MIDLAND RADIO
AND TELEVISION
SCHOOLS
INC.

POWER & LIGHT BUILDING, KANSAS CITY, MISSOURI

GROUP NO. 1

LABORATORY EXPERIMENTS

EXPS. NO. 1 TO 9

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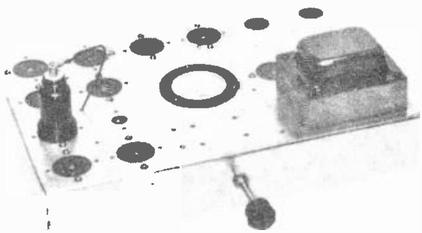
LABORATORY EXPERIMENTS

Group One



"When you have completed Lesson 10, you are ready to start your Home Laboratory experiments. The purpose of these experiments is to give you actual, practical experience in addition to the theoretical study contained in your lessons.

"The main unit to be built in this group of experiments is a tube tester. Tubes are furnished you in later shipments of equipment, but you can test the tubes in your own receiver or those of your neighbors."

EXPERIMENT I

SELECTING AND USING RADIO TOOLS

A wide variety of tools is not necessary for a proper start in Radio and Television experimental work. With your first shipment of laboratory equipment, Midland Television included the three most essential tools needed in the construction of your home laboratory experiments. The only addition which you might wish to make is a good pocketknife. Since practically every young man has one of these, we did not deem it necessary to include this item with the tools furnished.

The tools furnished are: a pair of long nose pliers, a screwdriver and a soldering iron. In addition to these tools, you will need rosin core solder and hookup wire. Both of these items are also furnished.

While it is not necessary, it may be that the student will desire to purchase additional tools; if that is the case, do not spend too much money for high-grade tools until you are doing service work and have extra money to spend. The real test of a skilled workman is whether or not he can do a satisfactory job with the tools he has at his disposal. It is not so much the tools you have, but rather the way in which you use them.

Perhaps all of us have the feeling that we are a good mechanic; that we know how to use tools and can do good work with them. However, we want to remind you at this time, the quality of your work will depend upon your skill in using tools. You should practice diligently to develop this art. If possible, arrange to watch a good mechanic, or better still, a good Radio man handle his tools.

Regardless of how much we write in the way of instructions for using tools, there is a certain "knack" which must be obtained before you can secure the maximum benefit from the use of tools. Try your best to acquire this "knack".

All of us at some time or another have used a screwdriver; therefore, there is very little need for instruction along this line. The use of a soldering iron will be described in Experiment 4, so in this experiment we are going to take up the use of long nose pliers.

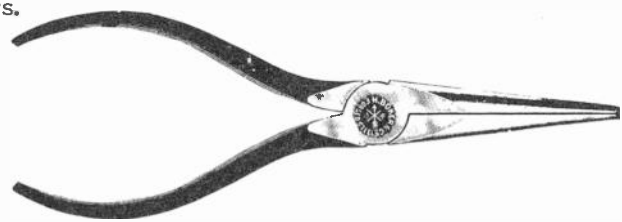


Fig.1 These are long-nose, side-cutting pliers, such as supplied with your home laboratory apparatus. Undoubtedly these are the most useful tool a radio man has.

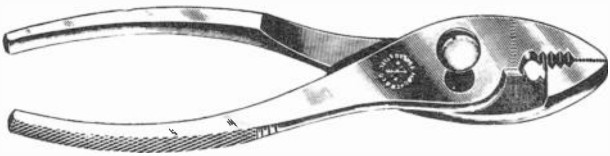


Fig.2 This type of plier is usually called automobile pliers. They are designed for heavy work and are not satisfactory for most radio and television applications.

1. THE LONG NOSE PLIER. Fig. 1 shows a view of the long nose pliers which are supplied with your regular experimental equipment. These are known as 5½" long nose, side cutting pliers. You will notice that there is considerable difference between these pliers and those shown in Fig. 2. The pliers shown in Fig. 2 are usually referred to as automobile pliers. They are blunt nosed; usually considerably larger than long nose pliers and are too awkward to use for satisfactory radio work. However, if the occasion should arise, pliers such as these are very handy for heavier work. They will not be necessary in conducting your regular home laboratory experiments.

In referring to Fig. 1, the small, round indentation just above the joint is the side cutting section of long nose pliers. The two cutting edges are used for cutting small wire. *WARNING: do not try to cut heavy wire with these cutters.*

The first thing you should learn is how to properly hold a pair of long nose pliers. This is shown quite clearly in Fig. 3. Grasp the pliers in this fashion and see how easy it is to manipulate them.

The pliers are forced shut by the pressure from the lower end of the thumb and the first and second fingers. The third and fourth

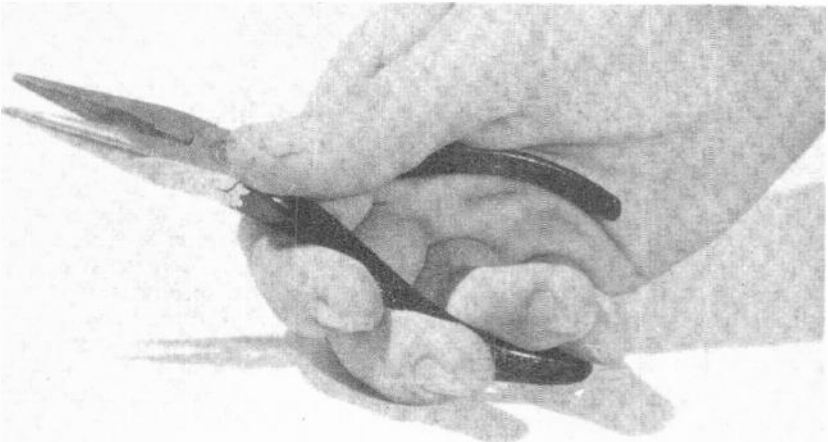


Fig.3 This illustrates the correct way to hold long-nose pliers.

fingers are placed inside of the plier handle in order to facilitate the opening of these pliers. If your hand is large, only the little finger need be used to open the pliers. Now that you have them properly grasped, try putting a nut on a small bolt, using the long nose pliers. Try this several times until you become proficient in the operation.

Fig.4 This type of plier is usually called lineman's side-cutting pliers. They are a heavy-duty tool used by electricians.

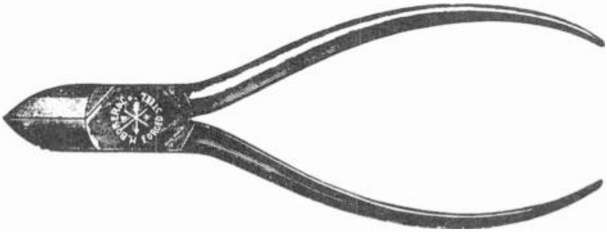


Fig.5 End-cutting pliers. This type of plier is used only for cutting wire. They are quite useful in that wire can be cut right down at the end of the nose.

If the pliers which you have are a little stiff (because they are new), grasp a handle in each hand and work them back and forth, several times. Also, place a drop or two of oil on the joint. The full appreciation of pliers will not become apparent until one has fully mastered their use.

Long nose pliers will last a long time if they are not abused. You should not try to handle too large a job with such a small plier. It is very dangerous to drop this kind of pliers on a cement floor, because you are apt to snap one of the handles. You should never try to cut anything larger than #14 wire with this kind of a cutter.

While your home experimental work does not call for the need of heavier tools, we are going to show you pictures of two heavier types of tools. Fig. 4 shows a picture of electrician's sidecutting pliers, more commonly known as lineman's pliers. These may be purchased in various sizes and the side cutters are capable of cutting quite large wire. Another very handy type of plier is known as the diagonal end cutting plier (shown in Fig. 5). The chief advantage of this type of plier is that a wire may be snipped with the very end of the plier's jaws. This makes it possible to get into tight places where it is impractical to use another type of tool.

EXPERIMENT 2

LEARNING TO SKIN WIRE

The hookup wire supplied for your home laboratory experiments is known as "pushback" wire. The insulation from this type of wire does not need to be skinned off. It is only necessary to cut the wire off at the desired length and then push the insulation back so as to expose the bare wire where it is desired to make a joint.

However, it may be necessary for the student to skin the insulation from wire which is not of the pushback construction. Such a type of wire is the 110-volt AC cord which is supplied with your experimental equipment.

1. PARALLEL CORD. This wire is known as "parallel lamp cord". It consists of two separate, insulated wires over which an outer covering has been placed. This wire is to be used in connecting the primary of your power transformer to the 110-volt AC lighting socket. One end of each wire is to be connected to the two primary terminals of the power transformer while the other end of each wire is to have an AC plug attached to it.

There are two ways to skin wire. The first, and perhaps the easiest for a beginner, is to use an ordinary, sharp pocketknife. In this case, the insulation of the wire is merely scraped off, taking care that the wire itself is not cut in two. The other method of skinning wire is by the use of pliers, either the lineman's type, end cutters or long nose pliers.

2. SKINNING WIRE. The first step in removing the insulation from the parallel wire is to use a pocketknife and split the outer covering as shown in Fig. 6. Approximately 1½" of this outer insulation should be removed. Now you are ready to remove the insulation from each individual conductor. You will notice by examination that each conductor consists of many small wires; this is called

"stranded" wire. This means that each wire is made up of many small wires twisted together and then an insulating cover placed over the wire strands. If you are going to use a good, sharp pocketknife, simply strip off at least ¾" of the insulation from each of the separate conductors. In carrying out this procedure, care must be taken that the small strands are not cut in two. After the insulation has been removed, grasp the strands of wire between the thumb and first finger and twist them together. This makes a more solid conductor. Later, we are going to show how these two ends should be connected to the AC attachment plug which is supplied to you.

Fig.6 This illustration shows parallel AC cord, which has been split ready to be attached to an AC plug.

While the skinning of wire with a pocketknife is, by far, the simplest procedure, it is not as fast as using pliers after you have learned how. It is rather difficult to describe this operation and it can be learned only by practice. Don't be discouraged if you spoil several inches of wire before you master this method of skinning the insulation from wire.

Grasping the long nose pliers as shown in Fig. 3, place the wire from which you wish to remove the insulation between the jaws of the pliers just above the cutter point. Be careful and do not cut the wire in two. Now smash down on the insulation on the wire by squeezing hard on the pliers. The purpose of this is to soften or "squash" the insulation surrounding the bare or stranded wire. Follow this procedure over the length of wire from which you wish to remove the insulation. The next step is to place the wire directly between the cutting jaws of the pliers. Now bring the cutters down so that they just start to pinch the wire. Be careful, or you will come down too far and cut the wire in two. Now, holding the wire in the left hand and pulling outward with the right hand, you will find that the insulation can, more or less, be "jerked" from the wire. By merely squeezing down on the insulation, but not cutting the wire, you have loosened the insulation at that point. Then, the outward jerk completed the movement. As before mentioned, the only way this procedure can be learned is through experience. Try it many times until you have acquired the "knack". If you are afraid of spoiling the 110-volt AC cord which we send you, secure some other insulated wire on which to practice. It is a great trick to be able to skin wire in this manner and not everyone can acquire the "knack". Keep trying so that you can boast to your fellow students that you can skin wire like a veteran.

When using lineman's pliers or end cutters, the wire may be smashed between the handles just back of or below the joint.

EXPERIMENT 3

LEARNING TO SPLICE WIRE

There is one way which most engineers agree is the correct way to splice wire. Therefore, it is advisable that the student learn to accomplish this feat in a very satisfactory manner. Throughout many years of experience, we have seen many kinds of wire splices. Some of them were fairly satisfactory while others were foolish and a great loss of time.

The first thing to do in splicing wire is to remove the insulation from the wire over the space to be used in the splice. This will vary in length, depending upon the size of wire and the mechanical strength needed. However, in ordinary radio and electrical work, 1½" of bare wire is sufficient. After the insulation has been removed, it is then necessary to clean the wire thoroughly. Remove all traces of insulation and oxidation[1]. There are two reasons for cleaning the wire thoroughly. First, after a good mechanical joint is made, you should also have a good electrical joint. Oxidation presents a high resistance to the passage of an electric current and the joint cannot be satisfactory unless it is clean. The second reason for cleaning the joint is so that it may be soldered conveniently. Soldering will be explained in Experiment 5.

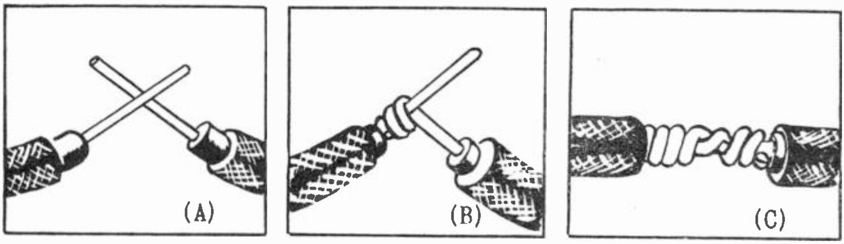


Fig. 7 (A) The first step in making a wire splice.
(B) The first twist in the joining process.
(C) The final joint as it should look before soldering.

After the insulation has been removed from the wire and it has been thoroughly cleaned, place the two ends as shown in Fig. 7A. Holding the joint in your left hand, wrap the end of one wire around the body of the other wire as shown in Fig. 7B. Then, holding the joint in your right hand, wrap the other end of the wire around the body of the other wire as shown in Fig. 7C.

If you are working with stiff wire, it may be necessary to use pliers in order to tightly wrap the end of the wire around the body of the other wire. Sometimes, it may even be necessary to hold the joint with one pair of pliers in the left hand and wrap the wire with another pair of pliers held in the right hand. However, this is only necessary when wire of a size #14 or larger is being used. This type of wire is very seldom encountered in radio work.

In order that a good mechanical joint may be made, the last loop or two should be wrapped extremely tight by the aid of pliers.

[1] Oxidation is a form of rust. This is caused by the oxygen in the air penetrating the surface of the conductor and setting up a resistance.

This is where the use of long nose pliers comes in very handy.

The length of the splice will depend upon the mechanical strength needed. If there is any danger of much tension being placed on the joint, it is advisable that the joint be at least 1½" or 2" long. However, if there is not to be any strain on the joint, a 1" joint will be quite satisfactory. After the joint has been made, it is advisable to solder the joint and then wrap it with insulating tape. This is necessary so that the bare wire cannot come in contact with any other bare wire or the chassis of the radio receiver or transmitter.

The hookup wire which is supplied with your experimental equipment is very satisfactory for making joints. It is advisable that you try this several times so that you will become proficient in this type of work. Remember, you are training to become a skilled technician.

Another type of joint which it is often necessary to make is where one wire is to be joined to another continuous wire. The joint just made was to splice the ends of two wires together.

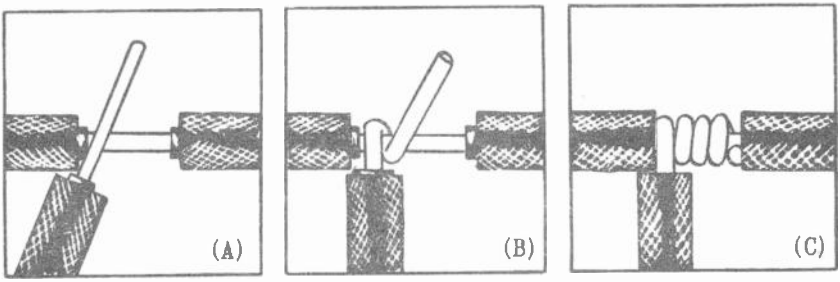


Fig. 8 (A) Joining the end of a wire to a continuous wire. This figure shows the preparation of the two wires. (B) Shows the start of the twist. (C) Showing the finished joint before soldering.

The first thing to do is to skin the insulation from the continuous wire to which another piece of wire is to be attached. This is shown in Fig. 8A. Depending upon the size of wire to be used, usually an inch of insulation is enough to remove. This can usually be done best with a good sharp pocketknife. Next, skin the insulation from the wire which is to be attached to the continuous wire as shown in Fig. 8B.

Now, wrap the end of the loose wire around the bare place on the continuous wire as shown in Fig. 8C. Be sure that you wrap the joint tightly. However, do not place the wraps too close together, because you are going to solder this joint later. You should leave enough space between the wraps so that you can run the solder down in between each turn, thereby securing a good mechanical and electrical joint. It is highly essential that the ends of both wires be cleaned very thoroughly.

One of the important things to remember in making a wire joint is that the joint must be mechanically as well as electrically secure. Do not depend upon the soldering to hold the wire mechanically.

EXPERIMENT 4

LEARNING TO PREPARE A SOLDERING IRON

Before it is possible to learn the technique of soldering, it is first necessary to learn something about the tools which you are going to use and the proper preparation of these tools.

There are two types of soldering irons used by radio men. One of these is the electric soldering iron, such as that supplied by Midland and shown in Fig. 9. The other type, an ordinary iron (copper) is shown in Fig. 10.

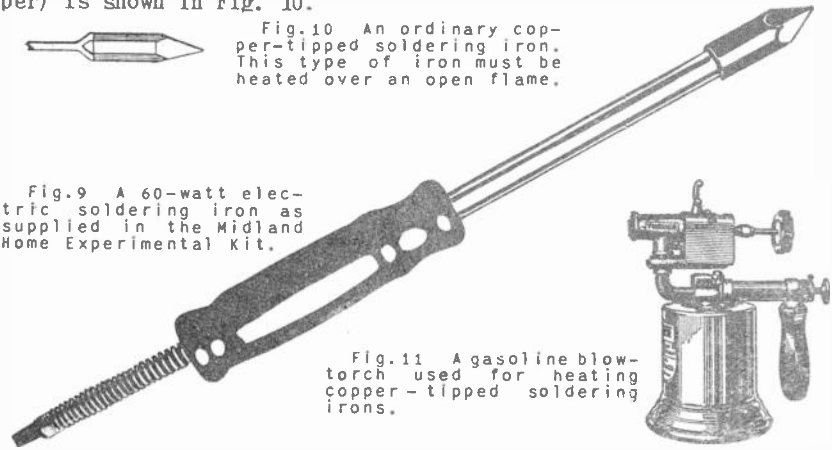


Fig.10 An ordinary copper-tipped soldering iron. This type of iron must be heated over an open flame.

Fig.9 A 60-watt electric soldering iron as supplied in the Midland Home Experimental Kit.

Fig.11 A gasoline blowtorch used for heating copper-tipped soldering irons.

The electric iron is heated by a wire-wound resistance unit placed in its body. The heat generated is then conducted to the copper point. The ordinary type of copper iron is heated by an open flame. This flame is generated by either a gasoline blowtorch such as that shown in Fig. 11 or by placing the iron over a gas flame such as a gas stove, gasoline stove, or a gas burner, generally called a Bunsen burner.

The ordinary type of soldering iron is rated entirely by the weight of the copper tip. In other words, it may be a 6-ounce, 10-ounce, or a 1-pound iron and, in some cases, even heavier. Electric soldering irons are rated according to the current or power consumption of the heating element. These will range from 40 watts for the smallest type of iron up to 200 watts for the large, commercial type of soldering irons. Besides the rating of the heating element, they also list the size of the soldering iron tip. Naturally, it would be unreasonable to expect an iron having a 40-watt element to be able to heat a tip of a given size as fast as an iron having a larger heating element. Also, during the process of soldering, heat is absorbed from the tip by the metal of the material being soldered. If the heating element is not large enough, the iron will be cooled off excessively by close contact with metal and a proper soldering job cannot be accomplished. Therefore, the size of the heating element of a soldering iron must be governed by the job to be done. If large and heavy objects are to be soldered, then a high-wattage heating element must be used if satisfactory work is to be expected. If only light parts are to be soldered, then an iron having a small heating element will be just as satisfactory as a larger iron. For radio work, a 60-watt element is usually quite satisfactory. However, where a great deal of work is to be done, such as in the manufacturing of radio sets, it is often necessary to use an iron having a 100-watt element.

In the successful use of solder, we must bear one important basic principle in mind; that is, the work which is to be soldered must be raised in temperature sufficiently to melt the solder. After this is accomplished, with the aid of a proper flux and especially made solder, we are sure to achieve a satisfactory result.

Failure to secure a temperature adequate for soldering demands is often traceable to lack of sufficient heat-conducting surface on our soldering iron or carelessness on the part of the operator to properly present this heat-conducting surface to the work for heat delivery. As a simple illustration of a correctly shaped point, we will make use of a conventional, external-heated iron (copper). In Fig. 12A, we have a blunt, heavy point that can deliver its heat with sufficient rapidity to overcome heat radiation in the work, while in Fig. 12B, the iron with its slender and longer point, there is danger it will not be able to overcome this trouble.

Fig. 12 (A) A correctly shaped soldering iron tip.

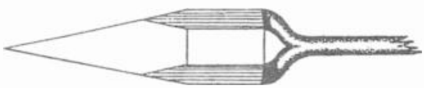


Fig. 12 (B) An incorrectly shaped soldering iron tip. The point is too long and narrow and will neither hold nor conduct heat to the surface to be soldered satisfactorily.

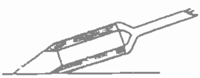


Fig. 13 (A) The correct way in applying a soldering iron to the work to be soldered.

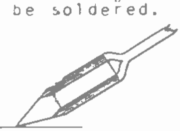


Fig. 13 (B) An incorrect way of applying a soldering iron to the work to be soldered. Notice that only the tip is touching the work.

To further illustrate how careless handling of soldering tools may defeat good tool design, first look at Fig. 13A and you will note that the entire iron surface is in contact with the work. Fig. 13B gives some idea of what may happen with the same correctly shaped iron in the hands of a careless operator. The iron in Fig. 13A is so positioned that the transmission of heat may be carried on with all rapidity, whereas in Fig. 13B, there is only a limited contact for this heat delivery.

Insecurely soldered joints, commonly termed "rosin joints", are often the direct results of the foregoing misapplication of soldering tools and form a never-ending source of trouble for the radio engineer. As a further aid in securing a rapid delivery of heat to our work, we must keep all soldering iron faces, solder-coated. (This is called "tinning" the soldering iron.) Oxides (rust) are not only poor electrical conductors, but they are also poor conductors of heat and a crust or film of oxide on your iron face will destroy efficiency in heat delivery. By solder coating our iron's working faces (tinning the iron), we actually accomplish a means of enlisting the natural law of capillary attraction to assist us in heat conduction. The webbing of the solder between the solder-coated face of the iron and the work will take care of all irregularities in the two surfaces, giving us a maximum contact. If this coating of solder becomes burned or oxidized by overheating the iron, it immediately manifests the fact by a slowness in heat transmission. Before any success will attend the use of a tool in this condition, it must have the working faces recoated with solder. This is best accomplished by heating the iron and then cleaning the faces with a file. (This should be done only when the iron is hot.) When the faces show clean and bright, rotate in melted rosin core solder upon a tin plate until they become solder-coated and adhesive to the molten metal; see Fig. 14. In following this procedure,

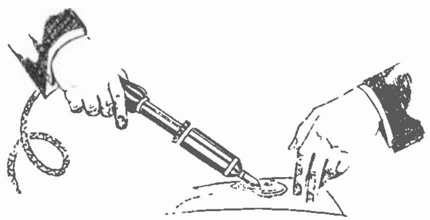


Fig.14 This illustrates the correct method in tinning a soldering iron.

it is advisable to use an old cloth and occasionally wipe the soldering iron points clean. Again recoating it by dipping it into the molten solder. Never use sal ammoniac or any other acid to clean or tin the iron in electrical or radio work as some of this material may be carried to your apparatus and cause trouble through its corrosive and conductive properties.

Before it is possible to do a satisfactory job of soldering, you must carefully observe the following pointers. NEVER TRY TO SOLDER WITH ONLY A WARM SOLDERING IRON. Turn the soldering iron on, give it plenty of time to heat and then, before attempting to do the soldering job, test the iron by applying a piece of rosin core solder to the point and observe whether the solder melts readily. If the solder is just mushy on the end of the iron, then it is not hot enough. If the solder tends to burn and sizzle a great deal, then the iron is probably too hot. However, it is better to have an iron which is too hot than one which is not hot enough. NEVER TRY TO USE AN IRON WHICH IS NOT CLEAN. Be sure all four surfaces of the soldering iron point are clean and well tinned. It is impossible to make a good soldered joint with a soldering iron that has a point which is dirty or pitted. DO NOT APPLY SOLDER TO THE JOINT TO BE SOLDERED UNTIL IT IS PROPERLY HEATED. A great deal more information concerning this procedure will be given in the following experiment.

EXPERIMENT 5

LEARNING TO SOLDER

We are indebted to the Kester Solder Company of Chicago for the major portion of the information contained in Experiments 4 and 5. Kester Solder is supplied in your kit.

Electricity, one of our most powerful and useful forces, responds to our wishes only when invited. This is accomplished through the use of suitable conductors for it to travel when we seek to bend this mighty force to suit our needs. Practically every substance of nature will conduct electricity, but some offer such resistance to its flow that they are commonly called insulators, or non-conductors.

Solder plays a very important part in the controlling of this great force. Solders are conductors, while the oxides of common metals are usually found to be non-conductors; hence the very important reason to "solder bond" electrical joints. No matter how carefully we try to make a mechanical connection electrically conductive, oxygen penetrates and oxidizes the surface (rusts), setting up a resistance. The more delicate the current to be controlled, the more detrimental this resistance becomes. Soldering joints effectively seals this connection against the penetration of atmospheric oxygen, eliminating all possibility of oxidation in your mechanical contacts. This means that your solder-bonded joint will not increase in resistance with age.

Still another reason for soldering connections is the fact that solder forms a tenacious, flexible binding medium of great endurance, adapting itself to expansion and contraction from changes in temperature. A mechanical contact may seem at times to possess an uncanny ability to loosen, presumably brought about by the unequal expansion and contraction of dissimilar metals when affected by a temperature change. Vibration will also tend to loosen unsoldered connections. The results caused by loosened contacts in radio operation is both annoying and deceptive. For this reason, if for no other, solder is indispensable in the construction of efficient and practical radio equipment. This is borne out by the fact that all radio receiving sets on the market today make use of solder-bonded connections. A radio receiver with its intricate and compact arrangement of parts and wires presents a minimum of space in which to manipulate tools with which to properly tighten mechanical connections. Once a joint or connection is properly "solder bonded", unless subjected to very severe shock, it will require no further attention during the life of the apparatus. This cannot be accomplished where unsoldered mechanical connections are employed.

In the handling of electrical energy commonly used in interior lighting, all wire splices are solder bonded to assist in the elimination of fire hazards. Loose connections are a common source for starting fires. In the construction of electrical equipment in general, such as motors, generators, electric signs, etc., solder plays a very necessary part, forming an impenetrable barrier which prevents oxide formation at vital connections.

In any soldering operation, it is necessary to use a flux in connection with solder. Flux is that substance whose duty it is to dissolve the oxides occuring on the surface of all metals. When heated, this substance dissolves the oxide and enables the solder, while molten, to alloy with the metal surface, effectively preventing a reoccurrence of oxidization. There are several types of flux used in soldering operations. These range in character from very strong acids to very mild acid-bearing substances. For delicate electrical or radio use, we should employ a flux whose residue is a poor conductor of electrical current, non-corrosive and which displays no tendency to collect moisture, dust or other foreign matter. THIS IS VERY IMPERATIVE.

There is no question but what soldering is made easier by using one of the stronger acids as a flux. However, to attempt the use of chlorides as fluxes in delicate electrical or radio construction is to invite disaster. The corrosive effect of the strong acid plus its affinity for moisture will cause an untold amount of trouble. This trouble may not occur immediately or for many months after the equipment has been placed in service.

Another type of soldering flux often used is called "soldering paste". These contain a limited amount of the stronger fluxing agent suspended in some organic grease or wax and the popular idea seems to be that the presence of this grease will prevent corrosive action. Unfortunately, this is not true as corrosion progresses even under this film of grease. Another detrimental feature in the use of paste will result in the fact that the organic greases or waxes that are universally employed in their manufacture overrun, when heated, onto the insulating material of parts and wires. This deteriorates and breaks down the insulating qualities of the material and, at a later time, will manifest this weakness in no uncertain manner. The active chloride agents contained in paste usually have a marked affinity for moisture. As these chlorides are distributed in a thin film over a distributed area adjacent to your soldering operations, they become an active medium in promoting dielectric losses.

Soldering paste, no doubt, has a legitimate field for use, but not in the soldering of delicate electrical and radio joints.

The leading electrical and radio manufacturers have spent large sums in experimental work and have conducted exhaustive research in determining the best flux for delicate electrical and radio use. They are unanimous in pronouncing rosin as the only safe flux for this type of work. Contrary to popular belief, rosin contains acid in its natural structure, yet it is non-corrosive in use, due to its physical characteristics. Rosin in its original state is not a very satisfactory flux, but when properly mixed and included as the core of the wire solder to be used, it proves to be one of the most satisfactory fluxes obtainable. Rosin core solder consists of a mixture of lead and tin, the metal wire having a hollow core in which is placed the rosin core flux.

It is not advisable to use rosin core solder with an external flux. Rosin is not compatible with the chloride fluxing agent and through its use with rosin core solder, the corrosive action produced may be attributed to the rosin. Rosin is slower in its fluxing action than the stronger acids; however, if the proper application of rosin core solder is obtained, the activity is surprising on metals possessing reasonable receptiveness.

Rosin core flux has the distinct advantages of being a poor conductor, non-corrosive and it does not have a tendency to gather moisture, dust or foreign matter. Therefore, this provides us with the best and safest electrical or radio flux.

Solder is an alloy composed of the two metals, tin and lead. These two metals are combined in variable proportions which reflects certain characteristics in the alloy and are the controlling factors for selecting solder for specific purposes.

In the actual process of soldering, the first thing you must keep in mind is that the work which is to be soldered must be raised in temperature sufficient to melt the solder.

When using rosin core solder, remember that the rosin must come in actual contact with the joint to be soldered. It will then be able to dissolve the oxides and float them from the surface to be soldered. Rosin is disintegrated with heat, so its actual fluxing life is limited to the time and the amount of temperature to which it is subjected in the soldering operation. *Do not apply solder and flux to the iron. Apply it directly to the joint to be soldered after it has obtained a temperature where it will melt and flow the solder.* We are not interested in soldering the iron or melting flux on it; what we want to accomplish is a securely soldered joint and the best and easiest way to secure it is to apply our cored solder directly to the heated surface.

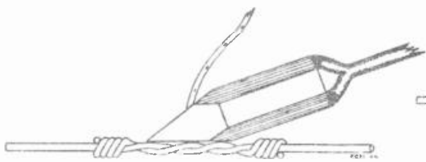


Fig. 15 (A) This illustrates the incorrect way of applying the iron and cored solder to the joint to be soldered.

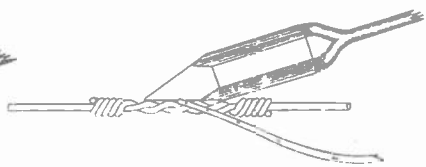


Fig. 15 (B) This illustrates the correct way in applying the iron and solder to the joint to be soldered.

By referring to Fig. 15A, you will see an example of an incorrect application of cored solder. Here the solder is being melted on the upper surface of the iron, forcing flux and solder to run around the entire iron point before it can reach its objective. This dissipates the active oxidizing agent of your flux before it has an opportunity to clean the surface upon which we wish the solder to adhere. On examination of Fig. 15B, you will note that instead of striking the solder on the side or upper face of the iron, it is kept directly at the junction of the work and contact face of the iron. This allows the flux to be expelled directly on the heated surface we wish to clean and solder, and furnishes us with the ideal application. After the solder and flux have melted, do not remove the iron until the solder is observed to flow freely and evenly over the surfaces where we desire adhesion. The failure of the solder to behave in this manner will indicate one or both of the following faults: the work to be soldered is insufficiently heated, or the work surface is too heavily oxidized and dirty to respond to the flux.

If the solder tends to act stringy and pulls into a lumpy surface as the iron is removed, it indicates a lack of sufficient flux and a change in the surface tension of the material. This is because there is no flux to act upon the oxides that are forming on the surface of the molten solder. A sparing reapplication of the cored solder will correct the trouble.

In carrying out any soldering operation, it is highly essential that the work to be soldered must remain still. Any vibration of the parts after the solder has been applied and has not yet cooled or set will cause a spongy, loose joint.

We cannot condemn too strongly the practice of allowing operators or engineers to hold one part of the work in their hand while joining it to another with solder. The great fault lies in their inability to hold the part steady at the critical period when the solder passes from its flux stage to hardness. The slightest tremor at that moment will result in a partically fractured joint which may not manifest its weakness at once, but at a later time will give way under strain. Remember that the correct way to form a joint for the control of electrical energy is to make it mechanically secure and electrically conductive first, then solder the joint. Do not blame the solder or flux and do not blame the workman as these results are beyond the control of either.

In attempting any soldering operation, it is advisable to carefully follow these suggestions. DO NOT USE TOO MUCH SOLDER. While it is necessary to completely cover the joint, still, it is possible to make a very messy joint by the application of too much solder or too much flux. BE SURE THE JOINT IS HOT BEFORE APPLYING THE SOLDER. It is very essential that the joint to be soldered is raised to a sufficient temperature to properly melt the solder before any solder is applied to the joint. BE CERTAIN THAT THE JOINT IS CLEANED BEFORE ATTEMPTING TO SOLDER. Using a file, a pocketknife, or sandpaper, be certain that any joint to be soldered has been thoroughly cleaned before attempting the soldering operation. Solder will not stick to dirty or corroded metal.

EXPERIMENT 6

MOUNTING CHASSIS EQUIPMENT

You will find in your first laboratory shipment a strong, steel chassis. Practically all of your home laboratory experiments are going to be constructed on this chassis. The holes that have been punched in this steel chassis are so arranged as to provide facilities for all of your experiments. Therefore, in conducting one experiment, it is possible that you may not use certain holes or certain equipment supplied you. Then, when conducting another experiment, perhaps another group of holes and another group of equipment will be used. Therefore, pay no attention to any surplus holes or equipment provided. Use only that apparatus which pertains to the experiment under consideration.

HERE IS A VERY IMPORTANT WARNING. IN CONDUCTING YOUR EXPERIMENTS, BE SURE TO FOLLOW DIRECTIONS CAREFULLY. ALSO, BE SURE TO KEEP IN MIND WHETHER OR NOT THE DIRECTIONS SUPPLIED MAKE REFERENCE TO THE CHASSIS WITH IT RIGHT SIDE UP, OR WITH THE CHASSIS UPSIDE DOWN.

The front of the chassis may be determined by the following. There are three ½"-holes equally spaced across the front. Below the center hole is a small hole. Later, this will be used to fasten the dial in place. The back of the chassis can be determined by the two slotted holes.

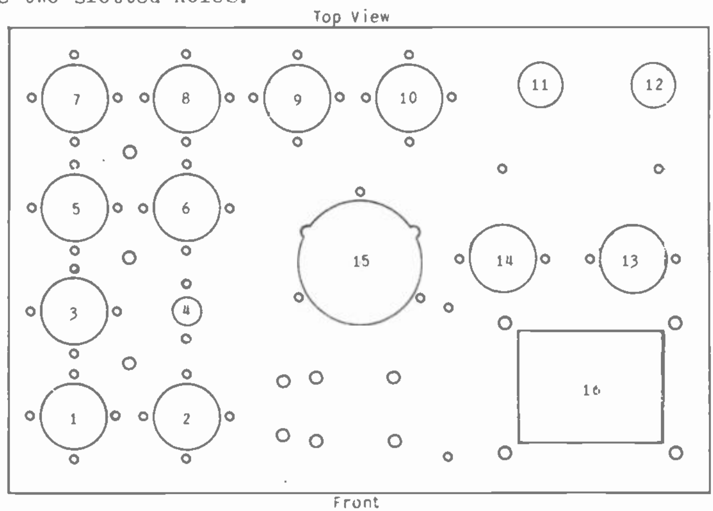


Fig. 16 A top view of the metal chassis on which you are going to build all of your experiments. It is a good idea to take a pencil and actually number the holes on your chassis.

A top view of the completed chassis is shown in Fig. 16. Notice that we have numbered each of the holes. This will make it convenient to describe the location of various equipment.

You are now ready to mount your equipment. The power transformer[1] mounts in the square hole marked 16. There are three wire leads, two green and one red coming from one side of the power transformer. These are the high-voltage leads. The transformer should be so mounted that these wire leads face toward the rear of the chassis. The transformer is slipped into place and then held securely to the chassis by four $\frac{8}{32}$ nuts provided for that purpose. If the transformer fits tightly, it may be forced into place.

The next piece of equipment to be mounted is the 0-50 milliammeter. This is fastened in hole 15 by three bolts and nuts. The meter is so positioned that it can be conveniently read from the front of the panel.

[1] The power transformer supplied you is designed for 110-volt, 60-cycle AC operation. If you do not have this type of supply, advise us what type of supply you have available before attempting to use your equipment.

Next mount the volume control. This is a 15,000-ohm wire-wound potentiometer. It is mounted in the center of the three holes on the front of the chassis and is held in place by a nut supplied as a part of the volume control.

Now you have 9 wafer sockets to mount. All wafer sockets are mounted below the panel with the top side of the socket bolted to the under side of the chassis by two $\frac{6}{32}$ bolts and nuts. You will notice that there are four mounting holes provided around each socket hole. The reason four holes are available is that this permits the socket to be mounted in any position. The mounting position of each socket is determined by the convenience of wiring that socket.

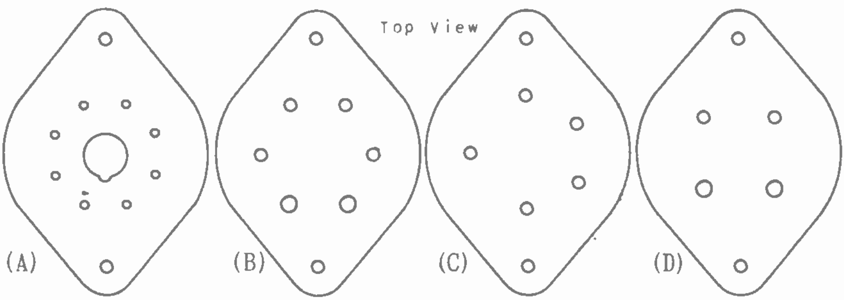


Fig. 17 An 8-prong octal socket. A 7-prong wafer socket. A 5-prong wafer socket. A 4-prong wafer socket. These views are all looking down on the top of the sockets.

We shall start by mounting the two 8-prong octal sockets in holes 1 and 2. A top view of one of these sockets is shown at A, Fig. 17. Inspection of the diagram and the socket will show that these sockets have a guide pin hole in the center and that the guide pin hole has a slot in it which makes it impossible for the tube to be placed in the socket except in one position. Each of the two 8-prong sockets are to be mounted so that this small slot points towards the front of the panel. (The chassis is right side up and front towards you.)

You are now ready to mount three 6-prong wafer sockets. These sockets are to be mounted in holes 3, 5 and 7. A top view of a 6-prong socket is shown at B, Fig. 17. Inspection of this diagram as well as the socket itself will reveal that, of the six holes, two are a little larger than the other four. These two holes are the filament or heater prongs on the socket. The three 6-prong sockets are to be bolted to the chassis with the heater prongs toward the left-hand side of the chassis. (Remember that you are looking at the top of the chassis with the front towards you.)

Next mount a 5-prong socket in each of the holes numbered 8 and 9. A top view of a 5-prong socket is shown at C, Fig. 17. Inspection of the diagram and socket shows that one prong is offset from the others. The two prongs opposite this offset prong are the heater prongs. When mounting the two 5-prong sockets in holes 8 and 9, the heater prongs are to be faced toward the rear of the chassis.

You have remaining two 4-prong sockets which are to be mounted in holes 13 and 14. A top view of a 4-prong socket is shown at D, Fig. 17. Here again you will notice that two of the prongs are larger than the other two. The two large prongs are the filament or heater prongs. The 4-prong sockets are to be mounted so that the filament prongs are toward the right-hand side of the chassis.

Now check carefully and see that all of your equipment is mounted exactly as described. Also be sure that all nuts are tight so that you will not have any trouble with the equipment.

EXPERIMENT 7

BUILDING A TUBE TESTER

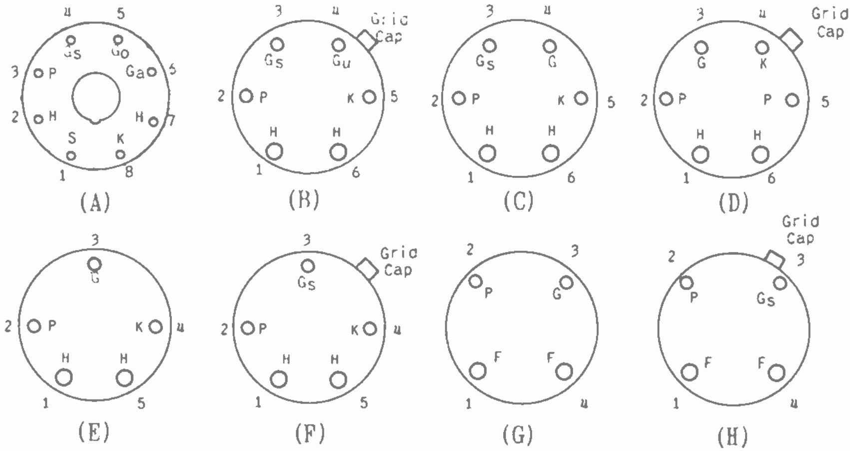
In this experiment you are going to build a simple transconductance tube tester. You should not attempt this experiment until you have completed the study of Lesson 12. The theory of operation covering this type of tube tester will be discussed thoroughly in Lesson 1 of Unit 2. However, since the testing of vacuum tubes is one of the most important service functions, we deemed it advisable that you should build this equipment first.

The equipment for this experiment was mounted on your chassis in Experiment 6, so now it is only necessary to wire up the circuit and learn to use the tester.

In Experiment 6, all instructions were given with the chassis right side up and the front towards you. *In this experiment, you will reverse the procedure as the chassis must be upside down to wire up the various sockets.* Therefore, all directions, except for the use of the tube tester, will be based on the fact that the chassis is upside down and the front towards you.

Fig. 18 shows a bottom layout view of the socket wiring which you are going to use in this experiment. Start your wiring with the two 8-prong octal sockets mounted in holes 1 and 2. Examination of A, Fig. 19, will show which of the prongs are the heater prongs on an 8-prong socket. Solder one end of a piece of hookup wire to prong 2 of socket 2. You will find that prong 2 is the second prong from the centering slot counting around the socket in a clockwise direction. Cut this piece of hookup wire so that it will reach prong 2 on socket 1. Push back the insulation and push the bare end into one of the holes on the socket prong. Do not solder the connection. Attach the loose end of another piece of hookup wire to the same socket prong, then solder the connection. The same mechanical performance will be repeated on the remaining sockets.

From heater prong 2 on socket 1, connect the wire to the heater prong on socket 3. The heater prong next to the plate prong is the one to use. A bottom view of socket 3 is shown at D, Fig. 19. From the heater prong next to the plate prong on socket 3, connect a wire to the same prong on socket 5. To this same prong, a piece of hookup wire is connected, then the joint soldered. A bottom view of this socket is shown at B, Fig. 19. Now, connect this piece



SYMBOLS: F--Filament; H--Heater; P--Plate; K--Cathode; G--Control Grid; Gs--Screen Grid; Ga--Anode Grid; Go--Oscillator Grid; Su--Suppressor Grid; ☐--Top Cap; S--Metal Shell.

Fig.19 (A-B-C-D-E-F-G-H) The sockets shown in this figure are all bottom views. Remember this in wiring up your experiments. Whenever more than one view of the same number of prong socket is shown, it means that a different type of tube is used in these sockets. Watch the difference carefully. Some tubes have the control grid attached to one of the base pins, while other tubes have the control grid coming out to a cap on the top of the tube.

of hookup wire to the heater prong next to the plate prong on socket 7. This is a 6-prong socket and a bottom view is shown at C, Fig. 19. From this prong, connect a piece of hookup wire to the heater prong next to the plate prong on socket 8. This is a 5-prong socket and a bottom view is shown at F, Fig. 19. Then, from this prong on socket 8, connect a piece of hookup wire to the heater prong next to the plate prong on socket 9. This is a 5-prong socket and a bottom view of this socket is shown at E, Fig. 19. From this heater prong, connect a piece of hookup wire to the filament prong next to the plate prong on socket 14. A bottom view of this socket is shown at G, Fig. 19. Connect another piece of hookup wire to this same prong, then cut this piece of hookup wire to a length of about 6 inches. Do not fasten this piece of hookup wire to anything at present.

Now, back to socket 2. Using a short piece of wire, connect the heater prong and cathode prong on socket 2 together. These are prongs 7 and 8 on the 8-prong socket. Also, connect one end of a piece of hookup wire to prong 7; the other end is connected to prong 8 on socket 1. At the same time, connect prongs 7 and 8 together in the same manner as was done on socket 2. Next connect a piece of hookup wire from prong 8 on socket 1 to the unused heater prong on socket 3. At the same time, connect the suppressor prong of socket 3 to this filament prong. This is marked cathode in D,

Fig. 19. Then connect a wire from this same heater prong to the unused heater prong on socket 5. At the same time this connection is made, connect the cathode prong to this same heater prong. From this heater prong, connect a wire to the unused heater prong on socket 7 and at the same time connect a piece of wire between this heater prong and the cathode prong on socket 7. Now from the heater prong next to the cathode prong on socket 7, connect a piece of wire to the heater prong next to the cathode prong on socket 8. At the same time, connect a piece of wire between the cathode prong on socket 8 and the heater prong next to the cathode prong on socket 8. From the heater prong on socket 8, connect a piece of wire to the unused heater prong on socket 9. Also connect the cathode to the heater. From this same heater prong, connect a piece of hookup wire to the unused filament prong on socket 14. At the time this connection is made, connect a piece of hookup wire about 6 inches long to the same prong and solder the connection. For the time being, do not connect this piece of hookup wire to anything.

The filament circuit and cathode prongs for all sockets except 13 should now be wired. Check them carefully to see that they conform to the diagram in Fig. 18.

Next, you are to wire up the plate circuit of all of the sockets. From the negative terminal of the milliammeter, connect a piece of hookup wire to terminal 3 on socket 2. (The positive terminal on the milliammeter has a red spot of paint on it. The negative terminal is the other one.) At the time a connection is made to terminal 3 on socket 2, also connect terminals 4, 5 and 6 to terminal 3. This may be done with a short piece of bare hookup wire. Then, from terminal 6 on socket 2, connect a piece of hookup wire to terminal 3 on socket 1. At the same time this connection is made, also connect the following terminals together: 3, 4 and 6 on socket 1. (PLEASE REMEMBER THAT TERMINAL 5 ON SOCKET 1 IS NOT CONNECTED TO TERMINAL 3.)

From terminal 3 on socket 1, connect a piece of hookup wire to the plate terminal on socket 3. At the same time, connect a wire between the plate terminal, the screen grid terminal and what is normally the cathode terminal of this tube. (This is marked plate terminal in D, Fig. 19.) From the plate terminal of socket 3, connect a piece of hookup wire to the plate terminal on socket 5. At the same time, connect a wire between the plate terminal, the screen grid terminal and the suppressor grid terminal of socket 5. From the plate terminal on socket 5, run a wire to the plate terminal on socket 7. Then connect the plate terminal and the screen grid terminal of socket 7 together. (THE TERMINAL WHICH IS THE SUPPRESSOR PRONG ON SOCKET 5 IS THE CONTROL GRID PRONG ON SOCKET 7. BE SURE YOU DO NOT CONNECT THE CONTROL GRID TERMINAL OF SOCKET 7 TO THE PLATE TERMINAL ON THIS SOCKET.)

Next connect a piece of hookup wire from the plate or screen grid terminal on socket 7 to the plate prong on socket 8. Connect the plate and screen grid terminals together. From the screen grid prong on socket 8, connect a piece of hookup wire to the plate prong on socket 9. Connect a piece of hookup wire from the plate prong on socket 9 to the plate prong on socket 14. Now fasten one pigtail end of a 700-ohm resistance[1] to the plate prong on socket 14. The other pigtail end of the 700-ohm resistance goes to the plate prong on socket 13. At the same time, a piece of hookup wire is connected between the plate and screen grid prongs on socket 13. This is shown at H in Fig. 19. DO NOT FORGET TO SOLDER ALL CONNECTIONS. DO NOT CUT THE PIGTAIL LEADS OFF RESISTORS EVEN IF THEY ARE LONGER THAN NEEDED.

The next procedure in wiring up the tube tester is to wire the 110-volt line to the primary of the power transformer. The primary is plainly marked on the power transformer. The AC attachment plug is connected to one end of the parallel AC cord as shown in Fig. 20.

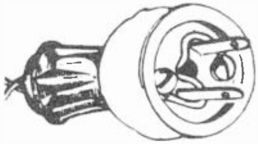


Fig. 20 This figure shows how the parallel AC cord is attached to the AC attachment plug. Note that the ends of the wires are looped around the plug blades before fastening them under the set screws.

Pass the other end of the AC cord through the hole in the left-hand back corner of the chassis. Pull enough of the wire through this hole so that it will conveniently reach the primary of the power transformer. Then, tie a knot in the cord on the inside of the chassis. This knot is fixed so that any strain on the cord will not pull the connections loose from the power transformer. Now, skin the insulation from the parallel AC cord and attach one wire to one primary terminal and the other wire to the other primary terminal on the power transformer. From the primary terminal which is next to the front of the chassis, run a piece of hookup wire up to the positive terminal of the milliammeter. Solder this primary terminal connection. *Be careful and do not overheat this terminal or you will unsolder the primary winding from the terminal lug.* From the opposite primary terminal lug, run a piece of hookup wire to the grid prong on socket 14. At the same time, connect one pigtail end of a 150-ohm resistance to this same grid prong, then solder the connections. The other pigtail terminal goes to the nearest switch terminal on the back of the volume control. There are five connections on the volume control; three on the side and two on the back. The two on the back, mounted on the piece of bakelite, are the switch terminals. The other three terminals are the potentiometer terminals which will not be used in this experiment. At the same time the pigtail end of the 150-ohm resistance is fastened to one of the switch terminals, also fasten one pigtail end of a 1,000-ohm resistor to the same terminal and then solder the joint. The other pigtail end of the 1,000-ohm resistance is connected to the other switch terminal. At the same time, solder a piece of hookup wire to this terminal. The other end of this hookup wire goes to terminal 8 on socket 2. *Be sure to solder all connections. Do not cut the pigtails from resistors.*

Now, cut a piece of hookup wire 6 inches long. Connect one end of this wire to prong 5 on socket 1. This is the grid prong. Also, connect the free end of another piece of hookup wire to the

[1] A color code chart is supplied with your first shipment of equipment so that you can tell the value of each resistor.

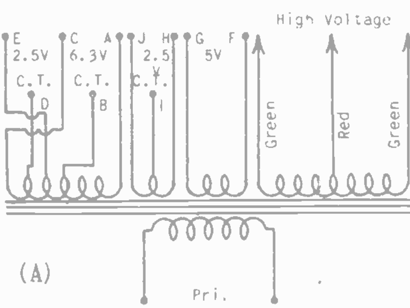
same terminal and solder the joint. The free end of the first piece of hookup wire goes up through the chassis by a small hole which is located in the center of holes 1, 2, 3 and 4. A small grid clip is attached then to this free end. The other piece of hookup wire connected to prong 5 is connected to the grid prong on socket 7. From there it goes to the grid prong on socket 9. Cut another piece of hookup wire 10 inches long and connect one end to the grid prong on socket 9. Run this wire up through the chassis by a small hole close to the socket. Solder a large grid clip to this piece of hookup wire. From the grid terminal on socket 9, connect a wire to the grid terminal on socket 14.

You have not as yet connected any wires to the filament prongs on socket 13. Cut two pieces of hookup wire 5 inches long and attach one to each filament prong on this socket. The free ends of these two wires are not connected to anything at present. Next, connect a piece of hookup wire from the filament prong next to the screen grid prong on socket 13 to the left side of the AC switch.

Now check all of your connections carefully and see that you have the tube tester wired up exactly as shown in Fig. 18. You should check this over three or four times to make sure.

You still have two leads connected to the filament prongs on socket 14 which have not as yet been connected to the power transformer. The connections for these leads as well as the two on socket 13 will depend entirely upon the tube to be tested. All of the filament or heater prongs of eight of the nine sockets are wired in parallel. Then, whatever voltage is connected to the two leads on socket 14 will be applied to all sockets in the tester except 13. The connections for socket 13 are separate from the others.

A schematic wiring diagram of the power transformer is shown at A in Fig. 21. All of the terminals are plainly marked on the



(A)

(B)

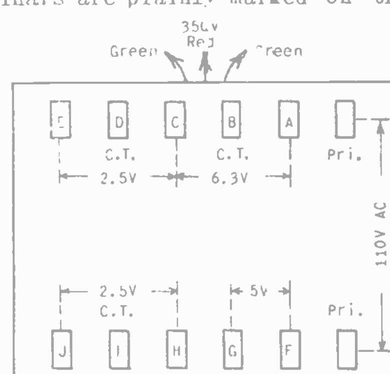


Fig. 21 (A) This figure shows the internal wiring diagram of the power transformer which is a part of your regular laboratory equipment.

Fig. 21 (B) This figure shows the terminal lugs on the power transformer.

VOLTAGE TABLE:

Make the following connections to secure the following voltages: 1.25 volts, H to I; 2 volts, B to D; 2.5 volts, J to H; 3.15 volts, A to Bp 5 volts, G to F; 6.3 volts, A to C; 7.5 volts, F to J (join G and H); 13.8 volts, F to C (join E to H and J to A).

transformer itself. Now by connecting the filament or heater prongs of the various sockets to the correct voltage needed for the tube under test, the tube will be operated with the correct heater voltage.

The regular voltages supplied by this transformer are 5 volts at 2 amperes, 2.5 volts at 3.5 amperes (with the winding center tapped) and a 6.3-volt winding at 1.6 amperes (with the winding center tapped). This same winding is also tapped so that 2.5 volts at 1.75 amperes may be secured. The 2.5-volt winding also has a center tap. At B in Fig. 21, we have reproduced the terminal board, just as it appears on the bottom of the transformer. We have lettered the various terminals to correspond with the winding and terminal letters of A in Fig. 21. Then, by following the table which is supplied, it is possible to get any voltage from 1.25 volts up to 14 volts.

In a commercial type of tube tester, a special rotary switch would be provided so that the desired filament voltage could be selected without difficulty. Since this tube tester is designed only for experimental purposes, it will be necessary to make soldered connections to change the filament voltage. In testing a tube, first refer to the chart and determine its required filament voltage. Then, following Fig. 21, select the correct transformer terminals and connect the socket filament leads to these terminals by making a soldered connection. You can then test the tube according to the following directions:

1. TESTING TUBES. So that you may understand the operation of this tube tester a little more clearly, we have drawn a simpli-

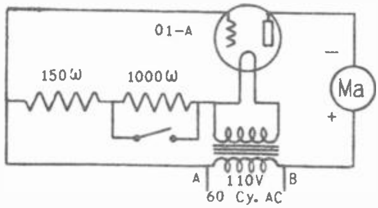


Fig. 22 This is a fundamental circuit diagram of a transconductance tube tester more commonly known as a "grid shift" tester.

fied diagram as shown in Fig. 22. This represents the testing of a three-element tube, such as an 01-A. Referring to this diagram, you will notice that the 1,000-ohm resistance is connected directly across the switch which is a part of the volume control. Let us assume that the switch is off (the volume control being in the extreme counter clockwise position). During the positive half of the AC cycle, point B will be positive and point A will be negative. Tracing the circuit out, we find that the side of the AC line B is connected to the milliammeter, then to the plate of the tube. Now, tracing the current flow, with A negative, we have a current flowing first through the 150-ohm resistance, through the 1,000-ohm resistance, up to the filament of the tube, through the tube from filament to plate, from the plate of the tube to the milliammeter, then back to the other side of the AC line which is positive. During the time A is positive and B is negative, no plate current will flow because the plate of the tube is then negative; no electrons will be attracted and so no current will flow.

Therefore, in this particular circuit, the tube is acting as a half-wave rectifier. With a pulsating direct current flowing through both the 150-ohm and the 1,000-ohm resistors, a voltage drop across the resistors will be developed. The grid of the tube is connected to the lower end of these resistances or at point A. The grid will then have applied to it a negative potential with respect to the filament by the amount of voltage drop across the two resistors. This negative grid voltage will have a limiting effect on the plate current flow. Now, when switch S is closed (On) by rotating the volume control in a clockwise direction, the 1,000-ohm resistance is shorted out of the circuit. This permits a greater plate current to flow for two reasons. First, there is no voltage drop across the 1,000-ohm resistance which increases the plate voltage. Second, with the lower voltage drop across the resistors, there is less negative grid voltage applied to the grid of the tube. Therefore, with less negative grid voltage, more plate current will flow.

Now, when you place a tube in the socket with the switch open, a certain plate current will flow, depending upon the tube's characteristics. When the switch is closed, shorting out the 1,000-ohm resistance, an increased plate current will flow, showing the effect of a change in grid voltage on the plate current. This is, in reality, testing the transconductance of the tube.

By testing a number of tubes known to be good, it is possible to secure comparative readings. Then, when other tubes are tested, their readings may be compared to the predetermined standard and thus it is possible to ascertain whether or not the tube under test is in good condition. An allowance of 25% from the listed values is permissible. However, if a tube tests less than 25% of the listed value, it should be discarded as it will no longer give satisfactory service. The opening and closing of the switch is called "grid shift testing". The reason for this expression is that the grid voltage is actually changed according to the voltage drop across the two resistances.

We have prepared an elaborate chart which lists over 80 different types of tubes. All you need to do is to refer to this chart when you wish to test a tube. In the second column, the filament voltage of the tube is given. Based on this filament voltage, you should make the proper transformer connections as shown in Fig. 21. The third column in this table shows in which socket the tube should be tested. Some tubes have their control grid connection brought out to a cap on the top of the tube, while others have their control grid connection brought out to one of the base prongs. Therefore, the fourth column in this table shows whether or not the grid clip is to be used and which grid clip should be used. The small grid clip is used when testing metal tubes and the large grid clip is used when testing glass tubes. **IF THE GRID CLIPS ARE NOT USED, BE CERTAIN THAT THEY DO NOT TOUCH THE METAL CHASSIS AT ANY POINT.** By referring to the diagram, you can see that the grid clip is connected to one side of the 110-volt line. With the tube tester turned on, it is possible to receive a shock from this clip.

Now with the tube plugged in the correct socket, the grid clip connected if necessary and the proper filament or heater connections made for the tube, insert the AC plug in the 110-volt 60-cycle AC lighting socket. As soon as the filament of the tube heats up, a plate current reading should be obtained. The correct value for this plate current reading is listed in column 5. Under these conditions, the volume control switch should be open (turned in the counter clockwise direction as far as it will go). Now, with this reading in mind, close the switch. (Turn the volume control in a clockwise direction.) When you close the switch, the plate current should immediately rise. This higher value is marked "grid shift" in column 6.

In testing tubes the original value of the plate current is not so extremely important nor is the actual plate current reading obtained after the grid shift is made. The real test as to the value or merit of a tube is the current difference secured during the two tests. Let us refer to the type 01-A tube. You will notice that the plate current reading is 2 and the grid shift reading is 10. This is a difference of 8 ma. Now, it is also possible to have a tube whose plate current reading is only 1 ma. and whose grid shift test is 11 ma. This is a difference of 10 ma., which indicates that the second tube is actually better than the first tube because of the greater difference in the two current readings. Another type 01-A tube might be tested and the plate current reading found to be 3 ma. with the grid shift reading 8 ma. This results in a difference of only 5 ma., which indicates that the tube is not as good as the other two tubes tested. In fact, the condition of this tube is questionable and it may be best to discard it.

Since rectifier tubes have no grid, there can be no grid shift reading. Therefore, in column 6, no values are recorded. Because a rectifier tube draws considerable current, it is advisable, when testing these tubes, never to open the switch. In other words, all tests should be made with the switch in the extreme counter clockwise position which is the "open" position.

There are a few types of tubes this tester cannot test. However, all of these will be found to be of an unusual type or having a filament voltage greater than 14 volts. Since only a comparatively few such tubes exist, we did not deem it necessary to change the design of our equipment to include these few tubes for which you will encounter very little use.

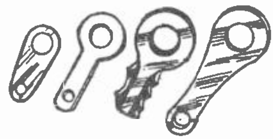
WARNING! THE MILLIAMMETER INCLUDED IN YOUR SHIPMENT OF LABORATORY EQUIPMENT IS A DIRECT CURRENT INSTRUMENT. UNDER NO CIRCUMSTANCES SHOULD YOU ATTEMPT TO TEST AN ALTERNATING CURRENT OR VOLTAGE. WHILE THE INSTRUMENT IS GUARANTEED AGAINST MANUFACTURING DEFECTS, NEITHER WE NOR THE MANUFACTURER CAN BE RESPONSIBLE FOR ACCIDENTS WHICH YOU MIGHT HAVE, CAUSING INJURY TO THE METER. IF THE METER IS CONNECTED EXACTLY AS PER INSTRUCTIONS AND USED ONLY IN THAT MANNER, NO DIFFICULTY WHATSOEVER SHOULD BE ENCOUNTERED. The reason the meter works in connection with this tube tester is that it is operating on pulsating direct current, due to the rectifying action of the tube under test. *Do not be in a hurry. Be* *safe, rather than sorry. Equipment is expensive. Avoid accidents and mistakes.*

EXPERIMENT 8

MAKING GROUND CONNECTIONS

When inspecting the wiring diagram of a piece of radio or television apparatus, you will often discover the symbol shown in Fig. 23. This can represent either of two things: first, that particular part of a circuit is connected directly by wire to a ground or earth connection; second, that a connection is made at this point to the metal chassis on which the radio or television equipment is mounted. The second reference is the one usually meant.

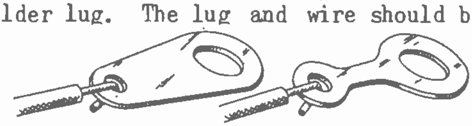
Fig. 23 (Left) The symbol for ground or chassis connections in Radio-Television wiring diagrams.
Fig. 24 (Right) Several different types of solder lugs.



It is generally customary to make all ground or return circuit connections directly to the metal chassis. Then, the metal chassis is usually connected to some suitable ground or earth connection. Since these connections are very important to the proper operation of radio and television equipment, it is highly essential that good connections be made.

In radio and television work, it very often becomes necessary to make connections directly to the steel chassis on which the apparatus is mounted. Since steel is a relatively poor conductor of heat, it is often advisable to secure a connection in another manner. This is easily accomplished by using what is known as a solder lug. Several different styles and shapes of solder lugs are shown in Fig. 24. These lugs consist of tinned pieces of copper. The large hole is provided so that the lug may be bolted directly to the chassis. Before this is done, the chassis should be cleaned thoroughly so as to provide a good, mechanical and electrical contact. The wire or wires are then placed in the outer hole, or clamp of the soldering lug; the joint is made mechanically secure and then the joint soldered. Fig. 25 shows a method of connecting a wire to the soldering lug. If possible, the soldering iron tip should then be placed underneath the solder lug. The lug and wire should be

Fig. 25 This diagram shows how a wire should be connected to a solder lug before soldering.



brought to a temperature high enough to melt the solder, then a small amount of rosin core solder should be applied to the joint. When the solder has run over the complete surface, the iron should be removed and the joint be allowed to cool. After every joint is made, test it to see that it is mechanically secure. In other words, take a pair of long nose pliers and wiggle the joint around severely in order to determine that the joint has been properly made. This will save a lot of trouble in the future from loose or rosin core joints. A rosin core joint means that the solder has not stuck to the joint, but has only been covered with a coating of rosin which leads you to believe that the joint is mechanically and electrically perfect.

In securing a good, external ground or earth connection, the first general rule to follow is that the ground lead should be as short and direct as possible. The question often arises, what are we to do when it is from 40 to 100 feet to ground? Under these conditions, it is wise to consider whether the ground should be made to a water pipe inside of the house or apartment, or whether a wire should be run directly to the ground and connected to a good ground rod.

If an inside ground is to be used, there is only one satisfactory place to make this connection; that is, to a cold water pipe. While it may be necessary to use a steam pipe, a hot water pipe, or some other grounded metal object, it is always much better, if possible, to use the piping of the cold water system. Under no circumstances should a gas pipe be used for a ground. Gas pipes usually have insulators in them at some place, and they are very poor ground connections. In addition to that, there is some little danger of fire where a gas pipe is used.

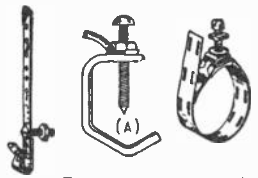


Fig.26 Three popular types of ground clamps. These clamps are used in making a connection to water pipes or ground rods.

It is practically impossible to solder to a cold water pipe. The reason for this is that the water within the pipe will cool the effects of soldering iron or blow torch before they have had a chance to properly melt the solder. Therefore, the proper way to secure a connection to a water pipe is by using a ground clamp. There are several such clamps available and are quite economical, ranging in price from 3¢ to 10¢ apiece. Three such ground clamps are shown in Fig. 26. The first thing to do is to scrape the pipe clean. Remove all paint, dirt and dust. This can best be accomplished by a file or sharp knife. After the pipe has been thoroughly cleaned, then wrap the ground clamp around the pipe and tighten it securely. The method of tightening will depend entirely upon the style of ground clamp used. Some types have a bolt through them, used to tighten the clamp, while others have a set screw such as the one shown at A, Fig. 26. This screw is tightened up against the pipe; the point bites into the pipe itself and makes a very satisfactory connection. The ground wire running to the receiver is then connected to the ground clamp.

An outdoor ground is usually the most reliable. It is also quite simple to install. An outside ground consists of nothing more than a 6-foot galvanized iron pipe, driven into the earth so that just about 4 inches of it protrudes, to which part the ground clamp is attached. Such a ground rod and its associated clamp is shown in Fig. 27.

Fig.27 A popular type radio ground rod. These ground rods may be purchased in lengths from three to six feet.

In Fig. 27, you will notice that the ground rod is pointed, making it easy to drive in the ground. When such a rod is installed, it should be placed at least 12 inches away from the wall of a building. If it is possible to drive the ground rod where water from the eaves will drip on the ground rod, this will make a more satisfactory connection. The reason for this is that the water dripping on the ground rod will keep the ground around the rod moist and, in that way, a better connection with the earth will be secured. A ground rod such as that shown in Fig. 27 may be secured from any electrical supply or mail order house. The rod may be purchased in either of two lengths, 4 feet or 6 feet. It is usually advisable to buy the 6-foot rod.

If it is impossible to obtain the regulation ground rod, then you can secure 6 feet of 1-inch galvanized water pipe. Have some threads cut on one end and on this, screw a metal pipe cap. This is to be used in driving the rod into the ground. The ground clamp can be placed directly below the pipe cap. The other end of the galvanized water pipe should be hammered into a wedge point to allow this end to be driven into the ground.

After a suitable ground connection has been made to a water pipe or ground rod, it is advisable to paint over the ground clamp. This will prevent corrosion and keep your apparatus operating in a more satisfactory condition.

EXPERIMENT 9

CONSTRUCTING A VOLTMETER

In your next group of experiments, you are going to construct several rectifier, filter and biasing systems. It will be necessary to have a voltmeter to measure the output of these devices. Therefore, in this experiment, you are going to construct a simple voltmeter, using the milliammeter and resistors supplied with your first shipment of experimental equipment.

WARNING! WHEN THE MILLIAMMETER IS TO BE USED AS A VOLTMETER, IT MUST BE DISCONNECTED FROM THE TUBE TESTER CIRCUIT.

The milliammeter furnished with your experimental equipment is an 0-50 ma. meter. This means that it takes a current of 50 ma. to produce a full-scale deflection. The meter has an internal resistance of approximately 60 ohms. Now using these two figures, we find by Ohm's Law ($E = IR$) that it will take a voltage of 3 volts connected directly across the meter to produce full scale deflection; that is, 50 ma. × 60 ohms = 3 volts.

Now if we connect a 1,000-ohm resistance in series with the milliammeter, we will then have a total of 1,060 ohms and we must produce a current of 50 ma. What voltage will be required? Using Ohm's Law, we find 1,060 ×.05 = 53 volts. Neglecting the 60 ohms internal resistance of the meter (because this produces an error of only 3 volts out of 50), we find that for each volt applied to the circuit shown in Fig. 28, there will be a deflection of 1 ma. on the meter. Therefore, in using this combination as a voltmeter, instead of reading the meter in milliamperes, we can read the scale directly in volts. With 10 volts applied across the circuit, the milliammeter would read 10, which gives us a representation of 10 volts. With 50 volts applied across the circuit, the milliammeter

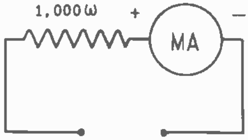


Fig.28 Wiring diagram showing connections for milliammeter and resistance in constructing a voltmeter.

would read nearly 50 (allowing for the error), which means that we could then read voltage directly on the meter.

The easiest way to construct the voltmeter is to unsolder one pigtail lead of the 1,000-ohm resistance from one of the switch connections. Connect this pigtail lead to the positive terminal of the milliammeter. (This is the terminal painted red.) Now connect a piece of hookup wire to the other pigtail end of the 1,000-ohm resistance. This can be done by soldering the wire directly to the pigtail lead without disconnecting the resistance from the switch. Another piece of hookup wire is connected to the negative terminal of the milliammeter. Now any voltage from zero to 50 can be measured by applying this voltage to the two pieces of hookup wire which you just made available. Your voltmeter will now read any voltage from 1 to 50 volts. WARNING! REMEMBER THAT THIS IS A DIRECT CURRENT METER; IT WILL NOT READ ALTERNATING CURRENT.

In your next shipment of experimental equipment, a 10,000-ohm resistance will be included so that you can make a voltmeter capable of reading from 5 to 500 volts.

If you care to test the accuracy of your voltmeter, secure a 45-volt B battery and connect it in series with the meter and the 1,000-ohm resistor. Your milliammeter should then read 45, which represents the voltage of the 45-volt B battery. If the error is more than 10%, then the resistance you are using is not of the correct value, or the meter may be slightly off calculation. A 10% error is not excessive for this type of equipment and there is nothing to worry about. If the error is as much as 25%, it would be wise to have both the meter and resistor tested for accuracy. This error is in excess of the usual accuracy of such equipment.

NO BATTERIES ARE FURNISHED WITH YOUR EXPERIMENTAL EQUIPMENT. THE 45-VOLT B BATTERY JUST MENTIONED IS NOT NEEDED UNLESS YOU DESIRE TO CARRY OUT THE TEST INDICATED FOR YOUR OWN INTEREST AND BENEFIT. IT IS NOT A PART OF YOUR REGULAR EXPERIMENTAL WORK.

You must remember that it takes 50 ma. of current to produce full-scale deflection. This is a rather large current drain for some equipment, so do not leave the voltmeter connected longer than necessary to secure a reading.

The text of this lesson was compiled and edited by the following members of the staff:

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GROUP NO. 2

LABORATORY EXPERIMENTS

EXPS. NO. 10 TO 19

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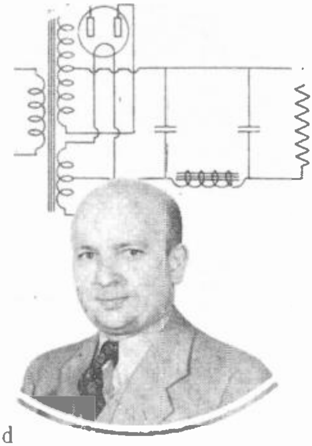
LABORATORY EXPERIMENTS

Group Two



"In this group of experiments, you are going to construct several power supplies and filter systems. You will also determine the effect of varying the grid bias on a vacuum tube.

"The power supplies and filter systems built in this group of experiments will be used in nearly all of the remainder of your experiments. Therefore, you should pay close attention to your work, do every experiment thoroughly and be sure that it works perfectly."

EXPERIMENT 10

BUILDING A HALF-WAVE RECTIFIER SYSTEM

To start this group of experiments, the extra equipment to be used will be mounted first. After the equipment is mounted, various wiring changes will be made and the results of these changes carefully checked.

In conducting this group of experiments, it will not be necessary to dismantle your tube tester, but, rather, only make one or two slight changes. Then, if you need to use the tube tester, it may be easily placed into service by reconnecting those parts which have been changed in order to accommodate this new group of experiments.

In your second laboratory shipment, you will find a double 8 mfd. electrolytic condenser. This condenser is to be mounted in hole 11. It is mounted in an upright position and securely fastened to the chassis by the large lock nut which is supplied with the condenser. The four wire leads which come out of the bottom of the condenser should be placed down through hole 11 and then the lock nut fastened securely in place.

The next piece of equipment to be mounted is the filter choke. This is to be bolted to the chassis by two $\frac{8}{32}$" bolts and nuts. The choke is bolted to two small holes directly in back of socket holes 13 and 14, or directly in front of the two holes 11 and 12. The two terminal lugs on the filter choke are to be mounted toward the front

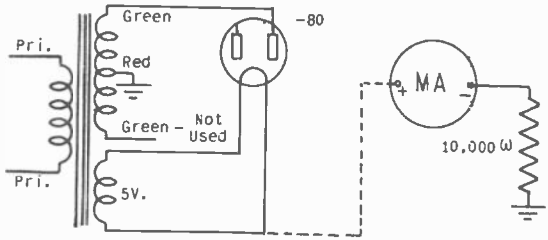


Fig.1 Wiring diagram of a half-wave rectifying system. Note that only one plate of the type 80 tube is being used.

of the chassis. (The chassis right side up.) This then places these two terminal lugs close to another hole through which connecting wires are to be run during the process of your experimentation.

In conducting these rectifier experiments, you will use the four prong socket in hole 13. First, disconnect the piece of hook-up wire which runs from the heater terminal next to the grid terminal on socket 13 over to the right-hand side of the 1,000-ohm resistance which is connected across the switch on the back of the volume control. (Remove the wire entirely.) Next, disconnect the 700-ohm resistance connected between the plate prong on socket 13 and the plate prong on socket 14. It is best to remove this resistance entirely. Next, remove the short piece of hookup wire which is connected between the plate prong and the grid prong on socket 13. After these changes have been made, it will not be possible to use socket 13 in connection with the tube tester; however, the balance of the tube tester wiring will not be disturbed.

Now connect the two heater or filament terminals on socket 13 to the two terminals of the 5-volt, 2-ampere winding on the secondary of the power transformer. These two 5-volt terminals are plainly marked in Fig. 18 of Group 1 experiments. These two connections are shown in Fig. 1 of this group. A bottom view of socket 13 is shown at Fig. 2.

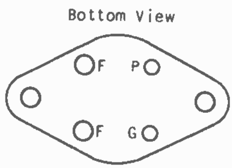


Fig.2 A bottom view of a four-prong socket. When holding a rectifying tube, the grid terminal is used as the second plate terminal.

Next, connect one of the green wires on the secondary of the power transformer to the plate terminal on socket 13. This connection is shown in Fig. 1. Place a solder lug under one of the nuts which holds the transformer in place and connect the red wire of the transformer secondary to this solder lug. Then, solder both connections. If the leads are too long, do not cut them off. Your experiment should then be wired as shown in Fig. 1. This constitutes a half-wave rectifier circuit. (It is not necessary to make any changes in the primary circuit of the power transformer; this was wired in your tube tester experiment.)

In Experiment 9, Group 1, you learned how to construct a voltmeter using the 0-50 ma. meter and a resistance in series. Now, in order to test the DC outpnt voltage of the half-wave rectifier just constructed, it will be necessary to have a DC voltmeter capable of measuring at least 400 volts. In your second laboratory shipment, you will find a high-wattage, 10,000-ohm resistance. Using this resistance, it is possible to construct a voltmeter reading 5-500 volts DC. In constructing a voltmeter, using the milliammeter, it does not make any difference to which side of the meter the resistance is connected. Therefore, in conducting this experiment, we are going to make the wiring as convenient as possible.

The next step is to disconnect the two wires that are now connected to the positive and negative terminals of the milliammeter. Just twist these two wires together and fix them so that the bare ends will not touch the chassis at any point. Then, when you wish to use your tube tester, all you need to do is to put these two wires back on the meter, take the rectifier tube out of socket 13 and go ahead testing tubes, using any socket except 13.

Now, connect one pigtail end of the 10,000-ohm resistance to the negative terminal of the milliammeter. Then, bolt a solder lug in place, using one of the small holes surrounding hole 6. Connect the other pigtail end of the 10,000-ohm resistance to this solder lug and solder the connection. Now, cut a piece of hookup wire approximately 10 inches long and connect one end of the hookup wire to the positive terminal of the milliammeter. The other end of the hookup wire is going to be connected to the point at which you wish to measure the voltage.

Place a type 80 tube in socket 13 and plug in the AC cord to a 110-volt, 60-cycle outlet. When the filament of the type 80 tube has had time to warm up, you are ready to test the DC output voltage of the half-wave rectifier system.

Now, turn off the rectifier system and connect the piece of hookup wire which is connected to the positive terminal of the milliammeter to either filament prong on socket 13. It is not absolutely essential that this connection be soldered, but you must be sure to have a tight connection. Turn the chassis right side up, plug it in the light socket and as the filament of the half-wave rectifier tube becomes heated, you will find that the meter reads the DC voltage of the rectifier system. (In this experiment, only one plate of the type 80 tube is being used.) The connections for the meter are shown by the dotted lines in Fig. 1. Using the 10,000-ohm resistance in series with the 50 ma. meter, your meter is capable of reading 5-500 volts. In this experiment, you will find that the half-wave rectifier shows a reading of approximately 16 ma. This is the same as 160 volts, because it is only necessary to add a zero to the milliammeter scale and read directly in volts. The voltage you secure will vary somewhat because of the difference in line voltage encountered at your home and that which was encountered here at our laboratories.

WARNING! IN CONDUCTING THIS EXPERIMENT, BE SURE THAT THE SECOND GREEN LEAD OF THE SECONDARY OF THE POWER TRANSFORMER IS NOT TOUCHING ANY PART OF THE METAL CHASSIS. ALSO, BE SURE THAT YOU DO NOT TOUCH ANY OF THE HIGH-VOLTAGE LEADS BECAUSE IT IS POSSIBLE TO SECURE QUITE A SHOCK, ALTHOUGH IT WOULD NOT BE DANGEROUS.

EXPERIMENT 11

BUILDING A FULL-WAVE RECTIFIER SYSTEM

In this experiment, it is only necessary to connect the loose green wire of the secondary of the power transformer to the grid terminal on socket 13. This terminal is marked G in Fig. 2. Be sure to solder the connection. After making this one connection, you will then have the experiment wired as shown in Fig. 3.

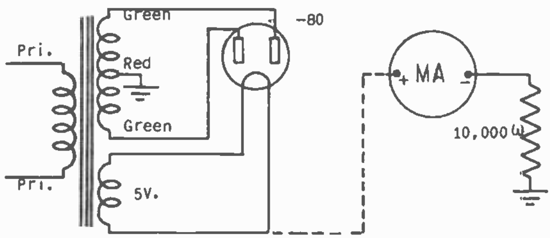


Fig.3 Wiring diagram of a full-wave rectifying system. Note the difference between this and Fig. 1.

Using the same voltmeter arrangement, test the DC output voltage of the full-wave rectifier system. In conducting this experiment in our laboratories, we found the voltage to be approximately 300. This is a difference of 140 volts between the full-wave and half-wave rectifier systems. While your voltage readings of each system may not coincide with those secured here in our laboratories, still, the difference between the two voltage readings should be very nearly the same.

When the milliammeter is reading, let us say, 30 ma., that amount of current is flowing through the 10,000-ohm resistance. This is considerable current for a 10,000-ohm resistance of the size supplied you, so it is not advisable to leave the experiment turned on for too long a time. Turn the experiment on long enough to secure the necessary readings, and then disconnect it so as not to cause any injury to the resistance.

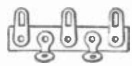
EXPERIMENT 12

CONSTRUCTING A CHOKE-INPUT FILTER SYSTEM

In this experiment, you will add a filter system to the full-wave rectifier system constructed in Experiment 11. In this and following experiments, several changes will be made in the filter systems. This will provide interesting instruction by noting the difference in results secured from the wiring changes made.

Disconnect the piece of hookup wire which runs from the positive terminal of the milliammeter to the filament terminal on socket 13. Next, run a piece of hookup wire from the filament terminal next to the plate terminal on socket 13 up to the right-hand terminal of the filter choke. Be careful that no bare wire touches the chassis at any point. Be sure you have good insulation where the piece of hookup wire goes up through the chassis. There is a hole in the chassis directly under the terminals on the filter choke which is to be used for running the wire up through the chassis to the filter choke terminals.

Fig.4 A three-lug terminal strip. These strips are used for mounting resistors or as terminals for wire connections.



Now, mount a terminal strip such as shown in Fig. 4 under the left-hand bolt which holds the filter choke in place. (The chassis is upside down.) The terminal strip supplied has three terminals to which connections may be made. Run a piece of hookup wire from the left-hand terminal of the filter choke to either of the outside terminals on the terminal strip. Solder the connection on the filter choke, but do not solder the connection on the terminal strip as yet.

Place a solder lug under the nut which is holding the filter choke and the terminal strip in place. Fasten it securely. There are four wires coming out of the bottom of the double 8 mfd. electrolytic condenser which you have mounted. The plain black wire and the black wire with the stripe are to be connected to the solder lug just placed. Be sure to scrape your connections clean and then solder.

There are two red wires coming out of the electrolytic condenser. These are the positive terminals of the condenser. One red wire is plain, while the other red wire has a white stripe running through it. Connect the plain red wire to the same terminal on the terminal strip to which you just connected the piece of hookup wire, the other end of which is connected to the left-hand terminal on the filter choke. Solder the connection. Your experiment should now be wired as shown in Fig. 5. (The red wire with the white stripe is not connected to anything at this time.)

