June 4, 1929. G. A. WELLS 1,715,879

HIGH RESISTANCE UNIT

Filed Feb. 3, 1928

Fig. 1.

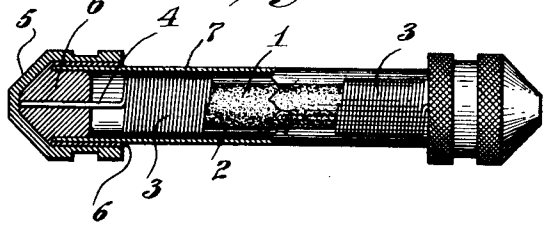
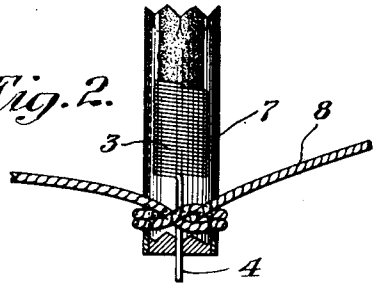
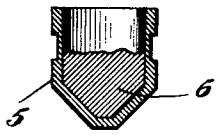


Fig. 2.





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his ATTORNEY

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UNITED STATES PATENT OFFICE.

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HIGH-RESISTANCE UNIT.

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This invention relates to resistance units, particularly to high resistance units used as grid leaks for thermionic tubes.

An object of my invention is the production of a high resistance unit, the resistance of which varies but slightly over an extended period of time and use.

Another object is the provision of a high resistance unit, which when used in thermionic tube circuits is substantially noiseless in operation.

A further object is the provision of a high resistance unit which can readily be calibrated.

Another object is the provision of a simple spring contact arrangement for gripping a high resistance element firmly and positively thereby assuring good electrical contact.

Still another object is the provision of an improved method of sealing a high resistance element within an enclosure in a substantially air-tight and moisture-proof manner.

Still another object is to provide means of taking up any residual moisture by use of a getter.

These and other objects and advantages and the manner of attaining them will appear more clearly in the following discussion.

High resistances of various types, designed particularly for use as grid leaks and resistance coupling units in vacuum tube circuits, are well known in the art. For example, resistances constructed from india ink, graphite pencil marks, and sputtered metals, among others, have proved useful. However, such units, in many cases, having the disadvantages of producing noise in the output circuit of vacuum tubes with which they are connected and of varying in resistance considerably over a period of time. The noise caused by such grid leaks may be due to a variety of causes, such as poor connections to the resistance element and possibly electrolytic action in the said element, provided moisture is present, while the change in resistance may be due to many reasons, more or less obscure. It is difficult to calibrate grid leak resistances of the type heretofore known to the art and to produce duplicate units having the same value of resistance.

According to my invention, I produce a resistance unit, the resistance of which varies but slightly with age and use, causes but very little disturbance in the output circuit of the tube with which it is used and can be constructed easily. I accomplish these results by utilizing a body of ceramic or other similar insulating material, which may be in the form of a rod, coated with a mixture of carbon and graphite that I preferably apply to the rod in dry condition. However, best results are obtained by using unglazed porcelain as the body to be coated. When the mixture is applied dry there can be little or no electrolytic action, which action may be caused by the presence of moisture. In order to insure that the resistance of the finished unit shall remain substantially constant, it is preferable thoroughly to clean the rod, to heat it sufficiently to drive off all moisture, and to keep it in a heated or thoroughly dry atmosphere between the steps of the assembly process. Connections may be made to the coated rod in any suitable manner but I prefer to utilize spring connections formed by coil springs of such dimensions as to grip the rod tightly when screwed or pushed on it.

In order to protect the unit from damage and to insure that the operating characteristics thereof shall not be affected by atmospheric or other conditions the element may be enclosed in a sealed tube, of glass or other insulating material, provided with suitable contact members at the ends. Such an enclosure can be effected by placing the resistance unit within a glass tube and then sealing the ends of the tube into metallic caps by means of solder or other metal such as Wood's metal. In sealing the tube into these caps I find that while solder may be used alone and may frequently be made air-tight, it is preferable to utilize with the solder a portion of resin. When solder and resin are used properly a very solid and apparently hermetically tight seal is secured. At any rate such a tight seal is obtained that a sealed tube containing powdered fused calcium chloride, or similar hygroscopic or deliquescent material can be submerged in water for days at a time without the calcium chloride or other material showing the slightest evidence of having taken up water, and these leaks may be similarly treated and not show a change in resistance from this cause.

