# NOTICE

Due to the wartime scarcity of Radio Parts, we have found it necessary to substitute a different model Power Transformer in our Power Supply Assembly. While electrically the same as the original, a new model, identified by the figures "1473", has a different arrangement of its numbered lugs or terminals.

On the next page you will find diagrams illustrating the changes of lug numbers and terminal connections that were necessary to make in the power supplies that use power transformer "1473" instead of the original power transformer.

Look underneath and see which power transformer is used in your supply:

1. If your transformer is NOT numbered "1473" you may go ahead with your power supply experiment exactly as indicated.

2. If your power transformer is "1473" it will be necessary to make the following changes in your experiment sheets, as these instructions were written for the original power transformer.

| Change Original Trans. Lug No. | to | New No. |
|---|---|---|
| 1 | ——— | 10 |
| 2 | ——— | 3 |
| 3 | ——— | 8 |
| 4 | ——— | 1 |
| 5 | ——— | 6 |
| 6 | ——— | 5 |
| 7 | ——— | 4 |
| 8 | ——— | 7 |
| 9 | ——— | 2 |
| 10 | ——— | 9 |

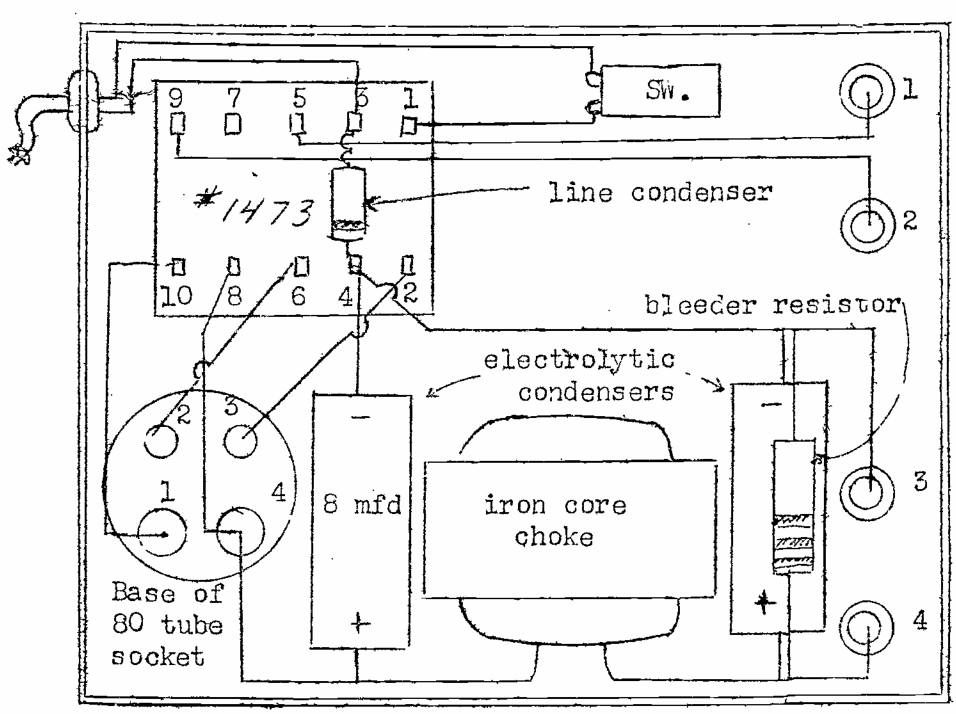
Kit:PSN

In the assembly of the power supply making use of the #1473 transformer, reversal of the leads to transformer terminals #8 and #10 may exist. Also, connections to terminals #5 and #9 or transformer terminals #1 and #3 might be reversed. However, as these are a.c. circuits, reversal of the connections will not affect the operation of the unit.

Except for qualifications given directly above, should your power supply be wired differently, making use of the #1473 transformer, please mark the discrepancies on the sketch below and mail the diagram in to us with explanations.

Do not send in any parts of your kit projects until you have written to us about the matter.

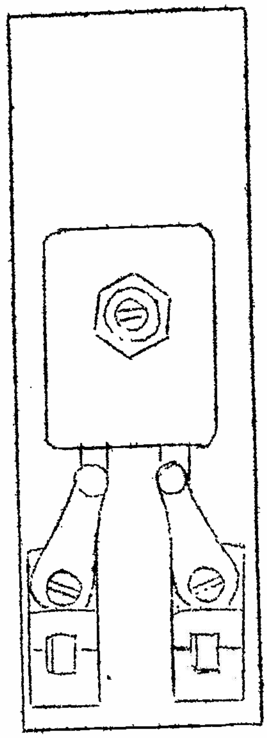
Wiring Diagram using transformer #1473 is shown below:



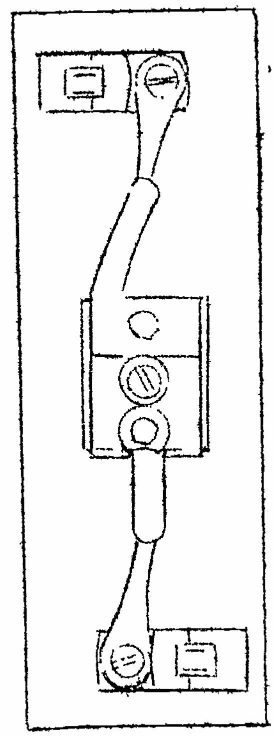

Kit:PSN

## NOTICE

### PADDER CONDENSER



1st TYPE



2nd TYPE

Due to the scarcity of Radio Parts, either of the above types of padder condenser may be included in your Home Laboratory Kit.

Electrically, both are the same and adjusted by the central screw. Both have two spring clip terminals to provide the same electrical circuits.

Although the 1st type is shown in the Pictorial Diagrams, it can be replaced by the 2nd type provided the corresponding wires are connected to each of its spring clip terminals, and either clip may be denoted as Terminal "1" or Terminals "2".

The DeForest's Training Home Laboratory has been designed to bring the advantages of class room and Laboratory work to the Home Study Student: To overcome many of the difficulties of learning by reading only: To provide a means for practical application of Electrical and Electronic principles and to give you a first hand, practical knowledge of the standard components and circuits which make up most of the ordinary types of electronic apparatus.

The various parts and sub-assemblies, which are included in the complete Home Laboratory, have been painstakingly selected to provide the widest possible variety of application and permit the assembly, as well as the operation, of most types of Electronic equipment.

Every assembly project has been carefully and completely worked out here in our Laboratories and every precaution has been taken to insure their proper operation. The Experiments or Job Sheets, pertaining to each shipment of parts, have been written from these properly made units, and especial care has been taken to make them complete in every detail. Therefore, above all else,

FOLLOW THE INSTRUCTIONS CAREFULLY.

We know you are anxious to secure operation of the various assemblies as quickly as possible and our step by step instructions have been written with that thought foremost in mind.

One wrong connection or one poor contact can make an entire assembly inoperative and may damage some of the parts therefore, we are going to ask that you take nothing for granted, go slowly and make sure that each and every piece of wire, not only attaches to the proper spring terminal at both of its ends but, makes proper electrical contact. Let us repeat,

DON'T HURRY - READ THE INSTRUCTIONS FIRST

As you progress with your Laboratory experiments, you will become familiar with many of the common circuit connections and will not require complete detailed instructions. However, for the first few hook-ups at least, you will actually save time and increase your knowledge more quickly by following each and every step, exactly as outlined, in the instructions of each job.

The complete parts of your Home Laboratory will be sent in a series of "Kits", each containing a number of separate parts.

Included with each kit will be a list of the parts it contains and a series of "Jobs" which are to be worked out. The individual parts will be required for future "Jobs", in addition to those included with each kit, and thus we suggest you immediately arrange for a carton, drawer or other convenient storage space, in which all of the parts can be kept without danger of loss or damage.

A working space, 30 inches long and 18 inches wide will be needed for some of the later "Jobs" and it will be well to make arrangements for it at this time. As the ordinary card table has a 30 inch by 30 inch top, you should have little trouble in arranging for space to set up your Laboratory. If at all possible, we suggest you make use of some table space, not used for other purposes, so that the various assemblies need not be distrubed, as long as you want to use them.

If you have a room of your own, the top of a dresser, desk or card table will provide ample working space. The parts can be stored in a drawer or carton, located close to the working space. This is convenient because all of the parts are not used in all of the jobs and, in order to check various actions, it will be necessary, at times, to substitute one part for another of different value or purpose.

## POWER SUPPLY

Like practically all electronic units, some outside sources of electricity is needed to operate the tubes and some means must be provided to convert the electrical energy of this outside source to the proper values of voltage and current. This converter unit is included in your Laboratory parts under the commonly used name of a "Power Supply".

There are two common sources of electrical energy, 6 Volt Batteries, and 110-120 Volt Alternating Current (a-c).

Make sure that the Power Supply unit of your Laboratory is designed for the kind and voltage of electricity you have available. This precaution applies only to the Power Supply as the experimental electronic circuits depend entirely on its output for their proper operation.

## LABORATORY JOBS

Each Laboratory Job is made up of three parts or sections. First, the "Outline" which contains a list of the parts required and a brief explanation of the purpose of the job. Details are given in respect to the name, purpose and con-

struction of each of the component parts, the type of circuit which is to be built and the commercial units which it duplicates or simulates.

Second, the "Wiring Procedure" which contains a complete and detailed, step by step, explanation for the placement of each piece of connecting wire. In order that you may know not only the physical location of each wire, but also its electrical position in the circuit, we have included two types of diagrams. One, a "Pictorial" or "Layout" diagram is really a "plan view" picture of the assembly which shows the actual shape of each part, the location of each terminal and the position of each wire.

To avoid confusion, these drawings show a separation between the various parts but, in the actual assembly, we suggest that you follow the arrangement of the "Pictorial" but move the parts close together.

The other diagram, known as a "Schematic" is a sort of technical shorthand and indicates only the electrical features of the circuit. The various parts are indicated by "Symbols" which, although simplified, are drawn to represent the actual arrangement or construction of the part.

Practically all technical work is done by means of "Schematic" diagrams and we want you to carefully check each one of them against each accompanying Pictorial. Be sure and make this comparison from an electrical standpoint because, at first glance, they may not look anything alike.

This particular arrangement is a very important part of your Laboratory work as it will teach you to read schematic diagrams, as drawn on paper, and readily check them against the actual assembly of the parts. Every Electronic technician must know how to read schematic diagrams and this feature of our Laboratory Training will enable you to gain this ability in the shortest possible time.

Third - The "Operating Procedure" which contains the details for placing the particular assembly in operation, for making any needed adjustments, for checking improper conditions as well as any precautions which should be observed.

## SCOPE OF LABORATORY JOBS

Starting with elementary but all important subjects, the succeeding Jobs take up the construction, operation, principles and test procedures for the commonly used circuits of Radio Receivers, Radio Transmitters, Audio Amplifiers, Photo Electric Cells, etc.

As the entire purpose of DeForest's Home Laboratory is to help train you in the study of Electronics, no attempt has been made to design the various assemblies along commerical lines. Instead, the use of spring clip terminals, for all connections on all parts, makes it possible to change circuits in the least amount of time.

Every effort has been made to design this Laboratory to provide maximum benefit in your studies. While the arrangement of the sub-assemblies greatly reduces the time consuming mechanical operations of mounting and making permanent connections, this part of your training has not been neglected because the speed at which you can construct circuits, by the use of our method, quickly provides you with a familiarity of the components sufficient to make the mechanical work extremely simple.

In conclusion, let us repeat —

1 - READ THE INSTRUCTIONS FIRST

2 - TAKE YOUR TIME

3 - FOLLOW THE DIRECTIONS EXACTLY

4 - MAKE SURE OF EVERY CONNECTION

5 - RECHECK EVERY CIRCUIT BEFORE YOU TURN ON THE POWER

6 - MAKE ALL ADJUSTMENTS SLOWLY

Please note: There are no questions to be answered in connection with the kit experiments.

# POWER SUPPLY

As you will learn later in your Home Study Training Program all ordinary types of Radio Tubes are essentially direct current units and arrangements must be made to supply some of their circuits with D.C. of comparatively high voltage. Other tube circuits require a comparatively low voltage which may be either D.C. or A.C.

The large assembly of this shipment is designed to operate on the common 110 volt, 60 cycle A.C. home lighting circuits and provide a high voltage D.C. as well as a low voltage A.C. for the operation of the various tube circuits to be constructed in the projects of this Home Laboratory program. That is why the unit is known as a "Power Supply".

The various parts of the Power Supply Assembly, as well as their principles of operation will be fully explained, as you advance in your training. Therefore, at this time, we want to give you only a general idea, together with a few tests, in order that you may begin your laboratory experiments without further delay.

An examination of the assembly will show that all of the various parts are mounted on a metal base or "chassis" which is made originally as shown in Figure 1 of the first page of illustrations. After the larger components have been mounted, the underside of the base will appear as in Figure 2.

None of the wiring is installed but, as we will explain that later, we want you to look at Figure 3 which shows the top of the unit. Here you see the main parts including the wafer socket, in which the rectifier tube is mounted.

Notice particularly the four insulated terminals, shown at the right of Figure 3, because you will use them for making connections to all of your experimental projects. To operate these terminals, you simply press on the insulated top moving it down a fraction of an inch. This movement produces an opening, through the body of the terminal and the wire, which is to be connected, is pushed through the opening. The top is then released and a spring forces it up sufficiently to clamp the wire securely in place.

The pictorial diagram, on the second page of illustrations, is a bottom view, similar to Figure 2, but of the complete assembly with all of the connecting wires in place. Notice here, the position of the parts appears to be opposite in the Pictorial Diagram when compared to Figure 3. However, if you will place the actual unit in the corresponding positions, you will find the drawings are correct.

Going back to the Pictorial Diagram, the large unit, shown at the upper left, is the power transformer. Its function is to convert the 110 volt, 60 cycle A.C. supply to both higher and lower voltages as required for the operation of the various tube circuits.

You will notice ten numbered terminal lugs on this unit, numbers 2 and 4 of which connect to the 110 volt supply through the "OFF-ON" switch, shown at the top center, and the two wire cord extending outside the base. Lugs 6 and 10 connect to power supply binding posts 2 and 1 respectively, while lug 8 is not used.

Lugs 1 and 3 connect to the tube socket terminals 4 and 1 respectively, as shown at the lower left, while lug 5 connects to socket terminal 2 and lug 9 to socket terminal 3.

The four openings in the socket correspond, in size and position, to the 4 prongs on the base of the type 80 rectifier tube. Notice carefully that openings 1 and 4 are larger than 2 and 3 and, when the tube is inserted in the socket from the top, the prongs on its base must coincide with the openings.

The large unit, shown at the bottom center, is the filter choke and the cylindrical units on each side are the filter condensers. The small cylindrical unit, shown on the right filter condenser, is the "Bleeder Resistance" while the unit of similar size, connected between transformer lugs 4 and 7, is the line condenser.

The left hand filter condenser connects from socket terminal 4 to transformer lug 7, while the right hand filter condenser connects from binding post 4 to binding post 3. The filter choke connects from socket terminal 4 to binding post 4, and the bleeder resistance from binding post 4 to binding post 3 which, in turn, connects to transformer lug 7.

The transformer, rectifier, filter choke and condensers operate to provide a high voltage D.C. at binding posts 3 and 4 while binding posts 1 and 2, provide a low voltage A.C.

The schematic diagram shows all of the electrical circuits of this Power Supply unit and, as the various parts are named and numbered, exactly as in the pictorial diagram, we want you to make a careful comparison of the two diagrams.

Remember, the Pictorial Diagram shows the bottom of the unit and therefore, when in use, it will be turned with this side down. The tube will be inserted from the top and connections made to the insulated binding posts, 1, 2, 3 and 4, which project from the top.

R

When the unit is turned over to its operating position, the order of the numbered binding posts will be reversed. Looking at the Pictorial Diagram, from the right margin of the illustration, No. 4 binding post is at the left. However, turning the unit over, with the binding posts still toward the right margin of the page, No. 4 binding post will be at the right as shown in Figure 3.

To help you become familiar with this Power Supply unit, your first Laboratory Experiment will be to make a series of routine tests to determine if all of its circuits are operating properly.

# POWER SUPPLY TEST

## Material Required

1 - Power Supply, Wired and Assembled
1 - Rectifier Tube
1 - Voltage Indicator

## OUTLINE

The subject of testing electronic equipment is an extremely large one and, while details will be explained later in your training, at this time we have made provisions for a few simple tests which will indicate whether or not your power supply is operating properly.

The tester, made under the trade name of "Tattelite", consists of a small neon lamp, mounted in a Tenite socket which contains a 200,000 ohm protective resistance. A red and a yellow test lead extend from the socket and terminate in insulated Test Tips.

When the tips are connected across a-c circuits of 60 volts up to 500 volts, both electrodes of the lamp appear to glow and, as the intensity of the glow is proportional to the voltage, the approximate value of the voltage can be estimated.

When the tips are connected across d-c circuits of 90 volts to 500 volts, only the negative electrode glows and here again, the intensity of the glow is proportional to the voltage. Also, as only the negative electrode glows, the test will instantly indicate the polarity of a d-c circuit.

Other applications are given in the instructions attached to this tester but, as far as this Power Supply unit is concerned, we are interested mainly in the tests mentioned above.

## PROCEDURE

Your first test will be of the primary circuit and, as a start, insert one of the Test Tips of the Tattelite, into each opening of the house wiring outlet you are going to use to operate the power supply. Both electrodes of the neon lamp should glow, indicating an a-c supply which is correct. Although you have already sent us information regarding your Home Lighting Circuits, a check here will make you doubly sure and also give you a chance to "Test the Tester" and see it operate.

Caution -- Should but one electrode of the Tester light up, do not plug in the Power Supply Cord. -- Make sure you have a 60 cycle a-c supply before plugging in.

When you feel sure the supply is correct, plug in the Power Supply Line cord and then, being careful not to touch any exposed terminals, place one Test Tip on transformer lug 2 and the other on the toggle switch terminal soldered to the line cord.

The test lamp should glow the same as when you inserted the tips in the outlet of your house wiring system, and indicate the line cord is in good shape and properly connected.

To test the toggle switch, place one test tip on transformer lug 2 and the other test tip on transformer lug 4. If the test lamp does not glow, snap the toggle switch lever and it should light up. If the test lamp does glow, snap the toggle switch lever and it should go out. While watching the test lamp, turn the switch off and on a few times to make sure it controls the primary circuit.

To test the high voltage winding of the transformer, turn the toggle switch on and place one test tip on transformer terminal 5 and the other on terminal 7. The test lamp should glow but its intensity should be brighter than when testing the primary circuit.

Then, leaving one test tip on transformer terminal 7, move the other test tip to terminal 9. This will check the other half of the winding and the intensity should be the same as when the test tips were on terminals 5 and 7.

For a final check, place one test tip on transformer terminal 5 and the other on terminal 9. The test lamp should glow with more intensity than for any of the previous tests.

To test the wiring of this high voltage circuit, place one test tip on the lug of insulated terminal No. 3 and then touch the other test tip first to socket terminal 2 and then to socket terminal 3. Both electrodes of the test lamp should glow in both of these positions.

Suppose, for example, that with the test prods on transformer terminals 5 and 7, the test lamp glows properly but, with the test prods on socket terminal 2 and insulated terminal 3, the test lamp will not light.

This indicates trouble and to locate it, you can hold one Test Tip on insulated terminal 3 and move the other from socket terminal 2 to transformer lug 5. If this change causes the test lamp to light, it indicates trouble in the connection between these two points.

R

To check the connection between transformer lug 7 and insulated terminal 3, you can hold one test tip on transformer lug 5 and then move the other one from transformer lug 7 to insulated terminal 3.

Remember, the test lamp will not light without a complete circuit so that, by keeping this fact in mind, it is not difficult to locate a break.

The other transformer secondaries do not develop sufficient voltage to make the test lamp glow therefore, to test this condition, place one test tip on transformer terminal 1 and the other on terminal 2. If the wiring is correct, the test lamp will not light.

In the same way, you can test the other transformer secondary by placing one test tip on transformer terminal 6 and the other test tip on terminal 10. Here again, the test lamp should not glow but, if it does, check the diagram against your assembly.

A rough check can be made on these low voltage windings by simply taking a short piece of hook-up wire and holding one end on one terminal and then quickly snapping the other end past the other terminal so as to make a quick contact. A spark, at the point of contact, indicates the circuit is alive.

Rectifier Tube

After these tests have been completed, turn off the toggle switch and turn the chassis base right side up. If you have not already done so, remove the rectifier tube from its packing.

Previously, we told you that two of the socket holes were larger than the others and now, you will see that two of the prongs, on the base of the tube, are larger than the other two.

With the base down, hold the tube an inch or two above the socket and then turn the tube until the two large prongs are directly above the two large socket holes. Then, holding the tube in this position, move it down until the prongs engage the holes of the socket. A pressure on the top of the tube will force it all the way into the socket which is its proper operating position.

When the tube is properly seated, plug in the line cord, and turn on the toggle switch. Look down into the top of the rectifier tube and you will see the filaments heat up until they glow a rather dull red.

You can now turn the assembly on its side, power transformer down and continue your tests with the voltage indicator. So

far, all tests caused both lamp electrodes to glow and indicated A.C. Now, if the rectifier is operating properly, we should find some high voltage D.C.

You already tested from insulated terminal 3 to socket terminals 2 and 3 and found A.C. was indicated. Now, with the tube in place and in operation, place one test tip on insulated terminal No. 3 and the other test tip on socket terminal No. 1. But one electrode of the test lamp should glow to indicate the presence of D.C.

In the same way, with one test tip on insulated terminal No. 3 and the other test tip on socket terminal No. 4, but one electrode of the test lamp should glow. This indicates D.C. at the rectifier end of the filter, therefore, as a final test, place one test tip on insulated terminal No. 3 and the other test tip on insulated terminal No. 4. Here again, but one electrode of the test lamp should glow to indicate that high voltage D.C. is available at these terminals.

Power Supply Operation

With but a simple "off-on" type of toggle switch as the only control, the operation of this power supply can not be complicated. However, there are several important points to keep in mind. They are important because by following them, the life of the rectifier tube will be increased. The possibility of transformer, or filter breakdown will be reduced. The danger of receiving electrical shocks will be almost eliminated and the operation of the future Home Laboratory Projects will be improved.

Perhaps the most important of these points is to remember, after these preliminary tests have been made, to never turn on the power supply unless you have some external circuit connected across insulated terminals 3 and 4.

As we explained earlier, the bleeder resistance is permanently connected in this position but an external circuit offers added protection to high voltage and thus reduces the possibility of punctured insulation.

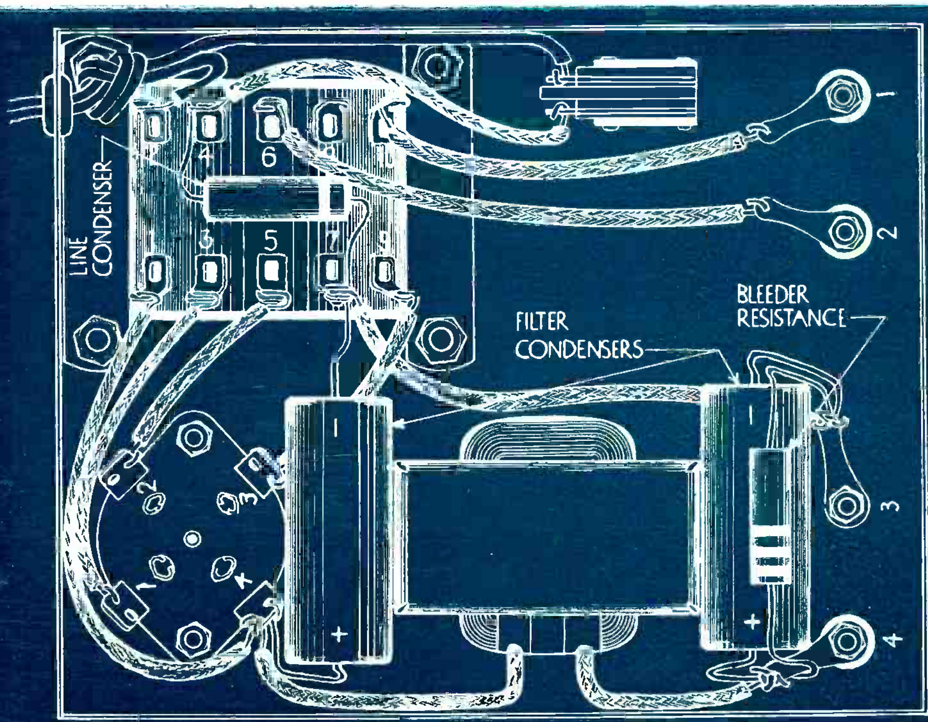
After the power supply has been in operation, before you touch any exposed terminals of any of your projects, make sure the toggle switch is off and then short across insulated terminals 3 and 4 with your screw driver blade or a piece of wire to make sure the filter condensers are completely discharged.

Always operate the power supply in its proper position, that is, with the tube vertical, and make sure that no pieces of

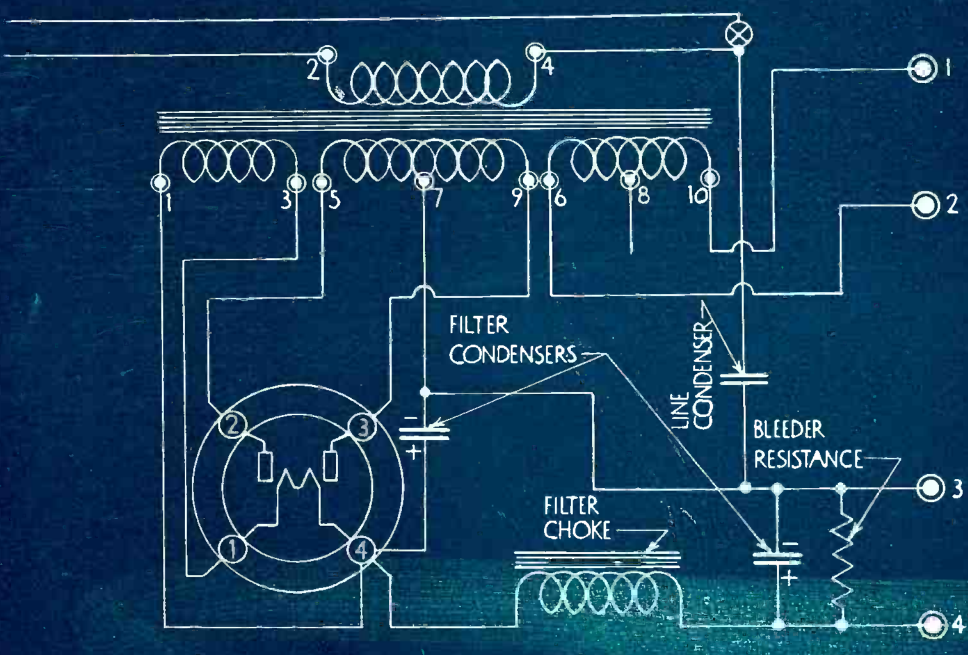
wire or metal objects collect under the chassis base. We purposely closed in all four sides of this chassis in order to protect both you and the unit. Don't nullify this protection by being careless.

As this power supply operated all of the other projects you will build, its toggle switch becomes the "Off-On" or control switch for them. Always use the switch and never pull off some external wire to stop operation.

The components of this power supply are first quality, standard parts and, with ordinary care, should provide lasting service. The voltages developed are sufficiently high to cause unpleasant shock therefore, give this unit the respect it deserves and it will provide you with almost unlimited possibilities for your future experiments.




PICTORIAL DIAGRAM




SCHEMATIC DIAGRAM

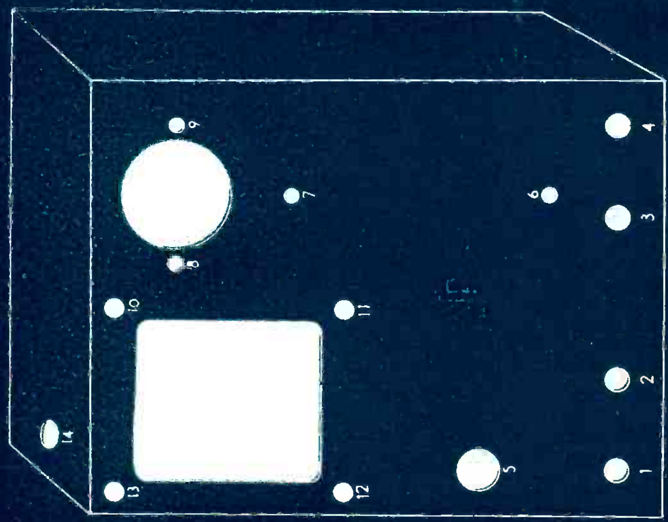


FIGURE 1

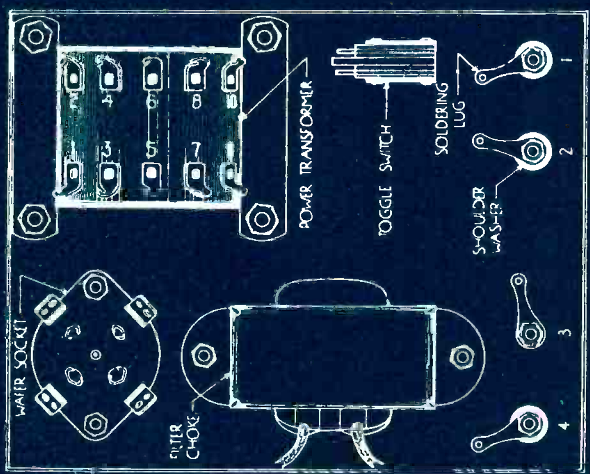



FIGURE 2

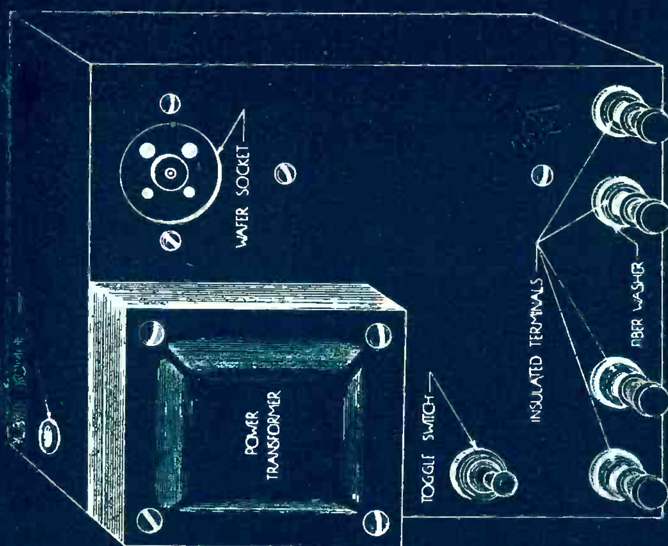



FIGURE 3

# HARTLEY OSCILLATOR

## Material Required

1 - Power Supply (Complete)
1 - Octal Socket (SA)
1 - Antenna Coil (SA)
1 - Padder Condenser (CA)
1 - 6SJ7 Tube
1 - Hook-up Wire

## OUTLINE

Starting with this project, you are beginning your regular series of Laboratory Experiments, and, as most of the following work will be built up on the same general plan, we want to include many of the essential instructional details at this time.

Turning to the first page of illustrations, we suggest that you fold it out so that you can check our instructions against the diagram at any time without turning any pages. All of the diagrams are printed on a "folded" sheet for your convenience and should be turned out while you are assembling, testing or operating the various units.

Looking at the Pictorial Diagram, on the upper part of the page, you will find it contains four main parts, or subassemblies.

1. The Power Supply which you tested for your former project. Notice carefully here that the insulated terminals of the power supply are numbered to coincide with the former explanations.

The Power Supply, shown in the schematic diagram, is the type which operates from a 110 volt 60 cycle A.C. lighting circuit. If your power supply is of this type, you will find this schematic is electrically the same as that shown in your last instructional sheet.

If your power supply is of another type, the position and numbering of its terminals coincide with these shown and you can therefore follow all of these instructions but need not pay any attention to the internal connection of the power supply as shown in the schematic diagram.

2. The Octal Socket which is mounted on a base with a separate spring terminal clip for each of the 8 contacts. If you are

not familiar with tube sockets, we suggest that you compare this assembly with the "Tube Symbol" shown in the Schematic diagram.

We have numbered the various terminals of the socket according to the Radio Manufacturer's Association, (R.M.A.) standards and it may be of help for you to mark them on the base as shown in the Pictorial diagram.

Looking at the Pictorial diagram, you will notice there is a keyway in the center opening of the socket and, starting with No. 1 for the terminal at the left of the key, our numbers increase in an anti-clockwise direction.

In the base diagram of the Schematic drawing, you will find the numbers increase as you go around in a clockwise direction.

This is a good illustration of our former explanation of working from both the top and the bottom. Our socket assembly is numbered from the top while the base diagram is numbered from the bottom. By holding the Pictorial diagram up to the light and looking at it from the back, or "bottom", you will find these numbers coincide with those of the Schematic diagram.

3. The Antenna Coil, mounted inside a metal shield can which in turn is mounted on a base. There are seven separate spring terminal clips also mounted on the base and we have numbered them to simplify our explanations.

For the internal connections of the actual windings of the coil, we want you to look at the schematic diagram. Here you will find terminals 2 and 3 connect to one winding while terminals 4, 5 and 6 connect to a second winding. The ends of this winding connect to terminals 4 and 6 while terminal 5 connects to a tap.

Going back to the antenna coil assembly of the Pictorial diagram, spring clip terminal No. 1 has no connections but will be used later merely as a support for some connecting wires. Terminals 2, 3, 4, 5 and 6 connect as shown in the schematic diagram while terminal 7 connects to the coil shield and can be used as a ground.

4. The Padder is an adjustable type of condenser found in many electronic applications in which a circuit must be tuned but operates at only one frequency. Most "Trimmer" and "Padder" condensers are of this same general type of construction and their use will be brought out fully as you progress with your training.

There are but two terminals for the condenser, which, as shown in the schematic diagram, connects across and tunes one of the coil windings. For convenience, the terminals are numbered 1 and 2.

As you perhaps know, it requires a comparatively high frequency voltage to transmit Radio signals through space and, at present, the vacuum tube is the best known and most widely used high frequency generator.

Because the lowest Radio Frequency is considered roughly as 10,000 cycles per second, with the higher values going up to millions of cycles per second, a tube used to generate these frequencies is commonly called an "Oscillator".

In order that you may learn Electronics as quickly as possible, your Laboratory experiments will start with the generation of Radio Frequencies and give you an idea of how they are produced and controlled.

You must remember here that all Radio signals on the air are under the control of the Federal Communications Commission (F.C.C.) and therefore none of these generating or oscillating circuits can be connected legally to an outdoor antenna or even to a long indoor antenna. By following our instructions closely, you will not cause Radio interference and thus will not be breaking any Radio regulations.

The circuit of this project is shown as a "Hartley" type oscillator and, in effect, it is really a miniature Radio Broadcast Station. It is also the general type of circuit used in many modern Superheterodyne Receivers as well as most models of R.F. test oscillators, therefore we want you to study its operation closely.

## WIRING PROCEDURE

You will find the wiring of these experimental laboratory Projects is extremely simple, once you have the idea and thus we want you to go slowly on this first experiment.

After you have all of the various terminals of each of the four sub-assemblies properly marked, or identified, arrange them on your work table in approximately the position shown by the Pictorial Diagram but with less space in between. For clarity, we show all right angle bends in the connecting wires but, of course, this is not necessary. However, we suggest you allow a little extra length for each wire so that you will be able to move the sub-assemblies somewhat, should you desire to do so. In general, keep the sub-assemblies close together and the connecting wires short.

Push back hook-up wire is used to make a connection. You push the insulation back until about ½ inch of the copper wire is exposed. Then, push down on the upper part of the spring clip terminal until the center closed loop projects through the central slot. The bare wire is then pushed through so as to pass over the outer spring, under the central loop and over the outer spring on the other side. Then, when you remove your finger, the outer part will spring up and hold the wire securely.

After one end is in place, you thread the wire over to the terminal which is to be connected, cut it off about ½ inch too long and then, following the method first explained, secure this end in the spring clip. A careful study of the pictoral diagram will show the proper appearance of these spring clip connections with the connecting wires in place.

Although the mechanical design is different, connections are made to the insulated terminals of the power supply in the same general way. When their insulated top is depressed, there is an opening all the way through the terminal body and the bared end of the wire should be pushed through. Then, when the top is released, the spring will hold the wire tightly.

After you become more familiar with these circuits, you will follow your own sequence of making connections but now, we will give a detailed, step by step procedure. Remember, each connecting wire must be bared at both ends and make a good metallic contact with the clip or terminal.

One wrong connection, one omitted wire or one poor contact can cause the entire project to be imoperative. Therefore, we suggest that you check-mark or draw a pencil line through each of the following connections immediately after you have made them and before you start another. Also, it will help to check each connection against the diagrams.

WIRING CONNECTIONS

1. From power supply terminal 1 to socket terminal 2.
2. From power supply terminal 2 to socket terminal 7.
3. From power supply terminal 3 to socket terminal 1.
4. From power supply terminal 4 to socket terminal 8.
5. From socket terminal 1 to antenna coil terminal 6.
6. From socket terminal 3 to socket terminal 8.
7. From socket terminal 4 to antenna coil terminal 4.
8. From socket terminal 5 to antenna coil terminal 5.
9. From socket terminal 6 to socket terminal 5.
10. From padder terminal 1 to antenna coil terminal 4.
11. From padder terminal 2 to antenna coil terminal 6.

These eleven connecting wires complete the circuit connections but, before going ahead, check them all over, at least once, to make sure they are all correct.

OPERATING PROCEDURE

When you feel sure the circuit is correctly wired, unpack the 6SJ7 tube and place it in the octal socket. To do this properly, start the large central projection on the tube base into the central hole of the socket. Then without any downward pressure, turn the tube slowly until the key and keyway come in line and the tube drops until the metal prongs engage the socket holes.

Never try and force the tube into the socket until the key and keyway are in line. Then, and then only is it safe to push the tube down and seat it properly. Also, by following this plan, the prongs of the tube will engage the proper socket holes and thus provide the proper circuit connections.

The high frequencies generated by the oscillator can not be heard by human ears but they are used to carry signals, which can be heard, from the transmitter to the receiver. To check the operation of this assembly you will need a radio receiver. Any receiver which picks up the ordinary Broadcast Programs will do.

If you do not have a Radio receiver, take your assembled oscillator to a friend or neighbor who has one. It is not necessary to make any direct connections to the receiver, thus your experiments will not disturb or injure it in any way. You will use it only to pick up the signals from your oscillator.

Experiment No. 1.

The purpose of this experiment is to detect the presence of a Radio Carrier and show the interference it can cause.

To perform this experiment, connect one end of a length of hook-up wire in the antenna coil spring clip terminal No. 4. The other end of the wire is twisted around the antenna lead-in wire of the Radio Receiver. Do not make an actual metallic contact here but simply leave the wire insulation in place and twist one insulated wire around the other.

Should the Radio Receiver be of the type which has a self-contained antenna, wind a few turns of hook-up wire around your hand to form a small coil or loop. Place this loop on the back of the receiver cabinet.

Turn on the Radio Receiver and tune in a Broadcast station near the low frequency end of the dial. That is, a station somewhere between 550 K.C. and 700 K.C.

Then, plug in the line cord of your oscillator and turn on the toggle switch of the power supply. It will take a few seconds for the tubes to heat and while you are waiting, take your screw driver and turn the adjusting screw of the padder condenser in an anti-clockwise direction until it begins to tighten. Do not put much pressure on this screw and do not turn it any more than necessary. It is used only to compress or release the condenser plates and must be treated like the delicate adjustment it is.

By this time, oscillator tube should be warmed up, therefore, turn the adjusting screw very slowly in a clockwise direction. As you reach a certain position, the receiver speaker will start to squeal or howl and, as you continue turning the adjustment in the same direction, the squeal will change in both pitch and intensity, finally dying out entirely.

By turning the adjusting screw slowly in an anti-clockwise direction from this position, you can again cause the squeal which will ruin the Broadcast Program the receiver is tuned to.

This is the action you will cause in all the Radio receivers of your neighborhood, if you connect your oscillator to an outdoor or a long indoor antenna. After hearing the noise, you can understand why the F.C.C. is extremely strict and may prosecute anyone who radiates illegal signals.

If, for some reason or other, your oscillator fails to cause this interference, check all the circuit connections carefully. Twist the hook-up wire around the Radio antenna lead-in a few more times. If you are using the small hand made loop, increase its number of turns and try it in different positions around the receiver.

Should none of these produce the desired action, reverse the coil connections so that socket terminal No. 4 connects to coil terminal No. 6 and socket terminal No. 1 connects to coil terminal No. 4.

Experiment No. 2.

The purpose of this experiment is to show that the adjusting screw of the padder condenser controls the frequency of your oscillator.

To carry out this experiment, tune in another station on the Radio Receiver, preferably at a higher frequency than the

station used in Experiment No. 1. Then, turn the adjusting screw of the padder condenser until you obtain the same interference as in the former experiment.

Try a number of different Broadcast stations, at various points on the dial of the Radio Receiver, and then slowly turn the adjusting screw of the padder condenser to cause interference with each one.

You will find that you can tune the interference with the padder adjusting screw much the same as you tune the stations on the Radio Receiver.

Perhaps you are wondering why it is necessary to tune in a Broadcast station for these experiments but, as we have already told you, the high Radio frequencies can not be heard. However, when the Radio frequency carrier of a Broadcast station is tuned in and the high frequency of your oscillator is tuned to about the same frequency a "Beat" note is produced and its frequency is low enough to be heard.

<u>Experiment No. 3</u>

The purpose of this experiment is to show the presence of your oscillator frequency on the "Tuning Eye" of a Radio Receiver.

To perform this experiment, the Radio Receiver you are using must have a "Tuning Eye" type of indicator. The kind in which the shadow angle reduces as the stations are tuned in.

To see this action, proceed as in Experiments 1 and 2 but, adjust the Padder condenser only until you cause the interference. Then, detune the Radio Receiver slightly until the shadow angle of the tuning eye opens.

Then turn the adjusting screw of the padder slowly about a half turn both ways while you watch the tuning eye. You will find one position of the adjusting screw will cause the eye to close in exactly the same way as when a Broadcast station is tuned in. This action can be seen at any part of the Broadcast Band Dial.

<u>Experiment No. 4.</u>

The purpose of this experiment is to show the effect of a Radio Frequency Carrier on a Radio Receiver with Automatic Volume Control.

To perform this experiment, proceed as in Experiment No. 3 but, after the Broadcast station has been detuned, turn up

the volume control of the Radio Receiver. This should cause quite a high level of noise or "static" in the speaker.

Then, turn the adjusting screw of the padder slowly until you find a point which causes a sharp and decided drop in the noise level of the speaker.

This shows that your oscillator is tuned to the same frequency as the Radio Receiver and that the energy of your carrier frequency has caused the automatic volume control of the Receiver to operate and reduce the sensitivity.

Go over these experiments carefully until you have no difficulty in tuning your oscillator to any point on the receiver dial, whether or not a Broadcast station is tuned in. This is important because, for your next project, it will be necessary to properly tune both the oscillator and the Radio receiver.

# WIRELESS MICROPHONE

Material Required

1 - Hartley Oscillator
1 - Headphone

## OUTLINE

In your experiments with the Hartley Oscillator, you proved the presence of a high frequency Radio Carrier but could actually hear it only by causing interference with another carrier.

From a more practical standpoint, this high frequency carrier can be used by itself, to carry signals or intelligence provided we can mix the signals with the carrier. This mixing is known as "Modulation" and, in the common type of Broadcast station, the signal controls the strength or amplitude of the carrier.

For this project therefore, we have a simplified arrangement by which your own voice can be used to modulate the high frequency of the oscillator and thus, in effect, give you a miniature Broadcast station.

At this point in your work, all of these circuits are of the simplest possible type but we want you to study them carefully because the principles of operation are the same as those used in all amplitude modulation types of Broadcast stations.

Do not expect the power and quality of this miniature station to compare favorably with a large commercial Broadcast station but, if you follow the circuits carefully and operate them properly, the results may surprise you.

## WIRING PROCEDURE

Turning to the diagrams of this project, we want you to compare them with those of the Hartley Oscillator. Checking carefully, you will find but one change. The connecting wire between socket terminals 5 and 6 has been removed. In its place, one headphone cord tip is inserted in terminal No. 5 and the other in terminal No. 6.

Should you have found it necessary to change any connections of the Hartley Oscillator, to obtain proper operation, use the corrected circuit for this project.

R

As we explained for the power supply assembly, we want you to compare the pictorial and schematic diagrams of every assembly you wire.

Experiment No. 1

The purpose of this experiment is to transmit voice signals from your oscillator to a Radio Receiver.

Following the plan of the Hartley Oscillator experiments, place the Radio receiver in operation, plug in your power supply and turn it on so that the oscillator will also be in operation.

First, tune the Radio receiver, preferably toward the low frequency end of the dial, to a position at which no Broadcast station signal can be heard. If the receiver has a "Tuning Eye", the shadow angle should be in its widest position.

Then, turn the adjusting screw of the oscillator padder condenser until the oscillator frequency is the same as that for which the receiver is tuned.

Next, hold the headphone close to your mouth and talk into the central opening. Use a low tone of voice but talk distinctly. If you don't know what to say, you can use the old reliable expression, "One, two, three, four, testing" and repeat it as often as you wish.

While talking into the phone, which is now acting as a microphone, turn the padder adjusting screw slightly, first one way and then the other, until your voice is loudest in the speaker of the Radio receiver. You can then adjust the Radio volume to produce the signal level you desire.

It is sometimes rather confusing to hear your voice both entering the microphone and leaving the speaker therefore, if possible, have someone else talk into the microphone while you adjust the oscillator padder and Radio Volume.

Make a note of the position of the Radio Tuning Dial at the point your oscillator comes in because then, if you do not change the padder adjusting screw, you will be able to tune it in at any time, like any other Broadcast station.

Here then, you have all the elements of a Radio Communication system. Your voice, entering the microphone, causes electrical pulses which modulate the high frequency generated by the oscillator.

Although the actual distance is small, this modulated high frequency is radiated to your receiver antenna where it enters the receiver, is amplified, demodulated and finally converted back to sound in the speaker.

Experiment No. 2

The purpose of this experiment is to demonstrate the frequencies generated by the oscillator actually radiate in space.

This experiment is really a continuation of Experiment No. 1 and, after both the oscillator and receiver have been carefully tuned for best results, you can increase the distance between them.

