# RADIO PROGRESS

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# How Your Grid Leak is Made

## *There Are Several Styles from Which You May Choose*

By HORACE V. S. TAYLOR

THERE is the story of the man who drove an automobile several months before he learned that there was such a thing as a storage battery on board his car. That was probably worse than the radio fan who operates his tube set without knowing anything about his grid leak, but that is no excuse for the latter.

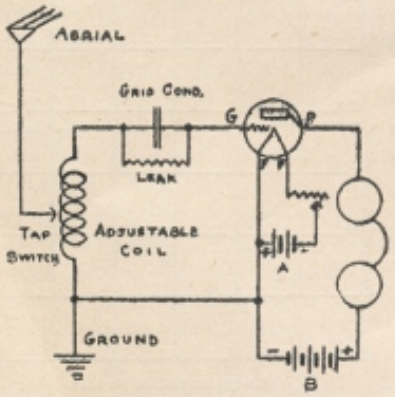


Fig. 1. This Hook-up Shows How Leak is Connected

Perhaps you may call to mind some set (remember we are not talking about crystal sets in this article) which has clips for a grid leak and yet no such unit is installed. However, that does not mean that it is working without a leak. There always must be one or else the tube will stop operating in a fraction of a second.

### Tube Like a Furnace

It is very much like the different ways of installing a hot air furnace in your cellar to warm your rooms in the winter time. All the newer installations have a cold air duct connecting the base of the furnace to an opening in the basement walls, and this serves to conduct the air from outside the house into the furnace, where it is heated and ascends to your rooms above.

Some of the older installations, however, neglected this duct and instead took the cold air from the cellar itself, which was warmed and sent upstairs. In this case the air which is heated certainly comes from somewhere. It could not be consumed from the cellar itself without being replaced, as such an action would cause a vacuum and the circulation would stop in a very short time. As a matter of fact, the various windows, doors and cracks around pipes and the like let in enough air to the cellar to furnish that used by the heating system. Of course this idea is not as good as having a definite duct which may have a damper for controlling its action.

### Where the Leak is Found

You certainly would not say because you see no duct at the base of your furnace that no air was passing up the hot air pipes. You can feel the higher temperature in upper rooms and you know that the air must be leaking in from somewhere. In the same way a set which has apparently no grid leak may work fairly well because the leakage over the insulation and through the socket base may be enough to approach the right value. No insulation (except a vacuum) is perfect, and a small amount of leakage goes on all the time from your grid terminals, wires and connections. However, a definite grid leak will be an improvement unless the set already has so many conducting paths that the resistance is already too low. Such cases, however, are not very frequent.

The electrons, which are shot off by the filament of the vacuum tube, shoot across to the plate under the attraction of the positive charge furnished by the "B" battery. However, a small proportion of these negative particles fall by the wayside—in other words, strike the grid wires and yield their charge to this element. This builds up a negative potential on the grid.

### Grid Blocked Without Leak

If there were an electric conducting path between the grid and the filament, this charge would immediately leak back to the filament, but the grid condenser allows no direct current or leakage of a charge to pass. The result would be that if there were really no leakage at all the charge on the grid would become more and more negative as the electrons piled up on it, until at last the repelling action exerted on the electrons leaving the filament would be tremendously great. "Like repels like" is the rule for electricity, and as a result no more electrons would be able to get through the strong negative field of the grid and so the plate would no longer receive any of these tiny visitors which make up the plate current. This is called "blocking."

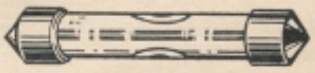

Fig. 2. Most Non-adjustable Leaks Take This Shape

Fig. 1 is the hook-up for a simple set using a leak and condenser. Although

the tuning coil is connected between the grid and filament as usual, the presence of the condenser allows only high (radio frequency) oscillations to pass, and the charge of direct current which is built up by the stray electrons inside the tube cannot get away. By putting in the grid leak as shown it allows this charge to be dissipated and so prevents blocking of the tube.