You are now ready to test the output voltage of your choke input filter system. You have a piece of hookup wire connected to the positive terminal of the milliammeter. Run this wire through the chassis, using hole 10, and then set the chassis right side up with the front toward you. The type 80 rectifier tube is again placed in socket 13. Plug the experiment in and allow time for the filament to become heated. Now, holding the lead which comes from the positive terminal of the milliammeter, touch the bare end to the left-hand terminal of the filter choke. This is point A in Fig. 5. In conducting this experiment in our laboratories, the voltage was

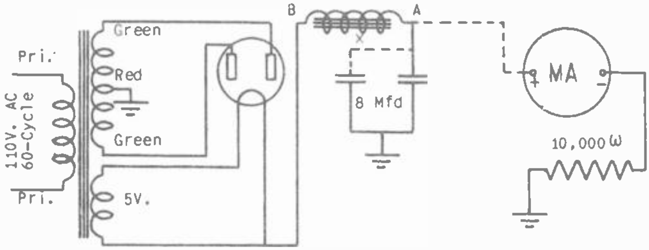


Fig.5 Wiring diagram of a full-wave rectifying system with a choke-input filter system.

approximately 280. As you will notice, this voltage is less than the voltage secured in Experiment 11 when we were testing only the output of the full-wave rectifier system as shown in Fig. 2. This same voltage can be secured by touching your voltmeter wire to the right-hand terminal of the filter choke which is point B as shown in Fig. 5. The difference in voltage between points A and B is due to the voltage drop through the filter choke. This is because the pulsations of the rectified DC have been smoothed out by the action of the filter choke and filter condenser. The output voltage is a much steadier DC voltage, but the voltage is reduced by this action.

Now turn your experiment off and connect the red wire with the white stripe to the same terminal strip lug to which the plain red wire is now connected. This completes the connection as shown by the dotted lines in Fig. 4 at point X. Now you have 16 mfd. connected across the output. With your experiment right side up, turn it on. Again, test the output voltage. This time you will notice that the output voltage has risen slightly. This is due to the charging action of the additional capacity which is placed across the output of the filter system. Here in our laboratories, the voltage was approximately 285, an increase of 5 volts.

EXPERIMENT 13

CONSTRUCTING A CONDENSER-INPUT FILTER SYSTEM

In conducting this experiment, it is only necessary to make one change in Experiment 12. Disconnect the red lead with the white stripe, running from the double 8 mfd. filter condenser to the lug on the terminal strip. This lead is then soldered to the heater terminal next to the plate terminal on socket 13. This connection change then makes your experiment wired as shown in Fig. 6. One section of the double 8 mfd. electrolytic condenser is now connected on each side of the filter choke. Using your voltmeter, test the voltage on each terminal of the filter choke. On the left-hand terminal you are testing the output voltage and it should be approximately 380. On the right-hand terminal, you are testing the input voltage to the choke and the voltage should be approximately 400.

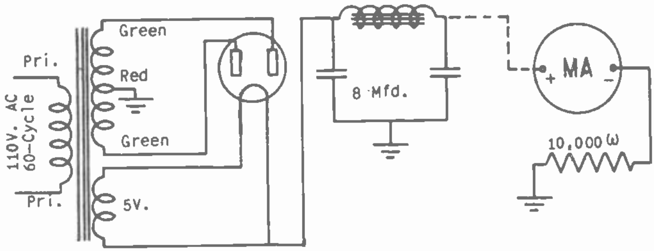


Fig.6 Wiring diagram of a full-wave rectifying system with a condenser-input filter system.

In this experiment, you will notice that the voltage is from 80 to 100 volts higher than the voltage encountered when testing the other experiments just completed. This is due to the input condenser action as described in Lesson 16.

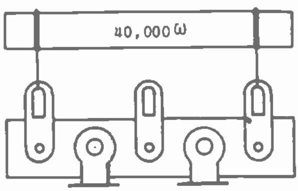
EXPERIMENT 14

BUILDING A VOLTAGE DIVIDER SYSTEM

In this experiment, you will add a voltage divider system to the power supply constructed in Experiment 13.

The pigtail lead from one section of the double 8 mfd. electrolytic condenser is now connected to one of the terminal lugs on the terminal strip. To this same lug is connected a piece of hookup wire which runs to the right-hand terminal on the filter choke. Now, to this same connection, solder one pigtail end of a 40,000-ohm resistance and connect the other pigtail end of the same 40,000-ohm resistance to the opposite terminal lug as shown in Fig. 7.

Fig.7 Diagram showing how to fasten resistor across terminal strip. If the pigtail leads on the resistor are too long, don't cut them off; bend them back.



(Even though the pigtail leads on the resistor are too long, do not cut them off. Also, do not let the resistor itself touch the metal chassis.) Now, from the pigtail lead last connected, run a piece of hookup wire over to the nearest of the outside terminals on the potentiometer volume control. This is one of the outside terminals of the three terminals located on the side of the volume control. From the opposite outside terminal, run a piece of hookup wire over to the plus terminal of the milliammeter. If you have followed directions carefully, you now have your voltage divider wired up as shown in Fig. 8. The 40,000-ohm resistance is connected between points A and B. The resistance unit of the volume control potentiometer is now connected between points B and C. There is no connection made at present to the center terminal of the volume control marked X in Fig. 8. With point C connected to the positive terminal of the milliammeter and point G connected to the negative terminal of the milliammeter (this has been connected in this manner for all previous experiments), we now have a total of 65,000 ohms of resistance across the filter system between point A and the chassis or ground.

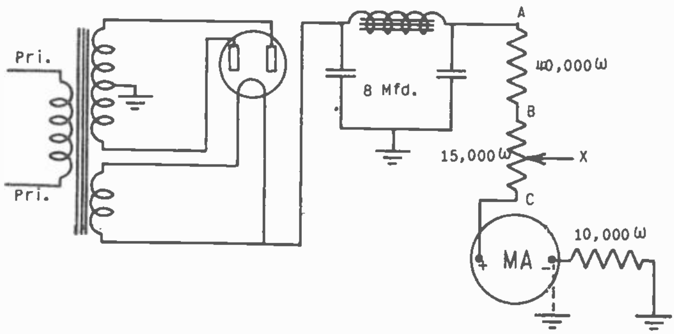


Fig.8 Wiring diagram of a voltage divider system, showing how to test bleeder current.

In Experiment 13, we found that the output voltage of the rectifier filter system was approximately 380 volts. Using Ohm's Law, we find that when 380 volts is connected across a resistance of 65,000 ohms, there will be a current of 5.8 ma. flowing. Turn on your experiment and, since the milliammeter is actually connected in series with the voltage divider resistance, it will measure the bleeder current flowing. If the value read on the milliammeter is within 10% of the calculated value, then you can be assured that your experiment is functioning satisfactorily.

Now using a piece of hookup wire, connect the negative terminal of the milliammeter to ground or chassis. This results in the 10,000-ohm resistor being short circuited or removed from the circuit. You then have 55,000 ohms of bleeder resistance connected across the output of the power supply between point A and the chassis or ground.

Using Ohm's Law, you can determine what current will be flowing when 55,000 ohms of resistance is connected across 380 volts. This is 6.9 ma. Turn on your experiment and actually test the current. You will notice that the current is higher because the size of the bleeder resistance has been decreased.

If you wish to carry this experiment one step farther, you can short out the volume control resistance by connecting a piece of hookup wire between points B and C. Then, calculate the bleeder current and also measure it.

EXPERIMENT 15

BUILDING A CONTINUITY TESTER

A continuity tester consists of nothing more than a meter in series with a DC voltage. The device is used to determine whether or not the continuity of a circuit is complete. It is possible to test resistors, transformers, coils and even condensers with a continuity tester. In testing resistors, transformers and coils, there should be a reading on the continuity tester meter to show that current is flowing in the circuit and that the circuit is complete. If no current flows, it is evident that the coil, resistor, or transformer is defective. In checking condensers with this device, if the condenser is in good condition, there should be no current flowing, and consequently, no meter reading. If the condenser is short circuited or leaking badly, a meter indication shows that the condenser is unsatisfactory for further use.

There are two ways to construct this tester. No batteries are supplied with your experimental equipment, so you may not desire to use the first method of building this tester. In case you decide to build this first type of continuity tester, you should wire the equipment as shown in Fig. 9. The illustration is self-explanatory and we do not feel as though you need additional information. The battery used is a standard 45-volt B battery. In testing a resistor, condenser, coil, or transformer, it is only necessary to connect the device across the two test leads as shown by the dotted lines in Fig. 9.

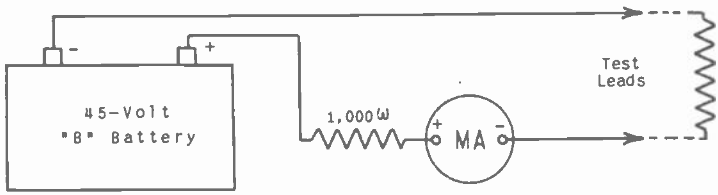


Fig.9 Schematic diagram of a continuity tester. The 1,000-ohm resistor is used as a current limiting device.

If you do not wish to secure a 45-volt B battery, then the necessary voltage for your continuity tester can be secured by following Fig. 10. Your equipment is now wired as shown in Fig. 8 (Experiment 14). To conduct this experiment, merely connect the 10,000-ohm resistor between the negative terminal of the milliammeter and the chassis or ground. Then, connect a piece of hookup wire about 15 inches long to the lug on the terminal strip which is now connected to the left-hand terminal of the filter choke. At the same time, disconnect the 40,000-ohm resistance which is connected between the two terminal lugs on the terminal strip. The piece of hookup wire just connected is now one of the test leads of your continuity tester. Disconnect the wire now connected to the posi-

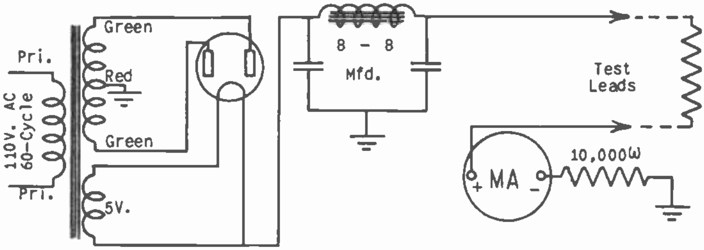


Fig.10 Wiring diagram of a continuity tester, using power supply for voltage source. The 10,000-ohm resistor is the current limiting resistor.

tive terminal of the milliammeter and connect another piece of hookup wire about 15 inches long to this positive terminal. This piece of hookup wire is then the second test lead of your continuity tester. After you have completed these changes, your equipment is then wired as shown in Fig. 10. To test the continuity of equipment or circuits, it is only necessary to turn on your power supply and connect the equipment to be tested between the two test leads as shown by the dotted lines in Fig. 10.

EXPERIMENT 16

SECURING GRID BIAS BY CATHODE RESISTOR METHOD

Only a few changes will be needed to convert Experiment 14 into this experiment. Whatever changes you made in conducting Experiment 15 should be replaced.

The 40,000-ohm bleeder resistance now soldered between the two lugs on the terminal strip will be left unchanged. Remove the piece of hookup wire that runs from the resistor to the volume control. Next, from point B, Fig. 8, ground one end of the 40,000-ohm resistor as shown at point D, Fig. 11.

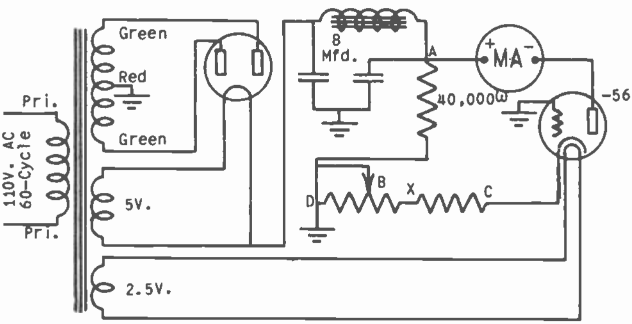


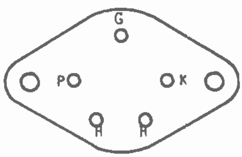
Fig.11 Schematic diagram showing how to secure grid bias by means of a resistance connected in series with the cathode of a tube.

To carry out this experiment, it is going to be necessary to use the 5-prong socket 8. This is socket 8 shown in Fig. 18 in your first group of experiments. Leave the filament or heater connections wired as they are. Now, carefully unsolder and remove all wires running to the plate, grid and cathode prongs. Do not disconnect these wires from the other sockets, because you may desire to use your tube tester again at some later time. Merely unsolder the connections which are made to these three prongs and bend the wires back so that they can be easily replaced.

Now connect the two heater leads, which are connected to the two heater prongs on socket 14, to the 2.5-volt terminals on your power transformer. In this way, you will have 2.5 volts applied to the heater or filament terminals of all sockets except 13. Socket 13, as you know, is being used as the rectifier socket and is now connected to the 5-volt winding on your power transformer.

Place a solder lug under the left-hand bolt holding socket 8 in place. (Remember that the chassis is upside down and the front toward you.) Next, run a piece of hookup wire from the grid terminal on socket 8 to the solder lug just placed. This grounds the grid terminal as shown in Fig. 11. A bottom view of socket 8 is shown in Fig. 12 so that you will use the correct prongs.

Fig. 12 Bottom view of a five-prong socket.



Next, it will be necessary to bolt a terminal strip under the other bolt which holds the filter choke in place. Naturally, this terminal strip is placed on the bottom of the chassis. It does not make any difference which of the two mounting holes is used on the terminal strip. A 700-ohm resistance is now mounted across the two outer terminals of terminal strip 2 which was just bolted in place. Do not solder the connection yet. Run a piece of hookup wire from the cathode terminal on socket 8 to the left-hand terminal on the terminal strip on which you just mounted the 700-ohm resistance. Solder the connections. From the right-hand end of the 700-ohm resistance, run a piece of hookup wire to one of the outside terminals on the volume control. The terminal nearest you is the one to use. Solder the connections. Be sure the 700-ohm resistor does not touch the chassis.

Solder a piece of hookup wire to the other outside terminal of the volume control. This is the terminal located nearest the chassis. The other end of this piece of hookup wire is to be grounded to the chassis by soldering to a conveniently placed soldering lug. When grounding the outside terminal lug of the volume control potentiometer, also connect a short piece of hookup wire to the center tap terminal of the volume control. This makes the connection as shown between B and D in Fig. 11. THE TERMINALS NOW BEING USED ON THE VOLUME CONTROL POTENTIOMETER ARE THOSE WHICH ARE LOCATED ON THE

SIDE OF THE POTENTIOMETER. THESE ARE THE RESISTANCE UNIT TERMINALS. THE SWITCH TERMINALS FORMERLY USED FOR THE TUBE TESTER ARE ON THE BACK OF THE VOLUME CONTROL MOUNTED ON THE SMALL BAKELITE SWITCH.

Remove whatever connections are now made to the positive and negative terminals of the milliammeter. Next, run a piece of hookup wire from the plate terminal on socket 8 to the negative terminal of the milliammeter. From the positive terminal of the milliammeter, run a piece of hookup wire over to terminal A as shown in Fig. 11. This terminal A is the terminal lug on the terminal strip which is now connected to the left-hand side of the filter choke, one of the positive leads of the filter condenser and to one pigtail end of the 40,000-ohm resistance. NOW IF YOU HAVE FOLLOWED DIRECTIONS CAREFULLY, YOUR EXPERIMENT SHOULD BE WIRED COMPLETELY, AS SHOWN IN FIG. 11.

The 700-ohm resistance is placed between points C and X in Fig. 11 so that when the volume control is turned completely in the direction toward terminal X, there will still be some bias voltage applied to the grid of the type 56 tube. Now plug a type 80 tube in socket 13 and a type 56 tube in socket 8. Turn your experiment right side up and then turn it on by plugging in the attachment plug to a 110-volt, 60-cycle house lighting current.

When the tubes have had time to warm up, you will have a plate current reading on the milliammeter, governed entirely by the amount of resistance connected between points C and B, Fig. 11. This resistance is controlled by rotating the arm on the potentiometer. When movable arm B is at point X in Fig. 11, then a cathode resistance of 700 ohms is connected in the circuit and this supplies bias for the type 56 tube. In our laboratory, using a sensitive voltmeter we found that this produced a grid voltage of -15 volts and the milliammeter showed a plate current of 19 ma. Now, as you gradually turn the volume control so that the movable arm moves farther away from X, thereby placing more resistance in the circuit, the voltage drop from B to C increases. The grid-bias voltage increases and the plate current decreases. In our laboratory we also found that with the movable arm at D (using all of the volume control resistance), we had a grid voltage of -28 volts supplied to the 56 tube and the plate current had dropped to zero.

In checking up the characteristics of the type 56 tube, you will find that with a plate voltage of 250 volts and a grid voltage of -13.5 volts, there should be a plate current of 5 ma. flowing. In this experiment, the plate voltage is approximately 430 volts when the plate current is zero and 380 volts when the plate current is 20 ma. With the volume control potentiometer in the ¾ "On" position, we will have a total of 4,000 ohms of resistance connected between cathode and ground. With a plate current of 6 ma. flowing through this resistance, a grid voltage of -24 volts will be produced.

EXPERIMENT 17

SECURING GRID BIAS BY THE BLEEDER RESISTANCE METHOD

In this experiment, you are going to demonstrate the method

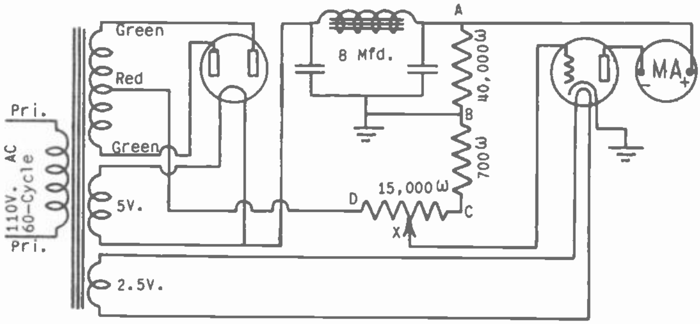


Fig.13 Schematic diagram showing method of securing grid bias by tapping off a portion of voltage divider.

of securing grid bias by taking off a tap on the voltage divider system. Noting the plate current changes which take place with variations in the grid voltage will readily demonstrate the effect of grid voltage changes as well as the means of adjusting the grid bias when it is secured by this method.

First, unsolder both ends of the piece of hookup wire now connected between the cathode terminal on socket 8 and one end of the 700-ohm resistor. Next, unsolder the piece of hookup wire now connected to the grid prong on socket 8. The loose end of this piece of hookup wire is now soldered to the cathode prong on socket 8. This will ground the cathode prong of socket 8 as shown in Fig. 13.

Remove the ground connections to the outside and center tap volume control terminals. Now run a piece of hookup wire from the grid terminal on socket 8 to the center tap terminal on the volume control potentiometer. Solder the connections.

The center-tap lead (red lead) of the high-voltage winding on the power transformer now connected to a ground lug is to be unsoldered from the ground lug and this same lead soldered to the center terminal on the terminal strip which is supporting the 700-ohm resistance. Next, run a piece of hookup wire from the outside terminal on the volume control (the one next to the chassis) to the same center terminal connection on the terminal strip to which the center tap of the high-voltage secondary is connected. Solder this connection. This is point D in Fig. 13.

One end of the 700-ohm resistance is already connected to an outside terminal on the volume control potentiometer. This is point C in Fig. 13. The other end of the 700-ohm resistance was formerly connected to the cathode prong on socket 8. This piece of hookup wire is to be removed and that end of the 700-ohm resistance is to be connected to the ground end of the 40,000-ohm resistance mounted on terminal strip 1. This is point B in Fig. 13.

There are no changes to be made in the plate circuit connections for this experiment.

If you will check your experiment carefully, it should be wired as shown in Fig. 13.

With a type 80 tube plugged in socket 13 and a type 56 tube plugged in socket 8, turn on your experiment. By varying the volume control; that is, as the movable arm varies from points C to D, the grid bias on the 56 tube will be varied and this in turn will vary the plate current. Since the center tap of the high-voltage winding of the power transformer is connected to point D on the volume control, it is necessary for the plate current to flow through the 15,000-ohm volume control and the 700-ohm fixed resistance in order to complete the circuit back to the chassis or ground. The voltage drop then between points D and B will supply the grid bias to the type 56 tube. When the movable arm of the volume control is at point C, the least grid voltage will be applied and the greatest plate current will flow. When the movable arm is toward point D on the volume control, the greatest grid bias will be applied to the 56 tube and the least plate current will flow.

Here in our laboratory, using a highly sensitive voltmeter, we measured the voltage from points B to X. When the movable arm X of the potentiometer was at point C, we had -7 volts of bias applied to the tube and the milliammeter indicated there was 5 ma. of current flowing. When the movable arm of the potentiometer was at the ¾ position, we had -25 volts of grid bias applied to the tube and the milliammeter indicated 2 ma. of current flowing. While you have no method of checking the grid voltage which is applied to the tube, your plate current readings should correspond closely to those secured here in our laboratory. In this experiment the plate voltage is very low because of the voltage drop across D to B. This voltage drop exists regardless of what plate current is flowing because of the bleeder current through A to B.

EXPERIMENT 18

TESTING EFFECT OF GRID BIAS AND EXCITATION

In this experiment, you are going to determine the effect of over-exciting the grid of a tube with fixed grid bias applied. In conducting this experiment, it is very advisable that you use extreme care in following directions. The reason for this is that the 110-volt, 60-cycle AC house lighting supply must be used for the grid-exciting voltage. If you are not careful in wiring your experiment and carrying out your tests, it may be possible that you could secure a shock from your equipment.

If you will refer back to Fig. 18, Group 1, Experiment 7, you will find that in constructing the tube tester, you connected the primary of the power transformer to the grid terminals of sockets 14, 9, 7, and 1; also, to the two grid clips which are used in testing tubes. The easiest way to secure the first connection in this experiment is to remove the small grid clip from the wire which now goes up through the small hole in the chassis directly between holes 1, 2, 3, and 4. Pull this wire down through the chassis and connect this loose end (from which you removed the grid clip) to the bottom outside volume control terminal. This is the one nearest you when the chassis is upside down. The wire now connected from this terminal to one end of the 700-ohm resistor is removed. This

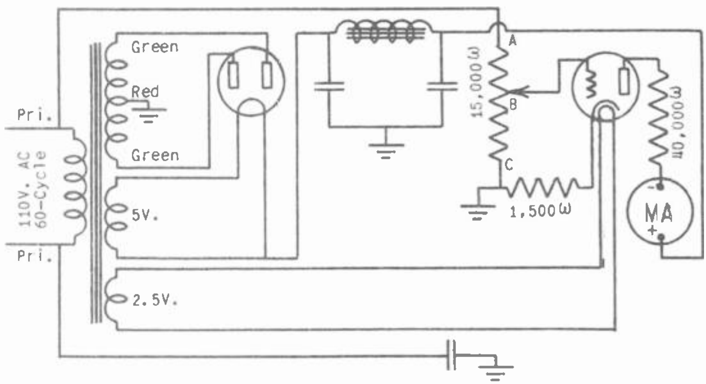


Fig.14 Wiring diagram showing method of supplying a variable AC voltage to the grid of a tube.

then becomes point A in Fig. 14. The grid terminal of socket 8 is connected to the center terminal of the volume control potentiometer. This is point B in Fig. 14. The other outside terminal on the volume control is to be grounded. The wire now connected from this terminal to the center-tap lead on the high-voltage secondary is to be removed.

The center-tap lead on the secondary of the power transformer is now soldered to the center terminal of terminal strip No. 2. Remove this connection and again ground this lead by soldering to a solder lug.

The cathode terminal on socket 8 is now grounded to a solder lug. Remove this ground connection. Solder one pigtail end of a 1500-ohm resistance to the cathode prong. Solder the other pigtail end of this resistance to the solder lug now placed under the left-hand bolt on socket 8.

One of the primary terminals of the 110-volt primary on the power transformer is now connected to the grid prong on socket 14. To the opposite primary terminal, connect one pigtail end of a .25 mfd. condenser. Solder the connection. The other pigtail end of the .25 mfd. condenser is to be fastened to any conveniently placed solder lug so that the other end of the condenser is grounded as shown in Fig. 14.

A piece of hookup wire is now connected between the plate terminal on socket 8 and the negative terminal of your milliammeter. Remove this piece of hookup wire and the 40,000-ohm resistor from across terminal strip No. 1. Solder one pigtail end of the 40,000-ohm resistance to the plate terminal on socket 8. The other pigtail terminal of the 40,000-ohm resistance is to be fastened to the negative terminal of the milliammeter. If the leads on the resistor are not long enough to reach, then solder a short piece of hookup wire to the end of the 40,000-ohm resistor and connect the hookup wire to the negative terminal of the milliammeter. If you have followed directions carefully, your experiment is then wired as shown in Fig. 14.

With the chassis right side up and the front toward you, plug a type 80 tube in socket 13 and a type 56 tube in socket 8. Turn the experiment on by plugging into a 110-volt, 60-cycle house lighting supply.

When the tubes have had a chance to warm up, you should have a plate current reading of approximately 5 ma. With the volume control turned in the extreme counter-clockwise position, the movable arm B is at point C. In this position, there is no grid excitation applied to the 56 tube. Now, as you rotate the volume control, the movable arm B moves toward point A and a 60-cycle voltage is applied to the grid of the 56 tube. As you start to pass the half-way position, in the rotation of the volume control, you will notice that the plate current starts to decrease. This means that the AC exciting voltage has exceeded the normal DC grid bias applied to the grid of the tube and so the tube is no longer acting as a linear amplifier. The over-excitation causes a decrease in plate current.

Using a highly sensitive voltmeter, in our laboratory, we found the tube to be working under the following conditions: A plate voltage of 180 volts was measured from plate to cathode; a negative grid voltage of 10 volts was measured from grid to ground. The plate current as indicated on the milliammeter is 5 ma. At the point where the first drop in plate current is indicated (while rotating the volume control knob in the clockwise direction), the AC exciting voltage measured 9 volts. Remember, this is a sine wave, so the peak voltage would be 9 × 1.4, or approximately 13.6 volts. As you will notice, this is more than sufficient to overcome the negative bias of the tube. As the volume control is rotated to the maximum position, that is, the movable arm B reaches point A, then the grid exciting voltage is measured as 17 volts, which gives a peak voltage of approximately 23.8 volts.

EXPERIMENT 19

BUILDING A VACUUM TUBE VOLTMETER

The vacuum tube voltmeter is a device which will measure either AC or DC voltages and one which, if properly designed, will not present any load to the voltage source being measured. It is rather difficult to calibrate this type of instrument, so in this experiment, you will use the vacuum tube voltmeter only as an output meter. For this use, no calibration is necessary.

Most output meters are comparatively expensive. Therefore, you will probably not wish to purchase one, but will find considerable use for this instrument in carrying out the procedure of aligning or adjusting radio receivers. An output meter is used in connection with oscillators of either the R.F. or A.F. type. When used with an R.F. oscillator, it is designed to read the set's comparative output, so as to facilitate the alignment of the radio frequency sections. When used with A.F. oscillators, an output meter can be used in calculating the frequency-response characteristics of A.F. amplifiers.

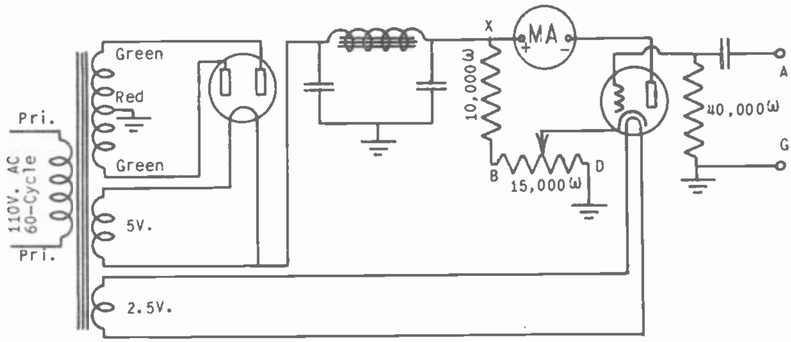


Fig.15 Wiring diagram of a vacuum tube output meter with zero adjuster.

You now have a piece of hookup wire connected from the terminal lug on the terminal strip, now connected to the left-hand side of the filter choke, to the positive terminal of the milliammeter. Leave this connection as is and then solder a 10,000-ohm resistance across terminal strip 1. During a previous experiment, one terminal of this terminal strip was grounded. If this connection still exists, be sure to remove the ground connection. The 10,000-ohm resistor is shown at X-B, Fig. 15.

From the free end of the 10,000-ohm resistance, run a piece of hookup wire to an outside terminal of the volume control resistance. (This is the terminal nearest you.) The grid wire to which you formerly had a grid clip attached is now connected to this terminal. Remove this wire and pass it back up through the chassis in case you might wish to use the tube tester again.

A 1500-ohm resistor is now connected between the cathode terminal on socket 8 and a solder lug located beside this terminal. Remove this resistor completely. You have a piece of hookup wire connected between the center-tap terminal on the volume control and the grid terminal on socket 8. Unsolder this piece of hookup wire at the end connected to the grid terminal on socket 8 and connect it to the cathode terminal on socket 8. This connection is shown at C in Fig. 15.

The other outside terminal (D) of the volume control is now grounded; leave it in this condition.

You now have a 40,000-ohm resistance connected between the plate prong on socket 8 and the negative terminal of the milliammeter. Remove this resistance completely. Connect a piece of hookup wire between the plate prong on socket 8 and the negative terminal of the milliammeter.

Next, connect one pigtail end of the 40,000-ohm resistance to the grid terminal on socket 8. At the same time, connect one pigtail end of a .25 mfd. condenser to the same grid prong on socket 8. (Remove the .25 mfd. condenser now connected from the primary of the power transformer to ground.) The other pigtail end of the 40,000-ohm resistance goes to the solder lug bolted under the left-hand terminal of socket 8. This provides a return connection for the grid through the 40,000-ohm resistor.

With the chassis upside down and the front toward you, you will find a slotted hole on the back right-hand side of the chassis. The aerial and ground terminal strip contained in your second laboratory shipment is to be mounted in this slotted hole by using two $\frac{6}{32}$" bolts and nuts. The aerial and ground terminals face toward the rear, while the two solder lugs face in. At the time this terminal strip is being bolted in place, put a solder lug under the nut next to the ground connection. Using a small piece of hookup wire, connect the ground lug to this solder lug and solder the connection. This provides the ground connection G as shown in Fig. 15. The other pigtail terminal of the .25 mfd. condenser is connected to the aerial terminal of this terminal strip. Solder the connection. This is point A in Fig. 15. In mounting the 40,000-ohm resistance and the .25 mfd. condenser, if the pigtail leads are too long, do not cut them off. However, be careful that no bare leads touch the chassis and that the unit is supported away from the chassis itself.

If you have carefully followed directions, the vacuum tube voltmeter will now be wired as shown in Fig. 15. Plug a type 80 tube in socket 13 and a 56 tube in socket 8. Before plugging your experiment into the AC lighting socket, be sure that the volume control is turned to the right as far as it will go. This is in a clockwise direction. Now, plug in your experiment and give the tubes time to warm up. Watch the milliammeter carefully. If you should have your volume control wired backwards, the plate current on the 56 tube will be very high. However, if you have it correctly wired, there will be no plate current indicated, even after the tubes have become heated. Then, carefully turn the volume control toward the left, or in a counter-clockwise direction. *Do not do this hurriedly.* As you turn it to the left, plate current will start to flow. Do not turn it any further left after plate current starts to flow, because the plate current is apt to become excessive.

Using this vacuum tube voltmeter, it is now very easy to test the output of a radio receiver. No specific directions can be given because practically every receiver differs to some extent. However, the diagram shown in Fig. 16 will give you an excellent idea about connecting the vacuum tube voltmeter to a receiver.

The aerial and ground strip mounted on the back of your exper-

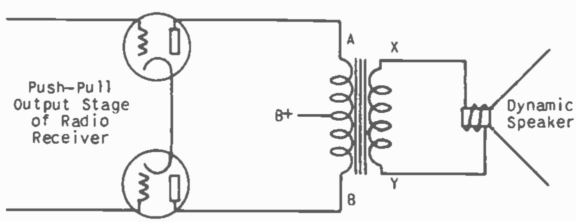


Fig.16 Demonstrating where to connect an outpot meter to measure the comparative output of a set under test.

iment are the input terminals to the vacuum tube voltmeter. If you have a radio receiver which has a dynamic speaker and push-pull output tubes, you can easily follow the directions given in Fig. 16, in connecting the vacuum tube voltmeter to the output of this receiver. Connect two pieces of hookup wire from the aerial and ground posts on the vacuum tube voltmeter to the voice coil connections on your loudspeaker. These are indicated as X and Y in Fig. 16. When the meter is properly connected, you are ready to turn it on by plugging it into the light socket. However, do not turn on the radio receiver as yet. Now, carefully adjust the volume control so that the plate current on the type 56 tube reads 1 ma. or a little less. After this is done, turn on the radio receiver and tune in a strong station. The milliammeter which is connected in the plate circuit of the type 56 tube will then rise and fall according to the A.F. variations which are taking place in the output circuit of the receiver. If there is insufficient voltage developed across the voice coil of the set, it may be necessary to change the connections to secure sufficient output voltage. Turn the radio receiver off and connect the two leads from the vacuum tube voltmeter to points A and B. This is from plate to plate on the push-pull output stage. Again, with the vacuum tube voltmeter adjusted so that the plate current is 1 ma. or less, turn on the radio receiver and again tune in a local station. This time there should be no question but what you will have sufficient A.F. energy to properly operate the vacuum tube voltmeter. The A.F. variations as they rise and fall will give you a good idea of how an operator "rides gain" on a broadcast program. In other words, he controls the volume of the music broadcast and watches a meter similar to the one you are now using. Oftimes, you can see the meter start to rise on an extra loud passage; then as the operator reduces the volume, the meter will stop rising and you can actually notice a difference in the sound output of your speaker.

If your radio receiver does not have a push-pull output stage, the vacuum tube voltmeter can be connected as follows: Connect the ground (G) connection on the terminal strip to the chassis or ground connection of the radio receiver. Then, connect the aerial connection (A) on the terminal strip to the plate terminal of the output tube on your radio receiver. This would be the same as connecting between A and ground or chassis as shown in Fig. 16.

Notes

(These extra pages are provided for your use in taking special notes)

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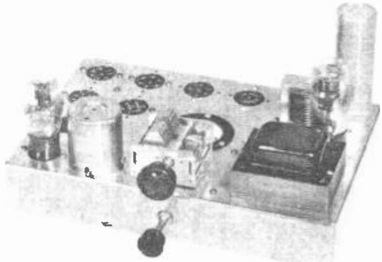
LABORATORY EXPERIMENTS

Group Three



"While the previous groups of experiments have undoubtedly been quite instructive and interesting, still, I am sure you are going to get a lot of fun as well as much valuable experience from the construction of the experiments in this group.

"Unquestionably, you will be surprised at the efficiency of the receivers you are going to build now. If you do your work carefully and learn to operate the sets efficiently, you should be able to receive broadcasting stations throughout the entire United States."

MOUNTING THE EQUIPMENT. To start this group of experiments, it is beat to unwire and remove all of the experimental equipment now mounted on your chassis with the exception of the power supply and 0-50 milliammeter. The power supply should be left intact, but all other equipment should be removed from your chassis and the solder removed from the socket prongs. This means, heat your soldering iron and remove all excessive solder from the various socket prongs. Also, carefully sort and keep your hookup wire so that you will be able to conduct this group of experiments without additional hookup wire.

The first piece of equipment to be mounted is the 15,000 ohm volume control potentiometer with a switch mounted on the back. This potentiometer is mounted in the middle one of the three holes on the front of the chassis. In fastening this potentiometer to the chassis, place the three connection lugs which are on the side of the potentiometer so that they face towards the right. (The chassis is upside down and the front towards you.) The next piece of equipment to be mounted is the two gang variable condenser which is included in your laboratory shipment. This condenser is bolted to the chassis by two 8/32 bolts. The condenser is mounted on the top of the chassis with the shaft facing toward the front. It is held in place by any two of the four holes located in the front center of the chassis. (It is best to use holes 17 and 20 as shown in Fig. 1.) The mounting of this condenser can easily be determined from the picture which is shown at the front of this group of experiments.

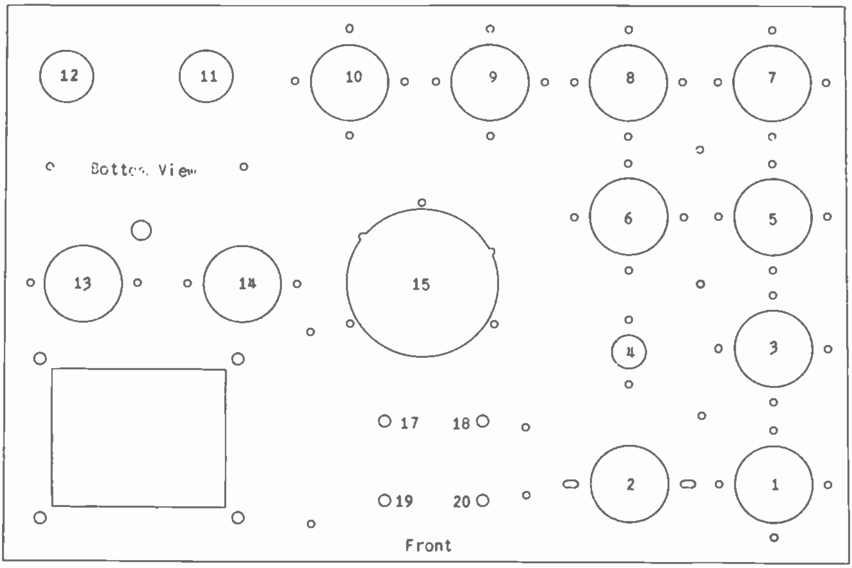


Fig. 1 A bottom view of your metal chassis showing mounting holes.

Next, you will mount the sockets to be used in this and the following group of experiments. With the chassis upside down and the front toward you, mount a five prong socket in both holes 1 and 2, Fig. 1. In mounting these sockets, mount the filament prongs toward the front of the chassis. A bottom view of the sockets is shown in Fig. 2, B.

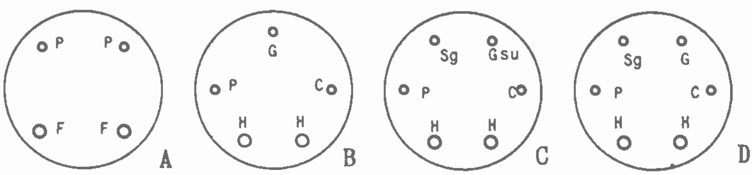


Fig. 2 A bottom view of four types of sockets used in this group of experiments.

Next, mount a six prong socket in holes 5, 3 and 10. In mounting these two sockets, mount the heater prongs next to the chassis. The six prong socket mounted in hole 5 will have its heater prongs toward the right. The six prong socket mounted in hole 8 will have its heater prongs toward the back of the chassis. The heater prongs on the socket mounted in hole 10 will be towards the left. (All of these directions are given with the chassis upside down and the front toward you.)

The next piece of equipment to be mounted is the small R.F. choke which is included in your laboratory shipment. This choke is bolted in either one of the two small holes around hole 4. (A bolt is furnished with the choke.) At the same time, it is advisable to bolt a solder lug in the hole in the center of socket holes 3, 4, 5 and 6. Also, place a solder lug under the right-hand bolt which holds sockets 1 and 2 in place.

With the chassis upside down and the front towards you, a special headphone jack strip is mounted in the left-hand slotted hole on the back edge of the chassis. The aerial and ground strip is mounted in the right-hand slotted hole on the back of the chassis. When you mount the aerial and ground strip, be sure to place a solder lug under the right-hand bolt which holds the strip in place. This solder lug is then connected to the ground terminal of the aerial and ground strip.

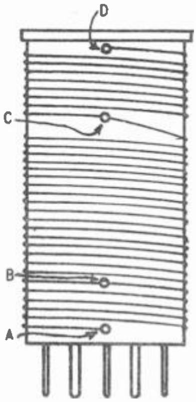
You must bear in mind that the power transformer is already mounted in hole 16; a four prong socket is mounted in hole 13; the double 8 mfd. electrolytic condenser is mounted in hole 12 and the filter choke is bolted to the chassis through the two small holes which are in front of holes 11 and 12. The power supply is completely wired up and there will be only one change made in this wiring.

EXPERIMENT 20

WINDING REGENERATIVE RECEIVER COIL.

In this laboratory shipment, you will find a five prong coil form which is to be wound with number 30 enameled covered magnet wire. This special coil will be used in several of the following receiver experiments. In carrying on this work, you must remember that the enamel coating on the magnet wire constitutes the insulation for that wire. If you are going to make an electrical connection, it is necessary to carefully scrape off this enamel coating with a sharp knife. If you do not want an electrical connection, then it is necessary that you take precautions to see that the enamel covering is not damaged.

The first procedure in winding this coil is to drive a nail in a table and place the spool of magnet wire down over this nail. Then, place something fairly heavy on top of the spool so that it will not turn too easily. This provides some friction, making it possible for you to wind the turns of your coil a little bit tighter. Now scrape about one-inch of the insulation from the end of the wire. There are to be three windings on this coil and these are shown in Fig. 3. Looking at the figure, you will notice there are four small holes in the side of the coil form. We are going to start the first coil at the bottom; therefore, pass the end of the magnet wire through the bottom hole marked A in Fig. 3 and pull it out through the top of the coil form. Next, pass the end of this wire down through the cathode prong on the coil form. (See Fig. 4.) Push it through the cathode prong until the bare end just comes through about one half of an inch. Bend this bare end over the prong so that it will not slip, but do not solder the connection as yet. Now, carefully take up the slack of the extra wire which you have unreeled by pulling it out through the small hole marked A.



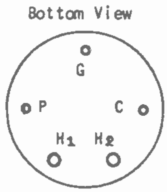


Fig. 4 (Above) Bottom view of plug-in coil.

Fig. 3 (Left) A constructional view of plug-in coil used for regenerative receiver.

You are now ready to wind the first coil. Holding the coil form so that the prongs on the form are in your left hand and the ridge on the top of the form in your right hand, wind towards you; that is, in a clockwise direction.[1] Be sure to keep the wire taut so that the turns will go on the coil form tightly and will not slip. Now continue to wind until you have 22 turns on this first coil. This number of turns will practically fill the space between holes A and B on your coil form. Cut the magnet wire off about three inches longer than necessary. Then, carefully scrape the insulation off the wire from the place where it will go through hole B out to the end. Push the wire through hole B and from hole B push the wire down through the heater prong (H_2) which is next to the cathode prong. Where this wire goes through the heater prong, be absolutely certain that it is bare inside of the prong. Now, bend the wire over at the end of the prong and solder this connection. With your soldering iron good and hot, place it alongside of the heater prong. Be sure to get the prong hot and then touch your rosen core solder to the end of the prong. This will melt the solder and cause it to run down inside of the prong. Use the soldering iron to remove any extra solder on the outside of the prong. Using pliers, cut off the magnet wire which is left sticking out the end of the prong. If you have been careful, you will secure a good joint. If you do not succeed the first time, try again until you are sure you have a good electrical connection between the prong and the magnet wire.

[1] Clockwise direction looking at the coil form from the left or bottom end and counter clockwise looking at the coil form from the right or top end.

We are now ready to wind the next coil which will be the secondary or center coil. Scrape about one inch of insulation from the end of your magnet wire and pass this through hole B and down through the cathode prong on the coil form. Be sure that the wire is bare where it goes through the cathode prong. Bend it over at the top and then solder the connection. This time you are soldering the starting of the primary or bottom winding and the starting of the secondary winding. Both wires are in the cathode prong. Be sure that you secure a good connection.

Holding the coil form as previously described, wind 90 turns for the secondary coil. In winding this coil, you will find that the specified number of turns does not quite fill the space between holes B and C. Therefore, the last turn on the secondary coil will slant upward on the coil form so that the end of the wire may be passed through hole C. Cut the wire off so that it is about three inches too long and pass the end of the wire through hole C, then scrape off the insulation from the wire about where it will pass through the coil prong. The end of this wire is to go through the grid prong. Be sure that the wire is bare where it goes through the prong, bend it over, solder this connection and then cut off the surplus wire.

The next and last coil to be wound is called the tickler or plate coil. It will be wound between holes C and D. Scrape the insulation from the end of the wire, pass it through hole C and then down through the plate prong on the five prong coil form. Be sure that the wire is bare where it goes through the prong, bend it over, solder the connection and cut off the surplus wire. Holding the coil form with the prongs in your left hand, wind towards you, or in a clockwise direction until you have 30 turns on this coil. This number of turns should just about fill the space between holes C and

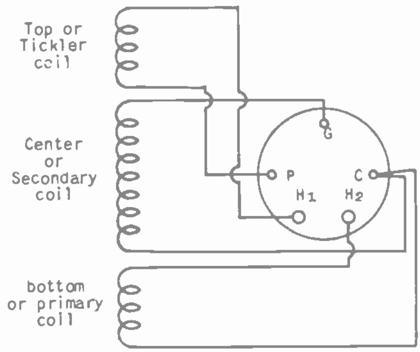


Fig.5 View showing internal connections for five prong coil form.

D. Cut the wire off about three inches longer than necessary, pass the end through hole D, scrape the insulation off the wire and then pass it down through the heater prong (H_1) next to the plate prong. Be sure that the wire is bare where it goes through the prong, bend it over, solder it and then cut off the extra wire.

Now, if you have carefully followed directions, you will have the three coils correctly wound. **YOU MUST BE VERY CAREFUL THAT EACH COIL IS WOUND IN THE SAME DIRECTION; THAT IS, CLOCKWISE.** Fig. 5

shows the internal connections for the three coils. It is advisable that you check up carefully and find whether or not you have made the connections as indicated.

If you have some sort of a battery, it is advisable to use your meter and this battery as a continuity tester to test the coil for good connections. In testing, you should find that you have continuity between the grid prong and the cathode prong and the heater prong (H_2) next to the cathode prong. This automatically tests both the primary and secondary coils. The tickler coil may be tested by connecting your continuity tester between the plate prong and the heater prong next to the plate prong. This tests the tickler coil.

In winding this coil, it will not make a great deal of difference in the operation of your receiver if you make a mistake in counting the number of turns; that is, one or two extra turns or one or two less turns will not make a great deal of difference. However, you should be careful and get the number of turns as nearly correct as possible.

EXPERIMENT 21

BUILDING A TWO-TUBE REGENERATIVE RECEIVER

(Grid Leak Type)

If you will follow the directions carefully in wiring and operating this receiver, you will be quite surprised at the splendid results which can be secured from such a small set.

The first thing to do in wiring this experiment is to check the wiring of your power supply system. The two green secondary leads on your power transformer should be connected to the two plate terminals of socket 13. (A in Fig. 2.) This is one regular plate terminal and the normal grid terminal. A wiring diagram for this experiment is shown in Fig. 6. You must also make sure that the heater terminals on socket 13 are connected to the 5-volt winding on the power transformer. The red lead from the secondary of the power transformer is solder to a lug placed under one of the transformer mounting bolts.

The red lead with the white stripe running through it from the double 8 mfd. filter condenser is now connected to one of the heater terminals on socket 13. To this same socket connection, a wire runs up to the filter choke which is mounted on the top side of the chassis. The two black leads from the 8-8 mfd. electrolytic filter condenser are soldered to a lug placed under the bolt which holds the filter choke in place. The red lead from the double 8 mfd. filter condenser is now connected to one of the terminal lugs on the terminal strip which is bolted to the right-hand bolt which holds the filter choke in place. (The chassis is upside down; the front towards you.) A piece of hookup wire coming from the other terminal of the filter choke is also connected to this same terminal lug. To this same terminal lug, attach one pigtail end of a 10,000 ohm high wattage resistor. The other pigtail end of the 10,000 ohm resistance is connected to the positive terminal of the milliammeter. At the same time this connection is made, also connect one pigtail end of a 40,000 ohm resistor. This connection is shown in Fig. 6. The other end of the 40,000 ohm resistance is soldered to a conveniently placed solder lug.

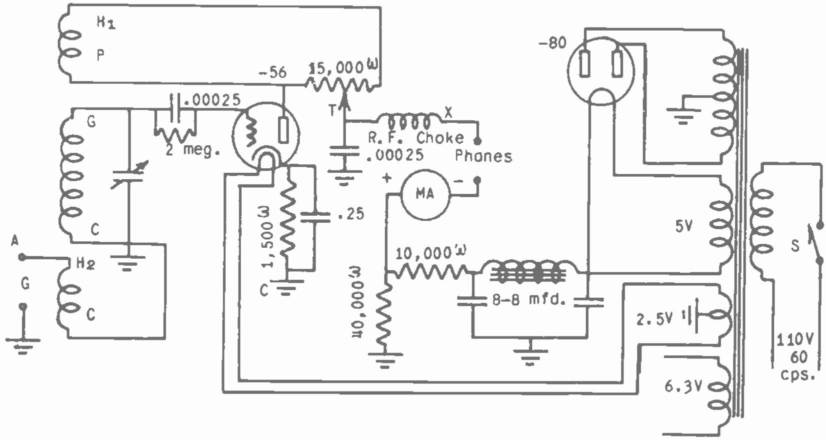


Fig.6 Wiring diagram of a two tube regenerative receiver using grid leak detection.

In conducting previous experiments, the 110 - volt AC cord was connected directly to the two primary terminals of the power transformer. In this experiment, we are now going to use the switch on the back of the volume control so that this switch will turn your receiver on and off. This switch is marked S in Fig. 6. With the chassis upside down and the front towards you, leave the end of the AC cord soldered to the terminal lug which is now the fartherest away from the front of the chassis. The other end of the 110-volt lead which is connected to the solder lug next to the chassis should be disconnected and connected to one of the switch terminals. The switch is a piece of bakelite mounted on the back of the volume control. On this control are two terminals. To one of these terminals, solder the 110-volt lead which was just disconnected. From the remaining terminal on the switch, run a piece of hookup wire over to the 110-volt lug which is next to the chassis. When you have completed these connections, the switch is then wired in series with the primary of the power transformer. With the chassis right side up and the front towards you, the switch is off when the volume control is turned in its full counter clockwise position. This is toward the left. Now, in order to turn the transformer on, merely rotate the volume control in a clockwise direction, or toward the right. The first part of the turn of the volume control snaps the switch on.

The next step in wiring up your experiment is to take two pieces of hookup wire about 14 inches long. Twist these two wires together, but be sure that the bare ends of these two wires do not touch. Now solder one end of these two wires to each of the heater prongs on the five prong socket which is mounted in hole 1. A bottom view of the five prong socket is shown at B in Fig. 2, so that you will make no mistake as to which are the heater prongs. Run this twisted pair of wires along the front of the chassis and in, under the volume control, over to the power transformer. The other two ends of these leads are to be connected to the 2.5 volt winding on the power transformer. The wires should be a little longer than necessary, but they should not be cut off, because later on, these same two leads are going to be connected to the 6.3 volt winding on the power transformer. Therefore, if you do not cut the leads now, you will not have to make new leads for a later experiment.

From the negative terminal on the milliammeter, run a piece of hookup wire over to the left-hand terminal on the headphone jack. Solder the connection. From the right-hand terminal of the headphone jack, run a piece of hookup wire over to one of the terminals on the small R.F. choke. This is connection X, as shown in Fig. 6. Now, to the other terminal of the R.F. choke, connect one pigtail lead of a .00025 mfd. condenser and also a piece of hookup wire, then solder the connection. The other pigtail end of the .00025 mfd. condenser goes to the solder lug which is mounted close to the R.F. choke. The other end of the hookup wire goes to the center terminal of the volume control potentiometer. This is connection T in Fig. 6.

The next step is to connect a piece of hookup wire from the outside terminal on the volume control potentiometer (the one nearest the chassis) to the plate prong on socket 2. At the same time, the hookup wire is connected to the plate prong on socket 2, also solder another piece of hookup wire to the same prong. The other end of the piece of hookup wire goes to the plate prong on socket 1. You now have the plate prong on socket 1 wired to the plate prong on socket 2 and from there to the outside terminal on the volume control potentiometer.

From the remaining outside terminal on the volume control potentiometer (this is the terminal nearest you), connect a piece of hookup wire over to the heater terminal next to the plate terminal on socket 2. This terminal is marked H_1 in Fig. 6.

Now solder one pigtail end of a 1500 ohm resistance to the cathode prong on socket 2. At the same time, a piece of hookup wire is run between this prong and the solder lug which is mounted right next to this prong. The result of this is, the cathode prong and one end of the 1500 ohm resistance is grounded. This connection is shown at C in Fig. 6. The other end of the 1500 ohm resistance is connected to the cathode prong on socket 1. At the same time this connection is made, connect one pigtail end of a .25 mfd. condenser to the same prong and solder the connection. The other pigtail end of the .25 condenser is connected to the solder lug which is bolted in the center of the four holes, 3, 4, 5, and 6. Be sure these connections are soldered. IF THE PIGTAIL LEADS ON CONDENSERS OR RESISTORS ARE TOO LONG, DO NOT CUT THEM OFF, BUT MERELY BEND THEM SO THAT THEY DO NOT TOUCH ANY METAL OBJECT. THIS IS DONE BECAUSE THE RESISTORS AND CONDENSERS WILL BE USED IN FUTURE EXPERIMENTS AND THE LONG LEADS MAY BE NEEDED.

In a variable condenser, the plates which move when the shaft is turned are called the "rotor" plates. These plates are connected to the frame of the condenser during the process of manufacture. Therefore, when the frame of the condenser is bolted to the chassis, the rotor plates are automatically grounded. The stator plates are those which do not move. On the two gang variable condenser which is supplied you, there is a small solder lug sticking out the side of the condenser attached directly to the stator plates. With the chassis right set up, connect a piece of hookup wire to the back stator section of the two gang condenser, using the left-hand solder lug. Solder the connection. Run this piece of hookup wire down through the chassis, using the hole which is directly below the stator plate solder lug connection. Be very careful that the bare wire does not touch the chassis where it goes through the hole. Be sure the insulation is good at this point. Connect the other end of this piece of hookup wire to the grid terminal on socket 2. At the same time, connect one pigtail end of a 2 megohm resistor and one pigtail end of a .00025 mfd. mica condenser to the same terminal and solder the connection. The other pigtail end of the 2 megohm resistance and the .00025 mfd. condenser goes to the grid terminal on socket 1. Solder the connections.

Now, connect a piece of hookup wire to the antenna terminal on the aerial and ground strip. Solder the connection. The other end of the antenna wire goes to the heater prong, next to the cathode prong on socket 2. This connection is marked H_2 in Fig. 6.

Now, if you have carefully followed directions, your experiment is wired as shown in Fig. 6. Check this over carefully so that you are sure you have made no mistakes. A type 80 tube is to be plugged into socket 13; a type 56 tube is to be plugged in socket 1 and the five prong coil form is to be plugged into socket 2. Next plug your headphones into the phono jack mounted on the back of the chassis. The headphone lead with the red stripe through it is to be plugged into the right hand terminal of the phono jack. (This is looking at the back of the chassis, right side up. This is the jack which is connected to the negative terminal of the milliammeter or Bt.)

OPERATING A REGENERATIVE RECEIVER. It reqiures considerable skill in operating a regenerative receiver if the maximum in results is to be secured. The only way such skill can be acquired is through practice.

Before attempting to operate this receiver, the aerial post on the A and G strip should be connected to a good aerial. The ground post on the A and G strip should be connected to a good ground connection. A satisfactory aerial for this receiver would be about 75 feet long and suspended at least 25 feet above the ground. In calculating the length at 75 feet, it is advisable to include the lead-in wire from the set to the aerial and also the length of the flat top of the aerial. Be sure the aerial is well insulated and that it is as far away from metal objects as possible. Securing a good ground connection was described in a previous experiment.

With the receiver connected to a good aerial and ground, the next thing to do is to plug the AC plug into a 110v, 60 cycle alternating current outlet. Be sure that you have a tight connection. With the tubes and regenerative coil in place, turn the volume control knob to the right. The first turn of the knob clicks the switch "on" and the set will start to warm up. After you have given it a minute to warm up, put the headphones on and advance the volume control to the right until you hear a squeal. Next, retard the volume control slowly until just where the squeal stops. Now, very carefully rotate your tuning condenser. As you turn the tuning condenser, you will hear a whistle. This whistle indicates that your set is tuned to the carrier wave of a broadcasting station. When this whistle is encountered, it indicates that the set is oscillating. Next, reduce the volume control very slightly. In reducing the volume control, it will be necessary to reduce the tuning capacity just a little in order to keep the station in tune. (Reducing the capacity involves the turning of the rotor plates so that they do not mesh as much with the stator plates.) Then, as you reduce the volume control a little bit more, you will also need to reduce the condenser capacity in order to keep the station in tune. Continuing this procedure, you will finally reach a place where the whistle stops and this indicates that, while the tube is acting as a regenerative detector, it is no longer oscillating. At this point, you should hear music or voice from the broadcasting station. By careful adjustment of the tuning condenser, you should be able to bring in most stations clearly and loudly.

The secret of success in the operation of this receiver depends upon the correct adjustment between the tuning condenser and the volume control. When these two are set just exactly right in relation to each other, you will be amazed at the distant reception which can be received on this set.

If you are unfortunate enough to live quite close to a powerful broadcasting station, you may find it impossible to tune out that station and bring in others. There is no remedy for that situation, because a regenerative receiver of this type is not selective enough to eliminate strong, local broadcasting stations.

LOOKING FOR TROUBLE. If the set fails to function, the first thing to do is to carefully check over all your connections. Be sure you have the set wired up exactly as shown in the wiring diagram. If this fails to disclose any trouble, then your mistake is probably with the regenerative or tickler coil. This is the top coil wound on your coil form and, if the set refuses to squeal or whistle, it is evident that this coil is reversed. To correct this situation, you reverse the connections now made to the plate prong and to the heater prong (H_1); that is, you connect the wire which is now connected to the plate prong over to the heater prong (H_1). You connect the wire which now goes to the heater prong (H_1) over to the plate prong. This reverses the leads and should produce regeneration.

If you have any further trouble, it is advisable to use your Midland Consultation Service and, in writing about this set, please describe in detail just what you have done and what seems to be wrong so that we can give you our best assistance in straightening out the trouble.

EXPERIMENT 22

BUILDING A REGENERATIVE TWO TUBE RECEIVER.

(Grid Bias Detector)

In this experiment, it is only necessary to make one change in the grid leak detector, Experiment 21, to change to a grid bias type of detector. However, you will find considerable difference in the operation of these two types of receivers.

You now have a 2 megohm resistor and a .00025 mfd. condenser connected between the grid prong on socket 1 and the grid prong on socket 2. Since you will want to use the grid leak type of detector later, it is not advisable to remove these two pieces of equipment. Therefore, to conduct this experiment, all you need to do is to connect a piece of hookup wire between the grid prong on socket 1 and the grid prong on socket 2. This shorts out the .00025 mfd. condenser and the 2 megohm resistor. The only grid bias received by the -56 tube is by the action of the 1500 ohm cathode resistor.

With a type 80 tube plugged into socket 13, a type 56 tube plugged into socket 1 and the five prong coil form plugged into socket 2, you are now ready to use this experiment. Connect the AC, turn on the receiver and give it time to warm up. The operation of this receiver is identical to the operation of the grid leak detector receiver which you just constructed. However, you are going to find two things which are considerably different. First, the plate current as measured on your milliammeter is going to be considerably less than when using the grid leak type of detector. The reason for this is that the tube operates on the negative bend of its characteristic curve which decreases the plate current, while, in the grid leak type of detector, the tube operates on the positive bend of its curve which gives an increased plate current. The decreased plate current results in a decrease in sensitivity, so you will find the results not quite as good as when using the grid leak type of detector. For this reason, the set will appear to act a little bit more critically. In other words, you will have to tune very carefully, working with both the tuning condenser and volume control in order to secure satisfactory results.

This is an excellent demonstration of the difference between grid leak detection and grid bias detection. If you will refer to Lesson 18, Unit 1, you will find that the grid leak detector works as a square law detector and, for that reason, is considerably more sensitive than the grid bias detector. Now, while it is true that the grid bias detector will have the best quality, still, this cannot be indicated on the headphones because of their limited frequency response characteristics.

EXPERIMENT 23

BUILDING AN IMPEDANCE COUPLED AUDIO FREQUENCY AMPLIFIER.

In this experiment, you will add an impedance coupled A.F. amplifier, using a type 42 power output tube, to the grid leak detector built in Experiment 21. It will not be necessary to mount any new equipment, but several changes in the wiring diagram will have to be made.

A circuit diagram showing the entire experiment is shown in Fig. 7. The first thing to do in wiring this experiment is to provide filament voltage for the type 42 tube which is to be used in socket 10. The type 42 tube requires a voltage of 6.3 volts. Cut two pieces of hookup wire approximately 10 inches long. Twist these two pieces of wire together. Be sure that the bare ends do

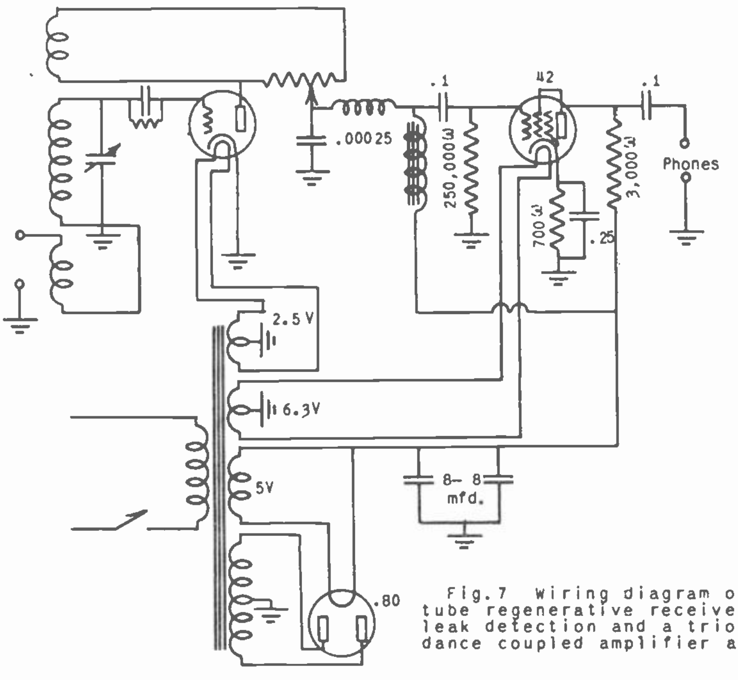


Fig.7 Wiring diagram of a three tube regenerative receiver. Grid leak detection and a triode impedance coupled amplifier are used.

not touch. One end of these two wires is to be connected to the filament prongs on the type 42 tube. A bottom view of this six prong socket is shown in Fig. 2D so that you will not make any mistakes as to which are the filament prongs. Solder these two connections. The other ends of the two twisted leads are to be connected to the 6.3 volt winding on your power transformer. In running these wires from socket 10 to the power transformer, run them in the most convenient manner so that they will be out of the way of the other wires of your set as much as possible.

You now have a piece of hookup wire connected to each of the two terminal lugs on the filter choke. Both of these pieces of hookup wire are to be completely removed. (Save this wire, because they will be replaced later.) The red positive lead of the double 8 mfd. electrolytic filter condenser now connected to the terminal lug on the terminal strip is to be removed and then connected to the heater terminal on the type 80 tube along with the red lead with white tracer from the double 8 mfd. condenser. This connection is shown in Fig. 7. Now, run a piece of hookup wire from the same heater terminal on the type 80 tube over to one of the terminal lugs on the terminal strip. To this same terminal lug, connect one pigtail end of a 3,000 ohm resistance and one pigtail end of the 10,000 ohm high wattage resistance which was used with the previous experiment. Solder this connection. The other pigtail end of the 10,000 ohm high wattage resistance goes to the positive terminal on the milliammeter. To the positive terminal is also connected one pigtail end of a 40,000 ohm resistance. The other pigtail end of this 40,000 ohm resistance is connected to ground by means of a conveniently placed solder lug. The other pigtail end of the 3,000 ohm resistance is to be connected to the plate terminal on the type 42 tube socket in hole 10. At the time this connection is made, use a piece of hookup wire and connect the screen grid terminal on the type 42 tube to the plate terminal. Also, place one pigtail end of a .1 mfd. condenser in the same terminal and solder the connection.

The piece of hookup wire which is now connected to the right-hand jack on the headphone jack is to be disconnected. The other pigtail end of the .1 mfd. condenser is connected to this jack in place of the hookup wire. The other end of this piece of hookup wire is connected to one terminal of the R.F. choke. This is left as is. The other end of this piece of hookup wire is to be connected to one of the free terminal lugs on the terminal strip. At the time this connection is made, connect a piece of hookup wire to the same terminal lug and solder the connection. The other end of this piece of hookup wire goes up to one of the terminals on the filter choke. The filter choke in this experiment is going to be used as the A.F. coupling choke To the remaining terminal on the filter choke, connect a piece of hookup wire and solder the connection. The other end of the piece of hookup wire just attached goes to the negative terminal on the milliammeter. This piece of hookup wire can be the wire which was formerly connected from the negative terminal of the meter to the left hand terminal on the headphone jack. Place a solder lug under the left hand bolt holding the strip in place and ground the left hand post to this lug using a short piece of wire. All of these connections are clearly shown in Fig. 7.

You now have a piece of hookup wire running from one terminal on the R.F. choke to a terminal on the A.F. or filter choke. To this same terminal on the R.F. choke, connect one pigtail lead of a .1 mfd. condenser. The other pigtail lead of this condenser is to be connected to the grid terminal on the type 42 tube. At the same time, this connection is made, connect one pigtail end of a 250,000 ohm resistance to the same terminal and solder the connection. The other pigtail end of the 250,000 ohm resistance is connected to the chassis by means of a conveniently placed solder lug. Be sure to solder the connection.

Now connect one pigtail end of a 700 ohm resistance and one pigtail end of a .25 mfd. condenser to the cathode terminal on the type 42 tube. Solder the connection. (The .25 mfd. condenser which is to be used at this point is the condenser which was formerly used across the cathode resistance on the type 56 tube. This condenser and resistor are to be removed.) The other pigtail end of the 700 ohm resistance and the .25 mfd. condenser are connected to ground or chassis by using a conveniently placed solder lug.

Now that we have removed the cathode resistor and the condenser from the type 56 detector tube, it will be necessary to ground the cathode on the type 56 tube. This can be done by placing a solder lug under the right-hand bolt which holds this five prong socket in place. Then, take a piece of hookup wire and connect between the solder lug and cathode prong and the tube's cathode will be grounded, as shown in Fig. 7. It will also be necessary to remove the piece of hookup wire which now runs from the grid prong on socket 1 to the grid prong on socket 2. This will then cause the -56 tube to be operated as a grid leak detector again.

Now, if you have followed directions carefully, your experiment should be wired up complete, as shown in Fig. 7.

Now plug a type 30 tube in socket 13, a type 56 tube in socket 1, the five prong coil form in socket 2 and a type 42 tube in socket 10. With the headphones plugged in, you are then ready to test this experiment. An aerial should be connected to the aerial post on the aerial-ground strip and a ground should be connected to the ground post. The set is to be operated exactly the same as Experiment 21. The only difference is this. There will be considerably more volume because of the additional stage of A.F. amplification. Also, there is apt to be a slight amount of hum, because our filter system does not use a filter choke. However, the hum is not excessive and I am sure you will be agreeably surprised at the extraordinary results which may be secured from this receiver. The chief factor in securing good results from any of these experiments is a good aerial and ground system and expert operation on the part of the experimenter. Your learning how to properly operate this equipment will insure extraordinary results. If you are careless in operation, you are apt to be disappointed in the results which can be secured.

EXPERIMENT 24

BUILDING A RESISTANCE COUPLED AUDIO FREQUENCY AMPLIFIER.

In building this amplifier, it will be possible for you to compare the results obtained when using resistance or impedance coupling. The three tube set built in this experiment will be used in conjunction with several following experiments, so it is advisable to do your work exceptionally careful to insure the best in results.

Since we do not need the filter choke as a coupling choke, we are going to again wire it into the power supply system. The first step, therefore, is to disconnect the two leads now connected to the filter choke; that is, disconnect both of these leads at both ends and remove them entirely. Unsolder the red with white tracer positive lead on the double 8 mfd. filter condenser from the heater terminal on the type 80 tube in socket 13. Run a piece of hookup wire from this terminal to one terminal of the filter choke. From the other terminal of the filter choke, run a piece of wire to the terminal lug on the terminal strip to which you now have connected the 3,000 ohm plate resistance for the type 42 tube and the 10,000 ohm high wattage resistance which is used as a bleeder resistance for the detector stage. To this same terminal lug, connect the positive terminal of the 8 mfd. filter condenser which you just disconnected from the type 80 tube.

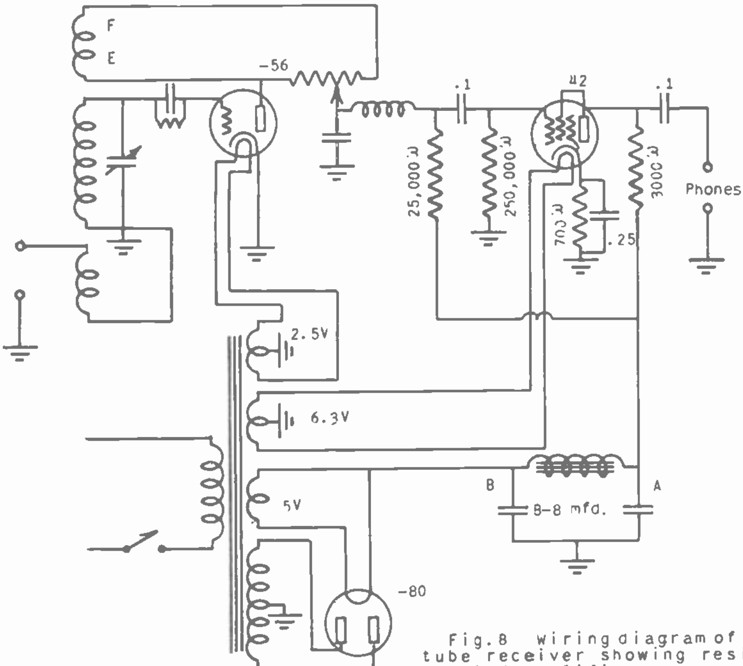


Fig.8 wiring diagram of a three tube receiver showing resistance coupled amplifier.

You now have a piece of hookup wire running from one terminal of the R.F. choke to a free terminal lug on the terminal strip. Disconnect this piece of wire entirely at both ends. Now, connect one pigtail end of a 25,000 ohm resistance to the negative terminal of your milliammeter. Solder the other pigtail end of the 25,000 ohm resistance to the lug on the radio frequency choke from which you just disconnected the piece of hookup wire. If you have followed the directions carefully, you will then have your experiment wired as shown in Fig. 8.

With a type 80 tube plugged in socket 13, a type 42 tube plugged in socket 10, a type 56 tube plugged in socket 1 and the five prong coil form plugged in socket 2, you are ready to test the results of this experiment. You will find the tuning of this receiver no different from the others which you have used. However, the hum should have been entirely eliminated because you now have the filter choke back in the power supply circuit and this should eliminate any hum which would be encountered in the system.

Since you do not have accurate instruments with which to measure the sensitivity of a receiver, it will be difficult for you to notice any difference in the operation characteristics between the resistance coupled amplifier and the impedance coupled amplifier. However, the amplification or sensitivity which can be secured from the resistance coupled amplifier is not quite as great as from the impedance coupled amplifier. The reason for this is that the audio frequency choke presents a greater load impedance to the type 56 detector tube and this results in greater amplification being secured. However, the ear will probably not detect the difference in the two circuits.

EXPERIMENT 25

CHANGING TUNING CONDENSER CAPACITY

(Series and Parallel)

In this experiment, it is only necessary to make two simple changes in your previous experiment to test the effect of connecting condensers in series or parallel. If you have the receiver built in Experiment 24 functioning properly, it is advisable to make a note of the approximate position of the rotor plates on your variable condenser with certain strong broadcasting stations tuned in. If possible, you should find stations that are easy to receive and at least one which requires practically the maximum capacity of the tuning condenser. You should also locate another station which comes in at the lower end of the capacity range of the tuning condenser.

Without changing any other part of your experiment, first unsolder the piece of hookup wire which is now connected to the stator plates on the back section of your tuning condenser. To this solder

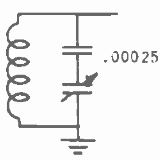


Fig.9 Diagram showing fixed condenser connected in series with tuning condenser.

lug, solder one pigtail end of a .00025 mfd. mica condenser. Now, bend the pigtail leads of this condenser so that it will stick up away from the chassis so there will be no danger of either pigtail end touching the chassis itself. Next, bend the loose pigtail end around in such a position that it just comes down and touches the piece of hookup wire which formerly connected to the stator plates. Solder this piece of hookup wire to the loose pigtail end. You will then have the .00025 mfd. condenser connected in series with the tuning condenser, as shown in Fig. 9.

Now, set your receiver into operation. With the material reduction in capacity of your tuning condenser, you will find that a station which formerly used only a very small amount of the tuning condenser capacity now requires practically all of the capacity. If you formerly received a station which required turning the rotor plates about $\frac{1}{4}$ in mesh with the stator plates, you will find that same station is now tuned in with the rotor plates turned $\frac{3}{4}$ of the way in mesh with the stator plates.

The maximum capacity of the back section of your tuning condenser is .00035 mfds. The capacity of the mica condenser which you just connected in series with the tuning condenser is .00025. Now, using your rule for calculating capacities in series, find the capacity of this series arrangement.

Leaving the one pigtail end of the .00025 mfd. condenser connected to the stator plates of the tuning condenser, unsolder the other pigtail end from the piece of hookup wire to which it was just connected. Connect the piece of hookup wire back to the solder lug on the stator plates and resolder the connection. Now, solder the loose pigtail end of the .00025 mfd. mica condenser to a solder lug which you have just bolted to the small hole in front of hole #4. You then have the two condensers connected in parallel, as shown in Fig. 10.

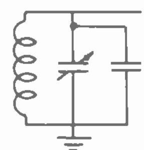


Fig. 10 Diagram showing fixed condenser connected in parallel with tuning condenser.

Set your receiver into operation and tune in stations in the usual manner. You now have the .00035 mfd. tuning condenser connected in parallel with the .00025 mfd. mica condenser. Using this arrangement, you will find that a station which formerly used practically the entire capacity of the tuning condenser now uses only about $\frac{1}{3}$ of the capacity, or even less. Using your formula for capacities in parallel, calculate the total capacity of the two condensers.

EXPERIMENT 26

CHECKING HUM IN AMPLIFIERS

After completing Experiment 25, you should return your equipment to the same condition as used in Experiment 24. In this experiment, you will study the effects, on the amount of hum present in the output of this receiver, when various changes are made in the filter circuit.

The red lead with the white tracer coming from the 8-8 mfd. electrolytic filter condenser is now connected to one of the terminal lugs on the terminal strip. This is connection A as shown in Fig. 8. Unsolder this connection. The second section of the 8-8 mfd. electrolytic condenser is then no longer in use. Turn on your receiver and operate it in the usual manner. You will notice a slight increase in hum and this will be most noticeable when there is no station tuned in on your set.

The red lead coming from the 8-8 mfd. electrolytic filter condenser is connected to one of the filament terminals on the type 80 tube (socket 13). This is connection B as shown in Fig. 8. Unsolder this connection so that both sections of the filter condenser are inoperative. Then, operate your receiver in the usual manner and note the amount of hum present in the output. In the filter circuit now being used, only a choke is available, since both sections of the filter condenser have been disconnected.

The next step in this process is to remove the choke from the circuit so that there will be no filter in the power supply system. The easiest way to do this is to short the choke out. Use a piece of hookup wire and solder one end of it to the heater terminal on the type 30 tube, and the other end to the terminal lug on the terminal strip to which the choke is connected. This shorts out the choke and prevents it from being a art of the filter circuit. This procedure is the same as connecting a piece of hookup wire between points A and B in Fig. 8. Now, turn on the receiver again and operate it in the usual manner. You will find that the hum is exceptionally loud, in fact, completely intolerable. In other words, no stations can usually be received with the set in this condition, because the pulsating direct current supplied the receiver tubes causes so much noise in the output that it is usually impossible to hear a broadcasting station over or through this noise.

The next step in this process of experimentation is to resolder the two condenser leads to their respective positions, leaving the choke short circuited. Now you have 16 mfds. of capacity connected across the output circuit of the filter, with no choke in the circuit. This is the same type of connection as was used in Fig. 7 of Experiment 23. With these connections made, operate the receiver in the usual manner and note the difference in hum when using only the choke, or when using only the capacity. You will find, I am sure, that the capacity alone provides the best filtering. However, the complete action of the two condensers and the choke supplies the nearest to a pure direct current output and, of course, gives the best results.

EXPERIMENT 27

TESTING EFFECTS OF REGENERATION

(Including the effects of degeneration)

In this experiment, you should return your apparatus to the same condition as existed in Fig. 8 of Experiment 24. With this receiver functioning correctly, you are then ready to test the effects of regeneration. I am sure you will be surprised at the difference between a receiver using regeneration and one which does not. There will be two marked differences. First, there will be a noticeable decrease in volume on a given station, and, second, the selectivity of the receiver will be materially reduced. Where it was possible to separate stations before, you will find it practically impossible to do so when not using regeneration.

You now have a piece of hookup wire connected between the plate prong on socket #1 and the plate prong on socket #2. From there a piece of hookup wire connects to one of the outside terminals on the volume control potentiometer, (this is the outside terminal nearest the chassis). Unsolder the two pieces of hookup wire now attached to the plate prong on socket #2. Then, solder the ends of these two pieces of hookup wire together. This disconnects the plate of the type 56 tube from the tickler coil at the point marked E in Fig. 8, but leaves the plate of the 56 tube connected to the outside terminal on the volume control potentiometer. With the plate end of the tickler or regeneration coil disconnected, the effects of regeneration have been removed. In conducting this experiment, be sure to not permit the bare end of the two wires just soldered together to touch any other piece of apparatus or the metal chassis.

With this change made, now set the receiver into operation. The volume control potentiometer will still act as the volume control for your receiver, but it will no longer control regeneration. The set is tuned the same manner as in previous experiments, except that it is not nearly so critical in operation. However, if it so happens that you live any great distance from a broadcasting station, it is possible that you may not be able to receive stations when using this type of set. However, if you are able to pick up any of the stations which you usually receive, you will notice a marked decrease in volume over that when using the set in Experiment 24. Another thing which you will notice is that the set is no longer as selective as formerly, and that stations have a tendency to run together, or interfere with each other. This experiment then conclusively demonstrates the principles of regeneration as described in Lesson 23 of Unit 1.

The second part of this experiment is to test the effects of degeneration. Whenever degeneration occurs, it means that a voltage is built up in the plate circuit such as to oppose the voltages in the grid circuit, and, therefore, produce cancellation instead of addition. The first step in carrying out this part of this experiment is to resolder the two connections to the plate prong on socket #2. This returns the circuit to the same status as when used in Experiment 24, Fig. 8. If you have built your experiment properly, your regenerative coil, which is the top coil on the coil form, has been so connected that it will produce regeneration and, therefore, materially increase the selectivity and amplifying ability of the receiver. You are now going to reverse the connections on this coil so that it will produce degeneration instead of regeneration. The regenerative coil is now connected to the plate prong and the heater prong (H_1) next to the plate prong on socket #2.

There are two connections now made to the plate prong. Unsolder both of these. There is one connection now made to the heater prong (H_1) next to the plate prong. Unsolder this connection and move it over to the plate prong. Then, solder the two connections which you just unsoldered from the plate connection to the heater prong (H_1) next to the plate prong. This then reverses connections E and F, as shown in Fig. 8.

With these connections completed, you are now ready to place the receiver in operation. The volume control potentiometer will still control the volume of this receiver, but you are going to find that the results are very poor. In fact, the volume will be reduced considerasly over that experienced in the first part of the experiment, and you will find that the selectivity has also been reduced materially. The conclusion of this experiment definitely proves that regeneration is of material advantage in this type of receiver.

EXPERIMENT 28

BUILDING PENTODE OUTPUT AMPLIFIERS.

The first thing to do in constructing this experiment is to replace the changes just made in Experiment 27. In fact, you should place your receiver into operation so that it is functioning and is wired the same as shown in Fig. 8 of Experiment 24.

In our previous experiments, the type 42 power output tube has been operating as a triode; that is, the screen grid has been tied to the plate. In this particular experiment, you are going to change the type 42 tube from triode operation to pentode operation. This will produce a material gain in voltage and should cause your receiver to operate much more satisfactorily.

You now have a 3,000 ohm resistor connected from one of the solder lugs on the terminal strip over to the plate terminal on socket #10. (See Fig. 2, D.) Unsolder the pigtail lead of the 3,000 ohm resistance at the plate prong on socket #10. Then, solder the pigtail lead of a 4,000 ohm resistance to this plate prong, and, at the same time, unsolder the piece of hookup wire which is connected between the plate prong and the screen grid prong on socket #10. The free pigtail end of the 4,000 ohm resistance is now soldered to the free pigtail end of the 3,000 ohm resistance, and this results in supplying a total of 7,000 ohms as the plate load resistance for the type 42 tube, when operated as a pentode. Next, solder a piece of hookup wire to the screen grid terminal on socket #10 and then solder the other end of the piece oof hookup wire to the terminal lug on the terminal strip, to which one pigtail end of the 3,000 ohm resistance is now connected.

Now, if you have carefully followed directions, your experiment is wired as shown in Fig. 11. There is one precaution that you should take at this time. It will be necessary for you to so bend the pigtail leads on the 4,000 ohm and 3,000 ohm resistors so that there is no danger of any part of these resistors touching any of the equipment or the metal chassis. There is plenty of room underneath the chassis, so we are sure you will be able to arrange your experiment so that it will produce correct results.

