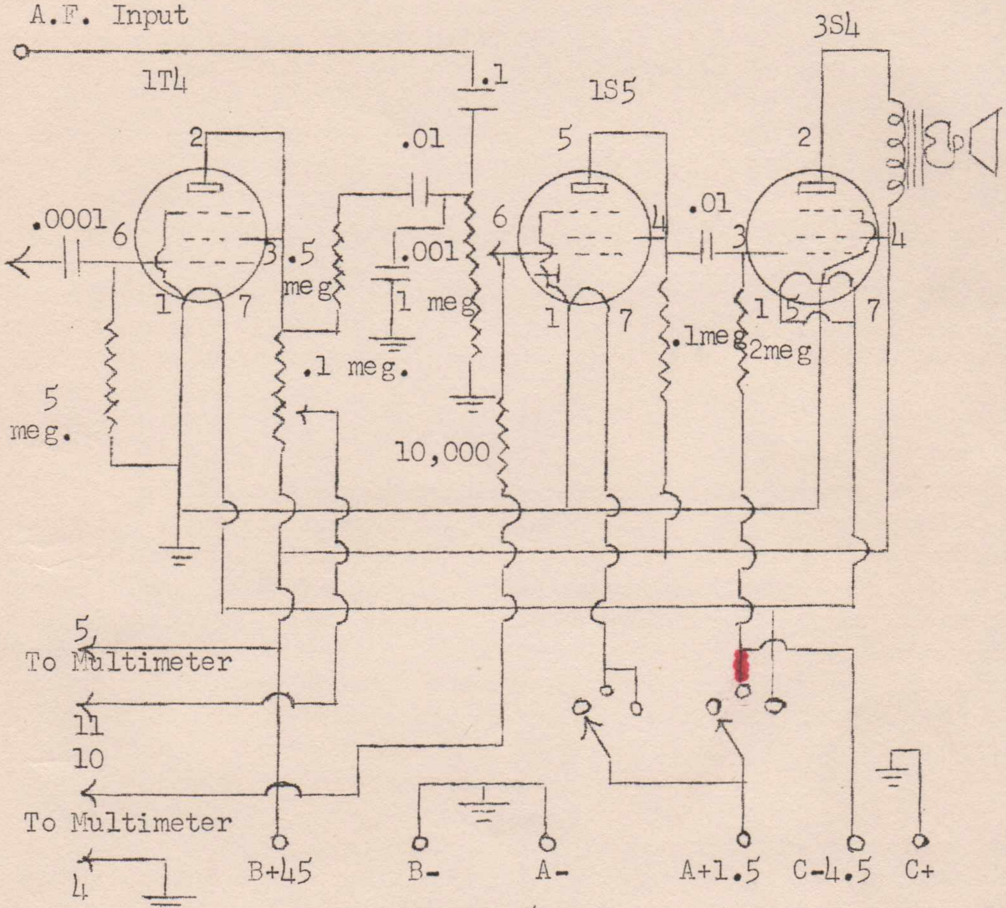

Figure 5.

When you are tracing signals through the radio frequency or intermediate frequency portion of a receiver, that is the section of the receiver prior to the detector, you should explore the receiver with the metal tip of the 1T4 probe.

If a fault in a receiver exists in the power output stage or loudspeaker then it will be desirable to continue tracing the signal through the audio frequency amplifying stages and you can either continue using the 1T4 valve or better still, plug one of your test leads into the socket marked "AF input" in figure 5 which will apply the audio frequency signals directly through the volume control to the 1S5 and 3S4 valves only. Because the signals will have been amplified by the early valves in the receiver, they will have sufficient strength to provide loud output even though they pass through only the 1S5 and the 3S4.

With the multimeter switch turned to the position marked "R.F." the meter is connected to the plate circuit of the 1T4 valve and consequently gives and indication of the strength of radio frequency voltage applied to the 1T4's grid. After you have had some experience in testing a number of receivers you will soon judge just what reading is normally obtained from a set that is in good order and consequently you will easily notice abnormal readings on the meter, which indicate a fault in the set.

When the multimeter switch is turned to the position marked "A.F." the meter is then connected to the grid circuit of the 1S5 valve and will register the strength of audio frequency signals reaching this valve. In this way the meter can be used as an output meter to assist in aligning the tuned circuits of receivers.

When the faults in a receiver have been rectified and it is simply necessary to align the tuned circuits, signals will be heard from the receiver's own loudspeaker and in this case it is not necessary for the signal tracer speaker to operate so that only the 1S5 valve is required to act as a rectifier for the output meter. When the switch at the left hand side of the signal tracer panel is turned to the centre position marked "Output Volts" filament voltage is applied only to the 1S5 valve so as to save battery current consumption by the other valves which are not in use.

From the above description it will be seen that the 1T4 acts as a grid leak detector with resistance coupling to the 1S5 first audio frequency amplifier which is again resistance coupled to the 3S4 power output valve.

CONSTRUCTION.

The signal tracer is constructed on the smaller of the two metal chassis, the valve sockets for the 1S5 and the 3S4 valves being mounted in the two holes furthest apart near the back flange of the chassis. The chassis is attached to the front panel by means of the threaded bushings on the controls which pass through the holes in the chassis, the holes in the metal panel and through the holes in the label. The .1 megohm potentiometer fits in the centre of the chassis and passes through the label at the position marked "Meter Zero". The 1 meg potentiometer fits through the chassis and label at the position marked "Attenuator". Do not mount the resistor panel in position until you have completed the earth wiring and filament wiring.

A test lead socket, passed through a red insulating bushing should be mounted in the hole at the right hand side of the etched label marked "A.F." and a second socket should be mounted through a black bushing in the lower hole near the earth symbol. Of course, a bakelite washer should be used at the rear of the panel so that these sockets are insulated from the main panel.

When you have mounted the sockets in place test for short circuits to the panel by means of your ohmmeter. If you obtain a reading when one test lead from the ohmmeter is touched to one of the sockets and the other test lead touched to a clean spot on the rear of the metal panel this shows that the threaded portion of the socket is not centrally located in the holes in the panel and is causing a short circuit. In this case you must loosen off the nut and centre the bushings before tightening it up again.

WIRING

The first step in wiring is to use a length of the 18 gauge bare tinned copper wire to connect together the central metal sleeves on each valve socket and also pin No.1 on the 1S5 socket and No.5 on the 3S4 socket. This length of wire should follow the path shown in the wiring diagram of Figure 6 and provides a convenient point of connection for all the points shown as connecting to earth in Figure 5. One end should be connected to the lower of the two tip jack sockets mounted on the front panel.