As the conducting material is applied to the rod in a dry condition, it is very easy to produce a unit of any desired resistance it being necessary merely to apply more material to decrease the resistance or to remove some to increase the resistance. Where a spring contact is used the length of active rod between the contacts, and hence the resistance

of the unit, can be varied by moving the contacts closer together or farther apart. This is particularly true of the type of spring contact which I disclose hereinafter.

In order that the invention shall be understood more clearly reference may be had to the following description and accompanying drawings illustrating one embodiment of my invention.

In the drawings, Fig. 1 shows a resistance unit constructed in accordance with my invention.

Fig. 2 shows such a unit in the process of assembly.

In these figures is illustrated a resistance unit comprising a rod 1 of ceramic material such as unglazed porcelain, coated with a mixture of graphite and carbon 2 and provided at its two ends with helical spring contact clips 3 each of which may be drawn out to form a connecting wire 4 which is positively connected to the contact caps 5, which may be of brass or other metal, by means of solder 6. Positioned around the rod 1 and within the caps 6 is a tube of glass or similar material 7. This tube fits fairly closely within the caps 5 and is held therein by a quantity of solder 6 which is positioned between the outer wall of the tube 7 and the inner wall of the contact cap 5. The connecting wire 4 preferably, but not necessarily, extends outwardly into contact with the inner wall of the contact cap 5, and in order to reduce heat conduction from the end caps to the coated rod during sealing the wire 4 may be left or allowed to remain relatively long, or several convolutions of the coil spring 3 might be interposed between the rod and wire 4. These convolutions should be slightly spaced from one another in order to reduce heat conduction to the point of contact of spring with the rod. The rod 1 as stated above consists of ceramic material, such as unglazed porcelain. While I prefer to use a rod of ceramic material such as porcelain, it is possible that there are other materials having suitable characteristics, that might be used as well. The coating 2 on the rod consists of a mixture of finely divided carbon and graphite, which is mixed in a suitable fashion and applied to the rod in any suitable manner, for example, as by rubbing it on with the fingers. The expression "carbonaceous material" used in the claims is intended to mean such materials as carbon or graphite, or the substantial equivalents thereof, as well as materials capable of reduction to the form of carbon, or combinations of such materials. The reason for applying a mixture of carbon and graphite to the rod is that sometimes when either carbon or graphite of certain kinds is used alone the resistance of the finished unit will be found to vary with time considerably. Generally in the case of carbon alone the resistance increases, while with graphite alone the resistance decreases. I have found that by properly preparing a mixture of carbon black or lamp black and graphite that a coating on the rod can be made to maintain more nearly a calibrated value of resistance over a longer period of time and of use than if either is used alone. The proper mixture of carbon and graphite will, of course, vary with the particular properties or qualities of the materials used, the proper mixture being determined for different materials by experimentation. In making the mixture carbon having a positive time resistance coefficient should be mixed with graphite having a negative time resistance coefficient, in such ratio as to give a resultant mixture having substantially zero coefficient. For example, I have found that when carbon produced by Godfrey L. Cabot Inc., of Boston, Massachusetts, under the name Elf-G, and Atcheson graphite are used, the ratio of carbon to graphite in the mixture used for coating the rod should be approximately 1 to 1 or 1 to 1½ parts by weight. The carbon and graphite are placed together in a receptacle and thoroughly mixed in any suitable manner, as by shaking the two materials together when dry. This mixture is then applied to the rod in dry condition in any desired manner. I find that the mixture can be applied satisfactorily by rubbing it on to the rod with the fingers, that is to say, a person can take a pinch of the carbon graphite mixture between the fingers and rub it thoroughly on the rod so that the rod acquires a smooth and even coating. After this has been done suitable contacts are made with the ends of the rod, as for example, by means of helices of bronze or other wire, such as I have illustrated in the accompanying drawing, and then the resistance of the element calibrated. If the resistance is found to be too low, a quantity of the coating material between the contacts can be rubbed off with a piece of silk cloth or other material. If the resistance is found to be too high more of the mixture can be rubbed on. Instead of the carbon graphite mixture being applied with the fingers it may be applied by means of brushes, rollers or similar mechanical equipment, and similarly, instead of rubbing the coating off in order to increase the resistance of the element, the coating may be reduced by subjecting the coated element to the action of an air jet, sand blast or by some other process.