The receiver is now ready to be placed into operation. Because of the extra voltage gain secured from the type 42 pentode tube, I am sure that you will find this receiver vastly superior to any

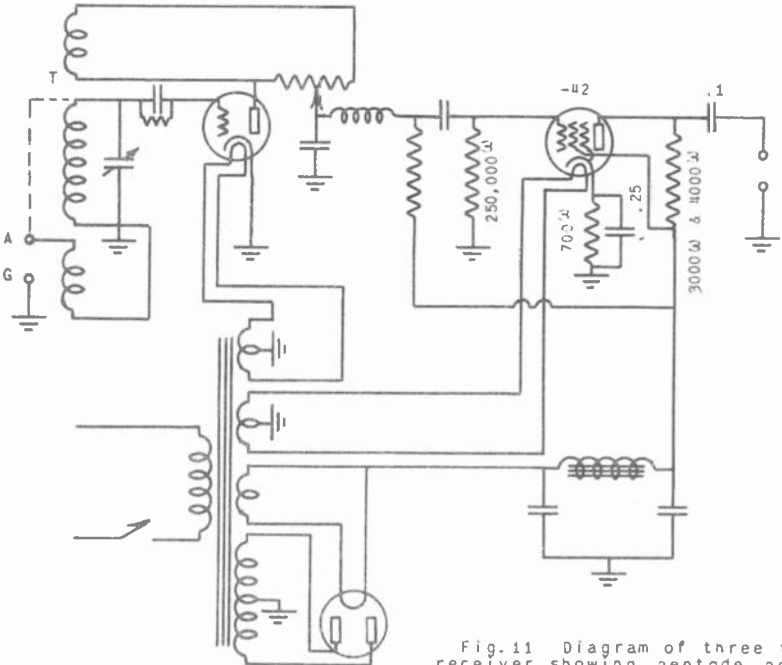


Fig. 11 Diagram of three tube receiver showing pentode power amplifier.

which you have constructed thus far. The receiver will operate exactly as described in Experiment 21 and, on the more powerful stations, it would be possible to operate a small loud speaker from this receiver. A loud speaker will be supplied with one of your later experimental shipments.

EXPERIMENT 29

CHECKING VOLTAGE GAIN OF R.F. TRANSFORMERS.

In this experiment, you are going to use the apparatus built in Experiment 28. Before attempting to conduct this experiment, be certain that your set is working good so that you will be able to notice any change in the results secured. You now have a piece of hookup wire connected from the aerial post on the A and G strip over to the heater prong (H_2) next to the cathode prong on socket #2. Unsolder the hookup wire at the heater prong (H_2) next to the cathode prong, and then connect this same lead to the grid prong on socket

#2. By making this change, the aerial will then be connected directly to the grid end of the secondary coil, as shown by the dotted lines and connection T in Fig. 11. This is the only change necessary in conducting this experiment.

When using the receiver built in Experiment 28, the aerial was connected to the primary coil and, since this is a step up transformer, it produced a voltage increase. This type of circuit also materially aids the selectivity. Now, in this experiment, the aerial is connected directly to the top end of the secondary coil. The transformer is no longer a part of the circuit and so we do not have a voltage gain due to the step yp action of the transformer.

With the receiver placed in operation, you will notice that there is a slight decrease in volume on the stations which you are able to pick up. You will also notice that there is a material decrease in the selectivity of this receiver. This type of receiver was popular in the years 1920 to 1924. It was known as the old "single circuit regenerative receiver". However, during that period, there were very few broadcasting stations and so selectivity was not as important as it is today. The reduction in volume was not material and the simplicity of construction caused the circuit to be used in a large number of the receivers built during that period.

After you have completed this experiment, it is advisable to return your apparatus to the condition under which it was operated in Experiment 28.

Notes

(These extra pages are provided for your use in taking special notes)

The text of this lesson was compiled and edited by the following members of the staff:

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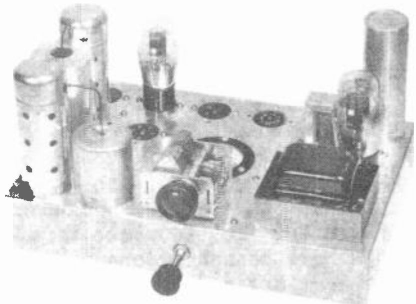
GROUP NO. 4

LABORATORY EXPERIMENTS

EXPS. NO. 30 TO 38

LABORATORY EXPERIMENTS

Group Four



"This group of experiments is in reality a continuation of the experiments just concluded. However, considerable additional experience will be provided by the building of new types of circuits.

The electron - coupled detector circuit which you are to build has surprising efficiency and the operation of this circuit will teach you the principles of this interesting type of detector."

EXPERIMENT 30

ADDING SCREEN-GRID UNTUNED R.F. AMPLIFIER TO TRIODE DETECTOR.

In this experiment, you are going to use one of the new type multi-mu screen-grid tubes, type 6D6, as an untuned radio frequency amplifier. This stage of amplification will precede the type 56 detector which you are now using and will provide additional sensitivity to Experiment #28.

You now have 6 prong sockets mounted in holes #5, #8, and #10. The 6D6 tube used in this experiment will be placed in socket #5. Since the heater voltage on a 6D6 is the same as the type 42 tube, it will be necessary to wire the heaters of these two tubes in parallel. Cut two pieces of hook-up wire approximately 10" long, twist these two pieces of wire together. Be sure that the bare ends do not touch. One end of these two wires is connected to the heater prongs on the type 6D6 tube. A bottom view of this six prong socket is shown in Fig. 1. Solder these two connections. The other ends of the two twisted leads are to be connected to the heater prongs on the type 42 socket, which is now mounted in hole #10. In running these wires from socket #5 to socket #10, run the wires along the side and back of the chassis and up near the top. In this way, the wires will be as much out of the way as possible. The complete wiring diagram for this experiment is shown in Fig. 2.

In Experiment #28, you had the radio frequency choke coil connected in series with the plate of the type 56 tube mounted in socket #1. This is shown in Fig. 11 of Experiment #28. Since it is going to be necessary to use this choke coil as a coupling coil between the 6D6 tube and the type 56 tube, it will be necessary to make some changes in your wiring as it now stands.

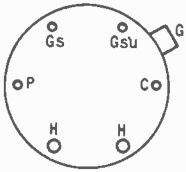


Fig. 1. Bottom view of six prong socket.

To one terminal of the R.F. choke, you now have connected one pigtail end of a .1 mfd. condenser and one pigtail end of a 25,000 ohm resistor. To the other terminal of the radio frequency choke, you now have connected one pigtail end of a .00025 mfd. mica condenser and one end of a piece of hook-up wire which goes to the center terminal on the volume control potentiometer. Remove all four of these connections. The radio frequency choke coil is now mounted in one of the small holes on one side of hole #4. In the other hole on the side of hole #4, bolt a terminal strip using a 6/32 bolt and nut. One of the terminal lugs on this terminal strip is going to be used as a supporting connection for the four connections which you just removed from the R.F. choke. Therefore, to the same terminal lug on this terminal strip, solder the pigtail end of the .1 mfd. condenser, the pigtail end of the 25,000 ohm resistor, the pigtail end of the .00025 mfd. mica condenser and the piece of hook-up wire. (The other end of this wire is connected to the center terminal on the volume control potentiometer.) This connection is shown at X in Fig. 2.

In Experiment #28, you had a piece of hook-up wire connected from the antenna terminal on the A & G strip over to the heater terminal (H2) next to the cathode terminal on socket #2. Unsolder this piece of hook-up wire at the heater terminal next to the cathode terminal, but leave it connected to the antenna terminal on the A & G strip. To the antenna terminal on the A & G strip, attach one pigtail end of a 25,000 ohm resistor. The other pigtail end of this resistor is to be soldered to ground. This can best be soldered to the ground post on the A & G strip. This is the 25,000 ohm resistor shown connected between aerial and ground in Fig. 2. The other end of the piece of hook-up wire which is now connected to the aerial lug is passed up through one of the holes around hole #6. To the other end of this piece of hook-up wire, solder a large grid clip. This grid clip is to go to the grid cap terminal on the 6D6 tube which is to be used in socket #5.

Now connect one end of a piece of hook-up wire to the B+ terminal on the terminal strip mounted next to the power supply system. This is point Y in Fig. 2. The other end of this piece of hook-up wire goes to one terminal lug on the radio frequency choke. At the time this piece of hook-up wire is connected to the radio frequency choke, connect one pigtail end of a 100,000 ohm resistor and solder the joint. The other pigtail lead of the 100,000 ohm resistor is to be connected to the screen grid terminal on socket #5. At the same time this connection is made, also connect one pigtail end of a .1 mfd. condenser, then solder the connection. The other pigtail end of the .1 mfd. condenser is to be connected to any conveniently placed solder lug. This condenser is shown as C_1 in Fig. 2.

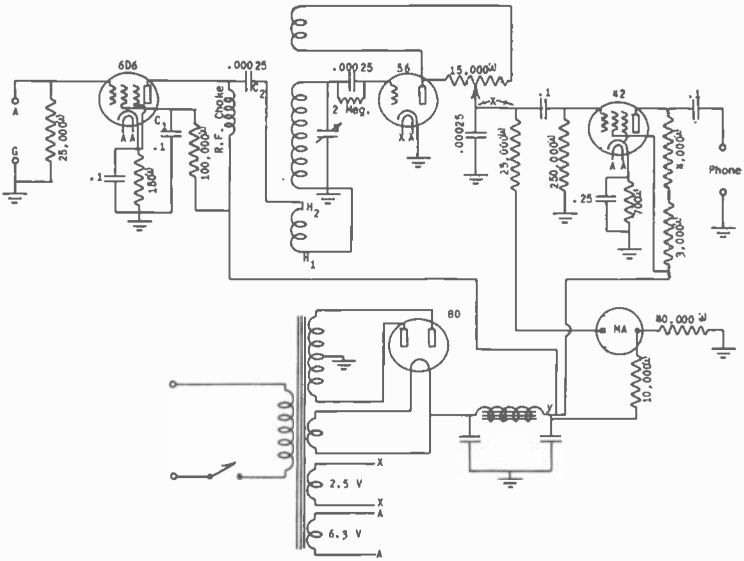


Fig. 2. Wiring diagram of four tube regenerative receiver using untuned type 6D6 R.F. amplifier.

Now connect a piece of hook-up wire to the free terminal of the radio frequency choke. Solder the connection. The other end of this piece of hook-up wire goes to the plate terminal on the 6D6 tube mounted in socket #5. At the time this piece of hook-up wire is connected to the plate terminal, also connect one pigtail end of a .00025 mfd. mica condenser to the same terminal and solder the connection. The other pigtail end of the .00025 mfd. condenser is to be connected to the heater prong (H_2) next to the cathode prong on socket #2. However, the pigtail end of this condenser will not reach, so it will be necessary to solder on a short piece of hook-up wire to the pigtail lead. The other end of the piece of hook-up wire then goes to the heater prong next to the cathode prong on socket #2. This condenser is shown as C_2 in Fig. 2.

Next connect one pigtail end of a 150 ohm resistor to the cathode prong on the type 6D6 tube mounted in socket #5. Also, connect one pigtail end of a .1 mfd. condenser to the cathode prong and solder the connection. At the same time, connect a piece of hook-up wire between the cathode prong and the suppressor prong on this socket and solder the connection. The other pigtail end of the 150 ohm resistor and the other pigtail end of the .1 mfd. condenser are to be grounded to any conveniently placed solder lug. It will probably be most convenient to use the solder lug which is now mounted in the center hole between holes #5, #6, #7, and #8.

Now, if you have carefully followed directions, your experiment should be wired up exactly as shown in Fig. 2. Next, plug a type 56 tube into socket #1, your 5-prong coil form into socket #2, a type 6D6 tube in socket #5 (connect the grid clip to the grid cap), a type 42 tube into socket #10, and a type 80 tube in socket #13. Then plug in your experiment to a 110-volt line and turn on the experiment. With an aerial and ground connected to the aerial and ground posts, and your headphones plugged into the headphone jacks, you are then ready to operate the receiver. There is no difference in the operation of this receiver and the one described in Experiment #28. However, you should notice an increase in sensitivity, because of the added stage of radio frequency amplification. If it so happens that you live comparatively close to a broadcasting station, there is a possibility that the type 56 detector tube will become overloaded and distortion will be indicated. There is no cure for this except the proper operation of your volume control potentiometer.

In case you have any difficulty and your experiment fails to operate satisfactorily, here are some of the things you can do in locating the trouble.

(1) Go over your wiring diagram and directions very carefully and make sure everything is connected exactly as shown and described. It is quite easy to overlook a mistake, so do this very carefully.

(2) Sometimes if you have a tendency to use too much solder, there is a danger of short circuiting some terminal lug on a socket by having the solder run down and make a connection between the terminal lug and the chassis. Check all of these carefully.

(3) Be certain that the pigtail lead of any condenser or resistor does not touch the chassis unless it is supposed to. Ofttimes, the pigtail ends of a condenser or resistor may be pushed through a solder lug terminal too far, and it will make contact with the chassis without your knowing that the condition exists. Careful checking will usually disclose such a condition.

(4) Because of the comparatively crowded condition of some of the resistors and condensers in your set, it is advisable to check up and see that the pigtail leads of a condenser and resistor do not touch each other unless they are supposed to. Check this over carefully.

EXPERIMENT 31

WINDING ELECTRON-COUPLED RECEIVER COILS.

In this experiment, you are going to change the regenerative coil which you wound in Experiment #20 to a different type of coil so that it will be possible to use an electron - coupled detector. In Experiment #20, you used four of the five holes drilled in the side of your coil form. These were holes A, B, C, and D of Fig. 3 in Experiment #20. Now, in this experiment, you are going to use holes A, B, D, and E. Hole C, as shown in Fig. 3, will not be used. (In case the coil form which you now have does not have hole E in it, it will be necessary for you to drill this hole with a very fine drill. Hole E is one-eighth inch above hole B. Drill this hole before starting to wind the coil.)

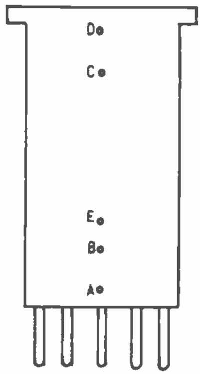


Fig. 3. Side view of five prong coil form.

The first coil to be wound is the primary or antenna coil. It is the coil which will be wound at the bottom of the coil form. Scrape the insulation from your magnet wire for about three-quarters of an inch, and then pass the free end through hole A. Pull it up through the top of the coil form and then pass it down through the heater prong (H_1) next to the plate prong on the coil form. Bend the end over and carefully solder the connection as per your instructions in Experiment #20. A bottom view of the 5 - prong coil form and the connections for these coils are shown in Fig. 4. Now, holding the coil form prongs in your left hand, and winding toward you, wind 21 turns of wire on the primary coil. Cut the wire off so that it will be sufficiently long and then scrape the insulation off at about where the wire will pass through the coil form prong. Pass the end of this wire through hole B, up through the top of the coil form and then back down through the heater prong (H_2), next to the cathode prong. Be certain that where this wire comes through the prong that it is bare so that a good soldered connection can be made. Then solder the connection.

The next coil to be wound is the cathode coil. Scrape the insulation from your magnet wire and pass one end of this wire through hole B, as shown in Fig. 3. After the wire is passed through hole

B, it goes down through the plate prong. Be certain the wire is bare where it goes through the plate prong, and then solder the connection. Then, holding the coil form with the coil prongs in your left hand, and winding towards you (this is in the same direction that you wound the primary coil), wind 7 turns of wire on your coil form. This should fill the space between the holes B and E, as shown in Fig. 3. Cut the magnet wire off so that it will reach, scrape the insulation from the end of the wire, then pass the end of this wire through hole E and down through the cathode prong. Do not solder the connection, but be sure that the wire is bare where it goes through the cathode prong. Now, scrape the insulation off from your magnet wire again, pass the end through hole E, and then down through the cathode prong again. In other words, the top end of the cathode coil and the bottom end of the secondary

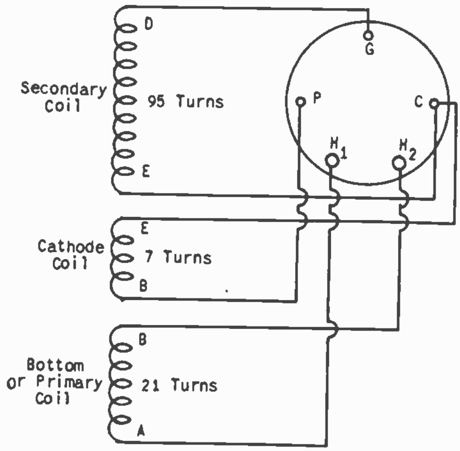


Fig. 4. Connection diagram for electron coupled regenerative coil wound on a five prong coil form.

coil are to be connected to the cathode prong as shown in Fig. 4. When you have this piece of wire inserted in the cathode prong, you can then solder the connection, take up the slack, and prepare to wind the secondary coil. Holding the coil in the same manner and winding in the same direction, wind 95 turns of wire on the secondary coil. This should practically fill the space between holes E and D, as shown in Fig. 3. When you have this number of turns wound, cut off the wire, scrape the insulation, pass the free end through hole D and then down through the grid prong on the 5-prong coil form. Be certain that the coil is wound tightly and that the wire is bare where it goes through the grid prong. Then solder the connection.

Now, if you have carefully followed directions, your electron-coupled coil is wound and the connections are made as shown in Fig. 4. THERE IS ONE WARNING THAT YOU MUST HEED. THIS COIL MUST BE WOUND SO THAT ALL PARTS OF IT ARE WOUND IN THE SAME DIRECTION, OR YOUR EXPERIMENT WILL NOT WORK AT ALL. With your electron-coupled regenerative coil wound, you are then ready to proceed with the next experiment.

EXPERIMENT 32

BUILDING AN ELECTRON-COUPLED DETECTOR.

In this experiment, you are going to use the special electron-coupled coil which you just wound in Experiment #31 to build one of the most sensitive and most interesting types of detector circuits known to the radio profession today. While you have just completed building some very interesting circuits, still, I am sure you are going to be extremely well pleased with the performance of this particular circuit.

It is going to be necessary to make a few changes in the circuit which you were using as shown in Fig. 2 of Experiment #30. However, we will hold these changes to a minimum, and if you follow directions carefully, you should have no difficulty in securing excellent performance from this three-tube receiver.

You now have 5-prong sockets mounted in holes #1 and #2 and 6-prong sockets mounted in holes #5, #8, and #10. Since the electron-coupled detector can be operated only when using a screen-grid type of tube, it is going to be necessary to mount a 6-prong socket in hole #1. Unsolder all of the connections which you now have made to the 5-prong socket in hole #1 and remove the socket. Unsolder any connections which you may have made to the six prong socket mounted in hole #8 and remove the socket. Then mount the 6-prong socket in hole #1 and the 5-prong socket in hole #8. In mounting the 5-prong socket, it does not make a great deal of difference in which direction the heater prongs are placed. However, in mounting the 6-prong socket in hole #1, be sure that the heater prongs are toward the front of the chassis.

In disconnecting the wire leads from the 5-prong socket when mounted in hole #1, you disconnected two heater wires. Now connect these same two heater wires to the heater prongs on socket #1, which is now a 6-prong socket. The other end of these two heater wires is connected to the 2½ volt terminals on your power transformer, because the type 56 tube took a filament voltage of 2½ volts. However, the type 6C6 tube which you are now going to use in socket #1 requires a filament voltage of 6.3 volts. Therefore, it will be necessary to change the two heater leads on your power transformer; that is, connect these two heater leads which were formerly connected to the 2½ volt terminals of the power transformer over to the 6.3 volts terminal on the same transformer. You will then have 6.3 volts applied to the 6C6 electron-coupled detector tube as shown at A, in Fig. 5.

In Experiment #30, you had a piece of hook-up wire running from the plate terminal on socket #1 over to the plate terminal on socket #2 and from there to one of the outside terminals on your volume control potentiometer. It will be necessary to remove these two pieces of hook-up wire. Next, to the plate terminal of the type 6C6 tube connect a piece of hook-up wire and solder the connection. The other end of this piece of hook-up wire is to go to the terminal lug on the terminal strip to which is now connected the following: The pigtail terminal of a .1 mfd. condenser, the pigtail terminal of a .00025 mfd. mica condenser, and the pigtail terminal of a 25,000 ohm resistance. Also, a piece of hook-up wire goes from this same terminal lug over to the center terminal on the volume control potentiometer. Remove the pigtail terminal of the 25,000 ohm resistance and remove the piece of hook-up wire which goes to the center terminal of the volume control potentiometer. After you have removed these connections, here is what you will have connected to this terminal lug on the terminal strip. The

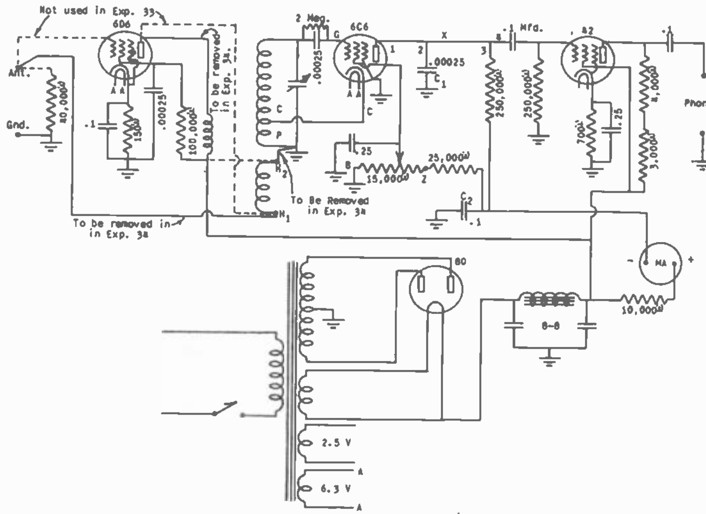


Fig. 5. Four tube electron coupled receiver with untuned R.F. amplifier.

pigtail end of a .1 mfd. condenser which is connected between the plate of the 6C6 and the grid of the type 42 tube. You will also have connected to this same lug, one pigtail terminal of a .00025 mfd. mica condenser. This is condenser C_1 in Fig. 5. The other pigtail terminal of this condenser is connected to a conveniently placed solder lug. To this same position, you will have a piece of hook-up wire, the other end of which is connected to the plate terminal on the type 6C6 detector tube placed in socket #1. Now after checking up, connect the pigtail terminal of a 250,000 ohm resistor to this terminal. All in all, you have 4 connections to the same terminal lug on the terminal strip. This is point $X_{1,2,3,4}$ in Fig. 5.

To the negative terminal of your milliammeter, you now have connected one pigtail end of a 25,000 ohm resistor.. To this same negative terminal, you should now connect the free pigtail end of the 250,000 ohm resistance which you just soldered to one of the terminal lugs on the terminal strip. Also, at the same time, connect one pigtail end of a .1 mfd. condenser. You may encounter a little difficulty in connecting three pigtail leads to the negative terminal on the milliammeter; however, if you are careful in your work, this can be accomplished.

Now connect the free pigtail terminal of the 25,000 ohm resistance to the outside terminal on your volume control potentiometer. (Thus is the outside terminal nearest you.) This is point Z in Fig. 5. To this terminal of the potentiometer, there is now connected a piece of hook-up wire which goes over to the heater terminal next to the plate terminal on socket #2. Remove this piece of hook-up wire entirely.

The other pigtail end of the .1 mfd. condenser is to be connected to ground. It should be soldered to any conveniently placed solder lug. This is condenser C_2 in Fig. 5.

At the present time, you have connected to the positive terminal of your milliammeter the pigtail end of a 10,000 ohm resistor, and the pigtail end of a 40,000 ohm resistance. The other pigtail end of the 10,000 ohm resistance goes to B plus output on your power supply. The other pigtail end of the 40,000 ohm resistance is connected to ground by soldering to a solder lug. The 10,000 ohm resistance should be left in the circuit, the 40,000 ohm resistance should be entirely removed.

There was a piece of hook-up wire connected from the center terminal of the volume control potentiometer to a terminal lug on the terminal strip mounted next to the radio frequency choke. This piece of hook-up wire is to be removed because it is not long enough to make the next connection. Now connect a piece of hook-up wire to the center terminal of the volume control potentiometer and solder the connection. The other end of this piece of hook-up wire goes to the screen grid terminal on socket #1, in which will be placed a type 6C6 tube. At the same time this piece of hook-up wire is soldered to the screen grid terminal, also solder one pigtail end of a .25 mfd. condenser. The other pigtail end of the .25 mfd. condenser is to be soldered to any conveniently placed solder lug. WARNING: IN MAKING CONNECTIONS WITH RESISTORS OR CONDENSERS, DO NOT CUT OFF THE PIGTAIL LEADS IF THEY ARE TOO LONG. THESE LONG LEADS ARE APT TO BE NEEDED LATER. MERELY FOLD THE LEAD UP, DO NOT CUT IT OFF.

From the outside terminal on the volume control potentiometer, (the one nearest the chassis), there is a piece of hook-up wire connected to the plate prong on socket #2. Leave this piece of hook-up wire soldered as is. Now connect a piece of hook-up wire from the plate terminal on socket #2 to a conveniently placed solder lug. This will probably be a solder lug placed under the left hand bolt which holds socket #2 in place. This is connection B and P in Fig. 5.

The next operation is to ground the heater prong (H_2) next to the cathode prong on socket #2. Place a solder lug under the right hand bolt holding socket #2 in place, and connect a piece of hook-up wire from the heater prong (H_2) next to the cathode prong to the solder lug. This is connection H_2 as shown in Fig. 5.

After completing Experiment #30, you had a 25,000 ohm resistance connected between the aerial and ground posts on the A & G strip. Remove this resistor entirely. You also had a piece of hook-up wire running from the aerial post on the A & G strip up to a grid clip, which was used formerly on the 6D6 untuned radio frequency amplifier tube. Remove the grid clip and pull the piece of hook-up wire back down through the hole in the chassis. This piece of hook-up wire should then be long enough to reach over to the heater prong (H_1) next to the plate prong on socket #2. This is connection H_1 in Fig. 5. The dotted lines shown connected to the aerial post show where these two connections were formerly made.

After completing Experiment #30, you had the pigtail end of a 2 megohm resistance, the pigtail end of a .00025 mica condenser and a piece of hook-up wire connected to the grid terminal on socket #2. These connections are to be left as is. The other end of the piece of hook-up wire was formerly connected to the stator plates on the back section of your tuning condenser. Now, since you are going to use both sections of the tuning condenser in an experiment to follow, it is going to be necessary to make a change at this time. Remove the piece of hook-up wire from the back stator section of the tuning condenser, and connect this same piece of wire to the front stator section of the tuning condenser. The wire should be long enough to reach, but in case it does not, then put a new piece of wire in its place. This will provide a connection between the solder lug on the front stator section of your tuning condenser over to the grid terminal on socket #2. The free pigtail end of the 2 megohm resistance and the .00025 mfd. mica condenser formerly went to the grid terminal on socket #1. However, these connections were unsoldered at the time we changed this socket from a 5-prong socket to a 6-prong socket. These two free pigtail terminals are now to be connected to one of the free terminal lugs on the terminal strip, which is mounted next to the radio frequency choke. At the same time, these two pigtail leads are connected to this terminal lug, also connect a piece of hook-up wire and solder the connection. The other end of this piece of hook-up wire is passed up through a convenient hole in the chassis and is made long enough so that it will reach the grid cap on a the 6C6 tube which is to be used in socket #1. Solder a grid clip on this piece of hook-up wire. This will then become connection G in Fig. 5.

The next connection to be made is to connect a piece of hook-up wire between the cathode terminal on socket #2 and the cathode terminal on socket #1. These connections are designated C and C in Fig. 5. In a previous experiment, the cathode terminal on socket #2 was connected to ground. Be sure to remove this ground connection.

Now take a piece of hook-up wire and ground the suppressor terminal on socket #1. The suppressor terminal of socket #1 can easily be determined by referring to Fig. 1. It is best to ground this terminal to a solder lug which has been placed under one of the bolts holding socket #1 in place.

In Experiment #30, you had a .00025 mfd. mica condenser connected between the plate prong on socket #5 and the heater prong next to the cathode prong on socket #2. It will be necessary to remove this condenser from the circuit, because the untuned radio frequency amplifier is not going to be used in this experiment.

Now place your electron-coupled detector coil in socket #2, a type 6C6 tube in socket #1, a type 42 tube in socket #10, and a type 80 tube in socket #13. Plug your headphones into the headphone jack, connect an aerial and ground to A & G posts on the aerial and ground strip and plug your receiver into the light socket. Turn the receiver on and give it time to warm up.

In operating this receiver, you will find that it operates practically the same as the other regenerative receivers which you constructed in previous experiments. However, you will find that this set is easier to tune, because you have smoother control of the regeneration. You will be agreeably surprised at the way in which this receiver will drag in the stations. However, if it so happens that you live comparatively close to a strong broadcasting station, you may have some difficulty in tuning out that station and securing weaker ones which are close in frequency.

Unless you have made some mistake in wiring up your receiver, you should have no difficulty whatsoever in getting this set to operate properly. The only possibilities for trouble beyond ordinary mistakes is in your electron-coupled detector coil. In winding that part of the coil which is connected between cathode and ground, if you are not careful and wind it in the same direction as the rest of the coil, it will be impossible to secure regeneration and so your set will not operate properly. Therefore, you must be very careful in the construction of the coil if you are to receive proper results.

EXPERIMENT 33

INCREASING SELECTIVITY OF ELECTRON-COUPLED DETECTOR.

After operating the electron-coupled detector stage which you built in Experiment #32, you will find that the experiment is not very selective (its ability to separate one station from another), but that it is quite sensitive. Your ability to bring in stations should be remarkable. Now, it so happens that a very simple change can be made which will materially increase the selectivity of this set. After making this change and testing out the results secured; it is then possible for you to use the receiver in whichever form gives you the most satisfactory performance.

You now have a piece of hook-up wire connected between the antenna post on the A & G strip, and the heater prong (H_1) next to the plate prong on socket #2. Unsolder this piece of hook-up wire at the heater prong and connect it to the cathode prong on socket #2. This then connects the antenna directly to the cathode of the type 6D6 electron-coupled detector. The heater prong (H_1) next to the plate prong is not connected to anything under these conditions.

When operating the electron-coupled detector in Experiment #32, you were using as the primary or antenna coil, the 21 turn coil connected between the two heater prongs H_1 and H_2. This antenna coil is comparatively large with respect to the secondary coil, and, while it produced considerable voltage gain (sensitivity), it materially reduced the selectivity of the receiver. Now in operating this experiment, the primary or antenna coil consists of that part of the coil connected between the cathode prong and the plate prong on the coil form. This is a 7 turn coil and is a part of the entire secondary coil. While the sensitivity may be reduced a little, selectivity will be materially increased, because of the reduction in the primary coil or the coupling between antenna and secondary, or the tuned circuit.

Two other interesting experiments can be conducted with your set operated in this manner. The first experiment is to connect a piece of hook-up wire between the two heater terminals; that is, between H_1 and H_2. This shorts out the primary coil which we are not using and changes the inductive relation between this primary and the secondary coil now in use. You will find that it changes the tuning of the set and perhaps may even change the sensitivity.

Next, remove this piece of hook-up wire and also remove the piece of hook-up wire which is now connected between the heater terminal (H_2) and ground. (This is the heater terminal next to the cathode terminal.) With this ground connection removed and the shorting connection removed, the coil is then entirely free and should have no effect upon the tuning of the receiver. Under these conditions, the set should operate most satisfactorily.

EXPERIMENT 34

ADDING SCREEN-GRID UNTUNED R.F. AMPLIFIER TO ELECTRON-COUPLED DETECTOR STAGE.

Since you have a 6-prong socket mounted in hole #5 completely wired up with the exception of one connection, it is going to be rather simple to add this untuned radio frequency amplifier to the electron-coupled 6C6 detector which you just constructed.

Disconnect the piece of hook-up wire which is now connected from the antenna post on the A & G strip to the cathode prong on socket #2. Pass this wire up through a hole in the chassis and again place a grid clip on the end of this wire. This grid clip is to be used on the grid cap of a 6D6 tube which will be used in socket #5. Next, connect a 40,000 ohm resistance across the aerial and ground posts of the A & G strip.

Unless you have previously removed it, you now have a piece of hook-up wire connected between one of the terminals on your radio frequency choke and the plate terminal on the type 6D6 tube mounted in socket #5. Remove this piece of hook-up wire entirely. Next connect a piece of hook-up wire from the plate prong on socket #5 to the heater prong (H_1) next to the plate prong on socket #2. This is the connection shown by the dotted line in Fig. 5, running from the plate of the 6D6 to the heater H_1. The connection shown by the heavy line has been removed between the R.F. choke and the plate of the 6D6 tube in socket #5: Also, the wire running from the antenna post to the heater prong H_1 and the ground connections from the heater prong H_2 to the solder lug have also been removed.

You now have a piece of hook-up wire connected from B plus of your power supply to one terminal of the radio frequency choke. To this same terminal of the radio frequency choke, you have one pigtail terminal of a 100,000 ohm resistance. The other end of this resistance is connected to the screen-grid terminal on socket #5, in which will be used a type 6D6 tube. Now connect a piece of hook-up wire to the same end of the R.F. choke to which you have the B plus lead and the 100,000 ohm resistance attached. The other end of this piece of hook-up wire is to be connected to the heater terminal (H_2) next to the cathode terminal on socket #2. This connection is shown by a dotted line in Fig. 5.

Now if you have followed directions carefully, you will have your experiment wired up properly. This will be according to the wiring diagram given in Fig. 5 and, insofar as the 6D6 tube is concerned, the wiring diagram is represented by dotted lines, instead of the heavy lines.

Place a 6D6 tube in socket #5, a 6C6 tube in socket #1, a type 42 tube in socket #10, a type 80 tube in socket #13 and your electron-coupled detector coil in socket #2. You are then ready to operate this receiver in the usual manner. You will find that the performance of the receiver has materially improved because of the added sensitivity provided by the 6D6 untuned radio frequency stage.

In adding radio frequency amplifiers, it is highly possible that unwanted regeneration may be produced, unless all parts of the set are properly shielded. Therefore, in completing this experiment, it is advisable to shield the 6D6 radio frequency amplifier tube and the 6C6 electron-coupled detector tube. In your last shipment of experimantal apparatus, you will find two tube shields.

These two tube shields consist of 3 pieces each. A base, the shield proper, and a top. Examination will readily show you that the base, when removed, can be bolted over the socket, using the same two bolts which hold the socket in place. Therefore, all you need to do is to remove the two bolts which now hold sockets #1 and #5 in place and bolt to the same position, a tube shield base. Then, place a tube in the socket, next place the shield itself over the tube and down firmly on the base, then connect the grid clip to the grid cap of the tube and put the tube shield's top on the top of the tube shield. However, you must be very careful that the tube shield top does not touch the wire leading from the grid clip or the grid clip itself. These tube shields will be used on all of your following experiments.

If your receiver seems to overload on the loud stations, the plate voltage on the 6D6 untuned R.F. amplifier should be reduced in the following manner. From one terminal of the R.F. choke, a piece of hook-up wire is connected to the B+ terminal of your power supply. Unsolder this wire at the output connection of the power supply and connect it to the positive terminal of the milliammeter. This then places the 10,000 ohm high wattage resistor in series with the plate and screen voltage supply of the 6D6 tube and will result in reduced voltages on these two elements. This will prevent the tube from overloading in case you have too much plate voltage applied to the tube.

EXPERIMENT 35

ADDING SCREEN-GRID TUNED R.F. AMPLIFIER TO ELECTRON-COUPLED DETECTOR STAGE

In this experiment, you are going to change the untuned R.F. amplifier which you built in Experiment #34 to a tuned R.F, amplifier. This change will provide additional selectivity and sensitivity to your receiver.

In your last shipment of experimental apparatus, you received a shielded R.F. coil. This coil was designed primarily to mount in hole #2, because it is to be used as the input stage for the 6 tube superheterodyne which you will build in the next group of experiments. Because of this, you may have just a little difficulty in mounting this shielded antenna coil in hole #6. However, if you follow directions carefully, you will be able to make the grade.

Fig. 6 shows a bottom view of this shielded antenna coil. A and B in this figure indicate the two mounting lugs which hold this coil shield to the metal chassis. C is the wooden spacer which holds the coil form in the center of the coil shield. Now with the chassis right side up and the front toward you, the antenna coil is to be mounted in hole #6, with the spacer C pointed toward your right. This is toward the milliammeter which is mounted in hole #16. Now, you will find that the mounting lug bolts A and B do not fit into the holes which surround hole #6. Therefore, it is going to be necessary for you to squeeze the shield so that these two mounting lug bolts will go into the two holes; one at the back and one at the front of hole #6. When mounted in this position, the spacing bar 6 is pointed todard your right. (The chassis is right side up and the front toward you.)

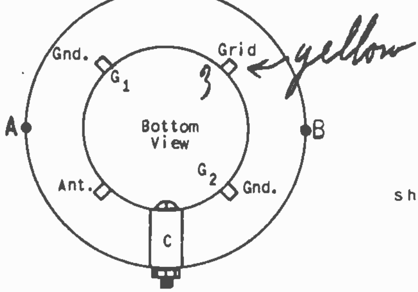


Fig. 6. Bottom view of shielded antenna coil.

Now turn the chassis upside down and the front toward you and put a 6/32 nut on each of the two mounting lug bolts. It does not make any difference if the ground terminal touches the metal chassis. You can tell which is the ground terminal by referring to Fig. 6 and counting around from the wood space pin. However, you must be very careful that the antenna connection does not touch the metal chassis. Bend this lug over so that it will be well away from the metal chassis and if there is any danger of this antenna lug touching the metal chassis, put a piece of heavy paper between the antenna lug and the metal chassis so that it cannot touch.

With the shielded antenna coil mounted in hole #6, we are now ready to wire up your experiment. First, solder a piece of hook-up wire to the solder lug on the back stator section of your two gang tuning condenser. Pass this wire down through the chassis, through a hole directly beneath the solder lug and connect the other end of this wire to the grid terminal on the shielded antenna coil. You can tell which is the grid terminal by referring to Fig. 6. At the same time this connection is made, connect another piece of hook-up wire to this grid terminal and solder the connection. Now, this piece of hook-up wire goes directly up through the center of the shielded antenna coil and must be made long enough so that after a grid clip is attached to the other end of this wire, it will reach the grid cap of the 6D6 tube which is used in socket #5. Cut the wire to the right length and solder on a large grid clip.

You now have a piece of hook-up wire connected to the aerial post on the A & G strip. To the other end of this piece of hook-up wire is connected a grid clip which in Experiment #34 connected to the grid cap of the tube which was placed in socket #5. Remove this piece of wire entirely. Also, remove the 40,000 ohm resisaance which is now connected between the A & G terminals on the A & G strip. To the aerial terminal on the A & G strip connect a piece of hook-up wire and solder the connection. The other end of this piece of hook-up wire goes to the antenna terminal on the shielded antenna coil. You must be very careful at this point to see that the antenna terminal is not grounded to the metal chassis. Your experiment would not work at all if this happened.

Now take a piece of hook-up wire and remove the insulation. This piece of hook-up wire should be approximately 2½" to 3" long. Connect one end of this piece of hook-up wire to the ground terminal, shown as G_1, Fig. 6. Solder the connection. Then, connect the same piece of bare hook-up wire to the ground terminal shown as G_2, Fig. 6. Now bolt a solder lug in the hole which surrounds hole 6, using the one closest to hole #15. Then, ground this bare piece of wire to this solder lug. The wiring diagram for Experiment #35 is shown in Fig. 7.

Now if you have followed directions carefully, you have your experiment wired as shown in Fig. 7. In this experiment, it is going to be necessary to carefully align the two sections of the tuning condenser if you are to receive satisfactory performance from your experiment. Place a type 6C6 tube in socket #1, a type 6D6 tube in socket #5, a type 42 in socket #10, a type 80 tube in socket #13, your electron coupled regeneration coil in socket #2, and you are ready to operate your experiment in the usual manner.

On the right-hand side of your tuning condenser are two small trimmer condensers. It is going to be necessary to accurately adjust these. The front trimmer condenser tunes the detector coil, while the rear trimmer condenser tunes the antenna coil. The actual setting of these two condensers will depend a great deal upon the antenna which you are using and the final construction of your electron-coupled coil. Therefore, it will be rather difficult for us to give you accurate instructions on how best to adjust these condensers. In order to get your set to operating at all, tune in some of the lower frequency stations and then with the front trimmer condenser adjusted nearly all the way in, adjust the rear trim-

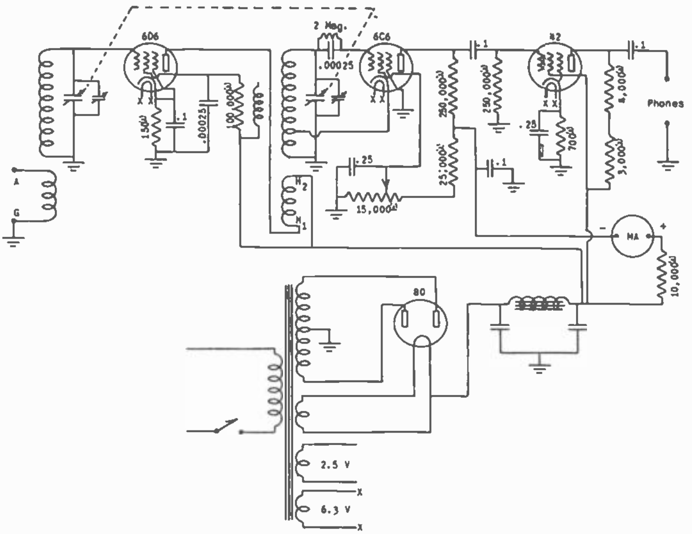


Fig. 7. Four tube electron coupled receiver with tuned R.F. amplifier

mer condenser until you receive the best results. Then, tune in some station between 1200 and 1400 kc. and, leaving the front trimmer condenser alone, carefully adjust the rear trimmer condenser until you secure maximum reception on the station to which you are listening. It is practically impossible to make this adjustment on a strong local station; in other words, you must adjust on a station which comes in a little weaker so that adjustment of the condenser will make a marked difference in the performance of the receiver.

The same instructions which were given in connection with Experiment #34 for the reductuon of the plate voltage on the 6D6 untuned R.F. amplifier also apply to this 6D6 tuned R.F. amplifier.

With these changes, it should be possible to secure remarkable results with this receiver. This tuned stage adds both selectivity and sensitivity to the receiver.

EXPERIMENT 36

CHANGING SCREEN GRID TUNED R.F. AMPLIFIER TO TRIODE TUNED R.F. AMPLIFIER.

In this experiment, it is going to be possible to check the performance characteristics between a 6D6 tube operating as a screen grid R.F. amplifier and the same tube operating as a triode amplifier.

We now have a 100,000 ohm resistance connected between the screen grid prong on socket #5 and the R.F. choke. We also have a .00025 mfd. mica condenser connected between the screen grid terminal and ground; remove both of these pieces of apparatus. Next, take a piece of hook-up wire and connect it between the plate terminal on socket #5 and the screen grid terminal on the same tube. You then will have your experiment wired as shown in Fig. 8. We have not drawn the entire receiver, because it is only necessary to show the changes which have been made.

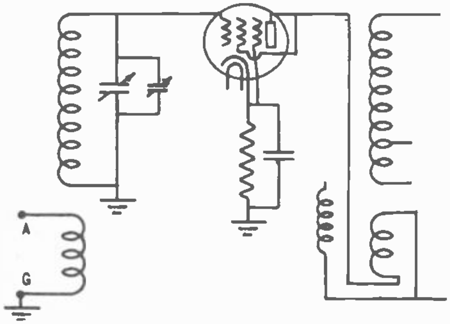


Fig. 8. Antenna stage showing triode connection.

The same tube arrangement and same operating procedure is used in this experiment as was used in the preceding experiment. While you will find that the set works very satisfactory, still, there will be a material decrease in the sensitivity because of the decrease in the amplifying ability of the tube operated as a triode instead of a screen grid tube.

The reason that this tube does not oscillate without neutralization is that the suppressor grid acts as a shield.

EXPERIMENT 37

WINDING SHORT WAVE ELECTRON-COUPLED REGENERATIVE COILS

In this experiment, you are going to be given directions for the winding of coils which will tune over a higher frequency band than the broadcast coil which you constructed in Experiment #31. The first of these two coils is a modification of the broadcast coil you now have and is designed to cover a frequency range of approximately 1500 kc. to 4500 kc. The broadcast coil form wound in Experiment #31 covers the approximate frequency range of 580 kc. to 1550 kc.

In constructing this first coil,[1] it is only going to be nec-

[1] Only one 5-prong coil form is supplied in your receiver experimental apparatus; therefore, if you wish to have a variety of coils, it will be necessary to purchase additional coil forms. These can be purchased from Midland Television, Inc. at a price of twenty cents each, postpaid.

essary to remove some of the turns which you have on the coil form wound in Experiment #31. The secondary coil, as shown in Fig. 4, has 95 turns on it. Remove 75 turns, leaving a total of 20 turns to make up the secondary coil of the new coil.

The cathode coil now has 7 turns. Remove 3 of these turns, leaving 4 turns on the cathode coil.

The primary coil now consists of 21 turns. Remove 8 or 9 of these turns to constitute the new primary coil.

In removing turns, you will find that your windings no longer fill the space between the holes in the side of the coil form. Therefore, it will be necessary to let some of your wire slant toward the hole; that is, the last turn will slant upward or downward, as the case may be, in order to reach the proper hole. If you do not care to remove the turns from your broadcast coil form, but are going to wind new coils, then follow the directions given in Experiment #31, and as shown in Fig. 4, except using the number of turns just mentioned for this coil.

Another short wave coil can be wound which will cover a much higher frequency range. This coil is designed to cover approximately the frequency range from 4000 kc. to 12,000 kc. In winding a coil of this type, it is absolutely essential that a larger size wire be used, and so, this coil cannot be a modification of your broadcast coil.

In your last shipment of experimental apparatus, you will find a spool of #20 double cotton covered magnet wire. Using this wire, you are going to construct this high frequency coil. Scrape the insulation from the magnet wire and pass it through hole A in the coil form, pull it up through the top of the coil and then back down through the heater prong (H_1) next to the plate prong. Be sure that the wire is bare where it goes through the prong and then solder the connection. Now, holding the coil form with the coil form prongs in your left hand, wind toward you and place 6 turns of wire on the primary coil. This number of turns will just exactly fill the space between holes A and B as shown in Fig. 3. Pass the end of the wire through hole B, pull it up through the top of the coil form, be sure that the insulation is scraped off the wire where it is going through the coil form prongs, and then pull this wire down through the heater prong (H_2) next to the cathode prong. Be sure that the wire is bare where it passes through the coil form prong and then solder the connection.

Fig. 9. View showing how to tap coil winding.

You are now ready to wind both the secondary and cathode coils. Scrape the insulation from your wire, pass the end of it through hole E and then down through the plate prong. Be sure the wire is bare where it passes through the plate prong and then solder the connection. Now, holding the coil form with the prongs in your left hand, wind toward you until you have 3 turns of wire on the coil form. Now, scrape ½" of insulation from the wire, but do not cut the wire in two. Then bend the wire as shown in Fig. 9 and solder so that the bend will remain fixed. After you have completed this operation, then continue winding until you have a total of 10 turns on the entire secondary. The secondary coil now includes the cathode coil; in other words, two separate coils will not be wound for this type. Since the number of turns will not fill the space between holes E and C, it is going to be necessary to let the last turn of wire slant upward so that the wire will pass through hole E. Scrape the insulation from the wire and pass it down through the grid prong on the 5-prong coil form. Be sure the wire is bare where it goes through the coil form, then solder the connection.

You now have your secondary coil wound with 10 turns of wire, with a tap made at the third turn. You are now ready to use that tap. Take a short piece of your #20 double cotton covered magnet wire and scrape the insulation from the end of the wire for about a ½". Twist this around the tap and solder the connection. Then

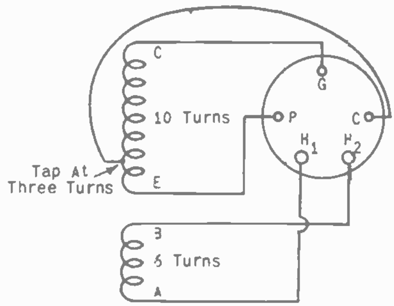


Fig. 10. Connection diagram for electron coupled short wave regenerative coil.

run this piece of magnet wire up over the top of the coil form and down through the center and through the cathode prong on the 5-prong coil form. Be sure the wire is bare where it passes through the coil form and then solder the connection.

You then have the coil form wound as shown in Fig. 10. The connections and number of turns are indicated on this figure.

EXPERIMENT 38

BUILDING ELECTRON-COUPLED SHORT WAVE RECEIVER.

In this experiment, it is going to be necessary to make some changes from Experiment #35, because you cannot use the tuned radio frequency amplifier with this type of receiver.

When completing Experiment #36, you had your tuned radio frequency amplifier operating as a triode amplifier. Therefore, we will start out and make the changes necessary on that experiment.

The 100,000 ohm resistance which formerly connected between the screen-grid prong on socket #5 and the R.F. choke is to be replaced. At the same time, connect one pigtail end of a .00025 mfd. mica condenser to the same screen-grid prong. The other end of the .00025 condenser is soldered to any conveniently placed solder lug. At the same time these connections are made, remove the piece of hook-up wire which is now connected between the screen-grid prong and the plate prong on socket #5. The experiment has now been changed so that the type 6D6 tube is operating as a screen-grid tube.

Since you may desire to use your broadcast coil and the tuned radio frequency stage ahead of the broadcast coil, we are not going to remove the shielded antenna coil which is now placed in hole 6, but rather, we are going to make a few changes so that this receiver can be used either as a short wave receiver or as a regular broadcast receiver.

You now have a piece of hook-up wire running from the antenna posts on the A & G strip over to the antenna terminal on the shielded antenna coil. Remove this piece of hook-up wire. Next, connect a piece of hook-up wire to the antenna terminal on the A & G strip and also connect one pigtail terminal of a 40,000 ohm resistance. The other pigtail terminal of the 40,000 ohm resistance is connected to ground. The other end of the piece of hook-up wire must reach up to the grid cap of the 6D6 tube. A grid clip is soldered to this wire. The balance of the connections do not need to be changed.

Now, to operate this receiver, you leave the piece of hook-up wire, which is now connected to the grid terminal on the shielded antenna coil, free; that is, this grid clip is not connected to the 6D6 tube. However, place a 6D6 tube in socket #5, and connect the grid clip to the grid cap, the lead coming from the antenna post. Place a 6C6 tube in socket #1, a type 42 tube in socket #10, and a type 80 tube in socket #13. Plug your experiment into 110-volt 60 cycle alternating current, connect an aerial and ground to the A & G posts, connect your headphones to the phone post and you are ready to operate this receiver.

Now, using the untuned R.F. stage, it is possible to use any one of three different coils in socket #2. You can use the broadcast coil wound in Experiment #31, which covers the frequency band of approximately 580 to 1550 kc. Or, you can use either one of the two short wave coils built in Experiment #37, the first one of these (the modified broadcast coil) covers the frequency band of approximately 1500 kc. to 4000 kc. The other short wave coil wound with #20 double cotton covered magnet wire covers approximately the frequency range 4000 kc. to 12,000 kc. Using the untuned radio frequency amplifier, the set will operate just the same as in Experiment #34. Because of the congestion which exists in some of the short wave bands, you are apt to find some difficulty in being able to separate one station from another. However, you will undoubtedly be surprised at the distance getting ability of this simple 4 tube receiver.

LABORATORY REPORT

Be sure to make out a complete and detailed report on the way the experiments in this group operated. List each one separately.

This procedure is followed so as to test your ability in making up reports instead of just answering examination questions.

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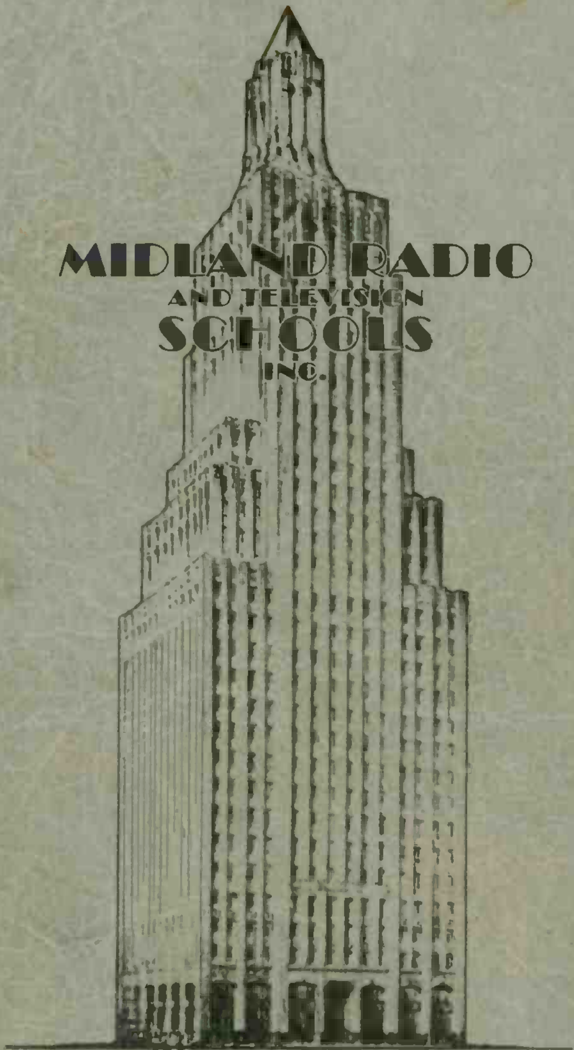

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GROUP NO. 5

LABORATORY EXPERIMENTS

EXPS. NO. 39 TO 45

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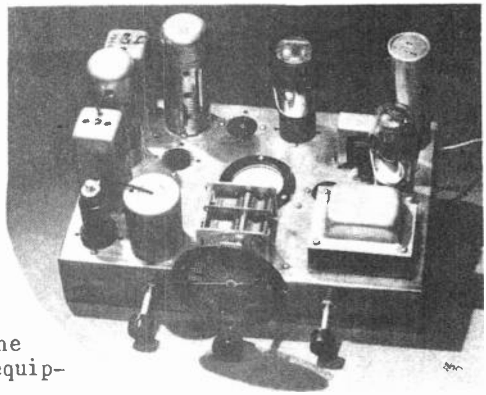
LABORATORY EXPERIMENTS

Group Five



"In this group you are going to conduct various experiments on superheterodyne receivers. These experiments will not only provide you with information on how various superheterodyne receivers operate, but will also give you actual experience in the proper adjustment of such equipment".

EXPERIMENT 39

MOUNTING SUPERHETERODYNE CHASSIS EQUIPMENT

Before starting to mount the necessary equipment used in this experiment, it is advisable that you first prepare your chassis. All equipment used in Experiment 38, except the power supply system, the two gang variable condenser and the milliammeter should be removed. Next remove all solder from the socket prongs, straighten out your hookup wire and, in general, clean up your chassis so that you can start afresh on this important group of experiments.

Fig. 1 shows a top view of your chassis with all of the holes properly numbered. It is advisable that you take a pencil or pen and ink and mark each of these holes as indicated on this diagram. Then, turn the chassis over and mark the holes on the bottom. Be very careful not to get mixed up when marking the holes on the bottom side.

The first equipment to be mounted will be the sockets which will be used in this experiment. An eight-prong socket is mounted in hole 1 and is so bolted that the guiding pin slot faces toward the front of the chassis. REMEMBER THAT THE CHASSIS IS UPSIDE DOWN AND THE FRONT TOWARD YOU. Next mount a six-prong socket in hole 5. This socket is so mounted that the filament prongs face toward the left-hand side of the chassis. This is done in order to facilitate wiring the experiment. Now, mount a six-prong socket in hole 8. This socket is mounted so that the filament prongs face the front of the chassis. A five prong socket is mounted in hole

9. This socket is also mounted so that the filament prongs face the front of the chassis. A third six-prong socket is mounted in hole 10. Mount this socket so that its filament prongs are toward the front of the chassis.

You now have a four-prong socket mounted in hole 13. This socket should have been so mounted that the filament prongs are next to the left-hand side of the chassis. (Remember, the chassis is upside down and the front toward you.)

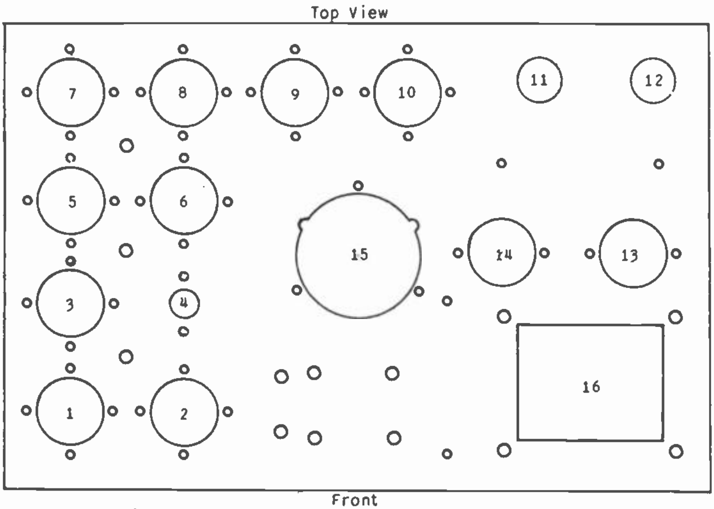


Fig. 1 This is a top view of your metal chassis showing the location of the various holes punched in this chassis. Each hole has been numbered so that a description of the use of this chassis is made easier for all concerned.

If you left the power supply intact, you now have the power transformer mounted in hole 16. The filter choke is bolted on the top side of the chassis, held in place by two bolts through small holes, just in front of holes 11 and 12. The milliammeter is now mounted in hole 15. The two gang tuning condenser is mounted by the proper holes on the top, front center of the chassis.

In your laboratory apparatus, you will receive a triple section, paper cased, electrolytic condenser. This is an 8-8-8 mfd. condenser with six wire leads coming out one end of the condenser, This special by-pass condenser is to be bolted to the chassis by two 8/32 bolts and nuts, using two holes just to the left of the tuning condenser holes, or just to the right of the power transformer. This condenser is mounted toward the front of the chassis. (Remember, the chassis is upside down and the front toward you.) Now, bolt this condenser in place so that the wire leads point toward the rear of the chassis. This will facilitate connections when we are ready to wire up the experiment.

The next piece of equipment to be mounted is a 500,000 ohm volume control potentiometer. This volume control potentiometer is to be mounted in the left-hand one of the three holes on the front of the chassis. It is held in place by a special nut provided for that purpose. In mounting this potentiometer, the three terminal lugs which come out the side of the potentiometer are to face toward the right.

In Fig. 2, you will find a view of an antenna coil, an I.F. transformer, special padding condenser, and oscillator coil. The antenna coil is shown at A, Fig. 2. As you will notice, it has two mounting lugs used to hold the coil in place. This antenna coil is to be mounted in hole 2. On the right and left side of hole 2, you will find two slotted holes. These holes are to be used in mounting this coil. Mount the antenna coil in hole 2 so that the wood spacing pin which holds the coil in the shield points toward the front of the chassis. Bolt this coil securely in place.

(A) (B) (C) (D)

Fig.2 (A) Cut away view of shielded antenna coil. (B) Cut away view of double tuned intermediate frequency transformer. (456kc.) (C) 5 plate low frequency padding condenser. (D) Oscillator coil showing primary and secondary. This coil is used with pentagrid converter tubes.

The next two pieces of equipment to be mounted are the I.F. transformers. A transformer of this type is shown at B, Fig. 2. Here you will notice that two lugs are provided to hold this transformer in place. The easiest way to determine the correct mounting position is to go by the grid lead which comes out of the top of the shield. Now, mount the intermediate frequency transformer in hole 3. You should use the small holes toward the front and back of hole 3 to mount this transformer. Then, in mounting the transformer, be sure that the grid lead points toward the rear of the chassis. Remember, however, that the grid lead comes out the top of the transformer. Besides the grid lead, which is green, there are three leads coming out of the bottom of the transformer. These leads are, respectively, red, blue, and black. Another I.F. transformer is mounted in hole 7. This time you should use the small holes which are to the right and left of hole 7. Also, the grid lead is to point toward hole 8. The grid lead comes out the top of the shield and is going to be connected to a tube which will be mounted in socket 8.

The next piece of equipment to be mounted is a special padding condenser. This condenser is shown at C, Fig. 2. It is to be mounted in hole 4. This condenser has an adjusting screw on its top side. The condenser is to be mounted on the underneath side of the chassis, but is to be mounted with the top side of the condenser up towards the bottom of the chassis. In this way, it is then possible to use a screwdriver to adjust this condenser through hole 4. The padding condenser is held in place by two 6/32 bolts and nuts and, in fastening this condenser, be careful that you do not screw the bolts down so tightly that you will break the isolantite base of the special condenser.

The next piece of equipment to be mounted is the oscillator coil. The oscillator coil is shown at D in Fig. 2. This coil is provided with a special bolt and nut. Do not remove the nut because you are apt to damage the small wires which connect from the two coils to the terminal lugs on the terminal strip of this coil. The oscillator coil is to be mounted in the small hole in the exact center of large holes 1, 2, 3 and 4. Pass the bolt up through this small hole and then put a $\frac{3}{32}$ nut on the top side of the chassis, fastening this coil securely in place. Examination of the coil will show it has five lugs on it. The side with the three lugs is to face toward the front of the chassis. This is done in order to make the wiring more convenient.

The 15,000 ohm volume control potentiometer should not be mounted until some connections are made to the antenna coil mounted in hole 2. You also have a special dial which is to be mounted in this experiment. However, it is advisable to leave the dial off the set until you are about ready to use it. In this way you will avoid any possibility of injury to this piece of apparatus.

Until such time as you are ready to mount your set and speaker in a cabinet, it is advisable to provide some sort of a speaker mounting so that you can continue with your experiments with the least possible inconvenience. We have found, here in our laboratories, that the easiest way to make a temporary speaker mounting is to use one of the large shipping boxes in which we send you your laboratory apparatus. This box measures 4½" by 8½" by 12½". In the bottom side, which is now pasted together with tape, cut a round hole, using a sharp knife, exactly 5½" in diameter.

Cut this hole as near the center of the bottom as possible. Then, using two special bolts, nuts and washers which we provide, bolt the speaker to the bottom of the box, with the speaker on the inside of the box. Two bolts and nuts will easily hold the speaker in place. Now, punch a hole in one end of the box and run the four wire leads out through this hole. These leads are going to be connected to your chassis. After this operation is completed, close the top of the box and tape it shut. This then provides a very effective baffle for your loudspeaker and also makes it convenient to use during this group of experiments.

Now, if you have carefully followed instructions, your experimental apparatus should be completely mounted and you are ready to wire up your first superheterodyne receiver. Remember this in carrying out this group of experiments--haste makes waste, and the more careful you are in following instructions, the better will be the results you are able to obtain.

EXPERIMENT 40

BUILDING A FIVE TUBE SUPERHETERODYNE RECEIVER

In building this five tube superheterodyne receiver, the first procedure will be to wire up the filament circuits and check the power supply rectifier system. Your power transformer is now mounted in hole 16. It has been so mounted that the three high voltage leads, which come out of the side of the transformer, are faced toward the rear of the chassis. One green secondary lead is to be connected to the grid prong on socket 13. The other green secondary lead is to be connected to the plate prong on socket 13. The two heater prongs on socket 13 are to be wired to the 5 volt, 2 ampere

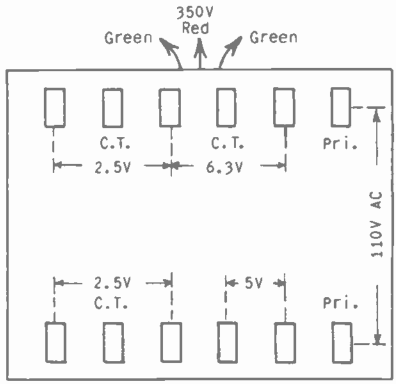


Fig.3 This is a bottom view of the terminal board on your power transformer. Be careful in mounting this transformer to see that it is mounted as per directions and also be very careful in making your connections so that you will be sure to get the right connections. C.T. stands for center tap.

windings on the power transformer. A bottom view of the power transformer is shown in Fig. 3, so that you will have no difficulty in ascertaining which are the 5 volt terminals. It is advisable to twist these two leads so as to prevent hum. The center or black lead of the secondary of the power transformer is to be grounded by soldering this lead to a solder lug which has been placed under one of the bolts holding socket 13 in place.

There are four leads coming out of the bottom of the double 8 mfd. electrolytic condenser now mounted in hole 12. The two black leads are to be grounded to a solder lug which has been placed under the left-hand bolt, holding the filter choke in place. One of the red leads is to be connected to the nearest filament terminal on socket 13. Next a terminal strip is to be bolted in place, using the right-hand bolt which holds the filter choke in place. The other red lead from the 8-8 mfd. filter condenser is to be connected to the center terminal of this three terminal strip. It is not necessary to solder this connection at this time, because other connections will be made to the same position. However, solder all other connections on the power supply system.

In this experiment, the filter choke is not going to be used. Therefore, if you have it connected in the circuit, disconnect all of its leads, but leave the choke mounted in place.

We are now ready to wire up the filament circuits of the various sockets used in this experiment. Cut two pieces of hookup wire approximately seven inches long. Twist these wires. Now, connect one end of each of these two wires to the two heater prongs on the eight prong socket mounted in hole 1. The heater prongs are prongs 2 and 7. These are shown at A, Fig. 4. The two twisted leads are now run over to the heater prongs on the six prong socket mounted in hole 5. If the leads are a little too long, cut them off so

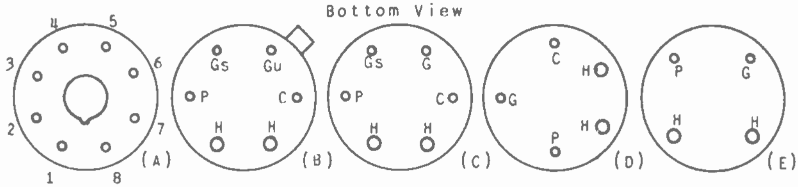


Fig.4 A bottom view of the various sockets used in this experiment. (A) 8-prong octal. (B) 6-prong with control grid out the top. (C) 6-prong sockets with control grid on base. (D) 5-prong socket with control grid on bottom. (E) 4-prong socket with control grid in base.

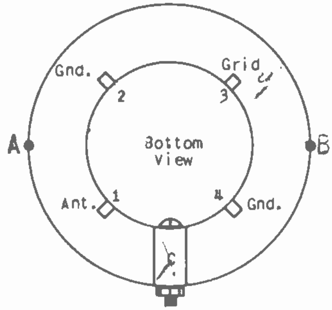
that your wiring job will be neat. In running this pair of leads go down the space between holes 1-2, 3-4, and 5-6. This will make a neat job of the wiring. Now, using two more twisted pieces of hookup wire, connect the heater prongs on socket 8 to the heater prongs on socket 5. Run the wires as short and as direct as possible. Now from the heater prongs on socket 8, run a pair of twisted leads over to the heater prongs on socket 10. All three of these sockets; that is, 5, 8, and 10, are six prong sockets and the heater prongs can easily be determined by referring to B, Fig. 4. From the heater prongs on socket 10, run a pair of twisted leads over to the 6.3 volt winding on the power transformer. These 6.3 volt taps can easily be determined by referring to Fig. 3. Now, solder all of these connections.

Next, connect a pair of twisted wires from the heater prongs on socket 9 over to the 2.5 volt taps on the power transformer. Be sure to use the separate 2.5 volt terminals, the ones located next to the 5 volt terminals. On the power transformer which is supplied you, there are two different 2.5 volt windings. However, one of these 2.5 volt windings is a part of the 6.3 volt winding as shown in A, Fig. 21, in your first group of experiments. In this group of experiments, we want you to be sure to use the separate 2.5 volt winding, the ones next to the 5 volt winding and not the one which is a part of the 6 volt winding. Be sure to solder all connections.

Remember this in conducting this group of experiments. It is going to require a large number of pieces of apparatus in constructing superheterodyne receivers. Therefore, neatness is very important if you are going to have a successfully operating set. *Therefore, follow directions carefully. It is highly important that you do things in the same order as they are described.* If you skip around from one thing to another, you will encounter a great deal of difficulty in being able to get all of the various pieces of equipment mounted in their correct places.

Now, so that you can mount the 15,000 ohm volume control potentiometer, you will first wire up the antenna coil which is mounted in hole 2. A bottom view of the terminal lugs on this coil is shown in Fig. 5. Be very careful in following directions so that the correct terminals will be used. First, bolt two solder lugs under the left-hand bolt which holds this antenna coil in place. Have one of these solder lugs facing toward the right and the other toward the left rear. From the solder lug which faces toward the right, connect a piece of bare hookup wire to the two solder lugs on the antenna coil which are to be grounded. These are both marked "gnd." in Fig. 5. One of them is just to the right of the wood spacer pin and is marked "terminal 4", while the other lug is diagonally opposite and is marked "terminal 2".

Fig.5 A bottom view of the shielded antenna coil to be mounted in hole 2. Directions for mounting the coil and locating the various terminal lugs are determined by counting from the spacer bar marked "C"



Now connect a piece of hookup wire to the solder lug on the front stator section of your two gang tuning condenser. Pass this wire down through the small hole directly under this solder lug and then solder the other end of this wire to the grid terminal on the antenna coil. The grid terminal is marked 3 in Fig. 5. At the same time this piece of hookup wire is connected to the grid terminal on the antenna coil, also solder another piece of hookup wire to the same terminal. Now, pass this last piece of hookup wire up through the center of the coil and through a small hole in the top of the coil shield. This wire must be made long enough to reach the grid cap of a tube which will be used in socket 1. Then, solder a small grid clip to this piece of hookup wire. This grid clip is to be connected to the grid cap of a type 6A8 metal tube which will be used in socket 1. The terminals which are covered up by the volume control mounted in the right-hand of the three holes in the front of the chassis are now wired up, so we will leave the remainder of these terminals until later in the experiment. Now, mount the 15,000 ohm volume control potentiometer in the right-hand hole. It is held in place by a special nut provided for that purpose. In mounting this volume control, the three lugs which are on the side of the volume control are to be faced toward the left of the chassis. Remember the chassis is upside down and the front toward you.

With this volume control and switch mounted, you are then ready to wire up the primary of the power transformer. Since the switch's position has been changed, it is going to be necessary to change the wiring to the primary of the power transformer. The easiest way to accomplish this is as follows:

Unsolder the 110 volt cord from the primary of the power transformer and then solder the two free ends to the two terminals on the switch which is mounted on the back of the 15,000 ohm potentiometer. Then lead this AC cord along the front of the chassis

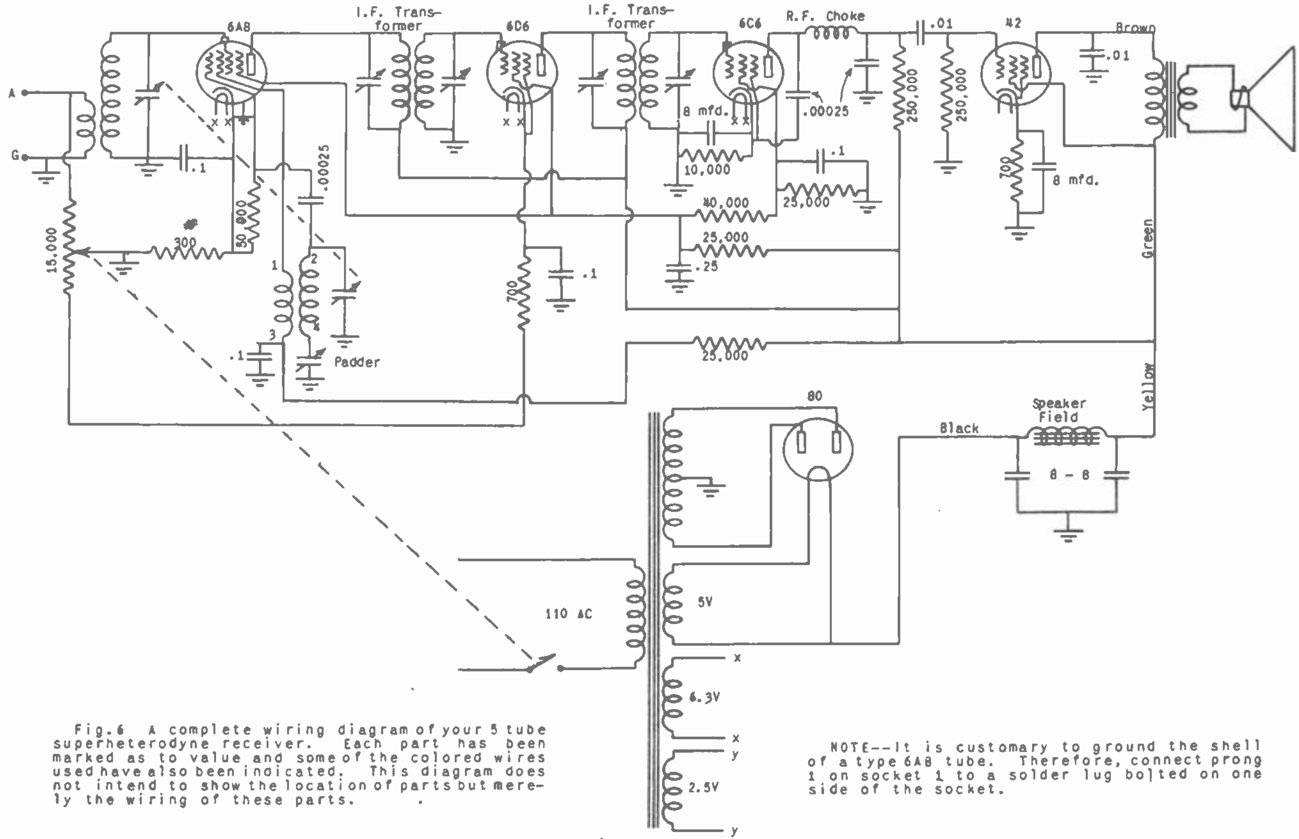


Fig. 6 A complete wiring diagram of your 5 tube superheterodyne receiver. Each part has been marked as to value and some of the colored wires used have also been indicated. This diagram does not intend to show the location of parts but merely the wiring of these parts.

NOTE--It is customary to ground the shell of a type 6A8 tube. Therefore, connect prong 1 on socket 1 to a solder lug bolted on one side of the socket.

until you get to the power transformer. Now, using a sharp knife, split the parallel cord. Do not cut the wire in two; merely split the outer insulation. Now, cut one of the wires in two. Scrape the two ends you have made. Connect one of these ends to one terminal of the power transformer and connect the other end to the other terminal of the primary of the power transformer. Then, place a knot in your cord at the back of the chassis so that any strain on your cord will not pull the connections loose. Your 110 volt attachment plug is then placed on the other end of the cord. Following this procedure, you will then have the switch wired in series with one side of the primary of the transformer. This connection is shown clearly in Fig. 6. Fig. 5 is a complete wiring diagram of the five tube superheterodyne you are now constructing.

The next procedure in wiring is going to be that of making several connections which would be hard to get to after certain resistors and condensers were placed. Therefore, even though you feel that this is not the right sequence in which to do things, still, we want you to know we have found this was by far the easiest method when this experiment was constructed here in our laboratories. This set was built no less than ten different times before its finished form was finally decided upon.

Place a solder lug under the back bolt which holds the intermediate frequency transformer, mounted in hole 3 in place. To this solder lug, attach the black lead which comes out of this I.F. transformer. The lead will be too long, so it should be cut off in order to make a direct short lead, the insulation scraped from the wire and a good soldered connection made to lug. USUALLY WE DO NOT RECOMMEND CUTTING OFF LEADS, BUT WHERE IT IS SPECIFIED IT IS ADVISABLE TO DO SO IN ORDER TO SECURE PROPER RESULTS. Next the blue lead which comes out of the I.F. transformer mounted in hole 3 is to be connected to the plate prong on the 8 prong socket mounted in hole 1. The plate prong is prong 3 as shown at A, Fig. 1. If the blue lead is too long, cut it off so that it just reaches. Be sure to make a good connection.

Next, mount a solder lug under each of the bolts which holds the I.F, transformer mounted in hole 7 in place. To the left hand one of these two solder lugs, connect the black lead which comes from this I.F. transformer. Do not solder the connection. The blue lead which comes from this I.F. transformer is to be connected to the plate terminal on the six prong socket which is mounted in hole 5. The plate prong of this socket can easily be determined by referring to B in Fig. 4. If the blue lead is too long, cut it off so that it just reaches and makes a good connection.

Now you are going to start with the actual wiring of the balance of the experiment. REMEMBER, ALL OF THESE DIRECTIONS ARE GIVEN WITH THE CHASSIS UPSIDE DOWN AND THE FRONT TOWARD YOU. The first thing to do is to mount a terminal strip by bolting in the front one of the four holes surrounding hole 6. This hole is right next to the padding condenser mounted in hole 4. Bolt the terminal strip so that it reaches over toward hole 5. The length of the terminal strip should run parallel to the front of the chassis. On this terminal strip there are three terminal lugs. Now, using the terminal lug nearest hole 6, connect the red wire which comes from the intermediate frequency transformer mounted in hole 3 and the red wire which comes from the intermediate frequency transformer mounted in hole 7. If these two red wires are too long, cut them off so that they just reach. Scrape the insulation from the wire and pass the bare end through this terminal lug. At the same time, connect a piece of hookup wire about 8 inches long to this terminal lug. Also, connect one pigtail end of a 250,000 ohm resistance. This will make four connections to this terminal lug, but if you are careful, they can all be placed in one lug. Then solder this connection. The other end of the piece of hookup wire goes to the center terminal lug now mounted under one of the bolts which holds the filter choke in place. This terminal strip is mounted down between holes 14 and 11. You do not need to solder this connection as yet.

To the screen grid terminal on the 8 prong socket mounted in hole 1, connect a piece of hookup wire and solder the connection. (The screen grid prong can be determined by referring to A, Fig. 4. It is terminal 4.) The other end of this piece of hookup wire is to be connected to the screen grid terminal on the 6 prong socket mounted in hole 5. The screen grid terminal can be determined by referring to B, Fig. 4, To this same terminal, connect another piece of hookup wire and also the pigtail terminal of a .25 mfd. condenser. Then solder the connection. We will come back to this connection later, but the piece of hookup wire just attached should be at least 8 inches long.

Now connect one pigtail lead of a .00025 mfd. mica condenser and also the pigtail lead of a 50,000 ohm resistance to terminal 5 on the 8 prong socket mounted in hole 1. Solder the connection. Next, connect a piece of hookup wire to terminal 6 on this 8 prong socket and solder the connection. The other end of this piece of hookup wire goes to terminal 1 on the oscillator coil. (Terminal 1 connection is shown in Fig. 6.) A bottom view of the oscillator coil is shown in Fig. 7, and you will have no difficulty whatso-

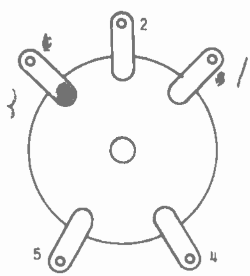


Fig.7 A bottom view of the oscillator coil showing the location of the various connection terminals. Be careful in following directions that you use the correct terminal.

ever in ascertaining which is terminal 1 by referring to this figure. Solder the connection. The other pigtail end of the .00025 condenser now connected to terminal 5 on socket 1 is to be connected to terminal 2 on the oscillator coil. At the same time this connection is made, also make the following connections: Connect a piece of hookup wire to the back stator section of your two gang tuning condenser. Solder the connection. The other end of this piece of hookup wire is passed down through the hole directly under this lug and is connected as directly as possible to terminal 2 on the oscillator coil and connection soldered. Terminal 2 connection is shown in Fig. 6.

Now take a bare piece of hookup wire and solder one end of it to terminal 4 on the oscillator coil. The other end of this bare piece of hookup wire is to be soldered to the nearest terminal lug on the padding condenser which is mounted in hole 4. Next, solder a piece of bare hookup wire to the other terminal on the padding condenser. The other end of this bare piece of hookup wire goes to the solder lug which is mounted under the left hand terminal holding the antenna coil in hole 2. Solder the connection.

One end of a 50,000 ohm resistance is now connected to terminal 5 on socket 1. The other pigtail terminal of this 50,000 ohm resistance is to be connected to the cathode prong which is terminal 8 on socket 1. At the time this pigtail connection is made to this prong, also attach one pigtail end of a 300 ohm resistance and also one pigtail end of a .1 mfd. condenser. Solder the connection. This means that there are three pigtail leads connected to the cathode prong or terminal 8 on socket 1.

To prevent unwanted radio frequency oscillations from taking place in your superheterodyne receiver, we are going to use what is known as a common ground return for several of the circuits. The piece of bare hookup wire now connected between one terminal lug on the padding condenser and the solder lug mounted under the bolt which holds the left hand side of the antenna coil in place is going to be this common ground return. To about the center of this piece of wire, connect the pigtail lead of the .1 mfd. condenser, the other end of which is connected to prong 8 on socket 1. This grounds one end of this condenser. The other pigtail lead of the 300 ohm resistance, one end of which is now connected to prong 8 on socket 1, is to be connected to the center terminal on the volume control potentiometer mounted directly over hole 2. The pigtail leads on this 300 ohm resistance will just reach. At the time the pigtail lead connection is made to the center terminal of the volume control potentiometer, also connect a piece of hookup wire to this same terminal and solder the connection. The other end of this piece of hookup wire is to be connected to the common ground terminal just mentioned.

Now cut a piece of hookup wire approximately 10 inches long. Connect one end of this piece of hookup wire to one of the outside terminals on the volume control potentiometer. The one nearest you is the one to use. Then solder this connection. The other end of this piece of hookup wire is going to be connected to the antenna terminal on the aerial and ground strip which is to be mounted in the right hand slotted hole on the back of your chassis. However, before attaching this piece of hookup wire to the aerial post, it is going to be necessary to provide a special shield for this wire.

Here is how that shield is made. Cut another piece of hookup wire approximately 12 inches long. Solder one end of that piece of hookup wire to the common ground terminal. Now carefully mark your antenna wire. Tie a piece of string around its free end so that there will be no doubt as to which one is the aerial wire. Now hold these two wires out toward you and start twisting the ground wire around the aerial wire. Make a twist about every half inch along the aerial wire. Here is what you are doing. You are wrapping the ground wire around the aerial wire in order to partially shield it. After you have the wires twisted together, run this pair of wires as directly to the aerial post on the A & G strip as is possible. Cut the aerial wire so that it just reaches nicely and solder this aerial wire to the aerial post on the A & G strip. Then solder the ground wire to the ground post on the aerial and ground strip. At the same time, place a solder lug under the right hand bolt which holds the aerial and ground strip in place, and ground the ground post on the A & G strip to this solder lug. You then have a ground wire wrapped completely around the aerial wire from one end to the other. You also have this ground wire grounded at both ends. This will provide an excellent shield for the aerial wire and prevent unwanted radio frequency oscillations from taking place in your receiver. REMEMBER, YOUR CHASSIS IS UPSIDE DOWN AND THE FRONT TOWARD YOU DURING THIS PROCEDURE.