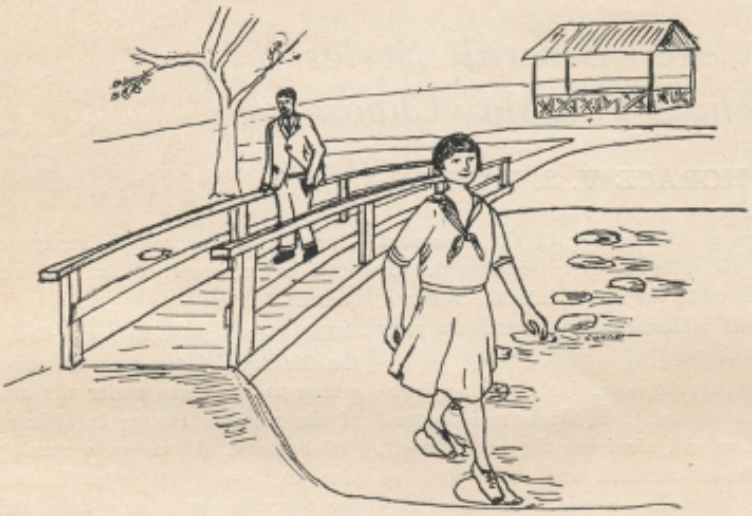

**Fig. 3. This Principle Explains Why Leaks Consisting of Separate Grains Are Not as Good as Those with a Continuous Resistance**

By using the proper value of leak, the average voltage or bias on the grid is kept as a value which gives the greatest amount of loudness from your detector tube. Notice that we say the *average* voltage. As a radio signal comes in the oscillations coming down from the aerial, through the tuning coil, pass easily through the capacity of the condenser and so are impressed on the grid. This fluctuation causes a similar change in the quantity of electrons getting across from the filament. Another result is that the number striking the grid varies from instant to instant, and so the grid potential also changes. As soon as the audio waves stop for an instant the grid potential is immediately restored to its average value and the action is ready to begin all over again.

You may wonder why it is not better to use a "C" battery on the detector instead of a grid leak and condenser. As a matter of fact, this is sometimes done and it works very well. However, there are two disadvantages of this scheme. In the first place it is found that the changes in average bias on the grid make this scheme of detector action more sensitive than that of using a *steady* bias from a "C" battery. And then a "C" battery must be renewed every few months, which is a bother and an expense, while a grid condenser and leak will last indefinitely.

### Don't Worry About Small Changes

From this you can see that to get the right average voltage on the grid you must use a leak with the right amount of resistance. To be sure, this is not very critical, and a change of 10 or 20 per cent has practically no effect. But if the set has say twice or half as much resistance as it should, then the reception will be not nearly as good.

There are two general classes of leaks, —the fixed and the adjustable. The advantage of the former is its simplicity and cheapness. The objection to it is that in many sets the right value of megohms is not used. (A megohm you recall is one million ohms.) To be sure, in adjusting your set you may try out values labelled 1, 1½, 2, 3, 4, etc. But you must remember that the figures on its label means nothing in the life of the average grid leak. Still, if you use a reliable brand, which has been tested, then you can believe that the labels are telling the truth.

### Meet the Variable Leak

The other style of unit is the adjustable leak. This has the advantage that you do not need to pay any attention to the label at all, as you make your own value of megohms. The disadvantages here are that the adjusting handle is a tempting device for the experimenter to play with and further, even if this is not monkeyed with, the resistance of the leak may change from time to time and the unit may even become worthless through wear if the adjustment is manipulated too often.

A form of fixed leak which is very popular appears in Fig. 2. The end caps form the conducting terminals for the high resistance inside the tube. There are several ways of making such a device. One is to make a paste of finely divided carbon, which is usually obtained in the form of lamp black. This is mixed with some non-conductor, like paper or clay, and the whole thing mixed into a smooth mass.

### Squeezed Into a Ribbon

This is then put into a sort of pump where a piston presses on the paste contained in a cylinder. At the end is a small hole through which the doughy mass is squeezed in the form of a fine ribbon. This is dried and then attached to metal ends. The latter are finally soldered to the brass ferrules, which are seen at the ends of practically all non-adjustable leaks.

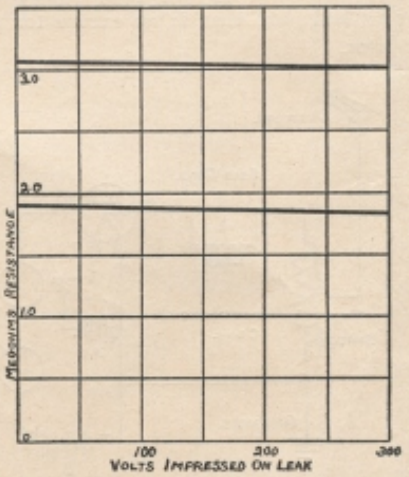


**Fig. 4. A Good Leak is Quite Steady in Resistance, Even with Varying Voltage.**

Another type of high resistance is obtained by cutting absorbent blotting paper into narrow strips and soaking these in India ink. The latter has very finely divided carbon for its basis. This is eagerly sucked up by the blotting paper and when dried forms a conducting path with a very high resistance for its length.