Referring more particularly to Fig. 1, it will be noted that I have provided helical coil spring contact members 3 which are slipped over the ends of the rod 1. These contact members 3 are preferably applied after the rod has been excessively coated with the conducting material, and may be utilized in calibrating the resistance of the element by sliding the members closer together or farther apart, as it is desired to decrease or increase

the resistance of the unit. The coil spring member 3 is made of ordinary or phosphor bronze spring wire and is preferably coiled tightly together to a slightly smaller inside diameter than the diameter of the rod to which it is applied. The ends of the rod might be slightly chamfered in order to insure the easy positioning of the spring. The spring is positioned on the coated rod by pushing or screwing in such a manner that the coils of the spring expand slightly and permit the spring to be pushed onto the rod. After the spring has been placed on the rod it may be rotated slightly in the reverse direction in order to insure a more positive contact and a greater gripping action of the spring on the rod.

In order to protect the element from foreign matter and from mechanical injury during use, the tube 7 is provided. As stated above, this tube may be of glass or any insulating material which will withstand the heat treatment described. This tube is held within the contact caps 5 in any suitable manner, preferably by means of solder. Wood's metal or other similar material which is flowed around the outside of the tube between the tube and the inside of the cap, while in a molten condition. While plain solder, Wood's metal, or other material alone may be found satisfactory in some cases, a much more firm and air-tight seal is secured by placing with the molten solder a very small quantity of resin. With resin mixed with molten solder the bond between the glass tube and the cap is so firm that it is impossible unless heated to remove the cap from the tube without breaking the tube. This joint furthermore is entirely moisture-proof and appears to be an hermetic one. In making the joint good results can be secured by using a slow setting solder such as that known as 40–60.

This feature of the glass tube and seal is of considerable importance as by virtue of it the stability of the operation of the resistance is to a large extent insured. Various methods may be used for assembling the element, the contact caps, and tube. For example, I have found that it is possible to make a very satisfactory joint by the following method. First, placing in an empty contact cap a small quantity of solder, with no resin, which is melted by holding the cap in a flame, then thrusting into the cap the element complete, when within the tube. The metal is then allowed to solidify, after which the cap is slightly heated in the flame and the glass tube containing the element is worked from the cap while still having in the end thereof a plug of the solidified metal; which is firmly united to the contact wire of the element and tube also. No resin is used in plugging the tube in the first operation since resin vapor condensing in the element in some cases has a bad effect on the resistance of the element. Next, a piece of hard string 8 is tied by two half hitches or a clove hitch around and near the end of the glass tube, as illustrated in Fig. 2, next, a small quantity of solder and resin is placed in the now empty contact cap and the cap heated to melt the solder. Next, the glass tube carrying the plug of solder and the resistance unit is then thrust back into the cap. This action forces a portion of the molten solder up around the outside of the glass tube between the tube and the inner wall of the contact cap, so as to form in combination with the resin a very tight seal. The plug prevents any further quantity of metal from entering the tube. The string placed around the outside of the tube being pushed further on by the cap insures that the solder and resin shall fill in the entire space between the tube and the cap, as it prevents the molten solder from readily squirting out of the cap at one place. This process is similar in its effect to die-casting under pressure. After these steps have been taken the cap is found to be firmly sealed to the tube and soldered to the contact wire of the rod. The excess of solder that may have been forced out past the string can be removed by the thumb nail so as to leave a neat joint. The cap for the opposite end of the unit can be applied merely by having within the contact cap a suitable quantity of molten solder and resin, then after having slipped the same string to and around the other end of the tube in the manner described above, thrusting slowly into the cap the tube with the first end capped and containing the element complete. The molten solder does not rise within the glass tube to a very great extent, due to the air pressure within the tube, but is squeezed out between the outside wall of the tube and the inner wall of the cap in the manner described above and thereby forms a perfect seal. Solder alone does not always suffice owing to the unequal expansion of the members, but a mechanically strong joint is obtained by the use of resin in the above described way. Such small spaces or interstices as may exist evidently are filled by the resin, forming an hermetic seal.

It is preferable before and while carrying out the steps of the above process to have all the component parts of the unit thoroughly clean and dry, the rod, the mixture, the glass and contacts all being kept thoroughly heated to drive off all moisture.

In order to take up any residual moisture which may possibly remain inside of the sealed tube, a quantity of fused calcium chloride or phosphorous pentoxide may be placed within the tube before the final sealing operation is carried out to act as a getter.

As the entire make-up of the unit consists of inorganic materials not mixed with any binding material or carrier and protected from moisture and foreign substances, the

operating characteristics of the unit remain constant for a fairly long period of time. Furthermore, there is little or no electrolysis or other action which would tend to disturb the resistance values of the unit.