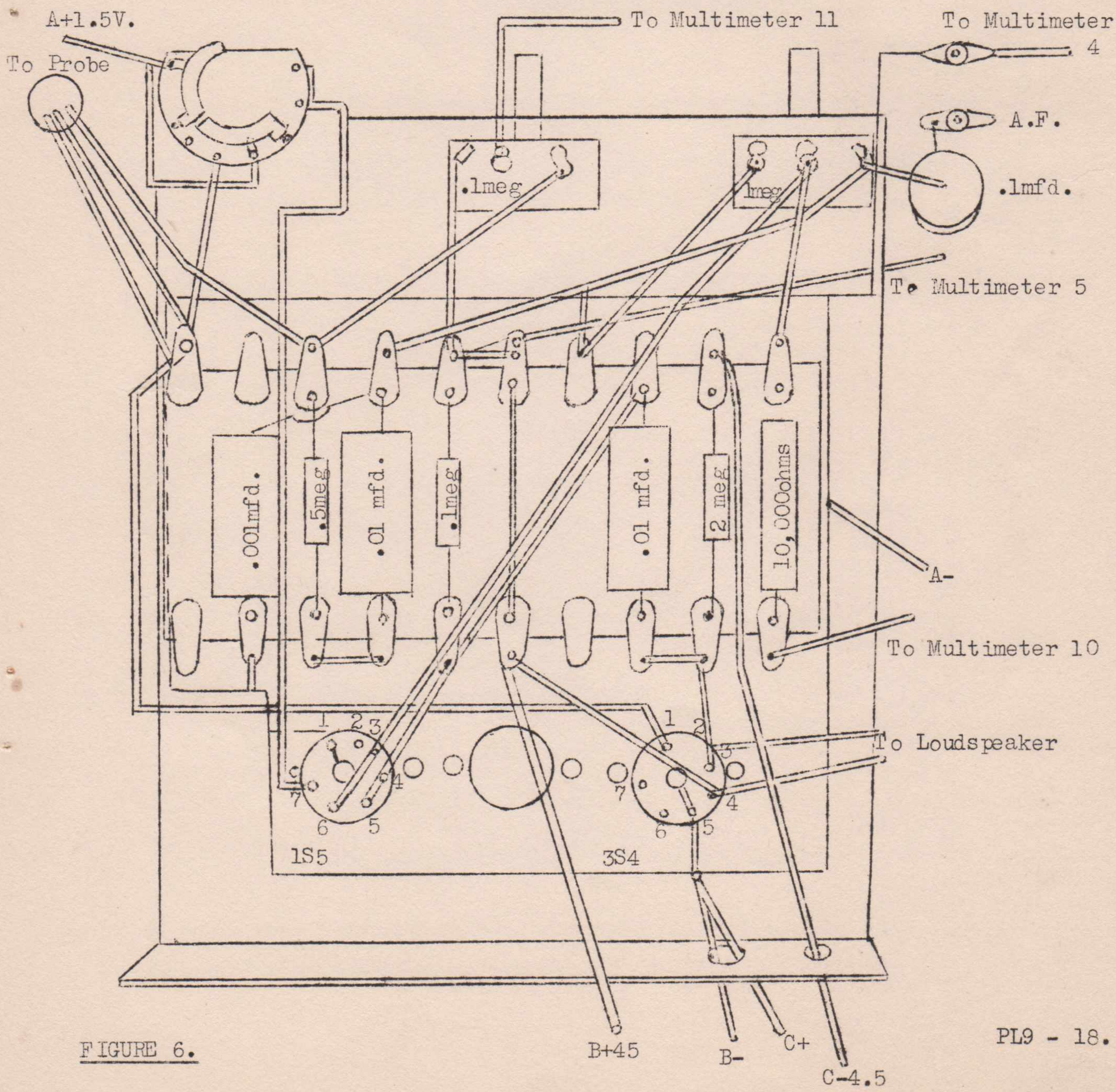

FIGURE 6.

You should next connect the positive filament terminals on the valve sockets to the filament switch and also pass the leads from the loudspeaker transformer down through one of the holes in the metal chassis to pins 2 and 4 on the 3S4 valve socket.

The various small resistors and condensers may now be mounted on the length of resistor panel in the positions indicated in Figure 6. After mounting these parts in place, the resistor panel itself can be attached to the metal chassis by means of two of the long $1\frac{1}{4}$" x $\frac{1}{8}$" bolts supplied with Kit No. 8. These bolts should be passed through the chassis, through solder lugs to which the earth wire can be attached, then a nut placed immediately under the solder lug. Further up on the bolt a second nut can be placed then the resistor panel can be put on the bolts and finally another nut will be placed on the end of each bolt so that the resistor panel is clamped between two of the nuts and is spaced about $\frac{1}{2}$ an inch away from the metal chassis. In mounting the 10,000 ohm resistor, at the right hand end of the resistor panel, you should leave its pigtail wires fairly long so that one of the nuts will fit under the resistor, between it and the panel.

Once the panel is mounted, you can complete the wiring in accordance with Figures 5 and 6. Although you will probably find it easier to place the wires correctly by referring to Figure 6 you should also trace each wire in the corresponding circuit diagram of Figure 5 so that you are familiar with the purpose of the wires and the parts to which they connect. The .1 mfd. condenser has one end attahced to the socket marked "A.F." and the other end soldered directly to the right hand lug on the 1 megohm potentiometer.

The wires in Figure 5 marked "To multimeter 11,5" should connect to switch contacts 11, and 5 on the multimeter switch. You should refer to Figure 4 of Practical Lesson 4 to locate these switch contacts. Similarly, the wires shown near the bottom of Figure 5 marked "To multimeter 10, 4" should connect to the multimeter switch contacts 10 and 4.

SIGNAL TRACER PROBE.

Before mounting the socket for the 1T4 valve onto the short end of the probe moulding, it is necessary to attach the various connecting wires to it. The probe is attached to the instrument by three lengths of differently coloured wires each about a yard long. One length of this coloured wire should connect to the centre cylinder of the socket and to socket lug No.1. The second wire should connect to pin No.7 and the third wire should connect to socket pins 2 and 3 which are joined together. The 5 meg.resistor should have one of its pigtails cut very short and this end soldered to pin No.1. The resistor should be mounted so that it stands out in the same direction as the lugs of the socket. Its other end, which should be about $\frac{3}{4}$ of an inch long should be soldered to pin 6. The pointed metal tip should have the hollow in the threaded end tinned by placing a little soldering flux in the hollow and then allowing some molten solder to flow down into the hole. When tinning this hole be careful not to allow the solder to run over the threaded portion of the tip or you will find it impossible to screw it into the moulding. Once you have tinned the hole you can screw the metal tip into the moulding as firmly as it will go. Next you should cut one of the wires from the .0001 mfd. condenser about half an inch long and place this condenser in the hole in the shorter portion of the tip so that its end protrudes down into the hole in the metal prod. The end of the condenser pigtail should be tinned with solder before placing it into the hole in the prod. If you now make your soldering iron quite hot and touch it to the side of the metal prod, where it extends outside of the bakelite moulding, you will find that after a few seconds the metal tip will become hot enough to melt the solder in the hole and so the end of the .0001 mfd. condenser will sink into the hole and will be securely soldered to the inner end of the metal prod.

The other end of the .0001 mfd. condenser should be cut about half an inch long and should be soldered also to pin No.6 on the 1T4 valve socket by placing the socket as close as possible against the bakelite moulding. You should now firmly press the socket into position in the moulding by causing the pigtail wires of the .0001 mfd. condenser to double up, allowing the socket to seat firmly on the flat surface of the moulding and the 5 meg. resistor to fit down beside the condenser. The lengths of hookup wire for connecting the probe to the instrument pass through the grooves in the moulding and come up around the edges of the socket and should then be passed through the hole in the thin moulded cover. The socket for the 1T4 is held in position by two 8BA screws and the cover is held on to the thicker portion of the moulding by means of three 8BA screws.

Before attaching the other ends of the long three wire cable to the signal tracer, you should test with your ohmmeter to determine that there are no short circuits.

When using the low resistance range of your ohmmeter, with the ohmmeter test leads connected to the two coloured wires in the cable, which connect to the filament negative and positive terminals of the 1T4 you should obtain a reading of 20 ohms which indicates that the filament is in order and that the wires are connected to the correct socket lugs.

On checking between either of the filament wires and the third wire in the cable there should be no movement of the needle's pointer from the left hand end of the scale. If the needle does move it indicates a short circuit in the probe due perhaps to the wire from the plate of the valve touching one of the other pins on the socket.

In order to keep the three strands of wire from the signal tracer probe tidy, they should be twisted or plaited together and passed through the rubber grommet which fits in the hole at the left hand end of the signal tracer label. They may then be soldered to the points indicated in Figures 5 and 6. The wire from lug No.1 of the 1T4 valve socket can connect to the bare 18 gauge tinned copper earth wire, the wire from pin 2 or 3 will connect to the third lug from the left hand end of the resistor panel and the wire from the filament positive socket pin No. 7 should connect to the first lug at the extreme left of the resistor panel rather than directly to the switch. This lug is better able to take any pull or strain exerted by the cable than the lugs on the switch itself.

When attaching the long lengths of hook-up wire for connecting to the batteries, make sure that the ends are securely soldered to lugs on the resistor panel, or in the case of the A-, B- and C+ leads, to the 18 gauge tinned copper wire at a point where it is also soldered to a soldering lug held firm by a bolt. This will prevent any accidental pull on these wires from upsetting the performance of the instrument. It is a good idea to pass these flexible leads through one of the $\frac{3}{8}$" diameter holes in the back flange of the chassis as this holds them tidily in place and further helps in resisting the strain of any pull on the leads. The length of these leads should be such that the A, B and C batteries stand in the space between the chassis and at the rear of the multimeter. You should be particularly careful to label the end of each of the battery leads by means of a paper label gummed onto the wire and distinctly marked A-, B+ etc., to avoid any chance of ever connecting the wires on to the wrong batteries.

TESTING VOLTAGES.

Before connecting the battery leads to the batteries themselves you should use your ohmmeter to test for short circuits between the ends of the wires as explained in previous lessons. With the ohmmeter set on the high ohms range, you should obtain no reading whatsoever between the C battery leads or B battery leads and none between the A battery wires when the switch on the front panel is turned to the positions marked "Off" or "Output Volts". In the position marked "On", there should be a reading due to the filament of the 1T4 valve inside the signal tracer probe. The 1S5 and 3S4 valves should not yet be inserted in their sockets.

With your ohmmeter test leads applied to the B+ and B- leads rotate the 1 meg. potentiometer marked "Meter Zero" on the panel and with the multimeter switch turned to the position marked "R.F." watch the meter scale to see that there is no movement of the pointer. If the pointer moves at all, this shows that a short circuit exists in the wiring of the signal tracer or in the multimeter switch and this should be rectified before proceeding any further. After making this test, return the multimeter switch to the D.C. position.

If everything is in order you may now attach the three pairs of battery leads to their correct battery terminals.

The next step is to test the voltages existing at the 1S5 and 3S4 sockets before inserting the valves. With your multimeter set on the 50 volt range and the negative test lead attached to the bare earth wire of the signal tracer chassis, you should obtain the following reading on the 1S5 valve socket. On pins 1, 2, 3 and 6 no reading. On pin 7 a reading of about $1\frac{1}{2}$ graduations when the filament switch is turnedto the positions marked "Output volts" or "On". On pins 4 and 5 you should obtain a reading of about 15 volts, that is, the needle should move nearly one-third of the way across the scale.