The wire, connected to antenna coil terminal No. 4 is really the transmitting antenna and, for the first experiment, you placed it close to the Receiver. Now, increase the distance between this wire and the receiver antenna. If possible, have some one talk into the microphone while you make the changes because then, you will not lose the signal entirely and can slightly retune the receiver for best results. It may also be necessary to increase the receiver volume but, if your receiver is sensitive and your oscillator has been assembled according to instructions, you should be able to transmit signals from one room to another.

In addition to the technical features of this experiment, it also has good entertainment value. With your oscillator in another room and a confederate to tune the Radio Receiver, you can cut it on regular Broadcast Programs to make personal announcements or remarks about other persons who may be listening to the Radio Program.

# ARMSTRONG OSCILLATOR

## Material Required

1 - Power Supply (Complete)
1 - Octal Socket (SA)
1 - Antenna Coil (SA)
1 - Padder Condenser (SA)
1 - 6SJ7 Tube
1 - Headphone
1 - Hook-Up Wire

## OUTLINE

From a practical standpoint, this project has the same application as the Hartley Oscillator experiments you have just completed. From a technical standpoint however, this circuit differs greatly from those previously given and therefore should have the same careful study.

The purpose of this Home Laboratory is to give you practical work and experience in the handling, wiring and operation of Electronic units. Therefore, we suggest that you completely disconnect this wireless microphone circuit and start all over again on this one.

As every terminal is provided with spring clip, it should not take many minutes to disconnect all of the wires and then reconnect the terminals according to the diagrams of this project.

We have tried both ways and know this plan is best and actually takes less time than checking the diagrams to see which wires have been changed in position and then making all of the changes correctly.

Looking at the schematic diagrams, you will find but one winding of the antenna coil was used for the Hartley type oscillator and the feedback action was obtained by connecting the cathode of the tube to the tap at terminal 5, so that part of the coil was in the plate circuit return.

Here, the tap is not used and the feedback action is obtained by the inductive coupling between the two coil windings. The winding between terminals 2 and 3 is in the plate circuit so that variations of plate current will induce voltages in the other winding which connects to the grid of the tube.

In the Hartley circuit, the headphone was connected between the screen grid and cathode but here, it is between the cathode and plate supply negative, or ground.

These are the principal changes but we will assume you have removed all of the wires from the sub-assemblies and are ready to start over.

## WIRING PROCEDURE

We will follow our former plan by listing each connection separately and giving the terminal at each end.

## WIRING CONNECTIONS

1. From power supply terminal 1 to socket terminal 2.
2. From power supply terminal 2 to socket terminal 7.
3. From power supply terminal 3 to socket terminal 1.
4. From power supply terminal 4 to antenna coil terminal 2.
5. From socket terminal 1 to antenna coil terminal 6.
6. From socket terminal 3 to antenna coil terminal 3.
7. From socket terminal 4 to antenna coil terminal 4.
8. From socket terminal 5 to one phone cord tip.
9. From socket terminal 6 to socket terminal 5.
10. From socket terminal 8 to socket terminal 3.
11. From antenna coil terminal 4 to padder terminal 1.
12. From antenna coil terminal 6 to padder terminal 2.
13. From padder terminal 2 to phone cord tip. Note -- this connection can be made by pushing the wire insulation back about one inch and then winding the bare wire tightly around the cord tip.

## OPERATING PROCEDURE

Check all of the connections carefully against both diagrams as well as the list just given. If you are in doubt, cross each connection off the list immediately after you have it completed.

Here again, you have a High Frequency oscillator and some of the following experiments parallel those of the Hartley type oscillator.

### Experiment No. 1

The purpose of this experiment is to detect the presence of a Radio Frequency carrier by means of a Radio Receiver tuned to another carrier.

To preform this experiment, you require the Radio Receiver used in the former experiments and again for a transmitting antenna, attach a length of wire to antenna terminal No. 4. This wire is placed close to the antenna or input circuit of the Radio Receiver.

Turn on the Radio and tune in a Broadcast station near the low frequency end of the dial. Then, turn on the Power Supply of your oscillator and wait a few seconds for the tubes to heat.

Next, tune your oscillator by slowly turning the adjusting screw of the padder and, when its frequency approaches that of tuned in station, the receiver speaker will howl or squeal. You will find the action here about the same as that of the Hartley type oscillator.

Should the oscillator fail to operate, after you have carefully checked the circuit, remove the wire from antenna coil terminal 6 to padder terminal 2 and make a connection from padder terminal 2 to socket terminal 6. Connect phone cord tip to antenna coil terminal 6 instead of padder terminal No. 2.

Experiment No. 2

The purpose of this experiment is to show the presence of "Harmonic" frequencies which are equal to even multiples of the carrier frequency.

If your receiver has a tuning eye, it can be used as the indicator, and your first step is to tune the receiver to a fairly low frequency, about 600 K.C., out at a point where there is no station carrier and the eye is open.

Then, carefully tune the oscillator, by turning the adjusting screw of the Padder, until the shadow angle of the tuning eye closes. This will indicate that the oscillator is tuned to about the frequency indicated on the Receiver tuning Dial. Without changing the oscillator adjustment, tune the Radio receiver to a frequency about twice that for which the oscillator was tuned and you will find a second point at which the tuning eye will close.

There may be a Broadcast station carrier at this second point and, while the oscillator will cause interference we suggest you alter the low frequency adjustment of both the Receiver and Oscillator and try the high frequency position again.

For the Broadcast Band, if the oscillator is adjusted to about 600 K.C. it should cause the Receiver tuning eye to close at 600 K.C. and also at 1200 K.C. This latter value is known as the "Second Harmonic" because it has twice the value of the "Fundamental" frequency to which the oscillator is tuned.

Experiment No. 3

For Radio Receivers without a Tuning Eye, the presence of Harmonics can be shown by the interference they cause to Broadcast station carrier frequencies.

Check over the Carrier Frequencies of the Broadcast stations your Receiver will pick up and then select two with frequencies such that one is approximately twice that of the other.

Then, tune in the station with the lower frequency and turn the adjusting screw of the oscillator padder until there is interference. Next, without changing the oscillator adjustment, tune the Radio Receiver toward the high Frequency end of the Dial and, when the second selected station is tuned in, the oscillator should again cause interference.

Experiment No. 4

The purpose of this experiment is to show the presence of harmonics by changing the frequency generated by the oscillator.

To perform this experiment, first turn the adjusting screw of the oscillator padder condenser in a clockwise direction until its head is flush with the barrel in which it is mounted. Then, turn on the Radio Receiver and tune in a station with a carrier frequency of about 1400 K.C.

Next, turn on the oscillator power supply and, after the tubes have had time to warm up, turn the padder adjusting screw slowly in an anti-clockwise direction until the oscillator causes interference in the receiver.

Continue to turn the adjusting screw slowly in an anti-clockwise direction and count how many positions cause interference in the Radio receiver. Turning the adjusting screw anti-clockwise or "out" reduces the fundamental frequency generated by the oscillator therefore, interference in the Radio Receiver which is tuned to about 1400 K.C. must be caused by Harmonics of lower fundamental frequencies of the oscillator.

Experiment No. 5

The purpose of this experiment is to show that the energy, fed back from the plate to the grid circuit of the oscillator tube must be in proper phase relation to cause oscillations.

To work out this experiment, tune the Radio Receiver to some Broadcast station and then tune the oscillator until it causes interference.

R

Then, turn off the oscillator Power Supply and short across terminals 3 and 4 of the Power Supply to make sure the filter condensers are discharged. We told you the antenna coil winding between terminals 2 and 3 was in the plate circuit of the tube and supplied the feedback energy. Therefore, to change the phase of this energy, simply reverse the connections to this coil.

To do this, remove the wires from antenna coil terminals 2 and 3 and then make the following connections.

1. From power supply terminal 4 to antenna coil terminal 3.
2. From socket terminal 3 to antenna coil terminal 2.

While making these changes, be careful not to disturb the tuning of either the Radio Receiver or Oscillator and after they are completed, turn on the oscillator Power Supply. The tubes will warm up but there will be no interference in the Receiver because the tube is not oscillating and no high frequencies are being generated.

Again, shut off thepower supply, short its terminals 3 and 4 and, without changing any adjustments, reverse the connections to antenna coil terminals 2 and 3. When you turn on the oscillator now, the interference returns and shows the oscillator is in operation again.

Keep this action in mind as it will come up again in your later projects.

Experiment No. 6

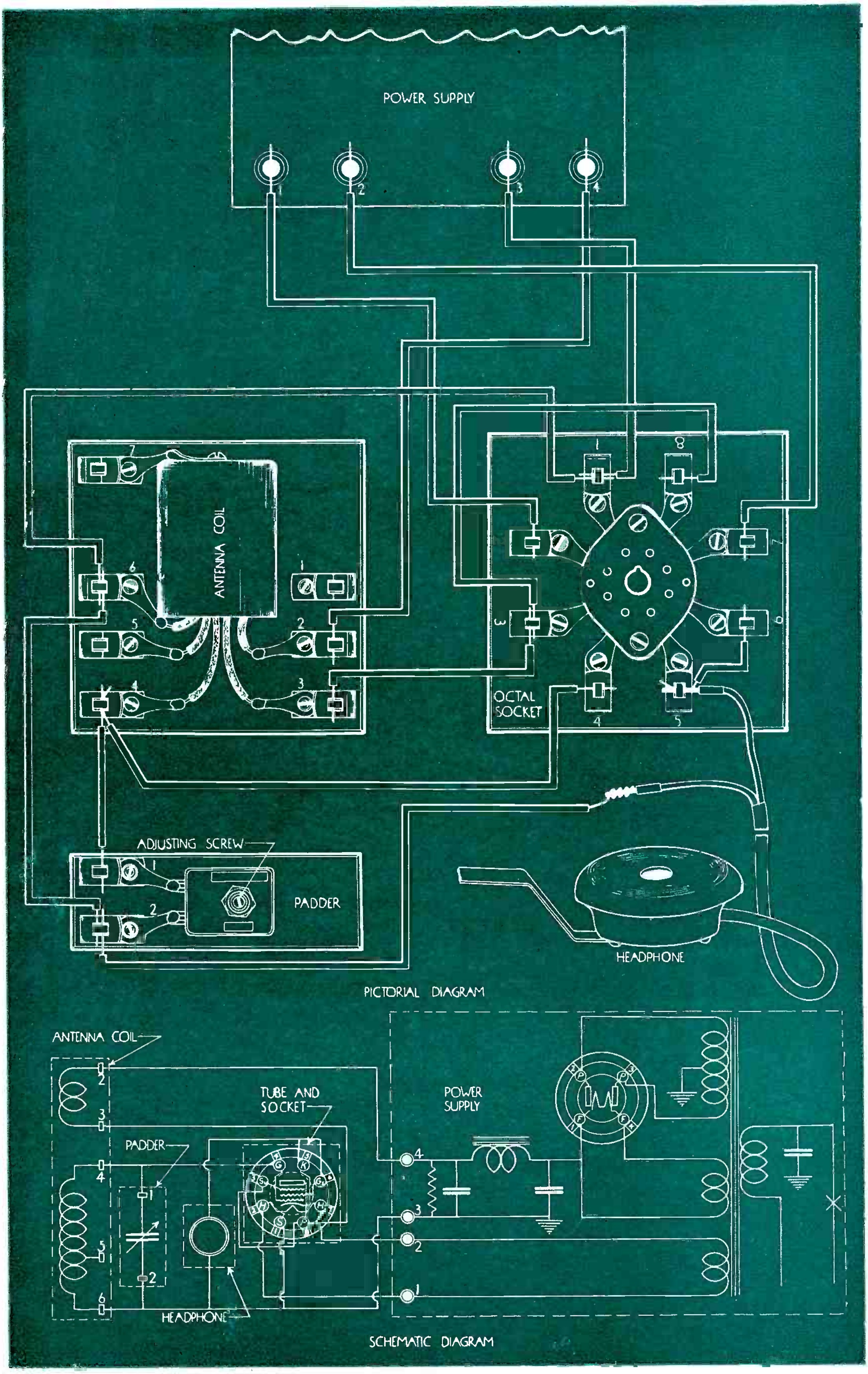
Although the headphone is in this circuit, it connects between the cathode and negative of the plate supply. In this position, it does not act very efficiently as a modulator, a fact which you can prove easily.

Following the experiments of the Wireless Microphone, tune the receiver to a low frequency where no signal is present and then tune the oscillator to this same frequency.

After the tuning has been carefully done, talk into the headphone and you will find there is some modulation effect but the result is not satisfactory.

In case you are curious, connected in this position, the headphones act mainly as a resistance to produce a negative bias voltage on the grid of the tube.

Your next shipment of equipment will include sufficient additional parts to enable you to build and operate two types of Radio Receivers and additional types of oscillators. The instructions for these projects are written on the assumption that you have completed and studied all the previous experiments. Therefore, for your own benefit and future progress, make sure of each circuit and experiment before starting another.


POWER SUPPLY
ANTENNA COIL
OCTAL SOCKET
ADJUSTING SCREW
PADDER
HEADPHONE
PICTORIAL DIAGRAM
ANTENNA COIL
TUBE AND SOCKET
POWER SUPPLY
PADDER
HEADPHONE
SCHEMATIC DIAGRAM

# DE FOREST'S
## TRAINING, Inc.

**HOME LABORATORY**
**KIT PROJECTS**
## SIMPLE RECEIVERS

Founded 1931 by

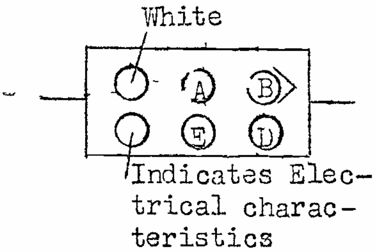


**Printed in the U.S.A.**

# COLOR CODES FOR CONDENSERS

Different types of color codes have been used for molded condensers. Amont the most popular are the following.

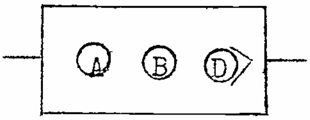
1946 Radio Manufacturer's Association Color Code




A black dot in place of the white indicates an Army-Navy unit, while a silver dot denotes Signal Corps and Army Air Forces. (For some condensers the second row appears on the reverse side.)

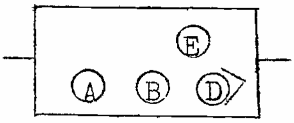
Color Codes Previously Used

3 Dot System

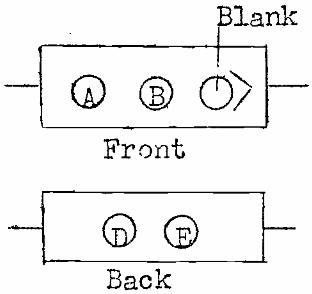



Example
A = Brown = 1
B = Black = 0
D = Brown = 10 (as a multiplier)
Capacity = 100 Micromicrofarads

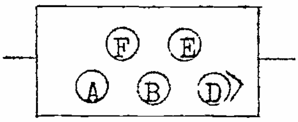
4 Dot Systems

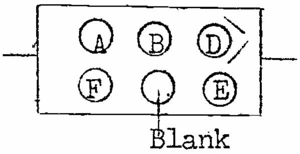



(And)

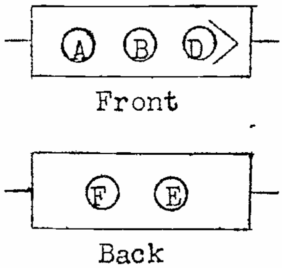



5 Dot Systems



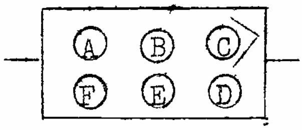




(And)



# COLOR CODES FOR CONDENSERS (cont.)

6 Dot System



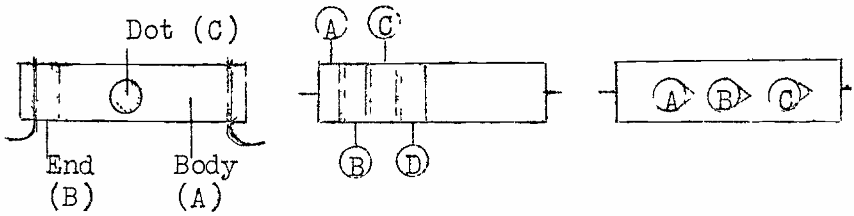

Example: A = Red  B = Red
C = Green  D = Orange
E = Gold  F = Blue

Capacity = 225,000 μμf ± 5%, 600 volts

CAPACITY TABLE (μμf)

| Dot Color | Significant Figures A | Significant Figures B | Significant Figures C | Decimal Multiplier D | Capacitive Tolerance E | DC Voltage F |
|---|---|---|---|---|---|---|
| Black | 0 | 0 | 0 | - | (+ or -) | - |
| Brown | 1 | 1 | 1 | 10 | 1% | 100 |
| Red | 2 | 2 | 2 | 100 | 2% | 200 |
| Orange | 3 | 3 | 3 | 1,000 | 3% | 300 |
| Yellow | 4 | 4 | 4 | 10,000 | 4% | 400 |
| Green | 5 | 5 | 5 | 100,000 | 5% | 500 |
| Blue | 6 | 6 | 6 | 1,000,000 | 6% | 600 |
| Violet | 7 | 7 | 7 | 10,000,000 | 7% | 700 |
| Gray | 8 | 8 | 8 | 100,000,000 | 8% | 800 |
| White | 9 | 9 | 9 | 1,000,000,000 | 9% | 900 |
| Gold | - | - | - | .1 | 5% | 1,000 |
| Silver | - | - | - | 0.01 | 10% | 2,000 |
| None | - | - | - | -- | 20% | 500 |

Color Codes for Resistors




Resistance Table (ohms)

| Dot Color | Significant Figure A | Significant Figure B | Decimal Multiplier C | Tolerance D | Dot Color |
|---|---|---|---|---|---|
| Black | 0 | 0 | - | (None = | Black |
| Brown | 1 | 1 | 10 | 20%) | Brown |
| Red | 2 | 2 | 100 | | Red |
| Orange | 3 | 3 | 1,000 | | Orange |
| Yellow | 4 | 4 | 10,000 | | Yellow |
| Green | 5 | 5 | 100,000 | | Green |
| Blue | 6 | 6 | 1,000,000 | | Blue |
| Violet | 7 | 7 | 10,000,000 | | Violet |
| Gray | 8 | 8 | - | | Gray |
| White | 9 | 9 | - | | White |
| Gold | - | - | .1 | 5% | Gold |
| Silver | - | - | .01 | 10% | Silver |

# SIMPLE RECEIVER

## Material Required

1 - Power Supply (Complete)
1 - Octal Socket (SA)
1 - Antenna Coil (SA)
1 - Tuning Condenser with Dial (SA)
1 - Potentiometer Control with Dial (SA)
1 - 100 MMF. Condenser (SA)
1 - .0005 MF. Condenser (SA)
1 - .1 MF. Condenser (SA)
1 - 2.2 Megohm Resistor (SA)
1 - 470 M Resistor (SA)
1 - Headphone
1 - 6SJ7 tube
- Hook-Up Wire

## OUTLINE

At this time, we assume that you have completed all of the experiments, listed for the Wireless Microphone of your Home Laboratory, and are familiar with the method by which the various sub-assemblies are connected. Also, we trust that you have studied the illustrations carefully and are beginning to read the schematic diagrams in addition to following the Pictorial Diagrams.

To help you in this respect, we have enlarged the Diagrams for this shipment, placing the Pictorials on one page and the Schematics on another. This has been done to help you study the schematic diagrams which, as we have already explained, are used almost entirely in technical work.

Therefore, we suggest that you first wire up each project or experiment, making use of both diagrams if necessary. Then, after it operates properly remove all the connecting wires, fold in the Pictorial Diagram and rewire the project by following the Schematic Diagram only. It may seem a little difficult at first but, after you have practiced on a few different projects, you will find the Schematics can be followed much easier than the Pictorials. That is why they are in general use in the industry.

Looking over the list of material for this project, you will see that most parts of the Simple Receiver Shipment are required in addition to all but the Padder Condenser of the Wireless Microphone. Checking with the Pictorial Diagram you will find a total of nine sub-assemblies, the power supply and headphone.

The general method of assembly remains exactly the same as for the projects of the Wireless Microphone Shipment but, of course, the

actual position of the connecting wires must conform exactly to the circuit under construction.

By this time you see that, except for their length, the connecting wires are all alike and, as a matter of convenience, we suggest you provide a container, such as a cigar box, to keep them in order. Whenever you remove a connecting wire, straighten it out and place it in this container and then, as you advance in this work, you will have a supply of ready cut wire.

Color Codes

At the bottom center of the Pictorial Diagram you will see a sub-assembly marked "2.2 Meg. Resistor" and checking the actual unit you will find it has colored bands or dots on it. Due to the use of large numbers of this type of resistor and the wide variety of their values, the Radio Manufacturers Association, (R.M.A.), have adopted a standard color code for the purpose of identification. These colors and their corresponding numerical values are as follows:

| | |
|---|---|
| Black - 0 | Green - 5 |
| Brown - 1 | Blue - 6 |
| Red - 2 | Violet - 7 |
| Orange - 3 | Gray - 8 |
| Yellow - 4 | White - 9 |

For the older type resistors, the body color was first, the end color second and the "dot" or "band" color third. Thus, a resistor with a red body, green end and orange dot had a value of

- Red - Green - Orange -

- 2 - 5 - 000 -

which is read as 25000 ohms. Note here, the last color indicates the number of "zeros" or "ciphers" which are to follow the first two numbers.

On some of the later types of resistors, all of the code colors are in the form of bands and the values are read by starting with the colored band closest to the end of the body. Using the colors mentioned above, for this method there would be a red band at one end, a space, a green band, a space and an orange band. The actual reading remains as already explained.

In addition, there is sometimes a fourth band to represent the accuracy of the resistance value. When there are only the three colored bands the resistor has a value within + or - 20% of its rating. When a silver band follows the colored

bands, the resistor has a value with + or - 10% of its rating. When a gold band follows the colored bands, the resistor has a value within + or - 5% of its rating. The 10% resistors are perhaps in most common use.

As shown in the pictorial diagram, the left hand band of the 2.2 meg. resistor is closest to the end therefore you read from left to right and should find the colors Red, Red and Green. This indicates "2", "2" and "5" which is read 2,200,000 ohms and dividing by 1,000,000 gives a value of 2.2 megohms.

Looking at the Pictorial Diagram again, the sub-assembly directly above the 2.2 meg. resistor contains a "100 MMF." condenser. Units of this type are sometimes stamped with the value of their capacity which here would be "100 MMF." or ".0001 MF." or may be color coded in much the same way as the resistors.

In the pictorial diagram, you will notice this condenser has three dots, separated by arrowheads, which point from left to right. The dots are colored according to the resistor code and read in the indicated direction but the values are in micro-microfarads.

Here, for a value of 100 MMF., the left hand dot is brown, the center dot black and the right hand dot brown. Checking with the color code, the numerical values are "Brown - 1", "Black - 0" followed by "Brown - 1", which indicates the number of zeros or ciphers.

In the upper right corner, the Pictorial Diagram shows a .1 MF. condenser and to its left a .0005 MF. condenser. These are of the "Tubular" type and, having waxed paper as the dielectric, are also known as "Paper" condensers.

Here, you will find the specifications are printed on the outer surface of the body and include the capacity, the maximum working voltage, (WV) and a distinctive mark at one end marked "Outside Foil" or "Ground".

Unless otherwise shown, the capacity is given in microfarads, (MF.) and the working volts in D.C. Remember here, that if used on an A.C. circuit, the voltage should not exceed .7 of the D.C. working volts because the maximum value of A.C. is about 1.4 of the effective or commonly used value.

The end, marked "Outside Foil", connects to the outside sheet of the assembly and, under certain conditions, will act as a shield. Therefore, it is common practice to connect this side of the condenser to the ground or low potential side of the circuit in which it is installed.

The tuning condenser consists of two separate sections, or gangs, which have a common or "ground" terminal, shown as "2" in the pictorial diagram. For this project, but one of the gangs is used.

The potentiometer is a variable resistance with a total value of 500,000 ohms. This value remains fixed, between the outer terminals 1 and 3 of the pictorial diagram, but has a movable contact connected to terminal 2. Thus, by rotating the dial, the actual resistance between terminals 1 and 2 or 2 and 3 can be varied.

The circuit shown here is a simple, single tube Radio Receiver, the tube acting as a detector, and can be used to receive signals or programs from local or nearby Broadcast stations.

To avoid wiring errors, we suggest that you identify the various sub-assemblies and then mark them plainly with their value. This marking can be done with an ordinary pencil but keep the pencil marks away from the unit, solder lugs and terminals. Also, as suggested for the projects of the Wireless Microphone Shipment, properly mark or identify all the terminals of all the sub-assemblies.

When this has been done, arrange the parts in the approximate position shown by the Pictorial Diagram but, to shorten the connecting wires, move all the wood bases close together. Here again, we show all the bends in the connecting wires as right angles but, of course, this is not necessary. However it is a good plan to allow a little extra length of wire to avoid any strain or pull at the terminals.

You should have an assortment of connecting wires, used in the last project and these can be used again. In fact, we suggest you use them wherever possible and cut new lengths only when necessary.

Just in case you have forgotten, to make a connection you first push the wire insulation back until about 1/2" of the bare copper wire is exposed. Then push down on the upper part of the spring terminal until the central closed loop projects up through the central slot. The bare wire is then pushed through so as to pass over the outer spring, under the central loop and over the outer spring on the other side.

All this is done while the outer spring is held down but now, when it is released, it will spring up and hold the wire securely. After a time, this spring may lose some of its tension but this can be remedied easily by bending up the spring before inserting the wire.

Once more, we want to repeat our former instructions and remind you that one wrong connection, one omitted wire or one poor contact can cause the entire project to be inoperative. Therefore, we urge you to take your time, follow the step by step procedure and check-mark or draw a line through each connection immediately after it has been made. You can check the Pictorial Diagram, the Schematic Diagram or the following list of connecting wires.

Because of their greater number, the connecting wires are separated into groups, "A", "B", "C", etc., each of which centers around a sub-assembly and, by making the connections in this order, the chances of error will be greatly reduced.

WIRING CONNECTIONS

A - Power Supply
1. Terminal 1 to Socket Terminal 2
2. Terminal 2 to Socket Terminal 7
3. Terminal 3 to Socket Terminal 1
4. Terminal 4 to Potentiometer Terminal 3

B - Octal Socket
1. Terminal 1 to Coil Terminal 7
2. Terminal 1 to Coil Terminal 2
3. Terminal 3 to Coil Terminal 2
4. Terminal 4 to 100 MMF. Condenser Terminal 2
5. Terminal 5 to Socket Terminal 3
6. Terminal 6 to Socket Terminal 8
7. Terminal 8 to 470 M. Resistor Terminal 2

C - Antenna Coil
1. Terminal 4 to Tuning Condenser Terminal 3
2. Terminal 6 to Tuning Condenser Terminal 2
3. Terminal 7 to Coil Terminal 6

D - Miscellaneous
1. Tuning Condenser Terminal 3 to 100 MMF. Condenser Terminal 1
2. 100 MMF. Condenser Terminal 1 to 2.2 Megohms Resistor Terminal 1
3. 2.2 Megohm Resistor Terminal 2 to 100 MMF. Condenser Terminal 2
4. Potentiometer Terminal 1 to Socket Terminal 5
5. .1 MF. Condenser Terminal 1 to Phone Cord Tip
6. .0005 MF. Condenser Terminal 1 to Socket Terminal 5
7. .0005 MF. Condenser Terminal 1 to Phone Cord Tip
8. 470 M Resistor Terminal 2 to .0005 MF. Condenser Terminal 2
9. .0005 MF. Condenser Terminal 2 to .1 MF. Condenser Terminal 2
10. 500 M Potentiometer Terminal 2 to 470 M Resistor Terminal 1

Ground Check

Power Supply Terminal No. 3 should connect to the following terminals through one or more connecting wires.

No. 1 - Socket
No. 2 - Antenna Coil
No. 3 - Socket
No. 5 - Socket
No. 1 - .0005 MF. Condenser
No. 1 - 500 M. Potentiometer
No. 7 - Antenna Coil
No. 6 - Antenna Coil
No. 2 - Tuning Condenser
One Phone Cord Tip

The purpose of this ground check can be seen more readily by referring to the Schematic Diagram where you can trace the circuit from power supply terminal No. 3 to each of the other terminals listed above.

OPERATING PROCEDURE

When you feel sure the circuit is completely and correctly wired, connect the power supply to its source, make sure the rectifier tube is in position and then insert the 6SJ7 tube in the octal socket. Remember to turn this tube until the key lines up with the socket keyway before pushing it down.

Experiment No. 1

Like any radio receiver, this project will require an antenna to enable it to pick up the Broadcast signals and because of its simplicity, may need a more efficient antenna than a larger, more sensitive multi-tube type receiver. It is difficult for us to give you any exact antenna dimensions which will be satisfactory in all locations therefore, the following suggestions are general and must be adapted to your own individual location.

If you live within 25 miles of a Broadcast Station of average power, 25 to 50 feet of insulated wire, strung inside your room should be sufficient. If you live further away or the closest Broadcast Station operates at low Power, an outdoor antenna may be necessary.

This outdoor antenna should be of the "old fashioned" type made up of a horizontal wire strung between two supports with the lead-in wire connected to one end. The length is not critical but the greater the distance between the antenna and surrounding objects, the more efficient it will be.

If you obtain your power from a commercial electric lighting circuit a "ground" connection may not be needed but better results may be obtained by reversing the position of the attachment plug in the outlet.

If you obtain your power from a storage battery a good ground connection should improve the reception of Radio signals. An acceptable ground can be made by driving a metal rod or pipe, three or four feet into damp earth. Any sustem of underground water pipinc can also be used as a ground but, in every case, it is essential to make a good, tight electrical contact to the pipe. Caution -- Never use a gas pipe for a ground.

Assuming that you have prepared these connections, attach the antenna wire to terminal 3 of the antenna coil and, if a ground is used, attach it to terminal 2 of the antenna coil or any other terminal listed on the "ground check" of the wiring procedure.

Then, turn ON the power supply switch and wait a few seconds for the tubes to warm up. Place the headphone to your ear and, if the circuit has been properly wired, you should hear a sort of hum like that when you remove a telephone receiver and are waiting for the operator to answer.

Next, turn the potentiometer dial clock-wise for one half its rotation and then turn the tuning condenser dial very slowly from the position in which the movable plates are fully meshed to that in which they are completely unmeshed. Somewhere in between these positions, you should hear one or more Radio Broadcast Stations and their volume can be adjusted by moving the potentiometer dial.

The condenser dial is set so that the numbered divisions are at the bottom and pass in front of the wooden base. By making a pencil mark on the base, directly below the condenser shaft, the divisions of the dial can be used to "log" the stations. Should it be necessary to re-set the dial, hold the outer part which carries the scale and turn the inner part, or knob proper, anti-clockwise. This part will screw off and expose a hexagon nut which should be unscrewed a turn or two. The dial can then be pulled forward until it is loose on the shaft.

The movable condenser plates should then be fully meshed with the stationary plates and the dial turned until the end of its scale is in line with the "logging" mark you placed on the wood base. Make sure the divisions of the scale will all pass this mark when the dial is turned in a direction to unmesh the condenser plates. Should the dial scale move away from the mark, turn the dial half way around and start from the other end of the scale.

When the dial and condenser plates are in their proper relative positions, tighten the hexagon nut, screw the knob back on and the job is done.

Should you fail to receive any Radio Signals, shut off the Power Supply and carefully check all of the connections against the diagrams. It is easy to make a mistake, all of us do at times, so do not feel discouraged if you find some wires in the wrong position. While making this check, also make sure that every wire end is held firmly by the spring clip terminals.

After you feel doubly sure that the circuit is correct, turn on the Power Supply and listen again. Should you still fail to hear any signals turn the tuning condenser dial more slowly because it is very easy to pass over a weak signal.

As additional tests, feel of the metal tube because, under normal operating conditions, it becomes quite warm. Then, with the dial of the 500 M potentiometer in its extreme clockwise position, use the voltage indicator and test across the following pairs of terminals, placing one test tip on each.

Power Supply Terminal 3 - Power Supply Terminal 4
Power Supply Terminal 3 - Tube Socket Terminal 8
Socket Terminal 8 - Socket Terminal 1
Socket Terminal 8 - Socket Terminal 3
Socket Terminal 8 - Socket Terminal 5
Socket Terminal 6 - Socket Terminal 5

One electrode of the Test Lamp should glow in each of these positions to indicate the presence of high voltage D.C.

As another check, you can moisten the tip of your finger and then, one at a time, touch it to terminal 3 of the tuning condenser and both terminals of the 100 MMF. condenser as well as those of the 2.2 meg. resistor. When these contacts are made, a click in the receiver indicates the circuit is in operating condition but requires greater input voltage. It may then be necessary to increase the length or height of the antenna.

We mention these various possibilities, not because we anticipate you will have difficulty in making this assembly operate but merely to emphasize the many possible causes of trouble and suggest a method of test in case it is needed.

## Experiment No. 2

In experiment No. 1, we mentioned the importance of an antenna and want you to learn that the antenna coil is really an important part of the antenna circuit. Looking at the schematic

diagram, with the antenna attached to terminal 3, the coil between terminals 2 and 3 is in series with the antenna and all antenna current will be in it.

As this signal current is A.C. there is a transformer action in the complete antenna coil, the winding between terminals 2-3 operating as the primary while the winding between terminals 4 and 6 operates as the secondary.

With more turns on the secondary there is a voltage step up and, as the secondary is tuned by the variable condenser, voltages at the resonant frequency are amplified. Checking against your regular Lessons, you will see that the tube is operating as a Grid Leak type of Detector and the tuned circuit is across the grid circuit.

For this experiment, we want you to move the antenna connection from terminal 3 to terminal 5 of the antenna coil. Under these conditions the winding between terminals 4 and 6 will operate as an auto-transformer, the entire winding as the secondary and the part between terminals 5 and 6 as the primary. Here again, there is a voltage step up and we want you to make a careful comparison between signals received under these conditions and those received for Experiment No. 1.

It may help you here to tune in a station and, while listening, move the antenna wire from terminal 5 to terminal 3 and back again. You may find it necessary to move the tuning condenser dial slightly to obtain the best signals for each connection.

## Experiment No. 3

For this experiment, we want you to connect the antenna wire to terminal 4 of the antenna coil which, in effect, places the antenna and ground in parallel to the tuned circuit.

Thinking along the lines of Experiments 1 and 2, the winding between terminals 4 and 6 of the antenna coil now merely act as a sort of choke coil and the voltage drop across it is applied to the grid circuit of the tube.

This experiment is important because, like many other people, you may have an idea that maximum signals will be obtained by connecting the antenna directly to the grid circuit. However, you can now compare the signals, with the antenna connected to terminal 4, against those when it is connected to terminals 3 and 5.

When the connection is made to terminal 4, you will find that not only is the signal level reduced but the tuning is broadened. By this we mean that you must turn the tuning dial of

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This experiment is important because, like many other people, you may have an idea that maximum signals will be obtained by connecting the antenna directly to the grid circuit. However, you can now compare the signals, with the antenna connected to terminal 4, against those when it is connected to terminals 3 and 5.

When the connection is made to terminal 4, you will find that not only is the signal level reduced but the tuning is broadened. By this we mean that you must turn the tuning dial of

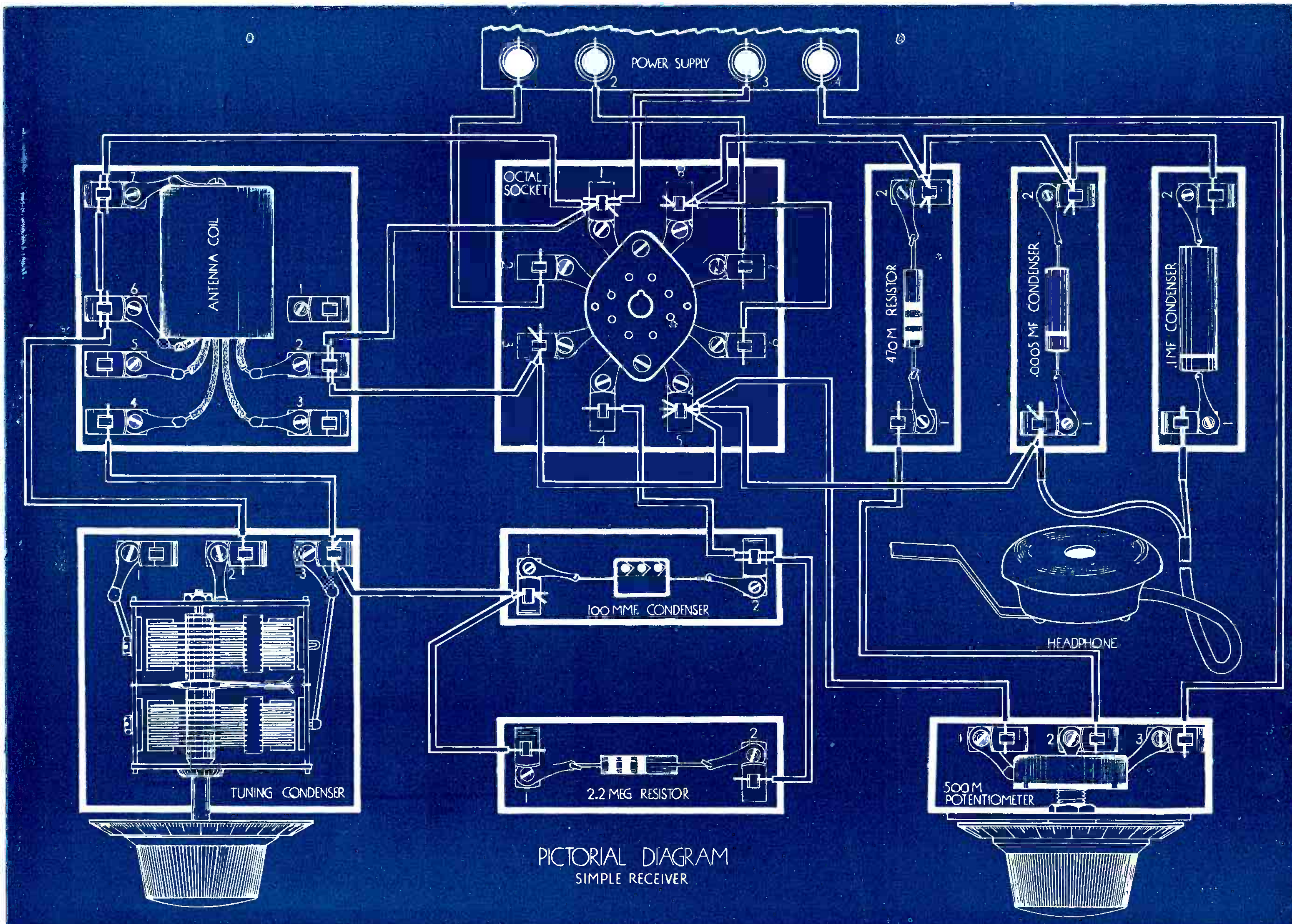
the condenser a greater distance to "tune out" the signal. Under this condition, it would be difficult to separate two stations, which tune fairly close to each other and thus this experiment shows the direct connection of the antenna reduces the "Selectivity" of the circuit.

Experiment No. 4

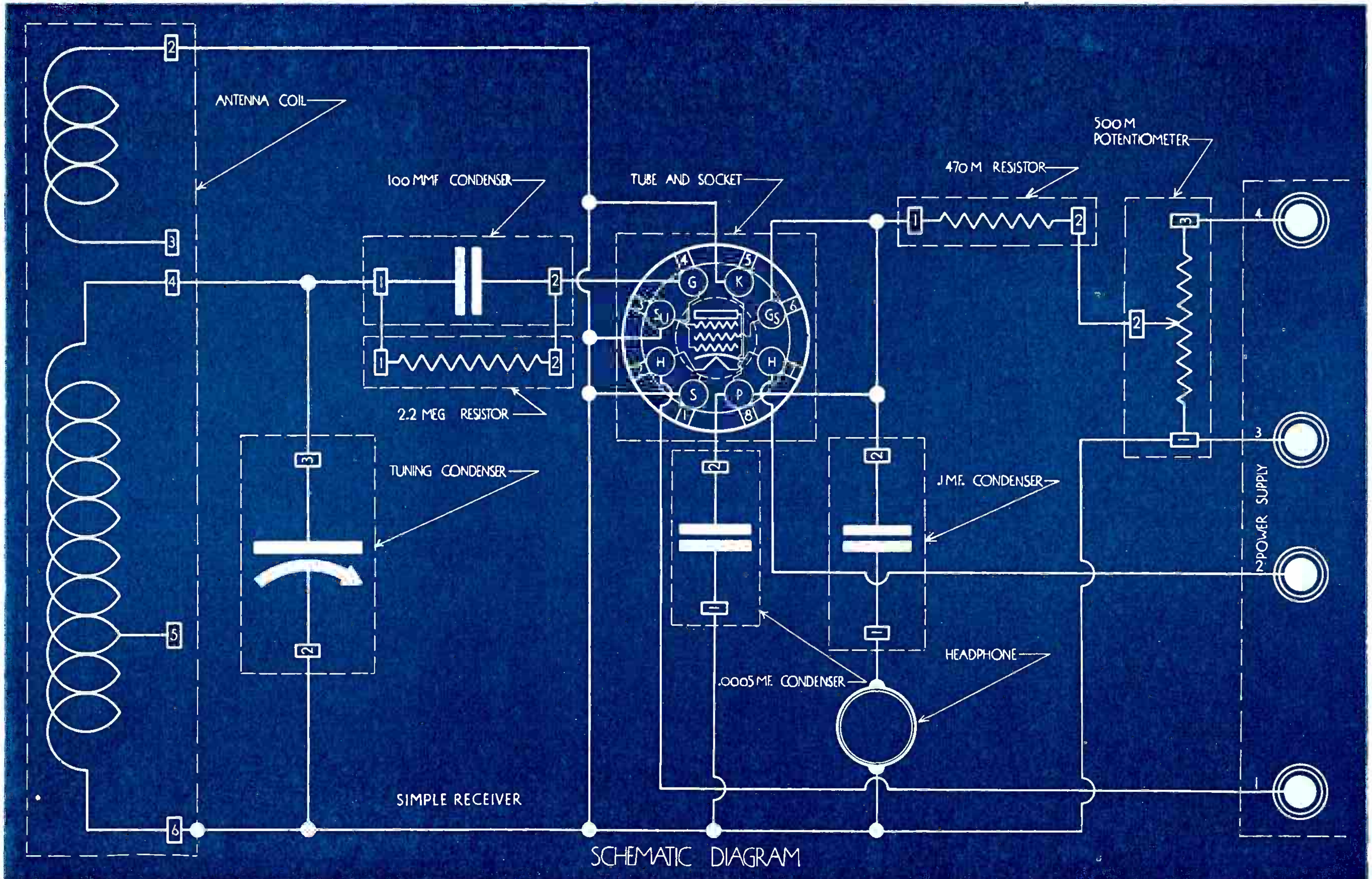
Referring to the regular Lessons again, the Schematic Diagram here coincides with those of a grid leak detector. The 100 MMF. condenser is the grid condenser while the 2.2 megohm resistor is the grid leak.

As shown in the diagrams, these two units are connected in parallel to each other and in series with the grid of the tube. In circuits of this general type, sometimes you will find the grid leak is connected from grid to ground or cathode and we want to check this action.

To make this circuit change, remove the connecting wire between terminal 1 of the 100 MMF. condenser and terminal 1 of the 2.2 megohm resistor. Then run a connecting wire from terminal 1 of the 2.2 megohm resistor to terminal 2 of the tuning condenser. Do not remove or change any other connections and then operate the receiver again and check the signals against those of the former experiments.
Do not feel disappointed in the operation of this simple circuit. If you can hear and understand the signals in the headphone, that is all you should expect because, for the next project we are going to show you how, without adding any parts, the performance can be greatly improved.




PICTORIAL DIAGRAM
SIMPLE RECEIVER




SCHEMATIC DIAGRAM

# REGENERATIVE DETECTOR

## Material Required

1 - Power Supply (Complete)
1 - Octal Socket (SA)
1 - Antenna Coil (SA)
1 - Tuning Condenser with Dial (SA)
1 - Potentiometer with Dial (SA)
1 - 100 mmfd Condenser (SA)
1 - .0005 Mfd Condenser (SA)
1 - .1 Mfd Condenser (SA)
1 - 2.2 Meg. Resistor (SA)
1 - 470 M Resistor (SA)
1 - Headphone
1 - 6SJ7 Tube
- Hook-up Wire

## OUTLINE

Checking this list of material, you will find it corresponds exactly to that of the simple receiver and, although the tube operates as a Regenerative Detector, the assembly of the parts makes up another form of one tube Radio receiver.

As we mentioned in the last project, you are going to rewire these same sub-assemblies in order to improve the sensitivity and selectivity of the simple receiver. This improvement is obtained by feeding back into the grid circuit of the tube some of the signal energy which has been carried over to the plate circuit.

The action here can be followed more readily by referring to the schematic diagram and, starting from the No. 4 terminal of the Power Supply, you can trace a circuit through the 500 M Potentiometer, 470 M Resistor, the winding between terminals 2 and 3 of the antenna coil and back to terminal 8 of the socket. As terminal 4 of the Power Supply is "B+" and terminal 8 of the socket connects to the plate of the tube, all of the plate current must pass through one winding of the antenna coil.

To follow the action here, we will assume terminal 5 of the antenna coil connects to an antenna while terminal 6 is grounded and a Radio signal has been tuned in as explained for the Simple Receiver. Due to the action of the tube, these signals will be amplified and appear in the plate circuit to cause the operation of the headphone. Here however, they will also appear in the winding between terminals 2 and 3 of the antenna coil.

We have already told you that Radio signals are A.C., and that the antenna coil can operate as a transformer. Under the conditions mentioned above, the winding between terminals 2 and 3 will act as the primary of a transformer and induce similar voltages in the other winding which can be thought of as the secondary.

The fact that the original signal voltage appeared across this same secondary winding does not alter the action explained above and it may help you to think of the antenna coil as having two primaries. One, between terminals 5 and 6, connected in series with the antenna and carrying the original signal current. The other, between terminals 2 and 3, in series with the plate circuit of the tube and carrying the plate current. When the connections are made properly, these two primaries will aid each other to induce a higher voltage across the secondary.

This higher secondary voltage, impressed on the grid circuit of the tube will cause a greater signal in the plate circuit and thus, acting through the winding of the antenna coil will cause a still higher secondary voltage. This action can continue until the tube operates as an oscillator and will not permit the reception of the Radio signals, therefore, it is necessary to provide some sort of a control which is done here by using the potentiometer to adjust the plate and screen grid voltages.