Next, it is necessary to connect a short piece of hookup wire from the outside terminal on the volume control potentiometer (the terminal nearest you) to the antenna terminal on the antenna coil. The antenna terminal is terminal 1, as shown in Fig. 5, and both of these connections should be soldered.

Now to the remaining outside terminal on the volume control potentiometer (the terminal nearest the chassis) connect another piece of hookup wire and solder the connection. The other end of this piece of hookup wire is to be connected to the closest terminal lug on the terminal strip which is bolted at the side of hole 6. Do not solder this connection because we will connect a resistor to this point later on.

The next procedure is to connect one pigtail end of a .1 mfd. condenser to the suppressor grid prong on the 6 prong socket which is mounted in hole 5. You can easily determine which is the suppressor grid by referring to B in Fig. 4. Then take a short piece of hookup wire and connect the suppressor grid prong to the cathode prong on this same socket. To the cathode prong, solder one pigtail end of a 700 ohm resistor. The 700 ohm resistor to be used in this particular position is a 1 watt resistor. Solder these connections. The other pigtail end of the 700 ohm resistance is to be connected to the terminal lug to which you just connected a piece of hookup wire coming from the outside terminal on the volume control potentiometer. Then solder this connection. The free pigtail end of the .1 mfd. condenser is to be connected to a solder lug which is placed under the right hand bolt holding the intermediate frequency transformer in hole 7 in place. It is not necessary to solder this connection at this time.

Now place a solder lug under the front bolt, which holds the

8-8-8 mfd. paper filter condenser in place. To this solder lug, connect the two black wires and the yellow wire which comes out of the other end of this by-pass condenser. Scrape the insulation from these three wires, carefully insert the bare ends through the solder lug hole and then solder the connection. In this way the negative terminal of all three of the condensers contained in this cardboard case are all properly grounded. The positive leads on these condensers will be connected as you finish wiring these experiments.

With the chassis bottom side up and the front toward you, there are four holes in which bolts can be placed to hold the two gang tuning condenser to the chassis. The right hand back one of these holes should be used. When the 8/32 bolt is screwed into the two gang tuning condenser, be sure to place a solder lug underneath and tighten it good and tight.

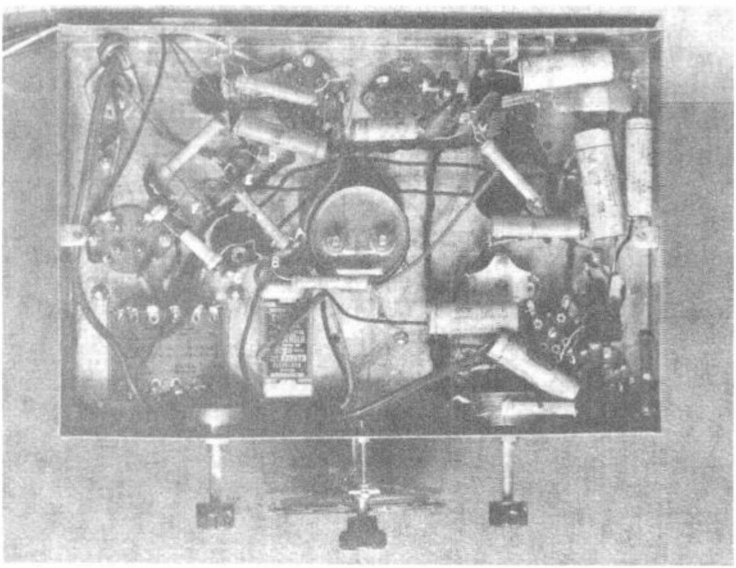


Fig. 8 A bottom view of the completed 5 tube superheterodyne chassis. This view is given to show the location of various parts, particularly the terminal strip which you will mount.

A three lug terminal strip is now to be bolted to the small hole at the right of hole 14. A view showing this terminal strip and its location in relation to the terminal strip which is now bolted under the right hand bolt holding the filter choke in place, is shown in Fig. 8. We shall call the terminal strip bolted under the filter choke bolt, terminal strip 1 and we shall call the terminal strip bolted at the right of hole 14 terminal strip 2. Then it will be a great deal easier to make these next connections and follow directions.

One of the red leads from the 8-8 mfd. filter condenser is now connected to the center lug of terminal strip 1 (lug E). You also have connected to this same lug, a piece of hookup wire which is extended up to a terminal strip mounted at the side of hole 6. Now to this same lug, connect a piece of hookup wire and also the pigtail end of a 25,000 ohm resistance. Then solder the connection. There will then be four connections made to this same lug. The other pigtail end of the 25,000 ohm resistance goes to the front lug marked "A" in Fig. 8. (Terminal strip 2.) Do not solder this connection as yet. Now the short piece of hookup wire just connected to the center lug E on terminal strip 1 is to be connected to the outside lug D on this same terminal strip. At the time this connection is made, connect the pigtail end of a 25,000 ohm resistance to lug D on terminal strip 1. Also, connect a second piece of hookup wire to the same lug and then solder the connection. At this time, you will have three connections made to lug D on terminal strip 1. The other pigtail end of the 25,000 ohm resistance just connected goes to lug F on terminal strip 1. At the same time this resistor pigtail is fastened to this lug F, also fasten one pigtail end of a 40,000 ohm resistance. You now have a piece of hookup wire connected to the screen grid terminal on socket 5. At that time, we told you to make that lead about 10 inches long. This lead is now to be run down and connected to lug F on terminal strip 1. You will then have three connections made at this point, and you are to solder the connections.

To lug D on terminal strip 1, you now have an extra piece of hookup wire connected. The other end of this piece of hookup wire goes to the screen grid terminal on socket 10. The screen grid terminal can be determined by referring to C in Fig. 4. Do not solder this connection as yet.

The free end of the 40,000 ohm resistance is to be connected to lug B on terminal strip 2. At the same time, connect one pigtail end of a 25,000 ohm resistance and also a piece of hookup wire, then solder the connection. You will have three connections then to lug B on terminal strip 2. The other end of the 25,000 ohm resistance is to be connected to the solder lug which was placed under one of the bolts holding your two gang condenser in place. Solder the connection. The other end of the hookup wire connected to lug B on terminal strip 2 is to go to the screen grid terminal on socket 8, The screen grid terminal can be determined by referring to B in Fig. 4. At the time this piece of hookup wire is connected to the screen grid terminal, also connect one pigtail end of a .1 mfd. condenser, then solder the connection. Since the connections around socket 8 are going to be rather congested, it is essential that you follow directions very carefully and conduct each operation exactly in the order in which they are given. Now, connect one pigtail end of a 10,000 ohm resistance to the suppressor prong on socket 8. The suppressor prong can easily be determined by referring to B in Fig. 4. Then take a short piece of hookup wire and connect from the suppressor prong to the cathode prong on socket 8 and solder the suppressor connection. Now to the cathode prong on socket 8, connect one pigtail end of a .00025 mfd. mica condenser. To this same cathode prong, it is then going to be necessary to connect one of the red positive leads on the 8-8-8 mfd. by-pass condenser. The nearest red terminal should be used. This wire, in all probability, will not reach the cathode prong on socket 8, so it is going to be necessary to splice the wire. In splicing this wire, add a piece of wire, solder the joint, and then secure a piece of friction tape to put over this joint. The other end of this hookup wire is then to be connected to the cathode prong on socket 8 and the connection soldered.

You now have a solder lug bolted under the left hand bolt which holds the intermediate frequency transformer in place at hole 7. To this solder lug is fastened the black lead which comes out of this intermediate frequency transformer. To the same solder lug, now connect one pigtail end of a .00025 mfd. mica condenser and then solder the connection.

To the screen grid prong on socket 8, you have one pigtail end of a .1 mfd. condenser connected. The other pigtail end of this condenser is to be connected to the solder lug which is bolted under the right hand bolt holding the I.F. transformer mounted in hole 7 in place. To this same solder lug, attach the free pigtail end of the 10,000 ohm resistance just mounted. You will then have three connections made to this solder lug. When these are made, be sure that the connection is soldered.

The free pigtail end of a .25 mfd. condenser, one end of which is connected to the screen grid prong on socket 8, is to be connected to the solder lug bolted under the I.F. transformer bolt located at the back of hole 3.

You are now ready to undertake one of the most important steps in the entire construction of this receiver. As you will have noticed, we have not as yet mounted the radio frequency choke. The reason for not mounting it previously is that we did not want it in the way during the time we were constructing the rest of the experiment. Some of the chokes sent out by Midland have a small bracket on them, while other chokes do not. If your choke does not have such a bracket, it will be necessary for you to make one in order to properly mount the choke coil. The drawing of this bracket is shown in Fig. 9. The long side of the bracket is 1 inch long.

Fig.9 Two views showing the construction and size of the special bracket needed to mount the R.F. choke. A view of the mounted choke is also shown.

The short side of the bracket is $\frac{1}{2}$ inch long. The bracket itself is $\frac{3}{8}$ of an inch wide. It can be made of brass, aluminum or copper. Magnetic materials such as steel or iron cannot be used. Bolt the bracket to the choke as shown in Fig. 9, and then you are ready to mount the radio frequency choke in its correct position.

REMEMBER, YOUR CHASSIS IS UPSIDE DOWN AND THE FRONT TOWARD YOU. The bracket is to be bolted to the left hand bolt which holds the aerial and ground strip in place. In bolting this radio frequency choke in place, the choke part itself should point toward the left side of the chassis.

Careful inspection of this location will show that the terminal nearest the chassis on the radio frequency choke is less than 1 inch away from the plate terminal of socket 8. The plate terminal on socket 8 can be determined by referring to B, Fig. 4. Now, connect a piece of hookup wire to the plate terminal on socket 8 and solder the connection. The other end of this piece of hookup wire goes to the lower terminal on the radio frequency choke, and under no circumstances should this piece of wire be more than 1 inch long. If it is longer than this, then you have the choke misplaced.

You now have one pigtail end of a .00025 mfd. condenser connected to the cathode prong on socket 8. The other pigtail end of this .00025 condenser goes to the same terminal on the radio frequency choke as the one to which the plate terminal on socket 8 is connected. When this operation is completed, solder the connection.

Now to the outer terminal; that is, the remaining terminal on the radio frequency choke, you are going to make the following connections. You have one pigtail end of a .00025 mfd. mica condenser connected to a solder lug bolted under the left hand bolt on the I.F. transformer in hole 7. The other pigtail end of the condenser is to go to the outer terminal on the R.F. choke. To this same terminal, connect one pigtail end of a .01 mfd. condenser. Sometime previously in your experiment, you connected one pigtail end of a 250,000 ohm resistance to one of the terminal lugs on the terminal strip mounted at the side of hole 6. The free pigtail lead of this 250,000 ohm resistance is to be connected to this same outside terminal on the R.F. choke.

If you have followed directions carefully, you have two connections made to the inside terminal on the R.F. choke and three connections made to the outside terminal on the R.F. choke.

The free end of the .01 mfd. condenser connected to the R.F. choke is now to be connected to the grid terminal on socket 10. The grid terminal of this socket can be determined by referring to C in Fig. 4. At the time this connection is made, connect one pigtail terminal of a 250,000 ohm resistance and solder the connection.

Now bolt a solder lug to the small hole at the right of the left hand slotted hole in the back of your chassis. To this solder lug, attach the free end of the 250,000 ohm resistance, the other end of which is connected to the grid terminal on socket 10.

To the plate terminal on socket 10, attach one pigtail lead of a .01 mfd. condenser. The other pigtail lead of this condenser is connected to the solder lug mounted on the back of the chassis. At the same time, also connect to this same solder lug, one pigtail end of a 700 ohm resistance. (The 700 ohm resistance used here is a 2 watt resistor.)

The free end of the 700 ohm resistor is to be connected to the cathode prong on socket 10. The cathode and plate prongs can be determined by referring to C in Fig. 4. To this same cathode terminal you must also connect one of the red leads on the 8-8-8 mfd. paper by-pass condenser. This lead should reach, so all you have to do is run it over there, attach it to the cathode prong and solder the connection.

Earlier in this experiment, we connected one pigtail end of a 25,000 ohm resistance to lug E on terminal strip 1. The other pigtail end of this 25,000 ohm resistance is to be connected to lug A on terminal strip 2. At the same time this connection is made, connect a piece of hookup wire and then solder the connection. The other end of this hookup wire goes to lug 3 on the oscillator coil. Lug 3 can be determined by referring to Fig. 7. Lug 3 is also connection 3 in Fig. 6. As this connection is made, connect one pigtail end of a .1 mfd. condenser, then solder the connection. The other pigtail end of the .1 mfd. condenser is to be connected to the common ground connection directly to the left of the oscillator coil. When this connection is made, be sure it is soldered.

The last connections to be made before connecting the dynamic loudspeaker to your receiver is the grounding of the center tap terminals of the 6.3 volt and the 2.5 volt windings on your power transformer. Remember, you are using the 2.5 volt terminals which are located on the front side of the power transformer next to the 5 volt winding. From the center tap lug of this 2.5 volt winding, run a piece of hookup wire over to the center tap lug of the 6.3 volt winding. From this lug connect another piece of hookup wire to the solder lug bolted on the right-hand side of socket 13. Then, solder these three connections. In this way, the center tap of the 6.3 volt winding and the center tap of the 2.5 volt winding will be grounded. This procedure helps to prevent a certain amount of hum from getting into the output of the receiver.

You are now ready to mount the special airplane dial you received with your last shipment of apparatus. In this shipment of equipment, you will find a $\frac{6}{32}$ bolt about $1\frac{1}{2}$ inches long. This bolt has two washers and three nuts on it. At the bottom of the dial upright is a small slot. Now, put two washers next to the head of the bolt and then screw one of the nuts up close to this point and then slip the combination in the bottom of this slot and tighten it up. Now, slip the dial hub on the shaft of the condenser. Next set your condenser at full capacity; that is, turn the rotor plates as far as they will mesh with the stator plates. Then, carefully set the pointer on your dial at 100. Then, tighten the set screw securely and bolt the upright of the dial to the chassis. Put a $\frac{6}{32}$ nut on the $1\frac{1}{2}$ inch bolt, then slip this long bolt through the small hole which is directly below the center hole in the front of your chassis. On the back side of the chassis then put on another $\frac{6}{32}$ nut. Now, adjust these two $\frac{6}{32}$ nuts so that the front support of the dial is parallel with the face of the chassis. When you have secured this condition, tighten both $\frac{6}{32}$ nuts so that the dial will remain securely in place.

With that operation completed, you are ready to connect the loudspeaker to the output of your receiver. There are four wires coming from the speaker itself. Two of these are connections to the output transformer which is mounted on the speaker chassis. The other two wires are the field connections on the speaker. The yellow wire coming from the speaker is to be connected to the screen grid prong on socket 10. Then solder the connection. This is one of the field wires. The black wire coming from the speaker is also a field wire and should be soldered to the B+ filament prong on socket 13. To this same prong is now connected one of the red leads coming from the 8-8 mfd. filter condenser. This is the B+ point of your rectifier system. In using this circuit, the loudspeaker field coil is to act as the filter choke.

The brown lead coming from the output transformer on the loudspeaker is the plate lead. This lead is to be soldered to the plate prong on socket 10. The green wire is the B+ lead going to the output transformer on the speaker. This B+ lead should be soldered to lug D on terminal strip 1. This is B+ output of your rectifier filter system.

Now, before placing tubes in your receiver, it is advisable that you very, very carefully go over all of your connections three or four times. The success of this experiment is going to depend upon how carefully you have followed directions. After you have made certain that all of your connections are correct, the next step is to carefully adjust the placement of each part so that there will be no danger of short circuits or grounded apparatus. If you will refer to the picture shown in connection with this experiment, you will be able to ascertain where we here in our laboratories placed most of this equipment. However, here are some rules to follow. You should never let the body of a resistor touch the chassis or ground. Resistors are not insulated very good and so, this would ground the resistor before it was intended to be grounded, even though one end might now be connected to ground. Therefore, carefully check the placement of each resistor. The 50,000 ohm grid leak resistor now connected between terminals 5 and 8 on socket 1 should be so placed that it is kept as far away from the metal chassis as possible. Bend the pigtail leads so that each resistor will stay firmly fixed in place, but do not cut off any pigtail leads, because later you may need that length for another experiment.

The next apparatus to be carefully placed is the various bypass condensers used. Be sure that the pigtail leads do not touch the resistors or the chassis unless these pigtail leads are supposed to be connected to those points. In other words, be careful that the condensers are not grounded unless they are actually connected to the chassis or ground. Reference to the photograph of the bottom of the set will show the placement of this equipment. It is highly essential that you carefully follow all directions so that your set will give maximum performance.

If you have followed directions carefully, you are then ready to continue with the next experiment which will be the operation and alignment of this very important receiver.

EXPERIMENT 41

ALIGNING A SUPERHETERODYNE RECEIVER

This experiment will provide important experience for you, but it will be necessary for you to follow directions implicitly.

Two of the tubes used in this experiment must be shielded, so if you have not as yet mounted your tube shield bases, then it is advisable to do so at this time. A type 6A8 tube is going to be used in socket 1. Place that tube in this socket and connect the grid clip which comes out of the top of the antenna coil mounted in hole 2.

A type 6D6 tube is to be used in socket 5. Be sure that a tube shield base is in place. Place the 6D6 tube in socket 5, put the shield cover down over the tube and then connect the grid lead which comes out of the I.F. transformer mounted in hole 3, to the grid cap of this tube. Now put on the grid cap shield. A type 6C6 tube is going to be used in socket 8. Be sure a tube shield base is in place, then place a 6C6 tube in socket 8. Place a shield over the tube; connect the grid lead coming out of the I.F. transformer mounted in hole 7 to the grid cap of this tube and then put on the grid cap shield. A type 42 tube is to be placed in socket 10 and a type 80 tube is to be placed in socket 13.

Now connect an aerial to the A post on the aerial-ground strip; then connect a good ground to the G post on the aerial and ground strip, plug the AC cord in the 110 volt, 60 cycle lighting supply socket and you are ready to operate the receiver.

The volume control and AC switch are mounted on the left, while the control now mounted on the right will later be used as a tone control. The dial, of course, which tunes the condenser is mounted in the center.

Before attempting to align your receiver, it is highly important that you conduct a thorough review of Lessons 27 and 30 in Unit 1. It is also important that you have completed Lessons 3 and 10 in Unit 2.

WARNING: THE PADDING CONDENSERS WHICH CAN BE REACHED FROM THE TOP OF EACH OF THE TWO I.F. TRANSFORMERS HAVE BEEN ADJUSTED HERE IN OUR LABORATORIES AND, UNDER NO CIRCUMSTANCES SHOULD THEY BE TOUCHED UNTIL YOU HAVE THE SET OPERATING FAIRLY SATISFACTORILY. TO MOVE THESE CONDENSERS WILL MEAN THAT YOU WILL BE UNABLE TO RECEIVE ANYTHING OVER THIS SET EVEN THOUGH IT IS CORRECTLY WIRED.

There are three padding condensers which will have to be adjusted in aligning this set. The low frequency padding condenser is mounted in hole 4. It can be adjusted with an insulated screw driver from the top side of the chassis. The back section of your two-gang tuning condenser tunes the oscillator coil of this superheterodyne receiver. A padder condenser is connected across this condenser and is mounted on the right rear side of the two gang tuning condenser. The front section of your two gang tuning condenser tunes the antenna coil on this receiver. The padding condenser for this tuning condenser is located on the right front side of your tuning condenser. IN MAKING ALL ADJUSTMENTS, AN INSULATED SCREW-DRIVER SHOULD BE USED.

The first step in the alignment procedure is to take your screwdriver and turn the padding condenser mounted in hole 4 as far to the right, or in a clockwise direction, as it will go. Do not force it; just merely screw it up tight. After this is done, back it off or unscrew it one-quarter of a turn.

The next step is to screw the trimmer condenser mounted on the back stator section of your tuning condenser up as tight as it will go. This is to the right or in a clockwise direction. The third step is to unscrew, or turn toward the left in a counter clockwise direction the trimmer condenser which is across the front stator section of your tuning condenser. Turn this condenser out just about as far as it will go.

You are now ready to turn the set on. Rotate the volume control to the right almost as far as it will go. Then, carefully tune your receiver. To properly align the receiver, you should first tune in a high frequency station; that is, a station which comes in on your dial somewhere between 10 and 30. Tune it in very carefully. If the station happens to come in a little weak, or if your set is not quite correctly adjusted, you may have difficulty in finding a station. However, a little patience will bring great rewards.

Since you do not have an R.F. oscillator, it is going to be necessary for you to make all adjustments by ear. This is very difficult to do, but it can be accomplished satisfactorily if you will be careful.

Now with a station tuned in, reduce your volume control until you can just hear the station. It is impossible to make adjustments if the volume control is turned on loud, because then your ear cannot designate between small changes in volume. With your set adjusted this way, use an insulated screwdriver and adjust the high frequency trimmer across the oscillator tuning condenser (the back section of your two gang tuning condenser). Adjust this trimmer condenser until the station comes in loudest. In adjusting the condenser, if the station becomes too loud, reduce the volume control so that small changes in volume can be noticed by the ear.

Now, rotate your dial and tune in a station operating in the low frequency band. It is advisable to tune in a station somewhere between 70 and 90 on the dial. With this station properly tuned in, you are now ready to adjust the low frequency padding condenser mounted in hole 4. Turn the volume of your set down so that you can just hear the station. Then, carefully adjust the low frequency padding condenser until the station comes in the loudest. A little practice in this operation will help you materially in being able to secure the right kind of an adjustment.

Now, go back to the high frequency station; that is, some station operating between 10 and 30 on the dial. Tune the station in carefully and then readjust the oscillator padder condenser. (This padder is on the back section of your two gang tuning condenser.) Now with this adjustment completed, very carefully adjust the front padder condenser on your two gang tuning condenser. Adjust this condenser until the station is received the loudest. As the station's signal increases, turn the volume control down so that you can just barely hear the station. In this way it is possible to make closer adjustments.

With this adjustment completed, you are now ready to touch up the tuning of your I.F. transformers. The front I.F. transformer is mounted in hole 3. In the top of this I.F. transformer is two small holes. The right-hand one of these two holes tunes the tuned circuit which is connected in the plate circuit of the 6A8 first detector circuit. The left-hand one of these two holes tunes the tuned circuit connected in the grid circuit of the 6D6 I.F. amplifier tube.

With a high frequency station properly tuned in and the volume control set so that you can just hear the station, then very carefully adjust the right-hand tuning condenser on the first I.F. transformer. A considerable amount of care will be necessary in properly adjusting this transformer and it may be a little while before you can get on to just how this should be set.

IN ADJUSTING ANY PADDER CONDENSER, BE VERY CAREFUL AND DO NOT USE ANY PRESSURE ON YOUR SCREWDRIVER. THIS EXTRA PRESSURE TENDS TO PUSH THE TOP PLATE DOWN TOWARD THE LOWER PLATE AND THEN WHEN THE PRESSURE IS RELEASED, THE CAPACITY CHANGES AND YOUR ADJUSTMENT IS NOT CORRECT.

With the high frequency padder and the first I.F. transformer padder properly adjusted, you are then ready to continue on through the I.F. stage. Next, you can carefully adjust the left-hand trimmer on the I.F. transformer. From there, you can go to the two trimmer condensers on the second I.F. transformer mounted in hole 7. It does not make a great deal of difference which one of these two you adjust first. With this procedure completed, now tune in a low frequency station operating somewhere between 70 and 90 on the dial and again readjust the low frequency padder mounted in hole 4. After this procedure is completed, the set should be working very good.

While the kilocycle numbers on your dial are not supposed to be extremely accurate, still, they will provide an approximate tuning position so that stations can be located according to the frequency on which they operate. Now, if you find that your dial readings are entirely incorrect, then you can follow this procedure in helping the situation. It may not be possible to get the dial readings exactly right, but at least you can correct the situation some by using a little bit of care.

Here in Kansas City we have a broadcasting station which operates on a frequency of 1320 kc. In tuning our receiver, we found this station was coming in at about 30 on the dial, or at approximately 1200 kc. This then indicated it was going to be necessary to make some correction on the dial. Here is how it is accomplished.

While the station came in at 30, it should have come in approximately half way between 20 and 30. Therefore, move the dial pointer to that position. This means you have decreased the capacity of the tuning condenser. Now, with the tuning condenser set, here is the way that you bring the station back in. You increase the capacity of the trimmer condenser connected across the back section of your tuning condenser. Do this carefully and you will be able to bring the station back in, then adjust it carefully until you have everything tuned just right. When you have completed this operation, then adjust the front tuning section trimmer condenser until you secure best results.

It does not make any difference whether or not you have a station that comes in around 1300 kc. Any station will do, just so you know the frequency of that station and have a good idea of where it should come in on the dial. Then a suitable correction can be made.

Now, let us assume that you want to correct the reading on the low frequency end of the dial. Here in Kansas City, we have a broadcasting station operating on 610 kc. We found, however, in adjusting our set that the station came in at about 575 kc. Or, in other words, it came in at too low a frequency setting. Therefore, we set the pointer at a position just a little higher than 600, a setting that would represent 610 kc. Then, we carefully increased the capacity (by turning to the right, or in a clockwise direction) of the low frequency padding condenser mounted in hole 4. Adjust the condenser carefully until the station comes in right. After this procedure has been completed, it is then advisable to tune in a high frequency station and go through the entire procedure of aligning the set again.

If it so happens that the high frequency station comes in at a dial setting that is too high, let us say that the 1320 kc. station came in at 1400 kc., then here is what you do. You set the dial pointer at about the place where the station should come in and then this time, decrease the capacity of the padder condenser across the oscillator or the back section of your two gang tuning condenser. Carefully adjust it until the station tunes in correctly.

Let us go back to the low frequency end of the dial and assume that the station at 610 kc. came in at about 650 kc., or at a frequency setting too high for the station desired. In this case, you set the dial pointer at about the place where it should be and decrease the capacity of the low frequency padder condenser mounted in hole 4. Adjust it until the station is coming in as it should.

If stations along about the center of the dial seem to be off, then it is advisable not to try to correct for these frequency settings. It is advisable to make corrections only for the low or high frequency end of the dial.

After you have the dial readings approximately correct, then tune in a high frequency station and go through the entire procedure of aligning the set; that is, adjust both of the trimmer condensers on both sections of the two gang tuning condenser and then adjust all of the padder condensers on each of your I.F. transformers. All of these adjustments should be made on a station at the high frequency end of the dial. The only adjustment which should be made at the low frequency end of the dial is the low frequency padding condenser mounted in hole 4.

If you have followed directions carefully and have adjusted your set properly, you will be amazed at the performance of this receiver. Here in Kansas City, we were able to tune in stations all over the United States, using only a 20 foot piece of wire as an aerial. Therefore, if you do not receive the best of results to start with, don't give up, but keep right on working and you will win.. This set has amazing possibilities, if properly handled.

Following are some symptoms of improper performance and the best method of locating such difficulties:

1. *Filament of tubes light, but set dead.* There are innumerable things which cause such a condition; therefore, we are going to give you some pointers in looking for trouble of this nature. Looking at the front of the set, lean it up on its right side and the 8-8 mfd. electrolytic condenser will keep the set from toppling over. Now turn the set on and you can make the first test. First, you are going to check and see if the type 42 output amplifier is functioning. All you need to do is to touch your finger on the grid terminal of the type 42 tube mounted in socket 10. If you get a clicking sound, a little pop, it is pretty good evidence that this stage is functioning satisfactorily. Now take the grid cap shield off the type 6C6 detector tube and touch your finger to this grid cap. If you get a louder popping sound, then you can be reasonably sure that the detector stage is working all right and that the 42 stage is amplifying because of the louder pop.

Next take the grid cap shield off of the 6D6 intermediate frequency amplifier tube and touch the grid cap. You should also get a popping noise which indicates that in all probability this stage is operating. You see, we have started at the loudspeaker and have tested back through each stage to see where the trouble might lie. The next point is to touch the grid cap on the type 6A8 tube. This should give you a loud squeal and, in this case, you can then be sure that all stages are amplifying.

However, if during this process of testing, you found a stage which refused to give the pop as you touched the grid cap, then you can be reasonably sure that your trouble exists in that stage.

Now let us assume that you got the loud squeal from touching the cap of the 6A8, but still can get no signal from your receiver.

The next thing to test is the antenna connection. Remember that when you made the twisted lead which runs from the aerial and ground post on the A & G strip, you must be sure to have the two wires connected correctly. It would be very easy to have the ground wire connected to the antenna post on the antenna coil instead of having the aerial wire connected to this post. Check this carefully and if there is any doubt that you might have this wrong, then carefully make a new twisted pair of wires, marking the antenna wire so there will be no danger in getting these two mixed up.

2. *Set seems to be alive, but stations cannot be tuned in.* If this symptom is indicated in your receiver, then it is evident that one of two things is wrong. First, it is possible that the oscillator section of the 6A8 tube is not operating. If this condition is suspected, then carefully check the connections you have made to the oscillator coil and see that all of these are correct. Next, it would be a good idea to use the continuity tester built in Experiment 15 and test the continuity of each of the oscillator coils. You see, there is a primary and secondary coil and both of these should test continuity. The secondary or tuned part of the

coil can be tested by connecting between terminals 2 and 4. The plate or primary part of this coil can be tested by connecting between terminals 1 and 3.

If the trouble is not found in the oscillator section of your receiver, then, in all probability, your receiver is completely out of line, and while it would work otherwise, still no stations can be received because of the complete misalignment of the tuned circuits.

Since you do not have a radio frequency test oscillator, then there is not much opportunity of your being able to find this trouble by yourself. Therefore, it is advisable to go to some radio service man and have him line up the intermediate frequency amplifier. It is to be lined up at a frequency of 456 kc. With the I.F. amplifier properly lined up, it is then comparatively easy to adjust the tracking or general alignment of the oscillator and radio frequency sections of the first detector. This means the adjustment of the two padding condensers on the tuning condenser and also low frequency padding condenser mounted in hole 4.

3. Some component part defective or burned out. If you are still unable to get the receiver to operate and you are absolutely certain that all wiring directions have been followed carefully, it is then advisable to take a continuity tester and test each individual piece of apparatus. This should be done as described in Lesson 1 of Unit 2.

WRITING TO MIDLAND. If you have occasion to write to our Consultation Service Department about the performance of this receiver, please be very explicit in the information which you give us. In other words, tell us all you have done in trying to get the set to operate, everything you have tried and what you have been able to find in connection with the performance of the receiver. By all means, do not write us and say, "My set does not operate, what shall I do?" It is impossible for us to tell here in Kansas City what may be wrong with your set a hundred or a thousand miles away.

If all efforts to make your set operate are of no avail, then it is possible for you to carefully pack this set in a large box and send it to us EXPRESS, PREPAID, and we shall be glad to go over it for you and find out where your troubles are. Do not do this except as a last resort, and be sure to write a letter letting us know that you are sending the set to us.

In packing the set, here is what you should do. The tubes can be left in the chassis. Then take some strong heavy paper and wrap the set in this paper. However, be sure to remove the tuning dial, because it is apt to get injured in shipment. You can also remove the loudspeaker and it will not be necessary to send the speaker to us. After the set is wrapped, then pack it carefully in a box which is much larger than the set itself. Use excelsior or paper and pack all around the set carefully so that there will be no danger of it being damaged in shipment. Your set will be tested, repaired and returned to you as soon as possible.

EXPERIMENT 42

BUILDING A TONE CONTROL

This experiment will not only provide you with experience in adding a tone control to any receiver, but it will also add something to the performance of your set. With this tone control added, you will be able to check the results of using such apparatus.

You now have a .01 mfd. condenser connected from the plate terminal on the type 42 tube mounted in socket 10 and a solder lug which is mounted at the side of the left hand slot on your chassis.

Remember, in doing all of your work, the chassis is upside down and the front toward you.

Remove this .01 condenser and save it, as you will need it for future use. You now have a 500,000 ohm potentiometer mounted in the left hand of the three front holes on your chassis. The three terminal lugs on the side of this volume control should face toward the left. Now, connect one pigtail end of a .25 mfd. condenser to the lug which is nearest the bottom of the chassis. This is the one farthest away from you. The other pigtail end of this .25 condenser is to be soldered to any conveniently placed solder lug. Perhaps it would be advisable to place a solder lug under the left hand bolt which holds socket 13 in place. Solder this pigtail lead to that solder lug.

Now connect one end of a piece of hookup wire to the center terminal on the 500,000 ohm potentiometer. Then, running this piece of hookup wire as directly as possible, connect the other end of this piece of hookup wire to the plate terminal on socket 10. Solder the connection. Your tone control is then installed.

Now place your receiver into operation in the usual manner. You will then find that by varying the 500,000 ohm potentiometer, you can vary the tone of your receiver. In one position, you will find that the speaker reproduces both the high and low notes of broadcasting. However, in the opposite position, the high notes are completely eliminated and the set will sound quite bassy. Of course, between these two points, you will have varying degrees of reproduction.

EXPERIMENT 43

BUILDING A 6-TUBE SUPERHETERODYNE RECEIVER

In this experiment, you are going to add a stage of audio frequency amplification to the 5-tube superheterodyne which you just completed. This, then, will make your final receiver constituting a complete 6-tube set.

A type 56 audio frequency amplifier is to be mounted in socket 9, As you will remember, the filament or heater terminals of this socket have been wired and so it will only be necessary to make a very few changes.

You now have a .01 condenser connected from one terminal lug on the radio frequency choke to the grid terminal on the type 42 tube mounted in socket 10.

Disconnect the pigtail lead now connected to the grid terminal socket 10. This pigtail lead is to be moved over to the grid terminal on the 56 tube which will be mounted in socket 9. At the same time this pigtail lead is attached to the grid terminal on socket 9, also connect one pigtail end of a 100,000 ohm resistance and then solder the connection. The other pigtail end of the 100,000 ohm resistance is to be connected to the ground terminal lug on the A & G strip. This places this resistor well out of the way and also provides a means of grounding one end. A diagram showing only the 56 audio frequency amplifier is given in Fig. 10.

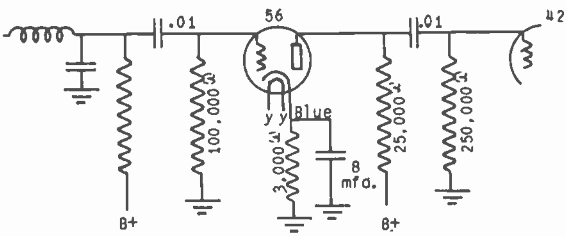


Fig.10 The wiring diagram needed in adding the type 56 audio frequency amplifier to your 5 tube superheterodyne, making a 6 tube set.

Now to the cathode terminal on socket 9, connect one pigtail end of a 3,000 ohm 2 watt resistor. To this same cathode connection, connect the blue lead coming from one end of the 8-8-8 mfd. by-pass condenser mounted in front of your milliammeter. Solder these connections. The other pigtail end of the 3,000 ohm resistance is to be soldered to any conveniently placed solder lug. This 3,000 ohm resistance by-passed with an 8 mfd. condenser then provides a cathode resistor for the type 56 audio amplifier and this cathode resistor supplies the grid bias for the type 56 tube.

Now to the plate terminal on socket 9, connect one pigtail end of a .01 mfd. condenser and one pigtail end of a 25,000 ohm 1 watt resistor. Solder the connection. The other pigtail end of the .01 condenser goes to the grid terminal on the type 42 tube now mounted in socket 10. Solder the connection. The other pigtail lead of the 25,000 ohm resistor goes to lug D on terminal strip [illegible]. This is the B+ output of your rectifier filter system. Solder the connection.

If you have carefully followed directions, your audio frequency amplifier is now complete and you are ready to operate your receiver as a 6 tube set. Place a type 56 tube in socket 9 and then place the other tubes in their corresponding sockets and turn on your receiver.

In using this set, you will find the sensitivity or volume has been materially increased. In fact, on strong local stations, you may have a little difficulty in being able to hold down the volume. However, another volume control is to be added later on and so this will not provide any material difficulty at this time.

Because of the increased audio frequency amplification, you will find that this set has slightly more hum in it than the set which you previously constructed. There is no particular remedy for this situation, but I do not believe you will find the hum objectionable, especially when a station is tuned in.

EXPERIMENT 44

ADDING AUDIO VOLUME CONTROL TO 6 TUBE SUPERHETERODYNE

You will find in operating the 6 tube superheterodyne receiver built in Experiment 43 that it may be difficult to properly control the volume. Therefore, in making a finished receiver, it is advisable to add a volume control between the 56 audio frequency amplifier and the type 42 power output stage. This can be done by installing a fixed tone control and then using the 500,000 ohm potentiometer as an audio frequency volume control.

The first thing to do in this experiment is to mount a 3 lug terminal strip under the bolt which now holds a solder lug at the right hand side of the left hand slotted hole cut in the back of your chassis. After this operation is completed, continue with the following procedure.

You now have a 100,000 ohm resistance connected between the grid terminal on socket 9 and the ground terminal on the A & G strip. Remove this 100,000 ohm resistance. You now have a 250,000 ohm resistance connected between the grid terminal on socket 10 and a solder lug bolted to the back of the chassis. Remove this 250,000 ohm resistance. Now connect one pigtail end of the 250,000 ohm resistor to the grid terminal on socket 9. Solder the connection. One pigtail lead of an .01 mfd. condenser is now connected to this lug. The other pigtail terminal on the 250,000 ohm resistance is to be connected to the ground terminal on the A & G strip. Then solder the connection.

Now, connect one pigtail terminal of the 100,000 ohm resistance to the plate terminal on socket 10. At the time this connection is made, remove the piece of hookup wire which is connected between the volume control and this terminal. The other pigtail terminal of the 100,000 ohm resistance is to be connected to the terminal lug nearest the left hand side of the chassis on the terminal strip mounted on the back side of the chassis.

You now have a .25 mfd. condenser connected between the 500,000 ohm potentiometer and a solder lug which has been bolted to the left hand side of socket 13. Leave the one pigtail terminal soldered to this solder lug, but remove the other pigtail terminal from the 500,000 ohm potentiometer. Now, swing the .25 mfd. condenser around so that its free pigtail terminal can be connected to the terminal lug on the terminal strip to which you now have one end of the 100,000 ohm resistance connected. Then, solder this connection. With this arrangement, you have connected from the plate of the type 42 tube mounted in socket 10, a 100,000 ohm resistance, and a .25 condenser connected in series to ground. This then forms your fixed tone control.

You now have a piece of hookup wire connected to one of the terminals on the 500,000 ohm potentiometer. Remove this piece of hookup wire. You also have one pigtail terminal of a .01 mfd. condenser connected to the grid terminal on socket 10. Remove this pigtail terminal. The other pigtail terminal of this same .01 mfd. condenser is connected to the plate terminal on socket 9. This connection is to be left intact. The following procedure is quite critical and it is advisable that you follow directions very carefully.

The 500,000 ohm potentiometer mounted on the front of the chassis is so mounted that the terminal lugs face toward the left. Now take a short piece of hookup wire and connect one end of this piece of hookup wire to any conveniently placed solder lug. The other end of the piece of hookup wire goes to the outside terminal lug nearest you; that is, the top terminal lug. However you are not ready as yet to solder this connection.

Now connect a piece of hookup wire to the outside terminal nearest the bottom of the chassis. Solder this connection. The other end of this piece of hookup wire is to go to the center terminal lug on the terminal strip mounted on the back left hand side of the chassis. However, before this piece of hookup wire is attached to that terminal lug, it is necessary to make a shield for this piece of wire. Here is how that shield is made. (You will follow the same procedure used in making the shield for the antenna lead.) Mark the lead to be shielded so that there will be no danger of your getting the two leads mixed up. Now connect a piece of hookup wire to the outside terminal on the 500,000 ohm potentiometer to which you now have a ground connection. With this accomplished, start in and carefully twist this ground wire around and around the other wire, making a twist about every $\frac{3}{8}$ of an inch. You now connect the other end of this piece of shielded hookup wire to the center lug on the terminal strip. To this same center lug, connect the free pigtail end of the .01 condenser and then solder the connection. The .01 condenser is connected from the plate prong on socket 9 to this shielded lead connected to the center lug on the terminal strip. The other end of the ground wire or shield wire around this lead is to be connected to a solder lug bolted to the back of the chassis. You then have the connections A and B as shown in Fig. 11 completed.

Now solder one end of a piece of hookup wire to the center terminal on the volume control potentiometer. Cut the length of this piece of hookup wire so that it will conveniently reach the grid prong on socket 10. Then mark this wire so that there will be no chance of getting it mixed up. Now solder the end of another piece of hookup wire to the grounded terminal on the 500,000 ohm potentiometer. It is going to be necessary to shield this grid lead and so again you will wrap this grounded piece of hookup wire carefully around and around the grid lead. Make a wrap about every $\frac{3}{8}$ of an inch. When you have the entire wire wrapped, then solder the shielded lead to the grid terminal on socket 10. Now remember, this must be the grid lead which is now connected to the center terminal of the 500,000 ohm potentiometer. The other end of the ground or shield wire is to be soldered to the solder lug which is now mounted with the terminal strip on the back left hand side of the chassis. When this operation is completed, you will then have connections C and D, as shown in Fig. 11, completed.

Now if you have followed directions carefully, you have the 500,000 ohm potentiometer connected as an audio frequency volume control as shown in Fig. 11. In this figure, we have shown only the plate circuit of the type 56 tube mounted in socket 9 and the grid and plate circuits of the type 42 tube mounted in hole 10.

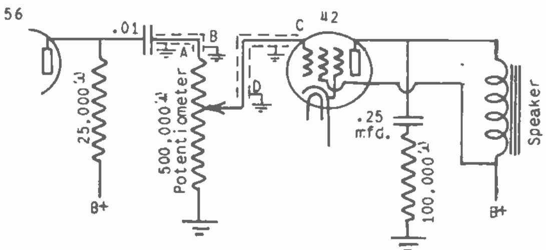


Fig.11 Wiring diagram showing the installation of audio frequency volume control and fixed tone control. Be sure to note which of the wires are the shielded leads.

With your volume control completed, you are then ready to operate the receiver, but this time you will have two volume controls, Place the correct tube in each of their respective sockets; that is, following the same procedure as that given in Experiment 43. Then, with a good aerial and ground connected to the aerial and ground binding post and your set plugged into a 110-volt, 60-cycle lighting socket, you are ready to operate the set.

The set is turned on by rotating the volume control potentiometer switch mounted on the left hand side of the chassis. (With the set in operation, remember that the set is right side up and the front toward you.) Turn the volume control in the right hand hole about ½ or ¾ of the way on and turn the volume control in the left hand hole about ½ or ¾ of the way on and tune in some station. In operating the set with this combination, you will find that the volume control located on the left hand side of the chassis really acts as a sensitivity control, the fine adjustment for volume being controlled by the volume control mounted on the right hand side of the chassis. In operating this receiver, it is best to follow this procedure. Operate the left hand volume control in as low a position as you conveniently can and still secure sufficient sensitivity. Then operate the right hand volume control at a point which is approximately ½ to ¾ of the way on. If you will follow this procedure, you will have the best tone quality and the least amount of noise pickup. A little experimentation on your part will readily disclose at which position the two volume controls should be operated in order to secure the most satisfactory results in your locality.

Since the instructions for installing this audio volume control and fixed tone control are so relatively simple, there is no reason why you should have any trouble, providing your set was operating satisfactorily as constructed in Experiment 43. However, it is very important that you be sure the two shielded leads are connected correctly. If you should reverse this procedure and connect either of these leads wring, your set might not function at all, or the set might operate just as though the 500,000 ohm audio volume control were not in place. It would depend upon which mistake you made. A little careful checking up on your part will readily disclose whether or not you have this experiment properly connected.

In marking any of the shielded leads so that you will be sure as to which lead is which, a little dab of paint or a colored thread tied around the end of the wire will help you to keep straightened out.

EXPERIMENT 45

BUILDING A DIODE DETECTOR

In this experiment you are going to change your 6 tube superheterodyne so that the type 6C6 tube will operate as a diode detector, instead of a grid bias detector. While, in all probability your set will not perform as efficiently with this type of detection, still it will provide you with experience in the building and operating of this type of equipment.

The first thing to do is to remove all connections now connected to the radio frequency choke mounted on the left hand side of the A & G strip. As soon as the connections are removed, then remove the choke coil itself. This is done because it will be mounted in a different position.

The 250,000 ohm resistance, one end of which is connected to the R.F. choke, the other end being connected to a terminal strip bolted at the side of hole 6, is to be removed. The next procedure is to remove all connections excepting the FILAMENT WIRES now connected to socket 8. The 10,000 ohm resistance now connected between the cathode prong on socket 8 and a ground lug is to be removed. At the same time, disconnect the red lead coming from the 8-8-8 mfd. condenser. Fold this lead up and place it out of the way because it will not be used in this experiment, but in all probability you will want to use it later.

The two .00025 mfd. mica condensers which were connected to the R.F. choke and socket 9 are to be removed entirely. When you have all this apparatus removed, you are then ready to actually start this experiment.

First, the radio frequency choke coil is to be bolted on the right hand side of the right hand slotted hole in which you now have the A & G strip mounted. In mounting this radio frequency choke, the choke itself is to be faced toward your right. REMEMBER, THE CHASSIS IS UPSIDE DOWN AND THE FRONT TOWARD YOU.

You now have the black lead coming from the I.F. transformer mounted in hole 7 connected to a solder lug mounted on the left hand side of this I.F. transformer. Unsolder this black lead from the ground lug and solder it to the lower terminal on the R.F. choke. At the time you do this, connect one pigtail lead of a .00025 mfd. condenser to the same R.F. choke lug and then solder the connection.

Now take a piece of bare hookup wire and connect the following prongs on the 6 prong socket mounted in hole 8 together. Connect the plate prong to the screen grid prong. From the screen grid prong to the suppressor grid prong; from the suppressor grid prong

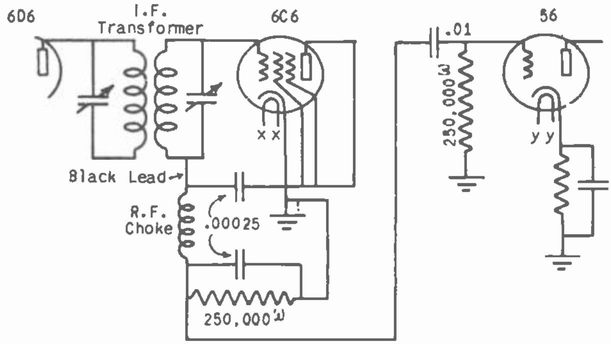


Fig.12 A wiring schematic showing the installation of a diode detector. The entire receiver is not shown, but rather only those changes which are necessary in changing the 6C6 detector tube from a grid bias detector to a diode detector.

to the cathode prong, and from there to the ground lug which is mounted under the left hand side of the I.F. transformer bolted in hole 7. The complete wiring diagram for the diode detector is shown in Fig. 12. Here we have given a diagram showing only the changes to be made as the balance of the set will not be disturbed.

Next connect the free pigtail terminal of the .00025 mfd. condenser, now connected to the lower terminal on the I.F. choke, to the ground lug bolted at the left hand side of hole 7.

The next procedure is to attach one pigtail terminal of a 250,000 ohm resistance and one pigtail terminal of a .00025 mfd. mica condenser to the cathode prong on socket 8, then solder the connection. The other pigtail terminal of the 250,000 ohm resistance and the .00025 mfd. condenser is to be connected to the outside terminal lug on the R.F. choke. (The one nearest you.) At the same time, connect one pigtail terminal of the .01 mfd. condenser, the other end of which is connected to the grid terminal on socket 9. Then solder the connection.

Now, if you have carefully followed directions, your experiment will be correctly wired and ready for operation. The 6 tubes are to be placed in the respective sockets, the set plugged in and an aerial and ground attached, and you are then ready to operate the experiment.

You must remember that a diode detector does not produce any amplification. Therefore, the gain or sensitivity of your receiver will be reduced from that which you secured in Experiment 43. However, you will find a material increase in the tone quality of your set because of the diode detector.

No adjustments need be made in operating this receiver, other than that which you used in your last experiment. However, because the output load on the secondary of the second intermediate frequency transformer has been changed, it may be advisable for you to readjust this I.F. transformer. (This is the I.F. transformer mounted in hole 7.)

Tune in a broadcasting station operating at the high frequency end of the band. Then adjust the second intermediate frequency transformer. You will find that the trimmer condenser located under the back hole in the shield can is still as critical in adjustment as it was with your previous experiment. The trimmer condenser located under the front hole in the shield can is the secondary of this I.F. transformer and because it is now working into a diode load instead of a regular load, you will find that this tuned stage does not tune as sharp as it did. However, by careful adjustment, you will be able to secure excellent performance from this receiver.

Because of the changes which have been made, including the rearrangement of some parts, it may be possible that your set will oscillate slightly when the left hand volume control is turned close to the "full-on" position. There is no particular remedy for this situation without completely re-designing and rebuilding the receiver. Therefore, all you need to do is to carefully operate the volume control and you will have no difficulty in securing excellent performance from this set. You will find, however, that while there has been an improvement in tone quality, there will be a noticeable decrease in sensitivity or volume. This is occasioned by the loss of gain which was produced by the 6C6 tube operated as a biased detector.

LABORATORY REPORT

Instead of answering examination questions on this group of experiments, we want you to prepare a report on the results secured from your work. This report is to be written in your own words and is to be quite thorough and complete.

Describe your work on each experiment and be sure to state the results secured. List a few of the stations you were able to receive and give the approximate dial reading for each.

In grading this report, originality and neatness will count along with the accuracy with which you completed each experiment.

NOTICE

Special plans have been prepared showing how to build a cabinet for this receiver. These plans will be sent at your request if you desire to build a cabinet for your receiver.

The text of this lesson was compiled and edited by the following members of the staff:

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MIDLAND TELEVISION

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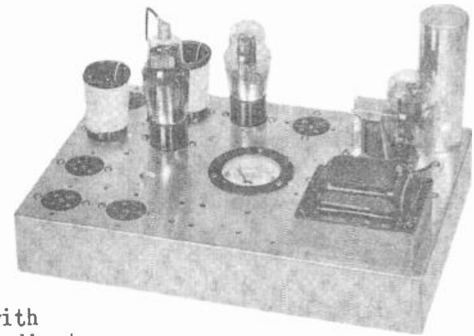
POWER & LIGHT BUILDING, KANSAS CITY, MISSOURI

GROUP NO. 6

LABORATORY EXPERIMENTS

EXPS. NO. 46 TO 62

LABORATORY EXPERIMENTS



Group Six

"While your experimental apparatus does not permit you to build high - powered transmitting equipment, still, these experiments will provide you with experience in the building, adjusting and operating of various types of radio transmission equipment.

"By carefully following directions, you will be able, in a practical way to substantiate a large majority of theoretical study which you are completing in the study of radio transmitters"

WARNING

IT IS POSSIBLE TO CONNECT THESE TRANSMITTER EXPERIMENTS TO AN AERIAL AND ACTUALLY RADIATE RADIO FREQUENCY SIGNALS. HOWEVER, THIS IS AGAINST THE LAW AND THE OPERATOR IS SUBJECT TO HEAVY PENALTIES. UNDER NO CIRCUMSTANCES SHOULD YOU ATTEMPT TO OPERATE THESE EXPERIMENTS ON THE AIR UNLESS YOU FIRST SECURE AN AMATEUR STATION AND OPERATORS' LICENSE. IF YOU ARE INTERESTED IN SECURING SUCH LICENSES, COMPLETE INFORMATION WILL BE SENT YOU BY MIDLAND AT YOUR REQUEST.

EXPERIMENT 46

WINDING OSCILLATOR COILS

To conduct this group of experiments, it will be necessary for you to dismantle your superheterodyne receiver. You can leave the equipment for the power supply system, the two-gang tuning condenser and the dial in place. However, it will be necessary to remove all other equipment.

After this equipment has been removed, then take your soldering iron and carefully clean each part; that is, remove the excessive solder, see that all wires are straightened and free from solder, and otherwise prepare your apparatus so that it can be used with the least possible inconvenience in conducting your transmitter experiments.

Since the first oscillator experiments to be built are of the tuned-grid, tuned-plate type, it will be necessary to wind two coils for these experiments. You now have a 5-prong coil form and, in your last shipment of apparatus, you will find a 6-prong coil form.

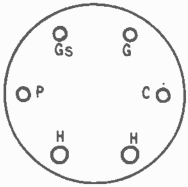


Fig.1

Fig.2

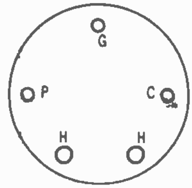


Fig.3

Fig.1 A bottom view of the prong locations on a six prong coil form.
Fig.2 Illustrating how to place a tap on oscillator coils.
Fig.3 A bottom view of the prong locations on a five prong coil form.

A bottom view of the 6-prong coil form is shown in Fig. 1. Two holes have been drilled in the side of this coil form. One near the top and one near the bottom. These two holes are going to be used in connection with fastening your magnet wire to the coil form. ALL TRANSMITTER COIL FORMS WILL BE WOUND WITH YOUR #20 DOUBLE COTTON COVERED MAGNET WIRE.

Scrape the insulation from the end of your magnet wire and push this through the lower hole in the side of your 6-prong coil form. Pull the wire out through the top of the coil form and then pass it down through the heater prong next to the cathode prong. Be sure the wire is bare where it comes through the heater prong, then solder the connection and cut off the surplus wire and solder. Now, carefully pull up all of the slack. Then, holding the coil form prongs in your left hand, wind toward you. Wind 9 turns of wire and then it will be necessary to make a special tap at this point. Here is how this tap is made. Scrape one-half inch of insulation from the wire, but do not cut the wire in two. Then bend the wire as shown in Fig. 2 and solder so that the bend will remain fixed. After you have completed this operation, then continue winding until you have placed 9 more turns of wire on your coil. At this point, make another tap just as you made the last one. Continue your winding and add 9 more turns of wire on your coil. Make another tap at this point; then continue your winding and add 9 more turns of wire to your coil. You will find that you then have 36 turns of wire on the completed coil. You will find that this number of turns of wire nearly fills the space between the two holes in your coil form. Cut the wire off so that it will be long enough to pass through one of the coil form prongs. Scrape the insulation from the end of the wire, pass it through the top hole in the side of your coil form and then down through the filament prong next to the plate prong on your 6-prong coil form. In this particular experiment, the taps will not be used. However, we have them available for future experiments.

You are now ready to wind your 5-prong coil form. There are several holes in the side of this coil form, but you are going to use the one nearest the bottom and the one nearest the top. Scrape the insulation from the magnet wire, pass it through the bottom hole, up through the top of the coil form and then back down through the heater prong next to the cathode prong on your 5-prong coil form. A bottom view of the 5-prong coil form is shown in Fig. 3. Be sure that the wire is bare where it passes through this coil form prong and then solder the connection.

Now wind 4½ turns of wire and make a tap, just as you did on the 6-prong coil form. Continue putting on 4½ more turns and making another tap until you finish your coil by winding a total of 36 turns. This number of turns will practically fill the space between the two outer holes on the side of your 5-prong coil form. Cut the wire off, pass it through the top hole in the side of the coil form, scrape the wire where it will go down through the coil form prong, and then pass this bare wire down through the heater prong next to the plate prong on your 5-prong coil form. Solder the connection, cut off the surplus wire, see that you do not have any extra solder on the side of the coil form prong.

EXPERIMENT 47

BUILDING TUNED-GRID, TUNED-PLATE OSCILLATOR SHUNT FEED

Now that you have wound the two coils necessary in constructing this experiment and your apparatus has been properly prepared, you are ready to start its construction.

A 5-prong socket is to be mounted in hole 2. The filament prongs on this socket are to be faced toward the left, (REMEMBER, YOUR CHASSIS IS UPSIDE DOWN AND THE FRONT TOWARD YOU.)

A 6-prong socket is to be mounted in hole 1. The filament prongs on this socket are to face toward the front of the chassis. Next, mount a 6-prong socket in hole 3. The filament prongs on this socket are to face toward the left.

Mount a 6-prong socket in hole 5. This time the filament prongs are to face toward the right; that is, next to the right hand side of the chassis. A 5-prong socket is to be mounted in hole 8. The filament prongs on this socket are to face toward the front of the chassis.

Your milliammeter is mounted in hole 15, the two-gang tuning condenser is mounted in the front center of the chassis, the power transformer is mounted in hole 16, a 4-prong socket is mounted in hole 13, your filter choke is mounted just in front of holes 11 and 12 on the top side of the chassis, and your 8-8 mfd. electrolytic condenser is mounted in hole 12. With all of this equipment in place, you are then ready to wire up the first of your experiments.

Your power supply circuit is wired as shown in Fig. 4. These are the same connections for the power supply system as have been used in many previous experiments. A terminal strip is bolted under the right hand bolt which holds the filter choke in place, and your B+ output terminal is supposed to terminate on one of the lugs on this strip. Therefore, in your experiment when it shows that a connection is made to B+, it means that the connection is made to this point. In this way, it will not be necessary to show the power supply system for each transmitter experiment.

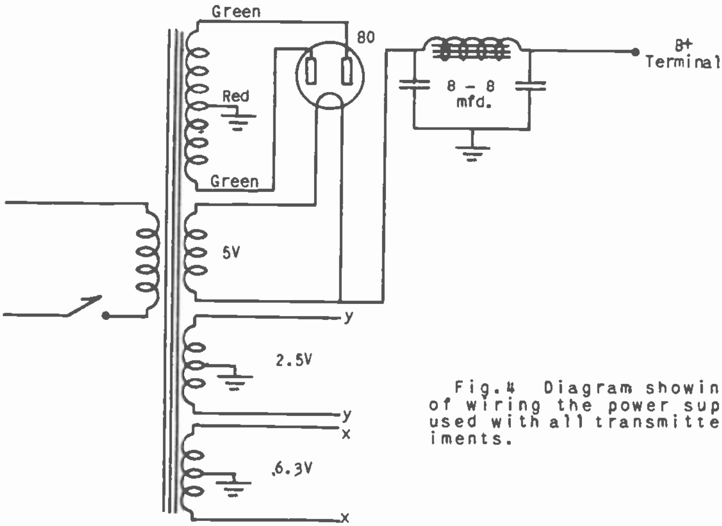


Fig. 4 Diagram showing method of wiring the power supply to be used with all transmitter experiments.

Now twist a pair of hookup leads together and connect two of the ends to the 6.3 volt filament terminals on your power transformer. Run these leads along the front side of the chassis just next to the bottom until they reach the filament prongs on the 6-prong socket mounted in hole 1. Solder these two leads to these two filament prongs. A bottom view of a 6-prong socket is shown in Fig. 1. Using another pair of twisted leads, connect one end of these two leads to the filament prongs on socket 1 and lead these along the right side of the chassis up near the bottom until they reach the filament prongs on socket 5. Solder these two leads to the filament prongs on socket 5.

Now take another pair of twisted leads and connect one end of these leads to the 2½ volt filament terminals on the power transformer. You are to use the 2½ volt terminals next to the 5-volt terminals. Run this pair of twisted leads as directly to the filament terminals on the 5-prong socket mounted in hole 8 as possible. Solder these leads to the two heater terminals.

In conducting your superheterodyne experiments of Group 5, you had the center tap of the 2½ volt winding and the center tap of the 6.3 volt winding on the power transformer connected to ground. If, by chance you have removed this ground connection, then, by all means, replace them at this time. This is most easily accomplished by connecting a piece of hookup wire from the center tap on the 2½-volt winding to the center tap on the 6.3 volt winding. From the center tap on the 6.3 winding, then connect a piece of hookup wire to a conveniently placed solder lug. It is advisable to have the center tap of these two filament windings grounded during all the experiments in this group.

WIRING THE EXPERIMENT. In all previous experiments, you have used the solder lug terminal on the left hand side of each of the stator sections on your two-gang tuning condenser. Upon examination, you will find that there are solder lug terminals on both sides of the stator sections of the two-gang tuning condenser. Take one of your .00025 mfd. mica condensers and connect one pigtail lead to the right hand terminal on the back stator section of your two gang condenser; solder the connection. The other pigtail lead of this condenser goes to the solder lug on the right hand of the front section of your two-gang tuning condenser. Solder this connection. You now have a .00025 mfd. mica condenser connected across the two stator sections of the two gang tuning condenser as shown at C in Fig. 5. This procedure is necessary to increase the maximum capacity of this tuning condenser.

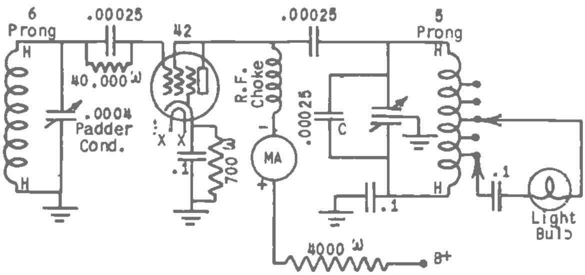


Fig. 5 Schematic diagram of a shunt fed, tuned-grid, tuned-plate oscillator using a type 42 tube as a triode.

Now take a piece of hookup wire and solder it to the back left hand lug on the back stator section of your two-gang tuning condenser. Pass the end of this piece of hookup wire down through the hole directly underneath this solder lug and connect the other end of this piece of hookup wire to the filament prong next to the plate prong on the 5-prong socket mounted in hole 2.

Using another piece of hookup wire, solder one end of this wire to the solder lug on the left hand front section of the stator plates on your two gang tuning condenser. Solder the connection. This wire is passed down through the chassis through a hole directly underneath the solder lug. The other end of this piece of hookup wire is to be connected to the filament prong next to the cathode prong on the 5-prong socket mounted in hole 2. Solder the connection.

Your radio frequency choke is now to be mounted by bolting it in the small hole which is directly in the center of the 4 large holes 3, 4, 5, and 6.

Now connect one pigtail end of a .00025 mfd. mica condenser to the heater prong next to the plate prong on the 4-prong socket mounted in hole 2. The other pigtail end of this same condenser is to be connected to the plate prong on the 6-prong socket mounted in hole 1. At the time this connection is made, connect a piece of hookup wire between the screen grid terminal and the plate terminal on this socket. Also, connect another piece of hookup wire to the same plate terminal and then solder these connections. The other end of this second piece of hookup wire is to be connected to one terminal on the radio frequency choke. Solder the connection. From the remaining terminal on the radio frequency choke, connect a piece of hookup wire, solder the connection. The other end of this piece of hookup wire is to go to the negative terminal on the milliammeter.

The 5-plate padder condenser used in your superheterodyne experiments is to be mounted in hole 4. Now from one of the terminal lugs on this padder condenser, connect a piece of hookup wire between that terminal lug and the heater prong next to the plate prong on the 6-prong socket mounted in hole 3. From the other terminal lug on this padder condenser, connect a piece of hookup wire to the heater terminal next to the cathode terminal on the 6-prong socket mounted in hole 3. Solder these connections. Now to the heater terminal next to the cathode terminal on the 6-prong socket mounted in hole 3, connect a piece of hookup wire to a solder lug which has been placed under one of the bolts holding the socket in place. Solder the connection. This provides a ground connection for the bottom end of the grid tank circuit to be used in this experiment.

To the heater terminal next to the plate terminal on the 6-prong socket mounted in hole 3, connect one pigtail end of a .00025 mfd. mica condenser and also one pigtail end of a 40,000 ohm resistance. Solder the connection. The other pigtail end of the condenser and resistor goes to the grid terminal on the 6-prong socket mounted in hole 1. Then solder the connection.

Connect one pigtail end of a 700 ohm resistance and one pigtail end of a .1 mfd. condenser to the cathode terminal on the 6-prong socket mounted in hole 1. The other pigtail end of the 700 ohm resistance and the .1 mfd. condenser is to be connected to a conveniently placed solder lug. It is probably easiest to accomplish this by placing a solder lug under one of the bolts which holds socket 5 in place. Connect one pigtail end of a .1 mfd. condenser to the heater prong next to the cathode prong on socket 2. Solder the connection. The other pigtail end of this condenser is to be grounded. This can be done by connecting it to any conveniently placed solder lug.

Connect one pigtail end of a 4,000 ohm resistor to the positive terminal on the milliammeter. The other pigtail end of this resistor is to be connected to the B+ terminal lug on the terminal strip mounted under the bolt which holds the right hand end of your filter choke in place. Now, if you have very carefully followed directions, your experiment will be wired up as shown in Fig. 5.

Now that you have your experiment completed, you are ready to operate it and then determine its efficiency. In your laboratory apparatus, you have a 7.5 watt light bulb and a screw base socket.

To one of the terminals on this socket, connect one pigtail lead of a .1 mfd. condenser. To the other terminal on this socket, connect a piece of hookup wire approximately 6 inches long. This .1 condenser and the light bulb will be used as a dummy antenna. Through its use it will be possible to change the load on your oscillator experiments and you will also be able to judge approximately the power output being secured from each experiment.

Using a screwdriver, set the .0004 padder condenser mounted in hole 4 at about half capacity. A little experimentation will show you when it is set at about the mid point. Plug a type 42 tube in socket 1 and a type 80 tube in socket 13. Plug your experiment into a 110 volt, 60 cycle outlet and you are ready to turn it on.

With the chassis right side up and the front toward you, turn on your experiment by rotating your volume control switch. As the tubes warm up, plate current will be indicated on your milliammeter. This plate current may be anything from 25 to 40 ma. Now with plate current indicated, carefully rotate your two gang tuning condenser. When the plate circuit is in resonance with the grid circuit, the type 42 tube will oscillate and the plate current will dip, showing that oscillations are occurring. The plate current, when the tube is oscillating, should be about two-thirds as much as when the tube is not oscillating.

Now, using an insulated screwdriver, if you increase the capacity of your padder condenser, you will find that it is also necessary to increase the capacity of your two gang tuning condenser, in order to keep the tube oscillating. You will also find that as you increase the capacity of your two gang condenser, you are decreasing the LC ratio. This results in a lower load impedance into which the type 42 tube is working and a resulting increase of plate current. You will find that with the higher capacity, the plate current will be 2 or 3 ma. greater than when you are using a low capacity. REMEMBER THAT IN ORDER TO GET YOUR TUNED-GRID, TUNED-PLATE, OSCILLATOR TO OSCILLATE, IT WILL BE NECESSARY THAT THE PLATE AND GRID TANK CIRCUITS ARE IN RESONANCE WITH EACH OTHER.

Now that you have your oscillator working properly, you are ready to load it. Set the screw base receptacle on your chassis in any convenient position. (It is not necessary to bolt it.) Now, solder one pigtail lead of the .1 mfd. condenser to any one of the lower taps on your five prong coil form mounted in socket 2. The piece of hookup wire is then to be connected to the next tap just above the one used for the condenser, or a tap 4½ turns away from the condenser tap. You now have your dummy antenna connected across 4½ turns of your plate tank coil. Turn your experiment on and carefully tune your plate tank condenser. If you conduct this experiment in a comparatively dark room, you will be able to see the light bulb glow. This indicates that your oscillator is oscillating and that it is delivering power to the dummy antenna. Turn off your experiment.

Now, move the piece of hookup wire to the second tap above the tap to which the condenser is connected. This time you will have nine turns of wire connected to your dummy antenna. Now, turn on your experiment and carefully tune your plate tank condenser. This time, if everything is working correctly, you should get a fairly bright glow from your 7½ watt light bulb.

Now, if you will screw this light bulb into a regular 110 volt light socket, you will be able to observe how brightly it lights up when 110 volts is applied to it and the light bulb is consuming a full power of 7½ watts. To the best of your ability, remember how bright this is and then try your experiment again. By comparing the brightness secured with the light bulb as a dummy antenna and the same light bulb screwed in a 110 volt socket, you will be able to estimate how much power is being dissipated in your dummy antenna system. This will indicate how much power output your oscillator is putting into the dummy.

Now, the next thing to do is to calculate the power input to your oscillator. Since you do not have a voltmeter with which you can measure the plate voltage, you will have to assume the value we measured here in our laboratories. With a plate current load of 30 ma., your power supply system will produce a DC voltage of approximately 350 volts. However, you do not have 350 volts applied to the plate of your oscillator tube, because you have a 4,000 ohm resistance in series with the plate. When you have 30 ma. flowing through a resistance of 4,000 ohms, you will have a voltage drop of 120 volts. Deducting this 120 volts from 350 volts, you have a plate voltage of 230 volts applied to your oscillator tube. With a plate voltage of 230 volts and a plate current of 30 ma., you will have a power input to your oscillator stage of 6.9 watts.

Now, if you estimate that your 7.5 watt light bulb is burning at about one-third brilliancy, then you have a power output of 2.5 watts, with a power input of 6.9 watts. This results in an efficiency of approximately 36%. This is excellent operation for this type of an oscillator.

In your oscillator experiments, you will notice that the plate current increases as you increase the load. This is according to the information you have studied in your lessons on the theoretical operation of this type of equipment.

EXPERIMENT 48

BUILDING TUNED-GRID, TUNED-PLATE OSCILLATOR SERIES FEED

It is going to be necessary to make only two changes in converting the shunt fed oscillator built in Experiment 47 to a series fed oscillator of the same type.

You now have a piece of hookup wire connected between the plate terminal on the 6-prong socket mounted in hole 1 and one of the terminal lugs on the radio frequency choke. Disconnect this piece of hookup wire from the plate terminal on socket 1 and connect the same end of this piece of hookup wire to the heater terminal next to the cathode terminal on the 5-prong socket mounted in hole 2.

You now have a .00025 mfd. mica condenser connected between the plate terminal on the 6-prong socket mounted in hole 1 and the heater terminal next to the plate terminal on the 5-prong socket mounted in hole 2. Remove this condenser entirely. Now take a piece of hookup wire, solder it to the plate terminal on socket 1. The other end of this piece of hookup wire is to be connected to the heater terminal next to the plate terminal on socket 2. Solder these connections. Now, if you have carefully followed directions, your experiment will be wired as shown in Fig. 6.

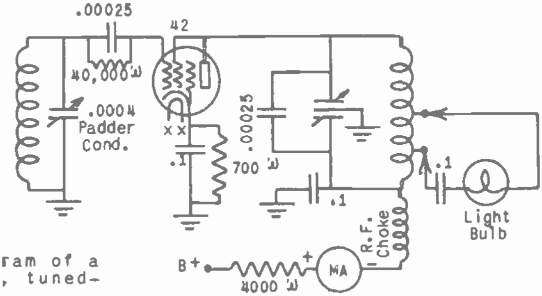


Fig.6 Schematic diagram of a series fed, tuned-grid, tuned-plate oscillator.

After you have completed wiring this experiment, you are then ready to test it out. The directions given for the operation of Experiment 47 will be followed in carrying out the balance of this experiment. In all probability, you will not note a great deal of difference in the operation between a series fed and a shunt fed tuned-grid, tuned-plate oscillator.

EXPERIMENT 49

BUILDING A COLPITTS' OSCILLATOR SERIES FEED

In carrying out this experiment, it is only necessary to make a few changes in converting Experiment 48 into this experiment.

You now have a piece of hookup wire connected between one of the terminals on the R.F. choke and the heater terminal, next to the cathode terminal on socket 2. Unsolder this piece of hookup wire at the heater terminal next to the cathode terminal and move it over to the grid terminal on socket 2. This is connection X as shown in Fig. 7.

You now have a .00025 mfd. mica condenser and a 40,000 ohm resistance connected between the grid terminal on socket 1 and the heater terminal next to the plate terminal on socket 3. Disconnect the two pigtail leads of these two pieces of apparatus from the heater terminal next to the plate terminal on socket 3. The free pigtail lead of the 40,000 ohm resistance is then to be connected to ground by using any conveniently placed solder lug. It will probably be most convenient to use the solder lug bolted at the left-hand side of socket 3. Solder the connection.

You now have a piece of hookup wire connected between the plate terminal on socket 1 and the heater terminal next to the plate terminal on socket 2. The piece of hookup wire is to be disconnected at the filament terminal next to the plate terminal on socket 2. It is to be moved over to the filament terminal next to the cathode terminal on socket 2.

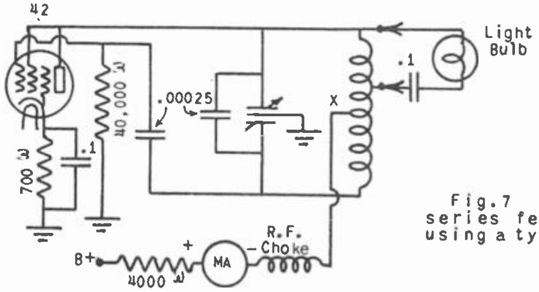


Fig.7 Schematic diagram of a series fed Colpitt's oscillator using a type 42 tube as a triode.

After you have completed this operation, you are then to connect the free pigtail lead of the .00025 mfd. mica condenser to the heater terminal next to the plate terminal on socket 2. The other end of this condenser is now connected to the grid terminal on socket 1.

Now, if you have followed directions carefully, your experiment will be wired as shown in Fig. 7. There remains only one other operation for you to complete before you test this oscillator. When you wound your five prong coil form, you placed a total of seven taps on that coil. We told you at the time that you would use these taps later on. You are now ready to use the first one. Cut a piece of your #20 double cotton covered magnet wire about six inches long. Very carefully scrape the insulation from both ends of this piece of wire. Now, pass one of the free ends down through the grid prong of the five prong coil form and solder the connection. The wire now comes up through the center of the coil form. It is to be bent over and connected to the center tap connection on your five prong coil. Put a little loop in the end of the wire, twist it around the center tap and solder the connection. This is connection X as shown in Fig. 7. Because the rotor plates, or the frame of your condenser is automatically connected to ground when it is bolted to the chassis, the ground or return circuit is provided by this ground connection.

Now place your five prong coil form in socket 2, a type 42 tube in socket 1 and a type 80 tube in socket 13. Plug your experiment into a 110 volt, 60 cycle alternating current supply and you are ready to operate the experiment.

In operating this experiment, you will not find the usual resonant point as you did in the tuned-grid, tuned-plate oscillator circuit. The Colpitts' oscillator will operate fairly efficiently over the entire frequency range of the inductance and capacity combination, since the grid is connected to one end and the plate to the other end of this tank circuit.

You are to load this oscillator in the same manner as was used in loading the other oscillator experiments. However, you will probably find that the circuit is not quite as efficient as the tuned-grid, tuned-plate oscillator. You will also find in tuning this oscillator that you do not have a noticeable dip in plate current, nor do you have a noticeable rise in plate current as the load is taken on or off the oscillator.

It is quite easy to remove the load from the oscillator without unsoldering the connections on the taps of your tank coil. All you need to do is to unscrew the light bulb and that removes the load.

EXPERIMENT 50

CONSTRUCTING A COLPITTS' OSCILLATOR CIRCUIT SHUNT FEED

In this experiment, you are going to change the method of applying plate voltage to the type 42 tube. The Colpitts' oscillator will become shunt fed instead of series fed as built in Experiment 49. Only a few changes are necessary to accomplish this.

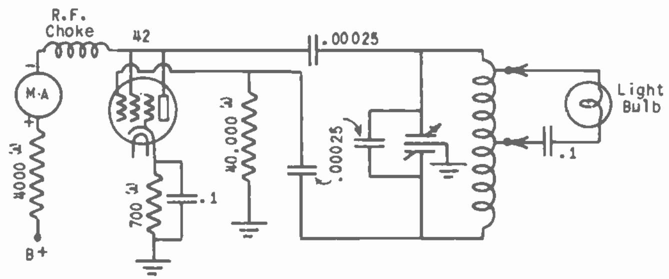


Fig.8 Schematic diagram of a shunt fed Colpitt's oscillator using a type 42 tube as a triode.

The wiring diagram for the shunt fed Colpitts' oscillator is shown in Fig. 8. You now have a piece of hookup wire connected between the plate terminal on socket 1 and the heater terminal next to the cathode terminal on socket 2. Remove this piece of hookup wire. Now connect one pigtail terminal of a .00025 mfd. mica condenser to the plate terminal on socket 1. The other pigtail terminal of this condenser is to be connected to the heater terminal next to the cathode terminal on socket 2.

You now have a piece of hookup wire connected between one of the lugs on the R.F. choke and the grid terminal on socket 2. Disconnect the piece of hookup wire at the grid terminal on socket 2 and connect this end of the piece of hookup wire to the plate terminal on socket 1. By making these changes, you will then have your experiment wired exactly as shown in Fig. 8.

In this experiment, no connection is to be made to the grid terminal on socket 2. This is the center tap terminal on the five prong coil form.

With your experiment wired, you are then ready to test it out, following identically the same procedure as that given in Experiment 49.

In this experiment you will probably find that the plate current runs a little higher than in the series fed type, although, in all probability, you will not secure any increased power output.

EXPERIMENT 51

BUILDING A FEEDBACK OSCILLATOR
SHUNT FEED

In this experiment you are going to construct an unusual type of oscillator circuit. It is known as a very stable type of oscillator circuit, but high power outputs cannot be secured. It will be easy to construct this experiment since it is only necessary to make two connections.

From the back stator section of your two gang tuning condenser, you have a piece of hookup wire connected to the heater prong, next to the plate prong on socket 2. Unsolder this piece of hookup wire from the heater prong and bend the wire back out of the way. Disconnect one pigtail end of the .00025 mfd. condenser, now connected across the two stator sections of your tuning condenser so that this capacity will no longer be in parallel with the tuning capacity. This disconnected wire is shown at X in Fig. 9. You can leave the other pigtail lead of the condenser connected to the other stator section, because later you will want to use this condenser in the same position. However, bend the free pigtail lead so that the free end does not come in contact with the stator section of the condenser. The wiring diagram of this oscillator is shown in Fig. 9.

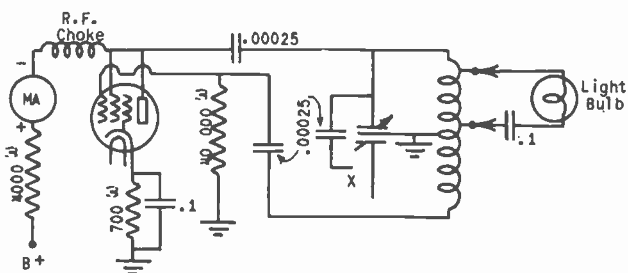


Fig.9 Schematic diagram of a feed-back oscillator. Shunt fed, using a type 42 tube as a triode.

Next, take a piece of hookup wire and connect it to the grid prong on socket 2. Solder the connection. The other end of the hookup wire is to be grounded to any conveniently placed solder lug. This can probably be accomplished easiest by connecting it to the solder lug now bolted under the left-hand side of socket 3. If you have carefully followed directions, your experiment is now ready to operate.

Because a greater amount of feedback is secured at the higher frequencies, you will find that this oscillator works most effectively on the high frequency end of the dial (minimum capacity).

In this experiment, the tank, or tuned circuit is entirely in the plate circuit of the tube; that is, it is connected between plate and ground or filament. Feedback is accomplished by inductive coupling between the plate tank coil and the grid coil.

You will follow the same procedure as that given for the tuning and loading of your previous oscillator experiments. However, in connecting your dummy antenna to this oscillator, you must connect the dummy antenna across the taps which are at the plate end of the coil. The power in this circuit is in the tuned tank circuit which is connected between plate and ground. Therefore, in connecting your dummy antenna, be sure that you connect your load as near the bottom of the coil as possible. Proper adjustment of this oscillator will provide excellent output and it is advisable to check the efficiency by dividing the power output by the power input.

EXPERIMENT 52

CONSTRUCTING A REVERSE FEEDBACK OSCILLATOR SHUNT FEED

In this experiment you will make a few changes so that the tuned or tank circuit will be in the grid circuit of your oscillator tube instead of in the plate circuit as it was in the previous experiment. Oscillations will be produced by the coupling which exists between the plate coil and the grid tank circuit.

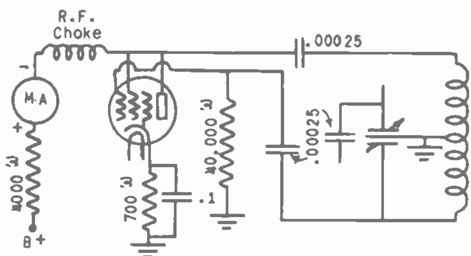


Fig.10 Schematic diagram of a reversed feed-back oscillator. Shunt fed, using a type 42 tube as a triode.

You now have a piece of hookup wire connected from the front stator section of your two gang tuning condenser to the heater terminal next to the cathode terminal on socket 2. Unsolder this piece of hookup wire at the heater terminal. Place the wire so that it will not come in contact with either the chassis or the heater terminal.

In the previous experiment, you disconnected the piece of hookup wire connected between the back stator section of your two gang tuning condenser and the heater terminal next to the plate terminal on socket 2. Replace this connection.

The .00025 mfd. condenser formerly connected between the two stator sections of the two gang tuning condenser is to be left disconnected in this experiment.

Now, if you have carefully followed directions, your experiment is wired as shown in Fig. 10 and you are ready to test out this type of oscillator.

This experiment is to be operated according to the procedure described in Experiment 51. Again you will find that the oscillator functions best at the high frequencies. You will also find that this oscillator does not produce as much power output as that secured in Experiment 51. You will also discover that the plate current is higher with the oscillator unloaded and that the stability does not seem to be as good as that encountered with the straight feedback oscillator. In connecting your dummy antenna, you must remember that it is to be connected to the tank circuit. This is the top end of the coil in this experiment.

EXPERIMENT 53

CONSTRUCTING A PUSH-PULL HARTLEY OSCILLATOR

In this experiment, you are going to construct the first of the push-pull circuits to be built in your transmitter experiments. It will be necessary to make quite a number of changes in carrying out this work.

In the last experiment, you disconnected the piece of hookup wire formerly connected between the front stator section of your two gang tuning condenser and the heater terminal next to the cathode terminal on socket 2. Reconnect this piece of wire. With this connection replaced, you now have a piece of hookup wire connected between the front stator section of your two gang tuning condenser and the heater terminal next to the cathode terminal on socket 2. You also have a piece of hookup wire connected between the back stator section of your two gang tuning condenser and the heater terminal next to the plate terminal on socket 2. These two connections will place your two gang tuning condenser across the outside terminals of your 5-prong coil form which is used in socket 2.