On the 3S4 socket, there should be no reading at lugs 5 or 6, $1\frac{1}{2}$ graduations at lugs 1 and 7 when the filament switch is in the "On" position only and a reading of full battery voltage at pins 2 and 4. On pin 3, there should be a very slight backward movement of the needle which may only just be noticeable.

If the voltage readings are correct, you may insert the 1S5 in the socket behind the switch and the 3S4 in the socket behind the 1 megohm potentiometer. On switching on, and touching the metal tip of the signal tracer probe there should be a click or a humming sound heard from the loudspeaker. If you do not hear any sound when the signal tracer tip is touched, then touch your finger to the red tipjack socket marked "A.F." If you hear a noise from the speaker when you touch this socket it indicates that the 1S5 and 3S4 valves are operating and so the fault must exist in the 1T4 valve or the parts connecting it to the grid of the 1S5. If there is still no sound when the "A.F." socket is touched then there is a fault in either the 1S5 or 3S4 stages. The 3S4 stage can be tested by momentarily disconnecting the C - wire from the negative terminal of the C battery and touching it on and off the battery lug. If the 3S4 is amplifying there will be quite a loud click each time the wire is touched to the C battery lug. If no loud click is heard then this proves the fault to be in the 3S4 stage or loudspeaker.

USING THE SIGNAL TRACER.

When using the Tracer, it is necessary to use one of your test leads or a similar wire to connect the chassis of the receiver you are testing to the socket marked "Earth" on the Tracer panel.

If you have a radio receiver available, you should explore the radio frequency portion of the receiver with the probe tip and trace the signals through from the aerial terminal, or grid of the first valve to the detector stage. So that you may hear the signals from the tracer's loudspeaker the receiver's volume control should be turned off or better still, the volume control may be turned on and the receiver's loudspeaker made ineffective by

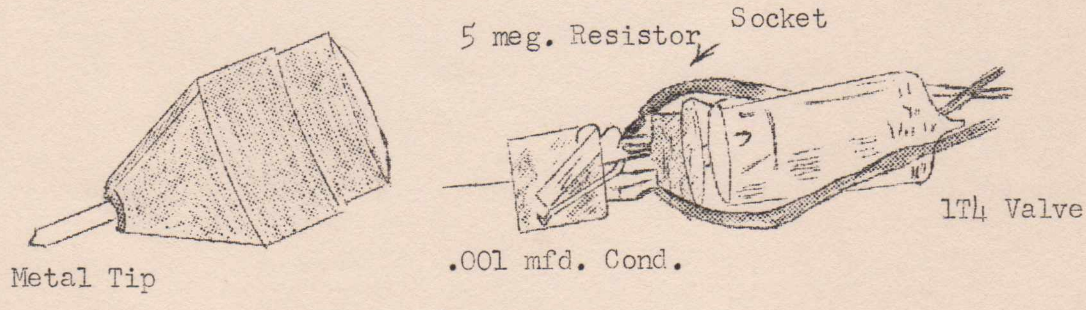

FIGURE 7.

means of a length of wire employed to short circuit either the voice coil or the loudspeaker transformer primary winding.

When using the probe for tracing signals through the early stages of a receiver, you should have the multimeter switch set to the position marked "R.F." In this position, the meter is connected in such a way as to indicate the plate current of the 1T4 valve and consequently, it will give some indication of the signal's strength reaching the grid of this valve and, after some experience is obtained in testing a number of typical receivers, you will be able to judge whether the signals are of normal strength or not by its indications.

When you switch on the signal tracer, the plate current of the 1T4 valve will cause the meter needle to deflect across towards the right hand end of the scale. You can make the needle register correctly at the right hand end of the scale by means of the knob on the front marked "Meter Zero". If you now touch the signal tracer probe to a point in the receiver where there are strong signals present, these signals will cause the plate current of the 1T4 to reduce, as it is acting as a grid leak detector and this will cause the meter needle to move back towards the left hand end of the scale. The stronger the signals, the further the needle will move towards the left hand end of the scale.

In modern superheterodyne receivers it is not unusual to find signals in the R.F. section of the receiver having a strength of up to 30 volts when the set is tuned to a powerful near-by station. This will not reduce the plate current completely to zero but you will be able to obtain some idea of the relationship between signal strength and meter reading from Figure 8, which will give you some indication of the relationship between the meter indication, on the upper scale marked up to 10 at the right hand end, and the radio frequency signal strength applied to the probe tip.

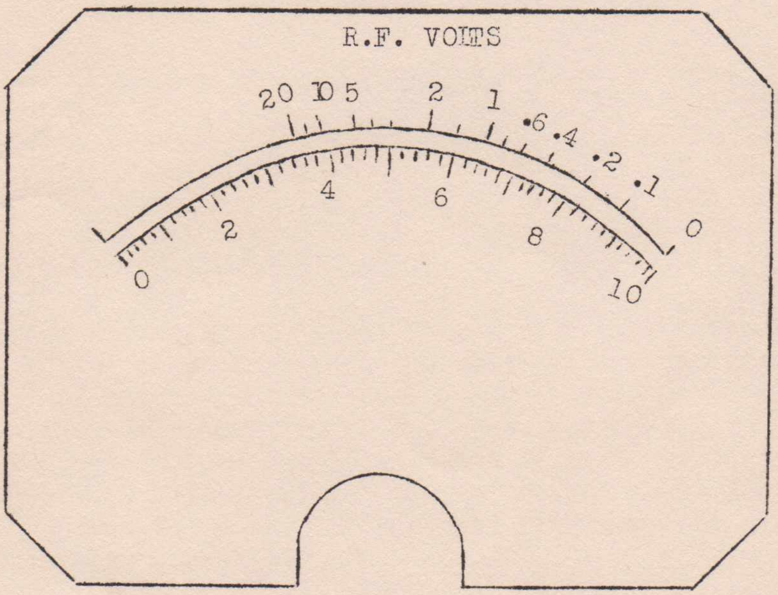

FIGURE 8.

In tracing signals through an inoperative receiver you should commence at the aerial end and work towards the loudspeaker. If you live in a district where there is a powerful broadcasting station nearby you will be able to pick up the signals from this station weakly, when your signal tracer probe tip is touched to the aerial terminal of the receiver. It will be necessary to rotate the tuning dial of the radio receiver until the signals heard from the signal tracer are at their loudest. These signals will be extremely weak in strength and consequently will provide practically no reduction in the indication of the meter. If you live in a district where you have no local broadcasting station available, then you will probably not be able to hear any signals at the aerial terminal of the receiver you are testing, but will perhaps hear them, when you touch the signal tracer probe to the grid of the first valve in the receiver. Again, the strength of signals will be determined by the setting of the tuning condenser on the receiver and you will find it necessary to move the tuning dial of the receiver until the signals are at their loudest.

If the receiver you are testing is a superheterodyne, the signals reaching the grid of the converter valve will be changed to an intermediate frequency, by being mixed with an oscillator frequency created in the set. On testing the oscillator circuits of the receiver, you will not hear any sound from the signal tracer's loudspeaker because the oscillator frequency is unmodulated. However, the oscillator should normally provide a strength of several volts and this will provide a substantial deflection on the signal tracer meter when the probe tip is touched to the grid or plate of the oscillator portion of the frequency changer valve in the receiver. This is the reason for providing both the meter and loudspeaker to indicate the presence of signals reaching the signal tracer.

At the plate of the frequency changer valve the strongest signal present will be the amplified oscillator frequency and this will provide quite a substantial movement of the meter needle at the plate of this valve, although the signals from the loudspeaker, representing the broadcasting station programme, will be rather weak. With checking at this point, you should again make sure that the receiver tuning dial is set correctly to bring in the signals at their greatest strength.

The next point to check is the grid of the first I.F. amplifier. The I.F. transformer will prevent the oscillator frequency signals from reaching the grid of this valve so that the meter needle will move much further up towards the right hand end of the scale again, tending to indicate a weaker signal. What it does really indicate is that the strong oscillator voltage is not present at this point and the deflection it does give will be dependent upon the strength of the intermediate frequency signal alone rather than on the oscillator strength.

At the same time, the signals from the loudspeaker will probably be a little weaker at the grid of the first I.F. amplifier than they were at the plate of the frequency changer because there is some loss in signal strength as the signals pass through the I.F. transformer.

If signals are reaching the grid of the I.F. amplifier, you may then test at the plate of the valve to see if the signals are being amplified by this valve. If this valve is working normally, the signals will be very much stronger at its plate and the sounds from the signal tracer's loudspeaker will be much louder and at the same time the meter needle will move further towards the left hand end of the scale.

If the receiver has a second I.F. amplifying stage then continue to follow the signals through to the grid of this valve, where one would expect the signals to be a little softer and the meter needle to move a little further to the right than at the plate of the preceding valve, due to the losses in the second I.F. transformer. At the plate of the second I.F. amplifier, if there is one, the signals will be much greater in strength again.