We want you to check this circuit very carefully as it is not only one of the common circuits of the early types of Radio receivers but has many variations and applications in modern equipment.

## WIRING PROCEDURE

In this project, all of the sub-assemblies and some of the connections are identical to those of the simple receiver but, at this early point of your laboratory work, it will be quicker and more satisfactory if you remove all of the connecting wires from all of the sub-assemblies of the Simple Receiver and start anew. We have found it very easy to make mistakes, when changing a number of connections, because it is difficult to keep track of exactly which wires are to be changed and which ones have been changed.

Therefore, we will assume you have all the wires off all the sub-assemblies which you have arranged on the plan of the Pictorial Diagram and are ready to start wiring according to the following list of connections.

## WIRING CONNECTIONS

A - Power Supply
1. Terminal 1 to Socket Terminal 2
2. Terminal 2 to Socket Terminal 7
3. Terminal 3 to Socket Terminal 1
4. Terminal 4 to Potentiometer Terminal 3

B - Octal Socket
1. Terminal 1 to Antenna Coil Terminal 7
2. Terminal 3 to Socket Terminal 1
3. Terminal 4 to 100 MMF. Condenser Terminal 2
4. Terminal 5 to Socket Terminal 3
5. Terminal 6 to .0005 MF. Condenser Terminal 2
6. Terminal 8 to Socket Terminal 6

C - Antenna Coil
1. Terminal 2 to 470 M Resistor Terminal 2
2. Terminal 3 to Socket Terminal 6
3. Terminal 4 to Tuning Condenser Terminal 3
4. Terminal 6 to Tuning Condenser Terminal 2
5. Terminal 7 to Terminal 6

D - Ground Wires
1. Potentiometer Terminal 1 to Socket Terminal 3
2. .0005 MF. Condenser Terminal 1 to Socket Terminal 5

E - Miscellaneous
1. Tuning Condenser Terminal 3 to 100 MMF. Condenser Terminal 1
2. 100 MMF. Condenser Terminal 1 to 2.2 Meg. Resistor Terminal 1
3. 100 MMF. Condenser Terminal 2 to 2.2 Meg. Resistor Terminal 2
4. Potentiometer Terminal 2 to 470 M Resistor Terminal 1
5. 470 M Resistor Terminal 2 to .1 MF. Condenser Terminal 2
6. .1 MF. Condenser Terminal 1 to Phone Cord Tip
7. Phone Cord Tip to .0005 MF. Condenser Terminal 1

## OPERATING PROCEDURE

When all the wiring connections have been made, check them over carefully to be sure all of them are correct. Then, turn the tuning condenser until the movable plates are fully meshed and turn the potentiometer dial, anti-clockwise as you face it, as far as it will go.

Connect your antenna to terminal 5 of the antenna coil and your ground to coil terminals 6 or 7. Insert the tube in the octal socket, connect the power supply to its source and turn it on. After the tubes have had time to heat up, listen in

the headphone to make sure the circuit sounds alive. From your experiments with the simple receiver, you should readily recognize this sound.

Experiment No. 1

With the circuit in operating condition and the potentiometer dial about $\frac{1}{4}$ turn from its extreme anti-clockwise position, turn the tuning dial slowly until you hear a Broadcast Station. You will find the operation about the same as that of the simple receiver.

When the station is tuned in to its loudest point, turn the potentiometer dial slowly in a clockwise direction until the volume of the signal starts to increase. This indicates that more signal energy in the plate circuit is feeding back into the grid circuit.

From this point, turn the potentiometer dial further in the same direction but more slowly, and you will find the signal continues to increase, then becomes distorted and finally disappears but may be replaced by a loud squeal or howl.

When the signal disappears in this way, due to an increase feedback, it indicates the tube is oscillating, a condition which you, as the operator, must not allow to continue. In this circuit, the oscillation of the tube will radiate from your antenna and cause interference in neighboring receivers.

Therefore make ita hard and fast rule to turn up the regeneration control only until the signal is comfortably loud. In case of a weak signal, turn the control up until you begin to hear distortion and then turn it down until the distortion disappears.

After you have properly adjusted the feedback or regeneration for one station, turn the tuning condenser dial slowly, through its entire range, to see how many other Broadcast stations you can pick up. You may find other stations tune in with a squeal in the headphone making it necessary to adjust the potentiometer dial as explained above. In fact, it can be used much like a volume control but, its action is not uniform for all positions of the tuning condenser and therefore it must be adjusted for every station.

With a little practice, you will find the feedback or regeneration control is not at all difficult to operate and can be readily adjusted to provide maximum signal strength without squeals or howls. Once more let us remind you not to operate this receiver with sufficient feedback to cause the tube to

oscillate. When this happens, you not only ruin the reception of your own signals but also cause interference for your neighbors.

Experiment No. 2

To prove conclusively that regeneration is caused by the plate current in one winding of the antenna coil, we want you to remove this winding from the circuit.

To make this change, first tune in some Broadcast Station which gives fair volume and then shut off the Power Supply. Short across power supply terminals 3 and 4, with your screwdriver blade, to make sure the filter condensers are discharged. Then, being careful not to change the setting of the tuning condenser, remove the connecting wire from coil terminal 3 and plate it in coil terminal 2 along with the wire which is already there.

Electrically, this change will merely remove the feedback or "Tickler" winding from the circuit and you can now turn on the power supply. You should now be able to hear the station tuned in before this change was made and a slight readjustment of the tuning condenser may be needed for best results.

Compare the former signals with the tickler coil in use against those now available with the coil out of the circuit.

Experiment No. 3

In our former explanation, we told you the tickler coil acted as a sort of second primary winding to help increase the voltage across the detector grid circuit. However, in order to provide a voltage increase, the "phase" of the voltage, induced by the plate current, must be correct.

To show this action you need only reverse the tickler coil connections, which will reverse the action and cause a reduction, rather than an increase of signal strength.

For experiment 2, you placed 2 wires in antenna coil terminal No. 2. Now you can remove them both and reconnect as follows:

From Octal Socket Terminal 6 to Antenna Coil Terminal 2.
From 470 M Resistor Terminal 2 to Antenna Coil Terminal 3.

Before actually making these changes, shut off the power supply and, as already explained, short terminals 3 and 4 to discharge the filter condensers.

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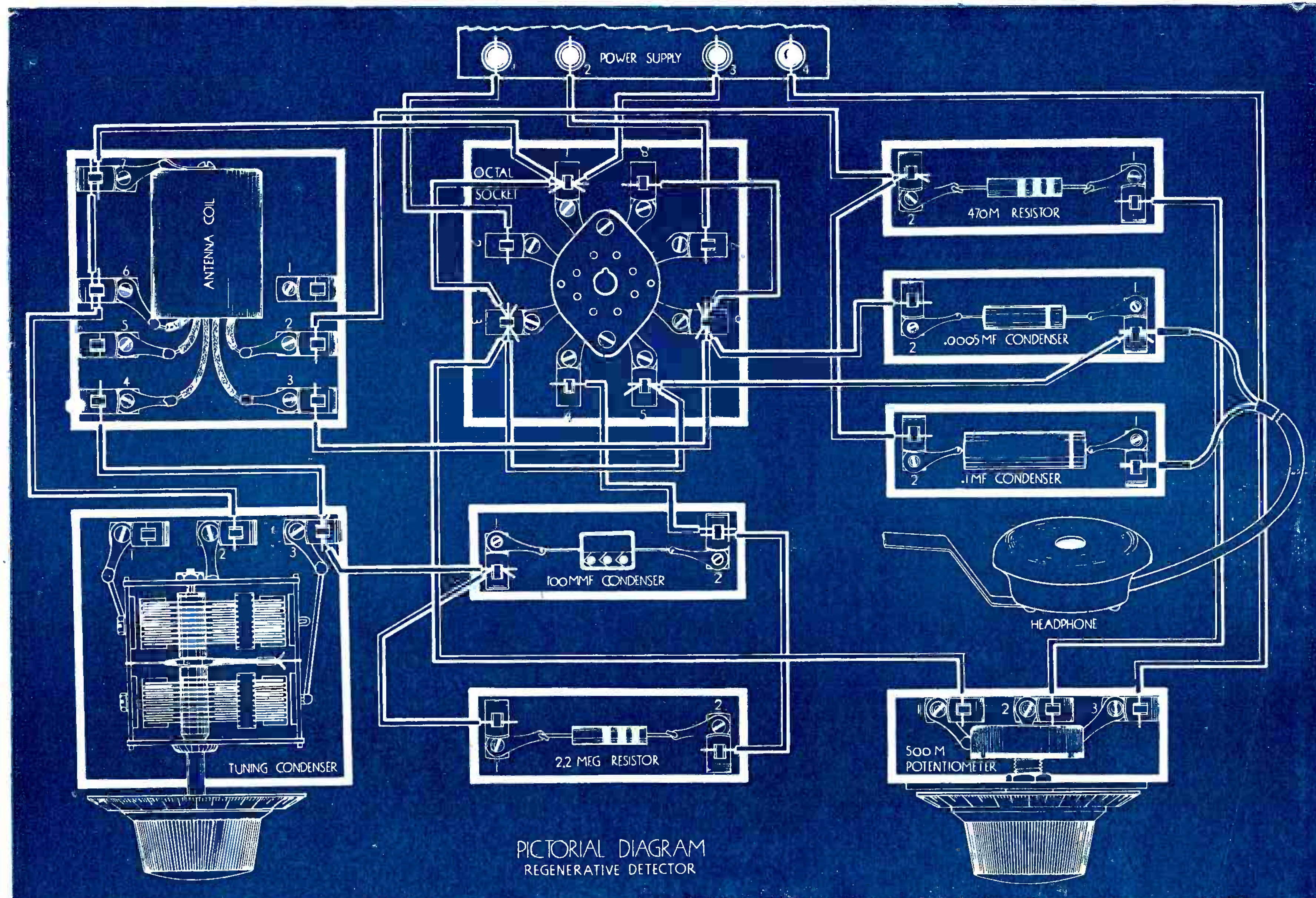
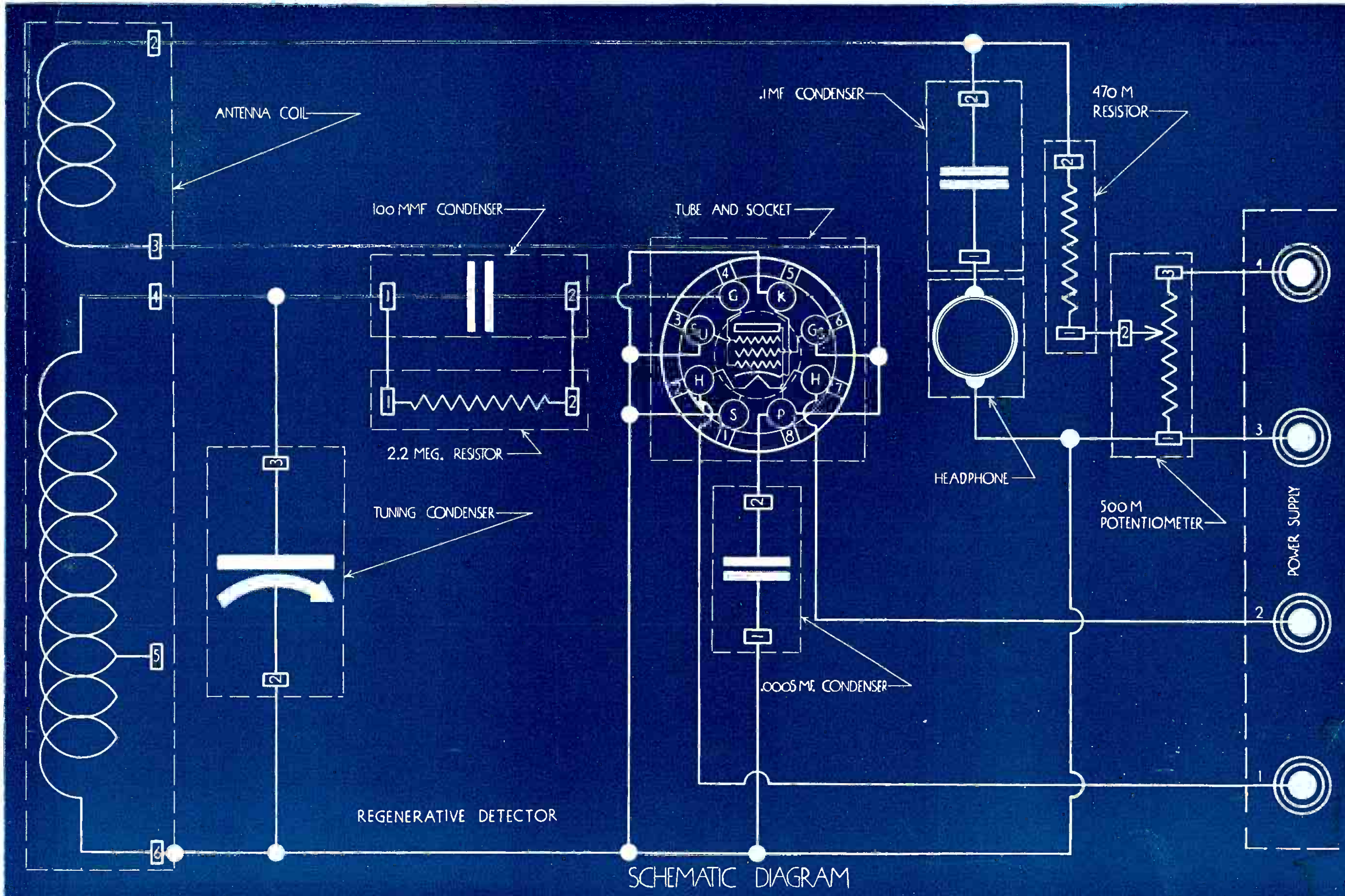
Before actually making these changes, shut off the power supply and, as already explained, short terminals 3 and 4 to discharge the filter condensers.

Tune the receiver until you hear the signals of one or more Broadcast stations. Turn the potentiometer dial and note its action. Compare the results with those obtained in Experiments 1 and 2 of this project.

The action shown by this experiment is of great importance and we want you to remember it in connection with any circuit, such as an oscillator, which depends on "feedback" for its operation.



POWER SUPPLY
OCTAL SOCKET
ANTENNA COIL
470M RESISTOR
.0005 MF CONDENSER
.1MF CONDENSER
HEADPHONE
100MMF CONDENSER
2.2 MEG RESISTOR
TUNING CONDENSER
500 M POTENTIOMETER
PICTORIAL DIAGRAM
REGENERATIVE DETECTOR


ANTENNA COIL
100 MMF CONDENSER
TUBE AND SOCKET
.1 MF CONDENSER
470 M RESISTOR
2.2 MEG. RESISTOR
TUNING CONDENSER
HEADPHONE
500 M POTENTIOMETER
POWER SUPPLY
.0005 MF. CONDENSER
REGENERATIVE DETECTOR
SCHEMATIC DIAGRAM

# ELECTRON COUPLED OSCILLATOR

## Material Required

1 - Power Supply (Complete)
1 - Octal Socket (SA)
1 - Antenna Coil (SA)
1 - Tuning Condenser with Dial (SA)
1 - Potentiometer with Dial (SA)
1 - 100 MMF. Condenser (SA)
1 - .0005 MF. Condenser (SA)
1 - .1 MF. Condenser (SA)
1 - 2.2 Meg. Resistor (SA)
1 - Headphone
1 - 6SJ7 Tube
- Hook-Up Wire

## OUTLINE

You will find this list of material checks closely with that of both the Simple Receiver and Regenerative Detector but the various sub-assemblies will be connected to provide another type of circuit. Therefore, from an electronic standpoint this project is different from those which precede it.

In your earlier experiments, you constructed and operated some basic types of oscillators and now, we want you to become familiar with another type known as an Electron Coupled Oscillator, (E.C.O.)

By a simplified definition, an Electron Coupled Oscillator is one in which the output or load circuit is coupled to the control grid circuit only through the electron stream of the tube. Because of this condition, the frequency of an E.C.O. is more stable than that of other ordinary self excited types and therefore it finds a wide application in Electronic equipment.

In our earlier explanations, we told you it was necessary that some of the energy in the output circuit be fed back to the input circuit in order to cause sustained oscillation and referring to the schematic diagram, we will explain the action here.

Starting at the No. 4, or high voltage terminal of the Power Supply, you can trace a circuit through a part of the potentiometer resistance to terminal 6 of the tube. When the tube is in operation, this path continues from terminal 6 to the screen grid, to the cathode and to terminal 5. From terminal 5, the circuit continues to terminal 5 of the antenna coil through a part of the winding to terminal 6 and then back to terminal 3 of the power supply.

The feedback action is obtained here by causing the cathode current to pass through a part of the coil connected across the grid circuit. Due to the auto-transformer action of the coil, variations of cathode current will cause variations of grid voltage which, in turn, will cause further variations of cathode current.

You will notice we have not mentioned the plate of the tube as yet and therefore it may help you to think of the screen grid as the plate of a triode tube oscillator. However, the plate is present in the tube and the screen grid is of open construction.

By applying a positive voltage to the regular plate, it will attract electrons and thus there will be plate current. As the electrons which reach the plate must pass through the control and screen grids they will vary at the rate of the oscillations which, in turn, are controlled by the inductance of the coil and capacity of the tuning condenser in the control grid circuit.

The oscillator frequency will thus appear in the plate circuit but, because of the electron coupling, variations in the load or plate circuit will have a comparatively slight effect on the oscillator frequency.

WIRING PROCEDURE

As before, we will assume you have the sub-assemblies arranged on the plan of the pictorial diagram and are ready to make the following connections.

WIRING CONNECTIONS

A - Power Supply
1. Terminal 1 to Socket Terminal 2
2. Terminal 2 to Socket Terminal 7
3. Terminal 3 to Socket Terminal 1
4. Terminal 4 to Potentiometer Terminal 3
5. Terminal 4 to Phone Cord Tip

B - Octal Socket
1. Terminal 1 to Antenna Coil Terminal 7
2. Terminal 3 to Antenna Coil Terminal 5
3. Terminal 4 to 100 MMF. Condenser Terminal 2
4. Terminal 5 to Socket Terminal 3
5. Terminal 6 to Potentiometer Terminal 2
6. Terminal 8 to Phone Cord Tip
7. Terminal 8 to .0005 MF. Condenser Terminal 2

C - Antenna Coil
1. Terminal 4 to Tuning Condenser Terminal 3
2. Terminal 6 to Tuning Condenser Terminal 2
3. Terminal 7 to Coil Terminal 6

D – Ground Wires
   1. Potentiometer Terminal 1 to .1 MF. Condenser Terminal 1
   2. .1 MF. Condenser Terminal 1 to Socket Terminal 1

E – Miscellaneous
   1. Potentiometer Terminal 2 to .1 MF. Condenser Terminal 2
   2. 100 MMF. Condenser Terminal 2 to 2.2 Meg. Resistor Terminal 2
   3. 100 MMF. Condenser Terminal 1 to 2.2 Meg. Resistor Terminal 1
   4. 100 MMF. Condenser Terminal 1 to Tuning Condenser Terminal 3.

By this time you should be able to go through these connections quite rapidly, because some of the circuits are used in all of the projects. However, do not make the mistake of becoming over confident. Always recheck all of the connections before turning on the Power Supply.

Remember, it always seems much easier and certainly is more satisfactory to make any corrections before the unit is placed in operation than to hunt for them after you find the circuit will not operate properly or at all.

Experiment No. 1

For this experiment we want you to check the operation of an E.C.O., and as the coil and tuning condenser combinations operate at Radio Frequencies, it will be necessary to make use of a Broadcast Radio Receiver. The procedure here follows closely that given for the former experiment in the Hartley type oscillator.

Instead of repeating, we will give you the main points of the experiment and refer you to the former experiment for full details.

Connect one end of a length of hook-up wire to terminal No. 1 of the .0005 MF. Condenser, twisting the other end around the antenna lead-in wire of the Broadcast Radio Receiver. If the receiver has a self contained antenna, wind a few turns of the hook-up wire around your hand to form a small coil and place it on the back of the Receiver Cabinet.

Turn on the Radio Receiver and tune in a Broadcast station. Turn on the Power Supply switch of your oscillator. Then turn the potentiometer dial anti-clockwise as far as it will go, returning it about ¼ of a turn in a clockwise direction.

By this time, the oscillator tube should be warmed up and your next move is to turn the tuning condenser dial slowly until there is interference with the signal in the Radio Receiver speaker. The action here will be like that previously explained for other types of R.F. oscillators.

Experiment No. 2

To show that the oscillator frequency is controlled by the tuning condenser, tune in another Broadcast station, at a different point on the Radio Receiver dial. Then, slowly turn the oscillator tuning condenser dial until there is interference with the Radio signal in the Radio Receiver.

Tune in a number of different Broadcast Stations, at various points on the Radio Receiver dial, but for each one, adjust the oscillator tuning condenser until there is interference. You will find the oscillator tuning is about the same as that of the Radio Receiver.

Experiment No. 3

To show that the screen grid of the tube is actually operating as a plate, to cause oscillation, tune the receiver and oscillator until there is interference in the form of a squeal or howl.

Then, turn the potentiometer dial, anti- or counter-clockwise until the howl stops. This movement of the potentiometer dial reduces the screen grid voltage and the disappearance of the howl proves the oscillator is no longer in operation.

Experiment No. 4

To show that the oscillator plate circuit has but a comparatively slight effect on the action, turn the potentiometer dial clockwise until the interference reappears in the Radio Receiver speaker. Then, remove the phone cord tip from the No. 4 terminal of the Power Supply.

This will remove the high voltage from the plate of the tube but the interference will continue to prove the oscillator is still in operation.

Experiment No. 5

When a tube is oscillating there is grid current therefore, a grid leak is used to provide the desired grid bias. The action here is about the same as that of a bias resistor connected in the cathode circuit of a tube operating as an amplifier.

Reconnect the phone tip in terminal 4 of the power supply and tune both the Receiver and Oscillator, if necessary, until the interference is present. Then disconnect the wire from either terminal of the 2.2 megohm grid leak resistor. This will remove the bias voltage on the grid of the tube and the interference will stop to prove the oscillator is not operating.

Experiment No. 6

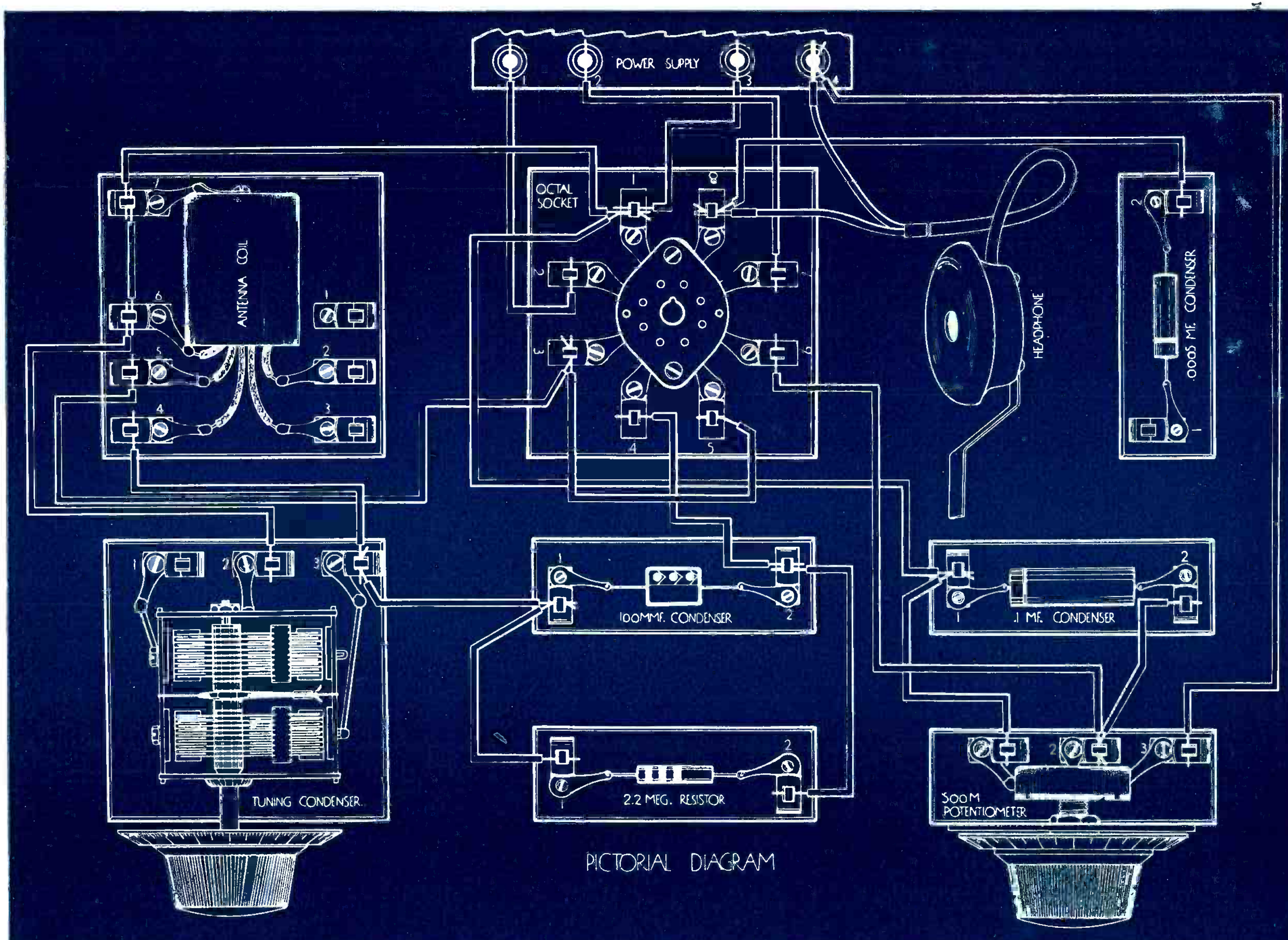
You may have noticed a similarity between the action here and that of the Regenerative Detector therefore, for this experiment we want you to operate the unit as a Radio Receiver.

To provide the proper conditions the following changes must be made in the wiring.

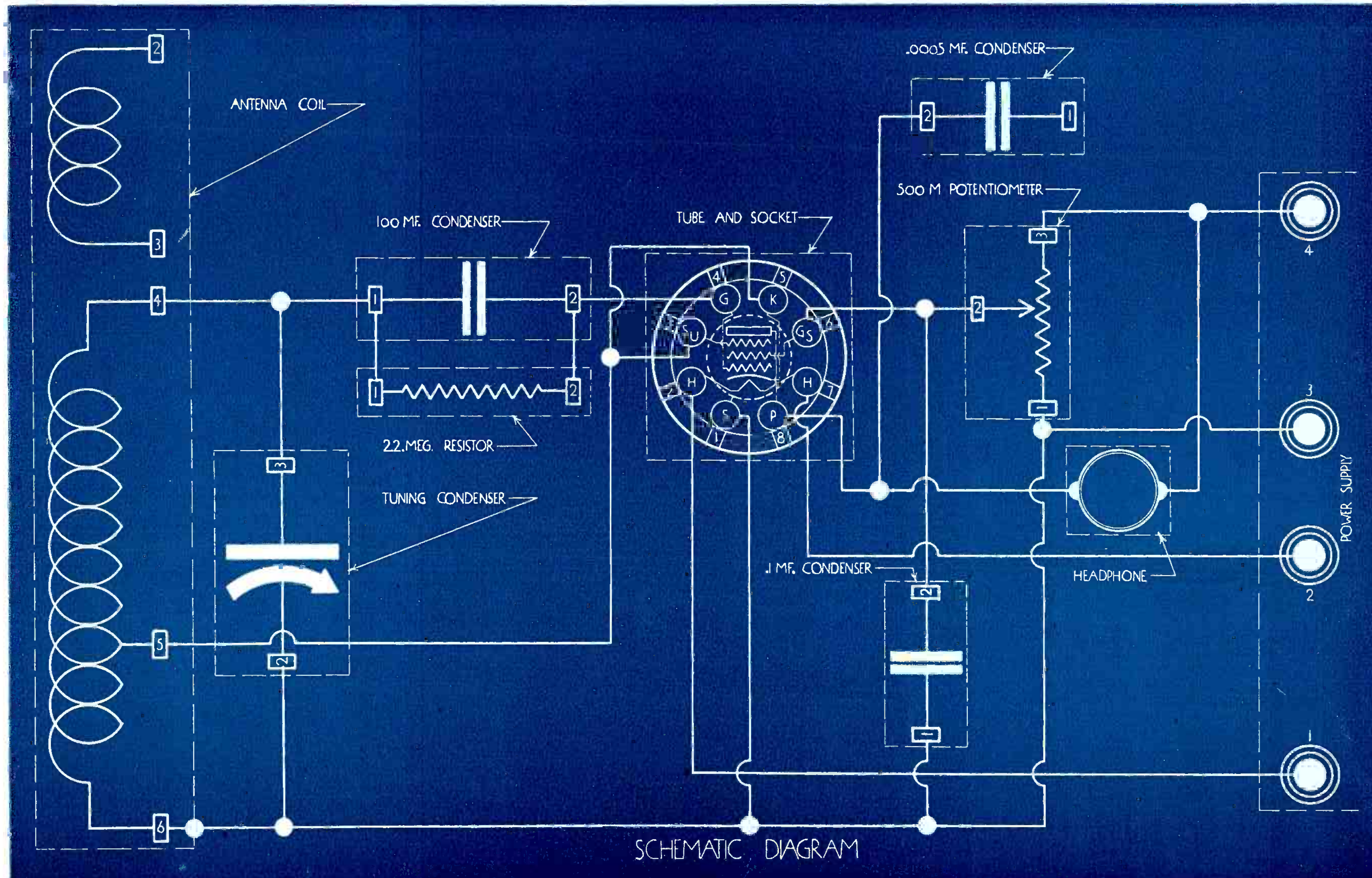
1. Connect an Antenna to Antenna Coil Terminal No. 3
2. Connect Antenna Coil Terminal 2 to Tuning Condenser Terminal No. 2
3. Connect the .0005 MF. Condenser Terminal No. 1 to the No. 1 Terminal of either the .1 MF. Condenser or the Potentiometer.

The circuit will now operate like the Regenerative Detector of the former project, the Potentiometer controlling the feedback or Regeneration.

Do not dismantle this circuit yet because, by making one or two simple changes, it will be used for experiments in the following project.



PICTORIAL DIAGRAM


ANTENNA COIL
100 MF. CONDENSER
22 MEG. RESISTOR
TUNING CONDENSER
TUBE AND SOCKET
.0005 MF. CONDENSER
500 M POTENTIOMETER
.1 MF. CONDENSER
HEADPHONE
POWER SUPPLY
SCHEMATIC DIAGRAM

# MODULATED R.F. OSCILLATOR

## Material Required

1 - Power Supply (Complete)
1 - Octal Socket (SA)
1 - Antenna Coil (SA)
1 - Tuning Condenser with Dial (SA)
1 - Potentiometer with Dial (SA)
1 - 100 MMF. Condenser (SA)
1 - .0005 MF. Condenser (SA)
1 - .1 MF. Condenser (SA)
1 - 2.2 Meg. Resistor (SA)
1 - Headphone
1 - 6SJ7 Tube
- Hook-up Wire
1 - .01 MF. Condenser (SA)
1 - 470,000 Ohm Resistor (SA)

## OUTLINE

Checking here, you will find we have added two items to the list of material which appeared on the former projects of this shipment but again, the connections are changed to provide a different circuit.

All of the former oscillators which you constructed, generated a high frequency which could be detected and heard only by the interference it causes when tuned to a frequency close to that of a Broadcast Station Carrier.

The high frequency Broadcast Station carrier can be tuned in directly because it is modulated by the signal. Thus, although the carrier itself cannot be heard, the modulating signal can. That is why the former oscillators you built can be classed as "Unmodulated" while the Broadcast Station carrier frequency is modulated.

As you perhaps know, modulation means mixing a low or audio frequency signal voltage with a high frequency carrier so that the high frequency varies in accordance with the lower frequency. In the common amplitude type of Modulation, the signal voltage varies the strength or "Amplitude" of the carrier while, in the newer Frequency Modulation systems, the signal voltage varies the frequency of the carrier.

As you will learn later, for voice and music, the signals are picked up by a microphone which converts them into electrical energy. This energy is amplified by means of vacuum tubes and finally applied to the carrier frequency to produce the desired modulation.

There are several methods by which this action can be shown, without the use of elaborate equipment, and for one of them we want to refer you back to the schematic diagram of the electron coupled oscillator.

Checking over the connections there, you will find the 100 MMF. condenser and 2.2 meg. resistor in parallel to each other and in series with the grid of the tube. In order to sustain oscillations, the feedback voltage usually drives the grid positive, in respect to the cathode, and therefore there is current in the grid circuit.

Due to the tube action, there can be current in one direction only and this pulsating current will cause a voltage drop across the grid resistor. The direction of this current is such that the voltage drop tends to make the grid negative in respect to the cathode., The charge and discharge of the condenser, connected across the grid resistor, tend to reduce the changes of current in the resistor and thus produce a more uniform voltage drop.

By selecting the proper values of capacity and resistance, the voltage drop across the combination may become so high that the negative grid voltage is sufficient to stop the oscillations. This condition is but momentary because, as the condenser discharges through the resistance, the voltage drop reduces and the oscillations start again. With the proper values, this action may take place from three or four to several thousand times a second.

Thus, by stopping and starting the oscillations at the rate of an audio frequency, we have a form of modulation which can be heard in a properly tuned radio receiver.

When an A.C. supply is available it can be applied to the oscillator grid circuit in such a way as to modulate the oscillator frequency at the comparatively low frequency of the supply. While the results are similar to those explained above, electrically this latter arrangement represents a somewhat different form of modulation.

The purpose of these circuits is to produce a modulated carrier frequency which can be tuned in and heard on an ordinary Radio Receiver the same as the modulated carrier of a Broadcast Station. We want you to go over the following experiments carefully because they will show you the principles of operation of the common types of modulated R.F. Test Oscillators.

<u>Experiment No. 1</u>

For this experiment you will need the Electron Coupled Oscillator of the last experiment as well as the Radio Receiver.

Turn off the oscillator power supply, short across its terminals 3 and 4 to make sure the filter condensers are discharged. Then remove the 100 MMF. grid condenser and replace it with the .01 MF. condenser.

Make sure the circuit is not changed in any other way and, with the exception of the capacity of the condenser, remains exactly as shown for the Electron Coupled Oscillator.

From your former experiments, you should have a fairly good idea as to about where the oscillator and Radio Receiver dials operate at the same frequency. Turn on both the Radio Receiver and the Oscillator but tune the Radio to some frequency at which no Broadcast station signal can be heard.

Then, set the oscillator tuning condenser dial to about the same frequency turning it slowly until some sound is heard in the Radio speaker. Even though the oscillator is not modulated, by this time you should recognize the sound when the oscillator is tuned through the frequency for which the receiver is set.

After both the oscillator and Receiver are tuned to the same frequency, turn the potentiometer dial slowly from one end to the other. You will hear a low frequency note in the speaker and will find the frequency can be varied by turning the Potentiometer dial.

The frequency of the note you hear is the rate at which the condenser-resistor combination in the grid circuit, is stopping and starting the high frequency oscillations.

The potentiometer controls the screen grid voltage which, in turn, affects the cathode current. The cathode current, in part of the coil, controls the feedback voltage and thus, the potentiometer dial can be used to vary the rate at which the oscillations stop and start.

<u>Experiment No. 2</u>

The time required to discharge a condenser depends mainly on the resistance of the discharge path and here, by reducing the resistance across the grid condenser, it should discharge more rapidly and increase the rate at which the oscillations are stopped and started.

For this experiment therefore, remove the 2.2 megohm resistor and replace it with the 470,000 ohm resistor. Here again, be careful not to make any other changes in the circuit.

After this has been done, you will hear a much higher frequency in the Radio speaker but, as before, the position of the potentiometer dial has a noticeable effect on the frequency of the sound.

Although it produces but a single note, the circuit you now have is a miniature Broadcast station and its signal can be received and heard on a Broadcast Receiver. Therefore, as a Modulated Oscillator, it becomes a useful piece of test equipment because it enables you to test a Radio receiver, at any part of the Broadcast Band, independently of the Broadcast stations. Also, its single note makes comparison of volumes much easier than when a regular program is heard.

Experiment No. 3

From your earlier experiments, you know the oscillator tuning condensers allow you to generate frequencies for the entire Broadcast Band. However, to increase its use as a test instrument, the oscillator tuning dial should be "calibrated" in terms of the frequency which is produced.

A fairly accurate calibration can be made by checking the oscillator output against Broadcast stations whose frequency is known. Any list of Broadcast stations shows their carrier frequency and as they have to maintain this frequency, within 25 to 50 cycles, it is sufficiently accurate for most purposes.

To calibrate this Modulated oscillator, first make a list of all the Broadcast stations which you can hear on your Receiver. Also, for each of these stations list their carrier frequency and the exact dial reading at which they are heard.

Then prepare a two column list, heading one column as "Dial Reading" and the other as "Frequency". Starting at one end of the Receiver Dial, tune in the first station and then, adjust the oscillator tuning dial until the oscillator note can be heard in addition to the station program. Disregard any squeals and tune the oscillator until only its note is heard.

After this has been done, write the oscillator dial reading in the first column of your prepared list and directly opposite, in the second column, the frequency of the Broadcast station.

Repeat this procedure for every Broadcast station you can hear, listing the oscillator dial reading and station carrier frequency for each. From this list you can read the oscillator tuning dial in terms of frequency and, if you desire, can use the values to make a curve of Oscillator Frequency against dial setting.

Experiment No. 4

This experiment can be performed only when 110 Volt A.C. power is available. If you are using a 6 volt supply, disregard the following explanations.

For this experiment we are going to use the frequency of the supply to modulate the higher frequency of the oscillator by means of the circuit shown in the following diagrams. You will find the connections are quite similar to those of the Electron Coupled Oscillator used for the last experiment therefore, we will list only the necessary changes.

First of all, replace the present grid condenser and resistor with the original ones having the values shown in the diagrams. Make sure all of the connections are correct for the Electron Coupled Oscillator and then change the connections as follows.

1. From Antenna Coil Terminal 5 to Socket Terminal 2
2. Add a wire from Socket Terminal 5 to Socket Terminal 7

After these changes have been made, the oscillator can be operated exactly as explained for the preceding experiments of this project. In this case, the note in the Radio speaker will have the same frequency as the power supply and while the potentiometer dial can be adjusted to stop and start the oscillations, it will have no effect on the frequency of the modulation as heard in the Radio Speaker.

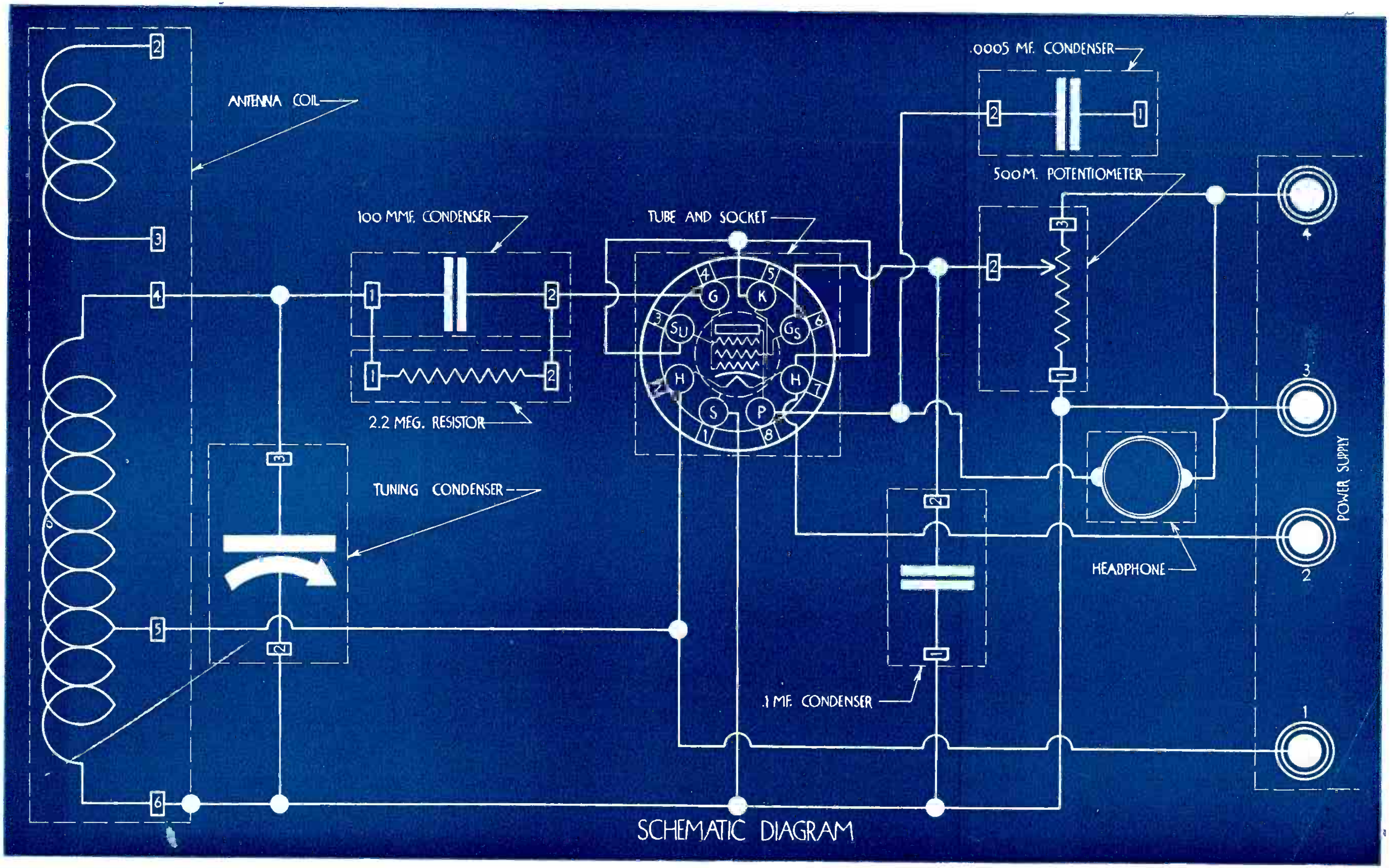
The next shipment of your Laboratory Equipment will include parts to permit you to add another tube to the simple Radio Receiver circuits of this shipment to provide amplification of either Radio or Audio frequencies.

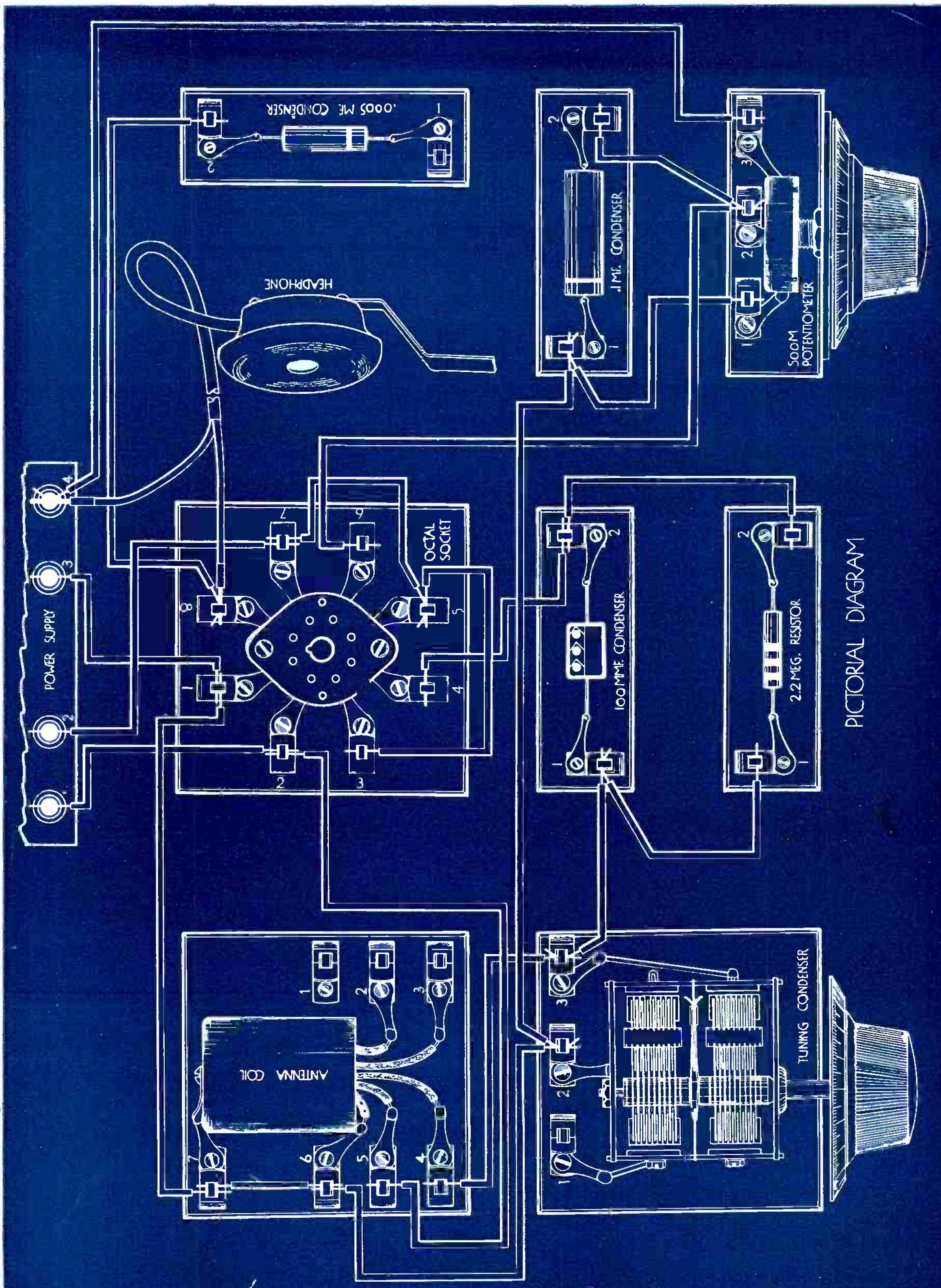
WON'T YOU LET US KNOW -- TOO?

We are anxious to find out how you like the "Home Laboratory" kits.