You now have one of the pigtail leads of the .00025 mfd. condenser formerly connected across the two stator sections of your tuning condenser disconnected. Leave this connection disconnected.

You now have a .00025 mfd. mica condenser connected between the plate terminal on socket 1 and the heater terminal next to the cathode terminal on socket 2. Remove this condenser. You also have a piece of hookup wire connected from the screen grid terminal to the plate terminal on socket 1. Remove this connection.

You now have a .00025 mfd. mica condenser connected between the grid terminal on socket 1 and the heater terminal next to the plate terminal on socket 2. Remove this condenser. You also have a 40,000 ohm resistance connected between the grid terminal on socket 1 and ground. Remove this resistance. Remember, your chassis is upside down and the front toward you.

You now have a 6-prong socket mounted in hole 3. However, in mounting this socket, the filament or heater prongs were faced toward the left. In carrying out this experiment, it is going to be necessary to remount the socket so that the heater prongs are toward the right. Previously, you also had a pair of filament leads connected to the heater prongs on the 6-prong socket mounted in hole 5. Disconnect these two heater leads from socket 5 and transfer them to the two heater terminals on socket 3. However, do not cut the wires off, because in a later experiment these will have to be moved back to socket 5. After completing this, you then have the heater terminals on socket 1 and the heater terminals on socket 3 connected to the 6.3 volts winding on your power transformer.

You now have a piece of hookup wire connected between the grid terminal on socket 2 and a solder lug or ground. Remove this connection. You now have a piece of hookup wire connected between the plate terminal on socket 1 and one terminal of the radio frequency choke. Remove this piece of hookup wire at the plate terminal on socket 1 and connect that same end of the hookup wire to the grid terminal on socket 2.

Now take a piece of hookup wire and connect one end of it to the plate terminal on socket 1. The other end of this same piece of hookup wire goes to the heater terminal next to the cathode terminal on socket 2. Solder the connections. Take another piece of hookup wire and connect one end of it to the plate terminal on socket 3. The other end of this piece of hookup wire goes to the heater terminal next to the plate terminal on socket 2. Solder the connections. Now take a piece of hookup wire and connect one end of it to the screen grid terminal on socket 3. The other end of this piece of hookup wire goes to the screen grid terminal on socket 1. Connect one pigtail end of a 40,000 ohm resistance to the screen grid terminal on socket 3 and solder the connection. The other pigtail end of the 40,000 ohm resistance goes to the terminal lug on the radio frequency choke which is now connected to the negative terminal of your milliammeter. Solder the connection. Connect one pigtail lead of a .1 mfd. condenser to the screen grid terminal on socket 1. Solder the connection. The other pigtail lead on this .1 condenser is to be connected to ground by soldering to any conveniently placed solder lug. You now have a solder lug bolted under the left hand bolt holding socket 3 in place. To this solder lug, connect a piece of bare hookup wire. The other end of this piece of bare hookup wire goes to the suppressor grid prong and the cathode prong on socket 3.

Next, bolt a solder lug under the back bolt which holds socket 1 in place. To this solder lug, ground the suppressor grid prong and the cathode prong on socket 1. Solder the connections.

Now connect one pigtail end of a .1 mfd. condenser to the terminal lug on the radio frequency choke. This is the same terminal lug now connected to the grid prong on socket 2. Solder the connection. The other pigtail end of the .1 condenser is to be connected to any conveniently placed solder lug so that the lead is grounded.

The balance of this experiment is comparatively complicated, so it will be necessary for you to follow directions carefully. Take a large grid clip and carefully solder to this grid clip one pigtail lead of a 25,000 ohm resistance and 1 pigtail lead of a .00025 mfd. mica condenser. Prepare a second large grid clip in identically the same fashion. A 6C6 tube will be used in socket 1 and a 6D6 tube will be used in socket 3. Since these tubes have their grid connection coming out to a cap on top of the tube, it is going to be necessary to make suitable arrangements for connections to these two grid leads.

Now, with your chassis right side up and the front toward you, bolt a solder lug to the top side of the chassis, using the small hole directly in the center of the four large holes 1, 2, 3, and 4. To this solder lug, solder the free pigtail terminals of both of the 25,000 ohm resistors, the other ends of which you connect to grid clips. This provides a ground connection for the two grid leaks for these two tubes.

Now, take two pieces of hookup wire approximately 2 inches long. Solder a piece of hookup wire to the free pigtail leads of both of the .00025 mfd. condensers now connected to the grid clips. It is necessary to lengthen these pigtail leads because they will not reach the correct tap on the 5-prong coil form, which is to be mounted in hole 2.

Now, place your 5-prong coil form in socket 2. Place a 6C6 tube in socket 1 and a 6D6 tube in socket 3. One of the grid clips is to be connected to the 6C6 tube and the other grid clip is to be connected to the 6D6 tube. It does not make any difference which of the two grid clips you use, just so long as after you have selected one, you continue to use that same grid clip on the same tube. If you were to reverse these two grid clips, your push-pull oscillator would not function.

The plate terminal of the 6C6 tube mounted in socket 1 is connected to the heater terminal next to the cathode terminal on the 5-prong coil form. This means that the plate of this tube is connected to the bottom end of the 5-prong coil. Now, in order to get your oscillator to oscillate, it will be necessary for the grid of this tube to be connected to the top end of this coil. Therefore, using the end of the piece of hookup wire soldered to the pigtail end of the .00025 mfd. condenser, connect this piece of hookup wire to the second tap from the top on the 5-prong coil. Put a little kink in the wire, twist it around the tap and solder the connection.

The other grid cap is connected to the grid of the 6D6 tube mounted in socket 3. The plate of this tube is connected to the heater prong next to the plate prong on socket 2. This means that the grid of this tube must be connected to the opposite end of the coil. In this case, it is going to be the bottom end. Therefore, solder the free end of the piece of hookup wire now connected to the .00025 mfd. condenser to the second tap from the bottom on the 5-prong coil form. Put a kink in the wire, twist it around the tap and solder the connection. Now, if you have very carefully followed directions, your experiment is wired up as shown in Fig. 11.

The operation of this experiment will not be a great deal different than that procedure used in connection with your other oscillator experiments. Your dummy antenna load is to be connected to the 5-prong coil, your experiment turned on and you are ready to test out the efficiency of this type of oscillator.

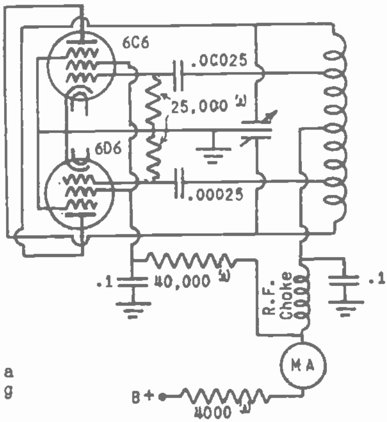


Fig.11 Schematic diagram of a push-pull Hartley oscillator using a 6D6 and a 6C6 tube.

You must bear in mind that it is not possible to secure as much power output with the two tubes of the type used in this experiment as is possible when using a type 42 tube whose normal power output capabilities is considerably greater. You can check the loading action on this push-pull stage by varying the number of turns connected to your dummy antenna and then also by unscrewing or screwing in the light bulb which throws the load on and off. This will give you some interesting experience in checking the operation of this type of equipment.

EXPERIMENT 54

CONSTRUCTING A PUSH-PULL ELECTRON-COUPLED OSCILLATOR

Later in your experiments, you are going to use a single ended electron-coupled oscillator, but since you already have two tubes set up for push-pull operation, we deemed it advisable at this time to complete all push-pull circuits and then continue with the balance of your transmitter experiments.

You now have a piece of hookup wire connected between the plate terminal on socket 1 and the heater terminal next to the cathode terminal on socket 2. Remove this piece of wire. You now have a piece of hookup wire connected between the plate terminal on socket 3 and the heater terminal next to the plate terminal on socket 2. Remove this piece of wire.

You now have a piece of hookup wire connected between the suppressor grid terminal, the cathode terminal and a solder lug on socket 1. Remove these connections. You have a piece of hookup wire connected between the suppressor grid terminal, the cathode terminal and a solder lug on socket 3. Remove these connections.

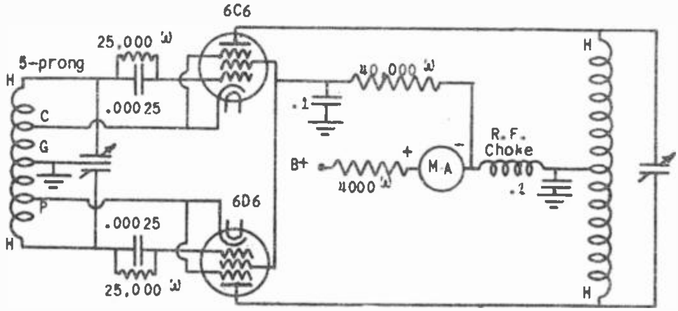


Fig.12 Schematic diagram of a push-pull electron-coupled oscillator using a 6D6 and a 6C6 tube.

A complete wiring diagram for this experiment is shown in Fig. 12. Your 5-prong coil form is going to be used in socket 2 and the 6-prong coil form is going to be used in socket 5. With these conditions in mind, you can then start wiring your experiment. You now have the pigtail leads of two 25,000 ohm resistors connected to a solder lug bolted in a small hole in the center of the four large holes 1, 2, 3, and 4. Unsolder these two pigtail leads and remove the bolt and solder lug. You now have the pigtail leads of the two .00025 mfd. condensers connected to two of the taps on the 5-prong coil form. Unsolder these two connections. Now fasten the pigtail lead of one 25,000 ohm resistance to its corresponding pigtail lead on a .00025 mfd. condenser. Then, to this combination, solder a piece of hookup wire approximately 5 inches long. Repeat this same operation with the pigtail leads of the resistor and condenser on the other tube. Also, solder on another piece of hookup wire approximately 5 inches long.

The resistor and condenser combination which is connected to the 6C6 tube mounted in socket 1 is to be connected to the heater terminal next to the cathode terminal on socket 2. The piece of hookup wire spliced to the two pigtail leads can be passed down through the chassis, using the small hole just to the right of socket 2. The piece of hookup wire connected to the resistor-condenser combination on the 6D6 tube mounted in socket 3 is to be passed down through the small hole which is in the center of the four large holes 1, 2, 3, and 4. The other end of this piece of hookup wire is to be connected to the heater terminal next to the plate terminal on socket 2.

Now take a piece of hookup wire and connect it from the suppressor grid prong to the cathode prong on socket 1. From there, it is to go to the cathode prong on socket 2. Solder these three connections. Take another piece of hookup wire and connect it from the suppressor grid prong to the cathode prong on socket 3. From there, this piece of hookup wire is to go to the plate prong on socket 2. Solder the connections.

Solder a piece of hookup wire to one of the terminal lugs on the padder condenser mounted in hole 4. The other end of this piece of hookup wire is to go to the heater terminal next to the cathode terminal on socket 5. At the same time this connection is made, also connect another piece of hookup wire and then solder the connection. The other end of this second piece of hookup wire is to go to the plate terminal on socket 3. Solder the connection.

From the other terminal lug on the padder condenser, solder a piece of wire. The other end of this piece of wire goes to the heater prong next to the plate prong on socket 5. Also, to this same prong, attach a second piece of hookup wire and solder the connection. The other end of this second piece of hookup wire goes to the plate prong on socket 1. Solder the connection.

You now have a piece of hookup wire connected between one terminal on the radio frequency choke and the grid terminal on socket 2. Unsolder this piece of hookup wire at the grid terminal on socket 2. Swing the end of this piece of hookup wire over to the grid terminal on socket 5. The grid terminal on this socket is the one next to the cathode terminal on a 6-prong socket. Solder the connection. Now take a piece of hookup wire and solder it to the grid prong on socket 2. The other end of this piece of hookup wire is to be connected to any conveniently placed solder lug. This then grounds the center tap terminal of the 5-prong coil form.

Now, if you have followed directions, your experiment is wired up as shown in Fig. 12. However, before you can operate your experiment, it is going to be necessary to make some connections on both your 5-prong and 6-prong coils. Cut a piece of #20 double cotton covered magnet wire and carefully scrape one-half inch of the insulation from each end. Pass one of these ends down through the grid prong on your 6-prong socket and solder the connection. The other end of this piece of wire is to be connected to the center tap terminal on your 6-prong socket and then the connection soldered. This will provide a ground connection for the 6-prong coil which you are going to use in socket 5.

You already have a piece of wire running from the grid prong to the center tap on your 5-prong coil form. However, in this experiment, it is going to be necessary to add two additional taps. Cut two pieces of #20 double cotton covered magnet wire 5½ inches long. Scrape one-half inch of the insulation from each end of the two wires. Pass one of these pieces of wire down through the cathode prong and solder the connection. This wire comes up through the center of the coil form, is bent over, and then is connected to the third tap from the bottom on the 5-prong coil. This is the first tap down from the center tap. Solder the connection. The other piece of magnet wire is to be passed down through the plate prong and soldered. This piece of wire then comes up over the top of the coil form and is to be soldered to the third tap down from the top of the coil form. The third tap down is the first tap up from the center tap on the 5-prong coil.

Now place your 5-prong coil form in socket 2, a type 6C6 tube in socket 1, a type 6D6 tube in socket 3, and your 6-prong coil form in socket 5. A type 80 tube is to be placed in socket 13 and then you are ready to operate your experiment. Plug it into a 110-volt 60-cycle alternating current source and turn the experiment on.

In completing this experiment, you are to go about the procedure of loading this push-pull oscillator just the same as you did in your other experiments. While the electron-coupled type of oscillator is very stable, still you will find that it is practically impossible to secure a great deal of power output from this particular oscillator. However, the experience provided in constructing and operating this type of equipment will be quite helpful to you as you proceed with your transmitter experiments.

EXPERIMENT 55

CONSTRUCTING A PUSH-PULL, TUNED-GRID, TUNED-PLATE OSCILLATOR CIRCUIT

In this experiment, you are going to use the 6D6 and the 6C6 tubes as triodes. A tuned-grid, tuned-plate oscillator depends on feedback from the plate to grid circuits in a triode tube to produce oscillations. Therefore, if we were to use these two tubes as screen grid tubes, no oscillations would be produced because of the neutralizing effect of the screen grid.

Before starting to wire this experiment, it will be necessary to disconnect several of the leads used in completing Experiment 54. You now have one pigtail lead of a 25,000 ohm resistance and one pigtail lead of a .00025 condenser connected to each of the two grid clips which go to the 6C6 and 6D6 tubes. Unsolder these resistors and condensers from the two clips. Also, remove completely the extra lengths of hookup wire which were connected to the pigtail leads. You now have a piece of hookup wire connected between the cathode prong and suppressor grid prong on socket 1. From the cathode prong, this piece of wire also went to the cathode prong on socket 2. Remove these connections. You now have a piece of hookup wire connected between the cathode prong and the suppressor grid prong on socket 3. This piece of hookup wire also goes to the plate prong on socket 2. Remove these connections.

You now have a piece of hookup wire connected from the screen grid prong on socket 3 over to the screen grid prong on socket 1. Remove this connection. You have one pigtail lead of a 40,000 ohm resistance connected to the screen grid prong on socket 3. The other pigtail lead of this 40,000 ohm resistance is connected to one of the terminals on the R.F. choke; remove this resistor. You have one pigtail lead of a .1 mfd. condenser connected to the screen grid prong on socket 1. The other end of this .1 condenser has been connected to a solder lug. Remove this condenser.

You now have a piece of hookup wire connected between the grid terminal on socket 2 and a solder lug or ground. Remove this ground connection. You now have a piece of hookup wire connected between one terminal on the R.F. choke and the grid terminal on socket 5. Unsolder this piece of hookup wire at the grid terminal on socket 5 and solder the same end of this piece of hookup wire to the grid terminal on socket 2.

You now have your two gang tuning condenser connected across the heater prongs on socket 2. These connections will remain. You now have your five plate padder condenser mounted in hole 4, connected across the heater prongs on socket 5. These connections will remain intact.

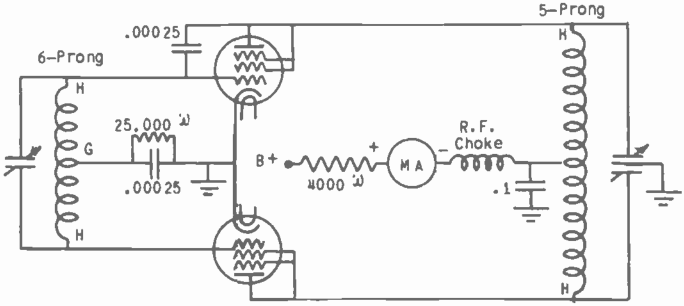


Fig.13 Schematic diagram of a push-pull, tuned-grid, tuned-plate oscillator.

A complete wiring diagram for this experiment is shown in Fig. 13. In conducting Experiment 54, the two extended pieces of hookup wire coming from the grid clips on the two tubes were formerly connected to the heater terminals on socket 2. If these wires have not previously been disconnected, do so at this time. To the heater terminals on socket 2, you should have no connections made except the two wires which come from the stator sections of your two gang tuning condenser.

Now, take a bare piece of hookup wire and connect it between the suppressor grid prong, the screen grid prong and the plate prong on socket 1. Solder the connections. Take another piece of hookup wire and connect it to the plate prong on socket 1. Solder the connection. The other end of this piece of hookup wire goes to the heater prong next to the cathode prong on socket 2. Solder the connection. A bottom view of this socket is shown at A, Fig. 14.

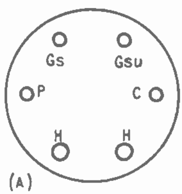
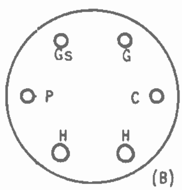


Fig.14 (A) Bottom view of a six prong socket. This is for tubes such as the 6C6 and 6D6 with control grid leads brought out the top of the tube.
(B) Bottom view of a six prong socket, for tubes with control grid brought out the base.



Now, take another bare piece of hookup wire and connect it between the suppressor grid prong, the screen grid prong and the plate prong on socket 3. Solder the connection. (This socket is shown at A, Fig. 14.) Attach a second piece of hookup wire to the plate prong on socket 3 and solder the connection. The other end of this piece of hookup wire goes to the heater prong next to the plate prong on socket 2. At the time this connection is made, also connect one pigtail lead of a .00025 mfd. condenser and solder the connection. The other pigtail end of this condenser is to be connected to the nearest terminal lug on the five plate padding condenser mounted in hole 4.

Now take a piece of hookup wire and connect it to the cathode prong on socket 1. Solder the connection. The other end of this piece of hookup wire is to be connected to any conveniently placed solder lug and the connection soldered. This grounds the cathode prong.

Take a piece of hookup wire and connect it to the cathode prong on socket 3. Solder the connection. The other end of this piece of hookup wire goes to any conveniently placed solder lug which grounds this cathode prong. Solder all connections.

Connect one pigtail lead of a .00025 mfd. mica condenser and one pigtail lead of a 25,000 ohm resistance to the grid prong on socket 5. Solder the connection. The other pigtail leads of this resistor and condenser are to be connected to any conveniently placed solder lug which will ground the other end of the resistor-condenser combination. A bottom view of this socket is shown at B, Fig. 14.

You are now to cut two pieces of hookup wire approximately 8 inches long. To each of these pieces of hookup wire, solder a large grid clip. The grid clips are to connect respectively to the 6D6 and 6C6 tubes used in this experiment. Pass the free ends of these two pieces of hookup wire down through the small hole in the center of the four large holes, 1, 2, 3, and 4. The free end of one of these pieces of hookup wire is to be connected to either of the terminal lugs on the padding condenser mounted in hole 4. The free end of the other piece of hookup wire is to be connected to the remaining terminal lug on the padder condenser mounted in hole 4. By following this procedure, you will then have the grid connections on the two tubes connected to the outside terminals on the 6-prong coil form which is to be mounted in socket 5.

Place your 5-prong coil form in socket 2, a 6C6 tube in socket 1, a 6D6 tube in socket 3, and a 6-prong coil in socket 5. A type 80 tube will be used in socket 13 and then you are ready to plug your experiment into a 110-volt, 60-cycle AC supply.

This experiment will be operated practically identically with the single ended tuned-grid, tuned-plate oscillator which you built in Experiment 48. The tuning procedure is identical and you will go about loading the oscillator in practically the same manner. In connecting your dummy antenna to the 5-prong coil form, you must remember that the dummy antenna is to be connected across taps which are at one end of the coil. In other words, you will use 4.5 or 9 turns of the coil, either at the top end of the coil or at the bottom end of the coil, but not in the center.

You will find in operating this experiment that it is not as efficient as the tuned-grid, tuned-plate oscillator built in Experiment 48. The reason for this is that the two tubes used do not have the power output capabilities of the single type 42 tube.

EXPERIMENT 56

CONSTRUCTING A SINGLE-ENDED ELECTRON-COUPLED OSCILLATOR SERIES FEED

In this experiment, you are going to start the first of a very interesting series of experiments. The conclusion of this series of experiments will lead to the construction of a master oscillator, buffer, power amplifier transmitter.

The first thing to do in carrying out this experiment is to disconnect all of the wires now connected to sockets 2, 3 and 5. In disconnecting these wires from sockets 2, 3 and 5, disconnect the wires at both ends; in other words, completely remove all connections going to these three sockets. However, here is one exception. You have a pair of twisted leads connected from the heater prongs on socket 1 to the heater prongs on the six prong socket mounted in hole 3. These two heater wires are to be moved back to the heater connections on the 6-prong socket mounted in hole 5. During the process of removing wires, it is also advisable to remove all of the connections made to socket 1, excepting the heater or filament leads. It is advisable to remove all connections made to the R.F. choke except the B+ lead. You now have a piece of hook-up wire connected from the negative terminal of your milliammeter to one terminal of the R.F. choke. Leave this connection intact, but remove all other connections.

After completing this work, it will be necessary to make one other change; you have a 6-prong socket mounted in hole 3. Remove this socket. You have a 5-prong socket mounted in hole 2. Remove this socket. With the chassis upside down and the front toward you, you are to mount the 6-prong socket in hole 2. In mounting this socket, be sure the heater or filament prongs are faced toward the left. Next, mount the 5-prong socket in hole 7. In mounting this socket, face the filament prongs toward the right side of the chassis.

Here is your situation to date. You have 5-prong sockets mounted in holes 7 and 8. You have 6-prong sockets mounted in holes 1, 2 and 5. Your power supply is to remain intact. You have the 2.5 volt filament winding on the power transformer connected to the 5-prong socket mounted in hole 8. You have no connections at the present made to the 5-prong socket mounted in hole 7. You have 6.3 volt filament connections made to the 6-prong sockets mounted in holes 1 and 5. You have no socket mounted in hole 3 at this time. You have no connections made to the 6-prong socket mounted in hole 2. Now, you are ready to wire up the balance of your experiment. A wiring diagram for this experiment is shown in Fig. 15.

With the chassis upside down and the front toward you, the following directions are to be carefully followed. Connect a piece of hookup wire from the heater prong next to the cathode prong on socket 7 to a solder lug bolted under the right-hand bolt which holds socket 8 in place. Also, to this same solder lug connect one pigtail end of a .00025 mfd. mica condenser, then solder the connections. The other pigtail lead of this .00025 condenser is to be connected to the heater prong next to the plate prong on socket 7. At the time this connection is made, also attach a piece of hookup wire and solder the connection.

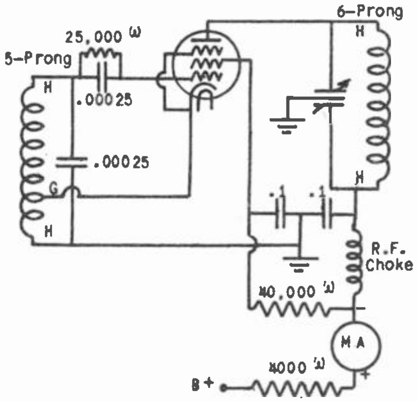


Fig.15 Schematic diagram of a single ended electron-coupled oscillator.

To a large grid clip, attach one pigtail end of a 25,000 ohm resistance and one pigtail end of a .00025 mfd. mica condenser. Solder these two pigtail leads. Place a type 6D6 tube in socket 5. Attach to the grid cap of this socket the grid clip to which you just soldered the resistor and condenser. Next, pass the piece of hookup wire (now connected to the heater terminal next to the plate terminal on socket 7) up through the chassis using the small hole which is in the center of the four large holes 5, 6, 7 and 8. The condenser-resistor combination is hanging down at the side of the 6C6 tube. Cut this piece of hookup wire off so that it just reaches the pigtail leads on these two pieces of apparatus and then solder the free end of the 25,000 ohm resistance and the .00025 mfd. mica condenser to the free end of the hookup wire.

Take a bare piece of hookup wire and connect it to the suppressor prong on the 6-prong socket mounted in socket 5. The other end of this wire goes to the cathode prong on this socket. From the cathode prong, connect another piece of hookup wire and solder the connection. The other end of this second piece of hookup wire goes to the grid prong on the 5-prong socket mounted in hole 7. Solder the connection.

Connect one pigtail lead of a 40,000 ohm resistance and one pigtail lead of a .1 mfd. condenser to the screen grid prong on socket 7. Solder the connection. The other pigtail lead of the 40,000 ohm resistance goes to a terminal lug on the R.F. choke. The terminal lug to use is the one now connected to the B- terminal of your milliammeter. (B+ of power supply.) Solder the connection. The other pigtail lead of the .1 mfd. condenser is to be connected to any conveniently placed solder lug.

Connect a piece of hookup wire to the front stator section of your two gang tuning condenser. This wire is passed down through the chassis, using a hole directly under the connection lug. The other end of this piece of hookup wire is to be connected to the heater terminal next to the cathode terminal on the 6-prong socket mounted in hole 2. At the time this connection is made, also connect one pigtail lead of a .1 mfd. condenser and then solder the connection. The other pigtail lead of the .1 condenser is to be connected to any conveniently placed solder lug. Now connect a piece of hookup wire to the back stator section of your two gang tuning condenser. This piece of hookup wire is passed down through the chassis, using the small hole directly under the solder lug. The other end of this piece of hookup wire is to be connected to the heater terminal next to the plate terminal on socket 2. At the same time this connection is made, also connect another piece of hookup wire and then solder the connection. The other end of this second piece of hookup wire is to go to the plate terminal on socket 5. Solder the connection.

The .00025 mfd. condenser formerly connected across the two stator sections of the two gang condenser MUST NOT be connected during the experiment.

Now, to the free terminal on the R.F. choke, connect a piece of hookup wire and solder the connection. The other end of this piece of hookup wire goes to the heater terminal next to the cathode terminal on socket 2. Solder the connection. If you have very carefully followed directions, your experiment is wired as shown in Fig. 15, and you are ready to test it. The 6-prong coil form is to be used in socket 2; a 6D6 tube is to be mounted in socket 5 and your 5-prong coil form is to be mounted in socket 7. However, before mounting the 5-prong coil you must make one change. In the last experiment, you had a piece of wire connected from the grid prong to the center tap on this coil. Leave the piece of wire connected to the grid prong, but move the other end of the wire from the center tap on the coil to the second tap from the bottom. Solder the connection. This tap is 9 turns from the bottom of the coil.

After the tubes have had a chance to warm up, you will have a plate current reading. Now, carefully rotate your two gang tuning condenser and when the plate tank circuit is in resonance with the grid tank circuit, you will have a very noticeable dip in plate current. This indicates your circuits are in resonance and that your oscillator is functioning satisfactorily.

Now, turn the oscillator off and connect your dummy antenna as you have been doing for other experiments. In loading this oscillator, you will notice an appreciable increase in plate current, with an increase in load. You will also find the oscillator to be quite efficient. In fact, in all probability you will be able to secure as much power output from this oscillator as from any of the previous oscillators built except those using the type 42 tube.

EXPERIMENT 57

CONSTRUCTING AN ELECTRON-COUPLED OSCILLATOR SINGLE ENDED; SHUNT FEED

In this experiment, you are going to change the series-fed oscillator constructed in Experiment 56 to a shunt-fed oscillator so that you can test the operating efficiency of these two different types of circuits.

With your chassis upside down and the front toward you, mount a terminal strip using the small hole at the left side of large hole 3. You now have a piece of hookup wire connected between one terminal lug on the R.F. choke and the heater prong next to the cathode prong on socket 2. Disconnect this piece of hookup wire at the heater prong next to the cathode prong. Swing this end of the wire over to the plate terminal on socket 5. At the time you do this, disconnect the piece of hookup wire which is now connected at that point; solder the connection.

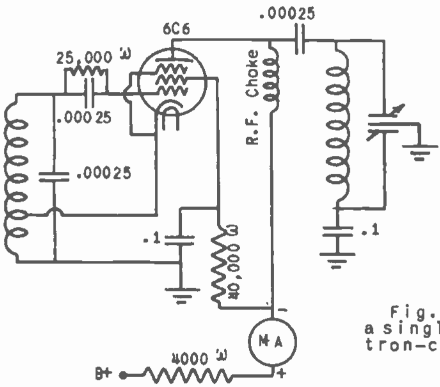


Fig. 16 Schematic diagram of a single ended, shunt fed, electron-coupled oscillator.

You formerly had a piece of hookup wire connected between the heater terminal next to the plate terminal on socket 2 and the plate terminal on socket 5. You just disconnected this piece of hookup wire at the plate terminal on socket 5. This piece of hookup wire is then to be connected to one of the terminal lugs on the terminal strip mounted at the side of hole 3. Connect one pigtail terminal of a .00025 mfd. mica condenser to the plate terminal on socket 5; solder the connection. The other pigtail terminal of the .00025 condenser is to be connected to the terminal lug on the terminal strip to which you just connected a piece of hookup wire; solder the connection. Now, if you have very carefully followed directions, your experiment will be wired as shown in Fig. 16. The same tube and coil arrangement is to be used in this experiment as was used in the preceding experiment. Therefore, after all of your parts are properly placed; turn on the experiment as it is ready for operation.

In operating this experiment, you will find that it operates identically the same as the series fed oscillator described in Experiment 56. Carefully load this oscillator, following the same procedure as usual and see if you can determine any difference in the operating efficiency between the two oscillators. You should carefully note the plate current drawn by each oscillator and judge the output. Knowing these two values, you can calculate the efficiency of such oscillators.

EXPERIMENT 58

BUILDING A SCREEN GRID BUFFER AMPLIFIER DRIVEN BY AN ELECTRON-COUPLED OSCILLATOR BUFFER AMPLIFIER, SERIES FEED OSCILLATOR, SHUNT FEED

In this experiment it will not be necessary to make a large number of changes. You now have a piece of hookup wire connected to one of the terminal lugs on the terminal strip mounted at the left of hole 3. Disconnect this piece of hookup wire at the terminal lug and connect it to the plate prong on socket 1. The plate prong on socket 1 is then connected to the heater prong, next to the plate prong on socket 2. Solder the connection.

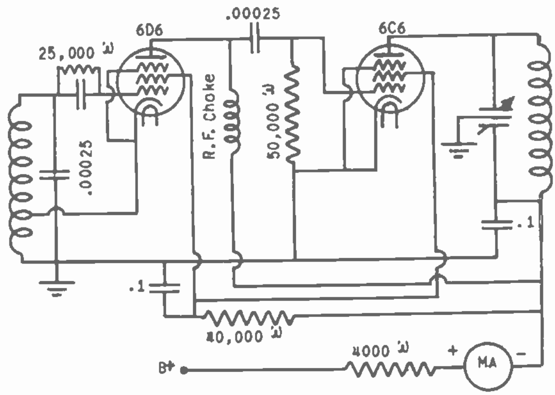


Fig.17 Schematic diagram of a shunt fed, electron-coupled oscillator driving a series fed, screen grid R.F. buffer amplifier.

Cut a piece of hookup sire approximately 8 inches long. To one end of this piece of hookup wire, connect a large grid clip. Pass the free end of this piece of hookup wire down through the small hole which is in the center of the four large holes 1, 2, 3 and 4. The free end of this piece of hookup wire is then to be connected to the terminal lug on the terminal strip to which you now have connected one pigtail lead of a .00025 mfd. condenser. To this same terminal lug, connect one pigtail end of a 50,000 ohm resistance and solder the connection. The other pigtail end of the 50,000 ohm resistance is to be connected to any conveniently placed solder lug. After following these directions, you have a .00025 mfd. mica condenser connected between the plate terminal on socket 5 and the grid cap on socket 1. Also, from the grid of socket 1, you have a 50,000 ohm resistance connected between there and ground. All of these connections are clearly shown in Fig. 17.

Now connect one end of a piece of hookup wire to the B- terminal on your milliammeter. The other end of this piece of hookup wire is to go to the heater terminal next to the cathode terminal on socket 2. Solder this connection.

Now connect a piece of hookup wire to the screen grid terminal on socket 1. Solder the connection. The other end of this piece of hookup wire goes to the screen grid terminal on socket 5. Solder the connection. Now, if you have carefully followed directions, your experiment is wired as shown in Fig. 17 and you are ready to operate it. Your five prong coil form is to be plugged into socket 7. A 6D6 tube is to be placed in socket 5 and its grid clip attached. A 6C6 tube is to be placed in socket 1 and its grid clip attached. Your 6-prong coil form is to be placed in socket 2. Plug the experiment into a 110-volt, 60-cycle AC source, turn it on and give the tubes time to warm up.

The two gang tuning condenser now tunes the plate tank circuit connected in the plate circuit of the 6C6 screen grid R.F. amplifier. After the tubes have had a chance to warm up, carefully tune the two gang tuning condenser until you notice a dip in the plate current. Your milliammeter is now measuring both the plate current of the oscillator and the R.F. amplifier. Therefore, the dip in plate current will not be as noticeable as it was when tuning the electron-coupled oscillator circuit.

After getting your circuits properly tuned, you are then ready to load this amplifier in the usual manner.

EXPERIMENT 59

CONSTRUCTING A HARTLEY OSCILLATOR SERIES FEED

In constructing this oscillator, you are building the first of a series of experiments which will have, as their conclusion, the construction of an oscillator, buffer, power-amplifier, transmitter.

In Experiment 58, you were using a 5-prong coil form in socket 7 as the grid coil of the electron-coupled oscillator. This coil is going to be used in the same position, but instead of operating in conjunction with an electron-coupled oscillator, it will operate in conjunction with a Hartley oscillator, using a type 56 tube mounted in socket 8.

To start this experiment, you should remove all connections now made to socket 7. Disconnect both ends of the leads going to this socket. You now have a large grid clip to which you attached a 25,000 ohm resistance and a .00025 mfd. mica condenser. The other end of these two pieces of apparatus are connected to the heater terminal next to the plate terminal on socket 7. This connection is to be removed and the condenser and resistor are to be disconnected from the large grid clip.

If you have carefully followed directions, you will have all connections removed from socket 7. As yet, you have made no connections to socket 8, except the heater terminals on this socket are connected to the 2.5 volt filament terminals on the power transformer. You are now ready to wire the Hartley oscillator experiment.

Connect one pigtail lead of each of two .00025 mfd. condensers to the heater terminal next to the cathode terminal on socket 7. Solder this connection. The other pigtail lead of one of the .00025 condensers goes to the heater terminal next to the plate terminal on socket 7. At the time this connection is made, also connect one end of a piece of hookup wire and solder the connection. The other end of the piece of hookup wire just connected goes to the plate terminal on socket 8. Solder the connection. The other pigtail end of the second .00025 condenser now connected to the heater terminal next to the cathode terminal on socket 7 is to be connected to the grid terminal on socket 8. At the time this pigtail connection is made, also connect one pigtail terminal of your 10,000 ohm high wattage resistor and then solder the connection. The other pigtail end of this 10,000 ohm resistance goes to the solder lug which is bolted at the right-hand side of socket 8. At the same time this connection is made, also connect one end of the short piece of hookup wire and solder the connection. The other end of the short piece of hookup wire goes to the cathode terminal on socket 8. Solder the connection.

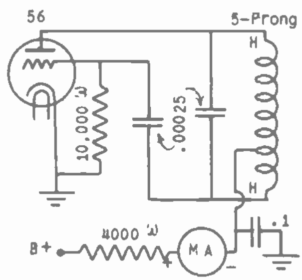


Fig.18 Schematic diagram of a series fed Hartley Oscillator.

Now, solder a piece of hookup wire to the grid terminal on socket 7. The other end of this piece of hookup wire is to go to the negative terminal on your milliammeter. Now if you have carefully followed directions, your experiment is wired exactly as shown in Fig. 18.

The only other thing which needs to be taken care of is the tap connection on your 5-prong coil. You now have a piece of wire which is connected to the grid prong on the 5-prong coil form. This wire comes out the top of the coil form and, for your last experiment, it was connected to the center tap of this coil. However, to start this experiment, this lead should be connected to the second tap from the bottom. This is nine turns from the bottom of the coil.

Now plug your 5-prong coil form in socket 7, a type 56 tube in socket 3, your type 80 tube in socket 13 and you are ready to operate the experiment.

Since the tank circuit for this oscillator is fixed tuned; that is, the .00025 mfd. condenser is connected across the two heater terminals of the 5-prong coil which is across the two outside ends of the 5-prong coil, it is impossible to tune this stage, so therefore, you do not have a direct indication as to whether or not the tube is oscillating. However, if the plate current exceeds 30 ma., then it is quite evident the oscillator is not oscillating. If the plate current is somewhere between 10 and 20 ma., this is a fair indication that the tube is operating satisfactorily.

Now, turn the oscillator off and proceed to load it in the usual manner. In all probability, you will find that you cannot use more than 4½ turns connected across your dummy antenna.

You can conduct some very interesting experiments with this oscillator by varying the tap connection on your 5-prong coil. In starting this experiment, you connected it to 9 turns from the grid end of the coil. Try varying this tap all the way from 9 to 18 turns. Each time you change the tap, also change your load and note the results on plate current and stability of operation. If your oscillator stops oscillating, it may be necessary to turn off your experiment, let it cool a minute and then turn it back on again in order to get it to again oscillate properly.

EXPERIMENT 60

CHECKING THE OPERATING CHARACTERISTICS OF AN ABSORPTION TYPE WAVEMETER

While you do not have all of the equipment necessary to build a regular absorption type wavemeter; still, you can construct a very usable substitute and, by using this wavemeter, you can check the principle of operation of this type of equipment.

You now have your five plate padder condenser mounted in hole 4. Remove this condenser from the chassis. Cut two pieces of hookup wire 5 inches long. Solder a piece of hookup wire to each of the terminal lugs on the five plate padder condenser. Now, using your 6-prong coil, set your padder condenser on top of the 6-prong coil. You will find that the terminal lugs just come down over the edge of the top of the coil. Set the two lugs in such a position that they are approximately in line with the plate and cathode prongs on the coil.

Now, bring one of the pieces of hookup wire down the side of the coil and wrap it around the plate prong. Cut the wire off so that it will just reach the heater prong next to the plate prong. Push the insulation back and solder the bare wire to the heater prong. This then connects one side of the five plate condenser to the top side of the 6-prong coil. Bring the other piece of hookup wire down the side of the coil, pull it up tightly, wrap it around the cathode prong and then bring this piece of hookup wire up so that it will reach the first tap above the bottom of the coil. Push the insulation back and solder this connection to that tap. You then have the other side of the condenser connected to the bottom end of the coil, nine turns above the end.

The reason for doing this is that this circuit must operate at the same frequency as your Hartley oscillator circuit, using all of the condenser and coil, the frequency would be lower than the Hartley oscillator and you could not get the two circuits to resonate. Therefore, we tap this coil so that we would have less coil with the same capacity and then you will have no trouble getting the two circuits to tune to the same frequency.

Now, here is how you use this indicating wavemeter. Set your Hartley oscillator into operation. After you are sure that it is operating satisfactorily, you can then check the operation of your absorption type wavemeter. Set the prongs of the 6-prong coil form down on the top of the 5-prong coil used in the Hartley oscillator. With the coil in this position, then take a screwdriver and carefully tune your absorption wavemeter by varying the capacity of the five plate padder condenser. At the same time, watch your plate milliammeter.

When the tuned circuit, constituting the absorption wavemeter, is at the same frequency as the Hartley oscillator, there will be a noticeable increase in plate current. This is occasioned by the fact that when the wavemeter circuit is at the resonant frequency, it will absorb power from the oscillator coil and you will have a plate current increase. You will find that this tuning is comparatively critical. You will also find that the wavemeter coil affects the oscillator coil, even though it is placed two or three inches from it.

Now, if you had a regular type of absorption meter, you would have a variable condenser on which you would mount a regular dial. Then, that wavemeter would be calibrated with the dial readings calibrated against frequency. By tuning the variable condenser and finding the dial reading at which the maximum plate current occurred, you would then be able to accurately read the frequency at which your oscillator was operating. While this type of wavemeter is not extremely accurate, still, it is satisfactory for some purposes. The chief purpose in this experiment was to demonstrate to you the principle of operation on which such types of wavemeters operated.

EXPERIMENT 61

BUILDING A PENTODE R.F. AMPLIFIER SERIES FEED

In this experiment, you are going to build an R.F. power amplifier, using a type 42 tube. Because of the screen grid in this tube, it will not be necessary to neutralize this stage. Therefore, you will be able to obtain a greater power output from this experiment than you have from any experiment built previously.

When you finished Experiment 58, you left a certain portion of your wiring intact, changing only the wiring made to socket 7 so that the Hartley oscillator could be constructed. In this experiment, it will be necessary to make some additional changes.

You now have a piece of hookup wire to one end of which is connected a large grid clip. The other end of this piece of hookup wire goes to a terminal lug on the terminal strip mounted at the left-hand side of socket 3. To this same terminal lug is connected a .00025 mfd. condenser and a 50,000 ohm resistor. Disconnect all of these connections from this terminal lug. The other pigtail end of the .00025 mfd. condenser is connected to the plate terminal on socket 5. To this terminal you also have connected a piece of hookup wire, the other end of which is connected to the R.F. choke. Remove both the condenser and the piece of hookup wire. Disconnect the remaining pigtail lead of the 50,000 ohm resistance. You now have a piece of hookup wire connected between the screen grid terminal on socket 1 and the screen grid terminal on socket 5. Remove this piece of hookup wire.

You have one pigtail end of a 40,000 ohm resistance and one pigtail end of a .1 mfd. condenser connected to the screen grid prong on socket 5. Disconnect these two pieces of equipment and remove them entirely. When you completed Experiment 58, you had a piece of hookup wire connected between the suppressor grid prong and the cathode prong on socket 1. These two prongs were then grounded by connecting a piece of wire to a solder lug placed at the back side of socket 1. Unsolder all of these connections.

Continuing with the wiring of this experiment, you now have the two stator sections of your two gang tuning condenser connected to the two heater terminals on the 6-prong socket mounted in hole 2. These connections are to remain intact. You also have a piece of hookup wire connected from the plate terminal on socket 1 to the heater terminal next to the plate on socket 2. Leave this connection as it is. You should now have a piece of hookup wire connected between the heater terminal next to the cathode terminal on socket 2 and the negative terminal of the milliammeter. To this same terminal, you also have one pigtail end of a .1 mfd. condenser connected. Be sure this connection remains intact and that it is well soldered. The other pigtail end of the .1 mfd. condenser goes to any conveniently placed solder lug so that this will provide a return circuit for the bottom end of your tank coil.

You now have a 4,000 ohm resistance connected between a terminal lug on the terminal strip mounted under the right-hand bolt holding the filter choke in place, and the positive terminal of your milliammeter. Disconnect this resistor's pigtail lead from the positive terminal of the milliammeter and attach it to one of the other terminal lugs on the same terminal strip. You now have a piece of hookup wire connected between the grid terminal on socket 7 and one of the terminal lugs on the R.F. choke. Remove this piece of hookup wire entirely. Now, connect another piece of hookup wire to the grid terminal on socket 7. The other end of this piece of hookup wire goes to the end of the 4,000 ohm resistance which you just attached to one of the lugs on the terminal strip. This places the 4,000 ohm resistance in series with the plate circuit of the 56 oscillator tube, but does not place this resistance in series with the type 42 power amplifier tube. Now, connect one pigtail end of a .1 mfd. condenser to the grid terminal on socket 7. Solder the connection. The other terminal of this .1 mfd. condenser is to be attached to any conveniently placed solder lug; solder the connection.

On the terminal strip bolted under the right-hand bolt which holds the filter choke in place, you have connected the B+ output of your power supply system. To this terminal lug, attach a piece of hookup wire and solder the connection. The other end of this piece of hookup wire goes to the positive terminal of your milliammeter. You now have a piece of hookup wire connected from the negative terminal of the milliammeter to one of the terminal lugs on the R.F. choke. Disconnect this wire from the negative terminal on the milliammeter and connect it to the positive terminal of the milliammeter. In this way, the screen current of the type 42 pentode tube will not flow through the milliammeter.

Now, connect one pigtail lead of a 700 ohm resistance and one pigtail lead of a .25 mfd. condenser to the cathode prong on socket 1. Solder the connection. The other pigtail leads on the 700 ohm resistance and the .1 mfd. condenser are to be connected to any conveniently placed solder lug.

Now, connect one pigtail lead of a .00025 mfd. mica condenser and one pigtail lead of a 25,000 ohm resistance to the grid terminal on socket 1. Solder the connection. The other lead of the 25,000 ohm resistance is to be connected to any conveniently placed solder lug so that it is grounded. The other lead of the .00025 mfd. condenser is to be connected to either of the end terminal lugs on the terminal strip mounted at the left side of hole 3. At the same time this pigtail lead is attached to this terminal lug, also attach a piece of hookup wire, then solder the connection. The other end of the piece of hookup wire goes to the plate terminal on socket 7. Solder the connection.

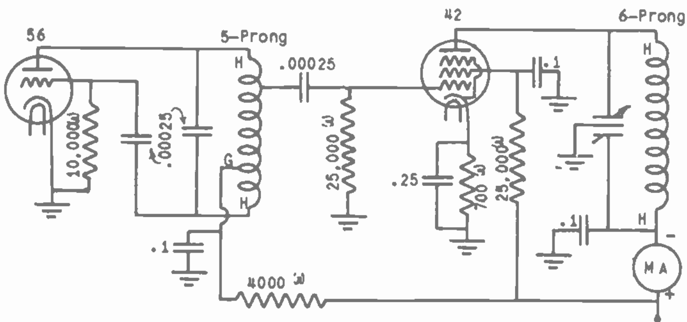


Fig.19 Schematic diagram of a Hartley Oscillator driving a pentode R.F. power amplifier. Both are series fed.

Now, attach one pigtail lead of a 25,000 ohm resistance and one pigtail lead of a .1 mfd. condenser to the screen grid prong on socket 1. Solder the connection. The other pigtail lead of the .1 mfd. condenser is to be connected to any conveniently placed solder lug so that it is grounded. The other pigtail lead of the 25,000 ohm resistance is to be connected to a terminal lug on the R.F. choke.

(The terminal lug to use is the one to which you now have a piece of hookup wire connected between that lug and the positive terminal of your milliammeter.) Solder the connection. Now, if you have carefully followed directions, your experiment is wired as shown in Fig. 19.

Before operating this experiment, it is necessary to connect one of the taps on your 5-prong coil. Unless you removed it previously, you now have a piece of magnet wire connected to the plate prong on this 5-prong coil form. This piece of wire comes up through the center of the coil form and is bent over the top. The other end of this piece of wire is to be connected to the second tap from the top end of the coil. The second tap is nine turns from the top. Solder the connection. This will be the grid excitation tap to be connected to the grid circuit of the type 42 tube.

Place your 6-prong coil in socket 2; a type 42 tube in socket 1; a type 56 tube in socket 3 and your 5-prong coil form is to be placed in socket 7. Plug in your experiment, turn it on and give the tubes time to warm up. Usually a type 42 tube will warm up more rapidly than a 56 tube. Therefore, it was highly essential that some protective bias be provided to prevent the type 42 tube from drawing excessive current before excitation could be applied from the type 56 Hartley oscillator. The 700 ohm resistor connected between cathode and ground and the plate current flowing through this resistance provides the necessary bias.

Grid bias for the type 42 tube is supplied by the 25,000 ohm resistance connected between the grid of this tube and ground. As soon as excitation is applied, then grid voltage is developed across this resistance which provides the working bias for the type 42 tube.

Before attaching your load to the type 42 tube's tank circuit, you will notice that when you tune the tank circuit to resonance, you will have a very marked dip in plate current. This shows the tube is working very excellently as a Class C amplifier. Now, apply a load to this tube in the usual manner. Here in our laboratories, this is the first experiment on which we found we could use as much as 12½ turns connected across the dummy antenna load. With a power input of approximately 14 watts, we were able to secure practically full brilliance of the dummy antenna light which then represented a power output of approximately 7½ watts. This is very excellent efficiency for this type of an experiment.

The type 42 tube does bot need to be neutralized because of the screed grid contained in this tube. However, in your next group of experiments, the type 42 tube is going to be used as a triode power amplifier and, in doing this, it is going to be necessary to use neutralization. That experiment will provide you with experience in carrying out that type of work.

EXPERIMENT 62

TESTING GRID CURRENT ON PENTODE R. F. AMPLIFIER

In this experiment, you are going to make some simple changes so that you can test the grid current flowing in the grid circuit of the type 42 pentode R.F. power amplifier. By knowing the grid current, it is then possible to calculate the amount of grid bias applied to the tube under operation.

You now have a piece of hookup wire connected between the heater terminal next to the cathode terminal on socket 2 and the negative terminal of the milliammeter. You have a piece of hookup wire connected between one of the terminal lugs on the R.F. choke and the positive terminal of your milliammeter. You also have a piece of hookup wire connected between the positive terminal of the milliammeter and the B+ terminal. Remove these three leads from the milliammeter. Connect them together and then solder the connection. These three wires can be so placed that they will not touch the chassis or any other piece of equipment on your experiment. This connection is to be only temporary, so it will not be necessary to mount it permanently.

You now have a 25,000 ohm resistance connected between the grid terminal on socket 1 and a solder lug or ground. Disconnect the pigtail lead of this 25,000 ohm resistance from ground. Connect this same pigtail lead to one of the free terminal lugs on the terminal strip mounted at the side of hole 3. To this same terminal lug, also attach a piece of hookup wire and then solder the connection. The other end of this piece of hookup wire goes to the negative terminal on the milliammeter. Now connect a piece of hookup wire to the positive terminal on the milliammeter. The other end of this piece of hookup wire is then connected to any conveniently placed solder lug.

After making these changes, you will then have your milliammeter connected in series with the grid resistor on the type 42 tube. Place your experiment in operation and, in so doing, be sure you have your dummy antenna connected in the usual manner.

After the tubes have had an opportunity to warm up, you will then have a small grid current reading on your milliammeter. Here in our laboratories, this grid current was 2 ma. With 2 ma. of current flowing through a resistance of 25,000 ohms, you will have a voltage drop of 50 volts. Therefore, you have 50 volts of grid bias produced by the grid leak resistance. You must not forget that you also have some grid voltage developed by the resistance connected between the cathode and ground on the type 42 tube. With a plate current of approximately 35 ma. and 700 ohms of resistance, you will have approximately 25 volts of bias developed across this resistance. This bias voltage added to the grid leak bias voltage will give you an approximate total of 75 volts of grid bias applied to the tube. Under these conditions, the tube will be operated somewhere between 2 and 3 times cutoff bias. This is one of the requirements for proper Class C operation.

After you have completed this experiment, you should return your apparatus to the same positions as when you finished Experiment 61.

EXAMINATION QUESTIONS

It is advisable for us to have an accurate check on the success of your experiments, so in order to provide this information, you are to answer the following examination questions, just as though this were another lesson.

1. In Experiment 47, did you have any difficulty in getting the oscillator to function properly? Give the plate current readings secured, both unloaded and loaded. Also, in giving the plate current readings, loaded, tell how many turns of the coil you had connected across your dummy antenna.

2. Did you find any difference in the operation between Experiments 47 and 48?

3. Describe the success you had with Experiment 49. Give the plate current readings secured both loaded and unloaded. How many turns of your oscillator coil did you have connected across your dummy antenna when you secured the maximum plate current readings?

4. Describe the results you secured with the two oscillators built in Experiments 51 and 52. Give the plate current readings and the effect of loading on these two oscillators.

5. Describe the results secured with Experiment 54. Give the plate current readings secured, both loaded and unloaded.

6. Describe the results secured when you constructed Experiment 56. Give the plate current readings secured both loaded and unloaded. What efficiency did you get from this experiment?

7. Describe the results secured when you constructed Experiment 58. What was the total plate current readings for both the oscillator and amplifier tubes and give the current both loaded and unloaded. How many turns on your output tank coil did you have connected across your dummy antenna when you secured the maximum plate current readings?

8. What success did you have when you built the absorption type wavemeter?

9. Describe the results of your Experiment 61. Give the plate current readings on the type 42 pentode power amplifier, both loaded and unloaded. Also, give the number of turns connected across your dummy antenna when you received the maximum power output. What was your calculated efficiency for this experiment?

10. Describe the results of your Experiment 62. What grid bias do you calculate you had applied to the type 42 pentode power amplifier tube? Give the grid voltage developed by the grid leak and give the grid voltage developed by the cathode resistance.

The text of this lesson was compiled and edited by the following members of the staff:

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GROUP NO. 7	**LABORATORY EXPERIMENTS**	**EXPS. NO. 63 TO 71**

LABORATORY EXPERIMENTS

Group Seven

"In this group of experiments you are going to construct several very interesting types of transmitter circuits.

"In the second experiment you will learn to neutralize radio frequency power amplifiers. This experience is exceedingly important.

"Again we want to warn you that these transmitter experiments are not to be connected to an aerial and ground unless you are the possessor of an amateur station and operator license."

EXPERIMENT 63
BUILDING A TRIODE POWER AMPLIFIER
(Series Feed)

When you finished Experiments 61 and 62, you had a type 56 tube operating in a series fed Hartley oscillator circuit, driving a type 42 tube operating as a pentode R.F. power amplifier. In carrying out this experiment, it is going to be necessary to make only a few minor alterations to change the operation of the type 42 tube from a pentode power amplifier to a triode power amplifier.

In completing Experiment 61, you have the plus terminal of your milliammeter connected to the B+ output of your power supply. From the negative terminal of the milliammeter, you have a piece of hookup wire connected to the heater terminal, next to the cathode terminal on socket 2. To this same heater terminal, you also have connected one pigtail end of a .1 mfd. condenser and also a piece of hookup wire which goes to the stator section of your tuning condenser. Remove all of these connections except the piece of hookup wire connected between the heater terminal next to the cathode terminal and the front stator section of your two gang tuning condenser.

The free end of the piece of hookup wire now connected to the negative terminal of the milliammeter is to be connected to the plate terminal on socket 2. Also to the plate terminal on socket 2, connect one pigtail end of a .1 mfd. condenser and solder the connection. The other end of the .1 mfd. condenser is to be grounded by using any conveniently placed solder lug.

At this time, it is advisable to stop and prepare the six prong coil form which is going to be used in socket 2, If you do not already have such a wire in place, pass a piece of magnet wire down through the center of the coil form and through the plate prong. Solder this wire in the plate prong. Then, bring this piece of hookup wire up through the center and over the edge of the coil form until the other end of it will just reach the center tap connection on the coil form. Loop the bare wire over this tap and solder the connection. You will then have the B+ of your power supply connected to the center tap terminal of your six prong coil and bypassed with a .1 mfd. condenser as shown in Fig. 1. In completing Experiment 61, the B+ terminal was connected to the bottom end of the coil instead of to the center. Be sure you have followed directions carefully so as to make this change.

In completing Experiment 61, you had a 25,000 ohm resistance connected between one terminal on the R.F. choke and the screen grid terminal on socket 1. Also connected to the screen grid terminal on socket 1 was the pigtail lead of a .1 mfd. condenser. Remove both the resistor and condenser as they will not be used in this experiment. Then, take a piece of hookup wire and connect the screen grid terminal on socket 1 to the plate terminal on the same socket. This connection is shown in Fig. 1.

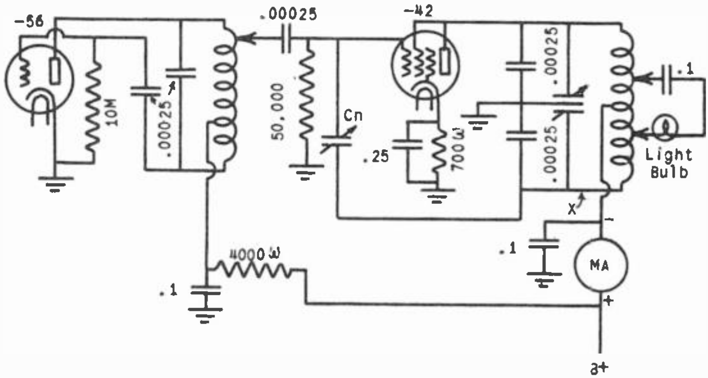


Fig. 1 A Hartley oscillator driving a series fed triode power amplifier.

In your last shipment of experimental equipment, you will find a small, two-plate, trimmer condenser. This condenser is to be used as the neutralizing condenser in this experiment. This is condenser Cn in Fig. 1. Now, with the chassis right side up and the front toward you, bolt a three lug terminal strip in the left-hand small hole at the side of hole 3. This terminal strip is bolted on the top side of the chassis and not underneath. Now, if you will examine the situation carefully, you will find that the two solder lugs on the two-plate trimming condenser will just fit two of the terminal lugs on the terminal strip. Take two pieces of hookup wire approximately six inches long. Pass the bare end of one of these pieces of hookup wire through one of the terminal lugs on the terminal strip and then through a solder lug on the neutralizing condenser. Wrap the wire around and then solder the connection. This will hold the connection securely in place. Take another piece of hookup wire and repeat the same operation on the second solder lug on the terminal strip and the second solder lug on the neutralizing condenser; that is, pass a piece of hookup wire through both of these solder lugs, solder the connection and, in doing so, you will have your neutralizing condenser firmly fastened in place to the terminal strip. In mounting the condenser in this fashion, it will be mounted on its side with the top side of the condenser facing toward the left of the chassis. A drawing showing how this condenser is mounted is shown in Fig. 2.

Fig.2 Showing how to mount neutralizing condenser on terminal strip.

In completing Experiment 61, the grid of the type 42 tube is connected to the tank circuit of the type 56 oscillator tube by using a .00025 condenser mounted on a terminal strip. Also, the type 42 tube has a 25,000 ohm grid leak connected from grid to ground on this tube. The .00025 mfd. condenser is to remain connected as is, but the 25,000 ohm grid leak is to be replaced with a 50,000 ohm resistor mounted in the same position.

Now, by carefully examining your neutralizing condenser, you will see that one of the solder lugs connects to the top plate while the other solder lug connects to the bottom or lower plate. The piece of hookup wire now connected to the lower plate on the neutralizing condenser should be run down through the chassis, using the large hole 3. Cut this wire off so that it will just reach. Solder the other end to the grid terminal on socket 1. This is the grid terminal of the type 42 tube as shown in Fig. 1. To the top or outside plate of your neutralizing condenser, you now have soldered a piece of hookup wire. Pass the other end of this wire down through the large hole 3, cut this wire off to the right length so that it will just reach the heater prong next to the cathode prong on socket 2. Push the insulation back, connect the bare wire to this prong and solder the connection. This is connection X as shown in Fig. 1.

With your chassis right side up and the front toward you, bolt a solder lug on the top of the chassis using the small hole which is just to the front left of large hole 14. On the right-hand side of your two gang tuning condenser is a solder lug on each set of stator plates. To the lug on the front stator section solder one pigtail end of the .00025 mfd. mica condenser. The other pigtail end of this condenser is to go to the solder lug just mounted. Do not solder this connection as yet. Now to the solder lug on the back stator section of the two gang tuning condenser, solder one pigtail lead of a .00025 mfd. mica condenser. The other pigtail lead of this condenser goes to the same solder lug, then solder the connection. You then have these two condensers connected in parallel with the two sections of the tuning condenser. This is necessary in order to increase the tuning capacity so that this circuit will tune to the same frequency as the oscillator.

It is now advisable to compare the wiring of your experiment with the diagram as shown in Fig. 1. If you have followed directions carefully, your experiment will be wired as shown and you are then ready to operate the experiment.

A six prong coil form is to be plugged in socket 2, a five prong coil form is to be plugged in socket 8, a type 56 tube is plugged into socket 7, and a type 42 tube is to be plugged into socket 1. A type 80 tube is to be plugged in socket 13 and you are then ready to connect your experiment to a 110 volt, 60 cycle line. Before operating this experiment, disconnect the wire which leads from B+ of your filter system to the plus terminal on your milliammeter. It is necessary to do this so that no voltage will be applied to the plate of the type 42 tube until this stage is neutralized.

TESTING THE OSCILLATOR. Since you do not learn to neutralize until the next experiment, the only part of our experiment which can be tested at this time is the type 56 oscillator. With all of the tubes and coils plugged into their proper places, turn the experiment on and give the tubes time to warm up. Now, in your shipment of laboratory apparatus, you found a small 2.5v flashlight bulb with three turns of wire soldered to it. This flashlight bulb is to be your neutralizing indicator. It will also indicate whether the oscillator is oscillating. Therefore, after the tube has warmed up, holding the small bulb in your hand, bring the coil of wire attached to the bulb close to the five prong coil mounted in hole 8. Be very careful and do not get it too close. As you bring the bulb close to the oscillator coil, the bulb should light, showing that the oscillator is operating properly. Do not bring the bulb any closer to the oscillator coil, or you will induce enough voltage into the light bulb to burn it out and it will be useless for further experiments.

EXPERIMENT 64

LEARNING TO NEUTRALIZE R.F. POWER AMPLIFIERS

Before attempting this experiment, the student should very carefully read over the information given in Lesson 3 of Unit 3 on neutralization. Be sure you have the process well in mind before attempting to follow the directions given here.

In starting this experiment, you must first make sure that no plate voltage is applied to the type 42 R.F. power amplifier. In the last experiment, you disconnected the lead from the B+ of the milliammeter which in turn removed plate voltage from the type 42 tube.

Now when you completed Experiment 61 you had a piece of hookup wire connected to the plate terminal on socket 7. This is the grid excitation lead to the type 42 tube. In connecting this piece of hookup wire to this terminal, another piece of wire was then connected to the second tap from the top on your five prong coil. In this experiment, you will find that this connection does not supply sufficient grid excitation to the type 42 tube when operated as a triode, so it will be necessary to remove this connection. The piece of hookup wire now soldered to the plate terminal on socket 7 should be unsoldered and moved over to the filament terminal, next to the plate terminal on the same socket; solder the connection. You then have the grid excitation terminal for the type 42 tube connected to the top end of the five prong coil form. This will provide the maximum grid excitation.

In order to reduce hand capacity effects, it would be a good idea for you to whittle a small wooden screwdriver out of a round piece of wood. Secure a round piece of wood similar to a lead pencil (but do not use a lead pencil) and shape one end of it like a screwdriver so it can be used to adjust your neutralizing condenser.

Now with all tubes and coils plugged in, connect your experiment to a 110 volt, 60 cycle lighting supply and turn it on. When the tubes have had a chance to warm up, use your neutralizing lamp and ascertain whether or not the type 56 oscillator is oscillating, following the directions as given in the previous experiment. When you are sure the oscillator is functioning satisfactorily, then take your wooden screwdriver and screw the two plates of the small neutralizing condenser in as far as they will go; do not force them, however. This means that maximum capacity will be used. With your neutralizing condenser in this position, hold your neutralizing lamp down over the six prong coil form and then very carefully tune your two gang tuning condenser until the neutralizing lamp lights. Carefully tune the tuning condenser until the lamp lights at maximum brilliancy.

With the neutralizing condenser set at maximum capacity, a voltage is being fed through this condenser which excites the tank circuit of the type 42 R.F. amplifier stage. Now, using your special wooden screwdriver, decrease the capacity of your neutralizing condenser. Each time you decrease the capacity slightly, it will be necessary to very carefully retune the final tank circuit. Continue this operation until there is no longer any indication of R.F. current flowing in the tank circuit, meaning that the circuit is entirely neutralized.

Now during this procedure you have been depending upon the current fed through the neutralizing condenser instead of that current fed through the interelectrode capacity of the type 42 tube. Therefore, it is advisable to repeat the process, doing it in the correct manner. Again, increase the capacity of the neutralizing condenser to maximum. Then, with your neutralizing bulb in place over your tank coil, tune your tank condenser until you have maximum brilliance of the indicating light. Now, decrease the capacity of your neutralizing condenser as far as you can and set it at minimum. Now, very carefully retune your tank condenser until your flashlight lamp again glows. This time, the flashlight lamp is being lighted by current circulating in the tank circuit which is present due to the current fed by the oscillator through the interelectrode capacity of the type 42 tube. Using your special screwdriver, increase the capacity of the neutralizing condenser and each time you increase it, carefully retune the tank circuit for maximum light brilliancy. You will soon find a place where the light goes completely out.

Now, by continuing to increase the capacity of the neutralizing condenser, the lamp will come on again and will be at maximum brightness when your tank circuit is in resonance. Now, decreasing the tuning capacity, you will find the place at which the light goes out on the decreasing side. The correct neutralizing condenser setting is exactly halfway between where the light goes out while the capacity is being increased and where the light goes out while the capacity is being decreased. If your neutralizing condenser had a dial on it, graduated in degrees, it would be possible for you to set it quite accurately and, in that way, your amplifier would be completely neutralized. Repeat this procedure several times so that you will become thoroughly acquainted with the process of neutralization.

If you have difficulty in holding the neutralizing coil down over the tank coil, you can squeeze the neutralizing coil together so that it will clamp around the tank coil and then you will not have nearly as much difficulty in keeping it in place while you are making other adjustments.

After you have your amplifier completely neutralized, you are then ready to operate the amplifier itself. THE FIRST THING, AND IT IS VERY IMPORTANT....YOU MUST REMOVE THE NEUTRALIZING LAMP FROM THE TANK COIL, OR YOU WILL BURN IT OUT.

Turn your experiment off, turn it over and reconnect the B+ lead to the positive terminal of your milliammeter. This again applies plate voltage to the type 42 tube. With the experiment right side up and the front toward you, turn the experiment on and, as the tubes warm up, the type 42 tube will draw plate current. As soon as the type 56 tube is oscillating you can then tune the tank circuit of the type 42 tube to resonance and this will be indicated by a noticeable dip in plate current. Do not use your neutralizing lamp to indicate R.F. currents in the tank circuit of the type 42 tube when plate voltage is applied to this tube, or you will immediately burn out the neutralizing lamp.

After the tank circuit of the type 42 tube is tuned to resonance, turn off the experiment and then you can load it in the usual manner, using your dummy antenna light bulb and .1 mfd. condenser.

Here in our laboratories, we found that with the dummy antenna disconnected and the tank circuit tuned to resonance, the plate current was approximately 30 ma. With the dummy antenna connected, the plate current increased approximately 15 ma. to a total of approximately 45 ma. You should receive comparable results.

IN TRYING TO NEUTRALIZE YOUR EXPERIMENT, BE SURE THAT YOUR DUMMY ANTENNA IS NOT CONNECTED TO YOUR TANK COIL, OR YOU WILL HAVE DIFFICULTY IN GETTING A SUFFICIENT INDICATION OF R.F. CURRENT IN THE TANK CIRCUIT WHICH WOULD ENABLE YOU TO NEUTRALIZE.

EXPERIMENT 65
BUILDING A TRIODE POWER AMPLIFIER
(Shunt Feed)

In this experiment it is only necessary to make a few changes in converting the type 42 tube from a series fed amplifier into a shunt fed amplifier.

You now have a piece of hookup wire connected between the negative terminal of your milliammeter and the plate terminal on socket 2. Unsolder this piece of hookup wire at the plate terminal on socket 2 and bring that end of the piece of hookup wire over to one of the terminals on the R.F. choke; solder the connection.

You now have a piece of hookup wire connected between the plate terminal on socket 1 and the heater terminal next to the plate terminal on socket 2. Unsolder this piece of hookup wire from the heater terminal next to the plate terminal on socket 2, bring the end of that wire over and connect it to the remaining lug on the R.F. choke. Then, solder the connection.

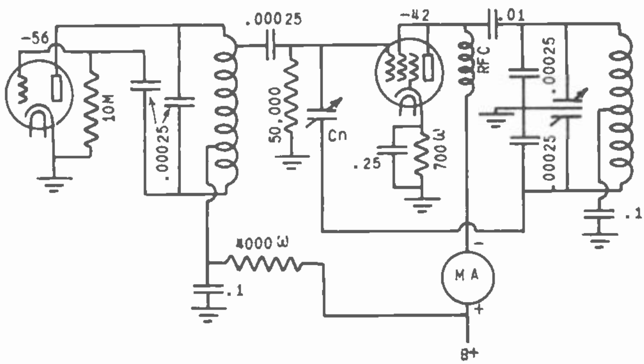


Fig.3 A Hartley oscillator driving a shunt fed triode power amplifier.

Now connect one pigtail lead of a .01 mfd. condenser to the plate terminal on socket 1. Solder the connection. The other pigtail lead of the .01 mfd. condenser is to be soldered to the heater terminal next to the plate terminal on socket 2.

Now, if you have carefully followed directions, your experiment is wired as shown in Fig. 3. In testing this experiment, follow identically the same procedure as that given in the previous experiment. You should again go through the process of neutralization so that you are sure of understanding every step of such a procedure. After you have the amplifier properly neutralized (that is, the shunt fed amplifier), you should then connect your dummy antenna load to the proper amplifier and get a comparative test of its efficiency.

There will be very little difference in the way this amplifier and the one described in the previous experiment works. However, if you find it a little less efficient, it will be because of the loss occasioned in the R.F. choke. In testing this amplifier here in our laboratories, we found that the minimum plate current with the type 42 stage unloaded was 30 ma. With the amplifier loaded to maximum, we found that the plate current increased 15 ma. or to a total of approximately 45 ma.

AS SOON AS YOU HAVE COMPLETED THIS EXPERIMENT, IT IS ADVISABLE TO RETURN YOUR EXPERIMENT TO THE SAME STATUS AS THAT DESCRIBED IN EXPERIMENTS 63 AND 64.

EXPERIMENT 66

WINDING BUFFER AMPLIFIER TANK COIL

In your last shipment of equipment, you will find a four prong coil form on which you are to wind the tank coil for your buffer amplifier. A bottom view of a four prong coil form is shown in Fig. 4. Two holes have been drilled in the side of this coil form, one near the top and one near the bottom. These two holes are going to be used in connection with fastening your magnet wire to the coil form. ALL TRANSMITTER COIL FORMS WILL BE WOUND WITH YOUR #20 DOUBLE COTTON COVERED MAGNET WIRE.

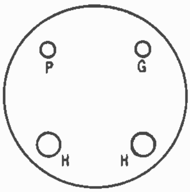


Fig. 4 Bottom view of four prong coil form.

Scrape the insulation from the end of your magnet wire and push this through the lower hole in the side of your four prong coil form. Pull the wire out through the top of the coil form and then pass it down through the heater prong, next to the plate prong. Be sure the wire is bare where it goes through the heater prong, then solder the connection and cut off the surplus wire. Now, carefully pull up all slack. Then, holding the coil form prongs in your left hand, wind toward you. Wind 4½ turns of wire and then make a tap at this point. Directions for making this tap were given in Experiment 48. After you have completed this operation, then continue winding until you have placed 20 more turns of wire on your coil. You will then have a total of 25 turns of wire on your completed coil. You will find that this number of turns of wire nearly fills the space between the two holes on your coil form. Cut the wire off so that it will be long enough to pass through one of the coil form prongs. Scrape the insulation from the end of the wire, pass it through the top hole in the side of the coil form and then down through the filament prong next to the grid prong on your four prong coil form. Solder the connection and cut off the surplus wire.

EXPERIMENT 67
BUILDING AN INDICATING TYPE WAVEMETER

In this experiment you are to follow the directions exactly as given in Experiment 60 in Group 6 of your laboratory experiments. However, instead of using the six prong coil form, you are to build this wavemeter on your four prong coil form. There are a fewer number of turns on your four prong coil form than there is on your six prong coil form, but still the padder condenser used will tune to the frequency used with your present transmitter.

After the padder condenser is properly mounted on the top of the four prong coil form, you are then ready to fix the indicating part of this wavemeter. At about the center of your four prong coil form, place the coil which is attached to your neutralizing lamp. Now, since this coil is too large to fit directly on the four prong coil form, it will be necessary for you to pinch down the turns so that they will be tight enough to remain fixed in place at about the center of the coil form. A neutralizing lamp is going to be used as the indicator instead of using the absorption principle as described in Experiment 60.

Now here is how you use this wavemeter. Set your transmitter into operation. After you are sure it is operating satisfactorily, you can then check the operation of your wavemeter. In Experiment 60 you were advised to place the prongs of your wavemeter coil directly down on top of your oscillator coil. However, if you were to do that in this experiment, you would receive so much energy that the neutralizing lamp would be immediately burned out. Therefore, in this experiment it is going to be necessary for you to hold the wavemeter coil between your thumb and first finger of your left hand and use your right hand for a screwdriver adjustment of the padder condenser. Hold the wavemeter coil approximately two inches from the tank coil of the type 42 tube. Then, adjust the padding condenser until the neutralizing lamp starts to light. At this point you must be very careful and not have the wavemeter coil too close to the tank coil or you will burn the lamp out. As the lamp gets brighter, pull the coil farther away from the tank coil and then by carefully adjusting the capacity of the padder condenser, you can secure maximum brilliance of the indicating lamp.

When the tuned circuit constituting the wavemeter is at the same frequency as the tank circuit of your type 42 tube, there will be a current induced in the tuned circuit of the wavemeter by mutual induction between the tank circuit and wavemeter circuit. If you hold the wavemeter circuit a few inches away from the tank circuit, you will find that this tuning is comparatively critical. Now, if you had a regular indicating type of wavemeter, you would have a variable condenser on which you would mount a regular dial. Then, that wavemeter would be calibrated with the dial readings calibrated in frequencies. By tuning the variable condenser and finding the dial reading at which maximum brilliance of the indicating light occurred, you would then be able to accurately read the frequency at which your transmitter was operating. The chief advantage of this wavemeter over the one constructed in Experiment

60 is that it is possible for you to hold the wavemeter coil quite a little bit further away than the absorption type. Therefore, there is less interaction between the two tuned circuits and it is possible to get a closer adjustment on the indicating type of wavemeter than with the absorption type of wavemeter. The accuracy of such a wavemeter is dependent entirely upon the indicating device and the accuracy of the calibration of the variable condenser. In expensive wavemeters, a thermocoupled milliammeter is used in place of the flashlight bulb. In that way, an accurate indication of the amount of current flowing in the wavemeter circuit is easily measured while the eye is rather deceptive in comparing the brilliance of a lamp. Nevertheless, this experiment will serve to illustrate the principles of operation of this type of equipment.

After you have checked the frequency of the output tank circuit, check the frequency of the oscillator by placing the wavemeter coil close to the tank circuit of the oscillator.

EXPERIMENT 68

BUILDING A SCREEN GRID BUFFER AMPLIFIER
(A Three Stage Transmitter)

In this experiment, we are going to use a type 6C6 tube as a screen grid R.F. buffer amplifier. This buffer amplifier will be connected between the type 56 oscillator and the type 42 power amplifier.

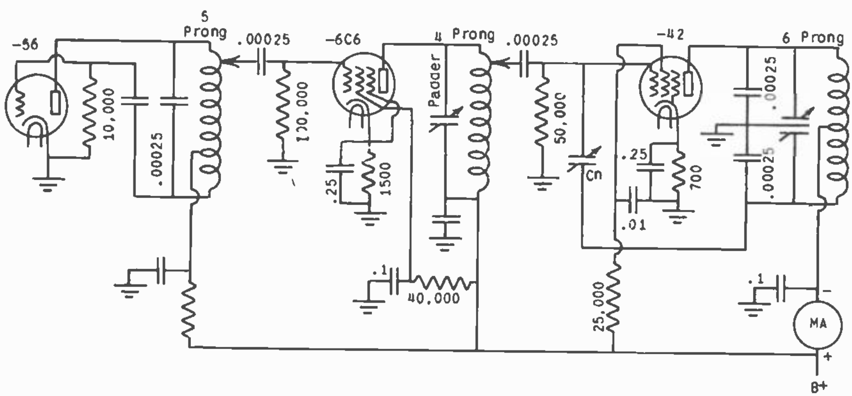


Fig.5 Diagram of three stage transmitter.

When you completed Experiment 47, you had a six prong socket mounted in hole 5. The filament or heater prongs on this socket are connected in parallel with the six prong socket now mounted in hole 1 and, in turn, both of these sockets are connected to the 6 volt winding on your power transformer.

The tank coil for this buffer amplifier stage is going to be the four prong coil form which you just wound. The tank condenser will be the padding condenser which you used in your superheterodyne experiments. Now, mount a four prong socket in hole 6. In mounting this socket, the filament prongs should face toward the front of the chassis. (Remember the chassis is upside down and the front toward you.) Next, your padding condenser is to be mounted in hole 4.

A complete wiring diagram for this experiment is shown in Fig. 5. As you will notice, no changes have been made in your type 56 Hartley oscillator circuit which uses the apparatus mounted in holes 7 and 8. In this experiment you are to change the type 42 power amplifier stage which uses the apparatus mounted in holes 1 and 2 from a triode power amplifier to a pentode amplifier. When you completed Experiment 65, you were instructed to return your apparatus to the same state as experiments 63 and 64. Be sure that you have done this before starting this experiment. You now have a terminal strip mounted on the underneath side of the chassis at one side of hole 3. On this terminal strip is connected a piece of hookup wire and a .00025 mfd. condenser. Remove the terminal strip and the condenser. The terminal strip will not be needed in this experiment and the condenser will be mounted elsewhere.

The next step in your procedure is to change the type 42 tube from a triode power amplifier to a pentode power amplifier. The reason for this change is that you can secure a greater power output using this tube as a pentode instead of a triode. You now have a piece of hookup wire connected between the screen grid prong and the plate prong on socket 1. Remove this piece of wire. Now connect one pigtail lead of a 25,000 ohm resistance and one pigtail lead of a .01 mfd. condenser to the screen grid prong on socket 1. Solder this connection. The free pigtail lead of the .01 mfd. condenser is to be connected to any conveniently placed solder lug. (Remember the chassis is upside down and the front towards you.) The free pigtail lead of the 25,000 ohm resistance is to be connected to the left-hand solder lug on the padder condenser which is mounted in hole 4. Do not solder this connection as yet, because another piece of wire is to be connected to this prong a little later on.

Now connect a piece of hookup wire to the heater prong next to the plate prong on the five prong socket mounted in hole 7. Solder the connection. The other end of this piece of hookup wire is to be connected to the plate prong on the four prong socket mounted in hole 6. At the same time this connection is made, connect one pigtail lead of the .00025 mfd. mica condenser and solder the connection. The other pigtail lead of the .00025 mfd. mica condenser is to be fastened to the grid prong on socket 6. Also, to this same grid prong attach one pigtail end of a 100,000 ohm resistance. To the same grid prong, also connect a piece of hookup wire approximately 6" long and then solder the connection. The other end of the 100,000 ohm resistance is to be grounded to any conveniently placed solder lug. Solder the connection. Next, the piece of hookup wire, one end of which is attached to the grid prong of socket 6 is to be passed up through the small hole in the chassis which is in the center of the four holes, 5, 6, 7, and 8. Cut this wire off so that its end just nicely reaches the grid cap on a type 6C6 tube which is going to be mounted in socket 5. Then, solder a grid clip to this piece of hookup wire.

Now connect a piece of hookup wire to the plate prong on the six prong socket mounted in hole 5. Solder the connection. The other end of this piece of hookup wire goes to the heater prong next to the grid prong on socket 6. At the same time, connect a second piece of hookup wire to this same prong and solder the connection. The other end of this second piece of hookup wire goes to the right-hand terminal lug on the padder condenser mounted in hole 4. At the same time this piece of hookup wire is connected to this terminal, also connect one pigtail terminal of a .00025 mfd. mica condenser and solder the connection. The other pigtail lead of the .00025 mfd. condenser goes to the grid prong on the six prong socket mounted in hole 1. At the same time this connection is made, also connect one pigtail lead of a 50,000 ohm resistance and solder the connection. (The 50,000 ohm resistance was connected to this grid prong when you completed the previous experiment.)

Now using a short piece of wire, connect the cathode prong and the suppressor prong on the six prong socket mounted in hole 5 together. Also connect one pigtail lead of a 1500 ohm resistance and one pigtail lead of a .25 mfd. condenser to the cathode prong on socket 5 and solder the connection. The other pigtail leads of the 1500 ohm resistance and .25 mfd. condenser are to be connected to any conveniently placed solder lug. A solder lug mounted at the side of hole 3 would probably provide the best position for these parts and yet have them out of the way as much as possible.

Now connect a piece of hookup wire to the left-hand terminal on the padding condenser and solder the connection. The other end of this piece of hookup wire goes to the heater prong next to the plate prong on socket 6. To this same prong attach another piece of hookup wire approximately 5" long; also connect one pigtail end of a .1 mfd. condenser and one pigtail end of a 40,000 ohm resistor; then solder the connection. The other pigtail end of the .1 mfd. condenser is to be connected to any conveniently placed solder lug. It is probably best to use the solder lug placed at the side of hole 9. The other pigtail end of the 40,000 ohm resistor is to be connected to the screen grid prong on the six prong socket mounted in hole 5. To this same prong, also connect one pigtail end of a .1 mfd. condenser and solder the connection. The other pigtail end of this .1 mfd. condenser is to be connected to any conveniently placed solder lug.

You now have a piece of hookup wire soldered to the heater prong next to the plate prong on socket 6. The other end of this piece of hookup wire is to be connected to the positive terminal of your milliammeter. Be sure you connect it to the positive terminal so that the plate current of the type 6C6 tube will not flow through the milliammeter.

Now if you have carefully followed these directions, your experiment is wired as shown in Fig. 5. A type 80 tube is to be plugged in socket 13. Your six prong coil form is to be plugged in socket 6, the type 6C6 tube is plugged in socket 5 and the grid cap is connected to this tube. Your five prong coil form is plugged into socket 7 and a type 56 tube is plugged into socket 8.

Set the capacity of the padder condenser mounted in hole 4 at about one-half capacity and then turn your experiment on. Do not have your dummy antenna load connected to the output tank circuit on the type 42 tube, placed in socket 1.