Finally, you should use the signal tracer probe to determine whether the signals are reaching the diode plate in the detector. In an old fashioned set the detector will not be a diode type and in this case you should see that the signals reach the grid of the detector valve.

After the detector in the receiver has done its work, the signals will be audio frequency. The best results will then be obtained by turning the multimeter switch to the position marked "A.F." and by using your positive test lead plugged into the tipjack socket marked "A.F." on the signal tracer. By using this test lead you can follow the audio frequency signals from the detector, to the grid of the first audio amplifier, to the plate of this valve, then through the coupling condenser to the grid of the second audio amplifier or output valve and finally to the loudspeaker in the receiver. When the receiver is working normally, the signals will continue to get progressively louder and when they become so loud that they sound distorted and cause the signal tracer's speaker to rattle you should turn back the "Attenuator" on the signal tracer to maintain them at a reasonable level.

The attenuator is fitted with a calibrated scale so that you will learn from experience on a number of receivers, the normal setting for the knob at different points throughout the audio system. Thus, after you have had some experience in testing a variety of types of receivers you will soon be able to judge, from the point to which the attenuator knob has to be turned, whether the receiver you are testing has the normal amount of amplification or not.

An input isolating condenser is contained in the signal tracer probe and also immediately behind the A.F. socket so that there will be no danger of the positive voltage at the plate of any of the valves in the receiver you are testing, affecting the signal tracer circuit.

When using your multimeter switch on the position marked "A.F." and also, when testing the audio sections of a receiver, the sounds you will hear will vary in loudness in accordance with the nature of the programme of the station to which you are listening and this will cause the meter needle to dance up and down on the scale rather than to provide a steady indication.

An alternative method of tracing the signals through the A.F. section of the receiver is to continue using the signal tracer probe on the A.F.stages. You will find that the tone quality is perhaps a little shrill when using the probe but it is sometimes quicker and more convenient to start at the aerial terminal of the receiver and trace right through to the loudspeaker with the one probe, rather than use the probe for the portion of the receiver up to the detector and then the test lead plugged in the socket marked "A.F." for the following portions of the receiver. If you are using the probe for following signals through the audio frequency stages of the receiver you may leave the multimeter switch set to the position marked "R.F." and so observe the strength of the signals by means of the deflection of the meter needle towards the left hand end of the scale just as when testing the R.F. section.

Naturally, in a receiver which is working normally, the signals will proceed to get stronger as you follow through the receiver towards the loud-speaker. If you find a point at which the signals suddenly become much weaker than they were at a preceding point, or where there are no signals present, then this indicates that the fault in the receiver exists between the point at which the signals have their normal strength and the first point at which the signals are very weak or entirely absent.

As you use your signal tracer for testing a variety of sets you will become gradually more proficient in using it and you will soon find that you are very rapidly able to determine the faulty stage, or group of parts in a receiver which is inoperative. The more practice you have in using the signal tracer the more useful you will find it and the quicker you will become at finding faults.

MODULATED R.F. OSCILLATOR.

The final unit to be constructed is a modulated R.F. oscillator which will provide a reliable source of signals at any of the commonly used frequencies to which radio receivers are capable of tuning, so that you may test the receiver even when there are no powerful broadcasting stations operating or in districts where there are no powerful signals available. You will find this very helpful in testing sets in conjunction with your signal tracer.

In addition, the signals from the oscillator will enable you to align the tuned circuits of receivers and so adjust them to give their best performance.

The circuit diagram of the modulated oscillator is shown in Figure No.9. From this diagram you will see that a 3S4 valve is employed as a radio frequency oscillator in a "Reinartz" circuit. That is, the tuned winding of the oscillator coil is connected to the valve's grid and oscillation is maintained by a reaction, or plate winding through which the plate currents of the valve pass.

In order to provide signals for testing purposes at a wide variety of different frequencies, five separate tuning coils are provided and can be selected by means of the two sections of the rotary switch. One section connects the tuned winding to the tuning condenser and to the grid of the valve through the .001 mfd. condenser, whilst the second switch section connects the plate of the valve to the appropriate plate winding on the coil being used.

An unmodulated carrier wave is not very satisfactory for testing purposes because when a receiver is tuned in to the carrier wave, one would hear nothing from the receiver's loudspeaker due to the fact that there is no programme or modulation present on the carrier. In order to produce an identifying tone, so that the signals can be heard from the loudspeaker of the set being tested, the 1R5 valve is used as an audio frequency oscillator. The iron cored transformer is connected to the grid and plate circuits of the 1R5,

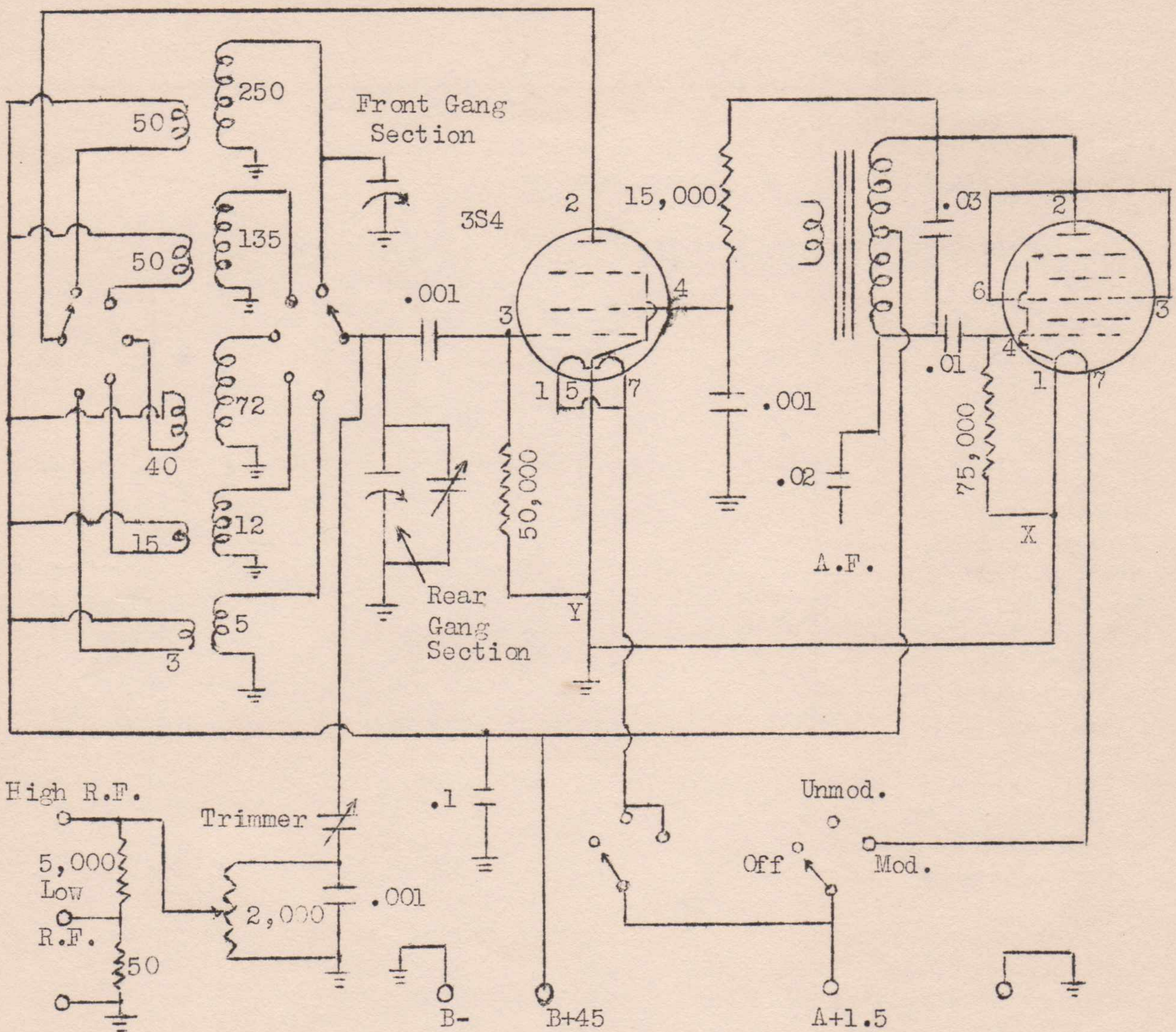

FIGURE 9.

the grids 2, 3 and 4 being joined to the plate of this valve so that it acts as a triode instead of as a converter valve. This valve is made to oscillate at a frequency of approximately 400 cycles per second by means of the .03 mfd. condenser which tunes the iron cored choke to this frequency. The 400 cycle voltage is then applied through the 15,000 ohm resistor to the screen grid of the 3S4 valve and by varying the screen grid voltage causes the plate current of this valve to fluctuate at 400 cycles per second and so the radio frequency voltage produced by the valve pulsates in strength at this frequency. When you tune signals from the oscillator on a receiver, you will hear the 400 cycle note coming from the receiver's loudspeaker.