Many students are writing letters, telling how much DeForest's handy "Block System" helps them build new circuits quicker -- how it speeds experiments -- and how it helps provide honest-to-goodness, practical Radio experience at home.

Won't you write us a little letter, too -- telling in your own words about the advantages of DeForest's "Home Laboratory" kits? We will very much value and will sincerely appreciate your comments.


ANTENNA COIL
100 MMF. CONDENSER
TUBE AND SOCKET
.0005 MF. CONDENSER
500M. POTENTIOMETER
2.2 MEG. RESISTOR
TUNING CONDENSER
HEADPHONE
.1 MF. CONDENSER
POWER SUPPLY
SCHEMATIC DIAGRAM


PICTORIAL DIAGRAM
POWER SUPPLY
OCTAL SOCKET
HEADPHONE
.0005 MF. CONDENSER
.1 MF. CONDENSER
500M POTENTIOMETER
100 MMF. CONDENSER
2.2 MEG. RESISTOR
ANTENNA COIL
TUNING CONDENSER

# TWO TUBE RECEIVER

## Material Required

1 - Power Supply (Complete)
1 - Antenna Coil
2 - Octal Sockets
1 - 2 Gang Tuning Condenser with Dial
1 - 500,000 Ohm Potentiometer with Dial
2 - 470,000 Ohm Resistors
1 - 2.2 Megohm Resistor
1 - 47000 Ohm Resistor
1 - 100 MMF. Condenser
1 - .0005 MF. Condenser
1 - .05 MF. Condenser
1 - .1 MF. Condenser
1 - Headphone
1 - 6SJ7 Tube
1 - 6SQ7 Tube
- Hook-Up Wire

## OUTLINE

Among the former projects, you constructed a simple Receiver and a Regenerative Detector, both of which operated as Broadcast Radio Receivers but, even at their best, you can understand why receivers of this type would not be satisfactory for general public use. When Radio first became popular, everyone was content to listen in with a headphone but now, after hearing the modern speakers of good fidelity, the headphone is not acceptable except for special services.

With this thought in mind, your first need is for louder signals which, from a technical standpoint, means greater amplification. There are a number of general methods by which this can be done but all require the use of additional tubes.

For this project, therefore, we are going to use the circuit of the former Regenerative Detector and add a second tube to increase the amplitude or strength of the signals which originally were heard in the headphone. Although the headphone will still be used, you will have no trouble in hearing the increase of volume due to the amplifying action of this second tube.

We want you to notice particularly that this added tube merely increases the amplitude of the signal, or audio, frequencies and therefore can be classed generally as an "Audio Amplifier". We will have much more to say about audio amplifiers a little later but now want you to remember that, as far as the signal is concerned, the amplifier follows the detector.

Turning to the schematic diagram of this project, compare the circuits of the left hand, or 6SJ7 tube, with those of the schematic diagram shown for the Regenerative Detector project of the last shipment. Here, we do not show the power supply terminals but you should know by now that No. 4 is "B+", No. 3 is "B-", while Nos. 1 and 2 are the low voltage heater supply. Instead of drawing actual lines, we show a "ground" symbol for "B-" and the same symbol for all other wires which connect to it.

The arrangement used to transfer signal voltages from the plate circuit of one tube to the grid circuit of the following tube is known as "Coupling". Here, the coupling is accomplished by means of an .05 MF. condenser and a 470 M resistor connected between the grid of the 6SQ7 tube and ground. Because of the parts used, this arrangement is known as "Resistance-Capacity" or more simply as "Resistance" coupling.

The .05 MF. "coupling" condenser prevents the D.C. potential of the plate circuit from reaching the grid of the following tube but, by the action explained in your regular Lessons, will "carry over" the signal voltages to the second resistor connected from grid to ground.

The signal voltages appearing across this grid resistor are impressed on the grid circuit and, with the tube operating as an amplifier, cause corresponding but larger changes of plate current. The headphone, connected in this plate circuit, carries the plate current and the larger changes cause louder signals.

In brief, to increase the amplitude of the signals, we have added a stage of audio amplification to the Regenerative Detector of the former project.

WIRING PROCEDURE

Looking at the diagrams of this project, you will find there are two octal sockets and two 470 M resistors. To identify these identical parts, the socket for the 6SJ7 tube, shown near the left of the pictorial diagram, will be called the detector (DET.) socket while the other, used for the audio frequency amplifier tube, will be the A.F. socket.

For the two resistors of like value, that in the plate circuit of the detector tube will be the "Plate" resistor while that in grid circuit of the A.F. amplifier tube, will be the grid resistor.

Looking at the Power Supply of the "Pictorial Diagram" you will notice the terminals are not numbered. However, you no doubt remember they are referred to as terminals 1, 2, 3, and 4 with terminal 1 at the left and terminal 4 at the right.

As this is your first multi-tube assembly, we suggest you remove all connecting wires from all the sub-assemblies and start the wiring from scratch. In the former wiring instructions we have followed the sub-assembly terminals with no regard for the circuits but here we will start the more technical method of wiring by circuits.

In the schematic diagram, you will notice the heater connections are simply extended from the sockets and do not lead anywhere. This is quite common commercial practice, as the tube types indicate a 6 volt heater supply and either end of each heater can connect to either terminal of the supply.

Therefore we will assume that with all connecting wires removed, you have the sub-assemblies in the approximate positions of the pictorial diagram and are ready to make the following connections.

A - Heater Circuits -

1. Power Supply Terminal No. 1 to Det. Socket Terminal No. 2.
2. Det. Socket Terminal No. 2 to A.F. Socket Terminal No. 7.
3. Power Supply Terminal No. 2 to Det. Socket Terminal No. 7.
4. Det. Socket Terminal No. 7 to A.F. Socket Terminal No. 8.

B - Plate Circuits -

1. Power Supply Terminal No. 4 to 500 M Potentiometer Terminal No. 3.
2. 500 M Potentiometer Terminal No. 2 to 470 M Plate Resistor No. 1.
3. Plate Resistor Terminal No. 2 to .05 MF. Condenser Terminal No. 2.
4. Plate Resistor Terminal No. 2 to .0005 MF. Condenser Terminal No. 2.
5. .0005 MF. Condenser Terminal No. 2 to Antenna Coil Terminal No. 2.
6. Antenna Coil Terminal No. 3 to Det. Socket Terminal No. 6.
7. Det. Socket Terminal No. 6 to Det. Socket Terminal No. 8.
8. Potentiometer Terminal No. 3 to one Headphone Cord Tip.
9. Other Headphone Cord Tip to A.F. Socket Terminal No. 6.

C - Control Grid Circuits -

1. A.F. Socket Terminal No. 2 to Grid Resistor Terminal No. 2.
2. Grid Resistor Terminal No. 2 to .05 MF. Condenser Terminal No. 1.
3. Det. Socket Terminal No. 4 to 100 MMF. Condenser Terminal No. 2.
4. 100 MMF. Condenser Terminal No. 2 to 2.2 Meg. Resistor Terminal No. 2.
5. 2.2 Meg. Resistor Terminal No. 1 to 100 MMF. Condenser Terminal No. 1.
6. 100 MMF. Condenser Terminal No. 1 to Tuning Condenser Terminal No. 3.
7. Tuning Condenser Terminal No. 3 to Antenna Coil Terminal No. 4.
8. Antenna Coil Terminal No. 6 to Tuning Condenser Terminal No. 2.

D - Ground Connections -

1. Antenna Coil Terminal No. 6 to Antenna Coil Terminal No. 7.
2. Antenna Coil Terminal No. 7 to Det. Socket Terminal No. 1.
3. Det. Socket Terminal No. 1 to Det. Socket Terminal No. 3.
4. Det. Socket Terminal No. 3 to Det. Socket Terminal No. 5.
5. Det. Socket Terminal No. 5 to .0005 MF. Condenser Terminal No. 1.
6. .0005 MF. Condenser Terminal No. 1 to Power Supply Terminal No. 3.
7. .0005 MF. Condenser Terminal No. 1 to 500 M Potentiometer Terminal No. 1.
8. 500 M Potentiometer Terminal No. 1 to Grid Resistor Terminal No. 1.
9. Grid Resistor Terminal No 1 to A.F. Socket Terminal No. 3.
10. A.F. Socket Terminal No. 3 to A.F. Socket Terminal No. 1.

E - Antenna Circuit -

1. Antenna Lead-in to Antenna Coil Terminal No. 5.
2. External Ground to Antenna Coil Terminal No. 6 or any of above group "D".

There are many variations to this general plan of wiring but, by following circuits and completing each circuit before starting another, the possibilities of error are reduced. In commercial work, the plan we gave for this assembly is often varied by completing each circuit to ground or to the metal chassis base.

## OPERATING PROCEDURE

The operating procedure here is the same as that already explained for the Regenerative Detector but we will repeat the main points.

After all the connections have been made and carefully checked at least once, place the tubes in their proper sockets. You must be careful here because the internal connections of the tubes are entirely different and, should they be reversed in position, the assembly will not operate.

As a general guide, place the 6SJ7 tube in the socket next to the antenna coil and the 6SQ7 tube in the socket which has a direct connection to the headphone. Start each tube easily in the central opening, turn it slowly until the key engages the keyway, and then push down.

Experiment No. 1

With all the tubes in place, turn on the power supply and wait a few seconds for the heaters to warm up. While you are waiting, turn the tuning condenser dial until the plates are fully meshed and turn the Potentiometer dial clockwise for about half its rotation.

Then, listen in the headphone for the usual "live" sound and if it is present, turn the tuning condenser dial slowly until a signal is heard. Listen closely, as the signal may be faint but, when you hear it, stop turning the tuning condenser dial and start turning the potentiometer dial slowly in a clockwise direction.

This is the regeneration control and will increase the volume of the signal but the dial should be turned only until the signal is comfortably loud without distortion. Remember here, too much regeneration will cause the tube to oscillate and not only ruin the reception of your signals but cause interference in neighboring Receivers.

Continue turning the tuning condenser dial slowly and, whenever a signal is heard, stop the condenser dial and adjust the Potentiometer dial for best results. As the tuning condenser plates approach their unmeshed position you will find the potentiometer dial requires a different setting to provide maximum signals without oscillation.

Should this project fail to operate as outlined above, shut off the power supply, short across its terminals 3 and 4 to discharge the filter condensers and then make a complete check

of the wiring. After this has been done, turn on the power supply and make the following tests with the voltage indicator.

For this check you want the indicator to show you exactly where the high voltage is present, therefore, in each case, one test tip is held on Power Supply Terminal No. 3, or some wire connected directly to it while the other test clip is held on Power Supply Terminal No. 4 or some wire connected directly to it.

For example, suppose for your first check you place one test tip on Power Supply Terminal No. 3 and the other on Power Supply Terminal No. 4. If one electrode of the test bulb glows, it indicates the supply is correct.

Next, following the wires of the pictorial diagram, you place one test tip on terminal No. 3 of the 500 M Potentiometer and the other on terminal No. 1 of the .0005 MF. condenser. The test here should be the same as that at the power supply because these latter two terminals connect directly to the forme.

If the indicator bulb does not glow in this second position, hold one test tip on terminal 3 of the 500 M Potentiometer and move the other test tip back to terminal No. 3 of the Power Supply. If the indicator bulb glows now, it shows either a broken wire or poor connection between Power Supply Terminal No. 3 and .0005 MF. Condenser Terminal No. 1.

The same general plan can be used for the entire circuit and, by shifting one test tip from one end to the other of each connecting wire, its electrical condition can be tested. Follow this plan for all high voltage circuits and the test bulb should glow when the test tips are held on the following pairs of terminals. Turn the Potentiometer dial all the way clockwise.

Power Supply 3 - Power Supply 4
Plate Resistor 1 - .0005 MF. Condenser 1
Potentiometer 3 - Potentiometer 1
A.F. Socket 6 - A.F. Socket 1
A.F. Socket 6 - A.F. Socket 3
Ant. Coil 2 - Ant. Coil 6
Ant. Coil 3 - Ant. Coil 6
Det. Socket 8 - Det. Sockets 1, 3, 5
Det. Socket 6 - Det. Sockets 1, 3, 5
.0005 Condenser 1- .0005 MF. Condenser 2

Should the test bulb fail to glow at any of the above positions, move the test tips, one at a time, to the other end of each

connecting wire, always working back toward Power Supply Terminals 3 and 4.

To check the low voltage circuits it is usually sufficient to feel of the tube. If it is noticeably warm or hot, its heater is in operation.

Experiment No. 2

To make a test of the action of this second tube we want you to compare the signals received with the Regenerative Detector only against those received with the circuit of Experiment No. 1 above. To be of any value, this comparison of signals must be made in a relatively short time, therefore you can change the circuit as follows.

Shut off the Power Supply and remove the connecting wire between terminal 1 of the .05 MF. condenser and terminal 2 of the 470 M grid resistor.

Remove the phone connections from terminal 6 of the A.F. socket, and terminal 3 of the 500 M potentiometer. Then reconnect the phone tips between terminal No. 1 of the .05 MF. condenser and terminal No. 1 of the .0005 MF. condenser.

In effect, these changes will restore the former circuit of the Regenerative Detector and you can then turn on the Power Supply and operate the unit. However, we suggest you tune in some particular broadcast station with a program which is to continue for at least 30 minutes.

Listen carefully to the signal, adjust both the Tuning Condenser and Potentiometer dials for best results and make a mental note of the quality as well as the volume of the signals.

Then, shut off the Power Supply and, without disturbing either of the dials, change the circuit back to its original form as shown in the diagrams of this project. When this has been done, turn on the Power Supply and, remembering the former signals, listen to the results now.

Experiment No. 3

As you perhaps know, to obtain proper results with resistance coupling, the plate resistor must have a value in correct ratio to the plate impedance of the tube. In general, and within reasonable limits, the higher the value of the plate resistor the greater the gain or amplification.

For this experiment we want to demonstrate this effect and therefore, with the circuit connected as shown in the diagrams of this project, want you to properly and carefully tune in some Broadcast Station noting carefully the volume of the signal in the headphone.

Then, without disturbing either of the dials, shut off the Power Supply, short terminals 3 and 4 with your screwdriver blade and remove the 470 M plate resister assembly from the circuit. According to the Pictorial Diagram, there is one wire in terminal 1 and two wires in terminal 2 of this assembly. Keep these wires in their proper relative position and connect them to the 47 M resistor which was included in this shipment. Other than the change in resistance value, the circuit should remain as shown in the diagrams.

After this has been done, turn on the power supply and compare the signals now with those received when the 470 M plate resistor was in use.

Experiment No. 4

This experiment is similar to Experiment No. 3 above but this time we want you to hear the effect of reducing the value of grid resistance in Resistance Coupling.

First, replace the original 470 M place resistor which you removed and properly tune in a Broadcast Station. Then, shut off the power supply and, without disturbing the dials, replace the 470 M grid resistor with the 47 M resistor you took out of the plate circuit.

When this has been done, turn on the Power Supply and listen to the signals, comparing them with those received before the change was made. To make sure the dials have not been moved, adjust them slightly until the loudest possible signals are heard. Of course, for a fair test, you must tune in the same station for both circuit conditions.

Experiment No. 5

Checking the diagrams, you will find the headphone connects directly to the high voltage supply and thus the phone is "Hot". By that we mean it is a part of the high voltage circuit and touching any of its terminals may result in a shock. Perhaps you have already found this out.

To remove the headphone from the high voltage supply circuit and yet allow the reception of signals, you can change its

circuit to that shown within the broken lines at the right of the diagrams.

To make the required changes, you will need the 47 M ohm resistor, used in Experiments 2 and 3, as well as a .1 MF. condenser.

After you are sure the power supply switch is off, remove one phone connection from terminal 6 of the A.F. socket and the other phone tip from terminal 3 of the Potentiometer. Then make the following connections, most of which are shown on the small right hand diagram.

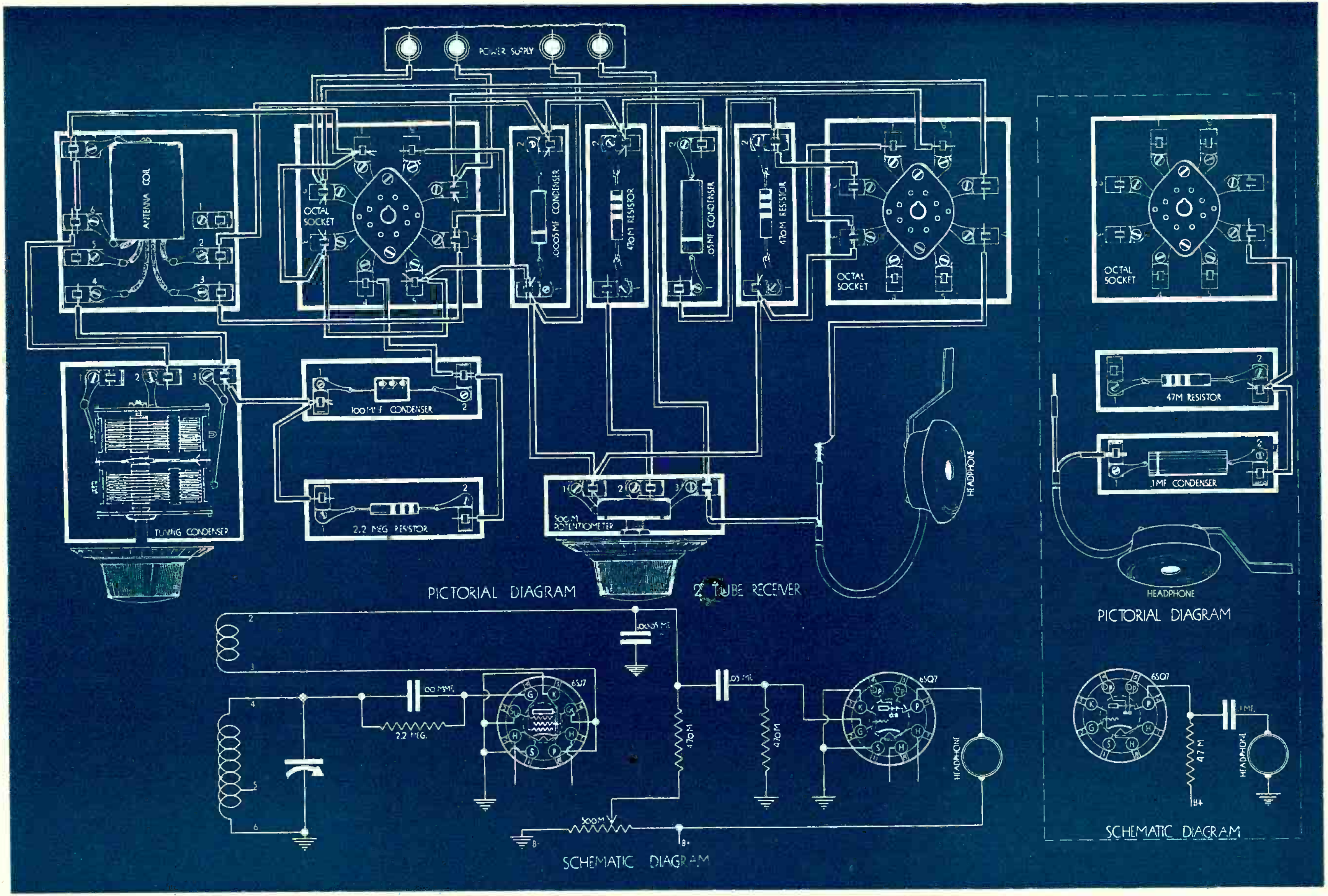
1. Terminal 6 of the A.F. Socket to Terminal 2 of the 47M Resistor.
2. Terminal 2 of the 47 M Resistor to Terminal 2 of the .1 MF. Condenser.
3. Terminal 1 of the 47 M Resistor to Terminal 3 of the Potentiometer.
4. One Phone Cord Tip to Terminal 1 of the .1 MF. Condenser.
5. One Phone Cord Tip to Terminal 1 of the Potentiometer.

As shown by the small schematic diagram, the plan here is similar to that used in the detector plate circuit.

The 47 M resistor acts as the plate load and carries the D.C. plate current. The .1 MF. condenser prevents the D.C. potential from reaching the phone but allows the A.C. signal voltages to act on the phone circuit and produce audible signals.

The changes of this experiment have little effect on the operation of the Receiver but we want you to carefully check the signals which you hear as you tune to different Broadcast Stations.

Before dismantling this circuit, turn to the following Project on "Wave Traps".


POWER SUPPLY
ANTENNA COIL
OCTAL SOCKET
.0005MF CONDENSER
470M RESISTOR
.05MF CONDENSER
470M RESISTOR
OCTAL SOCKET
100MMF CONDENSER
2.2 MEG RESISTOR
TUNING CONDENSER
500M POTENTIOMETER
HEADPHONE
PICTORIAL DIAGRAM
2 TUBE RECEIVER
22 MEG.
6SJ7
470M
6SQ7
HEADPHONE
B-
B+
SCHEMATIC DIAGRAM
OCTAL SOCKET
47M RESISTOR
.1MF CONDENSER
HEADPHONE
PICTORIAL DIAGRAM
6SQ7
47 M
B+
HEADPHONE
SCHEMATIC DIAGRAM

# TUNED RADIO FREQUENCY RECEIVER

## Material Required

1 - Power Supply (Complete)
1 - Padder Condenser
1 - Antenna Coil
2 - Octal Sockets
1 - R.F. Coil
1 - Audio Transformer
1 - Potentiometer with Dial
1 - 2 Gang Tuning Condenser with Dial
1 - 470,000 Ohm Resistor
1 - 2.2 Meg. Resistor
1 - 100 MMF. Condenser
1 - .0005 MF. Condenser
2 - .1 MF. Condensers
1 - Headphone
  - Hook-Up Wire

## OUTLINE

In the last project you added a stage of audio amplification to the Regenerative Detector of a former project in order to increase the output of signal level. While this arrangement works satisfactorily, it will not increase the sensitivity of the receiver because only those signals, originally heard in the Regenerative Detector circuit, are carried over to the audio amplifier.

For this project we are going to follow a different plan and install an amplifier between the antenna and the Detector because, with this arrangement, all signals in the antenna circuit will be amplified before they reach the detector. Thus, weak signals which could not operate the Regenerative Detector alone, will now be amplified before reaching the detector circuits.

This action will make the signals, heard with the detector alone, sound louder but the main advantage is that signals, formerly too weak to be heard at all, now can be picked up.

Operating in this position, the amplifier tube will have to handle signals at their carrier frequency and therefore it is called a Radio Frequency Amplifier. However, by tuning circuits to resonance, much greater voltages can be obtained therefore, as in the case of the simple receiver, we will tune the amplifier grid circuit.

Combining both of these actions, we have a "Tuned Radio Frequency" Amplifier, commonly abbreviated "T.R.F." and often applied to complete receivers which operate on this plan.

We want to remind you here that commercial types of receivers usually employ one or more stages of amplification between the antenna and detector as well as between the detector and headphone or speaker. At this time, however, we will employ but one TRF stage for the experiments of this project.

Compared to the two tube Receiver of the last project, here we employ both gangs of the tuning condenser and require an R.F. coil in addition to the Antenna Coil. Due to the R.F. amplification, a regenerative detector is not necessary and we have the grid leak type used in the former "Simple Receiver" project.

Briefly checking the schematic circuit, you will find the Padder Condenser connected in series between the antenna and terminal 5 of the antenna coil. Adjustment of this condenser "tunes" the antenna for best reception.

The winding, between terminals 4 and 6 of the antenna coil, connects across one gang of the tuning condenser and the combination is connected across the control grid circuit of the R.F. amplifier tube.

The potentiometer, operating as a rheostat, is connected between the cathode and ground as a variable bias resistor. In this position it acts as a gain control to vary the negative grid bias which, in turn, alters the effective amplification of the tube.

The primary winding of the R.F. coil is connected in series with the plate of the R.F. tube and therefore carries the plate current. Variations of plate current, caused by signal voltages on the grid of the tube, induce voltages in the R.F. coil secondary which is connected across the second gang of the tuning condenser.

With the exception of the antenna connection, this tuned circuit is the same as that in the grid circuit of the R.F. tube. Turning the tuning condenser dial will cause like changes in the capacity of both condenser gangs and therefore the tuned windings of the antenna and R. F. coils must have similar values of inductance in order that both circuits tune alike.

The balance of the detector grid circuit is about the same as that of the simple Receiver explained in our earlier project therefore we will not repeat the details.

In the Two Tube Receiver of the last project, you used a resistor and condenser to couple the headphone to the plate circuit of the output tube. Here, the headphone is coupled by means of an audio transformer, the primary of

which is in the plate circuit of the detector tube with the headphone connected across the secondary. Both of these arrangements are desirable as they prevent the high D.C. supply voltage from reaching the headphone and thus reduce the possibility of shock.

In order that you may determine which is the secondary and which is the primary winding of the transformer, the wires, connected to the lugs of your sub-assembly, have colored insulation. Check these carefully and remember, the red wire connects to one end of the primary and the yellow wire connects to one end of the secondary.

To prevent any errors, number the terminals of your transformer sub-assembly to conform with the pictorial diagram of this project. The red wire can be either terminal No. 3 or No. 4 while the yellow wire can be either terminal No. 1 or No. 2.

## WIRING PROCEDURE

Compared to the Two Tube Redeiver of the former project, there are so many changes in connections here that we suggest you remove all connecting wires, arrange the sub-assemblies according to the plan of the following Pictorial Diagram and start all over.

Assuming that this has been done, we will follow the general plan of the last project and list the connections according to circuits. Here however, with the exception of the Heater Circuits, we will complete each circuit back to ground or some point connected to terminal No. 3 of the power supply.

A - Heater Circuits -

1. Power Supply Terminal No. 1 to R.F. Socket Terminal No. 2.
2. Power Supply Terminal No. 2 to R.F. Socket Terminal No. 7.
3. R.F. Socket Terminal No. 2 to Det. Socket Terminal No. 8.
4. R.F. Socket Terminal No. 7 to Det. Socket Terminal No. 7.

B - Plate Circuits -

1. Power Supply Terminal No. 4 to Audio Transformer Terminal No. 3.
2. Audio Transformer Terminal No. 4 to Detector Socket Terminal No. 6.
3. Det. Socket Terminal No. 6 to .0005 MF. Condenser Terminal No. 2.
4. .0005 MF. Condenser Terminal No. 1 to Tuning Condenser Terminal No. 2.

5. Tuning Condenser Terminal No. 2 to R.F. Coil Terminal No. 1.
6. R.F. Coil Terminal No. 1 to Det. Socket Terminal No. 3.
7. Det. Socket Terminal No. 3 to Det. Socket Terminal No. 1.
8. Det. Socket Terminal No. 1 to R.F. Coil Terminal No. 5.
9. R.F. Coil Terminal No. 5 to Power Supply Terminal No. 3.
10. Audio Transformer Terminal No. 3 to R.F. Coil Terminal No. 3.
11. R.F. Coil Terminal No. 4 to R.F. Socket Terminal No. 8.
12. R.F. Socket Terminal No. 5 to R.F. Socket Terminal No. 3.
13. R.F. Socket Terminal No. 3 to .1 MF. Condenser Terminal No. 2.
14. .1 MF. Condenser Terminal No. 2 to Potentiometer Terminal No. 3.
15. Potentiometer Terminal No. 2 to .1 MF. Condenser Terminal No. 1.
16. .1 MF. Condenser Terminal No. 1 to Antenna Coil Terminal No. 6.
17. Antenna Coil Terminal No. 6 to Antenna Coil Terminal No. 7.
18. Antenna Coil Terminal No. 7 to R.F. Socket Terminal No. 1.
19. R.F. Socket Terminal No. 1 to R.F. Coil Terminal No. 5.

C - Screen Grid Circuits -

1. R.F. Coil Terminal No. 3 to 500 M Resistor Terminal No. 2.
2. 500 M Resistor Terminal No. 1 to R.F. Socket Terminal No. 6.
3. 500 M Resistor Terminal No. 1 to .1 MF. Condenser Terminal No. 2.
   (Note - do not confuse this .1 MF. Condenser with that already connected across the potentiometer.)
4. .1 MF. Condenser Terminal No. 1 to Tuning Condenser Terminal No. 2.

D - Control Grid Circuits -

1. Antenna Coil Terminal No. 4 to R.F. Socket Terminal No. 4.
2. R.F. Socket Terminal No. 4 to Tuning Condenser Terminal No. 1.
3. R.F. Coil Terminal No. 2 to Tuning Condenser Terminal No. 3.
4. Tuning Condenser Terminal No. 3 to 2.2 Meg. Resistor Terminal No. 1.

5. 2.2 Meg. Resistor Terminal No. 1 to 100 mmfd Condenser Terminal No. 1.
6. 100 mmfd Condenser Terminal No. 2 to 2.2 Meg. Resistor Terminal No. 2.
7. 2.2 Meg. Resistor Terminal No. 2 to Det. Socket Terminal No. 2.

E – Headphone Circuit —
1. One Cord Tip to Audio Transformer Terminal No. 1.
2. One Cord Tip to Audio Transformer Terminal No. 2.
3. Audio Transformer Terminal No. 2 to Det. Socket Terminal No. 3.

F – Antenna Circuit —
1. Antenna Lead-in to Padder Condenser Terminal No. 2.
2. Padder Condenser Terminal No. 1 to Antenna Coil Terminal No. 5.
3. External Ground to Antenna Coil Terminal No. 6 or other terminal connected directly to it.

Following this plan of wiring you will notice that each plate circuit is completed through the cathode of the tube and back to the No. 3 or negative terminal of the plate supply. This part of the plate circuit, between the cathode and supply negative, is commonly a part of the control grid circuit also.

Experiment No. 1

After all the connections have been made, check them over at least once, to be sure they are correct, and then turn on the Power Supply. While waiting for the tubes to heat, turn the tuning condenser dial so that the condenser plates are fully meshed. Also turn the potentiometer dial clockwise, as far as it will go, and then move it back about 1/4 turn.

The condenser tuning dial can now be turned slowly, in a direction to unmesh the plates, until a Broadcast Station signal is heard. Tune in the signal carefully and then adjust the potentiometer for best results. You will find this dial can be moved far enough, in either direction, to cause a loss of signal strength.

On local or nearby stations, the signals should compare favorable with those heard on the two tube receiver of the last project but, tune carefully for the full range of the tuning condenser to see if you can pick up some stations which were not heard before.

Experiment No. 2

On one side of each of the tuning condenser gangs you will find a slotted screw extending through a flat piece of metal. This arrangement forms a small capacity adjustable condenser, connected in parallel with the tuning condenser gang, and therefore called a "Trimmer".

The purpose of the trimmer is to compensate for variations of capacity, due to connecting wires and other constructional details, so that both gangs will tune their circuits alike. Because the capacity of the trimmer is small, compared to that of the main tuning condenser, you can check its setting only when the main condenser plates are unmeshed, which is the high frequency end of the tuning range.

For this experiment, first tune in the Broadcast Station which has the highest frequency carrier. In practice, this means to turn the condenser tuning dial, in a direction to unmesh the condenser plates, and tune in the last station you can hear.

Then, keeping your hand on the insulated handle of your screw-driver, turn the trimmer adjusting screws slowly until the signal in the headphone has maximum volume. It is sometimes necessary to adjust the tuning condenser dial slightly because, for best results, the final setting of the trimmers should leave them at about 1/2 of their maximum capacity.

When the trimmer condenser adjusting screws are turned out too far, there is but little spring tension on them and they will not hold. On the other hand, when they are screwed in tight, you can adjust them in one direction only.

Remember, the trimmers should be adjusted only when the main tuning condenser is set near its position of minimum capacity which means the plates are unmeshed. Unless your wiring just happens to provide the proper capacity, you will find an adjustment of the trimmers will improve the reception of signals.

Should the headphone start to squeal, while the trimmers are being adjusted, the r-f amplifier tube is oscillating and the potentiometer dial must be turned only until the howl stops. The howl indicates the receiver is close to its most sensitive adjustment.

Pay particular attention to the adjustment of these trimmer condensers because you will find them in practically all except the smallest types of commercial Radio receivers.

Experiment No. 3

We have already mentioned some of the advantages which result from the use of tuned circuits and, in many of the modern Radio Receivers, especially the Midget types, the antenna circuit is tuned. One common plan is to make the input coil, shown as the winding between Antenna Coil Terminals 4 and 6 in the diagrams of this project, of comparatively large diameter and use it also as a loop antenna.

For this experiment, we want you to investigate the effect of a tuned antenna and therefore included the padder condenser as a part of the antenna circuit. By changing the capacity of the padder, you alter the resonant frequency of the antenna circuit and, as this value approaches that of the carrier frequency of the station to which the Receiver is tuned, the effect should be quite pronounced.

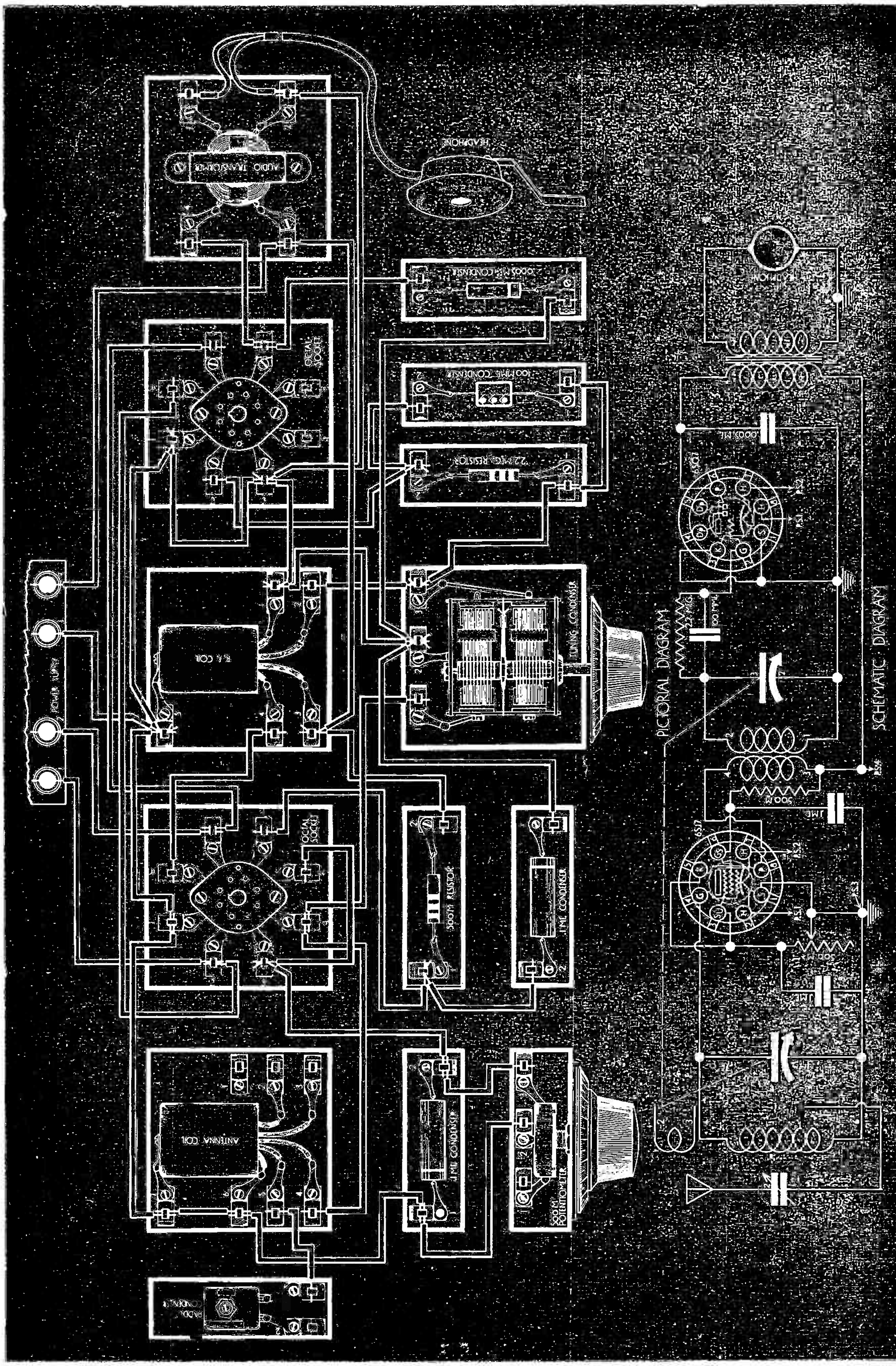
For a procedure here, tune in a Broadcast Station, preferably near one end of the tuning condenser range and then, slowly turn the adjusting screw of the padder condenser. When the signals sound the best, tune in another Broadcast Station and repeat the padder adjustment.

The padder adjustment may vary for the different stations but you should have little trouble in finding one adjustment which will provide fairly uniform reception over the entire tuning range.

Another method of obtaining uniform response over the entire tuning range is to use what is known as an "Aperiodic" circuit. This means the natural resonant frequency of the circuit is so far removed from the tuning range that all signals are received equally well.

Of course, a stronger carrier will produce louder signals in the headphone but, as far as the antenna circuit is concerned, all frequencies of the tuning range are amplified equally.

Another advantage of the tuned antenna is to increase the selectivity of the Receiver. You can prove this quite readily by adjusting the padder to detune the antenna and checking movement of the tuning condenser dial during which some Broadcast Station can be heard. Then, tune the antenna to this same station and check as before. The station should be heard only during a smaller movement of the dial to show the selectivity of the Receiver has been improved.


PICTORIAL DIAGRAM
SCHEMATIC DIAGRAM
HEADPHONE
AUDIO TRANSFORMER
POWER SUPPLY
R.F. COIL
ANTENNA COIL
TUNING CONDENSER
OCTAL SOCKET
100 MMF CONDENSER
2.2 MEG. RESISTOR
POTENTIOMETER

# DIODE DETECTOR

## Material Required

1 - Tuned Radio Frequency Receiver (Complete)
1 - 500 M. Resistor
1 - .05 MF. Condenser

## OUTLINE

This project is really a continuation of the Tuned Radio Frequency Receiver but, due to the general use of "Diodes" as detectors, we feel it is sufficiently important to be treated separately. The circuits, covered by the following explanations, will be found as Figure 3 in the diagrams included in the "Wave Traps" project.

As you already know, the action of the electronic emission inside a vacuum tube is such that current can pass in one direction only. Thus, a simple tube containing but two active elements, the Plate and Cathode (or filament) is called a diode and will operate as a rectifier. The rectifier tube of your Power Supply operates on this principle but usually it has two separate plates and is really a "Double Diode" to provide full wave rectification.

The detectors of the Radio Receivers used in your former experiments caused a similar action to "Demodulate" the high frequency carrier and allow the lower frequency signal to appear in their plate circuits. Having more than two elements they were arranged to provide some amplification in addition to their detector action. Although it has no amplification factor, the diode will act as a rectifier or detector with a minimum of distortion and therefore has come into quite common use. Operating as a detector, a diode handles but a comparatively small amount of power and therefore its plates can be made small.

Going back to the schematic diagram of the Tuned Radio Frequency Receiver, you will find that terminals 4 and 5 of the 6SQ7 tube each connect a diode plate (DP) which, in addition to the other elements, makes the complete tube a "Double Diode-Triode". This type of tube is commonly used as the second detector and first audio amplifier of a superheterodyne type of Radio Receiver to provide amplification as well as low distortion.

Referring to Figure 3 of the following illustrations, and checking the schematic diagram, you can trace the diode detector circuit and, starting at the left, there is the tuned secondary of a radio frequency coil like that used in the T.R.F. receiver.

Here the circuit is through a 100 MMF. condenser, in parallel to a 500 M resistor, to both diode plates of the tube. Inside the tube, the path continues to the cathode and from it back to the other end of the tuned circuit. The modulated R.F. voltage which appears across the tuned circuit will be impressed on the balance of the circuit but, due to the rectifying action of the diode, the current in the 500 M resistor will be in one direction only.

The charge and discharge action of the condenser, connected across this resistor, will "smooth out" the variations which occur at the carrier frequency but have little effect upon the variations which occur at the lower signal frequencies. As a result, only the signal voltages appear across the resistor.

To utilize these voltages, the .05 MF. condenser and 2.2 Meg. resistor are connected in series across the circuit and therefore the signal voltage will be present across them also. By connecting the control grid of the triode section of the 6SQ7 tube to the junction between these units, the capacity acts as a coupling condenser and the resistor acts as a grid load.

In most commercial arrangements you will find the parallel combination of condenser and resistor is connected in the cathode or ground side of the circuit but here, due to the common connection of both tuning condenser gangs, we used the connections shown in Figure 3.

WIRING PROCEDURE

As you have the T.R.F. receiver assembled, it is not difficult to convert it to make use of the diode detector and A.F. amplifier arrangement of the following Figure 3. In fact, these circuits were drawn to show only the changes which are required.

Therefore, we will first list the parts and connections which must be removed from the T.R.F. receiver circuit and then, in accordance with our former plan, give the connections which have to be made to complete this later circuit.

Referring to the diagrams of the T.R.F. receiver —

1. Remove the 2.2 Meg. Resistor and all connecting wires attached to both of its terminals.

This will remove one wire from Tuning Condenser Terminal No. 3, the wire from Detector Socket Terminal No. 2 and the wire from each of the 100 MMF. condenser terminals. This will

leave the 100 MMF. condenser and 2.2 Meg. resistor sub-assemblies without any wires in their terminals and, together with the .05 MF. condenser and 500 M resistor assemblies, arrange them all on the general plan of the Pictorial Diagram in Figure 3.

It is not necessary that they be placed actually between the R.F. coil and Detector Sockets but locate them close to the R.F. coil, Det. Socket and Tuning Condenser to keep the connecting wires short.

WIRING CONNECTIONS

After these changes have been completed make the following connections in the usual way.

1. From 100 MMF. Condenser Terminal No. 1 to 500 M Resistor Terminal No. 1.
2. From 500 M Resistor Terminal No. 1 to R.F. Coil Terminal No. 2.
3. From 100 MMF. Condenser Terminal No. 2 to 500 M Resistor Terminal No. 2.
4. From 500 M Resistor Terminal No. 2 to Detector Socket Terminal No. 4.
5. From Detector Socket Terminal No. 4 to Detector Socket Terminal No. 5.
6. From 500 M Resistor Terminal No. 2 to .05 MF. Condenser Terminal No. 1.
7. From .05 MF. Condenser Terminal No. 2 to Det. Socket Terminal No. 2.
8. From .05 MF. Condenser Terminal No. 2 to 2.2 Meg. Resistor Terminal No. 1.
9. From 2.2 Meg. Resistor Terminal No. 2 to Det. Socket Terminal No. 3.

Check all of these connections carefully and, for practice we suggest you draw a schematic diagram of the completed circuit. For this, you can copy the input and R.F. tube circuits of the T.R.F. receiver, including the primary of the R.F. coil.

Then insert the circuits of Figure 3 and complete the diagram by using the output circuits of the T.R.F. receiver. This type of work provides excellent drill both in circuits and reading diagrams. It also has important practical applications because, in your later commercial work, you may be called upon to make similar changes in existing circuits.

Experiment No. 1

After you have checked all the circuit connections, turn on the Power Supply and, following the plan already given for the T.R.F. Receiver, tune in a number of Broadcast Station signals.

A good way to make a check here is to move the tuning condenser dial slowly over its entire range and count the number of different stations which can be heard. Then, if you desire, you can stop at each station and adjust the potentiometer dial for best results.

Experiment No. 2

Due to the change in the circuit connections there may be a change in the tuning of the R.F. coil secondary. To check up here, tune in the Broadcast Station with the highest frequency and adjust the trimmer condensers on the tuning condenser.

The general procedure here is the same as that given for Experiment No. 2 of the T.R.F. Receiver.

Experiment No. 3

To determine the value of the A.F. amplifier section of the 6SQ7 tube, tune in some Broadcast Station which produces fairly loud signals.

Then without touching either of the dials, disconnect the phone cord tips from terminals 1 and 2 of the audio transformer and hold one tip on each of the 2.2 Meg. resistor terminals. You can make a regular connection, if you desire, placing the phone cord tips in the spring clips.

However, all we want you to do is listen to the signal, if any, which is heard when the headphone is connected across the 2.2 Meg. resistor. This is the signal voltage applied to the grid of the 6SQ7 tube and the louder signals, heard with the headphone connected according to the diagrams, are due to the amplification of the triode section of the tube.

# WAVE TRAPS

## Material Required

1 - 2 Tube Receiver (Complete)
1 - R.F. Coil
1 - Padder Condenser
- Hook-Up Wire

## OUTLINE

At the end of your experiments with the Two Tube Receiver we asked you to refer to this project before disconnecting the circuit. Therefore, we will assume it is still complete and in operating condition.

In case you overlooked our suggestion, it will be necessary for you to construct the Two Tube Receiver, given as the first project of this shipment. The T.R.F. Receiver will not do, as we are going to make use of the R.F. coil as a part of a Wave Trap to be connected in the Antenna Circuit.

The purpose of a Wave Trap is to prevent some unwanted frequency from entering or passing through a circuit and its action is based on the properties of resonance.

In general, there are two main types of resonant circuits, Series and Parallel. For the series circuit, as shown in Figure 1 of the following diagrams, the impedance is minimum at the resonant frequency, therefore it is known as an "Acceptor" circuit.

From the parallel circuit, as shown in Figure 2 of the following diagrams, the impedance is maximum at the resonant frequency, therefore it is known as a "Rejector" circuit.

This condition is true only at the resonant frequency of each circuit and, at frequencies above and below resonance, the impedance varies. For the series circuit, with minimum impedance at resonance, there will be an increase at other frequencies and the greater the frequence difference the higher the impedance.

For the parallel circuit, with maximum impedance at resonance, there will be a decrease at other frequencies and the greater the frequency difference the lower the impedance.

In the schematic diagram of the following Figure 1, we show a coil and variable condenser connected in series to make up a series circuit which, by changing the capacity of the variable condenser, can be tuned to resonance over a band of frequencies.

To use a circuit of this type as a wave trap, it is generally connected in parallel with the regular circuit and tuned to resonance at the frequency to be eliminated. With minimum impedance at resonance, it acts as a partial short across the regular circuit, reduces the total impedance and thus cuts down the voltage drop at the unwanted frequency.

For the schematic diagram of the following Figure 2, we show a coil and variable condenser connected in parallel. This makes up a parallel circuit, similar to those you have already operated in your Receiver Experiments, which, by changing the capacity of the variable condenser, can be tuned to resonance over a band of frequencies.

As a wave trap, a circuit of this type is usually connected in series with the regular circuit and tuned to resonance at the undesired frequency. With maximum impedance at resonance, the voltage drop across the trap circuit is also at maximum and causes a reduced voltage drop across other parts of the circuit.