Both these processes give good results when carefully worked out. However, there is a good deal of chance for variations in manufacturing with resultant lack of uniformity in the resistance. Of

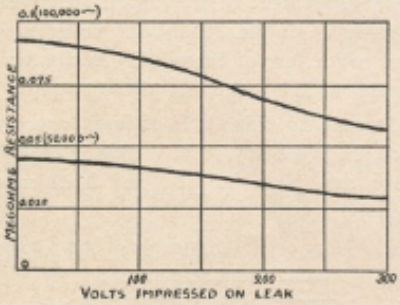


**Fig. 5. This Leak is for Use in a Resistance Coupled Amplifier**

course, too, such units may easily be affected by high humidity.

### Spinning a Wire of Glass

Another way of making grid leaks has recently been developed by Durham & Company. They use a very thin metallic film deposited on glass. As they report on this process, the apparatus for making the resistance filament consists of an ingenious and very efficient machine for the spinning of glass into a small wire shape of uniform diameter. This glass is spun in lengths of five hundred feet, wrapped on a reel, passed through a solution of the conducting material, then through a high temperature furnace through which furnace a steady flow of gas is maintained. A metal by-product of zinc is reduced to gas and through a process of heating the fine glass filament this metallic gas is "thrown down" or flashed on to the outer surface in varying degrees of thickness, depending upon the resistance that is required.

The glass wire with its conducting film is next coated in a chemical bath of insulating fluid and dried by the application of heat. The conducting film is thus thoroughly protected against atmospheric changes.

### Keeping the Meters Right

This metal-coated filament is then aged for a period of several days to enable the glass to reach its original consistency. The wire next goes to a department where it is cut into actual lengths required for the grid leak assembly, and where it is soldered to the end brass caps comprising the contacts at either end of the grid leak. This work is done by very skilled workers who are each capable of assembling in the neighborhood of five hundred leaks per day. After assembly the leaks are tested and stored in *trays*.. The meters used for such tests are, for the sake of accuracy, constantly checked against laboratory standards.

The metallic form of leak has some advantages. In the carbon type, even if the resistance is properly labelled at first, there is a chance that it might change in value. Carbon has a rather high temperature co-efficient which causes a *lowering* of resistance as the material gets hotter. This is just the opposite of most every metal whose resistance almost invariably increases with rising temperature. This effect, however, is not at all serious since the radio set never gets above room temperature and the fluctuations of heat between summer and winter are not great enough to cause much effect.

### Claim There is Arcing

Some manufacturers claim with carbon leaks that the passage of the current through the carbon resistance causes minute arcing between the particles of carbon which although not visible to the eye may be clearly heard in the form of hissing and scratching noises when subjected to high voltage or sudden impulses. This is particularly noticeable in such circuits as resistance coupled amplifier circuits, filter circuits, and even in the grid circuit they are subject to fluctuations of potential.

This theory, however, is in error. It has been found that the voltage necessary to maintain an arc does not decrease with the spacing between the electrodes when they are separated by microscopic distances, as they are in the leak. In other words, the voltage necessary to form such a tremendous number of arcs in series would be enormous. Instead of this the pressure from the electron charge on a grid leak is only a small fraction of a volt. There is no arcing at all in a grid leak.

### What Makes the Noise

However, it is quite true that many leaks make a lot of noise. The cause of this disturbance is to be found in the varying resistance which carbon has when subjected to a change of pressure. This is the action which you get in an ordinary telephone transmitter or in a microphone. The slightest vibration on a carbon path will cause an electrical noise if the particles of the material happen to be in the right condition of spacing and pressure.

This idea may be seen more clearly from Fig. 3. Here we have a path of stepping stones across the river. In the background we see a bridge. When the stones are working right the girl passes over them without any trouble at all. However, you can easily imagine that a slight disturbance here would have more effect on her smooth passage than a similar disturbance in the path of the man across the continuous bridge.

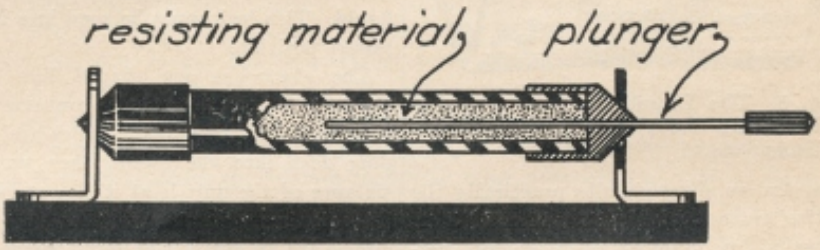


**Fig. 6. The Basic Principle of Most Variable Leaks**

### Voltage Leaves Resistance Unchanged

As an example of how constant the metallic grid leaks are, Fig. 4 shows the variation in resistance with different degrees of voltage impressed across them. The lower curve is for a two megohm leak and the upper for a value of three megohms. Notice that although they fall off very slightly they are almost steady in value way up to 300 volts. Of course, this high pressure would never be used in actual practice.