CONSTRUCTION.

The oscillator is constructed on the larger of the two chassis, the tuning condenser being mounted up on the four long ⅛" Whitworth bolts as explained previously. The placement of the valve sockets, coils and other parts can be determined from Figure 10 which shows the parts mounted on top of the chassis and from Figure 11 which shows the parts mounted under the chassis and is also a wiring diagram.

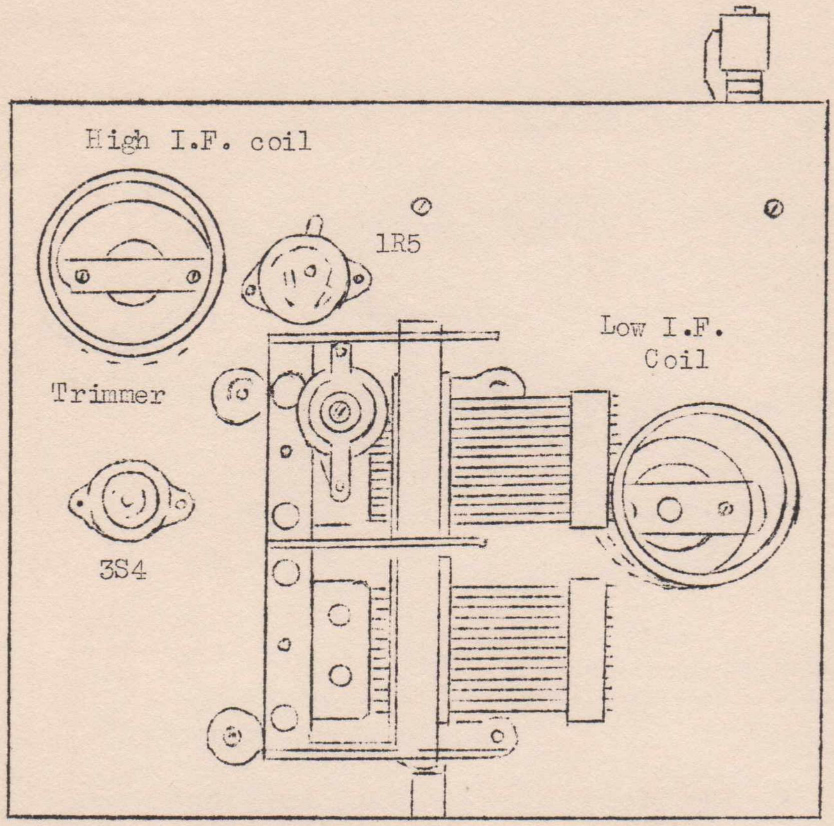

FIGURE 10.

The coils, two of which stand up on top of the chassis, should be mounted on last of all, but in carrying out the other wiring of the oscillator be sure that the wires are kept clear of the position in which the coil bracket and coils are mounted.

After the parts are bolted in position, you may commence your wiring by using a length of 18 gauge bare tinned copper wire to provide a convenient point to which the various parts, shown in Figure 9 as connecting to earth, may be attached.

You should next wire up the filament circuits of the valves and the filament switch. The wires from the tuning condenser section can be attached and passed down through the quarter inch diameter hole under the front section of the condenser gang. The potentiometer which acts as an attenuator and also the .001 mfd. condenser, 5,000 ohm resistor and 50 ohm resistor are the next parts to be installed.

As usual, the tipjack sockets should have been tested for short circuits to the panel when they were being mounted and before any wires were attached to them.

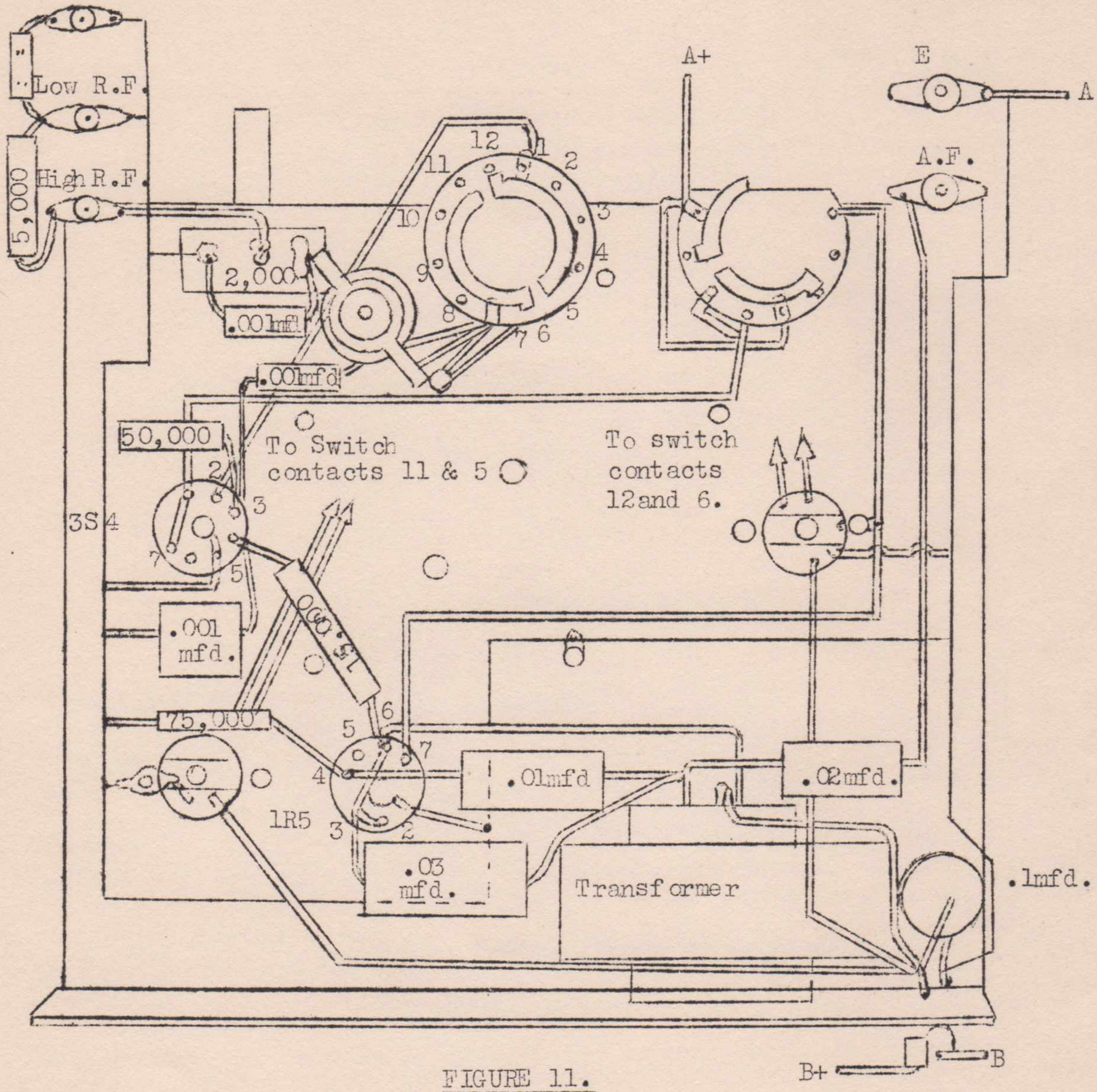

FIGURE 11.

After completing as much of the wiring as possible and mounting the various resistors and condensers you may commence to wind the coils.

COIL WINDING.

There are five separate tuning coils to be wound and it is important that you employ the correct coil former for each, otherwise you will find that there are no holes in the positions where you require them to terminate the ends of the wires.

Some superheterodyne receivers employ relatively low intermediate frequencies extending from about 150 kilocycles upwards. In order to provide signals to enable alignment at these frequencies, the first coil has been designed to tune down below 150 KC. In order to do this, a large tuning capacity is needed and this is achieved by using one section of the tuning condenser permanently connected across the secondary of this coil and in addition, when the band switch is set to the position marked "Low I.F." the second tuning condenser section is also connected across the circuit. Thus the secondary of this coil is tuned by both tuning condenser sections in parallel. The large tuning capacity available helps to tune to the low band of frequencies required. Even so, it will be necessary to wind 250 turns of the very fine, 34 gauge wire on the former. The former to be used is the one originally supplied for the winding of the broadcast coil in Lesson No. 6 and is the one which was used as the second I.F. transformer in your superheterodyne receiver. It is the one which has a 45 turn reaction winding near the top, a 90 turn secondary winding and a 40 turn primary wound over the lower part of the secondary. It also had a five turn winding underneath the secondary.

In employing it for this oscillator, it will be necessary to remove all of the original windings and to start at the uppermost pair of holes so as to fit in the 250 turns of 34 gauge wire. This winding will terminate at the lower set of holes and it will be necessary to wind the wire very carefully so that the turns lie neatly side by side in order to fit them in the space available.