One quite common application of wave traps is in the antenna circuit of Radio Receivers, especially those of the super-heterodyne type. Usually, the Wave Trap is tuned to the intermediate frequency to prevent signals, on a carrier at or near this frequency, from riding through the input stages, regardless of their tuning, and appearing in the output circuit.

In general, the purpose of a wave trap is to attenuate or eliminate some unwanted frequency and usually it is arranged to tune over a band of frequencies.

## PROCEDURE

For the following experiments, you are to connect both the series and parallel types of Wave Trap in the antenna circuit of the two tube receiver of the former project. As you may not be subject to interference, you can easily check the action of the wave trap by tuning it at one end of the Receiver Tuning Range and then checking the reception over the balance of the range.

### Experiment No. 1

For this experiment, you will require the R-F coil and padder condenser sub-assemblies which are to be wired, in series, by making the following connections.

1. From R-F Coil Terminal No. 1 to Padder Condenser Terminal No. 2.

2. From Padder Condenser Terminal No. 1 to Terminal No. 6 of the Antenna Coil of the two tube receiver.
(Note - There is a typographical error in Figure 1 and this wire connects to terminal No. 6 instead of terminal No. 5 as shown.)

Turn on the two tube receiver and tune in a station preferably at the low frequency end of its range. As we have mentioned before, at this end of the tuning range the tuning condenser plates will be fully meshed.

Then, without touching any of the receiver adjustments, connect terminal 2 of the R.F. coil to the antenna connection which is terminal No. 5 of the Receiver Antenna Coil. This will cause a reduction of signal strength but turn the adjusting screw of the padder condenser slowly, first one way and then the other, until the signal in the receiver is at minimum.

This shows the trap circuit is tuned to resonance and its low impedance is partially shorting the regular antenna circuit. Because of this "Shorting" action, it may be necessary to slightly retune the receiver, while adjusting the padder, to find the setting for lowest minimum signal.

After this has been done, tune in another station at the other end of the Receiver Tuning Range and you will find the effect of the trap, while noticeable on all stations, is much greater at the frequency for which it is tuned.

Experiment No. 2

Repeat the steps of Experiment No. 1 but tune the wave trap to the carrier frequency of a Broadcast Station which tunes in near the high frequency end of the Receiver Tuning Range.

Experiment No. 3

Repeat the steps of Experiment No. 1 but tune the wave trap to the carrier frequency of a Broadcast Station which tunes in near the high frequency end of the Receiver Tuning Range.

Experiment No. 3

For this experiment, you are to use the parallel type of Wave Trap circuit and must make the following changes in connections.

1. Remove the wire connected to Padder Condenser Terminal No. 1 and Receiver Antenna Coil Terminal No. 6.
2. Remove the wire connected to R.F. Coil Terminal No. 2 and Receiver Antenna Coil Terminal No. 5.
3. Connect R.F. Coil Terminal No. 2 to Padder Condenser Terminal No. 1.

4. Connect Padder Condenser Terminal No. 1 to Receiver Antenna Coil Terminal No. 5.
5. Padder Condenser Terminal No. 2 and R.F. Coil Terminal No. 1 should be connected the same as for the series type trap.

When these changes have been made and checked, tune in a station toward the low frequency end of the Receiver Tuning Range. Then, remove the antenna lead-in wire from terminal 5 of the Receiver Antenna Coil and connect it to terminal No. 1 of the R.F. coil.

Without touching any of the Receiver controls adjust the capacity of the Padder for minimum signal. In some cases, the signal may disappear entirely.

Then, without changing the padder condenser adjustment, tune in other stations on the Radio Receiver and you will find the trap has very little effect, especially on those near the high frequency end of the Receiver Tuning range.

Experiment No. 4

With all the adjustments set as for Experiment No. 3, tune in a station near the high frequency end of the Receiver tuning range and without touching the Receiver controls, adjust the padder for minimum signal.

Then, without touching the padder adjustment, tune in other Broadcast Station signals on the Receiver and you will find they come in with about normal volume, especially those near the low frequency end of the Receiver Tuning Range.

The experiments show you that, for this project, the parallel or "Rejector" type of circuit has better operating characteristics than the series or "Acceptor" type. However, you will find both types used in various applications to take advantage of the actions you have heard in the experiments of this project.

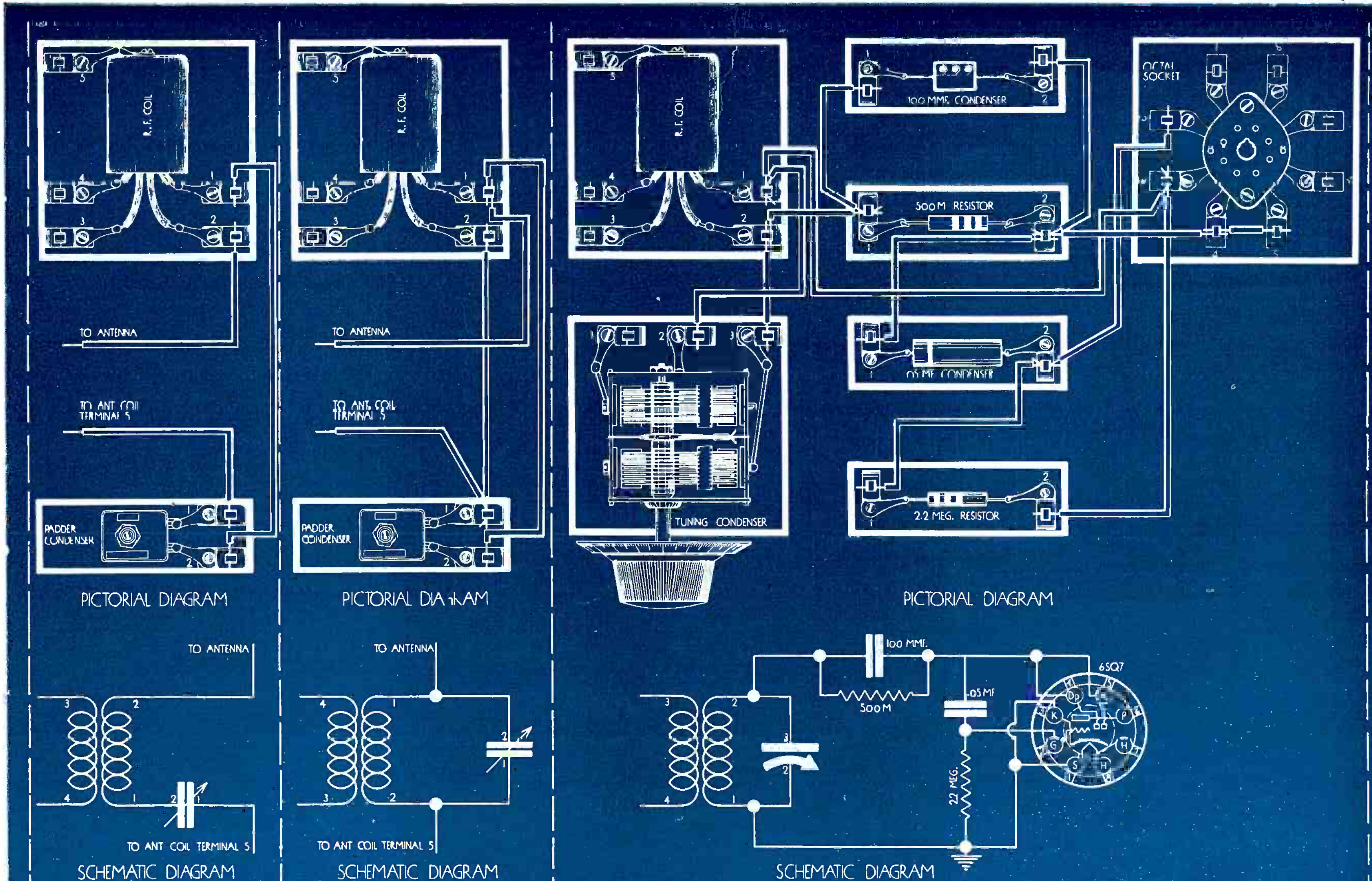



FIGURE 1

FIGURE 2

FIGURE 3

# TUNED GRID - TUNED PLATE OSCILLATOR

## Material Required

1 - Power Supply (Complete)
1 - Antenna Coil
1 - Octal Socket
1 - Padder Condenser
1 - R.F. Coil
1 - 2 Gang Tuning Condenser with Dial
1 - .0005 MF. Tubular Condenser
1 - 50 M (47,000) Ohm Resistor

## OUTLINE

In the earlier experiments, you have wired and operated various types of Radio Frequency oscillators and therefore, for this project we want you to construct a "Tuned Grid - Tuned Plate Type of Oscillator". This is considered as one of the basic types and has many applications, especially in Radio Transmitters.

Checking the schematic diagram here, you will find a coil and condenser combination in the grid circuit. The arrangement can be tuned, by means of the variable condenser, and is often referred to as a "Tank" circuit.

A similar arrangement is shown in the plate circuit and, using the term mentioned above, we have a "Plate Tank" as well as a "Grid Tank" circuit.

In our former explanations we stressed the fact that, in order to oscillate, some of the plate energy must be fed back to the grid circuit of the tube but, looking at the following diagrams, you will see no apparent means of coupling the grid and plate circuits.

They are both separate and complete while the position and shield cans of the coils will prevent any inductive coupling. Therefore, the coupling between the plate and grid circuits occurs inside the tube by means of the "grid-plate" capacity of these elements.

To explain the action briefly, we will assume the heater circuit is in operation and the cathode is emitting electrons but, there is no plate voltage and therefore no plate current. However, when the plate power supply circuit is closed, there will be an initial rush of plate current.

There are several methods of explaining the action which results but perhaps the simplest is to think of the plate,

of the sub-assemblies and have them arranged on the general plan of the following pictorial diagram.

Although the connecting wires are few in number, we will follow our former plan and list them according to their circuits.

A - Heater Circuit -
1. Power Supply Terminal 1 to Octal Socket Terminal No. 8.
2. Power Supply Terminal 2 to Octal Socket Terminal No. 7.

B - Plate Circuit -
1. Power Supply Terminal 4 to Padder Condenser Terminal No. 2.
2. Padder Condenser Terminal No. 2 to R.F. Coil Terminal No. 1.
3. R.F. Coil Terminal No. 2 to Padder Condenser Terminal No. 1.
4. Padder Condenser Terminal No. 1 to Octal Socket Terminal No. 6.
5. Octal Socket Terminal No. 3 to Octal Socket Terminal No. 1.
6. Octal Socket Terminal No. 1 to Power Supply Terminal No. 3.

C - Grid Circuit -
1. Octal Socket Terminal No. 2 to .0005 MF. Condenser Terminal No. 2.
2. .0005 MF. Condenser Terminal No. 2 to 50 M. Resistor Terminal No. 2.
3. 50 M. Resistor Terminal No. 1 to .0005 MF. Condenser Terminal No. 1.
4. .0005 MF. Condenser Terminal No. 1 to Tuning Condenser Terminal No. 3.
5. Tuning Condenser Terminal No. 3 to Antenna Coil Terminal No. 4.
6. Antenna Coil Terminal No. 6 to Tuning Condenser Terminal No. 2.
7. Tuning Condenser Terminal No. 2 to Octal Socket Terminal No. 3.

This project will provide a good place to practice wiring from a schematic diagram and on this basis, we offer the following suggestions.

Referring to the schematic diagram only, the heater of the 6SQ7 tube connects to terminals 7 and 8 which are therefore connected to a 6 volt supply. By this time, you should know that terminals 1 and 2 of your power supply provide 6 volts for the tube heaters.

The plate circuit connects to the supply "+", which is terminal No. 4 of your supply, passes through the secondary of the R.F. coil, connected in parallel to the padder condenser, and on to the plate of the tube which connects to terminal 6 of the socket.

This circuit is completed to the supply negative, terminal No. 3 of your power supply, through the cathode and terminal No. 3 of the socket. The supply negative is considered as "Ground" and therefore the shield of the tube, connected to socket terminal No. 1, also connects to the supply negative.

The grid circuit is completed from socket terminal No. 2, through the 50 M resistor and .0005 MF. condenser in parallel, through the secondary of the antenna coil and one gang of the tuning condenser in parallel, to the cathode of the tube.

OPERATING PROCEDURE

Because of the coil and condenser values, this circuit will oscillate at frequencies in the Broadcast Band and therefore its operation will be similar to the other R.F. oscillators previously constructed. This means that an ordinary Broadcast Radio Receiver is needed to check its operation.

To perform the following experiments, bring the Receiver conveniently close to the oscillator, connect it up and turn it on. Then, check the oscillator connections carefully and place the 6SQ7 tube in the socket. Do not turn on the Power Supply yet as you still have to provide some sort of a coupling between the oscillator and Broadcast Radio Receiver.

Experiment No. 1

Take a piece of hook-up wire, long enough to reach from the oscillator to the Radio Receiver and connect one end of it to terminal 4 of the antenna coil. The other end of this wire can then be placed close to or wrapped around the antenna lead-in wire of the Receiver. If the Receiver has a self contained antenna, form the end of this wire into a coil of a few turns and place it close to the back of the Receiver.

This connection is made to couple the oscillator output to the Receiver input and should be arranged exactly as explained for the Hartley, Armstrong and Electron Coupled Oscillators which you have already constructed and operated.

After the coupling has been made, turn on the oscillator Power Supply and turn the tuning condenser dial until the plates are about $\frac{3}{4}$ meshed. Also, turn the Padder Condenser adjusting screw, anti-clockwise, to the maximum capacity position.

You can now tune in a station on the Radio Receiver, selecting one near the low frequency end of the tuning range, and then slowly turn the padder adjusting screw in a clockwise direction until the oscillator causes interference with the Radio signal.

It may be necessary to readjust the position of the oscillator tuning condenser to cause or increase the interference and, for each setting you can readjust the padder condenser. You should have no difficulty in finding the setting of both oscillator condensers at which there is maximum interference with the Radio signal tuned in on the Receiver.

As previously explained, this interference is caused by the high frequency energy, generated by the oscillator, heterodyning with the high frequency carrier of the Broadcast Radio signal. The presence of the interference proves that the circuit you have built is oscillating.

Experiment No. 2

After you feel familiar with the method of tuning the oscillator, change the setting of the Radio Receiver dial until a different Broadcast Station is heard. Then adjust both the Tuning and Padder Condensers of the oscillator until there is interference with the Radio Signal.

You should have noticed by now that both oscillator condensers must be properly adjusted in order to cause oscillation and we want you to check back against the explanations given in the outline of this project. In this connection, your circuit uses the padder condenser for tuning the plate tank circuit and the regular tuning condenser for tuning the grid tank circuit.

By a proper adjustment of both of these, your oscillator can be made to cause interference at about all points of the Broadcast Radio Receiver tuning range.

Experiment No. 3

To prove definitely that this type of oscillator will not operate unless both the grid and plate tank circuits are adjusted properly, tune both the Receiver and Oscillator until there is a very definite and pronounced interference with some Broadcast Radio signal.

Then, without touching the oscillator tuning condenser, detune the plate tank by turning the adjusting screw of the padder condenser. Unless the original setting was close to the mini-

mum or maximum capacity position, a partial turn of the screw should detune the plate circuit sufficiently to stop the oscillations.

In much the same way you can first adjust the oscillator properly to cause maximum interference in the Radio Receiver and then, without changing the padder condenser adjustment, turn the tuning condenser dial. Here again, unless the original setting was close to maximum or minimum capacity, you can detune the grid tank circuit sufficiently to stop the oscillations.

Experiment No. 4

In the former experiments, the Radio Receiver coupling wire was attached to antenna coil terminal No. 4 which means the oscillator energy was taken directly from the grid tank circuit. However, your former experiments have shown that the windings of the antenna coil are inductively coupled and the oscillator energy should be available from both.

For this experiment therefore we want you to move the Radio Receiver coupling wire from terminal No. 4 to terminal No. 3 of the Antenna Coil. To complete the circuit, place a wire between antenna coil terminal No. 2 and antenna coil terminal No. 6.

Repeat the steps of Experiment No. 1 and compare the interference now with that obtained before.

Experiment No. 5

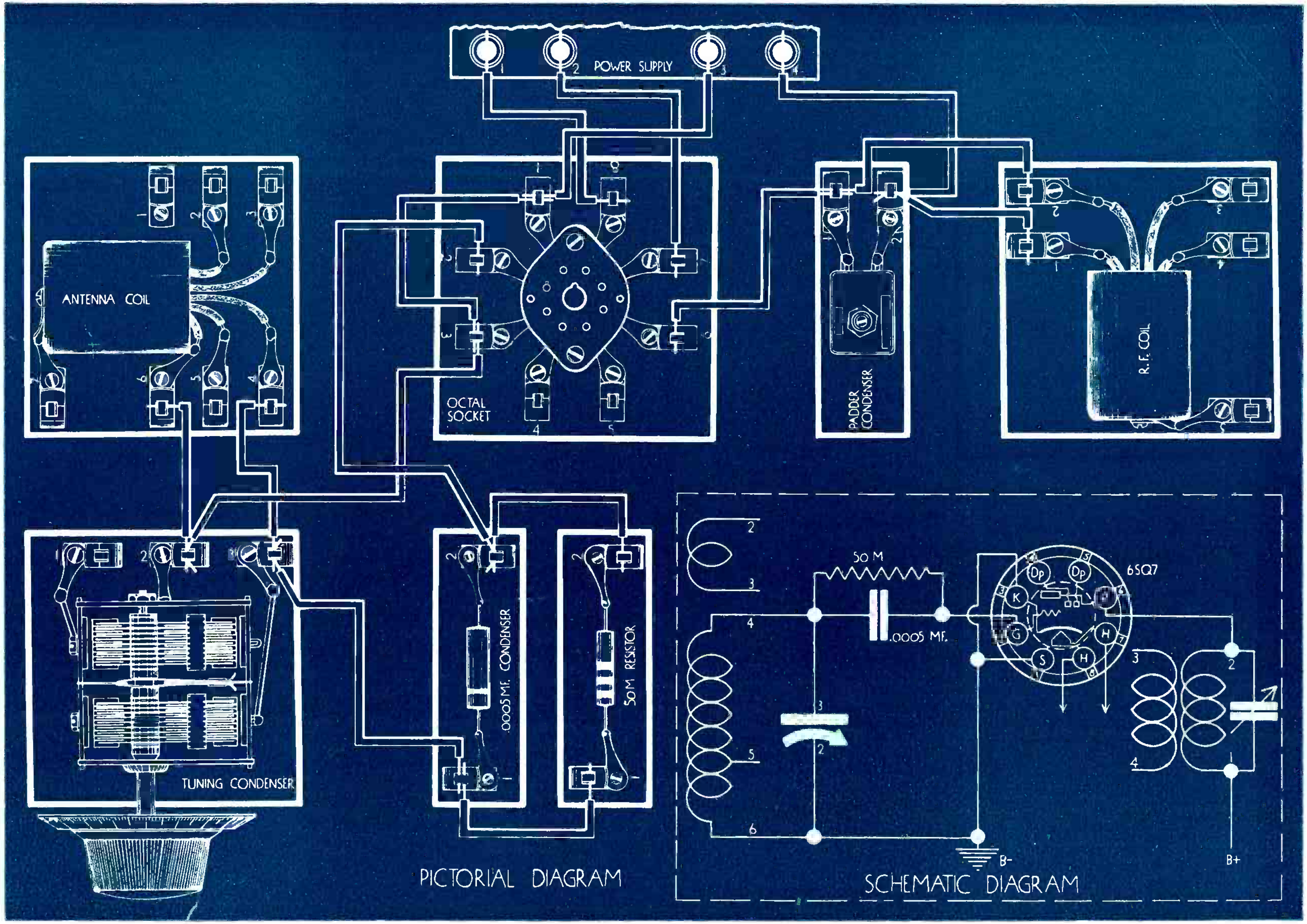
According to our explanations, the plate circuit should also carry energy at the oscillator frequency and, to prove this, you can couple the Radio Receiver to the plate circuit.

You can make a direct connection by connecting the Radio Receiver coupling wire to Terminal No. 2 of the R.F. coil but that will connect it also to the high voltage plate supply and make the wire "Hot".

A better plan is to follow the method of Experiment No. 4 and connect the Radio Receiver coupling wire to terminal 3 of the R.F. coil. To complete the circuit, terminal No. 4 of the R.F. coil should be connected to terminal No. 3 of the Power Supply. This arrangement will provide inductive coupling and allow only the High Frequency Oscillator energy in the coupling wire.

After these connections have been made, repeat the steps of Experiment No. 1 and compare the results with those obtained formerly in Experiments No. 1 and No. 4.

Your next shipment of Laboratory Equipment will include a speaker and Power Output tube which will be used, in the various projects, to handle signals at loud speaker volume. Practically all of the Experiments will pertain to the amplification of Audio Frequencies so that, as you advance still further, you can combine the former projects to construct more complete and commercial types of circuits.


POWER SUPPLY
ANTENNA COIL
OCTAL SOCKET
PADDER CONDENSER
R.F. COIL
TUNING CONDENSER
.0005 MF. CONDENSER
50 M RESISTOR
PICTORIAL DIAGRAM
50 M
.0005 MF.
6SQ7
B-
B+
SCHEMATIC DIAGRAM

# ONE STAGE AUDIO AMPLIFIER

## Material Required

1 - Power Supply (Complete)
1 - P.M. Speaker with Transformer
1 - Octal Socket
1 - Audio Transformer
1 - Headphone
- Hook-Up Wire
- 6SQ7 Tube

## OUTLINE

When constructing the Two Tube Radio Receiver of a former Project, you added a stage of audio amplification to a Detector in order to increase the strength or volume of the Radio signals. As you perhaps know, there are several important branches of Electronics, such as Public Address Systems, Electric Phonographs and Sound Pictures in which the entire systems operate at the signal or audio frequencies.

For work of this general type, no R-F Amplifiers, Detectors or Antennas are needed because the original signal frequencies are amplified and reproduced without change. Because these signals can be heard, all arrangements of this general type are classed as "Sound" systems and consist mainly of Audio Amplifiers.

In brief, all sound systems include an input device, which converts the signal energy to electrical energy. The electrical energy is then amplified, by means of vacuum tubes and their circuits, until the desired level or amplitude is obtained. The amplified electrical energy operates an output device which converts the signal back to sound energy.

For this type of service, the tubes operate as voltage amplifiers, to increase the amplitude, and as Power Amplifiers to supply the energy to operate the output device, usually a speaker. The circuits are therefore designed to utilize the amplifying action of the tubes without causing any change in the signal frequencies.

This last statement is important because, unless all signal frequencies are amplified properly, the reproduced signal will not sound like the original and we say the signal is distorted. In recent years, much progress has been made in the reduction of distortion which, of course, improves the fidelity.

There are four main methods of coupling the stages of an audio amplifier and they can be listed as,

1. Resistance-Capacity Coupling
2. Impedance-Capacity Coupling
3. Transformer Coupling
4. Direct Coupling

Numbers 1 and 3 above are in most common use and, for the experiments of the Projects for this shipment of parts, we are going to have you construct circuits for the first three. No. 4, direct coupling, has certain definite advantages but is inclined to be critical in operation and, therefore is not in common use.

## Experiment No. 1

Before going ahead with our usual wiring procedure, we want you to make this simple experiment as it will demonstrate the conversion of sound energy to electrical energy, a method of coupling and the conversion of electrical energy to sound energy.

As you perhaps know, practically all electrical generators will operate as motors when supplied with electrical energy. Normally they convert mechanical energy into electrical energy but, when supplied with electrical energy, they convert it into mechanical energy.

In Electronics, the microphones can be thought of as generators because they convert sound energy into electrical energy while the speakers compare to the motors because they convert electrical energy into sound energy. Here also, in many cases, the action is reversible and a microphone, supplied with electrical energy, will produce sound while a speaker, supplied with sound energy, will produce electrical energy. You have already proven this action when, in an earlier experiment, you use the headphone as a microphone.

For this experiment, therefore, we want you to follow the diagrams of Figure 1 and connect the headphone cord tips in terminals 1 and 3 of the P.M. Speaker. This will provide the circuit of the schematic diagram which shows clearly that the speaker and headphone are coupled by a transformer.

To check the action here, hold the headphone to your ear and then strike the speaker cone, lightly but sharply, with your finger. The sudden movement of the speaker cone and coil will generate sufficient electrical energy to cause a slight click in the headphone.

This proves that the speaker can generate electrical energy which is transmitted by the transformer to the headphone where it is converted to sound energy.

## WIRING PROCEDURE

For the main part of this project you are going to connect a tube between the speaker and headphone so that the improvement in action, over that obtained in Experiment No. 1, will be due to the amplifying action of the tube. As the circuit and connections are different from those of the preceding experiments, remove all connecting wires from the Power Supply, Octal Socket, Audio Transformer and P.M. Speaker. Then arrange these sub-assemblies according to the plan of the Pictorial Diagram in Figure 2.

## WIRING CONNECTIONS

Although this is a very simple circuit, we will list the connecting wires according to the circuit of which they are a part.

A - Heater Circuit -
1. From Power Supply Terminal No. 1 to Octal Socket Terminal No. 8.
2. From Power Supply Terminal No. 2 to Octal Socket Terminal No. 7.

B - Plate Circuit -
1. From Power Supply Terminal No. 4 to Audio Transformer Terminal No. 4.
2. From Audio Transformer Terminal No. 3 to Octal Socket Terminal No. 6.
3. From Octal Socket Terminal No. 3 to Octal Socket Terminal No. 1.
4. From Octal Socket Terminal No. 1 to Power Supply Terminal No. 3.

C - Grid Circuit -
1. From Octal Socket Terminal No. 2 to Speaker Terminal No. 1.
2. From Speaker Terminal No. 3 to Octal Socket Terminal No. 3.

D - Headphone -
1. One Cord Tip to Audio Transformer Terminal No. 1.
2. One Cord Tip to Audio Transformer Terminal No. 2.

Like most of the former circuits, Power Supply Terminal No. 3 may be grounded as shown in the Schematic Diagram.

Experiment No. 2

After you are sure these connections have been made properly, insert the 6SQ7 tube in the octal socket, plug in the power supply cord and turn on the switch. Allow about 30 seconds

for the tubes to heat and then repeat the steps of Experiment No. 1, tapping the speaker cone with your finger while holding the headphone to your ear.

Notice how much louder the headphone click is as compared to that heard in Experiment No. 1.

Experiment No. 3

To check the action of the speaker as a microphone have someone stand close to the speaker and talk directly into the cone. You will be able to hear them in the headphone but had better hold your other ear closed to shut off the direct sound of the voice.

You can perform this experiment by yourself but will find it quite difficult to talk into the speaker and, at the same time, hear your own voice in the headphone.

As a variation of this experiment, you can install new connecting wires, between the speaker and octal socket, up to a length of a few feet, place the speaker outside and close to door of your room. Then, have someone talk directly into the speaker cone and, because their voice can not be heard directly, the sound in the headphone will be much more distinct.

Experiment No. 4

In the former Experiments, we have emphasized the amplifying action of the tube but now, want you to learn that the coupling transformer also is important.

Shut off the Power Supply, short across its terminals No. 3 and No. 4 to discharge the filter condensers and then remove the connecting wires from all the terminals of the audio transformer. After this has been done, turn the audio transformer half way around and make the following connections.

1. From Power Supply Terminal No. 4 to Audio Transformer Terminal No. 2.
2. From Audio Transformer Terminal No. 1 to Octal Socket Terminal No. 6.
3. One Phone Cord Tip in Audio Transformer Terminal No. 3.
4. One Phone Cord Tip in Audio Transformer Terminal No. 4.

These changes will reverse the primary and secondary windings of the transformer and alter the coupling between the plate circuit of the tube and the headphone.

Turn on the Power Supply switch and check the signals in the phone against those heard in Experiments 2 and 3. The volume should be reduced but in case the signals are louder now, the transformer was improperly connected for Experiments 2 and 3 and, to avoid future errors, we suggest you number the terminals to conform to the diagrams of this project.

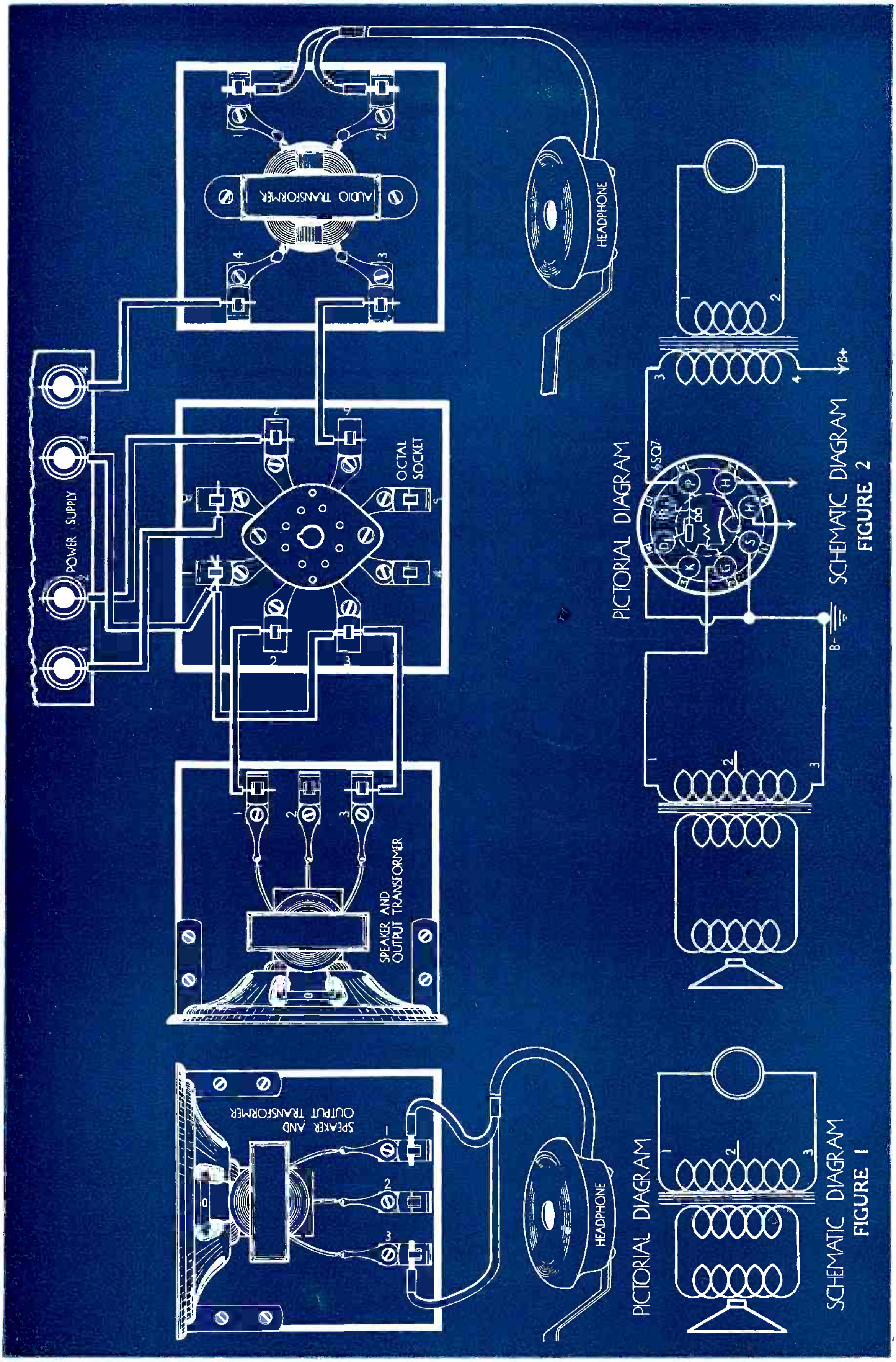



FIGURE 2

FIGURE 1

# IMPEDANCE COUPLED AMPLIFIER

## Material Required

1 - Power Supply (Complete)
2 - Octal Sockets
1 - Audio Transformer
1 - P.M. Speaker
1 - 470 Ohm Resistor
1 - 47000 Ohm Resistor
1 - 470,000 Ohm Resistor
1 - .05 MF. Condenser
1 - 10 to 16 MF. Condenser
1 - Headphone
1 - 6SQ7 Tube
1 - 6K6GT Tube
- Hook-Up Wire

## OUTLINE

The experiments of this project are really a continuation of those performed with the one stage amplifier because here, you add a second tube designed to deliver power to the speaker.

Following the general explanations of the last project, you will use the headphone as an input or microphone and connect one tube to act as a voltage amplifier. The various experiments will take up different methods of coupling this tube to the following Power Output type of tube which will drive the speaker. In all of this work, our main object is to bring out the important features of different basic circuits, tell you how to place them in operation and then point out the important points and actions. So far, we have made no attempt to arrange the circuits to resemble commercial units because we feel it far more important that you gain knowledge as well as skill in the wiring and tracing of circuits.

It has been our experience that once a student is able to wire a group of sub-assemblies, quickly and properly, he has no trouble in commercial work of a similar nature. In fact you will frequently find it easier to wire the component parts on a pre-drilled chassis than to wire similar parts mounted on separate bases.

For the work of the following experiments, you are going to make use of a transformer to couple the voltage amplifier tube to the power output tube. This circuit will provide the usual form of Transformer coupling which was one of the earliest methods employed in Audio Amplifiers. Although other methods have become popular, transformer coupling is still one of the

common forms and in some applications, such as between the output tube and speaker, has no satisfactory substitute.

Perhaps two of the main advantages of the transformer are,

1. For interstage coupling, the proper turn ratios make it possible to obtain some voltage gain in the transformer itself.
2. For the transfer of power, a proper selection of turn ratios provides a simple method of matching impedances.

Electrically, each winding of a transformer contains resistance, inductive reactance and distributed capacity and therefore when placed in an A.C. or signal circuit it can be classed as an impedance.

For impedance coupling, therefore, the primary and secondary windings of the transformer are separated to remove the inductive coupling between them. Each winding thus becomes an impedance and, as such, can provide the proper electrical conditions for its circuit.

Referring to Schematic Diagram (1) of the following illustrations, you will find the primary winding of the transformer, between terminals 3 and 4, is in series with the plate circuit of the 6SQ7 Voltage Amplifier tube. The secondary winding, between terminals 1 and 2, is in the control grid circuit of the 6K6GT Power Output tube.

As both these windings are mounted on the same iron core, they are inductively coupled and signals in the plate circuit of the 6SQ7 tube will induce voltages in the transformer secondary. Because of the circuit connections, these secondary voltages are impressed on the control grid circuit of the output tube and thus control its plate current.

The output transformer, mounted on the speaker of your subassembly, has its primary connected in the plate circuit of the output tube while its secondary connects across the voice coil of the speaker.

The action here is like that of the interstage transformer and changes of plate current in the primary induce corresponding voltages in the secondary. The secondary voltages cause variations of speaker current which, in turn, cause the speaker cone to move and set up sound waves.

For the interstage transformer, the secondary usually has more turns than the primary so that the secondary voltage will

be greater than the voltage drop across the primary. For the output transformer, conditions are entirely different because, for proper operation, the primary requires a comparatively high impedance while the speaker voice coil has a relatively low impedance. The transformer therefore will not only couple the speaker to the plate circuit of the tube but match the low impedance of the speaker voice coil to the higher impedance required for the plate circuit.

Without going into great detail we can tell you that the impedance ratio of a transformer is equal to the square of the turns ratio. For example, suppose the primary winding of the output transformer of Schematic Diagram (1) requires an impedance of 6400 ohms to provide the proper load for the plate circuit but, the speaker voice coil has an impedance of 4 ohms.

These values represent an impedance ratio of 6400 ÷ 4 = 1600 which, as stated above, is the square of the turns ratio. Therefore we extract the square root of 1600 and find the turns ratio is 40 to 1. That means roughly there will be 40 times as many turns in the primary as in the secondary.

Thinking only of signal voltages and currents, the secondary circuit will operate at 1/40 of the voltage and 40 times the current of the primary. Thus, the transformer makes it possible for the low impedance voice coil of the speaker to act as a comparatively high impedance load on the tube.

To let you actually try out various combinations of Impedance Coupling, in the later experiments of this project you will wire up the circuit of Schematic Diagrams (2) and (3).

Comparing Schematic Diagram (2) with Diagram (1) you will find a 470 M resistor is connected in the plate circuit of the 6SQ7 tube, instead of the transformer primary. The transformer secondary remains in the grid circuit of the 6K6GT tube and an .05 mfd condenser couples the plate and grid circuits.

An arrangement of this kind is often called "Resistance Impedance" coupling because the plate resistor and coupling condenser are connected as in resistance coupling but the transformer winding in the grid circuit operates as an impedance.

For the circuit of Diagram (3), the arrangement is reversed because the transformer primary acts as an impedance in the plate circuit while the 470 M resistor is connected in the grid circuit. The electrical position of the coupling condenser remains the same for both.

## WIRING PROCEDURE

For most of the former projects, we have suggested that you remove all connecting wires from all sub-assemblies before starting a new series of experiments. Although a few wires may have to be replaced in their former positions, no time is lost because you do not have to make a careful check to find out which they are. Therefore, we will again assume that all the connecting wires have been removed and that the sub-assemblies are arranged on the general plan of the following Pictorial Diagram.

The Pictorial Diagram coincides with Schematic Diagram (1) only. Schematic Diagrams (2) and (3) are variations which will be covered by different experiments. For the first time, there is no Pictorial Diagram for these schematics because we feel you should be sufficiently advanced in your work to make the required changes by means of the Schematic Diagrams only.

## WIRING CONNECTIONS

For this project, we will follow the circuit plan of wiring and list the connections accordingly. Note - The diagrams show one sub-assembly as a "10 to 16 MF. Condenser". This does not mean the condenser has a variable capacity but that the circuit is not at all critical and any capacity, from 10 MF. to 16 MF. will provide satisfactory results. Therefore this sub-assembly of your kit may be 10 MF., 12 MF., 16 MF., or even a higher value. The important point to watch here is the polarity. Make sure the negative or "-" terminal connects to Power Supply Terminal No. 3 or some other terminal connected directly to it.

A - Heater Circuits -

1. From Power Supply Terminal No. 1 to 6SQ7 Socket Terminal No. 8.
2. From 6SQ7 Socket Terminal No. 8 to 6K6GT Socket Terminal No. 2.
3. From Power Supply Terminal No. 2 to 6SQ7 Socket Terminal No. 7.
4. From 6SQ7 Socket Terminal No. 7 to 6K6GT Socket Terminal No. 7.

B - Plate Circuits -

1. From Power Supply Terminal No. 4 to Speaker Terminal No. 3.
2. From Speaker Terminal No. 1 to 6K6GT Socket Terminal No. 3.
3. From 6K6GT Socket Terminal No. 8 to 470 Ohm Resistor Terminal No. 2.
4. From 470 Ohm Resistor Terminal No. 2 to 16 MF. Condenser "+" Terminal.

5. From 16 m-f Condenser "-" Terminal to 470 Ohm Resistor Terminal No. 1.
6. From 470 Ohm Resistor Terminal No. 1 to Audio Transformer Terminal No. 1.
7. From Audio Transformer Terminal No. 1 to 6K6GT Socket Terminal No. 1.
8. From 6K6GT Socket Terminal No. 1 to Power Supply Terminal No. 3.
9. From Speaker Terminal No. 3 to Audio Transformer Terminal No. 4.
10. From Audio Transformer Terminal No. 3 to 6SQ7 Socket Terminal No. 6.
11. From 6SQ7 Socket Terminal No. 3 to 6SQ7 Socket Terminal No. 1.
12. From 6SQ7 Socket Terminal No. 3 to 47 M Resistor Terminal No. 2.
13. From 47 M Resistor Terminal No. 2 to 470 Ohm Resistor Terminal No. 1.

C - Control Grid Circuits -

1. From 6SQ7 Socket Terminal No. 2 to 47 M Resistor Terminal No. 1.
2. One Phone Cord Tip to 47 M Resistor Terminal No. 1.
3. One Phone Cord Tip to 47 M Resistor Terminal No. 2.
4. From 6K6GT Socket Terminal No. 5 to Audio Transformer Terminal No. 2.

D - Screen Grid Circuit -

1. From Speaker Terminal No. 3 to 6K6GT Socket Terminal No. 4.

Note - Some phone cords are made up of a central conductor and metallic shield which should connect to the "ground'. For any project using the headphone as a microphone reverse the phone cord tip connections and use the one with least noise.

Experiment No. 1

After all these connections have been made and checked, once at least, insert the tubes in their proper sockets, turn on the Power Supply and allow time for the tubes to heat up.

You can now repeat the experiments of the one stage audio amplifier but will find a marked increase in the level of the signal output. Here, by talking closely into the headphone, you will have no difficulty in hearing your own voice in the speaker.

As we suggested for the last project, by extending the wires to either the speaker or the headphone, so that one of them can be placed in an adjoining room, the action of the amplifier

can be checked more readily. Of course, with an arrangement of this kind, it will be necessary to have another person to talk into the phone or check the speaker output.

Another method of making a test is to place the headphone in front of the speaker of a Radio Receiver, which is in operation, and check the signal heard in the speaker of this amplifier.

Experiment No. 2

After you feel familiar with the action and operation of this circuit, we want you to compare the results with those of Impedance Coupling.

For this experiment, therefore, we want you to connect a resistance in the 6SQ7 plate circuit and install a condenser for coupling to the 6K6GT grid circuit.

Shut off the Power Supply switch, short its terminals 3 and 4 to discharge the filter condensers, and then remove the connecting wires from terminals 3 and 4 of the audio transformer. Do not remove the wires entirely but simple disconnect one end at the audio transformer.

Move the 6SQ7 socket and audio transformer sub-assemblies apart enough to place the 470 M resistor between them. Then, connect one resistor terminal to the 6SQ7 socket terminal No. 6. Connect the other resistor terminal to speaker terminal No. 3 with the wire which formerly connected to the audio transformer terminal No. 4. These changes will put the 470 M resistor in the plate circuit of the 6SQ7 tube in place of the transformer primary.

To couple the plate and grid circuits, you will use the .05 MF. condenser, by connecting one of its terminals to audio transformer terminal No. 2 and the other to 6SQ7 socket terminal No. 6. To make sure of the circuit changes, check them against Schematic Diagram (2).

After you are sure the circuits are correct, turn on the Power Supply and, after the tubes have warmed up, repeat the various tests of Experiment No. 1. Compare the results now with those obtained for Experiment No. 1.

Experiment No. 3

For this experiment we want you to reverse the unit by placing the transformer primary back in the plate circuit of the 6SQ7 tube while the 470 M resistor is moved over to the 6K6GT grid circuit as shown by Schematic Diagram (3).

At this time we suggest you make the changes using the schematic diagrams only as a reference. However, should you run into difficulty, you can check the following step by step procedure.

First - Remove the 470 M resistor and .05 MF. condenser from the circuit of Experiment No. 2 and connect the transformer primary back in as shown by the Pictorial Diagram and Schematic Diagram (1). This will restore the circuit of Experiment No. 1 but, if you are not sure, place the circuit in operation and check its action.

Second - Shut off the Power Supply and remove the ends of the connecting wires held in terminals 1 and 2 of the Audio Transformer. Notice here, there are two wires in terminal No. 1 which must be kept together and separate from the wire removed from terminal No. 2.

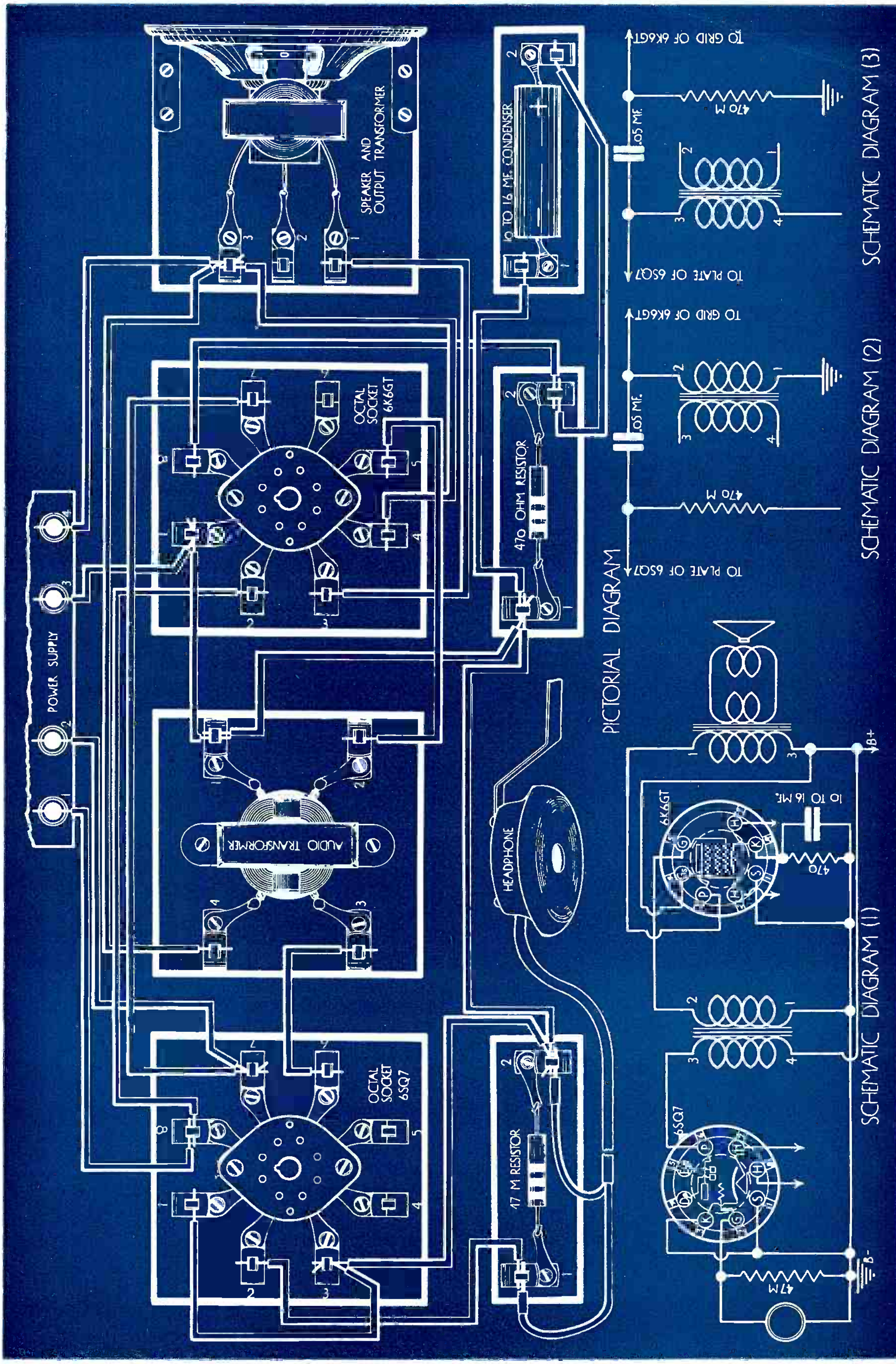
Third - Separate the Audio Transformer and 6K6GT socket assemblies sufficiently to place the 470 M resistor between them. Then connect the two wires which were formerly in terminal No. 1 of the audio transformer to one 470 M resistor terminal. As a check, one of these wires connects to 6K6GT socket terminal No. 1 and the other to terminal No. 1 of the 470 ohm resistor. The wire from 6K6GT socket terminal No. 5, connects to the other terminal of the 470 M resistor.