TESTING THE TRANSMITTER. As soon as your tubes have had an opportunity to warm up, then immediately tune your two gang tuning condenser to resonance which is indicated by minimum plate current on your milliammeter. With the tank circuit of your type 42 tube tuned to resonance, indicated by minimum plate current, you are then ready to tune to resonance the tank circuit of your type 6C6 buffer stage. Resonance on this stage is going to be indicated by maximum plate current on the milliammeter which is now reading the plate current on the type 42 stage. When maximum current is procured, it indicates that the buffer stage is supplying the maximum excitation to the type 42 stage which is indicated by an increase in plate current.

After this preliminary test has been made, here is a change you should make in order to test this transmitter further. You now have a piece of hookup wire connected between the plate prong on socket 1 and the negative terminal of your milliammeter. Remove this piece of hookup wire at the negative terminal of your milliammeter but leave it soldered to the plate terminal on socket 2. You now have a piece of hookup wire connected between the heater terminal next to the plate terminal on socket 6 and the positive terminal of your milliammeter. Disconnect this wire from the positive terminal of the milliammeter and move it over to the negative terminal of your milliammeter.

With this change made, you now have the following condition. There is no plate voltage applied to the type 42 stage and the plate current for the type 6C5 buffer stage is now being read by your milliammeter. With your experiment right side up, turn it on and give the tubes time to warm up. The type 56 oscillator is now driving your type 6C6 buffer stage. By tuning the padding condenser, resonance on the tank circuit of the buffer stage will be indicated by minimum plate current which shows that this stage is operating properly and the plate current for this tube is ready by the milliammeter.

After this portion of your experiment is completed, connect the B+ for the type 6C6 stage back to the positive terminal of the milliammeter and then connect the B+ for the 42 stage to the negative terminal of the milliammeter so that all stages of your transmitter have plate voltage applied, but the milliammeter is measuring only the plate current flowing in the plate circuit of the type 42 stage.

Now connect your dummy antenna (which consists of your light bulb and .1 mfd. condenser) across two taps on your six prong coil mounted in socket 1. Your dummy antenna will then be connected across nine turns on this output tank coil.

Now turn your experiment on and give the tubes time to warm up. When the set is operating, then tune your two gang tuning condenser to resonance with the light bulb unscrewed; that is, disconnected. Resonance will be indicated by minimum plate current. Now, screw in your light bulb, which means that your dummy antenna will be connected and retune your two gang tuning condenser for maximum brilliance of your dummy antenna light.

With this part of the experiment completed, you are then ready to test the effects of excitation on the type 42 tube. By tuning the tank circuit of the 6C6 buffer stage in and out of resonance, you will change the excitation applied to the output stage. When your 6C6 stage is in resonance, there will be maximum plate current flowing in the output stage and you will have maximum brilliance on your dummy antenna light. As the padding condenser is varied above and below resonance, you will note a decrease in plate current to a certain point on the type 42 stage and you will also notice a material decrease in the brilliancy of the dummy antenna lamp. This conclusively demonstrates the effect of varying the excitation on the output stage.

EXPERIMENT 69
CONSTRUCTING A SPEECH AMPLIFIER AND MODULATOR SYSTEM

In this experiment you are going to build the necessary speech amplifier and modulator to be used in connection with a modulated transmitter in the following experiment. Very satisfactory results can be secured from this experiment if you will follow directions quite carefully. Your six inch dynamic loudspeaker is going to be used as a microphone in this experiment.

To start with, remove all connections which you now have made to the following sockets: the six prong sockets mounted in holes 1, 2, and 5. However, in removing connections from these three sockets, do not remove the filament or heater wires connected to the heater terminals on sockets 1 and 5. Next, remove all of the wires which you now have connected to the four prong socket mounted in hole 6, Your Hartley oscillator, using a type 56 tube and the apparatus mounted in sockets 7 and 8 is to remain intact.

Now remove the six prong socket mounted in hole 2 and mount this socket in hole 3. In mounting this socket (with the chassis upside down and the front toward you), mount the heater prongs toward the right. Next, take two pieces of hookup wire and connect the heater prongs of socket 3 in parallel with the heater prongs on socket 5. After this wiring job is completed, you will then have the heater prongs on sockets 1, 3, and 5, connected in parallel and all of them in turn connected to the 6.3 volt winding on your power transformer. The heater terminals on your type 56 tube to be used in socket 8 are connected to the 2.5 volt filament terminals on your power transformer. The heater terminals on your type 80 tube used in socket 13 are connected to the 5 volt terminals on your power transformer.

You now have a 4,000 ohm resistance mounted on a terminal strip which is bolted to the chassis between holes 11 and 14. It uses one of the bolts holding the filter choke in place. Remove the 4,000 ohm resistance and all wire connections, but do not remove

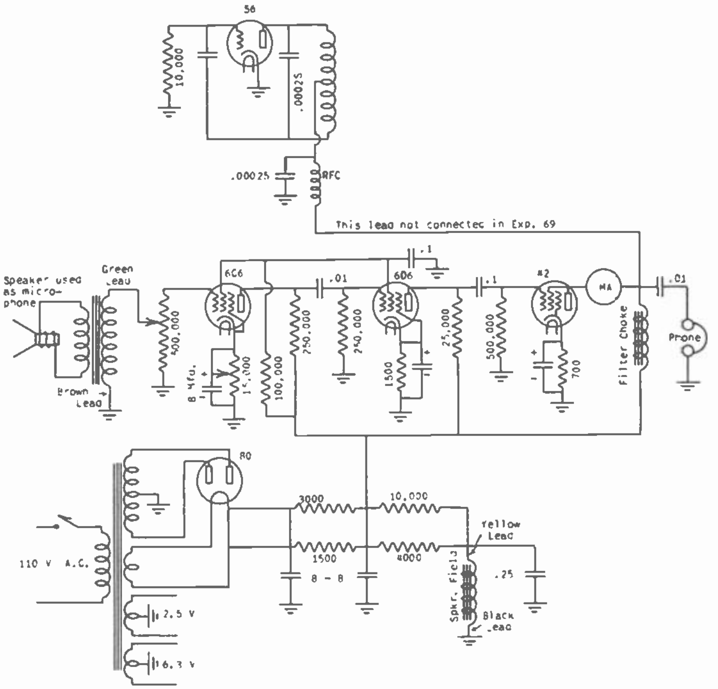


Fig.6 Diagram of speech amplifier and modulator connected to Hartley oscillator.

the terminal strip. You now have two pieces of hookup wire connected to the filter choke. Remove both of these pieces of hookup wire completely.

You are now ready to mount two extra pieces of apparatus. The 8-8-8 mfd. electrolytic filter condenser is to be mounted just to the right of the power transformer with the leads from this condenser facing toward the rear of the chassis. This condenser is held in place by two bolts and nuts, just the same as when you used it in connection with your superheterodyne experiment. With the chassis upside down and the front toward you, mount your 500,000 ohm potentiometer in the right-hand one of the three holes in the front of your chassis. In mounting this potentiometer, have the three terminal lugs on the side of the potentiometer face toward the right. Next, mount your headphone jack in the left-hand one of the two slotted holes in the back of the chassis. With these operations completed, you are then ready to start wiring your experiment.

WIRING THE EXPERIMENT. A wiring diagram for this experiment is shown in Fig. 6. Place a solder lug under the front bolt which holds socket 1 in place. Now, connect a short piece of hookup wire to the outside terminal nearest the chassis on the 500,000 ohm potentiometer. Solder the connection. The other end of this piece of hookup wire is to be connected to the solder lug just mounted. Solder the connection. Now, take a piece of hookup wire approximately 6" long and connect it to the remaining outside terminal on the volume control potentiometer. This is the terminal nearest you. Solder the connection. Pass the other end of this wire up through the small hole which is just to the right of hole 2. The end of this wire should be long enough to reach the grid cap on a type 6C6 tube which will be mounted in socket 1. If the wire is long enough, then solder a grid clip to this piece of wire. Also, be sure the connection made to the potentiometer is soldered.

Now, mount one of your three lug terminal strips, using the back hole around hole 2. To one of the solder lugs, connect the following: one end of a piece of hookup wire about six inches long, one pigtail end of a .01 mfd. condenser, and one pigtail end of a 250,000 ohm resistance. Solder this connection. The other end of the 6" piece of hookup wire is to be passed up through the chassis, using the small hole, which is in the center of holes 1, 2, 3, and 4. Be sure that the end of this wire will reach the grid cap on a type 6D6 tube which is to be mounted in socket 3. If the wire will reach, solder a grid clip on the end of it. The other pigtail end of the 250,000 ohm resistance is to be connected to any conveniently placed solder lug. A solder lug mounted under one of the bolts holding your two gang tuning condenser in place would probably be the most convenient. Solder the connection. The other pigtail end of the .01 mfd. condenser is to be connected to the plate terminal on socket 1. At the same time this connection is made, also connect one pigtail end of a 250,000 ohm resistance and solder the connection.

Your padder condenser is mounted in hole 4. While we do not intend to use the condenser in this experiment, still we are going to use one of the solder lug terminals on this condenser as a mounting lug for other pieces of apparatus. These connections will be made just a little later on in your experiment.

Now take a short piece of hookup wire and connect the suppressor prong to the cathode prong on socket 1. Solder the piece of hookup wire on the cathode prong. Next, connect a piece of hookup wire to the suppressor prong on this same socket. Do not solder the connection just yet. The other end of this piece of hookup wire which will need to be approximately 7" long is to be connected to the center tap terminal on your 15,000 ohm volume control switch mounted in the center of the three holes on the front of your chassis. In mounting this potentiometer, the terminal lugs are to face toward the left. Solder this connection. To the outside terminal on this potentiometer, solder a piece of hookup wire. The other end of this piece of hookup wire is to be connected to any conveniently placed solder lug.

You have six wire leads coming out of your 8-8-8 mfd. filter condenser. The two black leads and one yellow lead are to be connected to ground by soldering to a conveniently placed solder lug. A solder lug mounted under one of the bolts holding the two gang tuning condenser would probably be most convenient. Now connect one of the red leads to the suppressor prong on socket 1. This is the same as connecting it to the cathode prong. If it so happens that the red lead is not long enough to reach, it will be necessary for you to splice on a piece of hookup wire so that it will reach the correct prong. If you do make such a splice, be sure that you put a piece of tape around the bare place so that there will be no difficulty encountered by having this connection touch the chassis.

Now, connect one pigtail lead of a .1 mfd. condenser to the screen grid terminal on socket 1. Also to this same terminal, connect a short piece of hookup wire, then solder the connection. The other pigtail lead of the .1 mfd. condenser is to be connected to any conveniently placed solder lug. It would probably be advisable to place this condenser right alongside the back of the 500,000 ohm potentiometer and connect the pigtail lead to the solder lug which is now bolted under one of the bolts holding your two gang tuning condenser in place. The other end of the piece of hookup wire (now connected to the screen grid terminal on socket 1) is to be connected to the screen grid terminal on socket 3. At the same time this connection is made, connect one pigtail lead of a 100,000 ohm resistance and solder the connection.

The next operation is to connect one pigtail lead of a 25,000 ohm resistance and one pigtail lead of a .1 mfd. condenser to the plate terminal on socket 3. Solder these connections. The other pigtail lead of the .1 mfd. condenser is to be connected to the grid terminal on the six prong socket mounted in hole 5. Do not solder the connection at this time.

You are now ready to go back and pick up the loose ends on some connections you made. You have one pigtail lead of a 250,000 ohm resistance connected to the plate terminal on socket 1. The free pigtail lead on this resistor is to be placed in the left-hand solder lug on the padder condenser. You now have a 100,000 ohm resistance connected to the screen grid terminal on socket 3. The other pigtail lead on this resistor is to be connected to the same solder lug terminal on the padder condenser. You now have a 25,000 ohm resistance connected to the plate terminal on socket 3. The other pigtail end of this resistor is to be connected to the same solder lug terminal on the padder condenser. Also to this same solder lug terminal connect a piece of hookup wire approximately 6" or 7" long and then solder the connection. This means you have four things connected to this one solder lug terminal on the padder condenser. If you are careful, you will have no difficulty in getting the four connections on the one solder lug. Then, be sure to solder the connection.

The other end of the piece of hookup wire just connected to the solder lug on the padder condenser is to be connected to the center terminal on the three lug terminal strip mounted just to the rear on hole 14. Do not solder this connection as yet.

If you do not already have these solder lugs in place, bolt a solder lug under each of the two bolts which holds the four prong socket in hole 6. These will be used just a little later.

Now, take a piece of hookup wire and connect the cathode prong to the suppressor prong on socket 3. Also, connect one pigtail lead of a 1500 ohm resistance to the cathode prong and solder the connection. The other pigtail end of the 1500 ohm resistance is to be connected to the solder lug bolted under the front bolt holding socket 6 in place. Solder the connection. On your 8-8-8 mfd. filter condenser, you still have a free red lead. This red lead is to be connected to either the cathode or suppressor prong on socket 3. If the lead will not reach, it will be necessary for you to splice a piece of hookup wire onto it, tape this splice, and solder all connections.

You now have one pigtail lead of a .1 mfd. condenser connected to the grid prong on the 6 prong socket mounted in hole 5. To this same grid prong attach one pigtail lead of a 500,000 ohm resistance and solder the connection. The other pigtail lead of the 500,000 ohm resistance is to be connected to ground by using the solder lug bolted at the back of socket 6. Do not solder this connection as yet. Now connect one pigtail lead of a 700 ohm resistance to the cathode prong on the six prong socket mounted in hole 5. Also to this same prong, connect the blue lead which comes from your 8-8-8 mfd. filter condenser and solder the connection. If the blue lead is not long enough to reach, it will be necessary to splice a piece of hookup wire on, being sure to tape the bare place where the splice is made and solder all connections. The other pigtail lead of the 700 ohm resistance is to be connected to the solder lug which is mounted at the back of socket 6. Then solder this connection. There are two pigtail leads attached to this same solder lug.

You are now ready to make the necessary connections on the power supply system. It is extremely important that you follow directions carefully at this point so that you can avoid any possible injury to your apparatus. Your regular filter choke is going to be used as a modulation choke, so of course it cannot be used also to provide filtering in your power supply system. In order to avoid hum getting into the output of your speech amplifier modulator system, it is not possible to use the speaker field for a filter choke. Therefore, in this experiment, you are going to use a resistance-capacitance filter.

At the start of this experiment, you had two pieces of wire connected to the filter choke. You were advised to remove these. If you have not done so, do so at this time.

Now to the heater terminal nearest the rear of the chassis on the four prong socket mounted in hole 14, connect one pigtail lead of a 3,000 ohm resistance and one pigtail lead of a 1500 ohm resistance and one of the red leads from your 8-8 mfd. electrolytic filter condenser. Solder this connection. This means you will have four connections to this one heater prong. You can make that many connections to the prong if you are careful about your work. Be sure you have a good soldered connection. The other pigtail leads on the 3,000 ohm and 1,500 ohm resistors are to be connected to the right-hand terminal lug on the terminal strip mounted just to the rear of hole 14 connect a short piece of hookup wire which will reach over to the center terminal lug on the same terminal strip. Also connect one pigtail lead of a 10,000 ohm 1 watt resistor and one pigtail lead of a 4,000 ohm 2 watt resistor and then solder the connection. To this terminal lug on the terminal strip, you now have five connections. You have the pigtails from four resistors and one piece of hookup wire.

A short piece of hookup wire connects from the right-hand terminal lug to the center terminal lug on the terminal strip. To this center terminal lug you now have connected a piece of hookup wire which runs over to the solder lug on the padder condenser. Also to this same center terminal lug, connect the remaining red lead from your 8-8 mfd. electrolytic condenser. Do not as yet solder the connection. If you have not already done so, you must make certain that the two black leads coming from the 8-8 mfd. electrolytic filter condenser are grounded to some conveniently placed solder lug.

The free pigtail lead of the 10,000 ohm resistance and the 4,000 ohm resistance are to be connected to the left-hand terminal lug on your three lug terminal strip. Also to this same lug, connect one pigtail lead of a .25 mfd. condenser. Do not as yet solder this connection.

From the center terminal lug on the three lug terminal strip connect a piece of hookup wire. The other end of this piece of hookup wire is to go up through the chassis and connect to either one of the two terminal lugs on your filter choke. This filter choke is going to be used as the modulation choke. Connect another piece of hookup wire to the remaining solder lug on the filter choke and then solder the connection. Bring this piece of hookup wire down through the chassis and connect it to the positive terminal on your milliammeter. To the positive terminal on your milliammeter, also connect one pigtail terminal of a .01 mfd. condenser. The other end of the .01 mfd. condenser is to be connected to the right-hand terminal on your headphone jack mounted in the left-hand slotted hole on the back of the chassis. Solder the connection. Now place a solder lug under the left-hand bolt which holds this headphone strip in place. Take a piece of hookup wire and ground the left-hand terminal on the headphone jack. Also, to the same solder lug, connect the free pigtail terminal of the .25 mfd. condenser, the other end of which is connected to the left-hand terminal of your three lug terminal strip. Solder all connections.

When you completed Experiment 68, you had a piece of hookup wire connected between the grid terminal on socket 7 and the 4,000 ohm resistance which we formerly had mounted on the terminal strip mounted just to the back of hole 14. Remove this piece of hookup wire entirely.

Now connect a piece of hookup wire to the negative terminal on your milliammeter. The other end of this piece of hookup wire is to be connected to the plate terminal on the six prong socket mounted in hole 5. At the same time, also connect another short piece of hookup wire between the plate terminal and the screen grid terminal on this socket and solder all connections. The type 42 tube which is going to be used in this socket will be used as a triode instead of a pentode.

You are now ready to connect your microphone to the experiment. Remember, your dynamic loudspeaker is going to be used as a microphone. Pass the four wire leads coming from the dynamic speaker through the left-hand one of the three holes on the front side of the chassis. (Remember the chassis is still upside down and the front toward you.) The yellow wire lead coming from the loudspeaker is to be connected to the left-hand terminal lug on the three lug terminal strip mounted just to the rear of hole 14. To this same terminal lug, we have one pigtail lead of a 10,000 ohm resistance, one pigtail lead of a 4,000 ohm resistance, and one pigtail lead of a .25 mfd. condenser connected. Then, solder the connection. The black lead coming from the loudspeaker is to be connected to any conveniently placed solder lug. Be sure to solder the connection. The green lead coming from the dynamic loudspeaker goes over and connects to the center tap terminal lug on the 500,000 ohm potentiometer mounted in the right-hand one of the three holes on the front of the chassis. Solder the connection. The brown lead coming from the loudspeaker is also to be connected to any conveniently placed solder lug. Solder the connection. You must be sure to connect these leads exactly as indicated in these directions.

Now if you have carefully followed directions, your experiment is wired as shown in Fig. 6. You are then ready to test out your speech amplifier and modulator. This equipment will then be connected to the oscillator in the next experiment.

Plug a type 80 tube in socket 13. Plug a type 6C6 tube in socket 1. Plug a type 6D6 tube in socket 3. Plug your type 42 tube in socket 5. DO NOT HAVE YOUR TYPE 56 TUBE PLUGGED IN SOCKET 8 NOR DO YOU WANT YOUR FIVE PRONG COIL FORM PLUGGED INTO SOCKET 7. Connect your headphones to your headphone jack, plug your experiment into a 110 volt, 60 cycle alternating current lighting socket and turn your experiment on.

With the experiment right side up and the front toward you, place your loudspeaker microphone on the table in front of you and put your headphones on. Now, turn the 500,000 ohm potentiometer volume control as far to the right as it will go. This is on to its full extent. Then, turn your 15,000 ohm potentiometer volume control to the right until the audio tubes break into oscillation. This is a small low pitched squeal. Back up the volume control just a little and at this point your experiment is ready to be operated. Now by snapping your fingers in front of the loudspeaker, you should be able to get a distinct sound in your headphones.

Since it is practically impossible to satisfactorily hear yourself talk, it is advisable to have some other member of your family talk into the face of the loudspeaker and in that way you can listen to the quality of your experiment over your headphones. The quality in this experiment will be only fair because the loudspeaker makes only a fair microphone. However, the experiment is good enough to demonstrate to you the principle of speech amplification, and in the next experiment, modulation.

In this experiment you have two volume control systems. The 500,000 ohm volume control potentiometer controls the output from the loudspeaker and thereby controls the amplification of the entire amplifier. The 15,000 ohm volume control potentiometer is connected in series with the cathode of the first audio amplifier which uses a type 6C6 tube. By varying this potentiometer you vary the grid bias on this tube and in that way you affect its gain. Changing the gain in the first amplifier stage naturally changes the gain on all following stages and so you have two systems of volume control on your speech amplifier-modulator system.

If it so happens that you have an excessive amount of hum in the output of your modulator system, this can be improved upon by doing the following. First, reverse the 110v plug in the light socket. In other words, you may have it plugged in one way and then by reversing the plug, it may cut down on the hum. If it increases the hum, put it back the way you had it first. Another way of decreasing the hum somewhat is to make a good ground connection to your chassis. You may also find that when you touch your loudspeaker, additional hum is created. If this is the case, it will be necessary for you to merely set your loudspeaker on the table and not touch it with your hands. The experiment here in Midland's laboratories worked very well and we are sure that if you carefully follow directions, you will have no difficulty in getting good results from your experiments. We are quite sure you will find it all very interesting and constructive.

EXPERIMENT 70
BUILDING A MODULATED OSCILLATOR TRANSMITTER

In this experiment you are going to use the speech amplifier modulator system which you built in the preceding experiment to modulate your type 56 Hartley oscillator. Let us again warn you that this transmitter is not to be connected to an antenna and ground system unless you are the possessor of an amateur operator license and amateur station license.

You now have a .1 mfd. condenser connected between the grid terminal on socket 7 and a conveniently placed solder lug. Remove this condenser. The next thing to do is to mount your R.F. choke, using the right-hand hole at the side of hole 9. (REMEMBER YOUR CHASSIS IS UPSIDE DOWN AND THE FRONT TOWARD YOU.)

Now connect a piece of hookup wire to the grid terminal on socket 7. Also connect one pigtail lead of a .00025 mfd. mica condenser. Solder the connection. The other pigtail lead of the .00025 mfd. mica condenser is connected to any conveniently placed solder lug. The other end of the piece of hookup wire is to be connected to one of the terminal lugs on your R.F. choke. Solder the connection. Next, connect another piece of hookup wire to the free or remaining terminal on the R.F. choke and solder the connection. The other end of this piece of hookup wire goes to the negative terminal of your milliammeter.

If you have followed directions carefully, your experiment is now wired as shown in Fig. 6 and your type 56 Hartley oscillator is connected to your modulator. You should check over your wiring carefully to see that you have made no mistakes; then you are ready to operate the experiment.

Plug the same tubes in the same sockets as used in the preceding experiment; then plug your 56 tube in socket 8, your five prong coil form in socket 7, plug your experiment into a 110v, 60 cycle

AC lighting source and you are ready to operate the experiment.

Turn the experiment on and, using your neutralizing lamp bulb, ascertain that your oscillator is operating. When you have accomplished this, turn your experiment off, then connect your dummy antenna (your light bulb and .1 mfd. condenser) across 4½ turns (between two adjacent taps) on the plate end of your five prong coil form. The plate end is the top end of this coil.

With your dummy antenna properly connected, you are then ready to begin operating the experiment and ascertain whether or not your transmitter is being properly modulated. With your headphones on so that you can properly adjust your two volume control potentiometers, set the volume at about maximum position. Then, speak or whistle rather loudly into your microphone and you should notice an increase in the light brilliancy of your dummy antenna. Another way of partially checking this is to lightly tap the cone of the loudspeaker which sends a pretty good voltage surge through your amplifier and, in turn, will modulate the transmitter rather completely.

Another way of testing the modulation of your transmitter is to so place your neutralizing lamp above the five prong coil form that the lamp will glow at about half brilliancy. Then, when you speak loudly into the microphone, your neutralizing lamp should increase in brightness. In carrying on this experiment, you may find it is necessary to advance the volume control beyond the point where the tone quality is best before you can secure an appreciable indication of modulation. The reason for this is that the devices you are using to indicate modulation are rather insensitive and so the transmitter must be driven rather hard before they indicate properly.

If it so happens that in your home you have what is known as an all-wave receiver, it will be possible for you to pick up the output of this transmitter on that receiver. Here in our laboratories when this experiment was completed, it was operating on a frequency between 2200 and 2500 kc. If your present radio receiver will tune to that frequency, then merely set your transmitter somewhere close to your present set. You do not need to hook the transmitter to an aerial and ground, and you do not need a direct connection between transmitter and receiver. With your transmitter in operation, then carefully tune your receiver over the frequency band between 2200 and 2500 kc. and, in so doing, you should be able to pick up this transmitter without a great deal of difficulty. After you have picked it up, you can then experiment on volume adjustment, quality and other interesting things which you will find as you carry on this interesting work.

AGAIN LET US WARN YOU THAT THIS TRANSMITTER IS NOT TO BE CONNECTED TO AN AERIAL OR GROUND SYSTEM UNLESS YOU ARE NOW THE POSSESSOR OF AN AMATEUR STATION AND OPERATOR LICENSE. SINCE THE LOWEST FREQUENCY AMATEUR BAND IS FROM 1725 KC. TO 2,000 KC., IT WOULD BE NECESSARY TO MAKE SOME CHANGES IN THE FREQUENCY ADJUSTMENT OF THIS TRANSMITTER BEFORE IT WOULD BE ALLOWABLE TO PLACE IT ON THE AIR. THE REASON FOR THIS IS THAT AT THE PRESENT FREQUENCY AT WHICH THIS TRANSMITTER OPERATES, IT WOULD NOT FALL IN THE AMATEUR BAND AND IT WOULD CONSTITUTE ILLEGAL OPERATION.

EXPERIMENT 71
BUILDING A BEAT FREQUENCY AUDIO OSCILLATOR

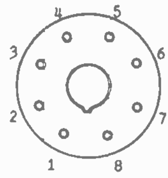
In this experiment, you are going to construct a very unusual piece of equipment. Beat frequency audio oscillators are used in testing any type of audio frequency equipment. In broadcasting stations, they are used particularly to test the frequency response characteristics of audio amplifiers and transmitters. The purpose of this experiment is to demonstrate the principle of operation of such equipment.

After completing your modulated oscillator in Experiment 70, it would be advisable for you to remove all of your equipment from the chassis, except the power supply system, the 15,000 ohm volume control potentiometer, and the 8-8-8 mfd. electrolytic condenser. After all equipment is removed, clean the solder from the socket prongs, straighten out all pigtail leads and make a general cleanup and prepare your equipment for this experiment.

The 500,000 ohm volume control potentiometer which you had mounted in the right-hand of the three holes on the front of the chassis is to be moved to the left-hand one of the three holes on the front of the chassis. The three terminal lugs are to be mounted toward the right-hand side of the chassis. REMEMBER IN THIS EXPLANATION, YOUR CHASSIS IS UPSIDE DOWN AND THE FRONT TOWARD YOU.

Mount a six prong socket in hole 2. In mounting this socket, the filament prongs should face toward the left. Next mount an eight prong octal socket in hole 10. In mounting this socket, the filament prongs are to face toward the left. Now, mount a five prong socket in hole 14. The filament prongs are to face toward the front of the chassis) Next, mount one of your intermediate frequency transformers which you used in your superheterodyne experiment in socket 1. The grid lead on this transformer is to face toward the right. (This direction is with the chassis right side up and the front toward you.) Next, mount another I.F. transformer in hole 9. The grid lead is supposed to face toward the right with the chassis right side up and the front toward you.

Fig.7 Bottom view of 8 prong octal socket.



You are now ready to wire the filament circuits of the various tubes to be used. Again, remember the chassis is upside down and the front toward you. Using a twisted pair of leads, connect the heater prongs on the six prong socket mounted in hole 2 to the 6.3 volt winding on your power transformer. Using another pair of twisted leads, connect the heater prongs on the eight prong socket, mounted in hole 10 to the 6.3 volt windings on your power transformer. A bottom view of the socket is shown in Fig. 7. The heater prongs are numbers 2 and 7. Using a pair of twisted leads, the filament prongs on the five prong socket mounted in hole 14 are to be connected to the 2.5 volt terminals on your power transformer. The filament prongs on the four prong socket mounted in hole 13 are already connected to the 5 volt terminals on your power transformer. These are to remain intact.

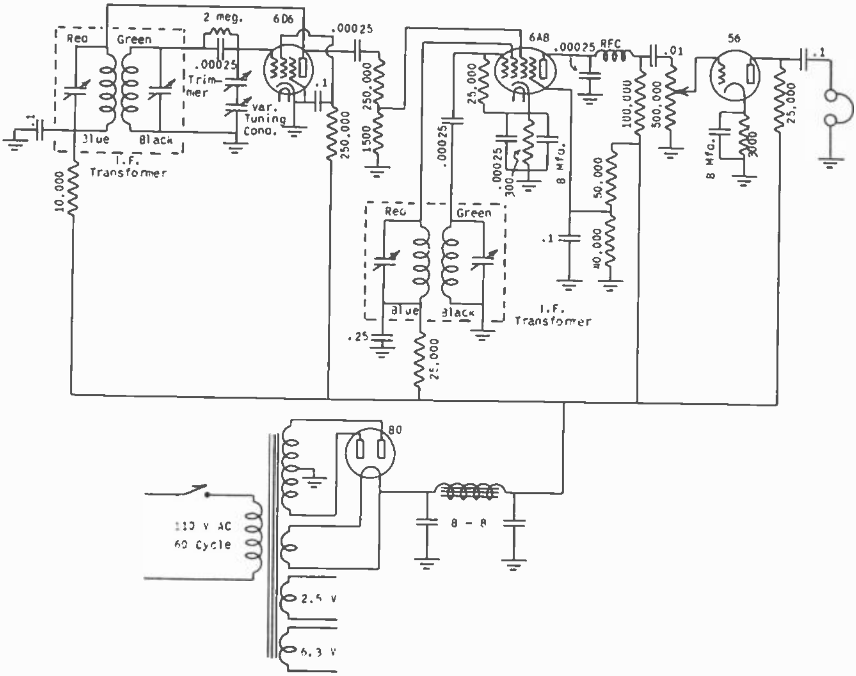


Fig.8 Diagram of a beat frequency audio oscillator.

A complete wiring diagram is shown in Fig. 8. Be sure to follow directions carefully. You now have a three lug terminal strip mounted under the right-hand bolt which holds the filter choke in place. Leave this terminal strip mounted as is. Now, mount two more terminal strips. One of these terminal strips is to be mounted under the right-hand bolt which holds the I.F. transformer in place at hole 9. The other terminal strip is to be mounted, using one of the small holes at the back side of hole 4. Your milliammeter is to be removed for this experiment, so mount your R.F. choke, using the back hole which surrounds the large hole 15. Your headphone terminal strip is to be mounted in the left-hand slotted hole on the back side of your chassis. In mounting this terminal strip, put a solder lug under the left-hand bolt holding this terminal strip in place and then take a piece of hookup wire and connect the left-hand terminal lug to the solder lug so that it will be grounded.

Solder one of the red leads coming from your 8-8 mfd. electrolytic condenser and also a piece of hookup wire to the heater terminal next to the plate terminal on socket 13. The other end of the piece of hookup wire is passed up through the chassis and connected to one of the terminals on your filter choke. Remember, in your last experiment, the filter choke was used as a modulation choke, but in this experiment, all connections were removed at the start. Connect another piece of hookup wire to the remaining terminal on the filter choke and solder the connection. The other end of this piece of hookup wire is to be connected to the left-hand terminal lug on the terminal strip mounted at the rear of hole 14. At the same time this connection is made, connect the other red lead from your 8-8 mfd. electrolytic condenser to the same lug. If you have not already done so, be sure that the two black leads coming from the 8-8 mfd. electrolytic condenser are connected to some conveniently placed solder lug.

To the left-hand terminal lug on the terminal strip just used, also connect one pigtail lead of a 25,000 ohm resistance, one pigtail lead of a 50,000 ohm resistance and another piece of hookup wire. Then, solder these connections. To this same terminal lug, you now have five connections. This is a little difficult to accomplish, but, if you are careful, you will have no trouble. The other pigtail lead of the 25,000 ohm resistance goes to the plate prong on the five prong socket mounted in hole 14. At the same time this connection is made, connect one pigtail lead of a .1 mfd. condenser and solder the connection. The other pigtail lead of the .1 mfd. condenser is to be connected to the right-hand terminal jack on the headphone jack mounted in the left-hand slotted hole in the back of the chassis. Solder the connection. The remaining pigtail terminal on the 50,000 ohm resistance is to be connected to the screen grid terminal on the eight prong socket mounted in hole 10. The screen grid terminal is terminal 4. A bottom view of the eight prong socket is shown in Fig. 7. At the same time this pigtail terminal is connected to terminal 4, also connect one pigtail terminal of a 40,000 ohm resistance and one pigtail terminal of a .1 mfd. condenser and solder the connection. The free pigtail terminals on the .1 mfd. condenser and the 40,000 ohm resistance are to be connected to ground by using any conveniently placed solder lug.

A moment ago, you connected a piece of hookup wire to the left-hand terminal on the three lug terminal strip mounted at the back of hole 14. The other end of this piece of hookup wire is to be connected to the left-hand terminal lug on the terminal strip which is mounted at the side of hole 4. However, do not solder this connection as yet.

Solder a piece of hookup wire to one of the outside terminals on the volume control potentiometer on your 500,000 ohm potentiometer. Use the lug nearest the chassis. The other end of this piece of hookup wire is to be connected to the center terminal lug on the three lug terminal strip mounted at the back of hole 14. At the same time this connection is made, also connect one pigtail lead of a .01 mfd. condenser and solder the connection. The other pigtail lead of the .01 mfd. condenser is to be connected to one of the solder lugs on the R.F. choke. Do not solder the connection as yet. Now, connect a piece of hookup wire to the center terminal lug of your 500,000 ohm potentiometer. Solder the connection. The other end of this piece of hookup wire is to be connected to the grid prong on the five prong socket mounted in hole 14. Solder the connection. Next, connect a piece of hookup wire to the remaining outside terminal lug on the 500,000 ohm potentiometer. The other end of this piece of hookup wire is to be connected to ground by using any conveniently placed solder lug. Be sure to solder all connections. This 500,000 ohm potentiometer is going to serve as the volume control for your A.F. oscillator.

Connect one pigtail lead of a 3,000 ohm resistance and one of the red leads coming from your 8-8-8 mfd. paper electrolytic condenser to the cathode prong on the five prong socket mounted in hole 14. Solder the connection. The end of the 3,000 ohm resistance is to be connected to ground by using any conveniently placed solder lug. At the same time this connection is made, connect the two black leads and one yellow lead coming from your 8-8-8 mfd. paper electrolytic condenser to ground. Solder the connection.

Mount a solder lug under the left-hand bolt which holds socket 10 in place. Then, take a short piece of hookup wire and connect the ground terminal on the eight prong socket mounted in hole 10 to this solder lug. This is terminal 1 as shown in Fig. 7.

It is advisable now to follow directions very carefully. To the cathode prong (prong 8 as shown in Fig. 7) on the eight prong socket mounted in hole 10, connect the following: the blue lead coming from your 8-8-8 mfd. paper electrolytic condenser; the black lead coming from the I.F. transformer mounted in socket 9; one pigtail lead of a 300 ohm resistance; one pigtail lead of a .00025 mfd. mica condenser. Solder the connection. The other pigtail lead of the .00025 mfd. mica condenser and the 300 ohm resistance are to be connected to any conveniently placed solder lug. The solder lug mounted on the left-hand side of the headphone jack strip would probably be the most convenient. The other pigtail lead of the 25,000 ohm resistance is to be connected to the grid terminal on the eight prong socket mounted in hole 10. The grid terminal in this instance is terminal lug 5. At the same time this resistor is connected to this point, connect one pigtail terminal of a .00025 mfd. mica condenser and solder the connection. The other pigtail terminal of the .00025 mfd. mica condenser is to be connected to the right-hand terminal lug on the three lug terminal strip mounted at the back of hole 14. At the same time this connectionsis made, connect a piece of hookup wire and solder the connection. The other end of this piece of hookup wire is to be passed up through a small hole in the chassis and is then to be connected to the green lead which comes out of the top of the I.F. transformer mounted in hole 10. Solder this connection and then put a piece of tape around the connection in order to avoid the possibility of a bare connection touching any metal part of the chassis.

Now connect a piece of hookup wire to the plate terminal on the eight prong socket mounted in hole 10. The plate terminal is 3 as shown in Fig. 7. Solder the connection. The other end of this piece of hookup wire is to go to the free terminal lug on the R.F. choke. At the same time this connection is made, also connect one pigtail terminal of a .00025 mfd. mica condenser and solder the connection. The other end of the .00025 mfd. mica condenser is to be connected to any conveniently placed solder lug. The red lead coming from the intermediate frequency transformer mounted in hole 9 is to be connected to the screen grid terminal on the eight prong socket mounted in hole 10. The screen grid terminal 6 is shown in Fig. 7. Solder the connection.

A little while ago, during your experiment, you connected one pigtail terminal of the .01 mfd. condenser to one of the solder lugs on your R.F. choke. At that time, you did not solder the connection. Now, to this same terminal, connect one pigtail lead of a 100,000 ohm resistance and solder the connection. The other pigtail terminal of the 100,000 ohm resistance is to be connected to the left-hand terminal on the three lug terminal strip mounted at the back of hole 4. You are connecting this resistor to the same terminal lug to which you formerly connected a piece of hookup wire, the other end of which goes to B+ of your power supply. At the same time this connection is made, also connect one pigtail lead of your 10,000 ohm wire wound high wattage resistor; also the pigtail lead of a 250,000 ohm resistance and the pigtail lead of a 25,000 ohm resistance. Solder the connection. To this left-hand terminal lug on the three lug terminal strip mounted at the back of hole 4, you now have connected the following apparatus: one end of a piece of hookup wire, one end of a 100,000 ohm resistance, a 10,000 ohm resistance, a 250,000 ohm resistance, and a 25,000 ohm resistance. This makes five connections, but if you are careful, you will have no difficulty in making them.

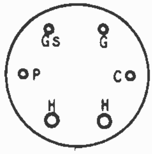
The other pigtail lead of the 250,000 ohm resistance goes to the screen grid terminal on the six prong socket mounted in hole 2. At the same time this connection is made, also connect one pigtail terminal of a .1 mfd. condenser and solder the connection. The other pigtail terminal of the .1 mfd. condenser goes to any conveniently placed solder lug.

Going back to the left-hand lug on your three lug terminal strip mounted at the side of hole 4, the remaining pigtail lead on the 10,000 ohm resistance is connected over to the right-hand terminal lug on the same terminal strip. At the same time this connection is made, connect one pigtail terminal of a .1 mfd. condenser and also connect the blue lead which comes out of the bottom of the I.F. transformer mounted in socket 1. Solder the connection. The other pigtail terminal of the .1 mfd. condenser is to be connected to any conveniently placed solder lug.

Back again to the left-hand terminal lug on the terminal strip at the side of hole 4, you have one pigtail lead of a 25,000 ohm resistance, the other end of which you have not connected. The other pigtail lead on this 25,000 ohm resistance goes to the left-hand terminal lug on the terminal strip which is mounted at the side of hole 9. At the time this pigtail lead is connected to this terminal lug, also attach the blue lead coming out of the I.F. transformer mounted in hole 9 and connect one pigtail terminal of a .25 mfd. condenser, then solder the connection. The other end of the .25 mfd. condenser is to be connected to any conveniently placed solder lug.

Mount a solder lug under the bolt at the right-hand side of socket 2. Connect a short piece of hookup wire to this solder lug and then connect this piece of hookup wire to the cathode terminal and the suppressor terminal on the six prong socket mounted in hole 2. The cathode terminal and suppressor terminal can be determined by referring to Fig. 9. At the same time these connections are made, connect the black lead coming out of the I.F. transformer mounted in hole 1 to either the solder lug or the cathode terminal and then solder all connections.

Fig.9 Bottom view of 6 prong socket.



Connect one pigtail lead of a .00025 mfd. mica condenser to the plate terminal on socket 2. Also to this same terminal, connect the red lead coming out of the bottom of the I.F. transformer mounted in hole 1. Solder the connection. The other pigtail terminal of the .00025 mfd. mica condenser is to be connected to the center terminal lug on the terminal strip mounted at the side of hole 4. Also, to this same terminal lug, connect one pigtail lead of a 250,000 ohm resistance and then solder the connection. The other pigtail end of the 250,000 ohm resistance is to be connected to the right-hand terminal lug on the terminal strip mounted at the side of hole 9. At the same time this connection is made, connect one pigtail terminal of a 1500 ohm resistance and also one end of a piece of hookup wire and then solder the connection. The other pigtail terminal of the 1500 ohm resistance is to be connected to ground by using any conveniently placed solder lug. Now, pass the free end of the piece of hookup wire up through the chassis, using any small hole and then lead this piece of hookup wire over to the grid cap of a 6A8 tube which is going to be used in socket 10. After making certain that the wire will reach, solder a grid clip on the end of this piece of wire.

The following directions are to be carried on with your chassis right side up and the front toward you. Now take a regular grid clip and to this grid clip attach the following: one pigtail lead of a .00025 mfd. mica condenser; one pigtail lead of a 2 megohm resistance; one end of a piece of hookup wire. Solder the connection. Next connect the pigtail lead of the 2 megohm resistance and the pigtail lead of the .00025 mfd. mica condenser together and then connect both of these leads to the green wire which comes out of the top of the I.F. transformer mounted in hole 1. Solder all connections. The piece of hookup wire connected to this grid clip is to be cut off so that it is only about an inch long. To the other end of this piece of hookup wire, solder one of the solder lug terminals of your little two plate trimmer condenser. To the other solder lug terminal on the two plate trimmer condenser, attach another piece of hookup wire. The other end of this piece of hookup wire is to be connected to the solder lug on the back rotor section of your two gang tuning condenser. Solder the connection.

Now if you have carefully followed directions, your experiment is wired exactly as shown in Fig. 8. However, it is advisable that you check this over thoroughly three or four times before preparing to operate your experiment.

HERE IS A GOOD PRACTICE TO FOLLOW IN WIRING A COMPLICATED PIECE OF APPARATUS LIKE THIS SO THAT YOU WILL NOT MAKE MISTAKES. USE A RED PENCIL AND EACH TIME YOU MAKE A SOLDERED CONNECTION, CHECK THAT CONNECTION OFF ON YOUR DIAGRAM (SUCH AS FIG. 8). ALSO EVERY TIME A CONNECTION IS MADE, CHECK THE PLACE IN YOUR LABORATORY EXPERIMENT DIRECTIONS, SHOWING THAT YOU HAVE COMPLETED THOSE DIRECTIONS. THEN WHEN YOU HAVE COMPLETELY WIRED YOUR EXPERIMENT, YOUR DIAGRAM SHOULD BE CHECKED COMPLETELY, SHOWING THAT YOU HAVE MADE ALL CONNECTIONS AS INDICATED.

Plug a type 80 tube in socket 13, a type 56 tube in socket 14, a type 6A8 tube in socket 10, then mount a tube shield base in hole 1, put a type 6D6 tube in socket 1, put the tube shield down over the top, but do not put on the top cover. Place the grid cap on the 6A8 tube and then place the grid cap on the 6D6 tube. In doing this, you will find it is necessary to so adjust your apparatus that no bare leads touch the tube shield. Remember, the grid clip on the 6D6 tube is supporting the little two plate trimmer condenser and is also supporting one end of the .00025 mfd. mica condenser and one end of the 2 megohm resistance. If you are careful, you will have no difficulty with this type of a connection. Plug your headphones into the headphone jack and connect your experiment to a 110 volt, 60 cycle AC socket. Turn the experiment on and give the tubes time to warm up.

It may be possible that you will have some difficulty in getting this experiment to operate properly. However, a little patience will produce large rewards and so do not give up if your first attempts are not successful. The first thing to do is to set your little two plate trimmer condenser at practically maximum capacity. The next thing to do is to set your two gang tuning condenser at practically maximum capacity. Now, you are ready to adjust the padding condensers on the two I.F. transformers. If when you completed your superheterodyne experiments, your I.F. transformers were operating properly and if since that time the padding condensers have not been touched, then in all probability, you will need to make no adjustment whatsoever on the I.F. transformer mounted in hole 9 and connected to the type 6A8 tube. It is certainly advisable to leave this I.F. transformer alone for the time being.

After the tubes have had a chance to warm up, carefully rotate your two gang tuning condenser. If by accident the oscillator is properly adjusted, you will find that the tone of your oscillator produced in the headphones will vary from a low pitched A.F. tone to a high pitched A.F. tone when you rotate the condenser. In testing out your experiment, you should turn your 500,000 ohm volume control potentiometer as far as it will go to the right. After you receive a proper tone output, you can then adjust the volume to suit your convenience.

If you receive no tone in your headphones when you turn the experiment on and rotate the two gang tuning condenser, then set the two gang tuning condenser at practically maximum capacity, the two plate trimmer condenser at maximum capacity (with the screw turned almost all of the way in), then, using a screwdriver, it will be necessary to carefully adjust the padders on the I.F. transformer mounted in hole 1. It does not make a great deal of difference on which of the two padders you start. However, in starting, work only on one and leave the other alone. Now, adjust this padding condenser until you receive a tone in your headphones. At first, it may be a very high pitched or it may be quite a low pitched sound. When you receive a tone in your headphones, then vary your two gang tuning condenser and see if, as you decrease the capacity, the tone in the headphones increases in frequency; that is, becomes higher pitched. If this does not happen, then in all probability it will be necessary for you to again readjust the padder condenser on the I.F. transformer mounted in socket 1. A little care and a little experimentation will produce good results.

The next adjustment which you can make on your oscillator is to change the range on your dial. In other words, in rotating your two gang tuning condenser, you may find that just a very small rotation of the condenser causes the tone of the oscillator to go from low pitch to high pitch in just a few degrees of rotation. This can be spread out by slightly decreasing the capacity of the two plate trimmer condenser connected in series with one section of the rotor plates on your two gang condenser. When you decrease the capacity on the two plate trimmer condenser, then set your two gang tuning condenser to maximum capacity and again readjust the padder condenser on the I.F. transformer mounted in hole 2. Set the padder condenser for a low tone. Then, by varying the two gang tuning condenser, you will find that the frequency increases as the capacity decreases. This time, the frequency range of the oscillator; that is, from low to high pitch, should be spread over a greater portion of the degree of rotation of your two gang tuning condenser.

Later on, when you study the function of cathode ray tubes, you will be taught a method of calibrating A.F. oscillators by comparing the output wave of the audio oscillator with that of a 60 cycle wave secured from the power lighting line. However, in this experiment, you are interested only in the principle of operation, rather than in the method of calibration.

In this experiment, the 6D6 tube is operating as an oscillator and the oscillator section of the 6A8 tube is operating as another oscillator. The output of these two oscillators are mixed in the electron stream flowing from the cathode to plate of the 6A8 tube. These two oscillators produce a beat note which is amplified by the type 56 audio oscillator and then reproduced in your headphones. The note received in your headphones is determined by the difference in frequency in operation of the two oscillators. That is the reason why this type of audio oscillator is known as a beat frequency oscillator. It is advisable that you study thoroughly the material given in Lesson 27, Unit 1, in order that you may refresh your memory concerning the operation of beat notes.

LABORATORY REPORT
GROUP 7

After completing this group of experiments you are to answer the following questions so that we can ascertain the success of your experimental work.

1. Explain in your own words the process of neutralization.

2. Did you notice any difference in neutralizing your amplifier when it was connected series or shunt fed?

3. Give the difference in results noted between the wavemeters built in Experiments 60 and 67.

4. Describe the results secured when completing experiments 69 and 70.

5. Describe the results secured with your audio oscillator. Since the two separate oscillators are operating at a frequency of approximately 456 kc., which is above audibility, how is an audio note produced?

RESISTOR COLOR CODE

Body Color		End Color		Dot Color	
Black	0	Black	0		
Brown	1	Brown	1	Brown	0
Red	2	Red	2	Red	00
Orange	3	Orange	3	Orange	000
Yellow	4	Yellow	4	Yellow	0000
Green	5	Green	5	Green	00000
Blue	6	Blue	6	Blue	000000
Purple	7	Purple	7	Purple	0000000
Gray	8	Gray	8	Gray	00000000
White	9	White	9	White	000000000

The body color of a resistor denotes the first significant figure, the end color the second significant figure and the dot indicates the number of ciphers after the first two significant figures.

Example: A 350 ohm resistor has an Orange Body, Green End, and Brown Dot. First significant figure is 3 (Orange Body), second significant figure is 5 (Green End) and one cipher following (Brown Dot).

(Courtesy Hygrade Sylvania Corp.)

NOTE: The letter "M" following a number used to designate the value of a circuit component, indicates that the number is to be multiplied by 1,000. Thus: 10M indicates 10,000.

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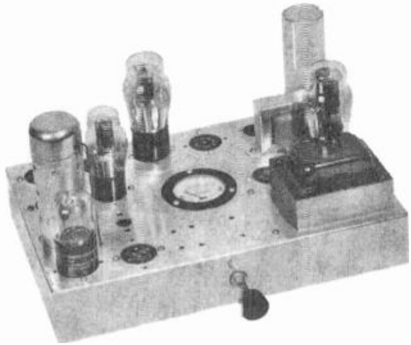
GROUP NO. 8

LABORATORY EXPERIMENTS

EXPS. NO. 72 TO 81

LABORATORY EXPERIMENTS

Group Eight



"Since more and more uses for photocells appear every day, it is my opinion that this group of experiments is as important as any you will conduct.

"In performing these experiments, just remember that you have actual working units. The only change necessary is the replacement of the milliammeter with a photocell relay. No student should attempt to conduct these experiments until he has completed Lessons 4 and 5 of Unit 5.

EXPERIMENT 72
BUILDING AND TESTING DC PHOTOCELL CIRCUITS

(Forward Type)

In this experiment you will build a forward-operating photocell circuit, using a DC supply. A forward circuit indicates that with light falling on the photoelectric cell, an increase in plate current will result. The increase in plate current will be noted on your milliammeter, but if a relay were connected in the plate circuit in place of the milliammeter, light falling on the photocell circuit would cause the relay to close. Then, according to the type of contacts on the relay, another circuit could be either opened or closed.

In completing Experiment 71, you had a beat frequency audio oscillator constructed. This is a comparatively complicated circuit and, in building it, you used most of your equipment. In carrying out this group of experiments, it is first advisable to completely dismantle the apparatus used in Experiment 71. You can save time by leaving the power supply intact if you so desire; that is, your power transformer will be mounted in hole 16, a four prong socket used for the type 80 rectifier tube is mounted in hole 13, your 8-8 mfd. electrolytic condenser is mounted in hole 12. You also have a terminal strip bolted under the right-hand bolt which holds the filter choke in place. All of this apparatus and wiring may be left intact. Your 15,000 ohm volume control potentiometer can be left mounted in the center hole of the three holes on the front side of your chassis. REMEMBER, YOUR CHASSIS IS UPSIDE DOWN AND THE FRONT TOWARD YOU.

After all equipment has been removed, it is advisable then to use your soldering iron and thoroughly clean the pigtail leads on your resistors, condensers, and also the terminal lugs on your various sockets. After this job is completed, you are then ready to mount the apparatus to be used for the next two experiments.

The milliammeter is to be mounted in hole 15. Next, mount a four prong socket in hole 1. In mounting this socket, the filament or heater prongs are to face toward the right side of the chassis. Next, mount a six prong socket in hole 3. In mounting this socket, the filament or heater prongs are to face toward the left of the chassis. Next, bolt a terminal strip to the chassis, using the small hole at the back of hole 4. With this equipment mounted, you are then ready to wire the experiment.

Using a twisted pair of leads approximately 10 inches long, solder one end of this pair of leads to the heater prongs of the six prong socket mounted in hole 3. The other ends of this pair of twisted wires are to be connected to the 6.3 volt terminals on your power transformer. This will supply 6.3 volts to the type 6C6 tube used in socket 3.

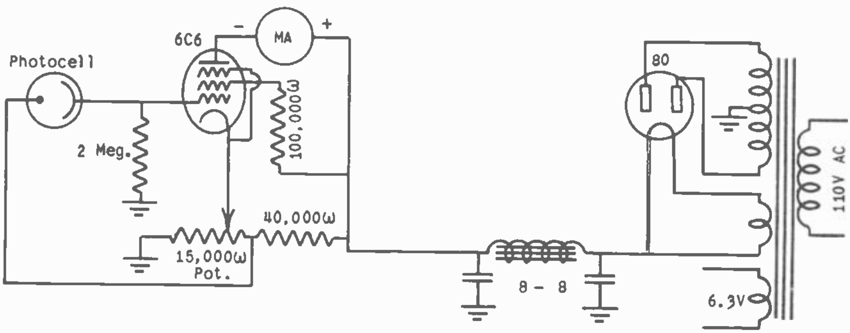


Fig.1 Wiring diagram of a forward-acting photocell circuit; DC operated.

If you did not disturb your power supply system, the switch on the back of your 15,000 ohm volume control potentiometer is connected in series with the 110 volt line. This switch will permit you to turn the experiment on and off. Also, your power supply system is wired as shown in Fig. 1. This is a complete wiring diagram for this experiment.

A bottom view of the four prong socket mounted in hole 1 is shown in Fig. 2A. A bottom view of the six prong socket mounted in hole 3 is shown in Fig. 2B. Now, take a short piece of hookup wire and connect it from the suppressor prong to the cathode prong on the six prong socket mounted in hole 3. Also, connect one end of a piece of hookup wire to the cathode prong and solder these connections. The other end of this piece of hookup wire goes to the center terminal on your 15,000 ohm volume control potentiometer mounted in the center hole on the front of the chassis. Solder the connection. Connect a short piece of hookup wire to one of the outside terminals on your volume control potentiometer and solder the connection. The other end of the piece of wire is to be soldered to any conveniently placed solder lug. The terminal to use is the one nearest the chassis. Your volume control potentiometer should be so mounted that the terminal lugs face toward the left of the chassis.

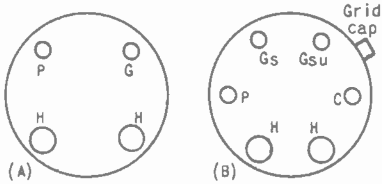


Fig. 2 Bottom view of 4 and 6 prong sockets. (A) Four-prong to hold photocell. (B) Six-prong to hold a 6C6 tube.

Now, connect a piece of hookup wire to the plate prong on the four prong socket mounted in hole 1. Solder the connection. You can determine which is the plate prong by referring to Fig. 2A. The other end of this piece of hookup wire is to be connected to the remaining outside terminal on your 15,000 ohm potentiometer. At the same time this connection is made, connect another piece of hookup wire and then solder the connection. The other end of this piece of hookup wire is to be connected to the right-hand terminal lug on the terminal strip mounted at the rear of hole 14. At the same time this piece of hookup wire is connected to that point, connect one pigtail lead of a 40,000 ohm resistance and then solder the connection. To the left hand terminal lug on the three lug terminal strip, you now have the B+ output of your power supply system connected with one of the leads from your 8-8 mfd. electrolytic condenser. To this same terminal lug, connect the remaining pigtail lead of the 40,000 ohm resistance. At the same time, connect two pieces of hookup wire and then solder the connection.

The other end of one of these pieces of hookup wire is to go to the positive terminal on your milliammeter. The other end of the remaining piece of hookup wire is to go to one of the terminal lugs on the terminal strip mounted at the side of hole 4. At the same time this connection is made, connect the pigtail lead of a 100,000 ohm resistance and solder the connection. The other end of the 100,000 ohm resistance goes to the screen grid terminal on the six prong socket mounted in hole 3. Solder the connection.

Connect a piece of hookup wire to the plate terminal on the six prong socket mounted in hole 3 and solder the connection. The other end of this piece of hookup wire goes to the negative terminal of your milliammeter.

Connect a piece of hookup wire to the filament terminal next to the grid terminal on the four prong socket mounted in hole 1.

To this same terminal, connect one pigtail lead of a 2 megohm resistance and solder the connection. The other pigtail lead of the 2 megohm resistance is to be connected to ground by using any conveniently placed solder lug. The other end of the piece of hookup wire is to be passed up through the chassis, using the small hole which is in the center of the large holes 1, 2, 3, and 4. This piece of hookup wire should be long enough to reach to the grid cap on the type 6C6 tube in socket 3. If the wire will reach, solder a grid clip to the end of this wire.

Now, if you have carefully followed directions, your experiment will be wired exactly as shown in Fig. 1. It is advisable, however, to check your wiring over carefully once or twice before turning on your experiment. Plug a type 80 tube in socket 13, a type 6C6 tube in socket 3, your special photoelectric cell in the four prong socket mounted in hole 1 and you are ready to operate the experiment. Plug your AC cord into 110 volt, 60 cycle alternating current supply and give the tubes time to warm up.

Using some sort of a pasteboard container; that is, a container such as tubes come in, or in fact anything which is light-tight, put this container down over the photoelectric cell so that no light can reach the cathode of the photoelectric cell. With your cell covered, you may or may not have plate current indicated on your milliammeter. Your 15,000 ohm potentiometer controls the grid bias on the type 6C6 tube and this, in turn, controls the plate current. Now, adjust your potentiometer so that you will have approximately 1 to 2 ma. of plate current flowing with the photoelectric cell covered.

Now, place a 60 or 100 watt light bulb 20 inches away from the photoelectric cell with the balance of the room in darkness. With the chassis right side up and the front toward you, you will notice that the cathode of the photoelectric cell faces toward the left end of the chassis. Therefore, the light bulb should be at the left end of the chassis. With your plate current adjusted to approximately 1 or 2 ma., remove the covering from the photoelectric cell. When the light from the light bulb strikes the photoelectric cell, there should be an immediate increase in plate current. The plate current should increase approximately 10 to 12 ma. If you do not obtain this increase, then it is evident you do not have your plate current adjusted properly with the photocell in darkness. It is a good idea to do some experimenting with this circuit so that you can judge for yourself how such apparatus functions.

You can bear in mind that if you had a photocell relay connected in the plate circuit of the 6C6 tube, this relay in turn could control practically any type of equipment. This is a very interesting experiment and I am sure you will find it a perfect demonstration of the information you studied in Lesson 5 of Unit 5.

EXPERIMENT 73

BUILDING AND TESTING DC PHOTOCELL CIRCUITS

(Reverse Type)

In carrying out this experiment, you are going to change the forward type of circuit built in Experiment 72 to a reverse type of circuit. The difference between a forward and reverse circuit is explained as follows. In a forward circuit, the plate current of its associated amplifier is adjusted to near zero with the photoelectric cell in darkness. Then, when the photocell is illuminated, an increase in plate current results. In considering the reverse circuit, the plate current for the associated amplifier is adjusted to near its maximum value with the photocell in the dark. Then, when the photocell is illuminated, the plate current will decrease. With a relay connected in the plate circuit of a reverse type of photoelectric cell circuit, the relay would be closed while the cell was in darkness. With the illumination of the cell, there would be a decrease in plate current with a resulting opening of the relay.

Only a very few changes will be necessary in carrying out this experiment. You now have a piece of hookup wire and one pigtail lead of a 2 megohm resistance connected to the filament prong next to the grid prong on the four prong socket mounted in hole 1. Remove both of these connections. Then, by bolting a solder lug to the right-hand bolt holding this socket in place, connect a piece of hookup wire between the heater prong next to the grid prong and this solder lug. This grounds the cathode of the photoelectric cell as shown in the complete wiring diagram for this experiment (Fig. 3).

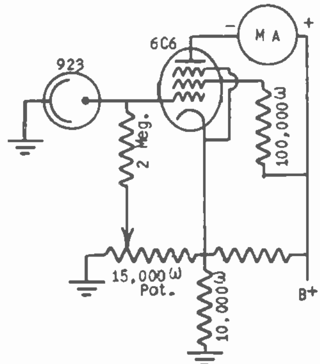


Fig. 3 Wiring diagram of a reverse-acting photocell circuit; DC operated.

You now have a piece of hookup wire connected to the plate prong on the four prong socket mounted in hole 1. Unsolder this piece of hookup wire from the plate prong. Next solder the pigtail lead of the 2 megohm resistance and also the free end of the piece of hookup wire, which goes up through the chassis to the grid cap on the 6C6 tube used in socket 3, to the plate prong on the four prong socket mounted in hole 1. The other pigtail lead of the 2 megohm resistance is connected to a solder lug bolted to the chassis. Unsolder this connection. This pigtail lead of the 2 megohm resistance is to be connected to one of the terminal lugs on the terminal strip mounted at the back of hole 4. To this same terminal lug, connect the piece of hookup wire which was formerly connected to the plate prong on socket 1. Solder the connection. The other end of this piece of hookup wire is now connected to the outside terminal lug on the 15,000 ohm potentiometer, but is to be moved to the center terminal lug on the 15,000 ohm potentiometer. (The outside lug nearest you is the one used.)

In the preceding experiment, you had a piece of hookup wire connected from the cathode terminal on the six prong socket mounted in hole 3 over to the center terminal lug on the 15,000 ohm potentiometer. This piece of hookup wire is to be moved from the center terminal over to the outside terminal on the same potentiometer. (The outside terminal lug nearest you is the one to be used.)

Now to the outside terminal lug nearest you, on the 15,000 ohm potentiometer, connect one pigtail lead of a 10,000 ohm resistance. Your wire wound, heavy duty resistance is the one which should be used here. The other pigtail lead of this 10,000 ohm resistance is to be connected to the chassis by using any conveniently placed solder lug. Now, if you have followed directions carefully, your experiment will be wired as shown in Fig. 3. Be sure to check things over carefully several times.

In operating this experiment, plug a type 80 tube in socket 13, a type 6C6 tube in socket 3, your photoelectric cell in socket 1, plug your experiment into a 110 volt, 60 cycle AC supply and turn the experiment on by rotating your volume control switch. After the tubes have had the opportunity of warming up, carefully cover the photoelectric cell so that no light reaches it. You should now have a plate current of approximately 8 ma. flowing. Now, carefully turn your potentiometer to the right (clockwise). Do this very slowly until you reach the point where the plate current just starts to decrease. At this point, your potentiometer is properly adjusted and you are ready to check the experiment. With your 60 or 100 watt light bulb placed about 20 inches from the photoelectric cell, remove the cover from the photoelectric cell and the plate current should immediately decrease. The decrease in plate current will be approximately 3 to 5 ma.

You should keep in mind that if a photoelectric cell relay was connected in the plate circuit of the 6C6 tube instead of the milliammeter now used, the changing of the light intensity on the photoelectric cell would in turn actuate the relay. This relay could then, in turn, be used to control any type of circuit desired. At this point you should make a thorough review of the information contained in Lesson 5, Unit 5, so that you can fix firmly in your mind the difference between pickup and release or drop-out current on a relay. While in this experiment it might take the full 7 or 8 ma. flowing in the plate circuit of the 6C6 to close the relay, it will be necessary to have a reduction of only a few milliamperes in order for the relay to drop out or open.

EXPERIMENT 74

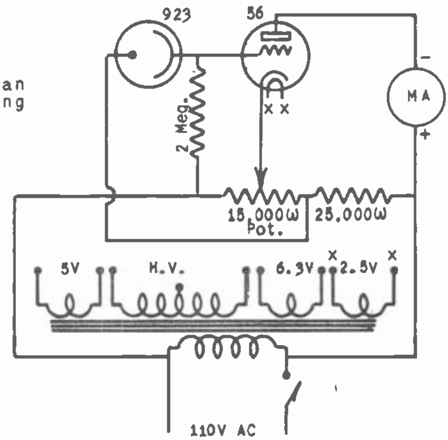
BUILDING AND TESTING AC-OPERATED PHOTOCELL CIRCUITS

(Forward Type)

In this experiment you will build the simplest possible type of photocell circuit; that is, this circuit constitutes a means of opening and closing a relay through the use of a photoelectric cell and, still, uses the minimum amount of equipment. A complete wiring diagram for this experiment is shown in Fig. 4.

You now have a short piece of hookup wire connected between the outside terminal lug nearest the chassis on your 15,000 ohm control, and a conveniently placed solder lug. Remove this piece of hookup wire entirely. On this experiment you are going to use the 110 volt AC line voltage for plate voltage. The most convenient place to connect to this line voltage is the two primary terminals on your power transformer. To the primary terminal which is nearest the front side of the chassis, solder a piece of hookup wire. The other end of this piece of hookup wire is connected to the outside terminal on the volume control potentiometer. The outside terminal nearest the chassis is the one to use.

Fig.4 Wiring diagram of an AC-operated, forward-acting photocell circuit.



You now have a piece of hookup wire connected to the center terminal lug on the 15,000 ohm potentiometer. The other end of this piece of hookup wire is connected to one pigtail lead of the 2 megohm resistance, both of them being attached to the terminal strip mounted at the rear of hole 4. Move this piece of hookup wire from the center terminal of the 15,000 ohm potentiometer to the outside terminal. (The outside terminal nearest the chassis is the one to use.) Do not change the 2 megohm grid leak or the other end of this piece of hookup wire.

In hole 3 you now have a six prong socket mounted. Remove all connections from this six prong socket, then remove the socket, and in its place, mount a five prong socket. The filament or heater prongs should be mounted toward the left side of the chassis. The same pair of twisted wires formerly used in supplying heater voltage to the six prong socket can be connected to the heater prongs on the five prong socket. The other ends of this pair of twisted wires were connected to the 6.3 volt terminals on your power transformer. Disconnect these two twisted wires from the 6.3 volt terminals and move them to the 2.5 volt terminals on your power transformer. This will supply 2.5 volts of heater voltage to the type 56 tube which is going to be used in socket 3.

In your preceding experiment, you had a piece of hookup wire connected between the cathode terminal on the six prong socket and one of the outside terminals on your 15,000 ohm potentiometer. Connect one end of this piece of hookup wire to the cathode terminal on the five prong socket mounted in hole 3. Solder the connection. The other end of this piece of hookup wire goes to the center terminal on your volume control potentiometer. Solder the connection. This wire is moved from the outside terminal to the center terminal.

In the preceding experiment, you had a piece of hookup wire connected from the outside terminal nearest you on the 15,000 ohm potentiometer and one end of a 40,000 ohm resistance mounted on the terminal strip at the back of hole 14. Remove this piece of hookup wire. You also had a 10,000 ohm resistance connected between this same outside terminal and a conveniently placed solder lug. Remove this resistance. At this time, you have no connections made to the outside terminal lug nearest you on your 15,000 ohm potentiometer. To this terminal lug connect one pigtail lead of a 25,000 ohm resistance and one end of a piece of hookup wire. Solder the connection. The other end of the 25,000 ohm resistance is to be connected to the primary terminal on your power transformer that is toward the rear of the chassis. At the same time this connection is made, also connect one end of a piece of hookup wire and solder the connection. The other end of this piece of hookup wire is to go to the positive terminal on your milliammeter. At the same time this piece of hookup wire is connected to the positive terminal, remove the piece of hookup wire which is now connected between the positive terminal on the milliammeter and the three lug terminal strip mounted at the rear of hole 14. The other end of the piece of hookup wire now connected to the outside terminal lug nearest you on the 15,000 ohm potentiometer is to be connected to the plate prong on the four prong socket mounted in hole 1. To this prong you now have connected one pigtail end of a 2 megohm resistance and a piece of hookup wire. Remove these two connections and solder the hookup wire just attached.

The piece of hookup wire which was formerly passed up through the small hole in the centers of holes 1, 2, 3, and 4, is to be removed. The free pigtail end of the 2 megohm resistance is to be connected to the filament prong next to the grid prong on socket 1. At the same time this connection is made, be sure to remove the ground connection which was formerly made at this point. To this same filament prong also attach one end of a short piece of hookup wire and solder the connection. The other end of this short piece of hookup wire is to go to the grid terminal on the five prong socket mounted in hole 3. Solder the connection.

In the preceding experiment you had a piece of hookup wire connected between B+ from the terminal lug mounted at the back of hole 14 over to one of the terminal lugs on the terminal strip mounted at the back of hole 4. This piece of hookup wire can remain in place, but remove the 100,000 ohm resistance which was connected between the same terminal lug and the screen grid prong on the six prong socket formerly mounted in hole 3. In your preceding experiment you had a piece of hookup wire connected between the negative terminal of the milliammeter and the plate terminal of the six prong socket mounted in hole 3. Leave this piece of hookup wire connected to the negative terminal on the milliammeter and connect the other end of this same piece of hookup wire to the plate terminal on the five prong socket mounted in hole 3. Solder the connection. Now, if you have carefully followed directions, your experiment is wired as shown in Fig. 4. The type 80 rectifier tube is not used in this experiment, because it is to be operated from 110 volts, AC; no DC supply being used. Plug your type 56 tube in socket 3; plug your photoelectric cell in socket 1; then plug your experiment into a 110 volt, 60 cycle alternating current supply and turn your experiment on.

After the tube has heated up, you may or may not have plate current indicated. If there is no plate current showing, then carefully adjust your 15,000 ohm potentiometer until you secure approximately 1 to 2 ma. of current. This adjustment is made with the photocell in the dark. Now, with your 60 or 100 watt lamp placed in its usual position, uncover the photoelectric cell. With light shining on the cathode of the photoelectric cell, the plate current should increase immediately. It will probably take some experimenting in order to secure the greatest amount of plate current change when light shines on the photocell. A little experimentation on your part will provide for you a fine working experiment which uses the minimum amount of equipment. All adjustments are made by varying the grid bias on the 56 tube. This is adjusted by the 15,000 ohm potentiometer mounted in the center hole on the front side of your chassis.

Again you should keep in mind that if a relay were used in place of the milliammeter connected in series with the plate of the 56 tube, this circuit could be used to control various pieces of apparatus. Since a pulsating current exists at the plate of the 56 tube, it would require a slightly different type of relay to be used on this type of circuit than when a pure DC current was used on the plate of the 56 amplifier tube.

EXPERIMENT 75

BUILDING AND TESTING AC-OPERATED PHOTOCELL CIRCUITS

(Reverse Type)

In this experiment you will build a reverse type of circuit, using AC operation. Since the sensitivity of a reverse type of circuit is lower than that secured from a forward type, it will be necessary to have higher plate voltage for this experiment than that which you used in the preceding experiment. Therefore, this experiment cannot be operated satisfactorily directly from a 110 volt AC source. Because of this, you will use one-half of the secondary of your power transformer. This will deliver an AC voltage of approximately 300 to 350 volts.

A complete wiring diagram for this experiment is shown in Fig. 5. A good way to guard against mistakes in wiring an experiment is to check off, on your wiring diagram, each connection as you make it. In other words, when you connect a piece of wire to a terminal lug, put a check at that point to indicate the connection is completed. Then, when you have followed all directions, you should have a check at every point of connection on your wiring diagram. This will help a great deal in avoiding mistakes. You now have one pigtail lead of a 2 megohm resistor and one end of a piece of hookup wire connected to the heater prong next to the grid prong on socket 1. Remove these two connections. You now have a solder lug mounted under the right-hand bolt, holding socket 1 in place. Take a short piece of hookup wire and connect between the heater prong next to the grid prong and this solder lug. This grounds the cathode of your photo-electric cell. Solder the connection. You now have a piece of hookup wire connected between the plate prong on socket 1 and one of the

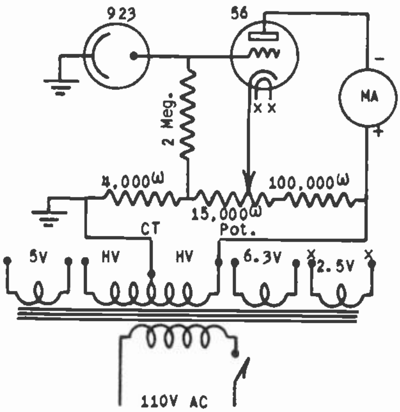


Fig.5 Wiring diagram of an AC-operated, reverse-acting photocell circuit.

outside terminals on your volume control potentiometer. Remove this piece of hookup wire. Now, connect the free terminal of the 2 megohm resistor and a piece of hookup wire to the plate prong on socket 1. Solder the connection. The other end of the piece of hookup wire goes to the grid terminal on socket 3. Solder the connection. The other end of the 2 megohm resistance is already connected to one of the lugs on the 3 lug terminal strip mounted at the rear of hole 4. Leave this connection as it is.

You now have a piece of hookup wire connected between the positive terminal on the milliammeter and one of the primary terminals on your power transformer. Disconnect this piece of hookup wire from the primary terminal on the power transformer and move it over to the grid prong on the four prong socket mounted in hole 13. At the same time this connection is made, also connect one pigtail lead of a 100,000 ohm resistance and solder the connection. This procedure provides a connection to one of the secondary terminals on your power transformer from which you will secure the high AC voltage necessary to operate this experiment. At the present time, the center solder lug on the three lug terminal strip mounted under one of the bolts which hold the filter choke in place should be unoccupied. To this center solder lug, connect the other pigtail lead of the 100,000 ohm resistance and also one end of a piece of hookup wire. Then solder the connection.

You now have a piece of hookup wire connected to one pigtail lead of the 2 megohm resistance, both of them being attached to the terminal strip mounted at the rear of hole 4. The other end of this piece of hookup wire is connected to the outside terminal on the 15,000 ohm potentiometer. The outside terminal nearest the chassis is the one to use. Do not change the 2 megohm grid leak or the other end of this piece of hookup wire. To this same outside terminal, connect one pigtail lead of a 4,000 ohm resistance. The other end of this 4,000 ohm resistance is to be connected to any conveniently placed solder lug. Solder the connection.

In your preceding experiment, you had a piece of hookup wire connected between the cathode prong on the five prong socket mounted in hole 3 and the center terminal lug on your volume control potentiometer. Leave this connection as it is.

To the outside terminal lug nearest you, you now have connected one pigtail lead of a 25,000 ohm resistance. Remove the resistance entirely. You now have a piece of hookup wire connected to one pigtail lead of a 100,000 ohm resistance which is mounted on the center terminal lug of the terminal strip mounted at the rear of hole 14. The other end of this piece of hookup wire is to be connected to the outside terminal lug on the volume control potentiometer. The outside terminal lug nearest you is the one to be used.

Now, if you have carefully followed directions, your experiment should be wired as shown in Fig. 5. Check this over several times so that you can be sure you have made no mistakes.

With your experiment completely wired, you are now ready to test it. Plug your photoelectric cell in socket 1, a type 56 tube in socket 3, and then plug your experiment into a 110 volt, 60 cycle AC supply. DO NOT USE A TYPE 80 TUBE IN SOCKET 13.

Turn your experiment on and allow time for the 56 tube to warm up. Now, with your photocell in darkness, adjust the plate current on your type 56 tube by varying your 15,000 ohm potentiometer. The plate current should be adjusted to a value ranging between 8 and 11 ma. Now, using your regular light bulb, placed at the usual distance from the photoelectric cell, expose the photoelectric cell to light. This should cause an immediate reduction in plate current. The reduction in plate current will amount to about one-half of the no-light plate current. In other words, if you have the plate current of the 56 tube adjusted for 10 ma. with the photocell covered; with the photocell exposed to light, the plate current should be approximately 5 ma.

By experimenting further, you will find you can adjust the plate current on the type 56 tube to a lower value of plate current with the photocell covered and then when the photocell is exposed to light, there will be about the same proportional 50% reduction in plate current. Because of possible danger to the 56 tube, it is not advisable to operate the plate current on this tube at a value exceeding 11 ma. It is even preferable to hold it slightly below that value.

EXPERIMENT 76
CONSTRUCTING A DIRECT-COUPLED RESISTANCE AMPLIFIER

In this experiment you will have your first contact with a direct-coupled type of resistance amplifier. Before attempting this experiment, it is advisable that you review material on this type of amplifier found in Lesson 19 of Unit 1. This is an unusual type of amplifier, but we are sure that the experience provided will help you to understand the theory of operation of such equipment. The amplifier to be constructed in this experiment will be used with the two experiments to follow. A complete wiring diagram for this experiment is shown in Fig. 6.

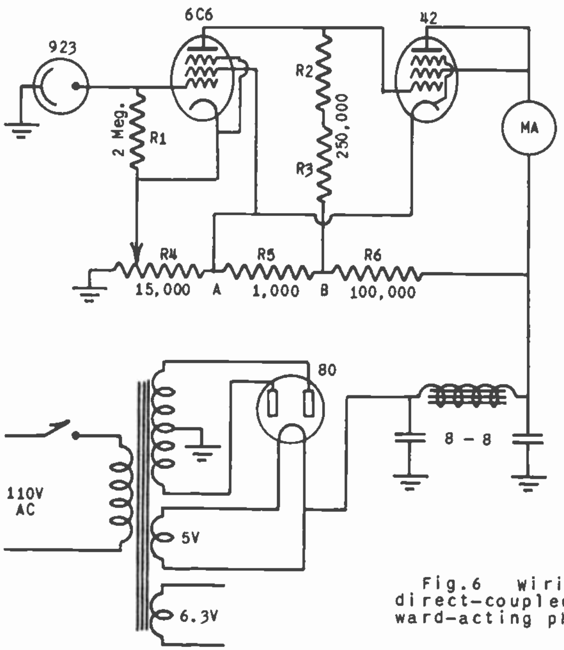


Fig.6 Wiring diagram of a direct-coupled, amplified, forward-acting photocell circuit.

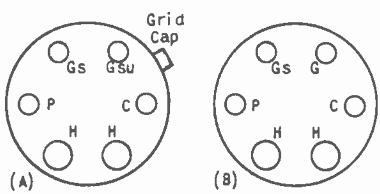
You now have a five prong socket mounted in hole 3. Remove this socket and remove all connections made to this socket. Now, mount six prong sockets in holes 3 and 5. In mounting these two six prong sockets, mount them so that the filament or heater prongs are toward the left side of the chassis. The chassis is upside down and the front toward you. You had a pair of twisted wire leads connected to the heater prongs on the five prong socket mounted in hole 3. This twisted pair of wires can now be connected to the heater prongs on the six prong socket mounted in hole 3. The other end of this pair of twisted leads is now connected to the 2.5 volt terminals on your power transformer. Move these two leads over to the 6.3 volt terminal lugs on your power transformer and solder the connection. Take another pair of twisted leads approximately 4 inches long. Connect one end of each of these two wires to the heater prongs on socket 3 and solder the connections. The other ends of these two pieces of wire are to be connected to the heater prongs on the six prong socket mounted in hole 5. Solder the connections. You now have 6.3 volts applied to the heater terminals of the two six prong sockets mounted in holes 3 and 5.

In the preceding experiment you had a piece of hookup wire connected between the cathode prong on the five prong socket mounted in hole 3 and the center terminal lug on your 15,000 ohm volume control potentiometer. This wire is still connected to the center terminal on the potentiometer. Now, connect the other, or free end to the cathode prong on the six prong socket mounted in hole 3. At the same time, take a short piece of wire and connect the suppressor prong to the cathode prong. Solder the connections.

In the preceding experiment, you had one pigtail lead of a two megohm resistance and a piece of hookup wire soldered to one of the lugs on the three lug terminal strip mounted at the rear of hole 4. Remove the piece of hookup wire entirely. This piece of hookup wire was formerly connected to the outside terminal lug on your volume control potentiometer. The pigtail lead of the 2 megohm resistance is now to be moved from the solder lug terminal strip to the cathode terminal on the six prong socket mounted in hole 3. Solder the connections. The other end of the 2 megohm resistance is to remain connected to the plate terminal on socket 1.

In the preceding experiment, you had a short piece of hookup wire connected between the plate terminal on socket 1 and the grid terminal on socket 3. Remove this piece of hookup wire. Now, attach another piece of hookup wire to the plate terminal on socket 1 and solder the connection. The other end of this piece of hookup wire is to be passed up through the chassis, using the small hole in the center of the four large holes 1, 2, 3, and 4. The end of this wire is supposed to reach the grid cap of a type 6C6 tube which is going to be used in socket 3. If the wire reaches, then solder a grid clip on the end of this wire.

Fig.7 Bottom view of 6-prong sockets. (A) Six-prong to hold 6C6 tube. (B) Six-prong to hold 42 tube.



Now, using a short piece of hookup wire, connect the plate terminal on socket 3 to the grid terminal on socket 5. Socket 5 is to hold a type 42 tube; a bottom view of sockets 3 and 5 is shown in Figs. 7A and 7B, respectively. This is provided so that you will not make any mistakes in determining which is the grid terminal on socket 5 and which is the plate terminal on socket 3. To the plate terminal on socket 3, also connect one pigtail lead of a 250,000 ohm resistance and solder both connections. The other pigtail lead of the 250,000 ohm resistance is to be connected to the solder lug nearest the front of the chassis on the three lug terminal strip mounted at the back of hole 4. To this same terminal lug, also connect a pigtail lead of a second 250,000 ohm resistance and solder the connection. The free pigtail lead of this second 250,000 ohm resistance is to be connected to the rear terminal lug on the three lug terminal strip mounted at the back of hole 4. To this same terminal lug, also connect one end of a piece of hookup wire approximately seven inches long and then solder the connection. The other end of this piece of hookup wire will be connected just a little later in the experiment.

You now have a piece of hookup wire connected to the negative terminal of your milliammeter. Formerly, the other end of this piece of hookup wire was connected to the plate terminal on the five prong socket mounted in hole 3. Now, the end of this piece of hookup wire is to be connected to the plate terminal on the six prong socket mounted in hole 5. At the same time this connection is made, use a short piece of hookup wire and connect the plate terminal and the screen grid terminal on socket 5 together. These two terminals can be determined by referring to Fig. 7B. Solder the connections.

Now, connect one end of a piece of hookup wire to the screen grid terminal on the six prong socket mounted in hole 3. Solder the connection. The other end of this piece of hookup wire goes to the cathode prong on the six prong socket mounted in hole 5. To this same cathode prong, connect a piece of hookup wire approximately 7 inches long and solder the connection. The free end of this piece of hookup wire will be connected later on in the experiment.

At the present time, you have one pigtail lead of a 4,000 ohm resistance connected to the outside terminal nearest the chassis on your 15,000 ohm potentiometer. Remove this 4,000 ohm resistance entirely. Now, using a short piece of hookup wire, ground the outside terminal nearest the chassis of your 15,000 ohm potentiometer. Solder the connections.

You now have a 100,000 ohm resistance connected from the plate prong on socket 13 and one of the terminal lugs on the three lug strip mounted at the rear of hole 14. Remove this 100,000 ohm resistance entirely.