After having wound the 250 turn coil, place some varnished insulating tape over the lower end of the tuning coil, near the mounting bracket and wind a plate winding consisting of 50 turns of the same 34 gauge wire over the top of the insulating tape. It will be necessary to hold the ends of this winding in place with a drop of molten wax, shellac or cement of some sort. Each end of this winding can be passed through one of the holes near the lower edge of the former but as there are only two available holes and two ends of the wire it will not be possible to thread the wire ends backwards and forwards through the holes to secure them firmly. Instead, each end of the winding must be passed through one hole and then, after being threaded through insulated tubing, they can be passed down through the large hole in the chassis in readiness for attaching to the switch and terminal. The three wires from the lower end of the former will need to be left about 6" long in order to reach the switch whereas the wire from the top end of the former will need to be about 8" long. When this coil is wound it may be mounted on the right hand side of the chassis as shown in Figure 10. All leads are passed down through the hole in the chassis. The two wires which attach to the switch are brought forward, towards the front of the chassis and then turned along towards the switch and attached to the switch as shown in Figure 12. The lower end of the 250 turn winding is soldered to the earth wire and the upper end of the 50 turn winding should be extended back, through insulated tubing to one of the terminals, mounted on the back corner of the chassis and which serve as a convenient point for the B+ connection.

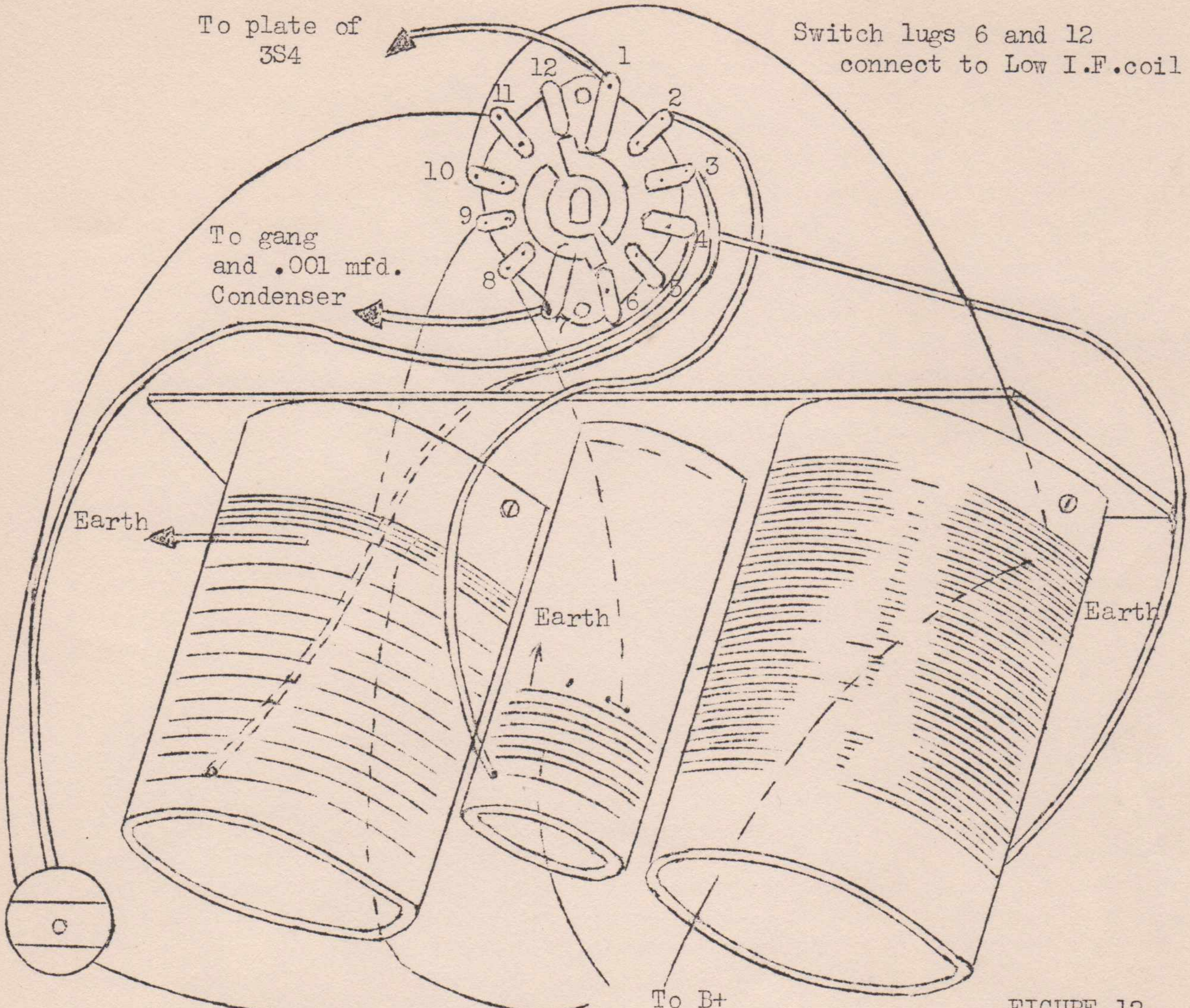

FIGURE 12.

Of course, it should be unnecessary to mention that in winding the coils you should see that both grid and plate windings are wound in the same direction as one another.

With the tuning condenser turned fully into mesh this coil will cover frequencies of about 140 kilocycles to about 450 kilocycles. It will probably not take in the frequencies of 455 and 475 kilocycles which are quite extensively used. For this reason, a second coil is provided to cover the higher intermediate frequencies and will start from about 320 kilocycles and cover up to about 900 or 920 kilocycles.

The second coil is wound on the larger former supplied with this kit and which was used for the oscillator coil in the superheterodyne receiver you constructed earlier in this lesson. It originally had a 30 turn winding near the top and a 69 turn winding near the bottom. It will be necessary to remove both of these windings and, starting at the top of the former, away from the mounting bracket, wind on 50 turns of 34 gauge wire as a plate winding and then, after about one-eighth of an inch space, wind on the tuned winding which consists of 135 turns of the fine 34 gauge wire. As this coil mounts near the rear corner of the chassis it will be necessary to leave the leads about 8" long in order that the upper end of the 50 turn winding and the lower end of the 135 turn winding may reach to the switch. The lower end of the 50 turn winding should be attached to the terminal being used as a connection for B+ and the upper end of the 135 turn winding should be connected to the earth wire.

The third coil will cover the broadcast band from about 600 kilocycles to about 1,800 kilocycles. The broadcast band itself actually starts at 550 KC but this frequency is well covered by the second coil and consequently, by starting the third coil at about 600 kilocycles it is able to go well on beyond 1,600 kilocycles so that there will be no difficulty in adjusting receivers at the extremely high frequency end of the broadcast band.

The third coil is wound on the former originally supplied with Lesson 6 and used for winding a shortwave coil. It was last used as the first I.F. transformer in the superheterodyne receiver and has at present 90 turns of 28 gauge wire and 40 turns of 34 gauge wire. The 40 turns of 34 gauge wire will be retained exactly as it is as a plate winding and the 90 turns of 28 gauge wire should be reduced to 72 turns. As you unwind the 18 turns from the top end of the secondary, away from the mounting bracket, you will find that by the time you have reduced the total number down to 72 there will be another pair of holes exposed through which you can terminate the end of the wire.

This coil is mounted on the bracket bolted underneath the chassis as shown in Figure 12 and its leads need be only a little over 4" long. The end of the 72 turn coil furthest from the bracket connects to the switch and the lower end of the 40 turn coil also connects to the switch, the upper end of the 40 turn coil passes through the centre of the former to the B+ terminal and the end of the 72 turn coil nearest the bracket is soldered to the earth wire.

The fourth coil is designed to cover portion of the shortwave band from approximately 3.5 megacycles to about 9.2 megacycles per second. These correspond to wavelengths of approximately 86 to 33.25 metres.

This coil is wound on the former previously used as the aerial coil in the superhet receiver that is, the one which had an 89 turn winding and a 25 turn winding on it.

To employ it as a shortwave coil former it will be necessary to reduce the 25 turn winding to 15 turns by unwinding 10 turns from the end nearest to the coil mounting bracket.

The 89 turns of wire should be completely removed and in their place you should wind 12 turns of 26 gauge wire, the thickest supplied with this kit. Instead of winding these turns closely side by side so that they occupy only about a quarter of an inch of length, they should be spread out evenly with almost an eighth of an inch space between each adjacent turn so that the 12 turns occupy the full length of 1¼" between the two pairs of terminating holes drilled in the former.

In winding this coil endeavour to make the spaces between the turns as even as possible and keep the wire taut so that it will not slip about and allow the turns to move out of position. If the spacing is not regular when you first wind the coil, then after you have threaded the ends through the holes so that the wire will not become loose again, you can then set to work to space the turns evenly one from the other. The ends of these wires will need to be left about 4" long and as in the case of the broadcast coil the end of the 12 turn winding furthest from the bracket connects to the switch and also the end of the 15 turn winding closest to the bracket connects to the switch.