Fourth - Connect one terminal of the .05 MF. condenser to audio transformer terminal No. 3 and the other condenser terminal to 6K6GT socket terminal No. 5 or to the terminal of the 470 M resistor which is already connected there.

This will complete the circuits of Schematic Diagram 3 with the transformer primary as the impedance load in the plate circuit, the .05 MF. condenser as the coupling unit and the 470 M resistor as the grid load.

After the circuit has been checked, turn on the power supply and repeat the steps of Experiment 1 carefully comparing the action now with that in the former experiments.

Checking the Schematic Diagrams, (1) is Transformer Coupling, (2) can be called Resistance-Impedance Coupling while (3) can be thought of as Impedance-Resistance Coupling. In the simple circuits of this project, these variations of coupling may not cause a pronounced difference of signal but the experiments will prove they are all operative and the work will give you a good drill in becoming familiar with the circuits.


SPEAKER AND OUTPUT TRANSFORMER
10 TO 16 MF. CONDENSER
OCTAL SOCKET 6K6GT
470 OHM RESISTOR
POWER SUPPLY
AUDIO TRANSFORMER
HEADPHONE
OCTAL SOCKET 6SQ7
47 M RESISTOR
PICTORIAL DIAGRAM
TO GRID OF 6K6GT
.05 MF.
470 M
TO PLATE OF 6SQ7
SCHEMATIC DIAGRAM (3)
TO GRID OF 6K6GT
.05 MF.
470 M
TO PLATE OF 6SQ7
SCHEMATIC DIAGRAM (2)
6K6GT
10 TO 16 MF.
470
B+
6SQ7
47 M
B-
SCHEMATIC DIAGRAM (1)

# HEARING AID AMPLIFIER

## Material Required

1 - Power Supply (Complete)
2 - Octal Sockets
1 - Audio Transformer
1 - P.M. Speaker with Transformer
1 - 500 M Potentiometer with Dial
1 - 470 Ohm Resistor
1 - 47 M Resistor
2 - 470 M Resistors
1 - 2.2 Meg. Resistor
1 - .1 mfd Condenser
1 - .01 mfd Condenser
1 - 10 to 16 mfd Condenser
1 - Headphone
1 - 6SJ7 Tube
1 - 6SQ7 Tube
  - Hook-Up Wire

## OUTLINE

For the Impedance Coupled Amplifier Project, you constructed a two stage audio amplifier made up of a Voltage Amplifier and Power Amplifier stages. Its purpose was to amplify the signals of the input circuit and supply them with sufficient power to operate the speaker.

While there are an almost unlimited number of applications for an audio amplifier of this general type, it is often necessary to make certain changes to suit particular conditions. As an example, for this project we are going to have you construct a two stage audio amplifier of a type suited for use as a hearing aid.

For this purpose, we desire a comparatively large amount of amplification but not a great deal of power output because the headphone will be used in the output circuit. To meet these conditions, the p-m speaker is connected as the input device, or microphone, the 6SJ7 is used in the first stage, as a voltage amplifier and the triode section of the 6SQ7 is used as the second stage.

The second, or output stage here is essentially the same as the first or voltage amplifier stage of the impedance coupled amplifier of the last project therefore, this entire circuit can be classed as a voltage amplifier.

The difference between the voltage and power stages of an amplifier is dependent on the types of tubes used although the

the output circuits of a power stage must be able to handle the power which is produced. Here, the characterisitcs of the tubes are such that they provide comparatively high gain but their construction is such that the power output is small.

Looking at the schematic diagram you will find the speaker, acting as a microphone, is transformer coupled to the grid circuit of the 6SJ7 tube. The plate circuit of the 6SJ7 tube is resistance-capacity coupled to the grid circuit of the 6SQ7 tube, the plate circuit of which is transformer coupled to the headphone.

In commercial units of this type, the three main requirements are small size, light weight and ample gain. The circuits are similar to that of this project, but, to make the unit completely self contained, small battery operated types of tubes are employed. However, the construction of this unit with the standard components of your Home Laboratory Equipment will give you first hand information in respect to the results which can be obtained.

Should you have a relative or friend whose hearing is below normal, we suggest you let them listen in when the unit is in operation. They may complain that the amplifier is noisy but that is usually a good sign because it proves they are hearing the many small background noises which normal hearing disregards but which they have not heard for a long time.

## WIRING PROCEDURE

Following our usual plan, we will assume that all the connecting wires have been removed and the various sub-assemblies are arranged on the general plan of the pictorial diagram.

Here again, we suggest you try to wire the circuit by following the schematic diagram only and, with this in mind there are several points we want to mention.

To make our former explanations complete, we have numbered the terminals of all the various sub-assemblies. However, a careful check of the schematic diagram will show you that any of the resistors could be reversed, end for end, without changing the circuit.

Also, as the signals are A.C., you could reverse terminal 1 and 3 of the speaker, terminals 3 and 4 or terminals 1 and 2 of the audio transformer, without changing the circuit.

For the condensers, conditions are different. The 10 to 16 MF. unit is of the electrolytic type and its "+" terminal must be connected toward the positive end of the circuit which, in this case, is the cathode of the 6SQ7 tube. The tubular types

of paper condensers, should have their "outer foil" or "ground" terminal connected toward or to the negative terminal of the plate supply. Here, the ground end of the .1 MF. condenser connects directly to terminal 3 of the Power Supply while the ground end of the .01 MF. coupling condenser connects to terminal 3 of the Power Supply through the 470 M resistor.

## WIRING CONNECTIONS

In order that you may check your wiring, we will list the connections according to the circuits.

A - Heater Circuits -

1. From Power Supply Terminal No. 1 to 6SJ7 Socket Terminal No. 2.
2. From 6SJ7 Socket Terminal No. 2 to 6SQ7 Socket Terminal No. 7.
3. From Power Supply Terminal No. 2 to 6SJ7 Socket Terminal No. 7.
4. From 6SJ7 Socket Terminal No. 7 to 6SQ7 Socket Terminal No. 8.

B - Plate Circuits -

1. From Power Supply Terminal No. 4 to Audio Transformer Terminal No. 3.
2. From Audio Transformer Terminal No. 4 to 6SQ7 Socket Terminal No. 6.
3. From 6SQ7 Socket Terminal No. 3 to 470 Ohm Resistor Terminal No. 1.
4. From 470 Ohm Resistor Terminal No. 1 to 10-16 MF. Condenser "+" Terminal.
5. From 10-16 MF. Condenser "-" Terminal to 470 Ohm Resistor Terminal No. 2.
6. From 10-16 MF. Condenser "-" Terminal to .1 MF. Condenser Terminal No. 1.
7. From .1 MF. Condenser Terminal No. 1 to 6SJ7 Socket Terminal No. 5.
8. From 6SJ7 Socket Terminal No. 5 to 470 M Grid Resistor Terminal No. 2.
9. From 470 M Grid Resistor Terminal No. 2 to Power Supply Terminal No. 3.
10. From Audio Transformer Terminal No. 3 to 2.2 Meg. Resistor Terminal No. 2.
11. From 2.2 Meg. Resistor Terminal No. 2 to 470 M Plate Resistor Terminal No. 2.
12. From 470 M Plate Resistor Terminal No. 1 to 6SJ7 Socket Terminal No. 8.

C - Grid Circuits -

1. From 6SJ7 Socket Terminal No. 4 to 47 M Resistor Terminal No. 1.
2. From 47 M Resistor Terminal No. 1 to Speaker Terminal No. 1.

3. From 47M Resistor Terminal No. 2 to Speaker Terminal No. 3.
4. From 47 M Resistor Terminal No. 2 to 6SJ7 Socket Terminal No. 5
5. From Speaker Terminal No. 3 to 6SJ7 Socket Terminal No. 3.
6. From 6SJ7 Socket Terminal No. 3 to 6SJ7 Socket Terminal No. 1.
7. From 6SQ7 Socket Terminal No. 2 to 470 M Grid Resistor Terminal No. 1.
8. From 470 M Grid Resistor Terminal No. 1 to .01 MF. Condenser Terminal No. 1.
9. From .01 MF. Condenser Terminal No. 2 to 470 M Plate Resistor Terminal No. 1.

D - Screen Grid Circuit -

1. From 2.2 Meg. Resistor Terminal No. 1 to 6SJ7 Socket Terminal No. 6.
2. From 2.2 Meg. Resistor Terminal No. 1 to .1 MF. Condenser Terminal No. 2.

Note - 6SQ7 socket terminal No. 1 may be connected to 6SQ7 socket terminal No. 3, as shown in the pictorial diagram, or to Power Supply terminal No. 3 as shown in the Schematic Diagram. We suggest you make the connection as shown in the Schematic Diagram and then during the experiments, change to the connection shown in the Pictorial Diagram and compare the results.

E - Headphone Circuit -

1. Connect one Phone Cord Tip to Audio Transformer Terminal No. 1.
2. Connect one Phone Cord to Audio Transformer Terminal No. 2.

Experiment No. 1

After all the connections have been made and checked, insert the tubes in their sockets, turn on the Power Supply and, after the tubes have had time to warm up, hold the headphone to your ear. Remember, as a hearing aid, the sounds in the headphone should be the same as those you would hear normally.

Perhaps one of the simplest test methods for work of this type is to place an ordinary spring wound alarm clock near the microphone. The tick of the clock will provide a steady uniform signal for test purposes.

Here for example, place the clock fairly close to the speaker and listen to the tick. Then, hold the headphone closely to one ear while you close the other ear with your finger. Compare the clock ticks heard in the headphone with those heard directly without the amplifier.

3. From 47M Resistor Terminal No. 2 to Speaker Terminal No. 3.
4. From 47 M Resistor Terminal No. 2 to 6SJ7 Socket Terminal No. 5
5. From Speaker Terminal No. 3 to 6SJ7 Socket Terminal No. 3.
6. From 6SJ7 Socket Terminal No. 3 to 6SJ7 Socket Terminal No. 1.
7. From 6SQ7 Socket Terminal No. 2 to 470 M Grid Resistor Terminal No. 1.
8. From 470 M Grid Resistor Terminal No. 1 to .01 MF. Condenser Terminal No. 1.
9. From .01 MF. Condenser Terminal No. 2 to 470 M Plate Resistor Terminal No. 1.

D - Screen Grid Circuit -

1. From 2.2 Meg. Resistor Terminal No. 1 to 6SJ7 Socket Terminal No. 6.
2. From 2.2 Meg. Resistor Terminal No. 1 to .1 MF. Condenser Terminal No. 2.

Note - 6SQ7 socket terminal No. 1 may be connected to 6SQ7 socket terminal No. 3, as shown in the pictorial diagram, or to Power Supply terminal No. 3 as shown in the Schematic Diagram. We suggest you make the connection as shown in the Schematic Diagram and then during the experiments, change to the connection shown in the Pictorial Diagram and compare the results.

E - Headphone Circuit -

1. Connect one Phone Cord Tip to Audio Transformer Terminal No. 1.
2. Connect one Phone Cord to Audio Transformer Terminal No. 2.

Experiment No. 1

After all the connections have been made and checked, insert the tubes in their sockets, turn on the Power Supply and, after the tubes have had time to warm up, hold the headphone to your ear. Remember, as a hearing aid, the sounds in the headphone should be the same as those you would hear normally.

Perhaps one of the simplest test methods for work of this type is to place an ordinary spring wound alarm clock near the microphone. The tick of the clock will provide a steady uniform signal for test purposes.

Here for example, place the clock fairly close to the speaker and listen to the tick. Then, hold the headphone closely to one ear while you close the other ear with your finger. Compare the clock ticks heard in the headphone with those heard directly without the amplifier.

Move the clock further away from the speaker and compare the ticks heard directly with those heard in the headphone. Keep on increasing the distance berween the clock and speaker until you can no longer hear the ticks directly or else they are no longer heard in the phone. Check closely to see if the direct or phone sounds die out first.

As we mentioned before, if you know someone who is partially deaf, let them wear the headphone and then talk to them. It should not be necessary for you to raise your voice nor talk directly into the speaker. Instead, talk naturally, exactly the same as if the amplifier were not in use.

If several persons are available, face the speaker toward the center of the room and, with the deaf person still wearing the headphone, start a general conversation. Notice if the action of the amplifier does not allow the deaf person to enter the conversation more than he would without it.

Experiment No. 2

In the diagram of this project, there is nomeans of controlling the gain of the hearing aid amplifier because, for the first experiment,we wanted you to operate it at maximum sensitivity. However, a gain or volume control is a logical and practical refinement found on nearly all commercial models.

For this experiment, therefore, we want you to add a control but, as a test of your circuit knowledge, we have not drawn a diagram. Instead, we are going to tell you what to do.

In general, we want you to connect your 500 M potentiometer across speaker transformer winding with terminals 1 and 3 and connect the grid of the 6SJ7 tube to t e movable contact of the control. With this arrangement, the potentiometer can be adjusted to allow any portion of the speaker signal voltage to be applied to the grid circuit of the tube.

To make these changes, shut off the power supply and then remove the following wires.

1. Between Speaker Terminal No. 1 and 47 M Resistor Terminal No. 1
2. Between Speaker Terminal No. 3 and 47M Resistor Terminal No. 2
3. Between 47 M. Resistor Terminal No. 2 and 6SJ7 Socket Terminal No. 5
4. Between 47M Resistor Terminal No. 1 and 6SJ7 Socket Terminal No. 4

After these wires have been removed, replace the 47 M resistor with the 500 M potentiometer control assembly and then make the following connections.

1. From Speaker Terminal No. 1 to 500 M Control Terminal No. 1.
2. From 500 M Control Terminal No. 2 to 6SJ7 Socket Terminal No. 4.
3. From Speaker Terminal No. 3 to 500 M Control Terminal No. 3.
4. From 500 M Control Terminal No. 3 to 6SJ7 Socket Terminal No. 5.

After these wires have been put in place, turn on the Power Supply and, while listening in the headphone, slowly turn the 500 M control dial. You will find there is a definite relation between the position of the dial and the volume of sound in the phone.

It is standard to arrange the control so that the volume of the signal will increase when the control dial is turned clockwise as you face it. Should your control operate in the opposite direction, reverse the connections to its terminals No. 1 and No. 3.

With the control operating properly repeat the steps of Experiment No. 1. If some hard of hearing person is listening to the phone, let him adjust the control for best results. You may be surprised to find he will not require all of the available volume.

Experiment No. 3

With the control in the grid circuit of the 6SJ7 tube, as used in Experiment No. 2, any noise in the control itself will be amplified equally with the signal and may be annoying. For this experiment therefore, we want you to move the control to the grid circuit of the 6SQ7 tube so that any noises generated in it will not be amplified equally with the signals.

For this arrangement, the total resistance of the control will replace the 470 M resistor in the 6SQ7 grid circuit while the grid will connect to the moving contact of the control.

To make these changes, first remove the control from the grid circuit of the 6SJ7 tube and restore the circuit to that shown in the diagrams. Then, remove the following wires.

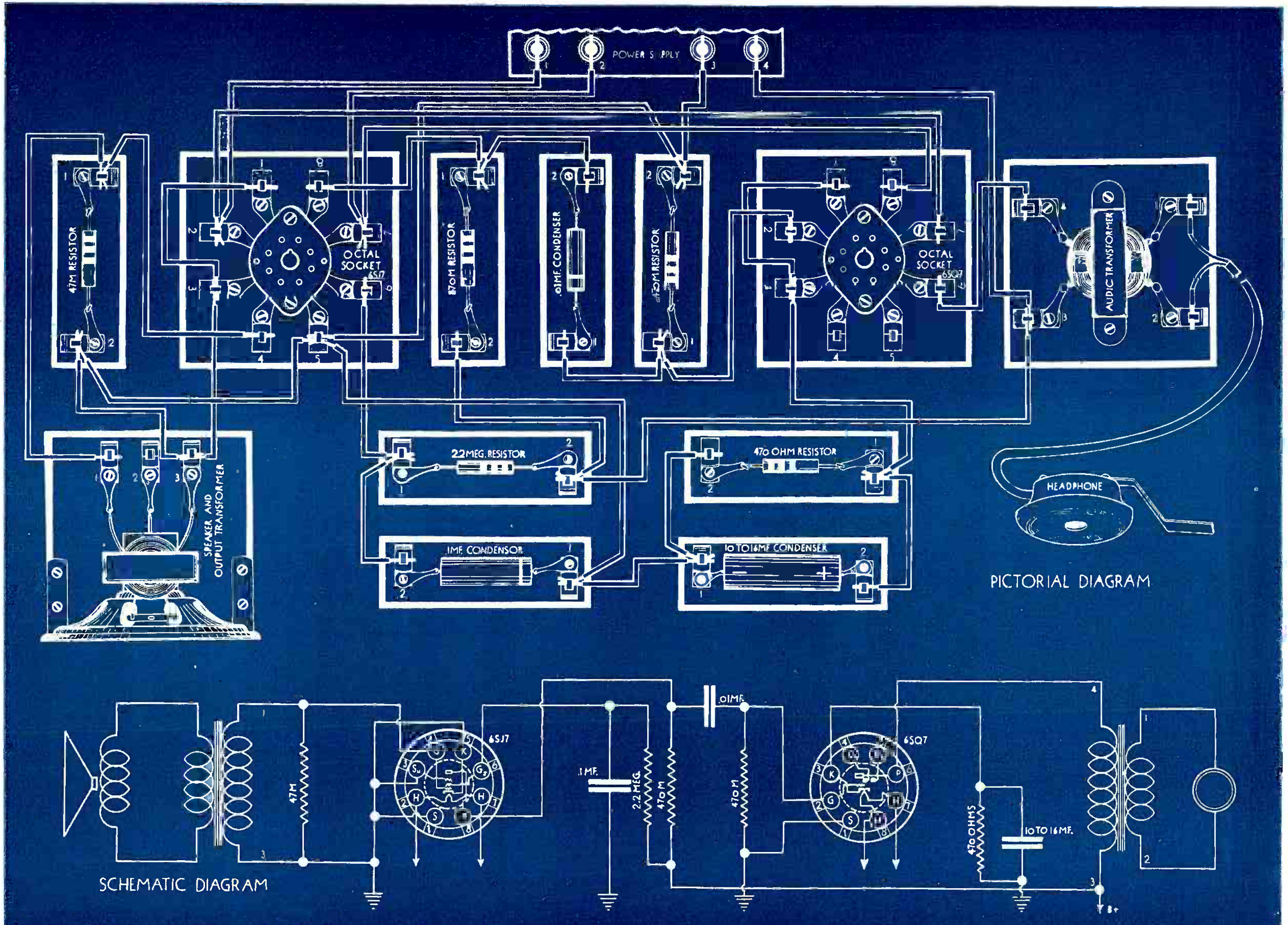
1. Between 6SQ7 Socket Terminal No. 2 and 470 M Grid Resistor Terminal No. 1.

2. Between 470 M Grid Resistor Terminal No. 1 and .01 MF Condenser Terminal No. 1.
3. Remove both wires from 470 M Grid Resistor Terminal No. 2 but do not disconnect the other side of these wires.

Replace the 470 M grid resistor assembly with the 500 M control and make the following connections.

1. From 6SQ7 Socket Terminal No. 2 to 500 M Control Terminal No. 2.
2. From .01 MF Condenser Terminal No. 1 to 500 M Control Terminal No. 1.
3. Connect the two wire ends, removed from Terminal No. 2 of the 470 M Grid Resistor, to Terminal No. 3 of the 500 M Control.

Turn on the Power Supply and compare the action now with that of Experiment No. 2. Also, repeat the various steps of Experiments No. 1 and No. 2 to see if a control of this type is not a worth while addition to a unit of this kind.


POWER SUPPLY
47M RESISTOR
OCTAL SOCKET 6SJ7
870M RESISTOR
.01MF. CONDENSER
470M RESISTOR
OCTAL SOCKET 6SQ7
AUDIO TRANSFORMER
SPEAKER AND OUTPUT TRANSFORMER
2.2 MEG. RESISTOR
470 OHM RESISTOR
.1MF. CONDENSOR
10 TO 16MF. CONDENSER
HEADPHONE
PICTORIAL DIAGRAM
47M
6SJ7
.1MF.
2.2 MEG.
470 M
.01MF.
470 M
6SQ7
470 OHMS
10 TO 16MF.
B+
SCHEMATIC DIAGRAM

# HEARING AID AMPLIFIER

## Material Required

1 - Power Supply (Complete)
2 - Octal Sockets
1 - Audio Transformer
1 - P.M. Speaker with Transformer
1 - 500 M Potentiometer with Dial
1 - 470 Ohm Resistor
1 - 47 M Resistor
2 - 470 M Resistors
1 - 2.2 Meg. Resistor
1 - .1 MF. Condenser
1 - .01 MF. Condenser
1 - 10 to 16 MF. Condenser
1 - Headphone
1 - 6SJ7 Tube
1 - 6SQ7 Tube
- Hook-Up Wire

## OUTLINE

For the Impedance Coupled Amplifier Project, you constructed a two stage audio amplifier made up of a Voltage Amplifier and Power Amplifier stages. Its purpose was to amplify the signals of the input circuit and supply them with sufficient power to operate the speaker.

While there are an almost unlimited number of applications for an audio amplifier of this general type, it is often necessary to make certain changes to suit particular conditions. As an example, for this project we are going to have you construct a two stage audio amplifier of a type suited for use as a hearing aid.

For this purpose, we desire a comparatively large amount of amplification but not a great deal of power output because the headphone will be used in the output circuit. To meet these conditions, the P.M. speaker is connected as the input device, or microphone, the 6SJ7 is used in the first stage, as a voltage amplifier and the triode section of the 6SQ7 is used as the second stage.

The second, or output stage here is essentially the same as the first or voltage amplifier stage of the impedance coupled amplifier of the last project therefore, this entire circuit can be classed as a voltage amplifier.

The difference between the voltage and power stages of an amplifier is dependent on the types of tubes used although the

Checking the Schematic Diagram here, against those of the former projects of this Shipment, you will find we are using the headphone as a microphone to feed the grid circuit of the 6SJ7 voltage amplifier which resembles the first stage of the Hearing Aid Amplifier.

This first stage is resistance-capacity coupled to the 6K6GT which operates as a power stage similar to that used in the Impedance Coupled Amplifier. This selection of tubes and circuits will provide both the Voltage Amplification and Power Output required for an outfit of this type.

It may be well to mention here that most amplifiers of this type, where the microphone is comparatively close to the speaker are troubled by what is known as "Acoustical Feedback". With or without a signal in the microphone, a disturbance in the speaker will set up a sound wave which travels back through the air and enters the microphone.

The sound is then treated like a signal, is amplified and causes a much greater movement of the speaker cone. This in turn sets up a stronger sound wave which acts as a louder signal in the microphone and, as such, causes a still greater movement of the speaker cone.

This "build up" action continues until there is a steady howl or squeal from the speaker which ruins all the desired signals and therefore must be avoided. Knowing the cause of the trouble simplifies the cure.

Perhaps the most common remedy is to simply reduce the gain of the amplifier, by adjusting the volume control, until the howl stops. This is not a very efficient method however, because, in order to stop the howl, the output level of the signal is also reduced.

Another plan is to locate the microphone in line with the edge of the speaker cone so that any sound waves from the speaker will strike the microphone edgewise and thus have a minimum effect.

Similar improvement can be obtained by installing horn type baffles or trumpets on the speakers so that the sound waves will be directed away from the microphone. In other installations, the microphones are enclosed in sound proof containers with a small opening on one side only. This practically eliminates all but the desired sound signals from reaching the microphone.

This feedback howl does not indicate trouble but instead, is a fairly reliable proof that the amplifier is operating efficiently and is often used as a sensitivity test.

For the ordinary installation, the usual procedure is to locate the speakers in a position which allows the minimum amount of coupling and then operate the system with the gain control well below the point of feedback howl. If the gain is set too high, there may not be sufficient feedback to cause the howl but there will be enough to distort the signals.

## WIRING PROCEDURE

Following our usual plan, we will assume that all of the connecting wires have been removed from all of the sub-assemblies which you have arranged on the general plan of the Pictorial Diagram. As you no doubt know by this time, the sub-assemblies do not have to be arranged exactly as we show them however, for this unit, we want you to keep the microphone at one end and the speaker at the other.

In developing these different projects here in our Laboratories, we have spent considerable time in arranging the sub-assemblies to require the smallest number and shortest lengths of connecting wires. This is the plan followed for commercial units of similar types and is not only more economical, as far as wire is concerned, but tends to improve the operation of the circuits.

Once again, we suggest that you wire up the sub-assemblies by following the schematic diagram only but, to provide a check, we will list the connections according to their circuits.

## WIRING CONNECTIONS

A - Heater Circuits -

1. From Power Supply Terminal No. 1 to 6SJ7 Socket Terminal No. 2.
2. From 6SJ7 Socket Terminal No. 2 to 6K6GT Socket Terminal No. 2
3. From Power Supply Terminal No. 2 to 6SJ7 Socket Terminal No. 7.
4. From 6SJ7 Socket Terminal No. 7 to 6K6GT Socket Terminal No. 7.

B - Screen Grid Circuits -

1. From Power Supply Terminal No. 4 to 6K6GT Socket Terminal No. 4.
2. From 6K6GT Socket Terminal No. 8 to 10-16 mfd Condenser "+" Terminal.
3. From 10-16 mfd Condenser "+" Terminal to 470 ohm Resistor Terminal No. 2
4. From 470 ohm Resistor Terminal No. 1 to 10-16 mfd Condenser "-" Terminal.
5. From 10-16 mfd Condenser "-" Terminal to 470 M Grid Resistor Terminal No. 1.
6. From 470 M Grid Resistor Terminal No. 1 to Power Supply Terminal No. 3.

7. From 6K6GT Socket Terminal No. 4 to 2.2 meg. Resistor Terminal No. 2.
8. From 2.2 Meg. Resistor Terminal No. 1 to 6SJ7 Socket Terminal No. 6.
9. From 2.2 Meg. Resistor Terminal No. 1 to .1 MF. Condenser Terminal No. 2.
10. From .1 MF. Condenser Terminal No. 1 to 470 Ohm Resistor Terminal No. 1.
11. From 6SJ7 Socket Terminal No. 5 to 6SJ7 Socket Terminal No. 3.
12. From 6SJ7 Socket Terminal No. 5 to .1 MF. Condenser Terminal No. 2.
    (Note – Do not confuse this .1 MF. condenser with that already connected to the screen grid of this tube. This one connects to the cathode.)
13. From .1 MF. Condenser Terminal No. 2 to 5 M Resistor Terminal No. 2.
14. From 5 M Resistor Terminal No. 1 to .1 MF. Cathode Condenser Terminal No. 1.
15. From 5 M Resistor Terminal No. 1 to .1 MF. Screen Grid Condenser Terminal No. 1.
16. From .1 MF. Cathode Condenser Terminal No. 1 to 6SJ7 Socket Terminal No. 1.

C – Plate Circuits–

1. From 6K6GT Socket Terminal No. 4 to Speaker Terminal No. 3.
2. From Speaker Terminal No. 1 to 6K6GT Socket Terminal No. 3.
3. From 2.2 Meg. Resistor Terminal No. 2 to 470 M Plate Resistor Terminal No. 2.
4. From 470 M Plate Resistor Terminal No. 1 to 6SJ7 Socket Terminal No. 8.
5. From 470 M Plate Resistor Terminal No. 1 to .01 MF. Condenser Terminal No. 1.

D – Grid Circuits –

1. From 6SJ7 Socket Terminal No. 4 to 500 M Potentiometer Terminal No. 2.
2. From 500 M Potentiometer Terminal No. 1 to .1 MF. Cathode Condenser Terminal No. 1.
3. One Phone Cord Tip to 500 M Potentiometer Terminal No. 1.
4. One Phone Cord Tip to 500 M Potentiometer Terminal No. 3.
5. From 6K6GT Socket Terminal No. 5 to 470 M Grid Resistor Terminal No. 2.
6. From 470 M Grid Resistor Terminal No. 2 to .01 MF. Condenser Terminal No. 2.
7. From 6K6GT Socket Terminal No. 1 to 470 M Grid Resistor Terminal No. 1.

Looking at the Schematic Diagram, you will see that all except the heater circuits are connected back to B-, your Power Supply Terminal No. 3, which is shown as "Ground". For some installations, the operation of the amplifier will be improved by actually making a connection to an "earth" ground.

The improvement will consist of a reduction in noise and pick up of man-made static. However, most 110 volt lighting circuits are grounded and, whenever there is interference, we suggest you reverse the position of the power cord plug in the outlet. Try it in both positions and use the one which provides the quieter operation.

Experiment No. 1

After the wiring is completed and checked, insert the tubes in the proper sockets and turn on the Power Supply. Also, turn the Potentiometer Dial all the way anti-clockwise and wait for the tubes to warm up.

Then, hold the headphones close to your lips and, with a low voice, talk directly into it while you slowly advance the Potentiometer Dial in a clockwise direction until you can hear your voice in the speaker.

As we mentioned before, it is not always satisfactory to listen to your own voice because you hear it internally as well as from the speaker. For a substitute, you can place a spring wound alarm clock near the headphone and use its ticks as a signal.

For this unit, perhaps a better experiment is to place a watch on the headphone and then turn up the gain until its ticking can be heard in the speaker. Also you can point the headphone in different directions or hold it at an open window, listening to the sounds which it picks up and amplifies.

Experiment No. 2

Earlier in our explanation we told you about acoustical feedback and, for this experiment want you to hear it and see how it can be prevented.

First, place the headphone directly in front of the speaker and then slowly turn the potentiometer dial in a clockwise direction. As soon as the howl begins, stop turning the dial and listen to the volume of the sound build up.

Then, without changing the position of the phone or speaker, turn the potentiometer dial anti-clockwise until the howl

stops. Turn the dial slowly, stopping and starting the howl several times and check the position of the dial.

You will find the starting and stopping positions do not coincide and, after the howl is present, the gain will be reduced below the starting point in order to stop it.

With the headphone in front of the speaker, the feedback is at maximum but, by carefully following the steps of this experiment you will obtain a working knowledge of operating the gain control to prevent feedback.

Experiment No. 3

For this experiment we want you to see and hear the affect of the relative positions of the speaker and microphone. Following the steps of Experiment No. 2, turn up the gain until the feedback howl just starts.

Then, pick up the headphone by the cord and move it slowly all around the speaker. At this time, do not allow the phone to turn in order that its opening will always point in the same direction.

As you move the phone toward the side of the speaker, the howl may stop and, when this happens, hold the headphone stationary and turn up the gain until the howl just starts. Then move the phone further and see if you can find a position to stop the howl.

Following this plan systematically you will find certain positions of the headphone which will permit a higher setting of the potentiometer without feedback howl. Naturally, the position which allows the highest gain without feedback is the most efficient and should be used.

Experiment No. 4

Many modern P.A. amplifiers employ what is known as "Inverse Feedback" in order to improve the fidelity of their output signals. This type of feedback is entirely electrical and consists of feeding energy from the plate circuit back to the grid circuit.

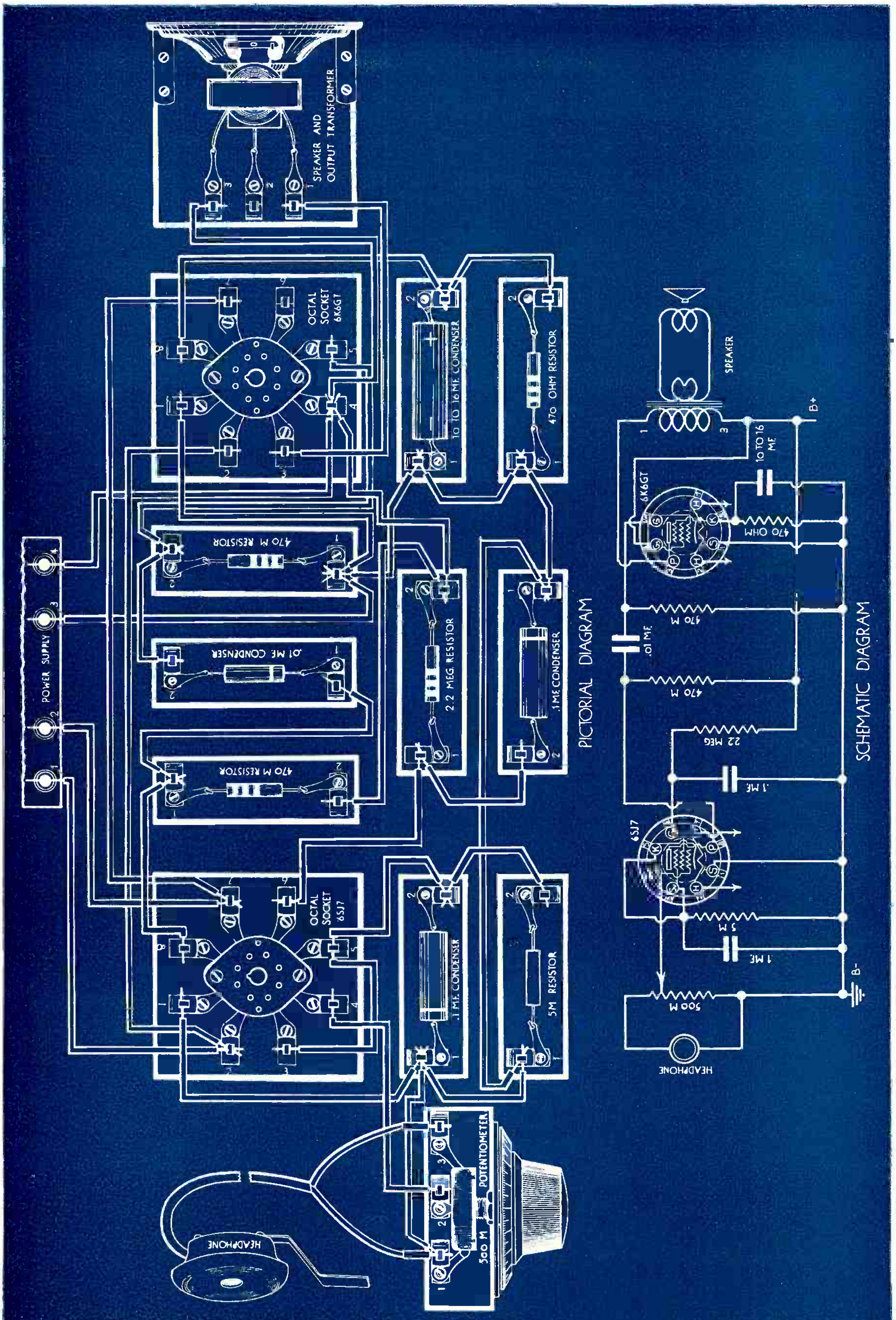
This is the same general action, explained for the earlier experiments with various types of oscillators but, there is one big difference. For the oscillator, the feedback voltage aids the input voltage to produce "Regeneration" while here, the feedback voltage opposes the input voltage to produce "Degeneration".

The degenerative feedback reduces the output but makes it more independent of variations in output and supply voltages as well as reducing the distortion. To check this action you need only to remove the 10-16 MF. condenser connected across the 470 ohm bias resistor of the 6K6GT tube. You may remember that the purpose of a condenser connected across a bias resistor is to reduce changes of voltage drop caused by changes of plate current. With the condenser removed, the voltage drop across the bias resistor will vary with the current in it.

To follow the degenerative action you need remember only that an increase of current in the bias resistor causes an increase of negative grid bias voltage. Thus, when a signal voltage reduces the negative grid bias there will be an increase of plate current which, passing through the bias resistor, causes an increase of negative grid bias voltage.

For this experiment therefore simply remove the 10-16 MF. condenser and then operate the amplifier. You will find a noticeable decrease of output but, repeat the steps of the former experiments and compare the results.

Do not dismantle this cirouit because, with a few changes you will use it for the following project.


SPEAKER AND OUTPUT TRANSFORMER
OCTAL SOCKET 6K6GT
10 TO 16 MF. CONDENSER
470 OHM RESISTOR
POWER SUPPLY
470 M RESISTOR
.01 MF. CONDENSER
470 M RESISTOR
2.2 MEG. RESISTOR
.1 MF. CONDENSER
OCTAL SOCKET 6SJ7
.1 MF. CONDENSER
5M RESISTOR
POTENTIOMETER
500 M
HEADPHONE
PICTORIAL DIAGRAM
SPEAKER
B+
10 TO 16 MF.
6K6GT
470 OHM
470 M
.01 MF.
470 M
2.2 MEG
.1 MF.
6SJ7
.5 M
.1 MF.
B-
500 M
HEADPHONE
SCHEMATIC DIAGRAM

# INTERCOMMUNICATING SYSTEM

## Material Required

1 - Power Supply (Complete)
2 - Octal Sockets
1 - P-M Speaker with Transformer
1 - 500 M Potentiometer
1 - 470 Ohm Resistor
1 - 5000 Ohm, 5 Watt Resistor
2 - 470 M Resistors
1 - 2.2 Meg. Resistor
1 - .01 MFD Condenser
2 - .1 MFD Condenser
1 - 10 to 16 MFD Condenser
1 - Headphone
1 - 6SJ7 Tube
1 - 6K6GT Tube
1 - Audio Transformer
1 - .05 MFD Condenser
Hook-up Wire

## OUTLINE

Checking this list of material you will find that, with the exception of the last two items, it is the same as given for the Public Address System of the former project. That is why we asked you not to dismantle the Public Address System circuit.

Going back to this circuit, you can readily see that, by placing the microphone in one room and the speaker in another you would have a convenient call system or sort of a one way telephone. Many systems of this type are in commercial use and are really nothing but a special application for a Public Address System.

However, two such systems, operating in reverse directions would make a two way conversation possible and double the efficiency of the outfit. In general, such an arrangement is known as an "Intercommunicating System".

From your former experiments you know that both the speaker and headphone will operate either as an input or output device therefore, by arranging the circuits so that these units may be connected alternately across the input and output circuits of the amplifier, you will have an intercommunicating system.

With an arrangement of this kind, an amplifier is made to do double duty, thereby reducing the cost of the equipment and, to prevent confusion, the usual commercial practice is to designate one microphone-speaker as the "master" and equip it with a "Talk-Listen" switch.

With the switch in the "Talk" position, the unit operates as a microphone and the signals it receives are amplified and reproduced in the other unit. With the switch in the "Listen" position, the unit operates as a speaker and reproduces the amplified signals picked up by the other unit.

There are many variations of this simple 1 Master - 1 Sub-Station arrangement and, by suitable switching, a complete system may consist of quite a number of Master Stations, Sub-Stations or both. In all cases however, there can be a signal in one direction only at any given instant.

For this project therefore, you are going to use the Public Address System of the former project and rearrange the circuits so that, by changing a minimum number of wires, you will be able to reverse the circuit positions of the headphone and speaker.

## WIRING PROCEDURE

If you followed the instructions and experiments of the last project you still have the Public Address Sustem set up complete with the exception of the 10-16 MF. condenser which was removed from the circuit. Your first step now is to connect this condenser back into the circuit.

If, for some reason, the Public Address System has been dismantled, reassemble it completely as shown by the diagrams of the former project because we are going to start our explanations here in the assumption that the circuit is complete.

The changes to be made are shown in the diagrams of this project and consist mainly of replacing the speaker transformer primary by the audio transformer primary as a load for the output tube. An .05 MF. condenser is installed to couple the output tube to the speaker and the four open ended wires, shown in the diagrams, are the connections which will be changed to act as a "Talk-Listen" switch.

To use the headphone as a microphone and the speaker as a speaker, the open end of the phone connects to the open end of the 500 M Potentiometer and the open end of the speaker transformer connects to the open end of the .05 MF. coupling condenser.

To use the headphone as a speaker and the speaker as a microphone, the open end of the speaker transformer connects to the open end of the 500 M potentiometer while the open end of the phone cord connects to the open end of the .05 MF. coupling condenser.

Thus, from an operating standpoint, it is necessary to change but two wires to reverse the direction of speech through the system. With a little practice, you can make these changes fast enough to permit a two way conversation with but little delay.

## WIRING CONNECTIONS

By this time, you should be able to make the changes and complete the circuits by referring to the schematic diagrams only but, in case you need a check, we will list the various connections as shown by the pictorial diagrams.

Starting with the Diagram of the complete P.A. System,

1. Remove the wire between Speaker Terminal No. 3 and 6K6GT Socket Terminal No. 4.
2. Remove the wire between Speaker Terminal No. 1 and 6K6GT Socket Terminal No. 3.

Place the Audio Transformer and .05 m-f condenser sub-assemblies in the approximate positions shown in the Pictorial Diagrams of this project and make the following connections.

1. From 6K6GT Socket Terminal No. 4 to Audio Transformer Terminal No. 4.
2. From 6K6GT Socket Terminal No. 3 to Audio Transformer Terminal No. 3.
3. From Audio Transformer Terminal No. 3 to .05 m-f Condenser Terminal No. 1.

If you are going to operate the speaker in another room or other remote location, you will need two wires long enough to extend from the speaker to the amplifier. A duplex cord, like that used for the extension cord of the power supply, will be suitable.

Connect one of the wires to Speaker Terminal No. 3 and the other to Speaker Terminal No. 1, place the speaker in the desired location and carry the connecting wires back so that their other ends may be connected to the amplifier.

One of these wires can be permanently connected to 6K6Gt socket terminal No. 1 and the other left so that it can be connected to 500 M potentiometer terminal No. 3 or .05 m-f condenser terminal No. 2.

To provide a similar flexibility for the phone connections, remove both phone cord tips from the 500 M potentiometer terminals. Then, take a piece of hook-up wire about 18 inches long and connect one end to potentiometer terminal No. 1.

Push back the insulation for about 2 inches at the other end and wrap the bare wire tightly around one of the phone cord tips. This will allow the other phone tip to be readily connected to potentiometer terminal No. 3 or .05 MF. condenser terminal No. 2.

Experiment No. 1

After these changes are complete, connect the loose phone cord tip to potentiometer terminal No. 3 and the loose speaker wire to .05 MF. condenser terminal No. 2. Then turn on the power supply and the amplifier should operate about the same as in the former experiments concerning it.

If the speaker is in some remote location, you may need a second person to check the operation but can use a spring wound alarm clock as a signal source. Place the clock near the headphone, turn up the gain and then go and listen at the speaker.

Experiment No. 2

To reverse the direction of the signal remove the speaker wire from terminal 2 of the .05 MF. condenser and the phone cord tip from terminal 3 of the potentiometer. Then place the phone cord tip in .05 MF. condenser terminal No. 2 and the speaker wire in 500 M potentiometer terminal No. 3.

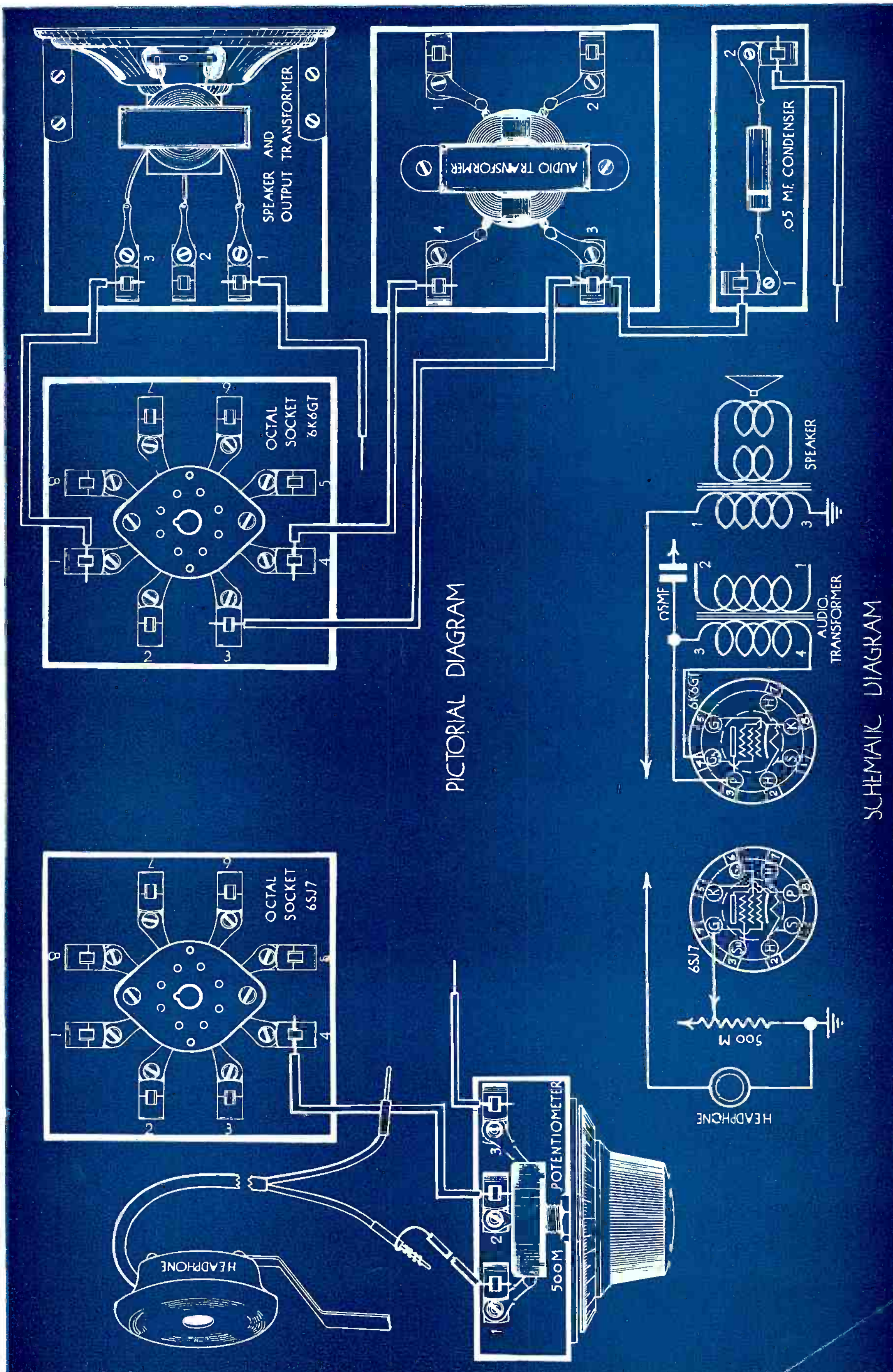
If you used an alarm clock for Experiment No. 1, place it in front of the speaker and then listen to the headphone. As the phone is located at the amplifier you can adjust the Potentiometer Dial to provide the desired signal level.