Now, it is time to check up on your power supply system. You now have a piece of hookup wire connected to the filament prong next to the plate prong on socket 13. The other end of this piece of hookup wire is connected to one of the terminal lugs on your filter choke. From the remaining terminal lug on your filter choke, you have a piece of hookup wire connected to the left-hand solder lug of the three lug terminal strip mounted at the rear of hole 14. You also have one section of your 8-8 mfd. electrolytic filter condenser (a red lead) connected to the filament prong next to the plate prong on socket 13. The remaining red lead on your 8-8 mfd. electrolytic filter condenser is connected to the same terminal lug to which you now have soldered a piece of hookup wire coming from your filter choke. The next thing to do is to connect one pigtail lead of a 100,000 ohm resistance to the same solder lug. Also, at the same time, connect one end of a piece of hookup wire and solder the connection. The other end of this piece of hookup wire goes to the positive terminal of your milliammeter. The wire which was formerly connected to the positive terminal of your milliammeter is to be removed. The free end of the 100,000 ohm resistance is to be connected to the right-hand solder lug of the three lugs on the terminal strip mounted at the back of hole 14. At the same time this connection is made, connect one pigtail lead of a 1,000 ohm resistance and, also, at the same time, connect the free end of the piece of hookup wire which is now connected to a pigtail lead of a 250,000 ohm resistance mounted on the terminal strip at the rear of hole 4. Solder the connections.

The free end of the 1,000 ohm resistance is to be connected to the center solder lug on the three lug terminal strip mounted at the rear of hole 14. To this same solder lug, you are to connect two pieces of hookup wire. You now have a piece of hookup wire connected between the outside solder lug nearest you on the 15,000 ohm potentiometer and the right-hand terminal lug on the three lug terminal strip. Move this wire over to the center terminal lug. In other words, you have a piece of hookup wire connected from the center terminal lug and the outside solder lug on your 15,000 ohm potentiometer. To this same center terminal lug, you are also supposed to connect the free end of the piece of hookup wire which is now connected to the cathode prong on the six prong socket mounted in hole 5. Solder the connections.

Now, if you have carefully followed directions, your experiment should be wired exactly as shown in Fig. 6. It is advisable that you check this over several times to make certain that you have made no mistakes. This experiment will be tested in connection with the next experiment.

EXPERIMENT 77

TESTING AMPLIFIED PHOTOCELL CIRCUITS

(Forward Type)

This experiment was constructed in the preceding experiment; however, in this experiment, we are going to learn more of its operation as well as checking the results which may be secured from such equipment.

Check carefully, and you will find that the photoelectric cell is connected in the grid circuit of the type 6C6 tube (as shown in Fig. 6) in such a manner that the photocell and the 6C6 tube are operating in what is usually known as a reverse type of circuit; that is, light falling on the photoelectric cell will cause the plate current of the 6C6 tube to decrease instead of increasing as is customary in the forward type of circuit. However, due to the extra stage of amplification, with a decrease in the plate current of the 6C6 tube, there will result an increase in plate current on the 42 tube. Therefore, the total result of this experiment will be that of a forward operating circuit instead of the reverse type.

Before investigating the theoretical operation of this circuit, let us first see how the operating voltages are applied to the 6C6 and 42 tubes. The three resistors, R4, R5, and R6 form a voltage divider across the output of the power supply, thus enabling the selection of proper voltages for the screen grid and plate of the 6C6. The grid bias for the 6C6 is not obtained by the voltage drop across the resistor R4, but instead by the drop across the 2 megohm resistor R1 connected in the photocell circuit. Only the photocell current will pass through R1. It flows in such a direction as to make the top of R1 negative and the bottom positive, thus placing a negative bias on the grid of the 6C6. The voltage difference between point A (between R4 and R5) and ground supplies the screen grid voltage to the type 6C6 tube. Notice that the cathode of the type 42 is connected to this same point; hence, the cathode of the 42 will be held at a positive potential, equal in value to the screen voltage on the 6C6. The plate voltage for the 6C6 is obtained at point B between R5 and R6 on the voltage divider, and the plate current of this tube must pass through the resistors R2 and R3. Since these two resistors have a total value of 500,000 ohms, the voltage drop produced across them by the flow of normal plate current will be rather high. Now, notice that the resistor R5 is low in value (only 1,000 ohms) and, as a result, the voltage drop produced across R5 is low. The bleeder current through R5 makes the right side positive and the left side negative, whereas the plate current through R2 and R3 makes the top negative and the bottom positive. The total voltage dropped across R2 and R3 exceeds that dropped across R5, so the plate of the 6C6 tube will be at a lower positive potential than the cathode of the type 42 tube. In other words, the plate of the 6C6 is negative with respect to the cathode of the 42 (point A) by an amount equal to the difference between the voltages dropped across R2 and R3, and R5. This difference in voltage may be from approximately 5 volts to 30 volts, depending upon the amount of plate current flowing through R2 and R3.

Since the control grid of the 42 is connected directly to the plate of the 6C6, the control grid of the 42 will also be at a negative potential with respect to the cathode of the 42. The grid bias on the 42 is equal to the difference between the voltages developed across R2 and R3, and R5. The drop across R5 is fixed and steady, whereas that across R2 and R3 changes with the plate current of the 6C6. The plate and screen of the 42 are tied together and connected through the milliammeter to the total voltage output of the power supply. The current in the plate circuit of the 42 will flow from B- (ground) through R4 to the cathode of the 42, from there to the screen and plate (tied together) and return to B+. In order to produce a current change in the type 42 plate circuit, it will be necessary to change the potential between the control grid and cathode of the 42 which may be done easily by changing the voltage drop across the resistors R2 and R3 in the plate circuit of the 6C6. The voltage drop across these two resistors may be changed by changing the plate current of the 6C6 which, in turn, is a function of the grid bias voltage developed across the 2 megohm resistor R1.

We are now ready to determine how the type 42 tube amplifies the DC output of the type 6C6.

When light is falling on the cell, its resistance will be low and a comparatively high current will be passing through it from the cathode to the anode through the 2 megohm resistance R1, then returning through a portion of R4. This current will develop an appreciable voltage across R1, thus making the negative bias on the control grid of the 6C6 high, and reducing the plate current. Since the plate current of the 6C6 is low, the voltage developed across R2 and R3 will be low; hence, the negative grid bias on the type 42 will be low and the current flowing through the plate circuit of the 42 will be high.

Plug your photoelectric cell in socket 1, the type 6C6 tube in socket 3, connect the grid lead, plug a type 42 tube in socket 5 and a type 80 tube in socket 13. Connect your experiment to a 110 volt, 60 cycle alternating current supply, turn your experiment on and give the tubes time to warm up. Now, using your 60 or 100 watt light bulb placed in the usual position, this experiment is to be adjusted with light shining on the photoelectric cell. With the cell illuminated, turn your potentiometer to the right very slowly (this is in a clockwise direction) until the plate current starts to decrease. Just before the plate current starts to decrease is the point where the circuit is correctly adjusted. This is approximately 23 ma. This adjustment is comparatively critical and it may be necessary for you to experiment a little before the correct position will be found. Now, cover the photoelectric cell so that it is no longer illuminated and the plate current should decrease immediately to approximately 3 or 4 ma.

When the potentiometer is properly adjusted (with the cell lighted) the current in the plate circuit of the 42 should be approximately 23 ma. Now, when the cell is darkened, the photocell resistance increases and the current through R1 decreases, which reduces the grid bias on the type 6C6 tube. This causes the plate current through R2 and R3 to increase, thus producing a higher negative voltage on the grid of the 42. The increased bias on the grid of the 42 will cause the plate current to decrease to approximately 3 ma. Thus, with light on the photocell, the current in the plate circuit of the 42 will be approximately 23 ma. When the cell is darkened, the current will decrease to about 3 ma. This is a much greater current change than was obtained in preceding experiments and is a result of the DC amplifier being connected to the output of the 6C6. With such a high current change in the plate circuit of the 42, larger relays may be operated and higher power circuits may be controlled.

EXPERIMENT 78

TESTING AN AMPLIFIED PHOTOCELL CIRCUIT

(Reverse Type)

In this experiment you will change the connections on your photoelectric cell so as to produce a reverse type of circuit instead of the forward type built and tested in the two preceding experiments. Again, by checking the connections on the photoelectric cell, you will notice that it is connected as a forward type of circuit. However, because of the current reversal occurring between the two stages of amplification, the total circuit operates as a reverse circuit. In a reverse circuit, light falling on the photoelectric cell produces a decrease in plate current.

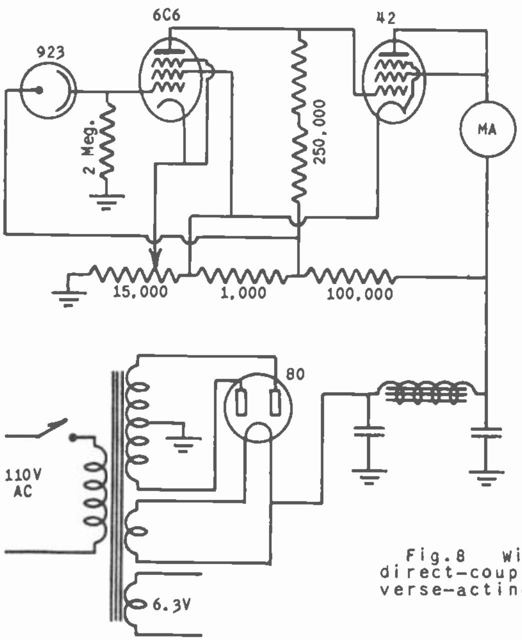


Fig.8 Wiring diagram of a direct-coupled, amplified, reverse-acting photocell circuit.

A complete wiring diagram for this experiment is shown in Fig. 8. You now have one pigtail lead of a 2 megohm resistance and one end of a piece of hookup wire connected to the plate terminal on socket 1. You also have the heater prong, next to the grid prong on the same socket, grounded. Remove the ground connection on the heater prong and move the pigtail lead of the 2 megohm resistance and the end of the piece of hookup wire to this heater prong. Solder the connection. Now, connect one end of a piece of hookup wire to the plate prong on socket 1. Solder the connection. The other end of this piece of hookup wire is to go to the bottom end of the second 250,000 ohm resistance, connected in the plate circuit of the 6C6 tube. This connection can be made by attaching the wire to the rear solder lug terminal on the three lug terminal strip mounted at the side of hole 4. Solder the connection.

One pigtail end of the 2 megohm resistance was formerly connected to the cathode prong on socket 3. Remove this pigtail lead from that solder lug and connect the same lead to any conveniently placed solder lug. This will ground the resistor.

After these changes have been completed, your experiment should be wired as shown in Fig. 8. Be sure and check it over carefully to avoid any possible mistakes. You are then ready to operate the experiment. Plug your photoelectric cell in socket 1, plug a type 6C6 tube in socket 3 and connect the grid clip to the grid cap of this tube. Next, plug a type 42 tube in socket 5 and a type 80 tube in socket 13. Your experiment should then be connected to a 110 volt, 60 cycle alternating current source; turn the experiment on and give the tubes time to warm up.

With the photocell in darkness, you are ready to adjust the grid bias on your type 6C6 tube. Continue to rotate (slowly) your 15,000 ohm volume control potentiometer knob. When the experiment is first turned on, there will be approximately 20 ma. of current. As you continue to rotate the knob, this current will be reduced and should be adjusted for a value somewhere between 10 and 20 ma. (Remember, the photocell is in darkness.) Now, with your 60 or 100 watt light bulb placed in its usual position, expose the photocell to light. With this exposure, you should find a reduction in plate current of 50% to 75%. Let us assume you have adjusted the plate current on the type 42 tube to a value of 10 ma. Then, when the photocell is exposed to light, the plate current should reduce to a value of approximately 3 to 5 ma. While this circuit is not quite as satisfactory as the one used in the preceding experiment; still, it conforms fairly well to the usual practices found with this type of circuit.

EXPERIMENT 79

MEASURING PHOTOCELL SENSITIVITY

In this experiment, you are going through the process of measuring (approximately) the sensitivity of your photocell. Before you can carry on this experiment, it will be necessary to make some changes in your apparatus.

When you completed the preceding experiment, you had a four prong socket mounted in hole 1 and six prong sockets mounted in holes 3 and 5. These sockets will remain intact. All connections except the filament or heater wires should be removed from the six prong socket mounted in hole 5. This socket is not going to be used in this or the next experiment.

In the preceding experiment, you had a short piece of hookup wire connected between the plate terminal on socket 3 and the grid terminal on socket 5. You also had one pigtail lead of a 250,000 ohm resistance connected to one of these points. Remove both 250,000 ohm resistances and the piece of hookup wire.

In the preceding experiment you had a piece of hookup wire connected between the negative terminal of your milliammeter and the plate terminal on the six prong socket mounted in hole 5. Connect this piece of hookup wire to the plate terminal on the six prong socket in hole 3. Solder the connection. The other end remains connected to the negative terminal of the milliammeter. In the previous experiment you had a piece of hookup wire connected between the screen grid terminal on the six prong socket mounted in hole 3 and one of the terminal lugs on the volume control potentiometer. Remove this piece of hookup wire completely. You also had a piece of hookup wire connected between the suppressor prong and the cathode prong on this same six prong socket. These connections are to remain intact. From the cathode prong on the six prong socket mounted in hole 3, you had a piece of hookup wire connected to the center terminal on your 15,000 ohm volume control potentiometer. Leave this connection as it is.

The B+ output of your rectifier filter system is now connected to the left-hand solder lug on the three lug terminal strip mounted at the rear of hole 14. Between the B+ output solder lug and the right-hand solder lug, you formerly had a 100,000 ohm resistance connected. A 1,000 ohm resistor is also mounted on this terminal strip. Remove these resistors entirely. Now, from the B+ output solder lug, connect a piece of hookup wire between that lug and the positive terminal of your milliammeter. Also, to the B+ output terminal, connect one pigtail lead of a 40,000 ohm resistance. The other pigtail lead of this 40,000 ohm resistance is to be connected to the right-hand terminal lug on the three lug strip mounted at the rear of hole 14. From this pigtail lead on the 40,000 ohm resistor, connect a piece of hookup wire between that point and the outside terminal lug on the volume control potentiometer. Solder the connection. The outside lug nearest you is the one to use. The remaining outside terminal lug on the volume control potentiometer is connected to ground. Leave this connection intact.

In the preceding experiment, you had a piece of hookup wire connected between one of the terminal lugs on the three lug strip at the rear of hole 14 and one of the terminal lugs on the three lug strip mounted at the rear of hole 4. This piece of hookup wire is now to be connected in the following manner: one end is to be connected to the B+ output terminal lug on the strip at the rear of hole 14. Solder the connection. The other end of this piece of hookup wire is to be connected to the rear terminal lug on the three lug strip mounted at the back of hole 4. To this same terminal lug, also connect one pigtail lead of a 10,000 ohm resistance and solder the connection. The other pigtail lead of the 10,000 ohm resistance is to be connected to the center terminal lug on the three lug strip mounted at the rear of hole 4. To this same center terminal lug also connect one pigtail lead of a 3,000 ohm resistance and solder the connection. The free pigtail lead of the 3,000 ohm resistance is to be connected to the screen grid terminal on the six prong socket mounted in hole 3. The piece of wire formerly connected to this screen grid terminal is to be removed entirely. To this same screen grid terminal also connect one pigtail lead of a 1,000 ohm resistance and solder the connection. The free pigtail lead of the 1,000 ohm resistance is to be connected to the front terminal lug on the three lug strip mounted at the rear of hole 4. To this same terminal lug also connect one pigtail lead of a 4,000 ohm resistance and one end of a piece of hookup wire and solder the connection. The other end of the 4,000 ohm resistance is to be connected to any conveniently placed solder lug. Solder the connection.

In the preceding experiment you had a piece of hookup wire connected between the plate terminal on the four prong socket mounted in hole 1 and one of the terminal lugs on the three lug terminal strip mounted at the rear of hole 4. Remove this piece of hookup wire. Now you have a piece of hookup wire connected to the front terminal lug on the three lug strip mounted at the rear of hole 4. The other end of this piece of hookup wire is to go to the plate terminal on socket 1. Solder the connection.

You now have one pigtail lead of a 2 megohm resistance and a piece of hookup wire connected to the filament terminal next to the grid terminal on socket 1. Leave these connections intact. The other pigtail lead of the 2 megohm resistance is connected to ground by using any conveniently placed solder lug. The other end of the piece of hookup wire goes up to the grid cap on the type 6C6 tube which is going to be used in socket 3.

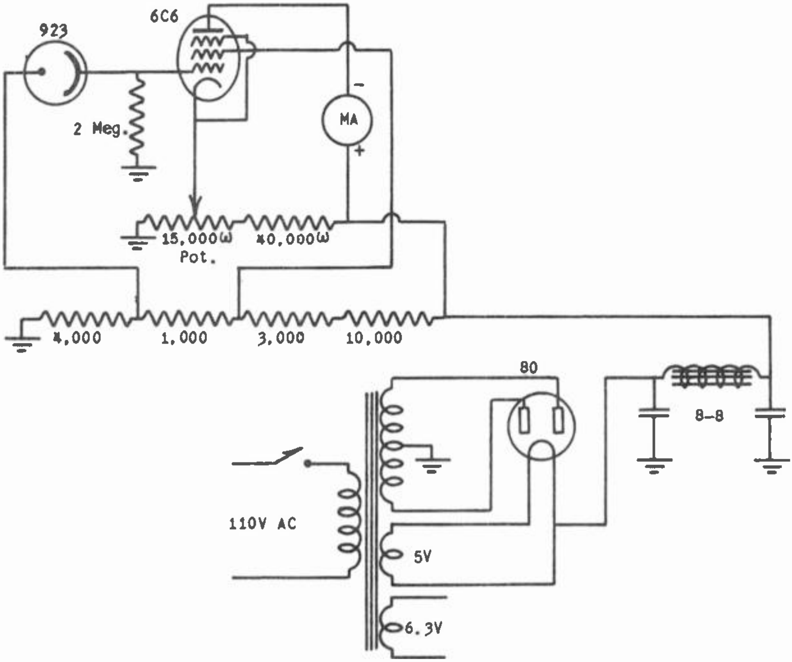


Fig.9 Circuit diagram of the equipment used in sensitivity and light measuring experiments.

Now, if you have carefully followed directions, your experiment is wired as shown in Fig. 9. Check it over several times to be sure you have made no mistakes. Plug a type 6C6 tube in socket 3 and connect the grid clip to the grid cap. Plug your photoelectric cell in socket 1 and plug a type 80 tube in socket 13. Connect your experiment to a 110 volt 60 cycle AC source and turn it on. When the tubes have had a chance to warm up, you are then ready to operate the experiment.

First, you should test your experiment and make certain it is functioning satisfactorily. With the photocell covered (in darkness), adjust the plate current on the 6C6 tube, using the 15,000 ohm potentiometer, to a value of approximately 1 ma. Now, expose the photocell to a 60 or 100 watt lamp and the plate current should increase from 3 to 7 ma. If this happens, your experiment is functioning satisfactorily and you can proceed with the balance of the experiment.

Since the only meter which you have in your experimental equipment is a 0-50 milliammeter, it will be necessary to use a current amplifier in measuring the sensitivity of your photoelectric cell. You will measure the current change in the output of an amplifier tube and, by dividing that by the gain obtained in the tube, determine the change taking place in the photocell circuit.

As you know from previous study, the term "transconductance" is an indication of the amplifying ability of a vacuum tube. Transconductance is determined by a small plate current change, divided by the small grid voltage change that will produce that small plate current change. (See Lesson 12, Unit 1.) This is represented in the following formula:

$$Sm = \Delta Ip \div \Delta Eg$$

Here, Sm is the transconductance; Δ represents a small change; ΔIp is the plate current change; ΔEg is the grid voltage change. If you will check in your tube manual, you will find that the mutual conductance of a type 6C6 tube varies from 1185 to 1225.

The following table represents the candlepower of several different sizes of General Electric frosted Mazda light bulbs as measured in our laboratories. All of these were measured with a filament voltage of 115 volts. In this experiment, any new bulb of a size given in the table may be used as a standard light source.

CANDLEPOWER RATING OF LIGHT BULBS

15 watt = 13.7 c.p.
25 watt = 23.5 c.p.
40 watt = 54.0 c.p.
60 watt = 81.0 c.p.
100 watt = 148 c.p.

In conducting this experiment here in our laboratories, a 40 watt frosted light bulb having a candlepower output of 54 was placed exactly 24 inches from the cathode of the photoelectric cell. This produced a maximum plate current change on the 6C6 tube of 4 ma. In carrying on this experiment, the plate current on the 6C6 tube was adjusted for 1 ma. with the photocell in darkness. Then, with the photocell exposed to the illumination of the 40 watt light bulb, the plate current read 5 ma., or it resulted in a 4 ma. change from no light to maximum light on the photocell. During this experiment, there must be no other light in the room other that that produced by the 40 watt light bulb. In carrying on this experiment, it is best to conduct it on a table which is covered with black cloth. Light reflections from such an arrangement will be reduced to a minimum.

In Lesson 3, Unit 5, you will find the information necessary to calculate the lumens of light incident on the cathode of the photoelectric cell. To make this calculation, it is necessary to know the candlepower of the light source, the distance from the light source to the photoelectric cell and the area of the cathode of the photoelectric cell.

The area of the cathode of the photoelectric cell supplied you is .43 square inch. The formula used for this calculation is:

$$\text{Lumens on Area} = \text{Candlepower} \times \text{Area} \div \text{Distance}^2$$

Here both the distance and area must be in inches. Substituting our values in this formula:

$$\text{Lumens on Area} = 54 \times .43 \div 24^2$$

$$= 23.22 \div 576$$

$$= .0403 \text{ Lumen}$$

Using the transposed formula for transconductance,

$$Eg = Ip \div Sm$$

Substituting the values found, we have:

$$Eg = .004 \div .001225$$

$$= 3.26 \text{ Grid Voltage Change}$$

In using this formula, you must remember that the plate current is in milliamperes while the formula itself is given in amperes. You must also remember that the transconductance of a tube is given in micromhos, while the formula is given in mhos. Therefore, the 4 ma. of plate current change becomes .004 ampere. Also, using the value of 1225 micromhos for the transconductance of the type 6C6 tube gives us a value of .001225 mhos.

Using the transconductance formula, we found that a voltage change of 3.26 was produced across the grid circuit resistor. This voltage drop across the 2 megohm resistance was produced by the photoelectric current. Therefore, to find the photoelectric current, we divide the 3.26 ma. by 2,000,000 ohms which gives us a photocell current of 1.13 microamperes. Since the sensitivity of photoelectric cells is rated in microamperes per lumen, we divide the .0403 lumen into the 1.13 microamperes and find that this photoelectric cell, under the conditions described, has a sensitivity of 28 microamperes per lumen.

Here in our laboratories, we found that this value checked rather closely with the microamperes per lumen as measured with a microammeter directly in the photocell circuit under the same conditions of light flux.

There is a wide variation in the candlepower output of light bulbs due to different manufacturing processes or their age. Also, the line voltage applied to the bulb would seriously affect the light source. Two photoelectric cells of identically the same type and make may have a wide variation in sensitivity. Therefore, if you secure any value from 15 microamperes to 50 microamperes per lumen, you can be comparatively well satisfied that your results are approximately correct.

EXPERIMENT 80
MEASURING LIGHT INTENSITIES

In this experiment, you are going to use your photoelectric cell as a photometer. Before conducting this experiment, you should review the material on this subject as given in lesson 3, of Unit 5.

This experiment should be conducted on a table which is covered with a black cloth so as to eliminate all possible light reflection. With your experiment right side up and the photocell facing toward the left, mount a 60 watt light bulb exactly 24 inches away from the cathode of the photocell. This distance should be measured from the center of the light bulb to the cathode surface on the photocell. Measure it as accurately as possible. In conducting this experiment, you can use any type of light bulb as a standard, just so long as its candlepower is accurately known. The reason that it is necessary to accurately know the candlepower of the standard is that the unknown light source is to be compared against a known or standard source. Here in our laboratories, we used a 60 watt light bulb. The table in the preceding experiment shows that this light bulb has a candlepower of 81. This candlepower output may vary somewhat with the age of the bulb and the line voltage. However, for all practical purposes, you can assume 81 candlepower as an acceptable value.

With the 60 watt light placed exactly 24 inches from the uncovered photoelectric cell, turn your experiment on and, using the 15,000 ohm potentiometer, adjust the plate current on the type 6C6 tube to exactly 5 ma. You must remember that all of the other lights in the room should be turned off.

In finding the candlepower of an unknown light source, do not make any changes on the adjustment of the 6C6 tube after you have secured the definite value of 5 ma. of plate current. Remove the 60 watt light bulb and replace it with some other size of light bulb. Move the position of the bulb to be measured (unknown) with respect to the photocell until the plate current is the same as secured with the 60 watt standard bulb. No adjustments are to be made on the photocell setup during the experiment. Now, accurately measure the distance from the cathode of the photocell to the center of the light bulb being measured. If the light bulb is smaller than 60 watts, it will be closer to the photoelectric cell and, if it is larger than 60 watts, it will be further away from the photocell in order to secure the same plate current readings as when using the standard 60 watt light bulb.

With the candlepower of the known or standard bulb given, the distance of the standard from the photoelectric cell and then the distance of the unknown from the photoelectric cell known (with the same value of plate current flowing), you are then ready to calculate the candlepower of the unknown bulb. This can be done by substituting your values in the following formula:

$$\text{Candlepower of Unknown} = \frac{\begin{pmatrix}\text{Candlepower}\\ \text{of Standard}\end{pmatrix} \times \begin{pmatrix}\text{Distance}\\ \text{of Unknown}\end{pmatrix}^2}{(\text{Distance of Standard})^2}$$

Substituting your values in this formula:

$$\text{Candlepower of Unknown} = \frac{81 \times 18^2}{24^2}$$

$$= \frac{81 \times 324}{576}$$

$$= \frac{26,244}{576}$$

$$= 45+$$

In this example, we were using a 40 watt bulb. You will find that the 45 candlepower compares very closely to the value given in the table in the previous experiment.

It is advisable that you try at least one or two different unknown light sources so that you can check your results and also compare the results secured with the table shown in the preceding experiment.

EXPERIMENT 81

BUILDING A THREE STAGE TELEVISION AMPLIFIER

In this experiment, you will add a two-stage amplifier to the equipment constructed in Experiment 79. This three stage amplifier will be built on the same general principles as those amplifiers which are designed and used for amplifying television signals. A complete wiring diagram for this experiment is shown in Fig. 10.

You now have a four prong socket mounted in hole 1 and six prong sockets mounted in holes 3 and 5. You also have a four prong socket mounted in hole 13. Now, if you are careful, you can move the six prong socket now mounted in hole 5 over to hole 6 without disturbing the filament connections. There is a pair of twisted leads connected between the heater terminals on socket 3 and the heater terminals on the six prong socket formerly mounted in hole 5. By moving this six prong socket to hole 6, the filament prongs must face toward the front of the chassis and, in that manner, the heater wires already connected will reach. In mounting the six prong socket in hole 6, it will be necessary to turn the terminal lug strip mounted at the rear of hole 4 so that it is parallel with the front of the chassis instead of being parallel with the right side of the chassis as it was used in former experiments.

Next, mount a five prong socket in hole 5 and, in mounting this socket, the filament or heater prongs will face toward the left side of the chassis. At this time, it is also necessary to mount your 8-8-8 mfd. electrolytic filter condenser, using the two holes just to the right of the power transformer. The leads coming from this condenser are faced toward the rear of the chassis.

You now have a 10,000 ohm resistance, a 3,000 ohm resistance, a 1,000 ohm resistance, and a 4,000 ohm resistance connected to the six prong socket mounted in hole 3, and the three lug terminal strip mounted at the rear of hole 4. Remove all four of these resistors entirely.

To the B+ output terminal on your power supply filter system; (this is the left-hand lug of the three lug strip mounted at the rear of hole 14) you now have one pigtail lead of a 40,000 ohm resistance and one end of a piece of hookup wire. The other pigtail lead of the 40,000 ohm resistance goes to the right-hand terminal lug on the same terminal strip and to this pigtail lead is also connected a piece of hookup wire. The other end of the piece of hookup wire goes to the outside terminal lug on the 15,000 ohm potentiometer. This is the terminal nearest you; the inside terminal is grounded. Keep these connections intact. From the B+ output terminal, you have a piece of hookup wire connected to one

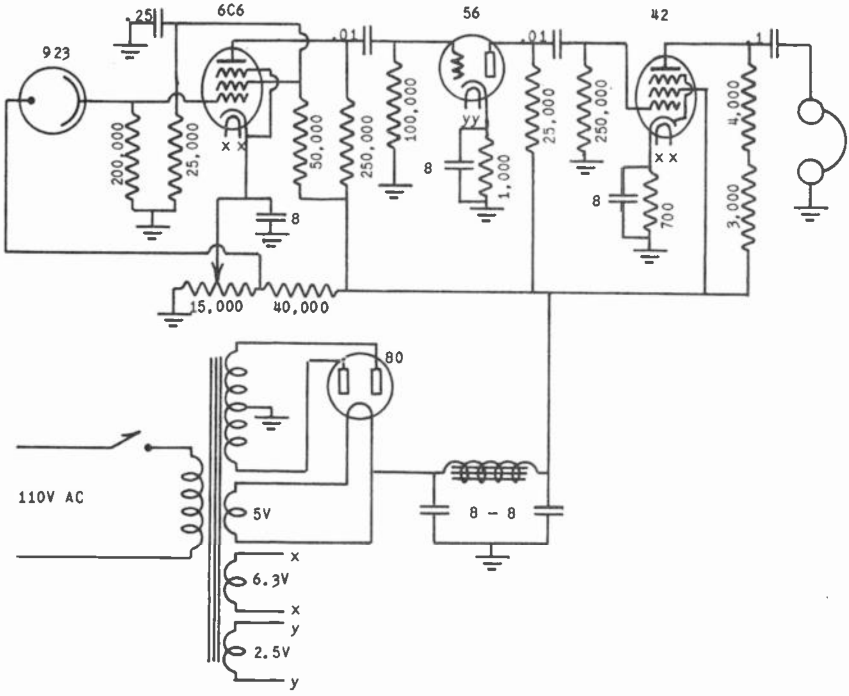


Fig.10 Wiring diagram of a three stage, resistance-coupled photo-cell amplifier.

of the terminal lugs on the three lug strip mounted at the rear of hole 4. Leave this piece of hookup wire as it is. Now, to this same terminal lug, connect the following: a short piece of hookup wire about two inches long, one pigtail end of a 250,000 ohm resistance and one pigtail end of a 50,000 ohm resistance. Solder the connections. The other end of the two inch piece of hookup wire is to be connected to the suppressor grid prong on the six prong socket mounted in hole 6. To this same suppressor prong, connect the following: one pigtail lead of a 3,000 ohm resistance and one pigtail lead of a 25,000 ohm resistance.

Connected to one of the terminal lugs on the strip mounted at the rear of hole 4, you now have one pigtail end of a 250,000 ohm resistance and one pigtail end of a 50,000 ohm resistance. The other pigtail end of the 250,000 ohm resistance is to go to the plate terminal on the six prong socket mounted in hole 3. To this same plate terminal, connect one pigtail end of a .01 mfd. condenser and solder the connection. The other pigtail lead of the .01 mfd. condenser goes to the grid terminal on the five prong socket mounted in hole 5. To this same grid terminal connect one pigtail lead of a 100,000 ohm resistance and solder the connection. The other pigtail lead of the 100,000 ohm resistance is to be connected to ground by using any conveniently placed solder lug.

Now, going back to the 50,000 ohm resistance, one end of which is connected to one of the lugs on the terminal strip mounted at the rear of hole 4, the other pigtail lead of this resistance is to be connected to the screen grid terminal on the six prong socket mounted in hole 3. To this same screen grid terminal also connect one pigtail lead of a .25 mfd. condenser and one pigtail lead of a 25,000 ohm resistance. Solder the connection. The other pigtail lead of the 25,000 ohm resistance and the other pigtail lead of the .25 mfd. condenser are to be connected to ground by using any conveniently placed solder lug.

Returning to the 25,000 ohm resistance, one end of which is connected to the screen grid terminal on the six prong socket mounted in hole 6; the other end of this 25,000 ohm resistance is to be connected to the plate terminal on the five prong socket mounted in hole 5. To the same plate terminal, also attach one pigtail end of a .01 mfd. condenser and solder the connection. The other pigtail end of this .01 mfd. condenser is to go to the grid terminal on the six prong socket mounted in hole 6. To the same grid terminal, also connect one pigtail end of a 250,000 ohm resistance and solder the connection. The other pigtail end of the 250,000 ohm resistance is to be connected to ground by using any conveniently placed solder lug. Solder the connection.

Your headphone terminal strip is to be mounted in the right-hand slotted hole on the rear of the chassis. (Remember the chassis is upside down and the front toward you.)

Now, returning to the 3,000 ohm resistance, one end of which is connected to the suppressor prong on the six prong socket mounted in hole 6; the other end of this 3,000 ohm resistance is to go to any one of the solder lugs on the three lug terminal strip mounted at the rear of hole 4 which is not now in use. To this same solder lug, also connect one pigtail end of a 4,000 ohm resistance and solder the connection. The other pigtail end of the 4,000 ohm resistance is to be connected to the plate terminal on the six prong socket mounted in hole 6. To this same plate terminal, also connect one pigtail end of a .1 mfd. condenser and solder the connection. The other end of the .1 mfd. condenser is to connect to the left-hand terminal on your headphone strip mounted in the right-hand slotted hole on the back of the chassis. Solder the connection. Now, place a solder lug under the right-hand bolt which holds the headphone strip in place and, using a short piece of wire, ground the right-hand terminal lug of this terminal strip.

The two black leads and the one yellow lead coming out of your 8-8-8 mfd. electrolytic condenser should now be connected to ground by using any conveniently placed solder lug. The blue lead coming from this same condenser (alongside of the yellow lead) should be connected to the cathode prong on the six prong socket mounted in hole 6. To this same cathode prong, also connect one pigtail end of a 700 ohm resistance and solder the connection. The other pigtail lead of the 700 ohm resistance is to be connected to ground by using any conveniently placed solder lug. Solder the connection.

One of the red leads coming from your 8-8-8 mfd. electrolytic condenser should now be connected to the cathode prong on the five prong socket mounted in hole 5. To this same cathode prong, connect one pigtail end of a 1,000 ohm resistance and solder the connection. The other pigtail end of the 1,000 ohm resistance is to be connected to any conveniently placed solder lug. Solder the connection.

When you completed Experiment 79, the suppressor prong was connected to the cathode prong on the six prong socket mounted in hole 3. From the cathode prong you had a piece of hookup wire running to the center terminal lug on your volume control potentiometer. These connections are to remain intact. However, to the center terminal lug on the volume control potentiometer, connect the remaining red lead coming from your 8-8-8 mfd. electrolytic condenser and solder the connection.

When you completed Experiment 79, you had a piece of hookup wire connected to the heater terminal next to the grid terminal on socket 1. To this same heater terminal is also connected one pigtail lead of a 2 megohm resistance. The other pigtail lead of the 2 megohm resistance is grounded and the other end of the piece of hookup wire goes to the grid clip which is to be connected to a grid cap on a 6C6 tube used in socket 3. Leave these connections intact.

In completing Experiment 79, you had a piece of hookup wire connected from the plate terminal on socket 1 over to one of the terminal lugs on the three lug terminal strip mounted at the rear of hole 4. Remove this piece of hookup wire entirely. Now, take a longer piece of hookup wire and connect one end of it to the plate terminal on socket 1 and solder the connection. The other end of this piece of hookup wire is to go to the outside terminal lug on the 15,000 ohm potentiometer. The outside terminal lug nearest you is the one to use. Solder the connection.

Now, if you have carefully followed directions, your experiment should be wired as shown in Fig. 10. Check over the wiring at least three times to avoid possible mistakes. Plug your photoelectric cell in socket 1. Plug a type 6C6 tube in socket 3 and connect a grid clip to the grid cap. Plug a type 56 tube in socket 5 and plug a type 42 tube into socket 6. Your type 80 tube is then plugged into socket 13 and your experiment is ready to be connected to a 110 volt, 60 cycle AC supply. Plug your headphones into the headphone jack mounted on the left rear side of the chassis. Turn your volume control switch on and give the tubes time to warm up. (The chassis is now right side up and the front toward you.

The volume on this amplifier is controlled by varying the bias on the grid of the 6C6 tube. When the experiment is turned on, the volume control is in such a position that no sound will be heard. Place your 60 or 100 watt light bulb 24 or 30 inches away from the cathode of your photoelectric cell. IN THIS EXPERIMENT IT IS ABSOLUTELY ESSENTIAL THAT THE LIGHT BULB BE OPERATED FROM A 60 CYCLE AC SOURCE. After the tubes have had a chance to warm up, advance your volume control in a clockwise direction (toward the right) until a humming sound is heard. This humming sound is the photoelectric cell responding to the 120 light variations per second caused by the 60 cycle current (having 120 alternations) flowing through the light bulb and, in turn, modulating the photocell with a 120 cycle note. The amplifier then amplifies the output of the photoelectric cell and the result is that you hear in your headphones the 120 cycle tone. Now, wave your hand in front of the photoelectric cell. You will be able to hear distinctly when the cell cuts on and off as your hand passes in front of the cell. The slower you do this, the slower the pulse involved; the faster you do it, the faster the pulse involved. You will notice this type of circuit is very sensitive; it has to be, if it is to amplify the low output voltage secured from the photoelectric cell.

LABORATORY REPORT
GROUP 8

After completing this group of experiments, you are to answer the following questions so that we can ascertain the success of your experimental work.

1. What is the difference between a forward and reverse type of photoelectric cell circuit?

2. Carefully describe the results secured when you built Experiment 72.

3. What would be your explanation for the difference in results secured between the forward type of circuit built in Experiment 72 and the reverse type of circuit built in Experiment 73?

4. How is it possible to use a photocell and its associated amplifier tube when AC is supplied to the plate?

5. Explain why it is that with light shining on the photoelectric cell there will be an increase in plate current on the type 42 tube when the photoelectric cell itself is connected as a reverse type of circuit.

6. Give the results you secured in conducting Experiment 79.

7. What size of light bulb did you use as your known and unknown and what candlepower did you receive for the unknown?

8. Describe to the best of your ability the results which you secured in conducting Experiment 81.

9. List a few of the possible uses for photoelectric cells.

10. Give your general impressions of the knowledge gained by conducting the experiments in this group.

Notes

(These extra pages are provided for your use in taking special notes)

Notes

(These extra pages are provided for your use in taking special notes)

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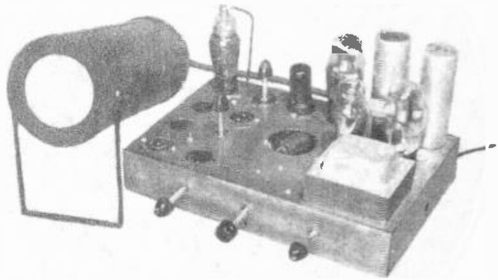
GROUP NO. 9

LABORATORY EXPERIMENTS

EXPS. NO. 82 TO 88

LABORATORY EXPERIMENTS

Group Nine



"Undoubtedly you will find this to be the start of your most interesting period of experimentation. In this group you will prepare all of the apparatus necessary for the proper operation of your cathode ray tube. Then, in the following group of experiments, you will find described, many interesting uses for this oscilloscope.

"As each experiment in this group is completed, no specific test will be made at that time. However, in the next group of experiments, you will have an excellent opportunity to test the results of your work."

EXPERIMENT 82
MOUNTING EQUIPMENT AND WIRING FILAMENT CIRCUITS FOR CATHODE RAY OSCILLOSCOPE

Before starting, it is advisable for you to dismantle the experiments conducted in the preceding group. After this equipment has been removed, take your soldering iron and carefully clean each part; that is, remove the excess solder, see that all wires are scraped clean, and otherwise prepare your apparatus so that it can be used with the least possible inconvenience in conducting your cathode ray tube experiment.

A top view of your chassis is shown in Fig. 1. Notice that each hole is numbered to make it convenient to describe the location of various parts.

First, you should mount the power transformer. The transformer is mounted in hole 16, and so placed that the three wire leads face toward the rear of the chassis. The transformer is slipped into place and then held securely to the chassis by four 8/32 nuts provided for that purpose. If the transformer fits tightly, it may be forced into place.

In your last shipment of supplies, you will find a 250,000 ohm potentiometer. With the chassis upside down and the front toward you, this is to be mounted in the left hand one of the three holes on the front side of the chassis. The volume control is held in place securely by a lock nut provided for that purpose. In mounting this potentiometer, the three terminal lugs should face toward the right of the chassis. Next, your 15,000 ohm volume control potentiometer with switch should be mounted in the center of the three holes on the front side of the chassis. This is held in place by a lock nut provided for the purpose, and the three terminal lugs should face toward the left side of the chassis. (Remember, the chassis is upside down, and the front toward you).

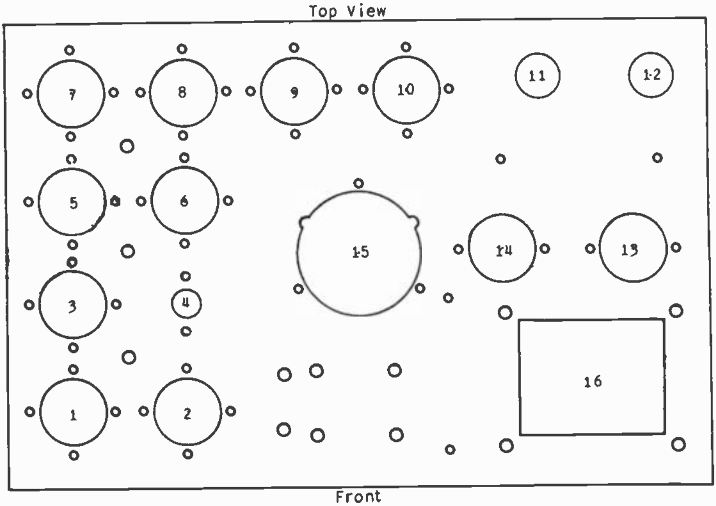


Fig. 1 This is a top view of your metal chassis showing the location of the various holes punched in this chassis. Each hole has been numbered so that a description of the use of this chassis is made easier for all concerned.

In your last shipment of equipment, you will find a 15,000 ohm potentiometer without a switch. This 15,000 ohm potentiometer is to be held in place by a lock nut provided for the purpose, and is to be mounted in the right hand hole of the three holes on the front side of the chassis. In mounting this potentiometer, the three terminal lugs should be placed toward the left side of the chassis. (Remember, the chassis is upside down, and the front toward you).

The next potentiometer to be mounted is a 500,000 ohm potentiometer, and it is to be bolted in place by using hole 4. The potentiometer can be held in place by a lock nut provided for this purpose. In mounting this potentiometer, the terminal lugs should face toward the rear of the chassis.

In your last shipment of equipment, you will find two large washers. These two washers are to be used in mounting a 500,000 ohm potentiometer in hole 8. Place one washer on the bottom side of the hole, and the other washer on the top side of the hole. The potentiometer and washers can then be locked in place by using the volume control lock nut. In mounting this potentiometer in hole 8, the terminal lugs are to face toward the right hand side of the chassis; that is, they should be next to hole 7.

You are now ready to mount a 4-prong socket in hole 13; in mounting this socket, the filament or heater prongs should face toward the left side of the chassis. A 4-prong socket is also to be mounted in hole 14. In mounting this socket, the filament or heater prongs should face toward the right side of the chassis.

The next piece of equipment to be mounted is your filter choke. This is mounted on the top side of the chassis, with the terminal lugs on the filter choke facing toward the front of the chassis. The filter choke is held in place by using the two small holes directly behind holes 13 and 14. Securely bolt the choke in place by using two 6/32 bolts and nuts.

In one of your previous shipments of equipment, you received an 8-8 mfd. electrolytic filter condenser, mounted in a metal container. This condenser is to be mounted in hole 12. In your last shipment of equipment, you received another filter condenser like the one previously used. This 8-8 mfd. electrolytic filter condenser is to be mounted in hole 11. Securely fasten these condensers in place with the large lock nuts supplied for the purpose.

With the chassis upside down and the front toward you, mount a 3-lug terminal strip under the left hand bolt which holds the filter choke in place. This terminal strip is mounted on the bottom side of the chassis. Under the same bolt, place a solder lug that is to be used in wiring up your experiment. Be sure to tighten the nut.

You are now ready to mount the other sockets which will be used in this group of experiments. A 6-prong socket is to be mounted in hole 10. The filament or heater prongs are to face toward the rear of the socket. Next, mount an 8-prong socket in hole 9. The centering pin on this socket is to point toward the rear of the chassis. A 6-prong socket is next mounted in hole 7, with the filament or heater prongs facing toward the rear of the chassis. In mounting this socket, also place a tube shield base in place on the top side of the chassis. A 5-prong socket is now to be mounted in hole 1, with the filament or heater prongs facing toward the front of the chassis. Remember, in following these directions, the chassis is upside down, and the front toward you.

The oscillator coil which was used in building your superheterodyne is to be mounted in the center of the large holes, 1, 2, 3, and 4. This is held in place by the special bolt provided for that purpose.

The paper encased 8-8-8 mfd. electrolytic by-pass condenser is to be mounted just to the right of the power transformer, using the two small holes provided for that purpose. The wire leads should face toward the rear of the chassis.

With this equipment mounted, you are now ready to wire up the filament circuits for the various tubes. Be sure to follow directions very carefully.

All filament leads should be twisted. Therefore, in cutting the wire long enough to accommodate the connections to the various sockets, remember to allow sufficient extra length for twisting the two leads. By using twisted leads, the possibility of hum in your oscilloscope is reduced.

Connect a wire to each of the five volt terminals on your power transformer. Using twisted leads, run this wire along the front and left side of the chassis to the two heater or filament prongs on the 4-prong socket mounted in hole 13. Be sure to solder all connections. This will supply filament voltage to the type 80 tube to be used in socket 13. A bottom view of this socket is shown in Fig. 2A.

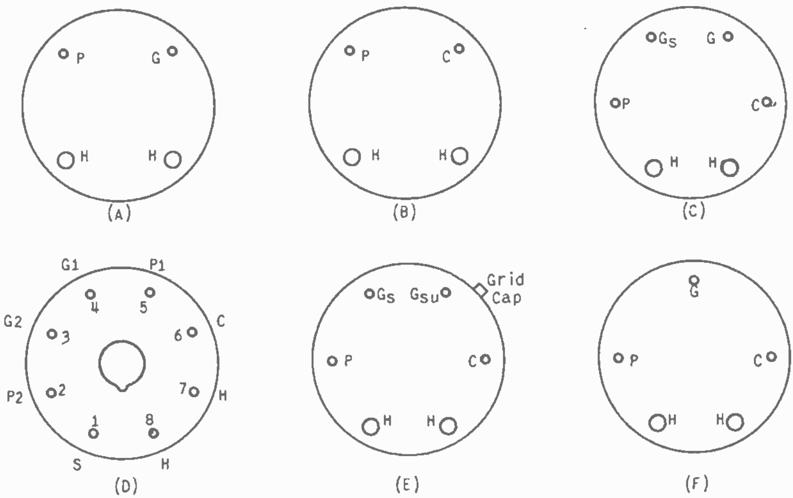


Fig. 2 Bottom view of tube sockets, showing position of the various terminals.

Connect a pair of twisted leads to the 6.3 volt terminals on the power transformer. Do not solder these connections yet. The other end of these two twisted leads are to go to the filament or heater prongs on the 4-prong socket mounted in hole 14. (Fig. 2B) A type 1-v rectifier tube is going to be used in this socket. Solder the connections on the socket terminals, but not on the power transformer. Now, connect another pair of twisted leads to the 6.3 volt terminals on your power transformer. These leads will have to be rather long. With these leads connected, solder the connections to the 6.3 volt terminals on your power transformer. This pair of twisted leads are to run along the left side of the chassis until you reach the back. Then, they run along the back of the chassis until you reach the filament or heater prongs of the 6-prong socket mounted in hole 10. A bottom view of this socket is shown in Fig. 2C. These leads are to be connected to the heater prongs on this socket. Then use another pair of twisted leads and run them over to the heater prongs on the 8-prong socket mounted in hole 9. A bottom view of this socket is shown in Fig. 2D. Using another pair of twisted leads, run these over to the heater prongs on the 6-prong socket mounted in hole 7. (Fig. 2E) Solder the connections. After following these directions, you will have heater voltage applied to the type 42 tube used in socket 10, the type 6SC7 tube used in socket 9., and the type 6C6 tube used in socket 7.

There remains only one tube to which we must apply filament voltage. Using a twisted pair of leads, connect one end of the leads to the 2½ volt filament terminals on the back side of your power transformer. These two 2½ volt filament terminals are alongside the 6.3 volt filament terminals. Be sure that you use this pair of 2½ volt terminals. With the chassis upside down and the front toward you, these terminals are found on the left rear side of the power transformer. Run this pair of heater leads along the left side of the chassis to the front, then along the front of the chassis, near the bottom, or underneath the volume controls, until you reach the filament or heater prongs on the 5-prong socket mounted in hole 1. A bottom view of this socket is shown in Fig. 2F. Be sure to solder all connections.

You are now ready to connect the 110 volt cord to the primary of the power transformer. With the chassis upside down and the front toward you, the 110 volt cord is passed through the small round hole on the left rear of the chassis. One terminal of the 110 volt cord goes directly to the right rear primary terminal on your power transformer. Solder this connection. The other lead of the 110 volt cord goes to one of the terminals on the switch which is mounted on the back of the 15,000 ohm volume control now mounted in the center hole of the three holes on the front of your chassis. Solder this connection. Using another short piece of wire, connect it between the remaining or free terminal on the switch over to the remaining primary terminal on your power transformer. The attachment plug is then connected to the other end of the 110 volt cord.

EXPERIMENT 83

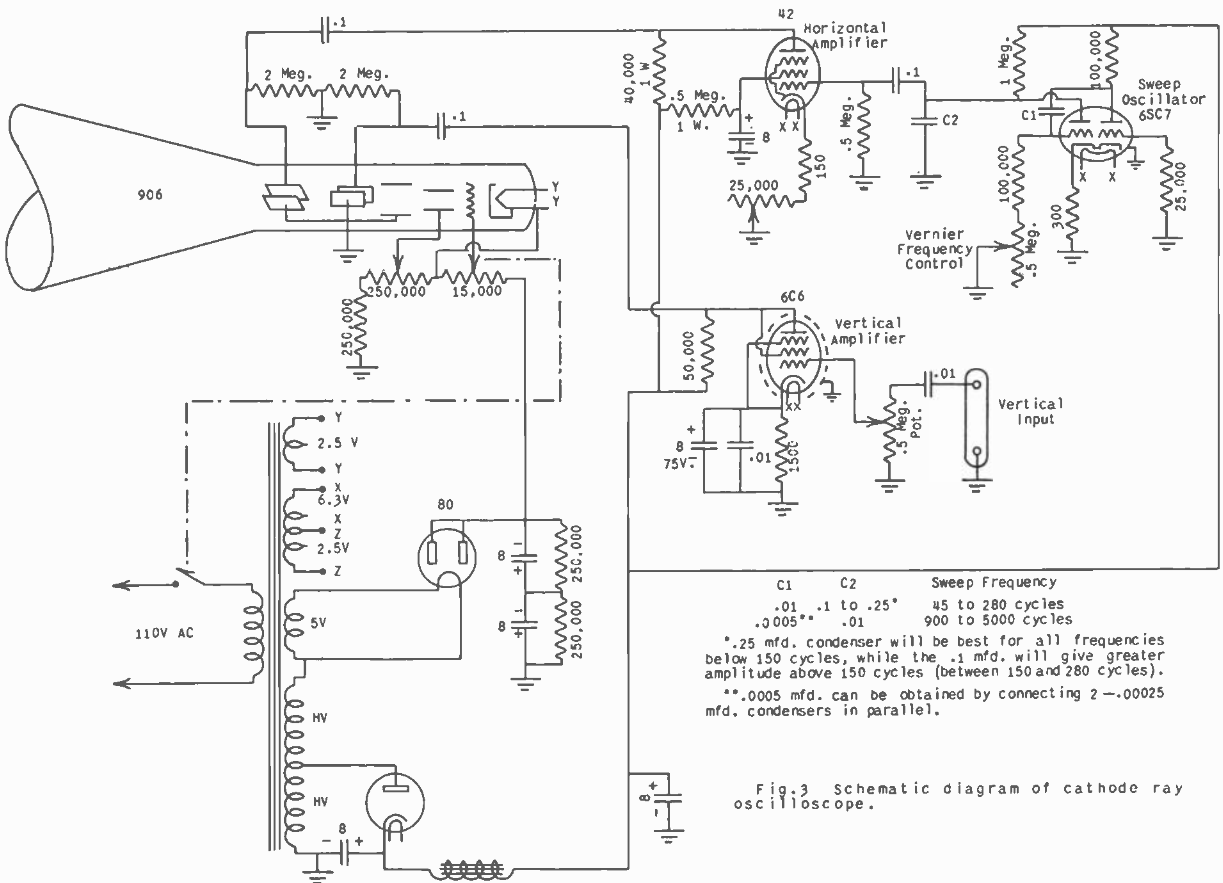
BUILDING CATHODE RAY HIGH VOLTAGE POWER SUPPLY

In mounting the equipment in the preceding experiment, you were advised that a type 80 tube would be used in socket 13. This tube is to become a half-wave rectifier for the high voltage power supply.

In the preceding experiment, a filament supply of 5 volts was connected to the heater or filament prongs on the 4-prong socket mounted in hole 13. You are now ready to complete the wiring for the high voltage power supply. A wiring diagram for this complete group of experiments is shown in Fig. 3.

Using a short piece of hookup wire, connect the plate and grid terminals on the 4-prong socket mounted in hole 13 together. Since a type 80 tube is to be used in this socket, this in effect, connects the two plates of the type 80 tube together. A bottom view of this socket is shown in Fig. 2A.

The high voltage connections on your power transformer are three wire leads which come out of the side of the transformer. In mounting the power transformer, it was so placed that these leads



C1	C2	Sweep Frequency
.01	.1 to .25*	45 to 280 cycles
.0005**	.01	900 to 5000 cycles

*.25 mfd. condenser will be best for all frequencies below 150 cycles, while the .1 mfd. will give greater amplitude above 150 cycles (between 150 and 280 cycles).

**.0005 mfd. can be obtained by connecting 2—.00025 mfd. condensers in parallel.

Fig.3 Schematic diagram of cathode ray oscilloscope.

face toward the rear of the chassis. Two of these leads are green in color, while the third lead is red. Place a solder lug under the left hand bolt which holds the 4-prong socket mounted in hole 13 in place. To this solder lug, connect one of the green leads and solder the connection. You should use the green lead which is closer to this connection. The other green lead should be connected to the filament or heater prong next to the grid prong on the 4-prong socket mounted in hole 13. Solder the connection. This connection is shown in Fig. 3.

The filter condenser for the high voltage power supply will be the 8-8 mfd. electrolytic condenser mounted in hole 12. In connecting this condenser, be sure to follow directions very carefully. Using the black lead which has a white tracer in it, connect this lead to the plate prong on the 4-prong socket mounted in hole 13. Solder the connection. At the same time, connect one pigtail lead of a 250,000 ohm resistance to the same socket terminal lug, and then solder the connection.

You now have a 3-lug terminal strip mounted under the left hand bolt which holds the filter choke in place. To the center terminal lug on this terminal strip, connect the following; connect the red lead with the white tracer in it, and the plain black lead from the 8-8 mfd. electrolytic condenser mounted in hole 12. Also, to this same center terminal lug, connect the remaining pigtail lead of the 250,000 ohm resistance, the other end of which is connected to the plate prong on the socket mounted in hole 13. To this same terminal lug, also connect another pigtail lead of a 250,000 ohm resistance and solder the connection. The remaining pigtail lead of the 250,000 ohm resistance is to be connected to any conveniently placed solder lug, so that this end of the resistor is grounded. Solder the connection. The plain red lead coming from the 8-8 mfd. electrolytic condenser mounted in hole 12, is also to be connected to the same solder lug. Solder the connection.

If you will check Fig. 3 carefully, you will see that the 250,000 ohm resistances are across each of the two sections of the 8-8 mfd. electrolytic condenser. This is necessary when operating electrolytic condensers in series. The output voltage of the high voltage power supply is approximately 900 volts. Therefore, the two condensers, each having a rating of 450 volts, can safely withstand the total voltage of this supply. In connecting these filter condensers, be sure to follow directions carefully, because if you connect an electrolytic condenser backward, you will immediately destroy its operation.

If you have followed directions carefully, the high voltage power supply for your cathode ray tube is now properly wired.

EXPERIMENT 84
BUILDING LOW VOLTAGE, HALF-WAVE POWER SUPPLY

The equipment for this power supply has already been mounted and the filament circuits wired. Therefore, it will only be necessary to complete the wiring in this experiment.

Since one power transformer is being used for both power supplies, it is necessary to use half-wave rectification. It is also necessary to separate the heater voltage from the cathode in the type 1-v rectifier tube. This is taken care of in the normal construction of this type of tube.

The type 1-v tube is going to be used in the 4-prong socket mounted in hole 14. The filament or heater voltage to this tube has already been wired.

The red high voltage lead coming from the secondary of the high voltage transformer is to be connected to the plate terminal on the 4-prong socket mounted in hole 14. Solder the connection. A bottom view of this socket is shown in Fig. 2B. The filter condenser for this power supply will be the 8-8 mfd. electrolytic condenser, now mounted in hole 11. To the cathode prong on the 4-prong socket mounted in hole 14, connect one of the red leads from the filter condenser and also a short piece of hookup wire. Solder the connection. The other end of the short piece of hookup wire is passed up through the hole in the chassis to one of the terminal lugs on the filter choke. Solder the connection. From the other terminal lug on the filter choke, connect a short piece of wire, and solder the connection. The other end of this short piece of hookup wire goes to the right hand terminal lug on the 3-lug terminal strip mounted at the rear of hole 13. To this same terminal lug, connect the other red wire lead with white tracer, from the 8-8 mfd. electrolytic condenser mounted in hole 11. Also, to this same terminal lug, connect a piece of hookup wire and solder the connection.

The two black leads coming from the 8-8 mfd. electrolytic condenser mounted in hole 11 are to be grounded by soldering them to any conveniently placed solder lug.

If you have followed directions carefully, your low voltage power supply is now wired as shown in Fig. 3. Check your connections carefully.

EXPERIMENT 85

BUILDING HORIZONTAL SWEEP CIRCUIT AMPLIFIER

A type 42 tube to be used in the 6-prong socket mounted in hole 10 is going to be used as the horizontal sweep circuit amplifier.

The filament or heater circuit for this tube has already been wired in a previous experiment. In connecting this experiment, the first thing to do is to mount a 3-lug terminal strip under the right hand bolt which holds the filter choke in place. This terminal strip is to be mounted parallel with the left side of your chassis. (Remember, the chassis is upside down, and the front toward you).

In the preceding experiment, you had a short piece of hookup wire connected to the right hand terminal on the 3-lug terminal strip mounted at the rear of hole 13. The other end of this piece of hookup wire is to go to the center terminal lug on the 3-lug terminal strip just mounted at the rear of hole 14. Do not solder the connection as yet.

To this center terminal lug, connect one pigtail lead of a

40,000 ohm resistance, and one pigtail lead of a 500,000 ohm resistance. Do not solder the connection as yet. The other pigtail lead of the 40,000 ohm resistance is to be connected to the plate terminal on the 6-prong socket mounted in hole 10. To this same terminal lug, also connect one pigtail terminal of a .1 mfd. condenser, and solder the connection. The free pigtail terminal of the 500,000 ohm resistance is to be connected to the screen grid terminal on the 6-prong socket mounted in hole 10. To the same screen grid terminal, connect one pigtail terminal of the 4 mfd. cartridge electrolytic condenser supplied in your last shipment of material. In connecting the pigtail lead of this special electrolytic condenser, be sure that the positive terminal of the condenser is connected to the screen grid terminal on the type 42 tube. Solder the connection. The remaining or negative pigtail terminal of the special 4 mfd. electrolytic tubular filter condenser is to be connected to any conveniently placed solder lug. It is satisfactory to use one of the holes that hold the meter in place, and fasten a solder lug to that point. Solder the connection.

Now connect a piece of hookup wire to the cathode terminal on the 6-prong socket mounted in hole 10. Solder this connection. The other end of this piece of hookup wire is to be connected to the outside terminal lug nearest the chassis, on the 15,000 ohm potentiometer mounted in the right hand hole of the three holes located on the front of the chassis. Solder the connection. To the center terminal lug on this same potentiometer, solder one pigtail lead of a 150 ohm resistance. The other pigtail lead of this 150 ohm resistance is to be connected to any conveniently placed solder lug. Solder the connection.

Connect one pigtail lead of a .1 mfd. condenser and one pigtail lead of a 500,000 ohm resistance to the grid terminal on the 6-prong socket mounted in hole 10. Solder the connection. The other pigtail lead of the 500,000 ohm resistance is to be connected to ground by using any conveniently placed solder lug. Solder the connection.

If you have followed directions carefully, the horizontal sweep circuit amplifier will now be completed. In carrying on this experiment, we left the pigtail leads of two .1 mfd. condensers disconnected. These will be taken care of in the completion of future experiments.

EXPERIMENT 86
BUILDING A SWEEP CIRCUIT OSCILLATOR

The 8-prong socket mounted in hole 9 is to be used for a type 6SC7 metal tube, used as a sweep circuit oscillator.

A bottom view of this socket is shown in Fig. 2D. You must watch your connections very carefully, since this tube is different from the ordinary 8-prong metal tube. The wiring diagram for the sweep circuit oscillator is shown in Fig. 3. Therefore, by following that figure, and watching the connections on the base of the tube socket, you should have no difficulty in wiring up this experiment.

A 3-lug terminal strip is to be bolted in the center of the four holes, 5, 6, 7, and 8. In mounting this 3-lug terminal strip, it should be so placed that the strip is parallel to the back side of the chassis. You now have a 3-lug terminal strip mounted next to hole 11. The B+ output of your power supply is connected to the center lug of this 3-lug terminal strip. To this same center lug, connect a piece of hookup wire, but do not as yet solder the connection. The other end of this piece of hookup wire is to be connected to the right hand terminal lug on the 3-lug terminal strip just mounted. Do not as yet solder the connection. (Remember, the chassis is upside down and the front toward you).

In your preceding experiment, you had one pigtail lead of a .1 mfd. condenser connected to the grid terminal on the 6-prong socket mounted in hole 10. At that time, you did not do anything with the remaining pigtail terminal. This pigtail terminal is now to be connected to plate #2 (terminal #2) on the 8-prong socket mounted in hole 9. Refer to the bottom view of the 8-prong socket shown in Fig. 2D, in order to ascertain which is plate #2 on the type 6SC7 tube which will be used in this socket. At the same time this pigtail terminal of the .1 mfd. condenser is connected to this terminal lug, also connect one pigtail lead of a 1 megohm resistance and one pigtail lead of a .25 mfd. condenser. Then solder the connection. The other pigtail terminal of the .25 mfd. condenser goes to a solder lug placed under one of the bolts which holds the A & G strip in place on the back right hand side of the chassis. Solder the connection. The other pigtail terminal of the one megohm resistance goes to the right hand terminal lug on the 3-lug terminal strip mounted between holes 5, 6, 7, and 8. At this time, do not solder the connection.

Place a solder lug under the rear bolt which holds socket 9 in place. Using a short piece of hookup wire, connect terminal #1 on socket 9 to this solder lug. At the same time, also connect one pigtail terminal of a 300 ohm resistor. Solder the connection. The other pigtail terminal of the 300 ohm resistance is to be connected to the cathode terminal which is terminal #6 on the 8-prong socket mounted in hole 9. Solder the connection.

To grid terminal #3 on socket 9, solder one pigtail lead of a .01 mfd. condenser and one pigtail lead of a 100,000 ohm resistance. Solder the connection. The remaining pigtail terminal of the 100,000 ohm resistance goes to the right hand terminal lug of the three terminal lugs on the potentiometer now mounted in hole 4. Solder the connection. The other pigtail terminal of the .01 mfd. condenser is to be connected to plate terminal #5 on the 8-prong socket mounted in hole 9. At the same time this connection is made, also connect one pigtail terminal of a 100,000 ohm resistor. Then solder the connection. The remaining pigtail terminal on this 100,000 ohm resistor is to be connected to the center terminal lug on the 3-lug terminal strip mounted by hole 11. At this time you can solder the connection.

Now connect one pigtail terminal of a 25,000 ohm resistance to the grid terminal #4 on the 8-prong socket mounted in hole 9. Solder the connection. At this time, bolt a solder lug to the left hand side of hole 6. To this solder lug, connect the remaining pigtail terminal of the 25,000 ohm resistance and also a short piece of hookup wire. Then solder the connection. The short piece of hookup wire is to be connected to the center terminal lug on the 500,000 ohm potentiometer mounted in hole 4. Solder the connection. The filament or heater circuit for this tube was wired at the first part of this group of experiments. Therefore, if you have followed directions carefully, your experiment is now completed. However, it is advisable to check all connections real carefully and compare them to the complete wiring diagram shown in Fig. 3, and to the base socket connections for the 8-prong socket shown in Fig. 2D.

EXPERIMENT 87
BUILDING VERTICAL AMPLIFIER

The vertical amplifier for your cathode ray oscilloscope is going to be a 6C6 tube, used in the 6-prong socket which you now have mounted in hole 7.

The filament or heater terminals for this socket were wired in the first part of this group of experiments. Therefore, we are ready to continue with the balance of this experiment.

Your aerial and ground strip should now be mounted in the right hand slotted hole on the back side of your chassis. At the time this strip is mounted, place a solder lug under the left hand bolt which holds this strip in place. Using a short piece of hookup wire, ground the ground terminal on the A & G strip. At the same time, also connect another short piece of hookup wire and one pigtail lead of a 1500 ohm resistor. Solder the connection. The other end of the short piece of hookup wire is to be connected to one of the outside terminal lugs on the 500,000 ohm potentiometer now mounted in hole 8. The outside terminal lug nearest the back of the chassis is the one to be used. Solder the connection.

Connect a piece of hookup wire to the center terminal of the 500,000 ohm potentiometer mounted in hole 8. Solder the connection. The other end of this short piece of hookup wire is to go to the grid terminal on the 6C6 tube mounted in hole 7. This can be accomplished by passing this piece of hookup wire up through the chassis, using a small hole directly under the center terminal lug. The piece of wire should reach the top grid cap of the tube, and a grid clip should be soldered to this piece of wire.

Now connect one pigtail end of a .01 mfd. condenser to the antenna post on the A & G strip. Solder the connection. The other end of this .01 mfd. condenser should be connected to the free outside terminal on the 500,000 ohm potentiometer mounted in hole 8. Solder the connection.

In mounting the aerial and ground strip, we connected one pigtail end of a 1500 ohm resistance to the ground terminal on this A & G strip. The other end of this 1500 ohm resistance is to be connected to the cathode prong on the 6-prong socket mounted in hole 7. At the same time, also connect one pigtail lead of a .01 mfd. condenser, and a short piece of hookup wire. Also, connect the blue wire lead coming from the 8-8-8 mfd. by-pass condenser mounted at the side of your power transformer. Then solder the connection. The other end of the short piece of hookup wire is to be connected to the suppressor grid prong and soldered. The other pigtail lead of the .01 mfd. condenser is to be connected to a solder lug placed at the right hand side of the aerial and ground strip. Solder the connection. The blue lead on your 8-8-8 mfd. by-pass condenser, has as its remaining lead, a yellow lead. This yellow lead comes out of the same section of the by-pass condenser. The yellow lead is to be grounded by connecting it to any conveniently placed solder lug. If you check Fig. 3 carefully, you will notice that there are two by-pass condensers connected across the cathode resistance for the type 6C6 tube. One of these by-pass condensers is an 8 mfd. condenser, which is a part of your 8-8-8 mfd. by-pass condenser. This by-pass condenser is designed to handle the low frequencies to be amplified by the vertical amplifier. You will also notice that there is a .01 mfd. condenser connected across the 1500 ohm cathode resistor. This is designed to pass the high frequencies to be amplified by the vertical amplifier. This arrangement is necessary, since an electrolytic condenser is not effective on the high frequencies above 7000 or 8000 cycles.

Take a short piece of hookup wire and connect the plate prong and screen grid prong on the 6-prong socket mounted in hole 7. Also, to the plate prong, connect one pigtail lead of a 50,000 ohm resistor and one pigtail lead of a .1 mfd. condenser. Solder the connection. The other pigtail terminal of the 50,000 ohm resistor is to be connected to the right hand terminal lug on the 3-lug terminal strip mounted between holes 5, 6, 7, and 8. At this time, you are ready to solder the connection. The remaining pigtail lead on the .1 mfd. condenser will be connected in your next experiment.

If you have followed directions quite carefully, your vertical amplifier should now be completely wired. It is advisable however, to check over your work carefully before proceeding with the next experiment.

EXPERIMENT 88

CONNECTING THREE-INCH CATHODE RAY TUBE

In your last shipment of equipment, you will find a short piece of 7-wire cable. This piece of cable is to be used in connecting your chassis to the cathode ray tube socket. It is extremely important that you follow directions carefully and accurately.

This 7-wire cable is to be prepared for use by first peeling off the outside covering for a distance of approximately eight inches. Then take a piece of tape and wrap it around the outside covering so that it will not unravel further. The 7-wire cable is to be passed through the rear of the chassis, using the left hand slotted hole. (Remember, your chassis is upside down, and the front toward you).

In the 7-wire cable you will find two of the wire leads that are a little bit heavier than the other five. These are the red and the black lead, and these two leads are to be used as the filament supply for the cathode ray tube. The red wire lead is to be connected to the left hand terminal of the 2½ volt supply on your power transformer. This terminal is near the left front corner of the chassis. Solder the connection, and be sure that you have a good connection. You must be sure to use the 2½ volt filament terminals on the power transformer that are next to the 5 volt terminals. On the power transformer supplied you with your equipment, there are two different sets of 2½ volt terminals. Be sure to use the one just described. The black wire lead is to be connected to the other or remaining outside terminal lug on the 2½ volt supply. This is the third lug from the left on the front side of your power transformer. At the same time this black lead is connected, also connect a short piece of hookup wire. Solder the connection carefully and thoroughly. The other end of this short piece of hookup wire is to be connected to the outside terminal lug nearest you, on the 250,000 ohm potentiometer mounted in the left hand hole of the three holes on the front side of the chassis. At the same time this connection is made, also connect another short piece of hookup wire. Then solder the connection. The other end of this short piece of hookup wire is to go to the outside terminal lug of the 15,000 ohm potentiometer mounted in the center of the three holes on the front of the chassis. The outside terminal lug nearest the chassis is the one to use. Solder the connection.

The yellow wire from your 7-wire cable is now to be connected to the center terminal lug on the 15,000 ohm potentiometer mounted in the center hole of the three holes on the front of the chassis. Solder the connection.

Now, to the outside terminal lug on the 15,000 ohm potentiometer (this is the terminal lug nearest you), solder a piece of hookup wire. The other end of this piece of hookup wire is to be connected to the grid prong on the 4-prong socket mounted in hole 13. Solder the connection. The connection just made is the high voltage connection for the cathode ray tube. Be sure that this wire clears the other wires and terminals.

Now connect one pigtail lead of a 250,000 ohm resistor to the outside terminal lug nearest the bottom of the chassis, that is, the lug farthest away from you, on the 250,000 ohm potentiometer mounted in the left hand hole of the three holes on the front of the chassis. Solder the connection. The other end of this piece of hookup wire is to be connected to a conveniently placed solder lug. Solder the connection.

The white wire of your 7-wire cable is to be connected to the center terminal lug on your 250,000 ohm potentiometer mounted in the left hand hole of the three holes on the front of the chassis. Solder the connection.

In completing the vertical amplifier in Experiment 87, you had one pigtail lead of a .1 mfd. condenser connected to the plate prong of the 6C6 tube used in socket 7. The other pigtail lead of this condenser is to be connected to the center terminal lug on the 3-lug strip mounted between holes 5, 6, 7, and 8. To this same terminal lug, also connect one pigtail lead of a 2 megohm resistance, and also connect the blue lead of your 7-wire cable. Then solder the connection. The remaining pigtail lead of the 2 megohm resistance is to be connected to any conveniently placed solder lug. Solder the connection.

In completing the horizontal sweep circuit amplifier described in Experiment 85, you had one pigtail terminal of a .1 mfd. condenser connected to the plate terminal on the 6-prong socket mounted in hole 10. The other pigtail terminal of this .1 mfd. condenser is to be connected to the rear terminal lug on the 3-lug terminal strip mounted at the side of hole 11. To this same terminal lug, also connect one pigtail lead of a 2 megohm resistance and connect the green wire of your 7-wire cable. Solder the connection. The other pigtail lead of the 2 megohm resistance is to be connected to ground by using any conveniently placed solder lug. Solder the connection.

There remains only the brown lead in your 7-wire cable to be connected to your chassis. This brown lead is to be connected to any conveniently placed solder lug. It is advisable to cut this wire short and so fasten it that it will hold the cable in place and prevent strain from being placed on any of the other leads in the 7-wire cable. Before continuing with your experiment, it is extremely advisable that you check all of your connections carefully.

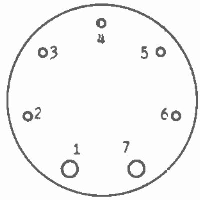
The three-inch cathode ray tube supplied as a part of your experimental apparatus, has a 7-prong base. Therefore, you will use a 7-prong socket to hold this tube. The special shield, supplied as a part of your equipment, has a hole in one end approximately three inches in diameter. The face of the tube is to sit up next to this hole. The other end of your shield is covered by a special cap or bottom plate. The socket which will hold the cathode ray tube is to be bolted to this plate. In this base plate are three holes; one in the center, through which you will pass your 7-wire cable. Then, just to each side of this hole, are two small holes to be used for the mounting bolts which will hold the 7-prong socket in place.

When you receive your special shield, the 7-prong socket will already be in place. As you will notice, two springs are provided, so as to give some flexibility in the mounting of your cathode ray tube. This provides a tight fit, so that the tube will be held snugly against the front of the shield.

Now pass the free end of your 7-wire cable through the center hole in the base of your tube shield. However, before doing this, peel approximately two inches of the outer covering from your 7-wire cable. Also, remove approximately one-half inch of insulation from each of the seven wires in the cable.

A bottom view of the 7-prong socket is shown in Fig. 4. You must be extremely careful in making these connections, because the slightest error is apt to result in the ruination of your cathode ray tube. Looking at the bottom of the socket, we are now ready to start connecting the various wires to the 7-prong socket. In Fig. 4, we have numbered these socket prongs, in order to help you keep from making mistakes. The red wire lead of your 7-wire cable is to be connected to prong #1. Looking at the bottom of the socket, with the filament or heater prongs toward you, this is the left hand one of the two filament or heater prongs. Remember, the heater prongs can be distinguished from the others because they are a little larger in size. Be sure to solder the connections.

Fig.4 Bottom view of 7-prong socket for the cathode ray tube.



Now, to terminal #2, connect the yellow wire lead in your 7-wire cable. Solder the connection. To terminal #3, connect the blue lead and solder the connection. To terminal #4, connect the white lead and solder the connection. To terminal #5, connect the green lead and solder the connection. To terminal #6, connect the brown wire and solder the connection. To terminal #7, the other filament or heater terminal, connect the black lead and solder the connection. Now if you have followed directions quite carefully, your oscilloscope will have been completed, and you will be ready for its use just as soon as you receive your next shipment of apparatus, which will consist only of the cathode ray tube and directions for its use.

Since only a slight error might cause injury to the tube, it is advisable that you go over this complete group of experiments several times, in order to ascertain that you have everything wired exactly as directed. Check your wiring against Fig. 3 very carefully. Be sure to check the bottom view of the various sockets so as to ascertain that you have every connection made as shown and described. This is extremely important before you place your cathode ray tube in the socket and prepare to use it as a cathode ray oscilloscope.

Note: In wiring up your experiment, you will notice that you wired the 2½ volt heater terminals to the 5-prong socket mounted in hole 1. The wiring of this socket was not completed, as it is not to be used until a later experiment. The same is true of the oscillator coil that you mounted in the small hole in the center of holes 1, 2, 3, and 4.

Notes

(These extra pages are provided for your use in taking special notes)

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GROUP NO. 10

LABORATORY EXPERIMENTS

EXPS. NO. 89 TO 108

of large holes 1, 2, 3, and 4. We have found that it will cause considerably less crowding of the apparatus if this oscillator coil is moved from this hole over to the hole just to the left hand side of hole 3. The oscillator coil is held in place by a bolt provided for that purpose. Next, you are to mount your radio frequency choke coil in the small hole which is in the center of the large holes 3, 4, 5, and 6. In mounting this choke coil, be sure that neither of its terminal lugs touch any of the terminal lugs on the oscillator coil.

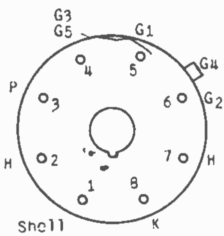


Fig. 1 Bottom view of 8-prong socket, showing terminal connections.

With this apparatus properly placed, you are then ready to wire your experiment. A complete wiring diagram is shown in Fig. 2. Remember in following these directions, the chassis is bottom side up and the front toward you. Now place a solder lug under each of the two bolts which hold socket 1 in place. Also, bolt a solder lug to the chassis, using the right hand hole at the side of large hole 5.

Connect one pigtail lead of a .25 mfd. condenser and one pigtail lead of a 150 ohm resistance to the cathode terminal on the 8-prong socket mounted in hole 1. Solder the connection. The cathode terminal is terminal #8, as shown in Fig. 1. The other pigtail terminals of the resistance and condenser are to be connected to the solder lug bolted at the right hand side of hole 5. Solder the connections.

To the cathode terminal on the 8-prong socket mounted in hole 1, which is terminal #8 in Fig. 1, connect one pigtail lead of a 50,000 ohm resistance and solder the connections. The other end of this resistance will be connected later.

To the solder lug which is bolted to the right hand side of socket 1, connect a short piece of hookup wire. The other end of this piece of hookup wire is to go to terminal #1 on socket 1. Also, to this same terminal, connect one pigtail lead of a .00025 mfd. mica condenser and also a piece of hookup wire approximately 5 inches long. Solder these connections. The other pigtail lead of the .00025 mfd. mica condenser will be connected later. The piece of hookup wire about 5 inches long is now to be passed up through the chassis, using one of the holes at the back of socket hole 1. This wire is to be made long enough so that it will reach the grid cap on a type 6A8 tube that is to be used in socket 1. Cut the wire to the right length and solder on a grid clip.

In mounting the oscillator coil, using the hole at the left hand side of hole 3, the three terminal lugs close together (terminals 1, 2, and 3, Fig. 3), should be placed toward the front of the

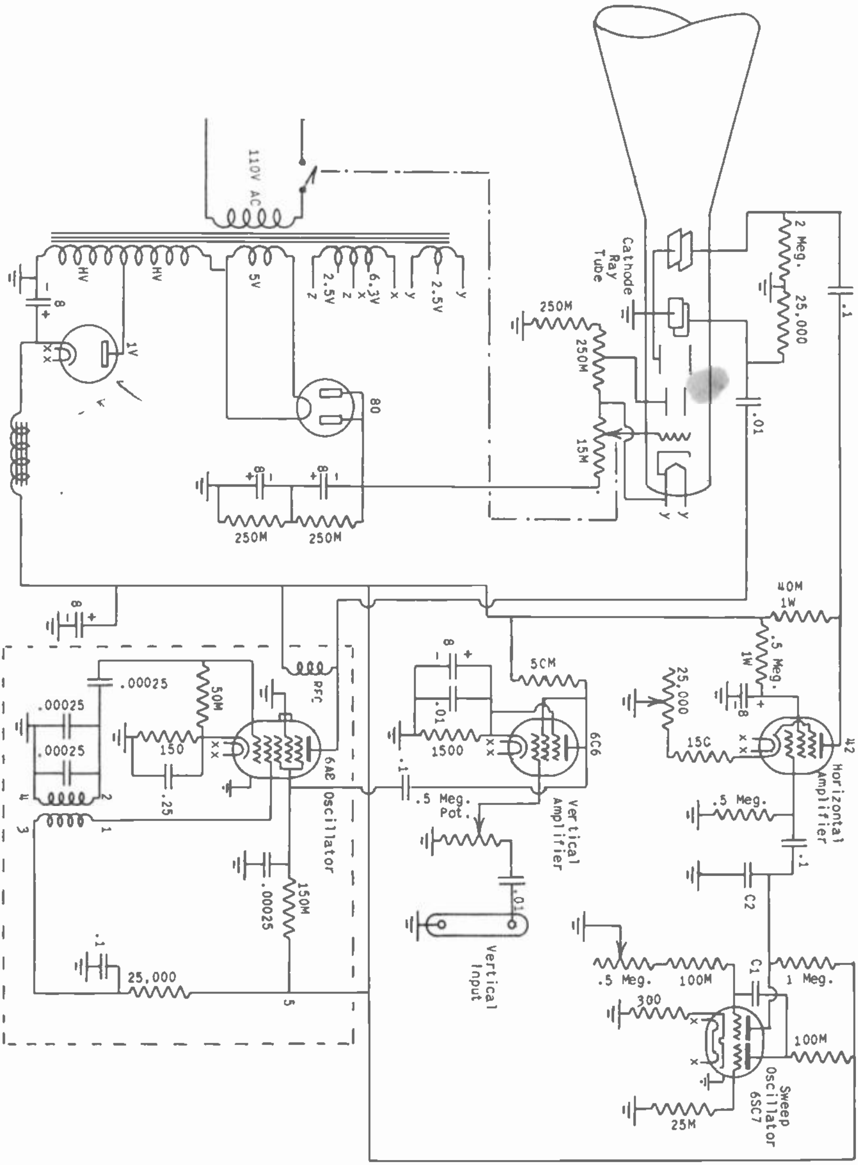


Fig.2 Complete wiring diagram of oscilloscope and modulated oscillator.

chassis. Remember, the chassis is bottom side up and the front toward you. A top view of the oscillator coil is shown in Fig. 3. Remember, this oscillator coil is mounted underneath the chassis with the top down; therefore, in looking at this oscillator coil, you will be looking directly at its top. Now connect a short piece of hookup wire to terminal #6 on the 8-prong socket mounted in hole 1. Terminal #6 is grid 2, as shown in Fig. 1. Solder this connection. The other end of this piece of hookup wire is to go to terminal lug #1 on the oscillator coil. Solder the connection.