The fifth coil, for covering the highest frequency section of the shortwave band, from about 8.5 to 26 megacycles corresponding to wavelengths from 35 to about 11.5 metres is wound on the small coil former supplied with this kit. You will notice that this former has grooves in it to help to maintain a uniform spacing of the wire turns.

Commencing at the end furthest away from the mounting hole you should use a length of the thickest 26 gauge wire and wind 5 turns. You will find pairs of holes in a convenient position for terminating the ends of this winding.

The plate winding consists of a little under three turns of the fine 34 gauge wire. You should start this winding at the end nearest to the mounting hole by threading the wire up and down through the pair of holes provided two or three times. The end of this wire should be brought to the outside of the former and left about 3" long so that it may be passed through a hole in the metal bracket upon which the coil is mounted, to the switch. In winding the plate winding it is necessary to arrange for the wire to be placed in the centre of the spaces between the turns of the secondary winding. There is enough flat area on the coil former between each of the adjacent secondary turns, to enable the fine wire to be wound in and to be spaced in the centre of the secondary turns. After winding almost three turns you will find another pair of holes provided through which this wire can be passed down, up and then down again to the inside of the former. It should then be threaded through a piece of insulating tubing and carried across to the B+ terminal when the coil has been mounted.

The broadcast coil and the two shortwave coils should be mounted on the metal bracket supplied with this kit as shown in Figure 12. A large bolt with a 5/32" Whitworth thread is provided for fastening the small coil former in position on the bracket.

All wires extending from the coils should be covered with insulated tubing and care should be taken to see that the two wires from each coil connect to diagonally opposite contacts on the switch, exactly in accordance with Figure 12.

In order that you may reach some of the lower switch contacts with your soldering iron, it is a good idea to complete the wiring to the two coils on top of the chassis firstly and then, before actually bolting the metal bracket holding the broadcast and shortwave coils in position, complete the wiring for these coils leaving the leads an inch or so longer than they need be. After you have completed the wiring you can then push the coil bracket back to its correct position and bolt it to the main chassis. The wires from the low I.F. coil should pass around the end of the coil bracket in the cut-out space provided and on no account clamp the coil bracket down on top of any wires which are underneath it.

You may find it still easier, to loosen the nut which holds the switch to the front panel and have the switch lying with its connecting lugs upwards more in accordance with the diagram of Figure 12 when carrying out the wiring. If you leave a little slackness in the leads you will then be able to turn the switch back to its correct angle and bolt it on to the chassis again before securing the coil bracket in position.

The final step in wiring is to attach the four leads for the batteries. Those for the A battery will extend from the filament switch and the earth wire whereas those from the B battery can be lengths of hook-up wire inserted in the terminals mounted on the rear flange of the chassis. All four wires should be cut to such a length that they will just reach the batteries comfortably when the batteries are standing in the space at the rear of the multimeter.

TESTING VOLTAGES.

Prior to attaching the wires to the batteries, test for short circuits with your ohmmeter and then, employing the 50 volt DC range and with the negative multimeter lead attached to the metal chassis or earth wire you should experience the following readings on the 3S4 valve socket:- no reading at pins 3 or 5, a reading of about $1\frac{1}{2}$ graduations at pins 1 and 7 when the switch on the front is turned to the positions marked "UNMOD." or "MOD." At pin 2 you should measure full B battery voltage on all five positions of the coil selector switch. If you obtain full B battery voltage on some positions and not on others then the absence of B+ voltage must be due to a wrong connection to one or more of the coils or a break in the plate winding of the coils connected to those points on the switch.

On socket lug 4 you should obtain a reading of between 30 and 35 volts.

At the socket for the 1R5 valve there should be no reading at pins 1, 4 or 5, a reading of $1\frac{1}{2}$ graduations at pin 7 in the switch position marked "MOD." only and a reading of almost full B battery voltage on pins 2,3 and 6.

If the voltages are normal you may insert the valves.

TESTING.

You can easily test the 1R5 audio frequency oscillator by inserting one of your test leads in the socket marked "A.F." on the signal tracer panel and touching the other end to the sockets marked "A.F." on the oscillator panel. With the signal tracer switched on and the oscillator switch turned to the position marked "MOD." you should hear a loud howl from the loudspeaker. The multimeter switch should not be in the position marked "A.F." when this test is made. If you do not hear a 400 cycle note and yet you have found your signal tracer to be working from previous tests, then this shows that the audio frequency oscillator section is not functioning. To confirm this, you should disconnect the end of the 75,000 ohm resistor from earth at the position marked "X" on Figure 9 and insert your multimeter on the 1 ma. range. There should be a reading of several graduations if the oscillator is functioning. If you obtain no reading this confirms that the oscillator is not working and you should carefully check over the wiring and see that all your connections are correct. You should also examine the enamelled wires emerging from the secondary of the iron cored transformer and see that they are effectively insulated from one another and from the back of the metal chassis. If necessary pieces of insulating tubing can be slipped over these to insulate them.

If you still cannot obtain any signals, check carefully the voltages available from your batteries. The B battery should be capable of supplying at least 38 volts and the A battery at least 1.25 volts when the oscillator switch is turned to the position marked "MOD."

Once you have found the A.F. oscillator to be functioning, you may test the R.F. oscillator section either by feeding its signals into a radio receiver and listening for the 400 cycle note from the receiver's loudspeaker or by touching the signal tracer probe tip to the oscillator tipjack socket marked "High R.F." The attenuators on both instruments should be turned fully on. If the R.F. oscillator is functioning,you should hear a faint 400 cycle note from the signal tracer loudspeaker and this note should be present on all bands although it will be strongest on the I.F. and broadcast bands and weaker on the shortwave bands.

If you cannot detect any signal when making this test, you should disconnect the end of the 50,000 ohm resistor from earth at the point marked "Y" in Figure 9 and connect the negative test lead from your multimeter to the end of the resistor whilst the positive test lead is clipped to the metal chassis or earth wire. On the 1 ma. range you should obtain a reading of several graduations if the valve is oscillating. You should check the strength of oscillation, by observing the position of the needle on all five bands and you should rotate the tuning condenser throughout its travel on each of the bands to make sure that the oscillator functions throughout the full range of each band.

If you cannot obtain any indication or obtain a reading on certain bands only then you should carefully check over the wiring to see that it is correct. No indication on any band suggests a wiring fault, defective valve or run down batteries. An indication on some bands and not on others indicates a fault in the switch connections or a mistake in winding the coils with which no indication of grid current is obtained.

The trimmer condenser which applies the radio frequency signal from the tuned circuit to the attenuator potentiometer should be screwed about half way up and left at that position.

If you cannot obtain any signals or if you obtain oscillation on some bands only then you may try exchanging the two 3S4 valves. Use in the oscillator the 3S4 which gives the greatest indication of grid current or which provides oscillation throughout all of the bands. The 3S4 in the signal tracer is not as critical as the one in the oscillator so the better tube should be used in the oscillator. After having determined that the oscillator is functioning either by means of the meter inserted at the point "Y" or by detecting the signals on your signal tracer you should apply the signals to a radio receiver and tune them in by setting the oscillator band switch to the position marked "B.C." so that it covers the broadcast band and finding the signals on the tuning dial of the receiver.

CALIBRATION.

The only method of accurately calibrating an oscillator is to individually check each instrument, once it has been completed, against a standard instrument of high accuracy and then individually mark the scale or tuning dial of the oscillator to indicate the frequencies produced on each of the bands.

However, if you have closely followed the coil winding instructions and the calibration instructions which follow, you will find that they will agree fairly closely with the calibrations on the front panel of your instrument. Check the accuracy as explained below.

If you find any substantial departure from the calibrated scale, which cannot be corrected by means of the trimming condenser or adjustment of the number of turns, then you should use this as a model and draw one of your own on good quality white paper using black "Indian" ink or drawing ink for the markings. This can then be covered by a sheet of celluloid or transparent plastic to keep it clean.

Once you have completed the instrument, you will have no difficulty in checking its accuracy on the broadcast band because, with the aid of a receiver, you can tune in stations of known operating frequency and at the same time feed in signals from your oscillator to the receiver's aerial terminal. The output lead from the oscillator can be either directly connected to the receiver's aerial terminal or just clipped on to the insulation covering the receiver's lead-in wire without making an actual connection to the aerial terminal, depending upon which gives the best results.

On tuning in a certain broadcasting station and then rotating the oscillator tuning condenser, with the switch set on the "B.C." position you should hear a whistle when the tuning condenser is set to approximately the position corresponding to the broadcast station's frequency on the printed scale.

You will probably find that there is not very much error at the low frequency end, near 600 kilocycles but that the error at the high frequency end, near 1,500 kilocycles may be fairly great. To provide some adjustment on the calibration at this end, the second trimmer condenser is wired across the rear section of the tuning condenser gang and you will find, if you alter the setting of this trimmer that you can move the oscillator dial setting considerably for any frequency so that you will probably be able to arrange for the beat whistle to be heard when the dial is pointing exactly to the frequency corresponding to the station you have tuned in on your receiver, at the high frequency end of the band.