Experiment No. 3

For this experiment you will need a helper because we want you to carry on a two way conversation. First, however, you had better practice changing the connections a few times so that you will be able to reverse the signal without delay.

With the circuit connected as for Experiment No. 2, have your helper talk into the speaker while you adjust the gain to suit. Then, when you are ready, reverse the speaker and phone connections, as previously explained, and talk back to him.

Although a double pole, double throw switch would change the connections more rapidly, it should not take you long, with but two wires to shift. Just imagine you are being very polite and after the other part stops talking, you want a few seconds to make sure he has finished before you answer. During this pause of a few seconds, you will have ample time to change the connections.



SPEAKER AND OUTPUT TRANSFORMER
AUDIO TRANSFORMER
.05 MF. CONDENSER
OCTAL SOCKET 6K6GT
PICTORIAL DIAGRAM
OCTAL SOCKET 6SJ7
HEADPHONE
POTENTIOMETER
500M
SPEAKER
.05MF
AUDIO TRANSFORMER
6K6GT
6SJ7
500 M
SCHEMATIC DIAGRAM

Packing Slip

SHORT WAVE RECEIVER (75)

DE FOREST'S TRAINING, INC.

This shipment of your home laboratory equipment should contain the following items.

1 - Octal Socket
1 - 6 Prong Socket (SA)
1 - 100,000 Ohm Resistor (SA)
2 - Coil Forms
1 - Roll #36 Enamel Wire
1 - Roll Hook-up Wire

Please check the items in this shipment against the above list and then answer the following questions.

Did you receive all the items in the above list?______________

If not which were missing?______________

Did you receive any extra parts?______Specify ______________

Were all the items received in good condition?______________

If not, which were damaged?______________

What is the extent of the damage?______________

Which item(s) require replacement?______________

When you have examined your shipment and answered the questions, please sign in the space provided below and then mail this sheet to us.

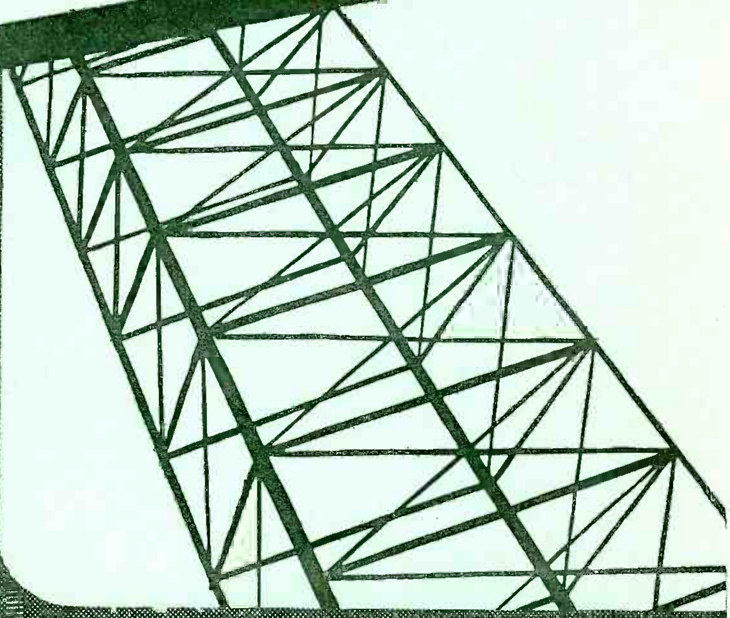
Name ______________ Student No. ______________

Street ______________

City______________ Zone_____State ______________

IN ORDER TO PREVENT DELAY OF THE NEXT SHIPMENT OF YOUR HOME LABORATORY EQUIPMENT, THIS SHEET, PROPERLY FILLED OUT, MUST BE RETURNED TO US IMMEDIATELY.

# HOME LABORATORY
# KIT PROJECTS
# SHORT WAVE RECEIVER



**DE FOREST'S TRAINING, INC.**

2533 N. Ashland Ave., Chicago 14, Illinois

# COIL DESIGN AND WINDING

## MATERIAL REQUIRED

Paper and Pencil

## OUTLINE

In all of the former projects, designed to operate at Radio Frequencies, you may have noticed that, in practically every case, the high frequency circuits were tuned. The main components of these circuits were an inductance, in the form of a coil, and a capacity, usually in the form of a variable condenser.

The purpose of a tuned circuit is to take advantage of the conditions which occur when the inductive and capacity reactances values are equal and the circuit is resonant. Reviewing briefly, reactance is measured in ohms and, for inductive reactance, the general equation is

$$X_L = 2\pi fL$$

while for capacity reactance

$$X_C = \frac{1}{2\pi fC}$$

when —

$X_L$ = Inductive Reactance in Ohms
$X_C$ = Capacity Reactance in Ohms
$\pi$ = 3.1416
f = frequency in cycles per second
L = Inductance in Henrys
C = Capacity in Farads

At resonance, $X_L = X_C$ and thus by substituting the formula values for these quantities we can write

$$2\pi fL = \frac{1}{2\pi fC}$$

and clearing fractions,

$$(2\pi fL)(2\pi fC) = 1$$

while, collecting terms,

$$(2\pi)^2 f^2 LC = 1$$

The $(2\pi)$ term is a constant but as we are interested in the relationship between L, C and F, we solve the last equation above for these terms and have,

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

and extracting the square root,

$$f = \frac{1}{2\pi\sqrt{LC}} \qquad (1)$$

which you may recognize as the common equation for the resonant frequency of a circuit. Notice, this equation shows the relationship between the resonant frequency, the inductance of the coil and the capacity of the condenser.

From a practical standpoint, it is customary to buy a variable condenser with a known maximum value of capacity and to figure roughly that the minimum capacity will be one tenth of the maximum.

Also, the desired frequency or Wavelength is known and thus it remains only to design a coil which will have the required inductance. There are really two distinct steps here. First, to calculate the proper value of inductance and second, to wind a coil which will provide this value.

There are a number of methods which can be followed and many short cuts are available in the form of "Winding Tables", "LC" tables and so on. However, for this project we want to give you a few simple equations so that, when necessary, you can design a coil without any other information.

To simplify the work further we will assume all coils are single layer solenoids, wound on a cylindrical form without any iron in the core. These are the type of coils commonly wound by hand and used to "Plug-In" for different Bands of Short and Long Wave receivers.

Inductance Required

The first step is to find the amount of inductance needed and we use the maximum capacity value of the tuning condenser with the lowest frequency of the band to be covered. These values can be substituted in equation (1) but there, f represents cycles per second, L represents the inductance in Henrys and C represents the capacity in Farads.

While these are the basic units, for the usual Radio circuits, the frequencies are generally stated in Kiloycycles or Megacycles, the Inductance in Milli-Henrys or Microhenrys and the

capacity in microfarads. With this in mind, we can adapt equation (1) to make its use more convenient.

As we are interested in finding the value of "L" transposing the terms of equation (1) we have

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

when

$L$ = inductance in henrys
$C$ = capacitance in farads
$f$ = frequency in cycles per second
$\pi$ = 3.14

The constant "3.14" can be multiplied by 2 and squared to give a value of 39.44 so that equation (2) will read

$$L = \frac{1}{39.44\ Cf^2} \qquad (3)$$

To use more common units, we can reduce the inductance to microhenrys, the capacitance to microfarads and increase the frequency to megacycles. As the L and C values are divided by 1,000,000 while the frequency, which is squared in the formula, is multiplied by 1,000,000, the changes cancel each other and we can write

$$L = \frac{1}{39.44\ C\ (Mc)^2} \qquad (4)$$

when

$L$ = inductance in microhenrys
$C$ = capacitance in microfarads
$Mc$ = frequency in megacycles

For example, the high frequency or "Short Wave" band of the ordinary all wave Radio receiver tunes from about 5.7 mc to 18 mc and we will asuume it is necessary to wind a coil for this band. Checking up, we will assume further that the tuning condenser has a maximum capacity or rating of .00014 mfd and we want to find the required inductance of the coil.

Substituting these values in equation (4)

$$L = \frac{1}{39.44 \times .00014 \times (5.7)^2}$$

Here we first multiply 5.7 by itself, to square it, and find a value of 32.49 to make the equation read

$$L = \frac{1}{39.44 \times .00014 \times 32.49}$$

Then multiplying these three factors we have,

$$L = \frac{1}{.179396784} = \frac{1}{.1794}$$

and dividing 1 by .1794,

$$L = 5.56 \text{ microhenrys.}$$

Inductance Formulas

To wind a coil which will provide a required value of inductance, it is necessary to consider four principal factors.

1. The diameter of the coil form
2. The length of the winding
3. The number of turns
4. The material of the core

At this time we are concerned only with high frequency coils, using air as the core, therefore need consider only the first three of the above factors. Also, thinking only of single layer solenoid coils, the work is simplified further.

By making measurements on a large variety of coils, having different lengths, diameters and numbers of turns, the following equation was found to be accurate enough for most practical purposes.

$$L = \frac{a^2 N^2}{9a + 10b} \qquad (5)$$

when --

L = Inductance of coil in microhenrys
a = Radius or 1/2 the diameter of the coil in inches
N = Number of turns
b = Length of the winding in inches

The equation (5) above is known as "Empirical" formula because it has been worked out from actual measurements instead of being derived mathematically like the former formulas of this Lesson. The "9" and "10" have no special meaning except that they are required to produce the proper answer.

Following the general plan of this explanation, we already know the required value of inductance but want to find the number of turns of wire which will produce it.

Therefore the terms of equation (5) can be transposed to read:-

$$N = \frac{\sqrt{L\ (9a + 10b)}}{a} \qquad (6)$$

Here, the diameter and length of the winding will be determined by the size of the form available or the amount of space reserved for the coil. One common type of plug-in coil form is 1-1/4" in diameter with a maximum length or winding space of 2". Therefore we will assume one of these forms is available to use for the coil which, from our former calculations, must have an inductance of 5.56 microhenrys.

Looking at equations (5) and (6) we see that for a form, 1-1/4" in diameter the radius "a" will equal 1/2 of 1-1/4 which is 5/8 of an inch. Dividing the 5 by 8 you will find 5/8 of an inch equals 0.625 inch.

For the length of the winding "b", we decide to use 1 inch only as this will allow ample space on the form. Now we know,

$L = 5.56$
$a = .625$
$b = 1.0$

and substituting these values in equation (6) --

$$N = \frac{\sqrt{5.56\ (9 \times .625 + 10 \times 1)}}{.625}$$

Multiplying 9 by .625 and 10 by 1 we have --

$$N = \frac{\sqrt{5.56\ (5.625 + 10)}}{.625}$$

adding 5.625 and 10,

$$N = \frac{\sqrt{5.56\ (15.625)}}{.625}$$

Multiplying 5.56 by 15.625,

$$N = \frac{\sqrt{86.875}}{.625}$$

Extracting the square root of 86.875,

$$N = \frac{9.32}{.625}$$

and dividing 9.32 by .625,

$$N = 14.9 \text{ or } 15 \text{ Turns.}$$

For the ordinary short wave coil, the size of the wire is not critical as usually, the turns must be spaced in order to make up the proper length of winding. For lower frequency coils, with a large number of turns, it is often necessary to refer to a windnng table, like that given below, to find the size wire which will allow the proper number of turns to be wound in the required length.

WINDING TABLE

| B and S Gauge | Bare | Enamel | D.C.C. | D.S.C. | Feet per ohm | Feet per lb. D.C.C. |
|---|---|---|---|---|---|---|
| | Approximate Turns per Inch | | | | | |
| 14 | 16 | 14 | 13 | x | 388 | 77 |
| 16 | 20 | 18 | 16 | x | 244 | 119 |
| 18 | 25 | 23 | 20 | x | 154 | 188 |
| 20 | 31 | 29 | 24 | x | 97 | 298 |
| 22 | 39 | 36 | 29 | x | 61 | 460 |
| 24 | 50 | 45 | 34 | 38 | 38 | 745 |
| 26 | 63 | 57 | 40 | 45 | 24 | 1120 |
| 28 | 79 | 71 | 45 | 53 | 15 | 1760 |
| 30 | 100 | 88 | 51 | 67 | 9.5 | 2534 |
| 32 | 126 | 120 | 60 | 77 | 6 | 3137 |
| 34 | 158 | 140 | 68 | 99 | 3.75 | 5181 |
| 36 | 200 | 180 | 76 | 114 | 2.36 | 7353 |

Here, the left hand column gives the B and S wire sizes and the next four columns to the right give the approximate turns for different insulations, which can be wound in a length of 1 inch.

Reading across the third line from the bottom for example, we find that #32 wire, when "bare" will wind 126 turns to the inch. When insulated with a coating of enamel, it will wind 120 turns to the inch. When double cotton covered, (D.C.C.), #32 will wind but 60 turns to the inch but when double silk covered, (D.S.C.), it will wind 77 turns to the inch. All these values assume the turns are wound close together.

Suppose your calculations show a coil requires 96 turns in a length of 1-1/4 inches. To convert this to turns per inch, you reason that 1-1/4 is equal to 5/4 and thus each quarter inch of winding will have 1/5 of 96 or a little over 19 turns. Then, as 1 inch equals four-fourths, it will have 4 times 19 or 76 turns.

Using arithmetic, you change the length of winding 1-1/4 inches to the fraction 5/4 inches, invert to 4/5 and multiply by 96, the total number of turns.

Working it out,

$$\frac{4}{5} \times 96 = \frac{4 \times 96}{5} = \frac{384}{5} = 76\text{-}4/5$$

GENERAL PROCEDURE

1. Determine lowest frequency of Band to be covered.
2. Determine maximum capacity of Tuning Condenser.
3. Calculate required inductance of coil.
4. Determine diameter and length of winding from coil form.
5. Calculate required number of turns.
6. Select wire size and insulation from winding table.

## Band Width

Quite often it is convenient to calculate also the highest frequency to which some given coil condenser combination will tune and a fairly accurate approximation can be had by assuming the minimum capacity of the condenser is 10% of the maximum capacity.

For this work, we want to find the frequency and using the values of our former explanation,

$C = 10\%$ of .00014 mfd = .000014
L = 5.56 Microhenrys

Substituting these values in equation (1), the result will be in megacycles as explained for equation (4). Thus we can write

$$Mc = \frac{1}{2\pi\sqrt{LC}}$$

and substituting the example values,

$$Mc = \frac{1}{6.28\sqrt{.000014 \times 5.56}}$$

Multiplying the values under the square root sign

$$Mc = \frac{1}{6.28\sqrt{.00007784}}$$

Extracting the square root,

$$Mc = \frac{1}{6.28 \times .0088}$$

Multiplying the terms of the denominator,

$$Mc = \frac{1}{.055264}$$

and dividing 1 by the denominator,

$$Mc = 18.09$$

Thus, according to our calculations 15 turns of wire wound in a length of one inch on a form $1\frac{1}{4}$" in diameter will be an inductance of 5.56 Microhenrys. Connected in a tuned circuit with a .00014 mfd condenser, the resonant frequency will be 5.7 megacycles.

As the condenser is variable, its capacity can be reduced to .000014 mfd at which point the circuit will be resonant at a frequency of 18 megacycles. Thus, this coil-condenser combination will tune over the band from 5.7 - 18 Mc.

For this project, your experiments will be in the form of design problems because, in the following project, you will not only design but actually wind and operate a short wave coil.

Experiment No. 1

You have a coil form, 1½" in diameter and want to wind a coil, 1½ inches long, which will tune the Broadcast Band 550 kc to 1600 kc when properly connected with a variable condenser which has a maximum capacity of .000365 mfd. The turns of the coil are to be close wound. How many turns are required, what size of wire and what kind of insulation will you use?

Following the steps of the previous explanation, the coil must have an inductance of approximately 230 microhenries and can be wound with 94 turns of #30 D.S.C. wire.

We have given you the answer only to let you check your work. The value of this project is in the practice you obtain in making the necessary calculations. Therefore, go ahead and figure it out yourself but, for your own benefit, don't try to work backwards from the answers we have given.

Experiment No. 2

For this problem we want you to calculate the inductance of a coil which consists of a 200 turn winding, 2 inches long, wound on a tube ¾" in diameter.

Your answer here should be approximately 240 Microhenrys.

Experiment No. 3

The specifications of a variable condenser are given as .000375 mfd maximum and .000015 mfd minimum. Assuming these values can be realized in a completed circuit, what value of inductance is needed to tune to 550 kc, the low frequency end of the Broadcast Band? What band of frequencies would this coil-condenser combination cover?

Your answer here should be approximately 223 microhenrys for the inductance of the coil. Using the problem values the tuning range would be from 550 kc to 2700 kc but using 10% of the maximum capacity as minimum, the range works out to 550 kc - 1740 kc and more nearly coincides with actual performance.

# SHORT WAVE RECEIVER

## Material Required

1 - Power Supply (Complete)
3 - Octal Sockets
1 - 6 Prong Socket
1 - 2 Gang Tuning Condenser with Dial
1 - 500 M Potentiometer with Dial
1 - Padder Condenser
1 - Audio Transformer
1 - Headphone
1 - P-M Speaker
1 - 470 ohm Resistor
1 - 5000 ohm Resistor
1 - 47 M ohm Resistor
1 - 100 M ohm Resistor
2 - 470 M ohm Resistors
1 - 2.2 meg Resistor
1 - 100 mmfd Condenser
1 - .0005 mfd Condenser
1 - .05 mfd Condenser
1 - .1 mfd Condenser
1 - 10-16 mfd Condenser
1 - 6 Prong Coil Form
1 - 6SJ7 Tube
1 - 6SQ7 Tube
1 - 6K6GT Tube
1 - Hook-up Wire

## OUTLINE

For the first project of this shipment, we gave you an explanation of a method by which coils can be designed and wound so that, when connected with a variable condenser of proper capacity, the circuit will tune to some desired band of frequencies.

For this project, we want you to make use of this information by actually winding a short wave coil and using it in a short wave receiver. The receiver circuit will be similar to those you have already constructed because the detector and audio amplifier of all receivers are much alike.

The tuning range of any receiver depends on the values of inductance and capacitance connected in the circuits tuned to the carrier frequencies and, to simplify your experiments, we will use a Regenerative Detector type of receiver which requires but one tuned input circuit. Thus, it will be necessary for you to design and wind but one coil for any particular band over which you want the receiver to operate.

## Wavelengths

In the early days of Radio, all Radio Transmission was measured in Wavelengths by Meters. However, as all Radio Energy travels at the same speed and one complete wavelength is equivalent to one electrical cycle, there is an exact relationship between the Wavelength and Frequency of Radio Energy.

It is a generally accepted fact that Radio Energy travels through space at the speed of light which is approximately 186,000 miles or 300,000,000 meters per second. While the more exact values of 186,284 miles and 299,796,000 meters per second are known, you will find the "round numbers" in more common use.

In the form of an equation this can be written as,

$$\text{Wavelength (meters)} = \frac{300{,}000{,}000}{f(\text{cycles})} \qquad (1)$$

As radio frequencies are usually expressed in Kilocycles or Megacycles, equation (1) can be reduced to read:

$$\text{Wavelength (meters)} = \frac{300{,}000}{\text{kc}} \qquad (2)$$

$$\text{Wavelength (meters)} = \frac{300}{\text{mc}} \qquad (3)$$

Notice here, the arrangement of terms is such that the wavelength will reduce as the frequency increases. Keep this in mind because it is easy to become confused.

Going back to the equations, the terms can be transposed to make them read:

$$\text{kc} = \frac{300{,}000}{\text{Wavelength (meters)}} \qquad (2a)$$

$$\text{mc} = \frac{300}{\text{Wavelength (meters)}} \qquad (3a)$$

## FREQUENCY RANGES

As we are interested in short waves at this time, some of the common services of this general class are as follows.

AMATEUR

| | | |
|---|---|---|
| 1,750 kc | - 2,050 kc | - 160 Meter Band |
| 3,500 kc | - 4,000 kc | - 80 Meter Band |
| 7,000 kc | - 7,300 kc | - 40 Meter Band |
| 14,000 kc | - 14,400 kc | - 20 Meter Band |
| 28,000 kc | - 30,000 kc | - 10 Meter Band |

INTERNATIONAL BROADCAST

| | | |
|---|---|---|
| 6,000 kc | - 6,200 kc | - 50 Meter Band |
| 9,500 kc | - 9,700 kc | - 31 Meter Band |
| 11,700 kc | - 11,900 kc | - 25 Meter Band |
| 15,100 kc | - 15,350 kc | - 20 Meter Band |
| 17,750 kc | - 17,850 kc | - 17 Meter Band |
| 21,450 kc | - 21,650 kc | - 17 Meter Band |

POLICE

| | |
|---|---|
| 1,610 kc | - 1,712 kc |
| 2,318 kc | - 2,490 kc |
| 5,135 kc | - 5,140 kc |

AVIATION

| | | |
|---|---|---|
| 2,900 kc | - 3,500 kc | - Plane to Ground (Night) |
| 4,100 kc | - 6,600 kc | - Plane to Ground (Day) |

From these condensed lists you can see there is a great deal of activity on the short waves and while we have listed mainly those stations which transmit voice, you will find many code stations operating in these bands.

Interested only in entertainment, the general public does not realize the large number of more important Radio services, many of which operate on short waves. The receiver we are going to describe will allow you to listen in on these various services and thus help you appreciate the importance of Radio.

The main purpose of this project is the actual winding of a short wave coil of your own design but as it is much more satisfactory to be able to try out a coil, as soon as it is finished, we will first explain the construction of the receiver.

Receiver Circuit

Looking at the schematic diagram of the following illustration you will find a three tube receiver made up of a regenerative detector followed by two stages of audio amplification.

The coil in the antenna circuit is the one you are to make and you will see it consists of but one winding with a tap near one end. The general appearance of the completed coil, wound on a plug-in type of form, is shown at the right of the diagram.

Notice here, the bottom of the coil form is fitted with prongs, similar to those of a tube base and, in this case, the six prongs will fit the six prong coil socket shown in the pictorial diagram. With this arrangement, the completed coil can be plugged into the socket, therefore the name "Plug-In" coil.

By winding a number of coils, each designed for a different band of frequencies, this circuit can be an "All Wave" receiver but it will be necessary to plug in the proper coil for each band. In your assigned work for this and the following project, you will wind two coils and therefore will be able to operate the Receiver on two entirely different bands.

Your first job is to assemble and wire the receiver and then wind the coil which you can plug in and try immediately.

WIRING PROCEDURE

Following the plan of our former explanations, we will assume that all of the connecting wires have been removed from all of the sub-assemblies which have been arranged on the general plan of the Pictorial Diagram. Here again, we urge you to try and wire up the various component parts by following the schematic diagram only because that is the method used in practically all commercial work.

WIRING CONNECTIONS

To give you a means of checking the various connections, we will list them according to the tube circuits.

A - Heater Circuits -

1. Power Supply Terminal No. 1 to 6SJ7 Socket Terminal No. 2.
2. 6SJ7 Socket Terminal No. 2 to 6SQ7 Socket Terminal No. 8
3. 6SQ7 Socket Terminal No. 8 to 6K6GT Socket Terminal No. 7.
4. Power Supply Terminal No. 2 to 6SQ7 Socket Terminal 7.
5. 6SQ7 Socket Terminal No. 7 to 6SJ7 Socket Terminal No. 7.
6. 6SQ7 Socket Terminal No. 7 to 6K6GT Socket Terminal No. 2.

B - Plate Circuits -

1. Power Supply Terminal No. 4 to 47 M Resistor Terminal No. 2.
2. 47 M Resistor Terminal No. 1 to 6SQ7 Socket Terminal No. 6.
3. 6SQ7 Socket Terminal No. 3 to .1 mfd Condenser Terminal No. 2.
4. .1 mfd Condenser Terminal No. 2 to 5 M Resistor Terminal No. 2.
5. 5 M Resistor Terminal No. 1 to.1 mfd Condenser Terminal No. 1.
6. .1 mfd Condenser Terminal No. 1 to Audio Transformer Terminal No. 2.
7. Audio Transformer Terminal No. 2 to 10-16 mfd Condenser "-" Terminal.
8. 10-16 mfd Condenser "-" Terminal to 100 M Resistor Terminal No. 2.
9. 100 M Resistor Terminal No. 2 to 6SQ7 Socket Terminal No. 1.
10. 6SQ7 Socket Terminal No. 1 to Power Supply Terminal No. 3.
11. 47 M Resistor Terminal No. 2 to Audio Transformer Terminal No. 4.
12. Audio Transformer Terminal No. 3 to 6J6GT Socket Terminal No. 3.
13. 6K6GT Socket Terminal No. 8 to 10-16 mfd Condenser "+" Terminal.
14. 10-16 mfd Condenser "+" Terminal to 470 Ohm Resistor Terminal No. 2.
15. 470 Ohm Resistor Terminal No. 1 to 10-16 mfd "-" Terminal.
16. Audio Transformer Terminal No. 4 to 500 M Potentiometer Terminal No. 3.
17. 500 M Potentiometer Terminal No. 2 to 470 M Plate Resistor Terminal No. 1.
18. 470 M Plate Resistor Terminal No. 2 to .0005 mfd Condenser Terminal No. 2.
19. .0005 mfd Condenser Terminal No. 2 to 6SJ7 Socket Terminal No. 8.
20. 6SJ7 Socket Terminal No. 3 to 6SJ7 Socket Terminal No. 5.
21. 6SJ7 Socket Terminal No. 5 to Coil Socket Terminal No. 2.
22. Coil Socket Terminal No. 6 to Tuning Condenser Terminal No. 2.
23. Tuning Condenser Terminal No. 2 to 500 M Potentiometer Terminal No. 1.
24. 500 M Potentiometer Terminal No. 1 to 5 M Resistor Terminal No. 1.

C - Screen Grid Circuits -

1. 6SJ7 Socket Terminal No. 6 to 6SJ7 Socket Terminal No. 8.
2. Audio Transformer Terminal No. 4 to 6K6GT Socket Terminal No. 4.

D - Grid Circuits -

1. Padder Condenser Terminal to Tuning Condenser Terminal No. 3.
   Note - The Pictorial Diagram shows Tuning Condenser Terminals No. 1 and No. 3 connected to the Padder Condenser but, for this project connect Tuning Condenser No. 3 Terminal directly to Padder Condenser Terminal No. 2. There is no connection to Tuning Condenser Terminal No. 1.
2. Tuning Condenser Terminal No. 3 to Coil Socket Terminal No. 1.
3. Coil Socket Terminal No. 1 to 2.2 Meg. Resistor Terminal No. 1.
4. 2.2 Meg. Resistor Terminal No. 1 to 100 mmfd Condenser Terminal No. 1.
5. 100 mmfd Condenser Terminal No. 2 to 2.2 Meg. Resistor Terminal No. 2.
6. 2.2 Meg Resistor Terminal No. 2 to 6SJ7 Socket Terminal No. 4.
7. 6SQ7 Socket Terminal No. 2 to 470 M Grid Resistor Terminal No. 1.
8. 470 M Grid Resistor Terminal No. 1 to .05 mfd Condenser Terminal No. 1.
9. .05 mfd Condenser Terminal No. 2 to 470 M Plate Resistor Terminal No. 2.
10. 6SQ7 Socket Terminal No. 1 to 470 M Grid Resistor Terminal No. 2.
11. 470 M Grid Resistor Terminal No. 2 to 6SJ7 Socket Terminal No. 1.
12. 6SJ7 Socket Terminal No. 1 to .0005 mfd Condenser Terminal No. 1.
13. 6K6GT Socket Terminal No. 5 to 100 M Resistor Terminal No. 1.
14. 100 M Resistor Terminal No. 1 to .01 mfd Condenser Terminal No. 2.
15. .01 mfd Condenser Terminal No. 1 to 47 M Resistor Terminal No. 1.

E - Miscellaneous -

1. One Headphone Cord Tip to Audio Transformer Terminal No. 1.
2. One Headphone Cord Tip to Audio Transformer Terminal No. 2.
3. Antenna to Unused Padder Condenser Terminal.
4. Ground Connection to Power Supply Terminal No. 3 or other Terminal Connected Directly to it.

E - Miscellaneous -

5. 6K6GT socket terminal No. 1 to 100 M ohm resistor terminal No. 2.

Check these connections over carefully, make sure they are all correct and then place the tubes in their proper sockets. Do not turn on the power supply yet because, without the plug-in coil in place, the circuits are not complete.

## Coil Design

Following the explanations of the former project on Coil Design, you can wind a coil which will tune to any of the frequencies listed in this project. However, your condenser has a relatively large capacity which means the inductance will be small and tuning difficult at the higher frequencies.

Therefore, we will assume you have chosen 7000 kc as the lowest frequency because, starting at this value, the coil should cover the 40 meter Amateur Band, as well as the 31 meter and 25 meter International Broadcast Bands. You should find plenty of radio signals in this part of the radio spectrum.

Your tuning condenser has a maximum capacity of .000365 mmfd per gang but, as only one gang is connected in the receiver circuit you just wired, this is your capacity value. Also, as 7000 kc is equal to 7 mc, this is your frequency value.

Substituting these values in Equation (4) of the last project,

$$L = \frac{1}{39.44 \times .000365 \times (7)^2}$$

Squaring 7 gives you 49 and multiplying this value by the other factors of the denominator,

$$L = \frac{1}{.70538}$$

and dividing 1 by this decimal

$$L = 1.41 \text{ microhenrys}$$

Your coil form is 1-1/4" in diameter which means a radius (a) of 1-1/4" ÷ 2 or 5/8" which is .625". For the length of the winding (b), you decide on 1 inch to simplify the calculations and leave an ample margin on the form.

Equation (6) of the former project states:

$$N = \frac{\sqrt{L(9a + 10b)}}{a}$$

and from the above, for your coil,

$L = 1.41$
$a = .625$
$b = 1.0$

Substituting these values in the equation,

$$N = \frac{\sqrt{1.41(9 \times .625 + 10 \times 1)}}{.625}$$

Multiplying 9 by .625 and 10 x 1,

$$N = \frac{\sqrt{1.41(5.625 + 10)}}{.625}$$

Adding the terms inside the parentheses,

$$N = \frac{\sqrt{1.41(15.625)}}{.625}$$

Multiplying 1.41 by 15.625,

$$N = \frac{\sqrt{22.03}}{.625}$$

Extracting the square root of 22.03,

$$N = \frac{4.7}{.625}$$

and dividing 4.7 x .625,

$N = 7.5$ turns

As shown by this result, your calculations frequently come out with fractional turns but it is well to remember that the connecting wires will add some capacity to the condenser circuit and usually it is safe to reduce the turns slightly.

This particular coil is shown in the illustration at the right of the pictorial diagram and, counting from start to finish you will find we have a little more than 7 turns but less than 7.5 turns.

Remember also, that even with careful calculations, it is frequently necessary to add or remove turns in order to make the coil circuit tune exactly to the desired band.

Size and Length of Wire

From the Winding Table, you can see that any of the listed sizes will wind more than 7 turns to the inch, therefore the turns of your coil will have to be separated from each other or what is known as "space wound". This is an advantage for coils of this kind as it reduces the distributed capacity.

While the size of the wire is not extremely critical, the larger sizes have less high frequency resistance and therefore are preferred. For your job, the ordinary push back hook-up wire will work out nicely but, because of the space winding, the insulation is not needed and must be removed.

To find the length of wire required, you need remember only that the circumference of a circle is 3.14 times the diameter. Here with a diameter of 1 1/4 inches the length of each turn of wire will be 1 1/4 x 3.14 = 3.92 or approximately 4 inches. With 7 1/2 turns, the total length of wire will be 7 1/2 x 4 = 30 inches.

However, the connections to the winding are made through the hollow prongs in the base and allowing 2 inches for each of 3 connections, the total length of wire is 36 inches.

Looking at the illustration of the coil, you will see three pairs of holes marked "Start", "Tap" and "Finish". The wire of the winding is threaded through these holes so that it may be brought down, inside the coil form, and threaded through the proper base prong to make the circuit connections. Notice here, the "Finish" holes are directly above prong No. 6, the "Tap" holes directly above prong No. 2 and the "Start" holes directly above prong No. 1.

To actually wind the coil, first take a piece of push-back hook-up wire, at least 36 inches long, bare the wire at one end and fasten it to a convenient hook or nail. If you happen to have a work bench with a vise, clamp the end in the vise.

The main idea here is to keep the wire straight, without bends or kinks, while removing the insulation and winding so that the turns of the finished coil will be uniform.

To remove the insulation, pull straight away from the fastened end, sliding your fingers along the insulation. You will find it pulls back readily for a few inches but, unless you move it along the wire, it will soon tighten.

A pull here and there along the entire length of wire loosens all the insulation and makes its removal easy. Remember, always pull away from the fastened end then, no matter how hard you pull, the wire will not kink.

With the wire still fastened at one end, thread the open end through one of the small holes directly above prong No. 6 of the illustration. This is marked finish but, for convenience we will start at this end.

Insert your long nose pliers inside the coil form, grasp the end of the wire and pull it up and out for 2 or 3 inches. Then, bend the end down toward the prongs inside the coil form. Grasp the wire again, with the ends of the long nose pliers about one inch from the outer end, and thread it down through the hollow center of prong 6 until it projects out of the bottom. Usually it is a good plan to pull the end out of the bottom of the prong until all the kinks inside the coil form are removed and the wire runs practically straight from the hole in the form down through the prong.

Cut off the open end of the wire, about 1/2" from the lower end of the prong and then bend the remaining end close alongside the prong. This will form an anchor and hold this end while you are winding.

Now, hold the coil form at right angles to the wire and move it back, away from the fastened end, until the entire length of wire is straight and tight. Then, holding the wire tight, turn the coil form slowly and sort of wind yourself up toward the fastened end. While turning the coil form you can move it sidewise slightly so that the turns will wind on in a spiral similar to that shown in the illustration.

By following this method, the wire is kept tight and straight so that the finished coil will have a professional appearance. Never hold the coil form stationary and try to wind the wire around it because, by this plan, it is almost impossible to prevent the wire from kinking.

After you have 7 and a fraction turns wound on the form, you can see where the end will pass through the small holes drilled directly above prong No. 1. Stop turning the coil form but do not let the wire become slack. Making this last connection is perhaps the hardest part of the entire job because, once the tension is lost, the entire winding becomes slack and the coil looks "sloppy".

Holding the tension by grasping the coil form in one hand use the long nose pliers and kink the wire slightly at a point about 2 1/2 inches beyond the hole in the form. This is where you will cut it off.

Before doing that however, unwind the wire a fraction of a turn and make a second kink in it just a little short of the holes. This is where the wire will be bent to pass through the hole to the inside of the coil form.

Then, place your thumb firmly on the wire, about one half turn from this second kink. Hold the form and the wire tightly in one hand. Then, quickly cut the wire at the first kink and make a right angle bend, toward the coil form, at the second kink.

The cut end of the wire can then be threaded through the hole and pulled from the inside of the form until the right angle bend is at the hole. For safety, you can then bend the end back, to form a sort of "U" at the hole, to prevent the wire from slipping.

The end is then threaded down through prong No. 1 and, pulled out the bottom until any kinks, inside the coil form, have been removed as explained for prong No. 6.

To make the tap, which should be a little over two turns from the No. 6 prong end of the winding, cut off 4" or 5" of the remaining piece of bared hook-up wire and make a right angle bend about 1/2" from one end. Holding the wire in your pliers, thread the other end down through prong No. 2 and thread the bent end through one of the tap holes. Make sure there are three coil wires below this tap wire. It may be necessary to shift the turns somewhat but if they are spaced equally, this condition will exist. Then, make a "U" bend in the end of this wire and thread it back through the other small "Tap" hole in the coil form. Reach inside the coil form with your pliers and close the "U" bend to lock the wire in the form. Then, pull the other end down through prong 2 as explained for prongs 1 and 6.

You are now ready to solder the connections and, for this job, will need a hot iron. To solder the wires to the prongs, yet prevent solder from tinning the outside, you follow a little different plan.

First cut off the wires close to the lower end of the prongs so that they do not extend more than $\frac{1}{16}$". With the soldering iron in a stand, or vise, lower one of the prong ends onto one of the faces of the soldering tip at right angles to it.

Then, feed a little rosin core wire solder into the spaces between the prong and iron tip. If the iron is hot enough the solder will melt immediately but adhere to the tip of the prong and some of it will work up inside, between the wire and the prong.

Feed a little more solder as before and then, lift the coil form straight up. If you have followed directions properly, the end of the prong will be covered with a smooth bead of solder, the wire will be firmly attached and there will be no solder on the outer surface of the prong. Follow the same plan for prongs No. 1 and No. 2.

To finish the tap, move the turns until, at a point between two and three turns from the prong No.6 end of the winding, the outside of the loop, threaded through the "tap" holes, is in contact with the wire of the coil. This point of contact can then be soldered in the usual way. Do not use much solder here but be sure you have a good joint.

Your coil is now finished but you had better check over the turns, shifting them slightly until all are spaced about the same and the winding has the general appearance of our illustration. Also, examine the prongs as some of the rosin flux from the solder may have been deposited on them. If so, scrape the prongs bright with a knife or sandpaper.

Experiment No. 1

Assuming you have completely wired the receiver circuits, explained earlier in the project, plug the completed coil into the 6 prong socket, exactly the same as a tube. Check here and make sure that the prongs to which the coil is connected coincide with those of the socket to which wires are connected.

Turn on the power supply and, while the tubes are warming up, turn the potentiometer dial all the way anti-clockwise and the tuning condenser dial until the plates are fully meshed.

Then listen to the headphone and turn the potentiometer slowly, in a clockwise direction until you hear the usual "plop" which indicates the detector is oscillating. Due to the large ratio of condenser capacity to the inductance of the coil, it will be necessary to tune this receiver very carefully.

A small movement of the condenser dial will make a comparatively large change in the resonant frequency of the tuned input circuit therefore the condenser tuning dial must be tuned very slowly.

You will find it a good idea to grasp the outer rim of the dial instead of the central knob when tuning.

Following this plan, turn the condenser dial, as slowly as you can, until you hear a squeal or note in the phones. If the note is intermittent, you are receiving signals from a code station. If the note is steady, tune carefully for loudest signal and then slowly turn the potentiometer dial until the steady note stops. At this time, you should hear an audio signal but you may have to retune the condenser slightly to bring it in properly. Except for the more critical tuning, the action here is like that of the Regenerative Detector built as a former project.

Moving the dial as slowly as possible, turn the condenser plates all the way from maximum to minimum capacity and back to maximum again. Repeat this movement several times, stopping to listen to any signals you may hear.

Experiment No. 2

It is a well-established fact that a tuned antenna circuit greatly increases the signal input voltage and regardless of your results with Experiment No. 1, a change in the antenna circuit should improve your reception.

To make this change, remove both connecting wires from the padder condenser and with their insulation in place, twist the wires together for two or three turns.

If your antenna lead-in wire has no insulation, connect a piece of insulated hook-up wire to its inner end and then twist this insulated wire around the insulated wire connected to terminal No. 3 of the tuning condenser.

When twisted together this way, two insulated wires form a small capacitance which, in effect, will shorten your antenna and bring its resonant frequency closer to carrier frequencies you are tuning.

After this change has been made, repeat the steps of Experiment No. 1 but, as the receiver should now be more selective it will require even more careful tuning.

Experiment No. 3

While performing Experiments No. 1 and No. 2 you should find a number of fairly loud signals. For this experiment there-

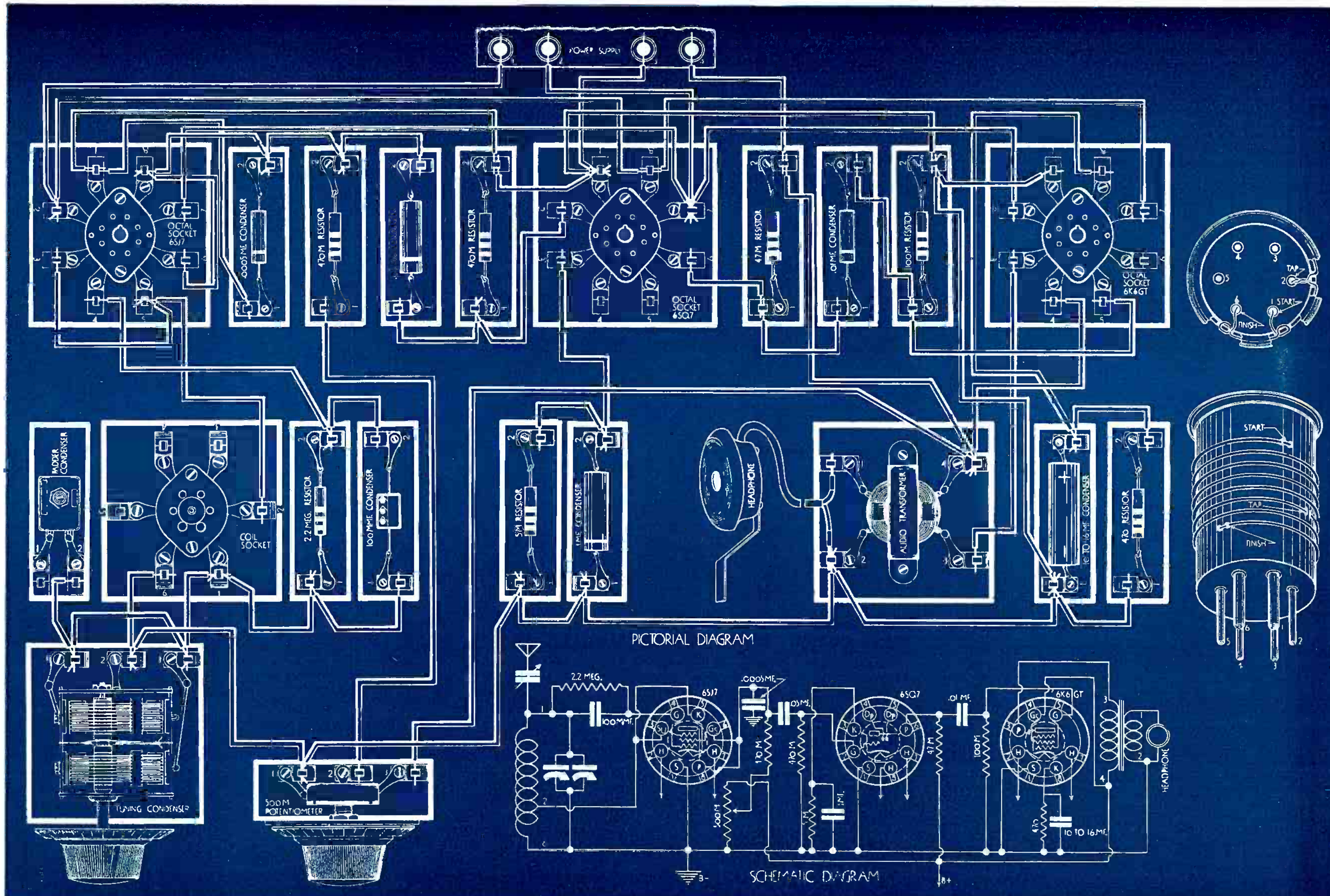
fore, we want you to replace the headphone with your speaker to allow more comfortable reception.

To make the change, shut off the power supply and remove all the connecting wires attached to the audio transformer. In the Pictorial Diagram, you will find 3 wires to terminal No. 4 and 2 wires, in addition to one phone cord tip, in terminal No. 2. Be sure and keep these groups of wire separate.

Replace the audio transformer with the speaker and connect to its terminal No. 1 the three wires which formerly connected to audio transformer terminal No. 4. The wire which was connected to audio transformer terminal No. 3 connects now to speaker terminal No. 3.

The two wires which formerly connected to audio transformer terminal No. 2 are a part of the "ground" connection to power supply terminal No. 3. To keep this circuit complete, replace these two wires with a single wire from 6SQ7 cathode .1 mfd condenser terminal No. 1 to the 10-16 mfd condenser negative terminal. You can now repeat the steps of Experiments No. 1 and No. 2 but the signals will be heard in the speaker instead of the headphone.

Do not dismantle this circuit because, for the next project, you are going to wind a "Long Wave" coil and use it again.


POWER SUPPLY
OCTAL SOCKET 6SJ7
.0005 MF. CONDENSER
470 M RESISTOR
470 M RESISTOR
OCTAL SOCKET 6SQ7
47 M RESISTOR
.01 MF. CONDENSER
100 M RESISTOR
OCTAL SOCKET 6K6GT
START
TAP
FINISH
PADDER CONDENSER
COIL SOCKET
2.2 MEG. RESISTOR
100 MMF. CONDENSER
5 M RESISTOR
1 MF. CONDENSER
HEADPHONE
AUDIO TRANSFORMER
10 TO 16 MF. CONDENSER
470 RESISTOR
PICTORIAL DIAGRAM
TUNING CONDENSER
500 M POTENTIOMETER
2.2 MEG.
100 MMF.
6SJ7
.0005 MF.
.05 MF.
6SQ7
470 M
47 M
.01 MF.
100 M
6K6GT
500 M
1 MF.
470
10 TO 16 MF.
HEADPHONE
B-
B+
SCHEMATIC DIAGRAM

# LONG WAVE RECEIVER

## Material Required

1 - Short Wave Receiver (Complete)
1 - 6 Prong Coil Form
1 - Roll #36 Enamel Wire

## OUTLINE

As we mentioned in the Outline of the Short Wave Receiver Project, the frequency range of any Receiver depends on the circuits tuned to the carrier frequency of the signal. In the receiver which you constructed, there was but one tuned circuit therefore its tuning range was controlled by the inductance of the plug-in coil

In checking over the "Long Wave" or "Low Frequency" allocations, you will find the 200 kc - 400 kc band covers several important Aviation services. The Government Weather and Radio Range Signals as well as the Airport Traffic Control signals are in this band and therefore, a Receiver which covers this range should provide signals of interest.

For this project, we want you to design and wind a coil for the 200 kc - 400 kc band so that the Short Wave Receiver of the last project can be operated as a Long Wave, Aviation Band Receiver.