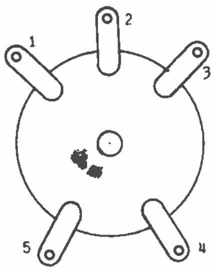


Fig.3 Top view of oscillatorcoil showing terminal numbers.

Now connect a piece of hookup wire approximately 5 inches long to terminal #3. This is the plate terminal on socket 1, as shown in Fig. 1. Solder the connection. The other end of this piece of hookup wire will be connected later.

Now to terminal #4, which is marked grids 3 and 5 in Fig. 1, solder a piece of hookup wire, one pigtail terminal of a 150,000 ohm resistance, and one pigtail terminal of a .00025 mfd. mica condenser. The condenser to be used is the one now connected to the solder lug placed at the right hand side of socket 1. Solder this connection. The other pigtail terminal of the 150,000 ohm resistance is to be connected to terminal lug #5 on the oscillator coil. To this same terminal lug #5, also connect one pigtail terminal of a 25,000 ohm resistance and one end of a short piece of hookup wire. Solder the connection. The remaining pigtail terminal of the 25,000 ohm resistance is to go to terminal lug #3 on the oscillator coil. Also, to terminal lug #3, connect one pigtail terminal of a .1 mfd. condenser. Solder the connection. The other pigtail terminal of the .1 mfd. condenser is to be connected to any conveniently placed solder lug connected to the chassis. Solder the connection.

The short piece of hookup wire now connected to terminal lug #5 on the oscillator coil should be connected to one of the terminal lugs on the radio frequency choke. To this same terminal lug, also connect another piece of hookup wire and solder the connection. The other end of this piece of hookup wire is to go to the right hand terminal lug on the terminal strip mounted between the large holes 5, 6, 7, and 8. This is the B plus terminal which supplies the plate voltage to the tubes used in holes 7 and 9. Solder the connection.

To terminal #5, marked G_1 in Fig. 1, on the 8-prong socket mounted in hole 1, connect one pigtail terminal of a .00025 mfd. mica condenser, and one pigtail terminal of a 50,000 ohm resistance.

Solder the connection. The 50,000 ohm resistor to be used is the one having one pigtail terminal connected to the cathode prong, or prong #8 on this same socket. This connection was made earlier in your experiment. The other pigtail terminal of the .00025 mfd. mica condenser is to be connected to terminal lug #2 on your oscillator coil. To this same terminal lug #2, also connect the pigtail terminals of two .00025 mfd. mica condensers. This means that to terminal lug #2 on the oscillator coil, you will have one pigtail terminal of each of three .00025 mfd. mica condensers. Solder the connection. If you are careful, you will find that three wires will fit into the lug satisfactorily.

The remaining two pigtail terminals of the two .00025 mfd. mica condensers now connected to terminal lug #2 are to be connected to terminal lug #4 on the oscillator coil. To this same terminal lug, also connect one end of a short piece of hookup wire and then solder the connection. The other end of this short piece of hookup wire is to go to the solder lug bolted under the left hand bolt holding socket 1 in place. Solder the connection.

You now have a piece of hookup wire connected to terminal lug #3, the plate terminal on the 8-prong socket mounted in hole 1. The other end of this piece of hookup wire is to go to the free terminal on the radio frequency choke. Also, to this same terminal lug, connect one pigtail terminal of a .01 mfd. condenser and solder the connection.

When you completed Experiment 88, you had a .1 mfd. condenser connected between the plate prong on the type 6C6 tube used in socket 7 and the center terminal lug on the three lug strip mounted between holes 5, 6, 7, and 8. To this same center terminal lug, you also had connected one pigtail lead of a 2 megohm resistor and the blue lead of your 7-wire cable going to your cathode ray tube. The 2 megohm resistor is to be removed entirely. In its place, you are to use a 25,000 ohm resistance. Connect one pigtail lead of the 25,000 ohm resistance to the center terminal lug on this terminal strip and solder the connection. The other pigtail lead of this 25,000 ohm resistor is to go to a solder lug at the left hand side of hole 6. Solder the connection. Now remove the pigtail lead of the .1 mfd. condenser connected to the center terminal lug on the terminal strip mounted between holes 5, 6, 7, and 8. This pigtail lead of the .1 mfd. condenser is then to be moved over to the left hand terminal lug on this same terminal strip. At the present time, you do not have a connection made to this terminal lug. A little earlier in the experiment, you connected one end of a piece of hookup wire to terminal #4 on the 8-prong socket mounted in hole 1. The other end of this piece of hookup wire is now to be connected to the same terminal lug to which you just connected the .1 mfd. condenser. Solder the connection.

You now have one pigtail end of a .01 mfd. condenser connected to one of the terminal lugs on the radio frequency choke. The other pigtail end of this .01 mfd. condenser is to be connected to the center terminal lug on the terminal strip mounted between holes 5, 6, 7, and 8. This is the same terminal lug to which you just connected one pigtail end of a 25,000 ohm resistance. Solder the connection. Now if you have quite carefully followed directions, your experiment should be wired exactly as shown in Fig. 2. You are then ready to start your experiments with your cathode ray oscilloscope.

Your cathode ray tube is to be plugged into the 7-prong socket mounted on the end of the special 7-wire cable. With the tube mounted in place, be sure that none of the socket prongs touch the cathode ray tube shield base. If there is any danger of this, wrap a piece of tape between the tube socket prongs and the tube shield base. Next, fit the shield down over the cathode ray tube and see that it is firmly seated in place. If the strength of the springs underneath the socket cause the cathode ray tube to push the shield off the tube base, it may be necessary to drop a piece of solder on two sides of the shield; that is, temporarily solder the tube shield base to the tube shield itself. Since this shield is tinned, you will find soldering to be quite easy.

A type 80 tube is to be used in socket 13, a type 1V tube in socket 14, a type 42 tube in socket 10, a type 6SC7 tube in socket 9, and a type 6C6 tube in socket 7. A little later in your experiment, a type 6A8 tube will be used in socket 1. However, you are not as yet ready to use this tube.

EXPERIMENT 90
CHECKING YOUR CATHODE RAY OSCILLOSCOPE

With all the tubes in their correct sockets, excepting the type 6A8 in socket 1, you are then ready to plug your experiment into a 110-volt, 60-cycle alternating current supply. Your oscilloscope has five controls mounted on it. There are three on the front of the chassis and two on the top. In placing the cathode ray tube and its shield, be sure that it is several inches away from the power transformer.

The 15,000 ohm potentiometer mounted in the center hole on the front side of your chassis operates the "off" and "on" switch as well as controlling the brilliancy on your oscilloscope trace. Rotate this control so as to turn your experiment on, then give the tubes time to warm up. After the tubes have heated up, there should appear on the end of the cathode ray tube a long, narrow trace. If this is blurred, it is evident that the spot is out of focus. The right hand control of the three on the front of the chassis (remember, the chassis is top side up, and the front toward you) is the focus control. Adjust this control until you secure a fine, even trace on the end of the tube.

In turning your experiment on, if you do not secure a long, narrow trace on the end of the tube, then it is evident that your sweep circuit oscillator is not functioning properly and you should immediately investigate all of the connections on the type 6SC7 tube and the type 42 tube mounted in holes 9 and 10. The potentiometer mounted on the left hand side of the front of your chassis is the amplitude control for the horizontal sweep circuit. This is the 25,000 ohm potentiometer connected in series with the cathode of this tube. The length of the horizontal trace can be varied by adjusting this control.

The frequency of the horizontal sweep circuit oscillator is controlled by the potentiometer mounted in hole 4 on the top of the chassis. This is the fine adjustment of your sweep circuit oscillator. It is then possible to make larger variations in the horizontal sweep circuit frequency by changing condensers C_1 and C_2, as shown in Fig. 3 of Experiment Group 9.

The type 6C6 tube mounted in hole 7 is the vertical amplifier. The input to this amplifier is controlled by the 500,000 ohm potentiometer mounted in hole 8. Throughout the use of your oscilloscope, this potentiometer will control the input voltage of the wave to be inspected on your oscilloscope.

Before continuing with your experiments, it is advisable that you become thoroughly acquainted with the operation of each of the five controls on your oscilloscope. Find out what each one does and the effects of its change on the pattern on the end of the cathode ray tube.

EXPERIMENT 91
DETERMINING MODULATION PERCENTAGE
(Linear Sweep)

In this experiment, you will use a 6A8 tube mounted in socket 1 as a modulated RF oscillator. This oscillator will be screen grid modulated using the output of the 6C6 tube mounted in socket 7, as the modulator.

Take a short piece of hookup wire and connect it to one side of the 6.3-volt filament winding on your power transformer. The other end of this piece of hookup wire is to be connected to the chassis by using any conveniently placed solder lug. This grounds one side of the 6.3-volt winding. A solder lug placed at the left hand side of socket 13 would probably be the most convenient. Now take another piece of hookup wire and connect it to the other side of the 6.3-volt filament winding on the power transformer. The other end of this wire is to be passed out through the back of the chassis, using the slotted hole on the left hand side and then run along the back of the chassis and connected to the aerial post marked "A" on the aerial and ground strip mounted in the right hand slotted hole on the back of the chassis. Referring to Fig. 3 in Experiment Group 9, this then places 6.3 volts across the input terminal strip of the 6C6 vertical amplifier.

Now with your experiment top side up, place all of the tubes in their correct sockets. This includes placing a type 6A8 tube in socket 1 and connecting the grid clip to the grid cap on this tube.

The 500,000 ohm potentiometer connected in the input circuit of the type 6C6 vertical amplifier tube, mounted in hole 8, is now turned to the left as far as it will go. This prevents any voltage reaching the input of the 6C6 tube.

Next turn your oscilloscope on and give the tubes time to warm up. This time there should appear on the end of your cathode ray tube a pattern approximately ½ to ¾ inch wide and extending for nearly the full width of the tube. If such a pattern is secured, it will indicate to you that the 6A8 oscillator is oscillating properly. You see, the RF output of this oscillator has been applied to the vertical plates on your cathode ray oscilloscope tube.

The length of the pattern on your tube can be controlled by adjusting the horizontal amplitude control mounted in the left hand one of the three holes on the front of your chassis. Next, vary the vernier frequency control mounted in hole 4 until the pattern appears to stand still on the end of the screen.

You are now ready to modulate the oscillator. Gradually increase the setting of the potentiometer mounted in hole 8 and carefully watch the results on your cathode ray tube. A peculiar, wavy pattern will be secured. Next, adjust the frequency vernier control mounted in hole 4 until this pattern stands still on the end of the tube.

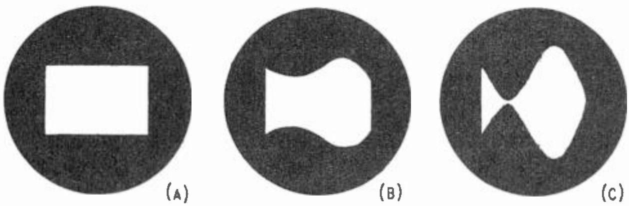


Fig.4 Patterns showing different percentages of modulation, using linear sweep. (a) Unmodulated carrier, (b) 50% modulation, (c) 100% modulation. 60 cycle horizontal sweep.

Now, by varying the input potentiometer mounted in hole 10, you can vary the percentage of modulation of the RF oscillator. Fig. 4 shows the type of pattern secured for various percentages of modulation. Fig. 4A shows the image appearing on the end of the tube with the oscillator functioning but unmodulated. This is known as the RF carrier. Fig. 4B shows the pattern when 50% modulation is effected. Fig. 4C shows the pattern secured when 100% modulation is employed.

Because your linear sweep oscillator is operating at a frequency of approximately 60 cycles, it is then possible to secure only one cycle of the wave on the end of the cathode ray tube. By slowing down the sweep circuit oscillator, it would be possible to create two separate and individual cycles on the end of the tube, and in that way, the percentage of modulation would be indicated a little more clearly.

You now have a .01 mfd. condenser connected between terminals #3 and #5 on the 8-prong socket mounted in hole 9. This is condenser C_1 as shown in Fig. 3 in Experiment Group 9. To decrease the frequency of operation of the sweep circuit oscillator, put another .01 mfd. condenser in parallel with C_1. This will then give you a combined capacity of .02 mfd. All you need to do is to connect another .01 mfd. condenser from terminal #3 to #5 on socket 9.

With this condenser in place, turn your experiment right side up and see that each tube is in its proper socket. Turn the experiment on and give it time to warm up. Next, turn the volume control mounted in hole 8 completely off, that is, to the left. Next, reduce the length of the scanning pattern on the end of the tube by using the horizontal amplifier amplitude control mounted in the left hand one of the three holes on the front of the chassis. Now, gradually increase the vertical amplifier input control until your pattern

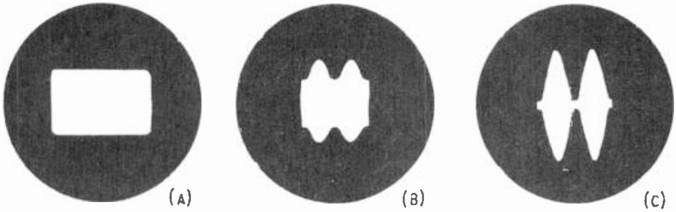


Fig.5 Various percentages of modulation as indicated by the linear sweep method. (a) Unmodulated carrier, (b) 50% modulation, and (c) 100% modulation. 30 cycle horizontal sweep.

becomes modulated. Then adjust the frequency vernier until this time you have two cycles on the front of your cathode ray tube instead of one. Figs. 5A, B, and C show the various percentages of modulation.

EXPERIMENT 92
DETERMINING MODULATION PERCENTAGE
(Trapezoid Pattern)

Before continuing with your experiments, it is advisable that you review carefully the information contained in Lesson 7 of Unit 3, pertaining to checking a transmitter with a cathode ray oscilloscope.

In conducting this experiment, it will be necessary to make some changes in the preceding experiment, therefore, you should follow directions quite carefully. You now have one end of a .1 mfd. condenser connected to the plate prong on the 6-prong socket mounted in hole 10. Disconnect this pigtail lead from the plate prong, but do not disturb the 40,000 ohm resistor which is connected to the same prong.

You now have a three-lug terminal strip mounted under the right hand bolt which holds the filter choke in place. The front lug; that is, the one nearest the front of the chassis, does not at this time have anything connected to it. Connect the pigtail terminal to the .1 mfd. condenser which was just disconnected from the plate prong on the 6-prong socket. Also, to the same terminal lug on this terminal strip, connect one end of a piece of hookup wire and solder the connection.

You now have a .1 mfd. condenser connected to the plate prong on the 6C6 tube mounted in socket 7. The other pigtail end of this .1 mfd. condenser is connected to one of the terminal lugs on the terminal strip mounted in the center of holes 5, 6, 7, and 8. The piece of hookup wire just connected to the terminal strip mounted under the bolt holding the filter choke in place is to be connected to the pigtail terminal on the .1 mfd. condenser now connected to the terminal lug mounted between holes 5, 6, 7, and 8. Make a temporary soldered connection.

With these connections in place, you are again ready to check the modulation percentage of your RF oscillator. Place all of your tubes in their correct sockets, connect your experiment to a 110 volt, 60-cycle supply and turn the experiment on. After giving the tubes time to warm up, you should find that with the volume control mounted in hole 8 turned off, that you now have a vertical trace on your cathode ray oscilloscope. The first thing to do is to adjust the intensity by varying the center control and adjust the focus by varying the right hand control of the three controls mounted on the front of the chassis. With this done, you are then ready to modulate the oscillator by varying the volume control mounted in hole 8. As you advance this volume control, the percentage of modulation will be increased, and a trapezoid pattern will be produced on the end of your cathode ray tube. If you will refer to Fig. 6, you will see that Fig. 6A indicates the carrier, that is, the RF carrier without modulation. Fig. 6B indicates the same carrier with 50% modulation and Fig. 6C indicates the same carrier with 100% modulation.

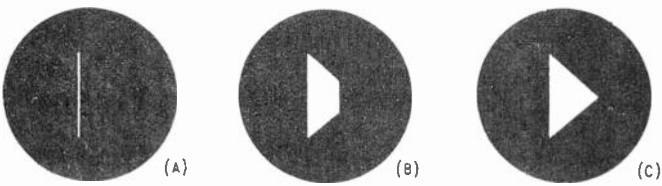


Fig.6 Oscillograms showing percentage of modulation. (a) Carrier only, (b) pattern produced with 50% modulation, (c) pattern showing 100% modulation.

Turn your experiment off and change the piece of hookup wire over to the plate pigtail terminal on the .1 mfd. condenser connected to the 6-prong socket mounted in hole 7. Make a temporary soldered connection. Now place your experiment into operation again. Without modulation, you should again have a vertical trace, the intensity and focus of which should be adjusted properly. Now by advancing the volume control mounted in hole 8, you will start modulating the oscillator. However, this time phase distortion is going to be indicated. Fig. 7 will give you an idea as to what can be expected on the end of your cathode ray tube.

EXPERIMENT 93
INSPECTING THE WAVEFORM OF THE POWER LINE

In this experiment, your apparatus is to be changed back so that it is connected as a regular cathode ray oscilloscope.

You now have a .1 mfd. condenser connected between two of the terminal lugs on the terminal strip mounted under the right hand bolt which holds the filter choke in place. Remove the piece of hookup wire connected to the terminal lug nearest the front of the chassis, and also disconnect one pigtail lead of the .1 mfd. condenser from this lug. The pigtail lead of this condenser is to be connected to the plate prong on the 6-prong socket mounted in hole 9. This is the connection formerly used.

You now have a 25,000 ohm resistance connected to the center terminal lug on the terminal strip mounted between holes 5, 6, 7, and 8, and ground. This 25,000 ohm resistance is to be removed and a 2 megohm resistance put in its place.

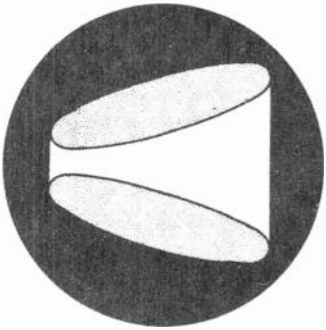


Fig.7 Pattern indicating phase distortion when using trapezoid method for showing percentage of modulation.

You now have a .1 mfd. condenser connected between the plate terminal on the 6-prong socket mounted in hole 7 and the left hand terminal lug on the terminal strip mounted between holes 5, 6, 7, and 8. Leave the pigtail lead of this condenser connected to the plate prong on socket 7, but disconnect the pigtail lead from the terminal lug on the terminal strip. This pigtail lead is then to be moved over to the center terminal lug on this same terminal strip. To this center terminal lug you should now have connected the blue wire from your cathode ray oscilloscope, one end of a 2 megohm resistance and one pigtail lead of a .1 mfd. condenser; then solder the connection.

Upon completing a preceding experiment, you had two .01 condensers connected between prongs 3 and 5 on the 8-prong socket mounted in hole 9. Leave these two condensers in place. You also had one side of the 6.3-volt filament winding on your power transformer grounded and the other side of the same winding connected to the A post on the A&G strip mounted on the back of the chassis. Leave this connection intact.

Now with the volume control mounted in hole 8, which is entirely to the left, turned off, see that all of your tubes are in the correct socket, except that this time you do not need to use the 6A8 tube in socket 1. Turn your experiment on and give the tubes time to warm up.

When the tubes have warmed up, you will have a narrow, horizontal trace on the face of your oscilloscope. The intensity and focus of this trace should be properly adjusted. You should also adjust the length of this trace so that it does not reach across the entire face of the cathode ray tube. With these adjustments made, you are then ready to apply a 60-cycle wave to the vertical amplifier. This is done by turning the volume control, mounted in hole 8, to the right. The vertical amplitude of the trace can be controlled by varying the vertical amplifier's input volume control.

You will notice that there are two complete waves shown on the front of your oscilloscope. If these waves refuse to stand still, it will then be necessary to adjust the frequency of your sweep oscillator. This is done by adjusting the potentiometer mounted in hole 4.

Close examination of the two waves on the face of your oscilloscope will show that one of the waves is a little wider than the other. This shows that some distortion exists. Later on in your experimental program, a means of correcting this distortion will be demonstrated.

EXPERIMENT 94
USING CATHODE RAY OSCILLOSCOPE AS OUTPUT METER

You now have a piece of hookup wire connected to the A post on the A&G strip mounted on the back of the chassis. Remove this piece of hookup wire entirely. One end of it, as you know, is connected to the 6.3-volt winding on your power transformer.

Before continuing this experiment, it is advisable that you review the information contained on using oscilloscopes in Unit 2.

Unless you have a receiver of your own, it will be impossible to conduct this experiment. The G post on the oscilloscope should be connected by a piece of hookup wire to the ground post on your radio receiver. Then, from the A post on your oscilloscope, connect a piece of hookup wire to the plate prong on the output tube in your radio set. If your radio set happens to use push-pull output, it is permissible to connect to either one of these plates of the push-pull tubes, but not to both of them. Your oscilloscope is now connected so that it will measure the output waveform of your radio receiver. In order to secure satisfactory results, it will be necessary to connect an audio oscillator to the audio system of your receiver, or it will be necessary to connect a modulated RF oscillator to the aerial and ground post on your receiver. The oscilloscope provides a means of accurately indicating any change in voltage in the output of your receiver, and therefore, it can be used as an output meter for aligning certain sets. This type of meter is considerably more accurate as an indicator than the ordinary moving coil meter.

Instead of connecting the cathode ray oscilloscope across the output stage of your receiver, it is possible to connect your oscilloscope across the diode load on the detector; then by turning the volume control down on your receiver, no noise will be coming from the loudspeaker. The oscilloscope will, however, be measuring the output of the diode detector, which in turn will show any changes made in the RF circuits of the receiver. Using the oscilloscope in this fashion is described quite thoroughly in Unit 2 of your regular course of instruction.

EXPERIMENT 96
TESTING POWER OUTPUT OF AUDIO AMPLIFIERS

In this experiment, the cathode ray oscilloscope will be used as a means of indicating distortion. It will be necessary to use either an AC ammeter or AC voltmeter to actually measure the power output of the audio amplifier.

Your equipment is to be connected as shown in Fig. 8. Here, as you will notice, an audio oscillator is connected to the input terminals of the audio amplifier under test. Then, instead of working the audio amplifier into a loudspeaker or a telephone line, it will be necessary to load the audio amplifier with a resistor of the correct value to match the impedance of the output circuit of the audio amplifier. As an example, if the audio amplifier is designed to work into a 500 ohm line, then the output of the amplifier must be connected across a high wattage 500 ohm resistor. The more accurate the value of this resistor, the more accurate your measurements. If the output of the audio amplifier is designed to work into a 6 ohm voice coil, it will then be necessary to connect the output of the audio amplifier into a 6 ohm resistor instead of the voice coil of the speaker.

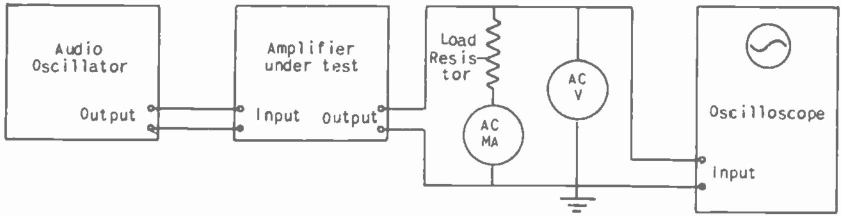


Fig.8 Blockdiagram showing arrangement for measuring power output from an audio amplifier.

If a good AC voltmeter is available, the voltmeter can be connected across the resistor, as shown in Fig. 8. If a good AC ammeter is available, then this ammeter can be connected in series with the resistor as shown in Fig. 8. It is not necessary to use both meters, but if used, they can provide a check on each other.

The cathode ray oscilloscope is connected across the load resistor as shown in Fig. 8.

At this time, it is advisable to remove one of the .01 mfd. condensers connected between terminals 3 and 5 on the 8-prong socket mounted in hole 10.

It is customary to test the power output of an audio amplifier at a frequency of 400 cycles. Therefore, set the audio oscillator at a frequency of 400 cycles and apply a small amount of voltage to the input of the audio amplifier under test. Then, advance the input volume control on the vertical amplifier so that a series of waves appear on the end of the cathode ray oscilloscope. Adjust the sweep circuit oscillator so that these waves then stand still on the oscilloscope.

With these adjustments made, you can then advance the volume control on the audio oscillator, thereby, applying a greater input voltage to the amplifier under test. This can be continued until the wave shown on the end of the cathode ray oscilloscope begins to indicate distortion. The distorted waves on the oscilloscope will look somewhat similar to the example shown in Fig. 9. When this point is reached, then back off the gain control on the audio oscillator until a pure sine wave such as shown in Fig. 9A is indicated. At this time, the audio amplifier is delivering its maximum undistorted power output.

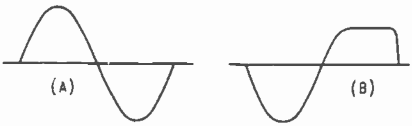


Fig. 9 (a) Wave produced when maximum undistorted power output of amplifier is exceeded.

If you are using an AC milliammeter to indicate the power flowing in the load resistance, then you would use the formula: $W = I^2R$. If you are using a voltmeter to measure the voltage across the load resistor, you would then use the formula: $W = E^2/R$. The power output at the point where distortion just starts to take place should then be calculated.

While it is not necessary, still if one desires, it would be possible to measure the power output of the audio amplifier at other frequencies than 400 cycles.

EXPERIMENT 95
SYNCHRONIZING A SWEEP CIRCUIT OSCILLATOR

Before continuing with this experiment, it is advisable that you review some of the material contained in Unit 5 on synchronizing sweep circuit oscillators.

Connect a piece of hookup wire approximately 1½ inches long to terminal #4 on the 8-prong socket mounted in hole 9. Before continuing, you must be sure that the insulation on this piece of hookup wire is good. Now take another piece of hookup wire, approximately 5 inches long and be sure that the insulation on one end of the wire is good. This means that the bare wire should not stick out of the insulation. Now wrap about one inch of this insulated wire around about one inch of the piece of wire connected to terminal #4 on socket 9. We do not want an electrical connection. *The bare ends of the wire are not to be connected together.* Where these two pieces of insulated wire are twisted together, they form a very small capacity. This capacity will then feed a synchronizing voltage into the grid of the sweep circuit oscillator tube. The other end of the second piece of hookup wire is to be connected to the center terminal lug on the terminal strip mounted between holes 5, 6, 7, and 8. To this terminal lug you now have connected the blue lead going to your cathode ray tube.

With your oscilloscope connected in this fashion, then any voltage that is being fed to the vertical deflecting plates on the oscilloscope will also be applied to the synchronizing grid on the sweep circuit oscillator. This, then, synchronizes the horizontal sweep with the vertical input voltage. If too great a synchronizing voltage were applied to the synchronizing grid on the sweep circuit oscillator, the pattern resulting from such an operation would be materially distorted.

EXPERIMENT 97

CHECKING HUM WITH CATHODE RAY OSCILLOSCOPE

The G post on your cathode ray oscilloscope is to be connected to the receiver chassis under test. The A post on your oscilloscope is then to have a piece of hookup wire connected to it so that this hookup wire can be connected to various places in the receiver.

The first place to which you should connect your oscilloscope is the B+ output of your receiver. This can be the top end of the voltage divider, if the set has one, or the output connection on the filter choke, which may be a separate choke or the speaker field. When this wire is first connected to the set, if the set is turned on, the horizontal trace on your oscilloscope will be deflected entirely off the screen of the tube. This happens until the input condenser on your oscilloscope is charged. As soon as it is charged, you will have a narrow, horizontal sweep line on the face of your cathode ray tube. As long as this line remains straight, you can be sure that your power supply is adequately filtered. It will, of course, be necessary for you to turn the gain control on the vertical amplifier nearly to its full "on" position.

Now turn the gain control on your vertical amplifier to the "off" position. Move the oscilloscope lead from the B+ output on your receiver power supply over to the filament prong of the rectifier tube. Then, gradually increase the vertical gain control on your oscilloscope. At this point, you will immediately note an AC wave on the end of your cathode ray tube. This is an indication that hum is present. The wave on the end of your oscilloscope tube will not be a sine wave, but the actual waveform will depend entirely upon whether the receiver under test uses a choke or condenser input filter system.

If it is convenient to do so, you can now connect your oscilloscope lead back to the B+ output of your power supply system on the receiver. Then, disconnect the output filter condenser and note whether an AC hum is produced from such an operation. Next, unhook the center filter condenser, providing your set has three sections of filter capacity. If it does not, then disconnect the first filter capacity and note the hum existing. This kind of a test will then indicate whether or not your filter capacities are functioning properly.

With both of the filter capacities in their proper position, take a piece of hookup wire and short out the filter choke. By doing this, you can note the hum on your oscilloscope and in that way ascertain the effectiveness of the filter choke.

EXPERIMENT 98
USING A CATHODE RAY TUBE AS HIGH SENSITIVITY VOLTMETER

In this experiment you will use your cathode ray tube as a high sensitivity voltmeter. It will be necessary to make one or two changes in the wiring of your experimental apparatus.

You now have a .1 mfd. condenser connected between the plate prong on the 6-prong socket mounted in hole 7, and the center terminal lug on the terminal strip mounted between holes 5, 6, 7, and 8. Remove this .1 condenser. It will be used again later, however.

You now have a .01 mfd. condenser connected between the A post on your input strip and one of the terminal lugs on the potentiometer mounted in hole 8. Disconnect the pigtail lead of the .01 mfd. condenser which is now connected to the A post on the A&G strip. Leave the condenser in the set because it will be used again later.

Now take a piece of hookup wire and connect one end of it to the A post on the A&G strip. The other end of the piece of hookup wire is to go to the center terminal on the terminal strip mounted between holes 5, 6, 7, and 8. Solder this connection. Under these conditions, you now have the A post on the A&G strip connected directly to the vertical deflecting plates on your cathode ray tube.

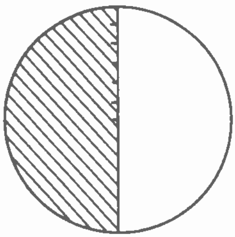


Fig.10 Showing arrangement for using oscilloscope to measure voltages. The marks on the paper are ¼-inch apart.

Now cut a piece of paper half round so that it will just cover one-half of the front of your cathode ray tube. This is shown in Fig. 10. Turn your equipment on and set the horizontal sweep oscillator into operation. Adjust the intensity and focus of the horizontal trace in your cathode ray tube. Just where this trace crosses the edge of the paper on the front of your cathode ray tube, draw a line and mark this zero. The paper should be so set that its edge is at right angles to the horizontal trace. While doing this, it will be necessary to take a small piece of wire and short the A&G posts on the A&G strip.

Under normal conditions, the deflection sensitivity of your cathode ray tube is 60 volts per inch. In other words, for each 60 volts applied to the vertical deflection plates, the beam on the cathode ray tube will be deflected one inch. Therefore, 15 volts will deflect the beam one-fourth of an inch. It is then advisable to mark off divisions on your paper scale starting from zero, going up, each one-fourth of an inch. Remember, the cathode ray oscilloscope measures DC voltage or peak AC voltage.

When applying a DC voltage to the vertical deflection plates, you will move the horizontal trace up and the reading on the scale will show you the voltage applied to the tube. When putting an AC voltage on the vertical deflection plates, you will have a deflection indicated above and below the zero line. We are interested only in the deflection above the zero line, and remember that this is reading peak AC volts. All of these voltage measurements are to be made, of course, with the short removed from the A&G posts on the A&G strip. Also, if an AC voltage is applied to the vertical deflection plates, it is advisable to turn the frequency control unit mounted in hole 4 for the horizontal sweep oscillator as far to the right, or in a clockwise direction, as it will go. This will give you greater accuracy in reading the voltage applied to your tube.

When applying a DC voltage to the input of the oscilloscope, the positive of the DC voltage should be connected to the A post on the A&G strip. This will then provide an upward deflection of the beam.

EXPERIMENT 99
DETERMINING THE EFFECT OF GRID BIAS CHANGE

Disconnect the piece of hookup wire which you now have between the A post on the A&G strip and the center terminal lug on the terminal strip mounted between holes 5, 6, 7, and 8. Replace the .1 mfd. condenser which was connected between the plate terminal on socket 7 and the center terminal lug on the terminal strip. Also, connect the pigtail terminal of the .01 mfd. condenser back to the A post on the A&G strip. The cathode ray oscilloscope is then returned to normal.

At this time, you have connections made between the vertical deflection plate and the grid of the sweep circuit oscillator in order to provide synchronization. It is advisable to leave this connection intact.

You now have one side of your 6.3-volt filament winding on your power transformer grounded. Take a piece of hookup wire and connect it to the other 6.3-volt filament winding on the power transformer. This wire is then run through the back of the chassis and up to the A post on the A&G strip. This will then again supply a 60-cycle voltage to the vertical deflection plates on your cathode ray oscilloscope.

Turn your oscilloscope on and get the usual 60-cycle sine wave on the end of your cathode ray tube. Adjust the brilliance and focus so that you have a nice trace. The sine wave should be so set that it covers approximately one-half of the face of the tube.

It will be necessary to adjust the frequency control potentiometer mounted in hole 4 so that synchronizing takes place at the proper point and a pure sine wave is secured on the face of the tube.

Now vary the amplitude control of the vertical amplifier and note that the wave itself is not distorted. This is true regardless of the amplitude of the wave on the face of the oscilloscope.

Now take a short piece of hookup wire and connect it across the cathode bias resistance on the type 6C6 tube mounted in hole 7. This is a 1500 ohm resistor connected between the cathode of the

6C6 tube and a solder lug placed at the left hand side of the A&G strip. This shorts out the bias resistor and removes the grid bias from the 6C6 vertical amplifier.

Place your oscilloscope into operation and then examine the waveform produced on the end of the cathode ray tube. You will notice that distortion is present and that one of the waves on the end of the tube has been flat topped. This indicates that rectification is taking place.

Now remove the 1500 ohm cathode resistance connected in the cathode circuit of the 6C6 tube. In its place, put a 50,000 ohm resistor. This, as you will note, supplies a much higher bias to the grid of the 6C6 tube. Set your experiment into operation and check the waveform on your cathode ray oscilloscope. You will notice that with low amplitudes of the wave, there will be no distortion; however, as you increase the amplitude of the wave, meaning that you are applying a greater input voltage to the vertical amplifier tube, distortion will immediately become apparent.

EXPERIMENT 100
LISSAJOUS' FIGURES

Upon completing Experiment 99, you should return your oscilloscope to the same conditions as used in Experiment 93.

You now have a .01 mfd. condenser connected between the A post on the aerial and ground strip and one of the outside terminal lugs on the 500,000 ohm potentiometer, mounted in hole 8. Remove this .01 condenser and in its place, connect a .1 mfd. condenser.

You now have one pigtail lead of a .1 mfd. condenser connected to terminal 2 on the 8-prong socket mounted in hole 9. This is the plate prong on this particular socket. Disconnect this pigtail lead and move it over to the free terminal lug on the terminal strip mounted under the right hand bolt holding the filter choke in place.

You now have a piece of hookup wire connected between one of the 6.3-volt filament terminals on your power transformer and the A post on your A&G strip. Remove this piece of hookup wire. Now, to the free terminal lug to which you just connected the .1 mfd. condenser, connect a short piece of hookup wire and solder the connection. The other end of this short piece of hookup wire is to go to the 6.3-volt filament terminal on your power transformer. This, then applies 6.3 volts to the input of the horizontal amplifier. The sweep circuit oscillator will not be used in this experiment.

With these connections completed, it is possible to apply an AF voltage of an unknown frequency to the input terminals of the vertical amplifier and through the use of Lissajous' figures, determine the frequency. The input terminals are the A and G posts on the aerial and ground strip mounted on the back of your chassis. You will have a 60-cycle voltage connected to the horizontal amplifier and the unknown frequency is to be connected to the vertical amplifier.

Through the use of Lissajous' figures, it is possible to calibrate an AF oscillator. Since most students will not have such an instrument, we are going to show you the method used in checking an unknown frequency of approximately 60 cycles. Later, directions will be given for determining other unknown frequencies.

Connect one pigtail lead of a .1 mfd. condenser to either one of the primary terminals on your power transformer. Solder the connection. The other pigtail lead of the .1 mfd. condenser is to be connected to any conveniently placed solder lug. Solder the connection. Now connect a piece of hookup wire to the other primary terminal on your power transformer. Solder the connection. The other end of this piece of hookup wire is to be led through the back of the chassis, over to the A post on the aerial and ground strip. This connection will then enable you to apply a 60-cycle AC voltage to the input of the vertical amplifier.

Now place your oscilloscope into operation. Be sure that all tubes are in their correct sockets. In this experiment it will not be necessary to use the type 6SC7 tube in socket 10. With all the tubes in their correct sockets, plug your experiment in, turn it on and give the tubes time to warm up.

The input volume control mounted in hole 8 should be turned to the left as far as it will go. With this condition, no voltage will be applied to the vertical amplifier. You have, however, a 60-cycle voltage applied to the horizontal amplifier. With this voltage applied to the horizontal amplifier and your oscilloscope properly adjusted, you should have a long, narrow, horizontal trace. The focus and intensity of this trace should be adjusted.

Now, gradually increase the vertical amplifier volume control mounted in hole 8. This applies a 60-cycle voltage to the vertical amplifier. The result of these two 60-cycle voltages being applied to the two sets of plates on your cathode ray tube will be a straight line traced at a 45-degree angle to the horizontal, as shown in Fig. 11A. We suggest that you check the information given on this subject in Lesson 4, Unit 2.

Next, you will make a couple of changes so that an ellipse as shown in Fig. 11B will be secured. First disconnect the piece of hookup wire connected to the A post on the aerial and ground strip. To this end of the piece of hookup wire, connect one pigtail lead of a .01 mfd. condenser. Connect the other pigtail lead of the .01 mfd. condenser to the A terminal on the aerial and ground strip. This will then produce a phase shift in the AC voltage applied to the vertical amplifier and the resultant pattern on the screen will be an ellipse as shown in Fig. 11B.

Now remove the .01 mfd. condenser and connect in its place a .00025 mfd. mica condenser. This condenser will produce a greater phase shift and the resultant pattern will be similar to that shown in Fig. 11C.

The three patterns in Fig. 11 show the results when 60 cycles is applied to both sets of deflection plates.

Let us take a look at Fig. 12A. This is a Lissajous' figure having a ratio of 2 to 1. The ratio is determined by the number of loops which would touch a line drawn parallel to the center horizontal axis of the tube and near the top edge. This is line AB as shown in Fig. 12A. It will not be necessary for you to actually draw such a line on the end of your tube. In checking Lissajous' figures, it will also be necessary to have another line BC drawn at right angles to the horizontal reference line. This is line BC in Fig. 12A. In referring to Fig. 12A, you notice that two loops touch the horizontal line AB, and one loop touches the vertical line BC. This then indicates that you have a Lissajous' figure having a ratio of 2:1. Such a ratio indicates that the cathode ray spot is traveling twice as fast vertically as it is horizontally. Since we have a 60-cycle frequency applied to the horizontal plates of this tube, we know then that the vertical frequency would be 120 cycles, or twice as fast.

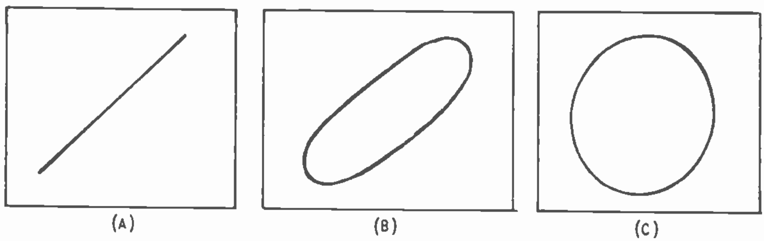


Fig.11 Lissajous figures produced by voltages with different phase relations. (a) Voltages in phase, (b) voltages slightly out of phase, (c) voltages approximately 90° out of phase.

If you were to secure this same pattern turned on its side; that is, reversed 90°, you would have one loop touching the horizontal line and two loops touching the vertical line. This would then indicate that the ratio was 1 to 2, or that the horizontal sweep was twice as fast as the vertical sweep. Another way of stating it would be that the vertical sweep was one-half of the horizontal sweep; therefore, our unknown frequency would be 30 cycles.

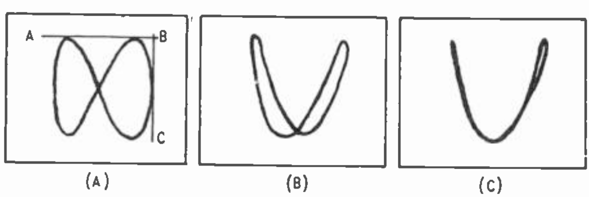


Fig.12 Lissajous' figures produced by voltages with a frequency ratio of 1:2, but with changing phase relations.

The pattern on the end of the cathode ray tube in most cases will not remain stationary. This is due to a slight continuous phase shift between the standard frequency and the unknown frequency. Therefore, during this shift in frequency, you may secure the pattern shown in Fig. 12B or 12C. However, all of these represent the same ratio as Fig. 12A. The correct figure can be obtained, however, by permitting the figure to drift. Before attempting to check the ratio of the Lissajous' figure, it is advisable to obtain the correct pattern as shown in Fig. 12A.

Now, let us examine Fig. 13. Here you will find a Lissajous' figure having a ratio of 3 to 1. You will notice there are three loops touching the horizontal line and one loop touching the vertical line. With three loops touching the horizontal line, caused by the vertical deflection, and one loop touching the vertical line, caused by the horizontal deflection; this would indicate the vertical deflection is three times that of the horizontal deflection. This would indicate a frequency three times as fast as the horizontal frequency, or 180 cycles.

Now let us take a look at Fig. 14. Here you will find a Lissajous' figure having a ratio of 3 to 2. You will notice that the vertical deflection causes three loops to touch the horizontal line, while the horizontal deflection causes two loops to touch the vertical line. This then means that the ratio of the vertical frequency is to the horizontal frequency as 3:2. Solving this for the unknown frequency, we have 3:2 = X:60. This would be 180 = 2X; dividing by 2, X = 90. The frequency of the unknown would then be 90 cycles.

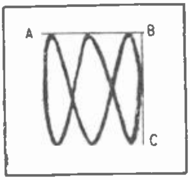


Fig.13 Lissajous' figure produced by voltages with a frequency ratio of 3:1.

By following this system, it is then possible to determine any unknown frequency. On a 3" cathode ray tube, it is possible to read a Lissajous' figure having a ratio of 10 to 1. This would then mean that you could not accurately determine an unknown frequency above 600 cycles. Now, however, by using a higher frequency as the horizontal sweep circuit standard, you could accurately check unknown frequencies of a much higher value. As an example, if you were to use a thousand cycle standard frequency, it would then be possible to check unknown frequencies as high as 10,000 cycles.

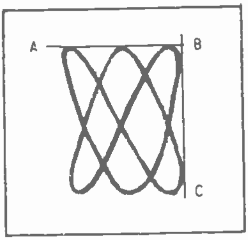


Fig.14 Lissajous' figure produced by two voltages with a frequency ratio of 3:2.

EXPERIMENT 101
PLOTTING DYNAMIC CHARACTERISTIC CURVES

In this experiment, you will use your cathode ray oscilloscope to plot the dynamic characteristic curve on a type 6C6 tube, operated as a triode.

In completing your last experiment, you had a .1 mfd. condenser connected between the grid terminal on the six prong socket mounted in hole 10 and the front terminal lug on the terminal strip mounted under the right hand bolt which holds the filter choke in place. Remove the pigtail terminal connected to the terminal lug on the terminal strip and again connect this to terminal 2 on the 8-prong socket mounted in hole 10.

You now have one side of the 6.3-volt filament winding on the power transformer grounded. The other side of this winding is connected by a piece of hookup wire to one of the terminal lugs on the terminal strip mounted under the right hand bolt which holds the filter choke in place. Remove this piece of wire entirely.

In completing the last experiment, you had a .25 mfd. condenser connected between one side of the primary on your power transformer and ground. The other side of the primary on the power transformer was connected by means of a piece of hookup wire to the A post on the aerial and ground strip. Leave these connections intact.

In completing experiment 95, you had special synchronizing leads connected to the grid terminal of the 8-prong socket which holds the 6SC7 sweep circuit oscillator. This is terminal 4 on socket 9. Remove these synchronizing leads.

You now have a 50,000 ohm resistance connected between the plate terminal on the 6-prong socket mounted in hole 7 and one of the terminal lugs on the terminal strip mounted between holes 5, 6, 7, and 8. Remove this 50,000 ohm resistance and in its place put a 4,000 ohm resistance. Solder the connection. You now have as a plate load for the type 6C6 tube, a 4,000 ohm resistance instead of the 50,000 ohm resistor formerly used.

You now have one section of your 8-8-8 mfd. by-pass condenser connected to ground. The other lead is connected to the cathode prong on the 6-prong socket mounted in hole 7. Disconnect the ground connection on this condenser so that the cathode resistance will not be by-passed by the 8 mfd. condenser.

Place the tubes in their correct positions, turn your oscilloscope on and give the tubes time to warm up. The volume control mounted in hole 8 should be turned as far to the left as it will go. Therefore, no AC voltage will be applied to the vertical input amplifier. With the oscilloscope in operation you should have a narrow, horizontal trace on the face of the tube. Adjust the focus and intensity of this trace.

Now apply some AC voltage to the vertical input amplifier by advancing the volume control mounted in hole 8, to the right. As you advance this control, you will secure a sine wave on the face of your oscilloscope. As you increase the amount of AC signal voltage applied to the vertical input amplifier, you will find that the top part of the sine wave begins to flatten off. As you further increase the input voltage, you will find that the bottom portion of the wave begins to flatten out. Since it is possible to apply nearly 110 volts to the grid of the vertical amplifier, you should not advance the gain control in hole 8 any more than just enough to indicate the two conditions described.

The indication given by these two traces is that as the wave is flattened out on the top side, the grid of the 6D6 is being driven positive, which on the dynamic characteristic curve indicates the tube is being driven into the positive region of the grid voltage-plate current characteristic. The distortion indicated on the bottom half of this wave indicates that when the grid signal voltage is increased to too great a value, the tube is then being operated on the curved portion of the lower end of the tube's grid voltage-plate current characteristic.

Now by making a change or two on your experiment you can plot an actual dynamic characteristic curve of the tube on the end of your oscilloscope. You now have a .1 mfd. condenser connected between terminal lug #2 on the 8-prong socket mounted in hole 9 and the grid terminal on the 6-prong socket mounted in hole 10. Remove this .1 mfd. condenser. Now connect a piece of hookup wire to the grid terminal on the 6-prong socket mounted in hole 10. Solder the connection. The other end of this piece of hookup wire is to go to the 6.3-volt filament terminal on your power transformer. The terminal to use is the one which is not now grounded.

Place your tubes in their correct sockets, turn the oscilloscope on and give the tubes time to warm up. The volume control mounted in hole 8 should now be turned to the left so that no voltage is applied to the vertical amplifier. Under these conditions you will secure a horizontal trace on the face of your oscilloscope. The length, focus, and intensity of this trace should now be properly adjusted.

Now, gradually increase the volume control mounted in hole 8. As the input signal voltage to the vertical amplifier is increased, you will find that the trace is no longer horizontal, but begins to assume an angle to the horizontal. The greater the input signal voltage to the vertical amplifier, the steeper the line, or the greater the angle will be. As you further increase the signal on the vertical amplifier, you will find that the line begins to bend. This indicates that the tube is being operated on the curved portion of its characteristic curve. The bend at the top of the line shows that the tube is being worked in the positive region of its grid voltage-plate current characteristic, while the bend at the bottom end of the trace shows that the tube is being worked on the negative curved portion of its characteristic, and this approaches the cutoff value of this type of tube.

Since the bend on this characteristic curve takes place at the top end of the curve first, and later at the bottom of the curve, this is evidence that the tube is not being operated strictly on the straight portion of its grid voltage-plate current characteristic. If it were operated on the straight portion only, the bend at the top and bottom of the trace would occur simultaneously. Since the curve appears in the positive region first, it indicates that the tube is being operated on the upper portion of the straight portion of its characteristic.

EXPERIMENT 102
BUILDING A HORIZONTAL SWEEP CIRCUIT OSCILLATOR

In this experiment, it will be necessary to make several changes in your equipment in constructing this horizontal sweep circuit oscillator.

At this time, remove all of the apparatus now connected to the 6-prong socket mounted in hole 7. The only connections which are to remain intact will be the heater or filament connections.

At the present time, you have an octal socket mounted in hole 1. Remove the octal socket and in its place mount a 5-prong socket. In mounting this socket, the filament or heater prongs should face toward the front of the chassis. You now have a pair of twisted hookup wires connected to the 6.3-volt heater terminals on your power transformer, the other ends of which were connected to the octal socket. Connect these two hookup wires to the heater prongs on the 5-prong socket mounted in hole 1 and then change the other ends from the 6.3-volt terminals to the 2.5-volt terminals on your power transformer. The filament terminals to use on the power transformer are the ones next to the 6.3-volt terminals. *Be sure that these are used.* Remember, these directions are given with the chassis upside down and the front toward you.

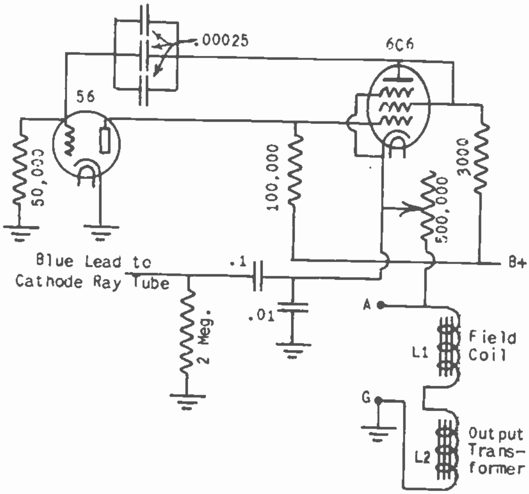


Fig.15 Wiring diagram of horizontal sweep circuit oscillator.

The volume control now mounted in hole 8 has one of its terminal lugs grounded, the A post on the aerial and ground strip is connected to another of the lugs, and a .1 mfd. condenser is connected between the center lug and the grid terminal on the 6-prong socket mounted in hole 7. Remove all of these connections from the 500,000 ohm potentiometer mounted in hole 8 and remove the .1 mfd. condenser from socket 7. The sweep circuit oscillator which you are constructing is to be wired as shown in Fig. 15. The field coil and output transformer of your loudspeaker will be used as chokes L_1 and L_2, as shown in this figure.

Now connect a short piece of hookup wire to the A post on your aerial and ground strip. Solder the connection. The other end of this piece of hookup wire goes to one of the outside terminals on the 500,000 ohm potentiometer, mounted in hole 8. The terminal nearest the back of the chassis is the correct one to use; solder the connection. Now, connect a short piece of hookup wire to the center terminal lug on the 500,000 ohm potentiometer mounted in hole 8. Solder the connection. The other end of this piece of hookup wire is to go to the cathode terminal on the 6-prong socket mounted in hole 7. To this same cathode terminal, also connect one pigtail lead of a .01 mfd. condenser and one pigtail lead of a .1 mfd. condenser. Using a small piece of hookup wire, connect the suppressor grid prong on the 6-prong socket mounted in hole 7 to the cathode prong. Solder the connections. The other pigtail end of the .01 mfd. condenser is to be connected to ground by using any conveniently placed solder lug. The easiest connection to make will be the solder lug mounted at the left hand side of the aerial and ground strip on the back of the chassis.

The other pigtail lead of the .1 mfd. condenser is to go to the center terminal lug on the terminal strip mounted between holes 5, 6, 7, and 8. To this same terminal lug, you should now have one pigtail lead of a 2 megohm resistance and the blue wire leading to your cathode ray tube. When these three connections are made to this lug, then solder the connections. The other pigtail terminal of the 2 megohm resistance is connected to ground.

Now take a short piece of hookup wire and connect the plate prong to the screen grid prong on the 6-prong socket mounted in hole 7. To either the plate or screen grid prong, also connect a piece of hookup wire and the pigtail terminal of a 3,000 ohm resistance. Solder the connection. The other end of the 3,000 ohm resistance is to go to the B+ terminal lug on the terminal strip mounted between holes 5, 6, 7, and 8. The B+ terminal is the one connected to the power supply in your preceding experiment.

The next procedure in your experiment is to mount a three-lug terminal strip under the right hand bolt at the side of hole 3. This terminal strip is to be so mounted that it is parallel to the side of the chassis. To the center lug on this terminal strip, now connect the piece of hookup wire, the other end of which is connected to the plate terminal on the 6-prong socket mounted in hole 7. Also, to this same center terminal lug, connect the pigtail leads of three .00025 mfd. condensers. Solder the connection. The other three pigtail leads go to the grid prong on the 5-prong socket mounted in hole 1. To this same grid terminal, also connect one pigtail lead of a 50,000 ohm resistance. Solder the connection. The other pigtail lead of the 50,000 ohm resistance is to go to the solder lug placed under the left hand bolt which holds the 5-prong socket in place. Solder the connection.

Connect a short piece of hookup wire to the cathode prong on the 5-prong socket mounted in hole 1. Solder the connection. The other end of this piece of hookup wire is to go to a solder lug placed under the right hand bolt which holds socket 1 in place. Solder the connection.

You now have a 100,000 ohm resistance connected between prong 3 on the 8-prong socket mounted in hole 9 and one of the outside terminal lugs on the potentiometer mounted in hole 4. Remove this 100.000 ohm resistance and, in its place, put a piece of hookup wire. Solder the connection.

To the B+ terminal on the terminal strip mounted between holes 5, 6, 7. and 8, connect one pigtail lead of a 100,000 ohm resistance. Solder the connection. The other pigtail lead of this resistor is to be connected to the nearest terminal lug on the terminal strip mounted at the side of hole 3. To this same terminal lug, also connect one end of a piece of hookup wire. The other end of this piece of hookup wire is to go to the plate terminal on the 5-prong socket mounted in hole 1. Solder the connection. Now, take a piece of hookup wire and connect it to the terminal lug on the terminal strip mounted at the right hand side of hole 3. The terminal lug to use is the one to which you now have the pigtail lead of a 100,000 ohm resistance and a piece of hookup wire. This piece of hookup wire is then to be passed up through the chassis, using some small hole nearby, and is to be made long enough so that it will reach the grid cap on the type 6C6 tube which is to be used in socket 7. With the wire cut off at the right length, solder on a grid clip.

In completing your preceding experiments, the G terminal on the aerial and ground strip was grounded by using a solder lug placed at the right hand side of this strip. Leave this connection intact.

There are four wire leads on your loudspeaker. The green wire lead is to be connected to the A post on the aerial and ground strip. The black wire lead is to be connected to the G post on the aerial and ground strip. These connections can be fastened under the head of the screw on this strip. The yellow and brown leads are now to be fastened together. If you cannot twist them together good and tight, then solder the connection. Throughout your experiments, be sure that the yellow and brown leads do not come in contact with the chassis.

If you have followed directions carefully, your experiment is now completely wired and ready to be tested. Place a type 80 tube in socket 13, a type 1V tube in socket 14, a type 42 tube in socket 10 a type 6SC7 in socket 9, a type 6C6 in socket 7, and a type 56 tube in socket 1. With these tubes in place, plug your experiment in and give the tubes time to warm up. In placing this experiment into operation, the 500,000 ohm volume control mounted in hole 8 should be set in about its center position. The volume control mounted in hole 4 should also be set in its center position. In operating this experiment, you must be extremely careful that the volume control mounted in hole 4 is not turned entirely to the right, or in a clockwise direction. To do so would result in no vertical deflection and if the horizontal sweep circuit oscillator was not operating satisfactorily, you would have nothing but a spot on the end of the tube, and this might cause the screen to be burned.

In operating this experiment to form a television scanning pattern, the former horizontal sweep circuit oscillator, operating at a frequency of approximately 60 cycles, is now to be used as the vertical oscillator. Therefore, it will be necessary to rotate the cathode ray tube 90°. The horizontal sweep line will then become a vertical sweep line.

In a modern television scanning pattern, you should have approximately 441 lines repeated at a rate of 60 frames per second. The 6SC7 sweep circuit oscillator is designed to operate satisfactorily at 60 cycles. This will produce your 60 frames per second. The type 6C6 tube and the type 56 tube operate together as a sweep circuit oscillator having a higher frequency, and this will produce the line frequency for your scanning pattern.

EXPERIMENT 103
OBSERVING TELEVISION SCANNING PATTERN

With the experiment plugged in and the tubes warmed up, you should now have a pattern appearing on the end of your cathode ray tube. It will be necessary to permit this experiment to warm up a little bit more than it was customary on previous experiments. This causes the sweep circuit oscillators to become more stable. The pattern on the tube will be approximately square.

The number of lines in the television scanning pattern on the end of your cathode ray tube is governed by the potentiometer mounted in hole 8. When you first turn your experiment on you should be able to readily ascertain the number of lines present. Now by turning this volume control in a clockwise direction; that is, to the right, you will reduce the number of lines. In fact, you will reduce the number of lines to the extent that there may be only approximately a half-dozen lines showing. At this time it is advisable to adjust the intensity and focus of the pattern on the end of your cathode ray tube.

When the horizontal oscillator is operating at a very low frequency; that is, only a few number of lines are indicated on your television scanning pattern, you will immediately notice that the lines are not straight. This is due to distortion in the sweep circuit oscillator. This distortion is prevalent because the inductance of the field of the loudspeaker is not adequate for operation at the lower frequency. To operate correctly at 60 cycles, the inductance of this coil should be at least 1000 henries.

Now increase the frequency of the horizontal oscillator by turning the volume control mounted in hole 8 to the left, or in a counter-clockwise direction. As you turn this volume control to the left, the number of lines will be increased materially. At the point where it is apparently impossible to distinguish the individual lines, you are operating at the top frequency where satisfactory results can be secured. At this point you should adjust the intensity and focus of the pattern on the end of your tube.

If the pattern on the end of your tube appears to be drifting, it is possible to adjust the frequency of the vertical sweep circuit oscillator by varying the potentiometer mounted in hole 4 so that the pattern will remain stationary. This then indicates that the vertical sweep circuit oscillator is operating at 60 cycles per second.

EXPERIMENT 104

CHECKING THE LINEARITY OF A SWEEP CIRCUIT OSCILLATOR

When completing Experiment 100, you had a .1 mfd. condenser connected between one side of the primary winding on your power transformer and ground. If during succeeding experiments, you removed this condenser, it is now necessary to replace this condenser. That is; connect one pigtail lead of a .1 mfd. condenser to one of the primary terminals on your power transformer. The other pigtail lead of the .1 mfd. condenser is to be connected to any conveniently placed solder lug. Solder the connection.

Take a small piece of well insulated hookup wire and connect it to terminal #4 on the 8-prong socket mounted in hole 9. Solder the connection. Now, take another piece of hookup wire and twist it around this short piece of hookup wire so that you have about one inch of hookup wire twisted together. Remember, the bare ends of these wires are not to touch each other. These two pieces of hookup wire form a small capacity. The other end of this second piece of hookup wire is to be connected to the remaining primary terminal on your power transformer. Solder the connection. The connection just made will supply a 60-cycle voltage to the grid of the sweep circuit oscillator mounted in hole 9. This will automatically provide synchronization at 60 cycles.

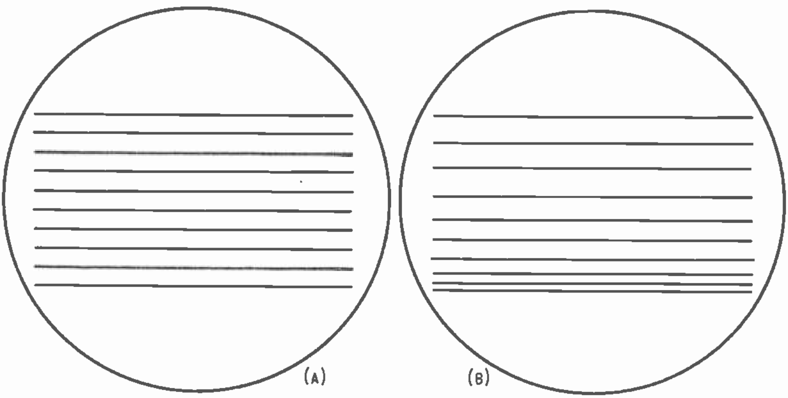


Fig.16(a) Pattern produced when vertical sweep is linear. (b) Pattern produced by non-linear vertical sweep.

Now with all tubes in their correct sockets, plug the experiment in and give the tubes time to warm up. Depending on the adjustment of the volume controls mounted in holes 4 and 8, you should now have a pattern on the end of your cathode ray tube. Adjust this pattern so that it appears to stand still. In making this adjustment you should use the volume control mounted in hole 4. With this adjustment, you will have the vertical sweep circuit oscillator adjusted for proper operation with the 60-cycle synchronizing voltage applied to the input circuit of this oscillator.

The next step in this experiment is to decrease the frequency of the horizontal sweep circuit oscillator. The frequency of this oscillator is controlled by the potentiometer mounted in hole 8. Decrease the frequency of the horizontal sweep circuit oscillator until you have approximately eight or ten lines on the face of your cathode ray tube. Carefully adjust the frequency of the horizontal oscillator so that the pattern appears to stand still.

Now if the linearity of your vertical sweep circuit oscillator is satisfactory, the eight or ten lines reproduced on the face of your tube will be spaced equally. This is shown in Fig. 16A. If the linearity of your vertical sweep oscillator is not satisfactory, then these lines will not be spaced equally, similar to that shown in Fig. 16B.

It is advisable that you study the material contained in Unit 5 of your regular course of instruction concerning the reasons for the non-linearity of sweep circuits.

EXPERIMENT 105

NOTING THE EFFECTS OF GRID CIRCUIT HUM ON A TELEVISION SCANNING PATTERN

In starting this experiment, it is advisable to remove the 8-8-8 mfd. electrolytic condenser mounted to the left front center of your chassis. By removing this condenser, you will have more room for conducting the balance of the experiments.

Since the connections to be made from now on are merely temporary, you will use a socket in place of a terminal strip. Bolt any extra socket which you may have to the chassis, using one of the holes which formerly held the 8-8-8 mfd. electrolytic condenser. The socket is bolted on the bottom side of the chassis.

The yellow wire leading to your cathode ray tube is now connected to the center terminal lug on the 15,000 ohm potentiometer mounted in the center of the three holes on the front of the chassis. Remove this yellow wire and connect it to any one of the prongs on the socket just mounted. To this same prong, connect one pigtail lead of a 150,000 ohm resistance and solder the connection. The other pigtail lead of the 150,000 ohm resistance is to be connected to the center terminal lug on the 15,000 ohm potentiometer. Solder the connections.

Now, place all tubes in their correct sockets, plug the experiment in and turn it on. When the tubes have had a chance to warm up you should have a scanning pattern on the end of your cathode ray tube.

Now adjust the frequency of the horizontal sweep circuit oscillator, using the control mounted in hole 8, until you have the usual complete television scanning pattern. Next, adjust the amplitude of the vertical sweep circuit oscillator; this is the left hand one of the controls on the front of your chassis, until the height of the scanning pattern is approximately three-quarters as great as the width of the scanning pattern. Now, adjust the intensity and focus controls until the television scanning pattern on the face of your cathode ray tube is just visible.

With these adjustments, you will now notice a dark band across the television scanning pattern. This indicates that hum is present on the grid of the cathode ray tube.

At this time you can conduct another experiment by varying the frequency of the vertical sweep circuit oscillator. This is accomplished by adjusting the potentiometer mounted in hole 5. As you vary this potentiometer in one direction, the dark hum band on your scanning will move upward; as you vary the potentiometer in the other direction, the hum pattern will move in a downward direction. Before leaving your experiment, adjust the potentiometer in hole 4 until the hum pattern remains stationary.

Now, connect one pigtail lead of a .1 mfd. condenser to the yellow lead connected to one of the prongs on the socket just mounted. The other pigtail lead of this .1 mfd. condenser is to be connected to the red wire which leads to your cathode ray tube. The red wire is now connected to one side of the 2.5-volt filament winding on your power transformer. Solder the connection. In doing this work, you must be sure that your experiment is turned off. In fact, it will be advisable to disconnect it from the 110-volt, 60-cycle supply.

Now place the tubes in their proper sockets, turn the experiment on, and give the tubes time to warm up. With this new connection, you will discover that the hum band formerly indicated on the face of your cathode ray tube has been eliminated entirely, or at least greatly diminished.

EXPERIMENT 106

NOTING EFFECTS OF HUM ON A TELEVISION SCANNING PATTERN WHEN APPLIED TO DEFLECTION CIRCUITS

Remove the 150,000 ohm resistance now connected from the center terminal on the 15,000 ohm potentiometer and the socket mounted just back of that potentiometer. Then connect the yellow wire which leads to your cathode ray tube, to the center terminal lug on the 15,000 ohm potentiometer.

You now have a 2 megohm resistance connected between the center terminal lug on the terminal strip mounted between holes 5, 6, 7, and 8 and ground. Disconnect the grounded lead on this 2 megohm resistance and connect it to the left hand terminal lug on the terminal strip just mentioned. You do not at this time have any connection made to the terminal lug in question. To this same terminal lug, also connect one pigtail lead of a 150,000 ohm resistance. The other pigtail lead of the 150,000 ohm resistor goes to ground. Solder the connections. Now, connect a piece of hookup wire to the center junction of the two resistors; that is, this piece of hookup wire goes to the center of the pigtail lead of the 2 megohm resistance and the 150,000 ohm resistance (point A in Fig. 17). The other end of this piece of hookup wire goes to the free pigtail lead on the .1 mfd. condenser which is now connected between one of the 2.5-volt terminals on the power transformer and the socket mounted just back of the 15,000 ohm control.

You now have a .1 mfd. condenser connected between one of the 2.5-volt terminals on your power transformer and the special socket mounted at the back of the 15,000 ohm potentiometer. Disconnect this pigtail lead from the 2.5-volt terminal and move it over to one of the primary terminals on your power transformer. The primary terminal to use is the one opposite to the primary terminal which is now grounded through a .1 mfd. condenser.

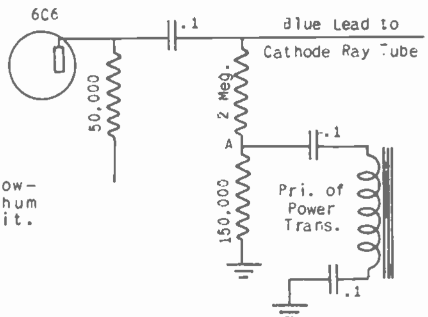


Fig.17 Wiring diagram showing method of introducing hum into horizontal sweep circuit.

Place all of your tubes in their correct sockets, turn the experiment on and give the tubes time to warm up. After the tubes have warmed up, you should have a television scanning pattern on the face of your cathode ray tube.

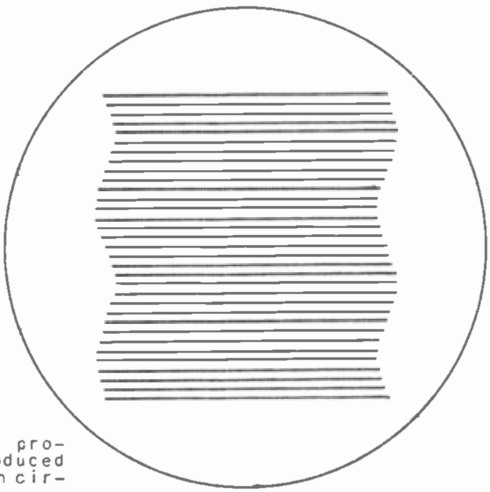


Fig.18 Showing pattern produced when hum is introduced into horizontal deflection circuit.

Now, since we have introduced hum into the horizontal deflection of your cathode ray tube, you will find that the pattern on the end of the cathode ray tube does not have straight sides as formerly experienced, but rather the sides of the pattern are distorted similar to that shown in Fig. 18.

Now remove the 150,000 ohm resistance connected to the terminal strip mounted between holes 5, 6, 7, and 8. Replace the 2 megohm resistance in its original position and disconnect the piece of hookup wire now connected to the .1 mfd. condenser mounted on the socket behind the 15,000 ohm control.

You now have one pigtail lead of a 2 megohm resistance and one pigtail lead of a .1 mfd. condenser connected to one of the terminal lugs on the terminal strip which is mounted under the right hand bolt holding the filter choke in place. Remove the pigtail lead of the 2 megohm resistance. In its place connect one pigtail lead of a 150,000 ohm resistance and solder the connection. The other pigtail lead of the 150,000 ohm resistance goes to the free or unused terminal lug on this same terminal strip. Also, to this same terminal lug, connect the pigtail lead of the 2 megohm resistance and a piece of hookup wire. Solder the connection. The other end of this piece of hookup wire is to be connected to the .1 mfd. condenser now connected to the socket mounted at the back of the 15,000 ohm potentiometer. These connections are shown in Fig. 19.

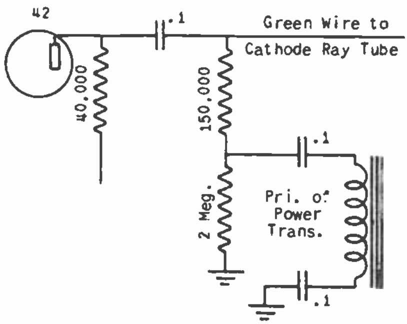


Fig.19 Showing method used to introduce hum into vertical sweep.

Place all of your tubes in their correct sockets, plug the experiment in and give the tubes time to warm up.

You should now have a television scanning pattern on the face of your cathode ray tube. At this time, it is advisable to adjust the frequency of your horizontal sweep circuit oscillator by varying the potentiometer mounted in hole 8. The number of lines on the face of your cathode ray tube should be reduced so that the space between the lines is readily discernible. Now, with hum introduced into the vertical sweep circuit, you will find that at either the top or bottom of the pattern, the lines will be separated considerably, while at the other end of the pattern, the lines will be just opposite. If the lines are spaced widely apart at the top, they will be cramped together at the bottom; if they are cramped together at the top, they will be spaced widely apart at the bottom.

If you had a television picture on the face of your cathode ray tube, this type of hum distortion would be exceedingly apparent.

EXPERIMENT 107

EFFECT OF TOO MUCH SYNCHRONIZATION ON TELEVISION SCANNING PATTERN

You now have one pigtail lead of a 2 megohm resistance and one pigtail lead of a 150,000 ohm resistance connected to one of the terminal lugs on the terminal strip mounted under the right hand bolt that holds the filter choke in place. Remove the 150,000 ohm resistance entirely and connect the pigtail lead of the 2 megohm resistance to the .1 mfd. condenser connected to the other end of the same terminal strip. Also, remove the piece of hookup wire connected between this terminal strip and the socket at the rear of the 15,000 ohm potentiometer. You can, at the same time, remove the .1 mfd. condenser now connected between one of the primary terminals on the power transformer and one of the solder lug terminals on the socket mounted at the back of the 15,000 ohm potentiometer.

You now have a synchronizing control applied to terminal #4 on the 8-prong socket mounted in hole 9. You will remember that previous instructions told you that the bare ends of the two twisted pieces of wire should not touch each other; that is, only a capacity was formed, instead of having an electrical connection. Now it is advisable to make an electrical connection.

The other end of the long piece of hookup wire is now connected to one of the primary terminals on the power transformer. Disconnect this end of the piece of hookup wire and connect it to one of the solder lugs on the socket mounted to the rear of the 15,000 ohm potentiometer. To this same lug connect the pigtail lead of a .1 mfd. condenser. The other pigtail lead of the .1 mfd. condenser is to be connected to one of the 6.3-volt filament terminals on your power transformer. The one to use is the one not now grounded.

Using these connections, you will now have approximately 6.3 volts applied to the synchronizing grid on the vertical sweep circuit oscillator.

Plug the tubes in their correct sockets, turn the experiment on, and give the tubes time to warm up. With the experiment in operation, you should now have a regular scanning pattern on your cathode ray tube. However, this time you will notice that severe distortion exists. The distortion is noticeable by the congestion of lines at one end of the pattern and the spreading out of the lines over the balance of the pattern. Congestion of the lines at one end of the pattern takes on the appearance of a bright line across this edge of the pattern. This bright line is created by the fact that a great many of the lines have been so compressed together as to create the illusion of one large bright line. The obvious remedy for such a situation would be to reduce the amount of synchronizing voltage used.

EXPERIMENT 108

BUILDING AND TESTING SYNCHRONIZING PICKOFF STAGE

In starting this experiment, it will be necessary to disconnect all of the apparatus which you now have connected to the 6-prong socket mounted in hole 7, the 5-prong socket mounted in hole 1, and the 500,000 ohm potentiometer mounted in hole 8. A wiring diagram for the experiment is shown in Fig. 20.

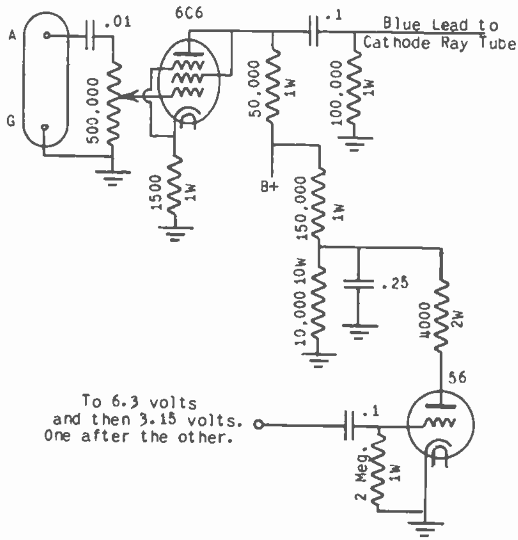


Fig.20 Wiring diagram of synchronizing pickoff stage.

You will first rebuild the vertical input amplifier, using the type 6C6 tube mounted in hole 7. Connect a short piece of hookup wire to one of the outside terminal lugs on the 500,000 ohm potentiometer mounted in hole 8. This is the terminal lug nearest the back of the chassis. The other end of this piece of hookup wire is to go to the solder lug mounted at the left hand side of the aerial and ground strip. Solder the connection. Now, connect one pigtail lead of a .01 mfd. condenser to the A post on the aerial and ground strip. Solder the connection. The other pigtail lead of this .01 mfd. condenser is to go to the remaining outside terminal lug on the 500,000 ohm potentiometer. Solder the connection. To the center terminal lug on the 500,000 ohm potentiometer, solder a piece of hookup wire. This piece of hookup wire is to be passed up through the chassis, using any convenient hole and should be made long enough to reach the grid cap on a 6C6 tube mounted in socket 7. With the wire made long enough, solder on a grid clip.

The suppressor grid prong on the 6-prong socket mounted in hole 7 is to be connected to the cathode prong on this same socket. Also, to this prong, connect one pigtail lead of a 1500 ohm resistor. Solder the connection. The other pigtail lead of the 1500 ohm resistance is to go to any conveniently placed solder lug. The solder lug mounted at the left hand side of the aerial and ground strip would probably be the most convenient. Solder the connection. Take a short piece of hookup wire and connect the screen grid prong to the plate prong on the 6-prong socket mounted in hole 7. To the plate prong, also connect one pigtail lead of a 50,000 ohm resistance, also one pigtail lead of a .1 mfd. condenser. Solder the connection. The remaining pigtail lead of the 50,000 ohm resistance is to go to the B+ terminal on the terminal strip mounted between holes 5, 6, 7, and 8. To this same B+ terminal strip, also connect one pigtail lead of a 150,000 ohm resistance. Solder the connection.

The remaining pigtail lead of a .1 mfd. condenser just connected to the 6-prong socket is to go to the center terminal lug on the terminal strip mounted between holes 5, 6, 7, and 8. To this same terminal lug you now have connected the blue wire running to your cathode ray tube and a 2 megohm resistance. Remove the 2 megohm resistance and in its place put a 100,000 ohm resistance. You should now have connected to this center terminal lug the blue wire leading to your cathode ray tube, one pigtail lead of a 100,000 ohm resistance, and one pigtail lead of a .1 mfd. condenser. Be sure that the other end of the 100,000 ohm resistance is grounded.

You now have one pigtail lead of a 150,000 ohm resistance connected to the B+ terminal on the terminal strip mounted between holes 5, 6, 7, and 8. The other end of this 150,000 ohm resistance is to go to the nearest terminal lug on the terminal strip mounted at the side of hole 3. To this same terminal lug connect one pigtail lead of a .25 mfd. condenser, one pigtail lead of a 10,000 ohm resistance, and one pigtail lead of a 4,000 ohm resistance. Solder the connection.

The other pigtail leads of the 10,000 ohm resistance and the .25 mfd. condenser are to be connected to ground by using any conveniently placed solder lug.

The other pigtail lead of the 4,000 ohm resistance is to be connected to the plate terminal on the 5-prong socket mounted in hole 1.

Now, connect a short piece of hookup wire to the cathode terminal on the 5-prong socket mounted in hole 1. The other end of this piece of hookup wire is to be connected to a solder lug placed under the right hand bolt holding this socket in place. Solder the connection.

Connect one pigtail lead of a .1 mfd. condenser and one pigtail lead of a 2 megohm resistance to the grid terminal on the 5-prong socket mounted in hole 1. Solder the connection. The other pigtail lead of the 2 megohm resistance is to go to any conveniently placed solder lug. Solder the connection. The other pigtail lead of the .1 mfd. condenser is to go to the center terminal lug on the terminal strip mounted at the side of hole 3. To this same terminal lug also connect one end of a piece of hookup wire and solder the connection.

At this time, it will be necessary to remove the synchronizing connections made to socket 9. Disconnect the piece of hookup wire connected between prong #4 on socket 9 and the pigtail lead of the

.1 mfd. condenser mounted on the socket mounted at the rear of the 15,000 ohm control.

At the beginning of this experiment, the piece of hookup wire connected to the center lug on the terminal strip mounted at the side of hole 3 is not to be used. Now, connect a piece of hookup wire to the A post on the aerial and ground strip. The other end of this piece of hookup wire is to go to one of the 6.3-volt filament windings on the power transformer. The 6.3-volt terminal to use is the one which is not now grounded. Be sure that the other terminal is grounded, as used in a previous experiment.

With these connections made, place all of your tubes in their correct sockets, plug the experiment in and give the tubes time to warm up. The volume control mounted in hole 8 should be turned as far to the left as it will go so that no signal input voltage will be applied to the grid of the vertical amplifier. In your preceding experiments, you had rotated your cathode ray tube 90° so that the horizontal sweep circuit oscillator and amplifier produced a vertical trace instead of a horizontal trace. This time, we want you to rotate the cathode ray tube so that the horizontal sweep circuit oscillator, the type 6SC7 tube mounted in hole 9 and the horizontal amplifier mounted in hole 10 will produce a horizontal trace. The intensity and focus of the trace can then be adjusted. Now, gradually increase the volume control mounted in hole 8 until you secure a sine wave on the end of your cathode ray tube. The amplitude of this should be adjusted so that it nearly covers the entire surface of the cathode ray tube.

Now, without touching any of your controls, except the intensity control which is the center volume control on your chassis, turn your experiment off and move the piece of hookup wire now connected between the A post on your aerial and ground strip and the 6.3-volt terminal on your power transformer over to the center tap on the 6.3-volt winding on your power transformer. This will then apply a voltage of 3.15 volts to the input of your vertical amplifier.

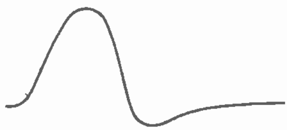
Now without changing any of the controls on your oscilloscope, turn the experiment on and adjust the intensity of the trace. The purpose of this portion of the experiment is for you to make a comparison in the vertical amplitude of the trace when using the 6.3 volts applied to the input of the amplifier and when using the 3.15 volts applied to the input. Now, disconnect the piece of hookup wire connected to the center tap terminal on your power transformer. This is the 3.15-volt terminal on the power transformer. The piece of hookup wire is then to be passed over the top of the chassis, down through hole 3 and connected to the plate prong on the 5-prong socket mounted in hole 1. Solder the connection.

You now have a piece of hookup wire connected to the center terminal lug on the terminal strip mounted at the side of hole 3. The other end of this piece of hookup wire is to be connected to the 6.3-volt terminal on your power transformer. With this connection made, you are now ready to test the synchronizing pickoff stage.

In this experiment, a type 56 tube will be used in socket 1 and the other tubes will be placed in their correct sockets. Turn the experiment on and give the tubes time to warm up.

With the volume control mounted in hole 8 set at the off position, you should have a horizontal trace on the face of your cathode ray tube. Adjust the focus and intensity of this trace. Next, gradually increase the gain on volume control 8. As you do so, you will secure a pulse which is similar to that shown in Fig. 21. With reference to the zero line, you will notice that this pulse is entirely in the positive direction. This pulse is known as a synchronizing pulse.

Fig.21 Oscillogram of synchronizing pulse.



Now, without changing any of the controls on your oscilloscope, turn the oscilloscope off and move the piece of hookup wire now connected to the 6.3-volt terminal on the power transformer over to the center tap terminal of the 6.3-volt winding. This will apply 3.15 volts to the input of the synchronizing pickoff stage. Solder the connection. Turn the experiment on and do not make any adjustments other than the intensity control. This time you will notice that the amplitude of the synchronizing pulse is practically the same with 3.15 volts applied as when 6.3 volts were applied to the synchronizing impulse stage. In checking the variation in voltage applied to the vertical amplifier, you found that the amplitude of the sine wave changed appreciably when varying the voltage 2:1.

This demonstrates the fact that when using a synchronizing pickoff stage for television synchronization purposes, you will have approximately the same amplitude reproduced from the synchronizing pickoff stage, even though the input voltage may vary over an appreciable range. This type of synchronizing pickoff stage produces the results mentioned while there are other types of synchronizing pickoff stages which do not work quite as satisfactorily in this respect.

Notes

(These extra pages are provided for your use in taking special notes)

Notes

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Notes

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