If there is very much error at the low frequency end of the band you can correct this by adding or subtracting turns to the 72 turn winding on the broadcast coil. Adding more turns would have the effect of needing the tuning condenser plates turned further out of mesh to produce a certain frequency, whereas removing turns would cause the tuning condenser plates to be turned further into mesh to produce the same frequency.

After altering the number of turns to provide the best degree of accuracy at the low frequency end you should again check the setting of the trimmer condenser, soldered to the top of the rear section of the tuning condenser gang and endeavour to make the calibration as accurate as possible once more at the high frequency end.

It is suggested that you carry out these adjustments on the broadcast band because this is the most important band on which to have a high degree of accuracy.

You will be able to check the accuracy of the I.F. band by employing "Harmonics" from the oscillator. For instance, when employing the high I.F. band, the oscillator will produce not only the signal frequency indicated on the dial plate but also the second harmonic of this frequency which will be twice as great. This means, that if you can tune in a broadcasting station on say 800 kilocycles and set your oscillator to produce a signal of about 400 kilocycles you should obtain the usual beat whistle. Similarly, if you can tune in a broadcasting station on say, 1,000 kilocycles you should also hear a whistle when the oscillator, on the "High I.F." band is producing a signal of 500 kilocycles. In this case, you would probably obtain still another whistle when the oscillator is turned to produce a frequency of 333 kilocycles because this would be one-third of 1,000 and the oscillator will produce harmonics not only at twice its fundamental frequency but also at three times, four times, five times, six times etc.

The same principle of employing harmonic frequencies may be used for checking the accuracy of calibration of the low I.F. band. In this case, you will probably be employing the fourth or fifth harmonic and for instance if you can tune in a station at 600 KC on your radio receiver dial then you should obtain a whistle when, using the "Low I.F." oscillator band, you have the tuning dial set to 150 kilocycles, because the fourth harmonic of 150 KC is 600 KC. Another whistle will be experienced when the dial is set to approximately 200 KC because the third harmonic of 200 KC is also 600 KC. Similarly, a further whistle will be experienced with the dial set to approximately 300 KC because the second harmonic of 300 KC is also 600 KC. In this way, the one broadcasting station on 600 kilocycles would enable the checking of the low I.F. band at three separate points and similarly, other broadcasting stations would enable a number of other checking points to be established.

If the I.F. coils are incorrect so that the signals corresponding to a half, a third, and a quarter of the operating frequency of the broadcasting station you happen to be using do not come at the correct position on the scale you can modify the number of turns on the tuned windings of these coils to make them correct. Of course, you cannot employ the trimmer condenser to correct errors at the high frequency end of these bands because once it is set to make the broadcast band track correctly, you should not alter it to correct errors on the I.F. bands. This is because of the fact that accurate calibration on the broadcast band is far more important than that on the I.F. bands.

The same principle of heterodyne checking can be employed by tuning in shortwave stations on a shortwave receiver and simultaneously feeding in signals from the oscillator. In this way you will be able to compare the frequency produced by the oscillator with that of actual broadcasting stations the frequencies of which you know.

In checking the shortwave coils you will probably obtain a response at two different tuning condenser settings when using a superheterodyne receiver, due to image effect or double spot tuning in the receiver. As you tune the oscillator dial, you will probably find two responses from the receiver, separated by twice the amount of the receiver's intermediate frequency. In most cases the two responses are nearly one megacycle apart. In most receivers the correct response from the oscillator will be the one with the oscillator tuning condenser plates turned further into mesh although in some receivers the one where the plates are turned further out of mesh would be correct. This will depend on the receiver design to some degree.

OSCILLATOR OUTPUT LEADS.

If you feed the signals from the oscillator to the receiver by means of the ordinary multimeter test leads you will find that the test leads radiate quite a lot of signal which may be directly picked up in the wiring of the receiver and which will make it difficult to regulate the volume of the receiver you are testing. To minimise this effect, a length of hook-up wire enclosed in metal braiding is supplied. This shielded wire should be made up into an output cable by cutting back the metal braiding for a distance of about 1" at each end. The insulation may then be removed from the hook-up wire for about ½" at each end and one end inserted into the red coloured test plug.

A length of hook-up wire about 4" long should have one end soldered on to the metal braiding and the other end soldered into the second split test plug.

At the other end of the cable the bared end of the hook-up wire should be soldered to one of the small alligator clips and again a length of hook-up wire about 4" long should have one end soldered on to the metal braiding and the other end soldered on to a second clip. These clips are intended for connecting to the aerial and earth terminals respectively of the receiver under test. The red coloured plug should plug in to one of the red coloured sockets on the oscillator, depending upon whether strong or weak R.F. signal output voltage is required and at the receiver end, the spring clip attached to the shielded hook-up wire should connect to the receiver's aerial terminal whilst the clip connecting to the metal braiding should connect to the receiver's earth terminal.

INSTRUMENT SHIELDING.

Even with a shielded output lead in use you will find, especially on the shortwave bands, that quite a lot of signals radiate directly from the oscillator to the circuits of a receiver under test and that the oscillator attenuator has little effect in regulating the loudness of sounds from the loudspeaker of the receiver. The reason for this will be that signals are radiating from the tuning coils and wiring of the oscillator and inducing voltages directly in the receiver without passing through the oscillator's attenuator. To avoid this it is desirable to completely enclose the oscillator chassis in a metal container.

The metal container, which should be a five sided box, should have dimensions of approximately 7½" long by 7½" deep by about 8" high. You may be able to procure a biscuit tin or similar container or alternatively, make something up out of tinplate, aluminium, copper, brass or any other sheet metal. A small hole can be cut in one side for the battery leads to pass through and the container should be brought up hard against the front panel so as to leave the least possible space or opening between the container and the panel.

If you use such a container be careful to see that it does not short circuit to the voltage tipjack sockets of the multimeter. The more effective the joint you can make between the box and the panel the less leakage there will be and the more effective will be the operation of the oscillator attenuator.

ALIGNMENT.

The process of aligning a receiver with the aid of a modulated oscillator is covered very extensively in textbooks and in the A.R.T.C. Radio Instruction Course and consequently there is no point in duplicating this work here. In carrying out the alignment work you may find that certain frequencies are covered at the high frequency end of one band or at the low frequency end of the next band on the oscillator. In this case, always choose the setting which involves the tuning condenser plates being turned furthest into mesh as it is more likely to retain accurate calibration over a long period of time than at a frequency which requires the oscillator tuning condenser plates to be set nearly fully out of mesh.

To obtain accurate alignment of the tuned circuits in a receiver it is desirable to employ an output meter rather than to rely on one's ears to judge the point of maximum output. It is for this purpose that the output meter is provided as part of the signal tracer and when aligning a receiver, you should connect the lead from the socket marked "A.F." on the signal tracer, to the plate of the power output valve on the receiver you are checking and have the multimeter switch set to "A.F." and the signal tracer switch set to "Output Volts" so that the signal strength produced by the oscillator will be registered on the output meter scale.

Be careful not to overload your meter due to excessively strong signals by keeping the attenuator control on the signal tracer turned well down when you are changing from one tuning frequency to another or for all preliminary adjustments.

BATTERY LIFE.

The A battery supplied with this unit, namely the 1.5 volt torch cell, is not large enough to be able to operate the full five valves for a long period of time and consequently, when you commence using your test panel regularly it will be desirable for you to replace the 1.5 volt torch cell with a much larger type of 1.5 volt cell. There is available a 1.5 volt dry cell measuring about 6" high by about 2½" in diameter. This type of cell is ideally suited as it will operate the five valves for about 200 hours before it requires replacement. The 45 volt B battery is quite large enough for powering the valves for normal usage but ultimately of course will become discharged and will have to be replaced with another. Any type of 45 volt battery may be used. On no account ever use an A battery which has a voltage greater than 1.5.

The C battery will probably last about 12 or 18 months before it has to be replaced but this of course will depend largely on how much use it has had in the previous experiments described in the earlier lesson papers. In any case, you always have your multimeter available for checking the voltage of these batteries. The voltage of the A and B battery should always be checked under load, that is, when the instrument is turned on, as a battery which is almost discharged will give a high voltage reading if it is tested with no load after a period of rest.

It is suggested that the instrument be supported and protected by being built into a wooden case or frame which may then be mounted at the rear of your workbench.

You have now assembled an extremely useful and highly efficient test panel which will enable you to speedily analyse practically any faults in radio receivers. You have available an oscillator which will act as a source of test signals at any time regardless of whether broadcasting stations are functioning or not, a signal tracer to help you rapidly locate the stage in a receiver in which a defect exists and also a multimeter to help you analyse the faulty stage to determine just what part is causing the fault. With the aid of these instruments and sound experience which can only be gained from a theoretical background supported by actual practical experience, you have everything necessary to enable you to develop into a really efficient service engineer. The theoretical training you need is contained in the A.R.T.C. Radio Service Engineering Course and the practical experience will come with practice in handling various receivers.