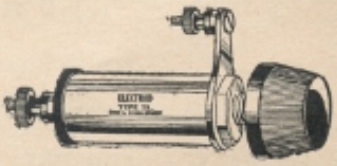

**Fig. 7. The Variation in This Unit is Obtained by a Screw**

A lower resistance for use in a resistance coupled amplifier must carry a great deal more current than an ordinary grid leak. It is therefore, not so

easy to build and is more expensive. Curves of the performance of such units appear in Fig. 5. The upper curve is for 90,000 ohms and the lower for 40,000.

Another form of resistance is illustrated in Fig. 6. We are now in the variable leak class. Several manufacturers use this general idea, but modified to suit their own processes. A tube is filled with a high resistance material and a metallic plunger carries the current and so short-circuits practically the entire amount of high resistance. This gives a low number of megohms, perhaps as small a value as 1/10.

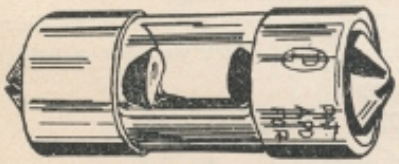

Fig. 8. The Liquid in Tube Touches More or Less of the Half-circle Ends

### Raising the Megohms

As the plunger is withdrawn to the right it leaves more and more of the resistance in the path of the current. When pulled way out there is no metal in circuit and so the resistance of the leak is at its highest—10 or 20 megohms depending on what kind of material fills the tube. One popular kind is Prussian Blue.

Fig. 7 shows the form of adjustable leak put out by the Electrad Company. Instead of sliding a plunger back and forth, a screw is used which gives very fine adjustment. It is also easy to mark the position of such a handle. It takes up considerably more space than the type shown in Fig. 6.

Another very ingenious way of changing the value of resistance is displayed in the "Turnit." This, as you see from Fig. 8, has the general shape of the ordinary grid leak except that it is much larger in diameter. The glass tube contains a liquid which has two electrodes dipping into at the ends. Most of the resistance of the tube lies at the contact between the electrodes and the liquid. This leak must be used in a horizontal position.

The electrodes are shaped like half circles. When the whole container is turned so that these half circles are dipping deep into the liquid, then the resistance of the unit is at its lower value. By rotating the tube so that the half circles are up out of the liquid instead of dipping into it at the ends, the ohms rise to a high value. Of course, intermediate positions give results between these two values.

One more kind of leak should be mentioned. This is the home made variable shown in Fig. 9. It is made right on the grid condenser by drawing pencil lines across from one terminal to the other. The current follows these lines and so relieves the grid of its blocking charge.

### Juggling with the Megohms

The more lines there are in parallel, the more current will be conducted, or in other words, the lower the resistance of the leak. If you have too many megohms, then draw a line or two across. If you get reckless and put on too many lines and so drop the megohms to a resistance which is too small, then the remedy is simple. Take out your eraser and rub a few of them off. As the lines disappear the megohms pile up again.

In making this style of leak, one caution is necessary. If a rope breaks in only one place it will not hold much weight. And if a pencil line reaches almost all the way to the metal end it will carry *no* current. In other words, the pencil mark must actually touch the end conductor to be of any value at all.

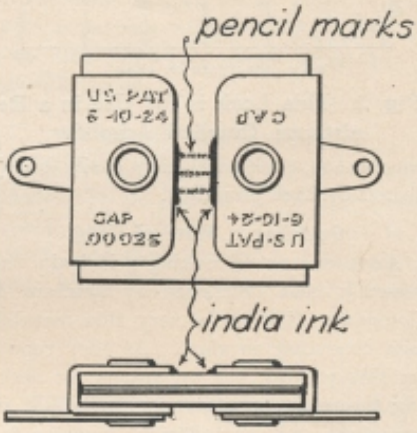


Fig. 9. The Home-made Leak. Don't Omit the India Ink

### Filling in the Cracks

That is where most home-made grid leaks fail. The metal cap at the end of the condenser stands up a little way as shown at the bottom of Fig. 9. A lead pencil, even with a very sharp tip, cannot get into the extreme corner. To get away from this difficulty, after several lines have been drawn, fill in the cracks at the bottom of the metal caps with a small amount of India ink, either the cake form or an ordinary liquid drawing ink like Higgins is satisfactory. This ink, as already explained, has a carbon base, and will carry the pencil line up into good contact with the metal.

Such a grid leak when well made is easily adjusted and is fairly constant in value, although of course, it is not as stable or as conveniently used as one of the manufactured articles, which we have described.