When working with these lower frequencies, their values are usually given in terms of Kilocycles while all our previous explanations were given in terms of cycles or megacycles. To avoid confusion here, you need remember only that one kilocycle is equal to 1000 cycles or one, one-thousandth of a megacycle. In the form of a Conversion Table.

Cycles = kc x 1000
kc = Megacycles x 1000

Notice here, the factor "1000" is used to change from cycles to Kilocycles and also from Kilocycles to Megacycles. Thinking of decimals, this means the decimal point is shifted three places to the right when you multiply and three places to the left when you divide.

For example:-

2000 cycles = 2 kc = .002 mc
400 cycles = .4 kc = .0004 mc
10,000,000 cycles = 10,000 kc = 10 mc

Reading each line from left to right you will find, for each "=" sign, the decimal point has been moved three places to the left. Reading from right to left, the decimal point has been moved three places to the right.

Keeping this simple rule in mind, you should have no difficulty in converting from one unit of measure to another. Of course, to convert cycles directly to Megacycles, the decimal point must be moved six places.

Coil Design

Following the steps of the Short Wave Coil and substituting in Equation (4) of the Coil Design Project, for a frequency of 200 kc, which is equal to .2 mc,

$$L = \frac{1}{39.44 \times .000365 \times (.2)^2}$$

squaring (.2) gives you .04 and multiplying this by the other factors of the denominator,

$$L = \frac{1}{.000575824} = 1736 \text{ Microhenrys}$$

As this is a comparatively large value, a large number of turns would be needed and winding the coil would be difficult. To help out here, you can connect both tuning condenser gangs in parallel to double the maximum capacity of the unit. Then, instead of .000365 mfd, your maximum capacity will be .000365 x 2 = .000730 mfd.

Substituting this value in the equation above, you will find

$$L = 868 \text{ Microhenrys}$$

Thus, for the same resonant frequency, by doubling the capacity the inductance is reduced to $\frac{1}{2}$ of its former value.

As the coil form has the same dimensions as that used for the Short Wave Coil, the radius (a) equals .625 inch and the length of winding (b) is one inch.

Substituting these values in Equation (6) of the Coil Design Project,

$$N = \frac{\sqrt{L(9a + 10b)}}{a}$$

$$N = \frac{\sqrt{868(9 \times .625 \times 10 \times 1)}}{.625}$$

Multiplying the factors and adding the terms in the parentheses,

$$N = \frac{\sqrt{868(15.625)}}{.625}$$

Multiplying the factors under the square root sign,

$$N = \frac{\sqrt{13562.5}}{.625}$$

Extracting the square root,

$$N = \frac{116.4}{.625}$$

Dividing by .625

$$N = 186 \text{ turns.}$$

Looking at the Winding Table of the Coil Design Project, you will find #36 enamel wire winds approximately 180 turns to the inch and should therefore be satisfactory. As we have already explained, the added capacity of the wiring usually compensates for a small reduction of inductance.

It is interesting to note, from an examination of the "Turns" equation above that an increase in the length of winding (b), will require a large total number of turns in the winding, but fewer turns per inch.

If you care to figure it out you will find a 1¼" winding requires 206 turns or 165 turns per inch while a 1½" winding requires 214 turns or 142 turns per inch.

Here however, to keep the dimensions of your coils uniform and reduce your winding to the minimum number of turns, we are sending a supply of #36 enamel wire. From the calculations, you can see that the turns must be close to each other but, the enamel is an insulation therefore the turns can actually touch without causing a short.

## WIRING PROCEDURE

Before starting to wind the coil, we want you to prepare the Receiver so that, when the coil is completed, it may be tried out at once. The wiring changes are very simple and

when completed, the circuit should conform to that shown in the Pictorial and Schematic Diagrams of the Short Wave Receiver.

Assuming your receiver is connected as explained for Experiment No. 3 of the Short Wave Receiver Project, make the following Connections.

1. Tuning Condenser Terminal No. 1 to Tuning Condenser Terminal No. 3.
2. One padder Condenser Terminal To Tuning Condenser Terminal No. 1 or No. 3.
3. Antenna to Unused Padder Condenser Terminal.

Depending on your personal preference, you can keep the speaker in the circuit or replace the headphone according to the Diagrams.

Winding the Coil

You will find the #36 wire is quite small in comparison to the hook-up wire used for the Short Wave Coil, and therefore it must be handled differently.

First, procure a small piece of fine sandpaper, about 1 inch square and fold it once with the sand side in. Then, holding the paper between your thumb and forefinger, place the wire inside the fold, allowing about 2 inches to project from one side.

Squeeze the paper together gently and pull the wire out. Allow the fold to open and repeat the process several times until all of the enamel is removed and the end of the wire is clean and bright.

Better practice this a few times because, if you squeeze too tightly, the wire will break when you pull it but, if you don't squeeze tight enough, the enamel will not be removed.

When the work is done properly, about 2 inches of the end of the wire should be free of all signs of the enamel insulation. This same plan is followed for all the smaller sizes of enamel wire because you can not solder to the snamel and unless it is removed, you can not make a satisfactory electrical connection.

Practice this work now because, if the wire breaks you will lose only a few inches of it. Should it break later on, you may have to rewind the entire coil.

When you feel satisfied you know how to do this job, remove the insulation for about 2 inches from the end of the roll of #36 wire and thread it from the outside in, through one of the small holes drilled closest to the prong end of the coil form, in line with prong No. 6.

Then, with your pliers, reach down inside the form, pull the wire until the insulation just shows inside the form and thread the end, from the inside out, through the other of the two small holes.

Pull the end out, until there is no slack inside the form and then thread it back, from the outside in, through the hole where you started. This will give you a short loop of wire, around the space between this pair of holes and form an anchor for this end of the coil.

To complete this part of the work, the end of the wire, which is now inside the coil form, is threaded down through the hollow center of prong #6. When it is through, pull it out the bottom of the prong until there is no slack inside the coil form. Any excess wire can be wrapped around the outside of the prong.

In the top view of the coil illustration, we have broken away the side wall of the coil form to show you the path of the wire when installed according to the explanations given above.

You are now ready to actually wind the coil but, due to the small size of the wire, can not follow the "Wind Up" plan explained for the Short Wave Coil. Instead, place the supply of #36 wire in a position which will allow it to unroll freely and then, using both hands, turn the coil form.

To maintain the proper tension here, you can use either a thumb or forefinger, but must hold it constantly on the wire approximately at the point it contacts the coil form. Then, as you turn the coil form, the pressure of your finger will cause a "drag" on the wire pulling it tightly around the form. Also, this same finger can be used to guide the wire and cause each succeeding turn to be close to the preceding turn.

After winding 4 or 5 turns, there may be small spaces between them but this can be remedied by pushing the wire sidewise until the turns are close together and parallel to the top and bottom of the coil form. However, always keep the tension finger on the wire to keep the turns tight.

Following this plan, at about 45 to 50 turns, the winding will start to cover the two small "tap" holes, located directly above prong #2.

Continue winding until the holes are half covered and then, still holding the wire tight against the coil form, cut it off about 3 inches beyond the hole and thread the end through the nearest hole from the outside in. Pick up the end of the wire, still on the roll, and thread it through the other tap hole, from the outside in. This will give you two wires inside the coil form and they must be pulled up until they extend above the top. Pull the second wire through until the ends of both are even and then twist them together until the twist extends down to the holes.

This will anchor the turns already wound and you can now untwist the ends only, down to the top of the form and remove the unsulation from each with sandpaper as previously explained.

After the enamel insulation has been removed, twist the ends together again and thread them down through the hollow center of prong No. 2 following the plan explained for prong No. 6.

Continue the winding, going ahead in the same direction as if the tap connection had not been made. Keep the turns close together and, outside of the small gap between the two "Tap" holes, the entire winding will appear to be continuous.

Continue winding, by the plan already explained, until the turns cover one inch of the coil form and reach the two small holes marked "Start" in the illustration. As explained for the tap, continue winding until the holes are covered for at least one half of their diameter and then cut the wire about 3 inches beyond.

This end is handled like that at the beginning but here, you must hold the tension on the winding while threading the wire in and out of the two small holes.

After the loop has been made and pulled tight, it will hold the wire in place and allow you to use both hands to remove the enamel from the end and thread it through the hollow center of prong No. 1.

The connections are completed by soldering as explained for the Short Wave Coil. First pull the wires out the ends of the prongs until there is no slack inside the coil form and then cut them off about $\frac{1}{16}$" below the ends of the prongs.

The soldering is done by placing the tinned face of the iron in a horizontal position, the prong is moved down until its end rests in about the center of the face. Rosin core wire solder is then fed around the bottom of the prong and, by capillary action, the melted solder will be drawn up inside, tinning the wire and prong to make a good joint.

Remember, keep the solder at the bottom of the prong and then lift the coil form straight up to prevent excess solder from collecting on the outer surface of the prongs.

Experiment No. 1.

When the coil is complete, plug it in the coil socket of the Receiver, checking carefully to see if the soldered prongs coincide with the proper socket terminals.

Turn on the power supply and, after the tubes warm up, follow the general plan explained for the Short Wave Receiver. Rotate the tuning condenser dial slowly and adjust the potentiometer when necessary to keep the detector tube oscillating. Code stations can be heard under these conditions but, when a sustained note occurs in the head-phone or speaker, the potentiometer should be adjusted until the note disappears and the audio signal is heard.

Although the tuning with this coil is not as critical as that of the Short Wave Band, it will be necessary to tune carefully to locate the various stations you can pick up.

Experiment No. 2

As previously explained, a tuned antenna circuit increases the sensitivity of a Receiver and here, the Padder Condenser can be used as an Antenna Tuner. For the lower frequencies of this 200-400 kc band, a fairly long antenna should be employed but, by tuning it properly, its efficiency can be increased.

To perform this experiment, we want you to tune in some station and then adjust the padder condenser until the signal strength is at maximum. For best all around results, this should be done at several points in the tuning range to provide the best average reception. However, should you decide to listen to some particular station only, then make your adjustment for best reception at its carrier frequency.

You may find the adjustment of the Padder has a very definite effect on the Tuning Range of the Receiver. Should you tune in some station at the extreme Maximum or Minimum setting of the tuning condenser, an adjustment of the Padder will make it possible to tune it in more readily.

Experiment No. 3

To prove that the Radio Frequencies in the plate circuit of an oscillating detector must be separated from the signal or audio frequencies, we want you to make a change in the circuit.

Looking at the diagrams, you will find a .0005 mfd condenser connected from the 6SJ7 detector plate to ground of Power Supply terminal No. 3. At 200 kc the reactance of this condenser is about 1600 ohms and at 400 kc it drops to about 800 ohms.

Thus, there are really two paths in the plate circuit, one through the condenser and one through the 470,000 plate resistor. From the values given above, you can see that, at the higher frequencies, the condenser partially shorts the plate resistor and little or no r-f voltages appear across it.

To check this action, simply disconnect this condenser, preferably at the clip which has but one wire in it, and then operate the receiver. You will find it difficult to make the detector tube oscillate over all the band and that the control becomes very unstable.

Keep this in mind because most detectors, Regenerative or not, have a similar condenser in their plate circuit.

# BEAT FREQUENCY OSCILLATOR

## Material Required

1 - Power Supply (Complete)
1 - Antenna Coil
1 - R-F Coil
1 - 2 Gang Tuning Condenser
1 - Audio Transformer
1 - P-M Speaker
3 - Octal Sockets
1 - Padder Condenser
1 - 100 mmfd Condenser
1 - .01 mfd Condenser
1 - 10 to 16 mfd Condenser
1 - 5 M Resistor
1 - 470 Ohm Resistor
1 - 6SQ7 Tube
1 - 6SJ7 Tube
1 - 6K6GT Tube

## OUTLINE

In a number of the former Projects, you constructed Vacuum Tube Oscillators, all of which operated at Radio Frequencies. While oscillators of this general type have many applications in Radio both for operation and testing, there are many cases in which it is desirable to generate lower, or audio frequencies.

Checking back on the Coil Design Project, you will find that comparatively large values of inductance and capacity will be required for resonance at low frequencies. While these values can be obtained for any particular frequency, it has been found impractical to construct variable units which would allow a low, or audio frequency oscillator to generate frequencies covering the entire audio band.

One common method of overcoming this difficulty is to build two Radio Frequency Oscillators, one operating at a fixed frequency and the other made variable. These two high frequencies are then combined or "Heterodyned" to produce a lower frequency equal to their difference. Because of this mixing action, in which one frequency "Beats" against another, units of this type are known as "Beat Frequency Oscillators".

For example, suppose we want an oscillator which will generate frequencies from about 30 cycles to 15000 cycles. Using a single oscillator, the frequency change is 15000 ÷ 30 = 500 times or 50,000%. On the other hand, if we design one fixed

oscillator to operate at 100 kc or 100,000 cycles, and a variable oscillator to operate from 100,000 cycles to 115,000 cycles, the frequency difference will vary from 0 cycles to 15,000 cycles.

Here the frequency change is from 100,000 cycles to 115,00 cycles, an increase of but 15% which is readily obtained by the ordinary tuning condenser operating in a circuit resonant at these values.

Because of these conditions, the beat frequency oscillator is commonly used for audio work although it has the disadvantages of more tubes and circuits as well as the tendency for both oscillators to pull exactly in step with each other when their frequency difference is small. However, by properly isolating the oscillator circuits, this latter disadvantage can be largely overcome although commercial types of these units are seldom accurate at extremely low frequencies.

In order that you may build and operate an oscillator of this general type, with the parts of your Home Laboratory, we have found it necessary to alter the conventional circuits somewhat. Your antenna and r-f coils, designed to operate at Broadcast Frequencies, require such a small percentage of change to cover the audio band that tuning by the usual methods becomes extremely critical. From the example given above you can see that a change of 15,000 cycles, or 15 kc, in the frequency of the variable oscillator will cover the entire audio band.

Thinking back to the Radio receivers you constructed, you may remember that but a small movement of the condenser tuning dial is required to change the resonant frequency by 15 kc. Following this same plan of tuning, the entire audio range of 15,000 cycles would be covered by the same small movement of the dial.

Also, to keep the number of parts at a minimum, the oscillator circuits are not completely isolated and will pull in step at the lower frequencies. However, the arrangement we are going to describe will not only demonstrate the principles of operation but has sufficient frequency range to make it useful.

Oscillators of this type are used for most audio work in connection with the various types of Sound Systems which include the Audio Amplifiers of Radio, Television and F-M Receivers, P-A Systems, Electric Phonographs, Sound Pictures etc.

## WIRING PROCEDURE

As the following circuit is entirely different from the others of this project, we will follow our usual plan of assuming that all of the connecting wires have been removed from all of the sub-assemblies and the required parts have been arranged on the general plan of the following Pictorial Diagram.

Once more, we urge you to follow the schematic diagram while connecting the various parts but, to give you a check, we will list the connections by the usual circuit plan.

## WIRING CONNECTIONS

A - Heater Circuits -

1. Power Supply Terminal No. 1 to 6SQ7 Socket Terminal No. 8.
2. 6SQ7 Socket Terminal No. 8 to 6SJ7 Socket terminal No. 7.
3. 6SJ7 Socket Terminal No. 7 to 6K6GT Socket Terminal No. 2.
4. Power Supply Terminal No. 2 to 6SQ7 Socket Terminal No. 7.
5. 6SQ7 Socket Terminal No. 7 to 6SJ7 Socket Terminal No. 2.
6. 6SJ7 Socket Terminal No. 2 to 6K6GT Socket Terminal No. 7.

B - Plate Circuits -

1. Power Supply Terminal No. 4 to Audio Transformer Terminal No. 4.
2. Audio Transformer Terminal No. 3 to 6SQ7 Socket Terminal No. 6.
3. 6SQ7 Socket Terminal No. 6 to .01 mfd Condenser Terminal No. 2.
4. 6SQ7 Socket Terminal No. 3 to 5 M Resistor Terminal No. 2.
5. 5 M Resistor Terminal No. 2 to Tuning Condenser Terminal No. 3.
6. Tuning Condenser Terminal No. 3 to Tuning Condenser Terminal No. 1.
7. Tuning Condenser Terminal No. 2 to 5 M Resistor Terminal No. 1.
8. 5 M Resistor Terminal No. 1 to Antenna Coil Terminal No. 5.
9. Antenna Coil Terminal No. 6 to Antenna Coil Terminal No. 7.
10. Antenna Coil Terminal No. 7 to 100 mmfd Condenser Terminal No. 2.
11. 100 mmfd Condenser Terminal No. 2 to .01 mfd Condenser Terminal No. 1.

12. .01 mfd condenser terminal No. 1 to r-f coil terminal No. 1.
13. R-F coil terminal No. 1 to r-f coil terminal No. 5.
14. R-F coil terminal No. 5 to 10-16 mfd condenser negative terminal.
15. 10-16 mfd condenser negative terminal to audio transformer terminal No. 1.
16. Audio transformer terminal No. 1 to power supply terminal No. 3.
17. Audio transformer terminal No. 3 to r-f coil terminal No. 4.
18. R-f coil terminal No. 3 to 6SJ7 socket terminal No. 3.
    Note - The schematic diagram shows r-f coil terminals No. 3 and No. 4 reversed. If the 6SJ7 tube does not oscillate, reverse these two connections.
19. 6SJ7 socket terminal No. 3 to 6SJ7 socket terminal No. 8.
20. 6SJ7 socket terminal No. 5 to 6SJ7 socket terminal No. 6.
21. 6SJ7 socket terminal No. 6 to 6K6GT socket terminal No. 1.
22. 6K6GT socket terminal No. 1 to 6SJ7 socket terminal No. 1.
23. 6SJ7 socket terminal No. 1 to Audio transformer terminal No. 1.
24. Audio transformer terminal No. 4 to speaker terminal No. 3.
25. Speaker terminal No. 3 to 6K6GT socket terminal No. 4.
26. Speaker terminal No. 1 to 6K6GT socket terminal No. 3.
27. 6K6GT socket terminal No. 8 to 470 ohm resistor terminal No. 2.
28. 470 ohm resistor terminal No. 2 to 10-16 mfd condenser positive terminal.
29. 470 ohm resistor terminal No. 1, to 10-16 mfd condenser negative terminal.

C - Grid Circuits -

1. 6SQ7 socket terminal No. 2 to 100 mmfd condenser terminal No. 1.
2. 100 mmfd condenser terminal No. 1 to antenna coil terminal No. 4.
3. 100 mmfd condenser terminal No. 2 to 6SQ7 socket terminal No. 1.
4. 6SJ7 socket terminal No. 4 to r-f coil terminal No. 2.
5. R-F coil terminal No. 2 to padder condenser terminal No. 1.

6. Padder Condenser Terminal No. 2 to r-f Coil Terminal No. 1.
7. 6K6GT Socket Terminal No. 5 to Audio Transformer Terminal No. 2.

Check all of the connections carefully and when you are satisfied they are correct, insert the tubes in their proper sockets.

Experiment No. 1

Turn on the power supply and, while the tubes are warming up, turn tuning condenser dial until the plates are meshed about half way. Then, adjust the padder condenser slowly until a note is heard in the speaker. As soon as the note is heard, do not adjust the padder further but turn the tuning condenser dial slowly and note the change in pitch or frequency of the note.

Should a note be heard in the speaker, with the condenser at either maximum or minimum capacity position, adjust the padder condenser slightly until the note disappears. Then, turn the tuning condenser dial and the note should reappear and be heard over most of the tuning range.

Should you hear nothing after readjusting the padder, you have turned its adjusting screw the wrong way and had better start the experiment all over again.

You will find the adjustment of the padder condenser causes the same change in the frequency of the speaker note as a change in capacity of the tuning condenser. However, we consider the padder condenser as controlling the frequency of the fixed oscillator and it should be set so that the note is heard over the greatest possible movement of the tuning condenser dial.

Note carefully if the pitch of the note goes up or down as the capacity of the tuning condenser is increased. From your former work you know that increasing the capacity in a tuned circuit lowers the frequency. Therefore, if the frequency of the speaker note increases as the frequency of the variable oscillator decreases it shows the frequency of the fixed oscillator is higher than that of the variable oscillator.

Remember, the frequency of the speaker note is equal to the difference of the oscillator frequencies therefore, if a reduction of the variable oscillator frequency causes an increase of this difference, the fixed oscillator is operating at a higher frequency.

Experiment No. 2

In commercial oscillators of this type, the tuning condenser dial is usually calibrated directly in terms of the audio frequency and you may be called upon to adjust one of them so that the dial will read correctly instead of backwards.

For this experiment therefore we want you to reverse the action of the tuning condenser. If your oscillator now operates so that an increase of tuning condenser capacity causes a decrease of speaker note frequency we want you to reverse it. Should your oscillator operate the other way, we still want you to reverse it.

To cause this reversal of condenser action, set the tuning condenser about midway in its tuning range and then slowly turn the padder adjusting screw in one direction as the speaker note changes in pitch and finally disappears. Then, continue turning the padder adjusting screw, in the same direction, until the note reappears and is at about the same pitch as when you started.

Should the speaker note fail to reappear almost immediately after it disappears, you are turning the padder condenser adjusting screw the wrong way. Turn the screw the other way while the speaker note reappears. passes through its entire frequency range, disappears and then appears again.

Repeat the steps of Experiment No. 1 and you will find now that the tuning condenser operates in the opposite direction as far as the frequency of the speaker note is concerned.

For a practical application of this condition, adjust your oscillator so that, according to the markings on your tuning condenser dial, an increase of the numbered idal reading will cause a higher pitch or increased frequency of the speaker note.

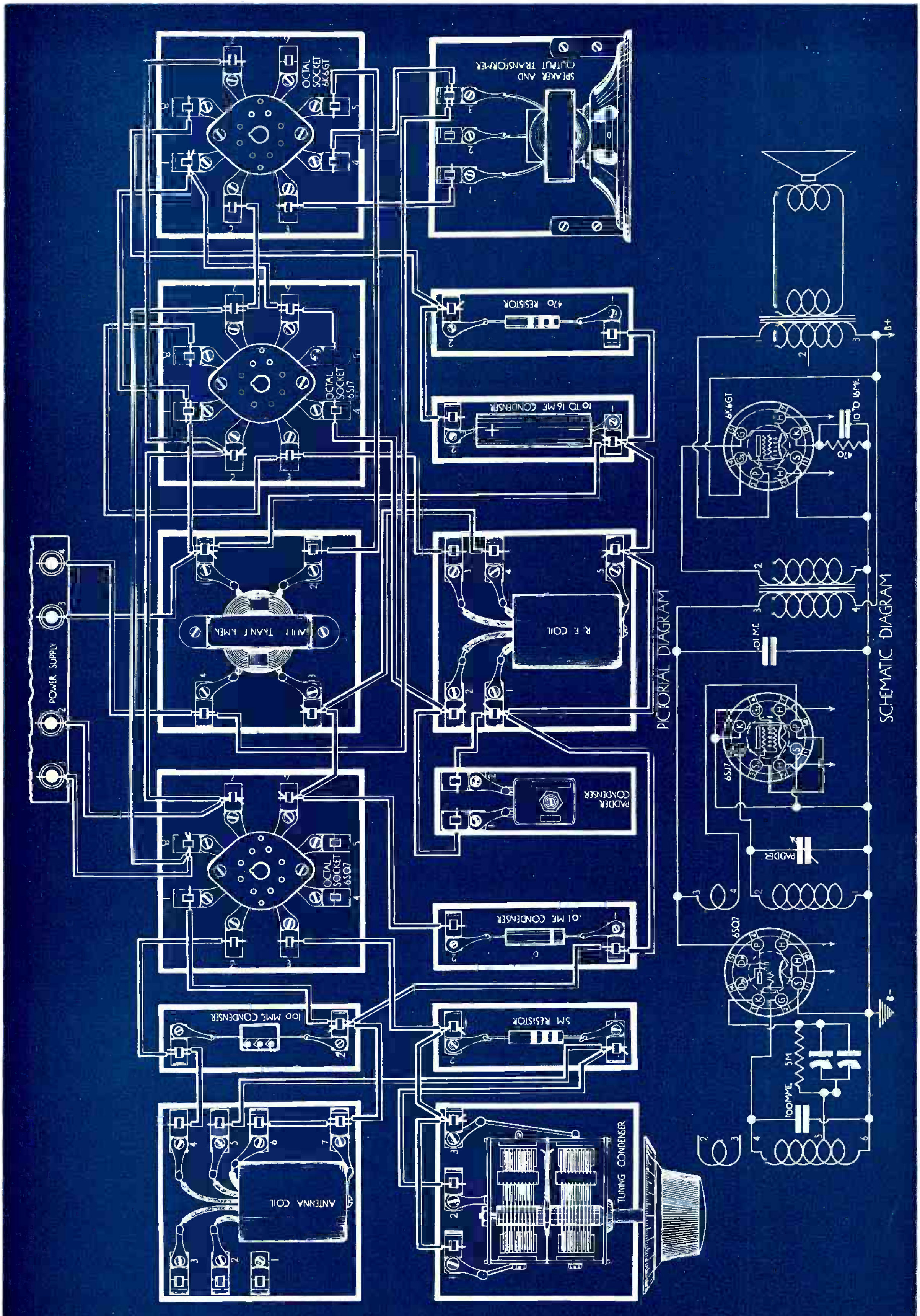
Experiment No. 3

The beat frequency oscillator of this project generates an audio note and therefore is typical of the principles used for Electronic music.

After you have completed Experiment No. 2, manipulate the tuning condenser dial to produce the eight notes of a musical scale in the speaker. Some of your notes may sound a little "sour" at first, but with a little practice, you should be able to produce a scale with all notes of good tone.

If you care to go further, you can practice the playing of simple tunes but remember your instrument resembles a slide trombone or violin in that there are no definite stops for each note. You can slide from one note to the next without any jumps or breaks.

Your next shipment will include parts to enable you to build several types of frequency generators, the first of which is an audio oscillator of simple design to produce a single frequency. Therefore, we want you to pay particular attention to the beat frequency oscillator of this project so that you can make a close comparison with the simple audio oscillator of the next.


PICTORIAL DIAGRAM
SCHEMATIC DIAGRAM
POWER SUPPLY
OCTAL SOCKET 6K6GT
OCTAL SOCKET 6SJ7
OCTAL SOCKET 6SQ7
SPEAKER AND OUTPUT TRANSFORMER
470 RESISTOR
10 TO 16 MF. CONDENSER
R. F. COIL
PADDER CONDENSER
.01 MF. CONDENSER
5M RESISTOR
100 MMF. CONDENSER
ANTENNA COIL
TUNING CONDENSER
6K6GT
6SJ7
6SQ7
PADDER
10 TO 16MF.
470
.01 MF.
5M
100MMF.
B+
B-

# DE FOREST'S
## TRAINING, Inc.

### - INSTRUCTION -

### DEVRY PROJECTOR

* * Founded 1931 by * *

# DEVRY PROJECTOR

In order to secure the full benefit from the Film Section of your Electronic Training, you must have good pictures, a good projector to show them and most important, know how to operate for best results.

We have spent a great deal of time and money in preparing your Film Lessons, have made arrangements to send you the best projector we could find, and expect that you will do your part in studying the following instructions very carefully.

Not only do we expect you to study these instructions, but feel sure you will follow them exactly, thus being able to secure perfect pictures right from the start.

## UNPACKING THE PROJECTOR

When you receive the projector package, do not be in too big a hurry to unpack it, but first clear off a table. Then open the package and lift the parts out, one at a time, placing them on the table.

We want you to be careful because, even though the DeVry projector is substantially and sturdily built, it is an expensive piece of machinery and should be treated accordingly. Remove all packing material from the large, or main part of the projector, as shown in Figure 1, which contains the lamp housing, gears and other mechanism for showing the films, and turn it so that the lamp housing is toward you.

The other main part, or Reel Bracket, of Figure 1, is made up with a shaft and pulley at each end and a thumb screw in the center. Check this over and make sure that both shafts turn freely.

## ATTACHING REEL BRACKET

To fasten the reel bracket to the projector, hold it over the two guide pins on the smooth plate in the position of Figure 1 with the pulleys on the lamp house side. As soon as the pins enter the holes in the plate of the bracket, insert the thumb screw in the central hole and turn it, to the right, until the bracket is tight.

Then you will notice a spring belt around the Drive pulley of Figure 1. Make sure it is in the pulley groove and then pull it back gently and slip it over the lower pulley on the reel bracket.

Be careful here not to stretch the belt any more than necessary because it is the tension of this spring that keeps the film properly wound while you are running the projector.

If you have followed directions, there are two reels on the table, one empty and the other containing the film. Notice that the centers have a star shaped hole on one side and a round one on the other as in Figure 2, A and B. At C we have a side view showing the slot in the hub.

In some makes of reels, you will find the central hole of different shapes and perhaps of the same shape on both sides. Regardless of these details, make sure that each of the reels fits all the way on the shaft as shown in Figure 3-B.

## PUTTING ON REELS

At Figure 3-A we show the lower reel shaft with the pulley on one side of the bracket. Notice the pin at the inner end and the lock at the outer end of the shaft. The pin fits into one of the points of the star hole in the reel, and thus allows it to be driven.

Take the empty reel, slip it on the shaft, star hole first, and turn it slightly until the pin engages and the reel is flush with the collar. Then snap the lock over to hold it in place as in Figure 3-B.

The loaded reel, or the one with the film wound on it, is placed on the upper shaft in exactly the same way and you are ready to thread the film.

## THREADING

As the film tears quite easily, before trying to thread it, study Figure 4 until you know the location and action of the various parts. A little time spent here will save trouble later on.

Turn the projector so that the lamp house side is away from you, and then check it up with Figure 4. At about the center you will find the sprocket, the teeth of which fit the holes, or perforations, in the film and drive it through the machine. Above and below the sprocket are the "Idlers" that hold the film in place.

In the center of the sprocket you will find a threaded hole for the hand crank. To attach this crank, start its threaded end in the hole and turn it to the right, "clockwise", until the threads are out of sight and the sprocket turns.

P

In Figure 4, we show the upper idler raised away from the sprocket, while the lower one is in the operating position. Both of the idlers have to be moved away from the sprocket to thread the film, so we want you to learn how it is done.

At the outer end of each idler, you will find a small button and by pressing this in toward the projector, the idler lock is released. Hold the projector with your left hand, place your right thumb or forefinger on the button of the upper idler and push it in and up.

Of course, you must first push the button in far enough to release the lock before you try to push the idler up, but try it a time or two and you will be able to do it in an instant. The lower idler works in exactly the same way, but is pushed down to move it away from the sprocket. Practice the opening and locking of these idlers a few times until you can handle them quickly and surely.

At the right of Figure 4, we show the film gate open but, on your projector, it will be closed. At this time, you can complete the assembly by inserting the lens, knurled end out, into the lens barrel. Push the lens into the barrel for about half of its length but not as far as shown in Figure 4.

After the lens is in place, the Film Gate can be opened, to the position shown in Figure 4, by pressing the spring, shown at the top of gate, away from you and pulling forward and down on the Lens Barrel.

The action here is about the same as that of idlers, so practice a few times until you can open and close the Film Gate without any trouble.

Remember all of these locks and parts work quite easily so don't try and force them. Follow these directions and you will have no trouble.

THREADING THE FILM

Now you are ready to thread the film and first pull out about $1\frac{1}{2}$ feet from the upper loaded reel. Then, following Figure 5, you raise the upper idler, lay the film over the sprocket so that the teeth come through the holes and then push the idlers back in place. You should hear a snap as the idler locks.

It is important that the film be properly placed, so to make sure, take hold of it on both sides of the sprocket and give a light pull back and forth. It should move slightly on the sprocket teeth, but if not, it is pinched and you will have to raise the idler and try again.

Then open the film gate and run the film through from top to bottom leaving the upper loop long enough so that you can see the lamp house screw head inside it.

Make sure that the film is straight and smooth for the entire length and is in the channel, then close the gate. Here again you must watch to see the film is not pinched.

Then, drop the lower idler and, leaving the lower loop about the same size as the upper loop, bring the film back under the sprocket, making sure that the teeth are in the holes. You next lock the lower idler and check up exactly the same as for the upper one. If you have done this properly, the length of the loops, from upper to lower will be about five inches and you will still have quite a long end of film.

This is brought around under the lower empty reel and the end placed in the slot of the reel hub. Then you give the reel a turn or two forward in the direction of the arrow until all the slack, between it and the lower idler, is taken up.

To check your work, give the hand crank a turn or two. If the loops of film remain the same, you have threaded properly. Should either loop shorten, it shows the film is pinched somewhere and you will have to re-thread it.

It has taken us quite a while to explain all these actions but they are really very simple, just four things to do.

First - place film under top idler.
Second - put film in through gate.
Third -- place film under bottom idler.
Fourth - put film around lower reel.

Take plenty of time at first and you will soon be able to thread the film while you count, one, two, three, four.

PROJECTION

The size of the pictures will depend on how far the projector is away from the screen. For your studies, any distance from 4 to 12 feet will work out nicely. You do not need any special screen, but will get the best pictures on a blank white wall. A light colored window shade also makes a good curtain.

While you will have to make your own arrangements, we suggest that you place the projector on your study table and show the pictures on the wall, or window shade, at the opposite side of the room.

After you have all this arranged, plug the line cord into your electrical supply, but make sure that the cord does not touch or interfere with the lower reel.

You will now see the light in the lamp housing and can turn the crank slightly until there is a spot of light on your screen, or turn the hand crank a few times until the title of the Film shows on the screen. The letters of the title may be all blurred or quite clear but, in either case, turn the lens slowly to the right or left until they are clear and distinct. This we call Focusing. If you have difficulty in obtaining a clear picture, move the projector closer to the screen.

If you want to raise the picture on the screen, place a book or magazine under the front of the base.

As soon as the picture is properly focused and placed, you are ready to run and simply turn the hand crank. You can run the picture fast or slow but, if you turn too slowly, there will be a flicker that is hard to watch. The correct speed is two turns per second, but be sure and turn at a uniform speed.

Occasionally, the picture on the screen may be cut off, at the top or bottom, with the remainder appearing below or above. When this happens we say the picture is "Out of Frame" but it can be brought in frame by means of the "Framer" lever.

To make this adjustment, move the framer lever, up or down, <u>while you are turning the crank</u>, until only one complete picture shows on the screen.

Should you want to study any particular part of the film, just stop turning and move the crank either way until the picture is bright and clear. By following this plan you can go through any part, or the entire reel, picture by picture, and take all the time you want for the study of each.

REWINDING

After the picture has been run through the projector, keep on turning the crank until the film passes through the sprocket and lower idler, and the end is hanging free. This brings all the film on the lower reel and to view it again, it must be rewound.

As shown by the broken line of Figure 6, to rewind, the end of film from the lower reel is brought straight up, without any twist, around the front of the hub of the upper reel, and placed in the slot as explained for threading the lower reel.

To make use of the crank for rewinding, lift the belt off the lower pulley, give the looped end a half turn and then place it on the upper pulley. As shown in Figure 6, this will form a "Crossed Belt" and drive the upper reel in the proper direction although the crank is turned in the same direction as when the film was projected. Continue to turn the crank until all of the film is back on the upper reel.

Before you start to rewind make sure that the film passes from the lower to the upper reel, on the front side of both, as shown by the dotted line of Figure 6.

Note:- When you are through with a reel and ready to return it, do not rewind. After you have run it the last time, simply remove the lower reel and send it back to us.

## OILING

Like any piece of machinery, the projector needs oiling occasionally, but you must be careful as too much oil may damage the film.

As a general rule, three drops of oil for each thousand feet of film will be correct. Your film Lessons are one hundred feet long so use the oil can only after you have run the Lesson through ten times.

You will find an oil hole at each end of the reel bracket, above the upper and lower shafts. A hole in the top of the frame takes care of the main shafts and each should be given three drops of oil for each thousand feet of film. When you oil these shafts it is a good plan to put a drop or two of oil on both ends of the claw.

Remember-- too much oil may damage the film.

## CLEANING

Dust and dirt are the main causes of poor pictures, therefore, you must keep the projector clean.

Before running the film, take a match or tooth pick, wrap a piece of soft cotton cloth around the end and carefully wipe out the film gate, taking special care to clean the edges of the square openings on both sides. Never use any metal tools here as any scratches will ruin the film.

The lens can be pulled out of the lens barrel and both ends wiped clean. Use a soft cloth and do not rub hard as a slight scratch on the lens will be greatly magnified in the picture on the screen. If possible, secure some lens tissue for this work.

Do not try to take the Lens apart as it is sealed at the factory and no dust can get inside. Never put your fingers on the lens as you will leave marks that are hard to clean off.

REPLACING LAMP

Like all other incandescent bulbs, the projector lamp will become blackened in time or the filament may break. In either case, it must be replaced and can be easily reached by removing the lamp house.

As shown in Figure 4, the "Lamp House Screw" is located on top of the body of the projector, and should be unscrewed only until the Lamp House is free and can be rocked back and forth. Still rocking it slightly, the housing can be pulled up until it lifts off.

The lamp will then be exposed and can be removed by first pressing it down in its socket and then turning it to the left. This releases the "Bayonet" pins and allows the bulb to be lifted out. Be sure and replace the lamp only with one of the same type and voltage rating.

PLAN OF STUDY

Like the rest of your studies, you should follow some definite plan for viewing the films and our suggestion is as follows:

First - Study the Reel Lesson carefully, and if any of the ideas or actions are not clear, go back and review your regular Lessons.

Second - Run the entire Film Lesson through the projector, stopping only to read the titles.

Third - Go through the Film and Reel Lesson together checking over each action, diagram or scene until you understand it perfectly.

Fourth - When you are ready to return the film do not rewind but after viewing it for the last time, remove the lower reel and mail it to us.

P

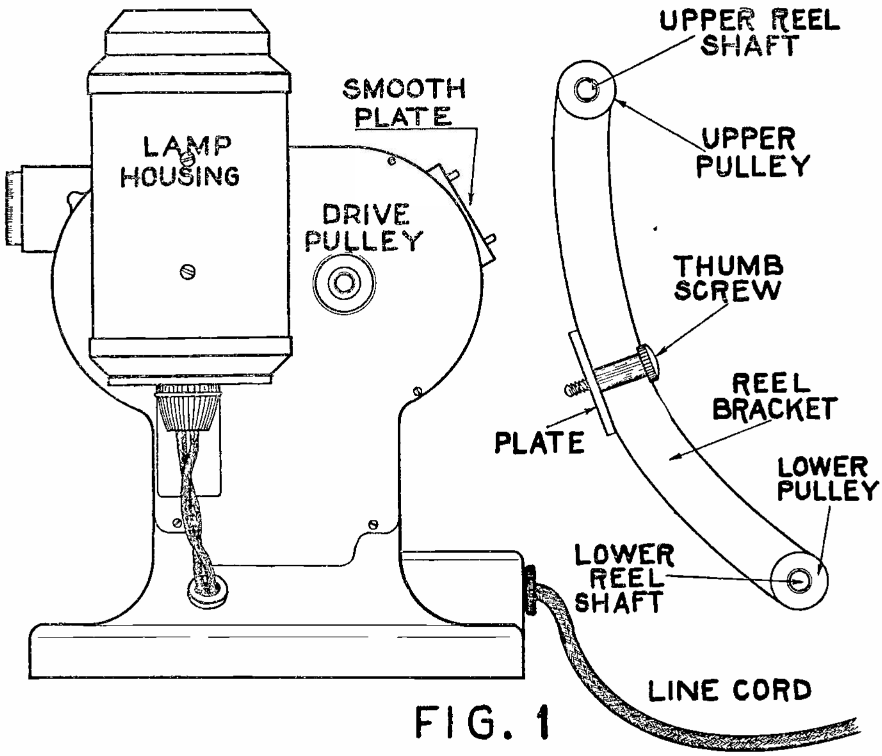



FIG. 1

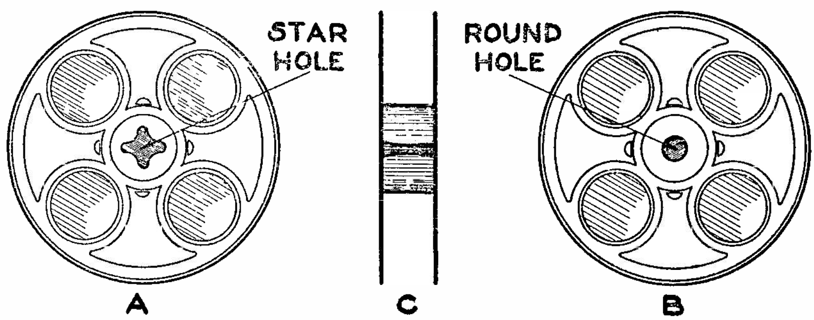



FIG. 2

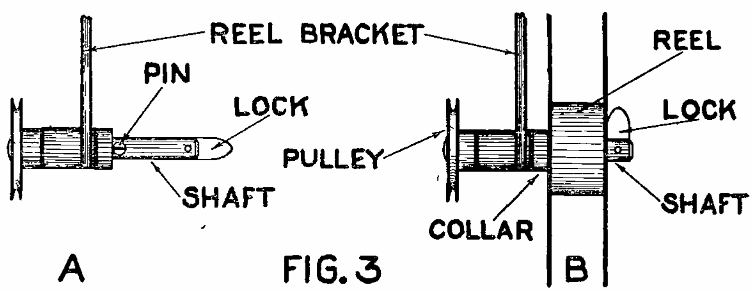



FIG. 3

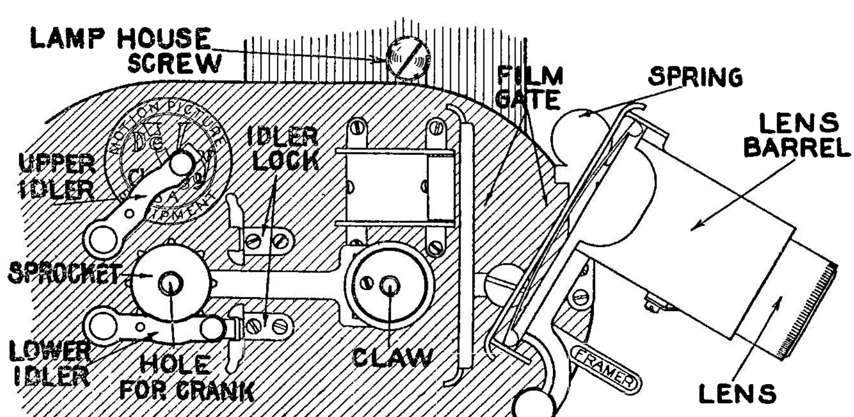



FIG. 4

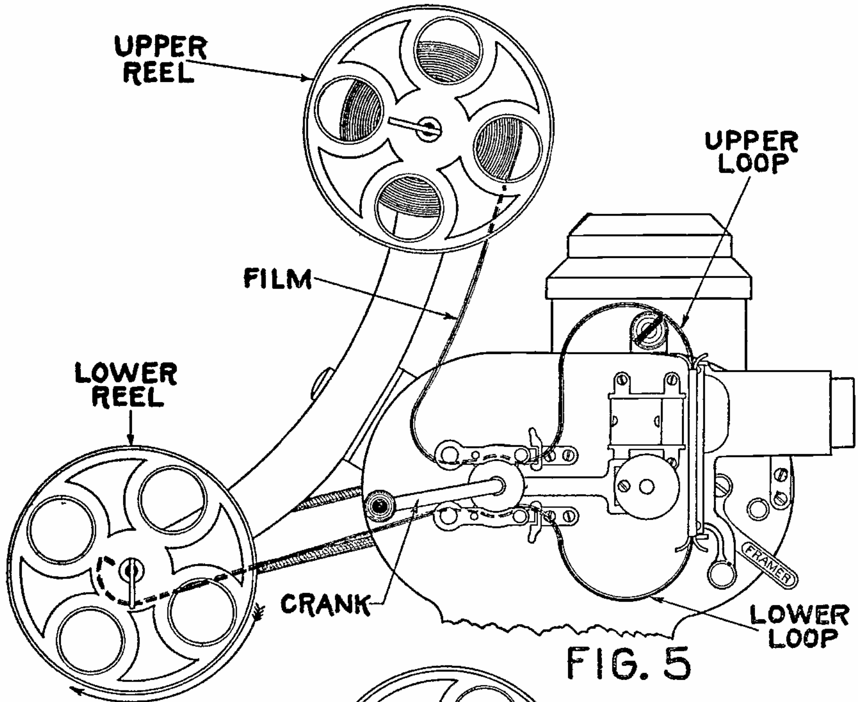

UPPER REEL
UPPER LOOP
FILM
LOWER REEL
FRAMER
CRANK
LOWER LOOP

FIG. 5

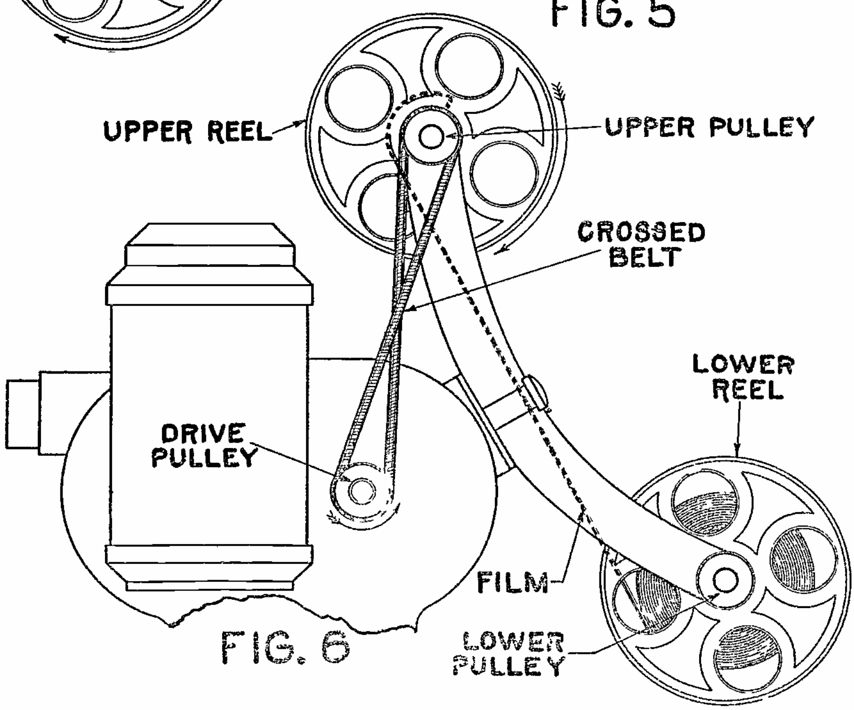

UPPER REEL
UPPER PULLEY
CROSSED BELT
LOWER REEL
DRIVE PULLEY
FILM
LOWER PULLEY

FIG. 6