In carrying out the above described process I find that ordinary commercial resin works well. However, it is possible that other resins or gums may be found to produce the same result. While I prefer to use solder and resin as my sealing agent it is possible that other materials such as Wood's metal, may be found to act as well with resin as solder does.

For making certain types of resistances the mixture of carbon and graphite set forth in the preceding description may be applied to a ceramic rod which has been rubbed with a relatively soft metal so as partially to coat the rod with particles of the metal. The metal particles will be spaced from each other slightly and this space will be filled in by the carbon graphite mixture. Resistances having a relatively low resistance can be constructed in this manner, as well as resistances of higher values. In making such an element copper, lead or the like can be used to coat the rod. Aside from the coating of the rod with metal particles the construction of a resistance unit would be carried out as described heretofore.

While I have disclosed, for the purpose of illustration, a particular embodiment of my invention, it will be understood that various modifications and adaptations, such as would occur to one skilled in the art, may be made without a departure from the spirit of the invention, as set forth in the following claims.

What I claim is:

1. The method of constructing a high resistance unit adapted to operate on low current values which comprises rubbing on an insulating base member of unglazed porcelain material a quantity of finely divided carbon and graphite in a dry thoroughly homogeneous state of admixture.

2. The method of constructing a resistance unit which comprises rubbing on a porcelain rod a mixture of one part Elf-G carbon to one and one-half parts of Atcheson graphite No. 2301, both in a finely divided and dry state.

3. A resistance element having a small time resistance coefficient, comprising a body of insulating material on which has been applied a mixture of Elf-G carbon and #2301 Atcheson graphite in a ratio varying between the limits of one to one and one to one and a half parts by weight.

4. A high resistance electrical unit of the class described which comprises as an essential part of its make-up a base member of unglazed porcelain material substantially impervious to moisture and ordinary acids, and a uniform substantially homogeneous appropriately attenuated coating of dry carbonaceous electrically conducting material carried thereon constituting the electrical resistance element of the unit, thereby providing a high resistance unit which, as compared with units of this general class heretofore known, retains a notably constant resistance value for extended periods of continuous operation under the low current conditions required of apparatus of this class.

5. An electrical resistance unit of high ohmic resistance adapted for operation on low current values, substantially as described, which comprises a base member of unglazed porcelain material and an appropriately thin and uniform dry coating of carbon and graphite in intimate and homogeneous mixture carried thereon constituting the high resistance electrically conducting element of the unit, thereby providing a high resistance unit capable of continuous operation under the condition above stated in an atmosphere of reasonably low moisture content without substantial change in resistance value for periods of time notably longer than are obtainable with apparatus of this class heretofore known.

6. An electrical resistance unit of high ohmic resistance adapted for operation on low current values, substantially as described, which comprises a base member of unglazed porcelain material and an appropriately thin and uniform dry coating of carbon and graphite in intimate and homogeneous mixture carried thereon constituting the high resistance conducting element of the unit, a substantially moisture-tight enclosure for the said base member and the electrically conducting coating thereon and a getter within said enclosure for taking up moisture within said enclosure and preventing any substantial action of moisture upon the said coating or base member, to thereby provide a high resistance unit capable of continuous operation under the condition above stated under any external conditions of moisture without substantial change in resistance value for periods of time notably long as compared with apparatus of this general class heretofore known.

7. The method of making a high resistance electrical unit of the class described which comprises coating a base member of unglazed porcelain material with an electrically conducting carbonaceous material applied to said base in dry finely divided state in the form of a coating attenuated appropriately to provide the required high resistance value, whereby a high resistance unit is provided which retains a notably constant resistance value for long periods of continuous operation under the low current conditions required of apparatus of this class.

8. An electrical resistance unit of high ohmic resistance adapted for operation on low current values which comprises a base member of unglazed porcelain material, an

appropriately thin and uniform coating of dry carbonaceous material carried thereon constituting the high resistance electrically conducting element of the unit, and a substantially moisture-tight enclosure for the said base member and the electrically conducting coating thereon, to thereby provide a high resistance unit capable of continuous operation under any conditions of moisture external to the unit without substantial change in resistance value for periods of time notably longer than can be attained with apparatus of this general class hereofore known.

9. A high resistance electrical unit of the class described which comprises as an essential part of its make-up a base member of unglazed porcelain material substantially impervious to moisture and ordinary acids, and a uniform substantially homogeneous appropriately attenuated coating of dry carbon carried thereon constituting the electrical resistance element of the unit.

10. A high resistance electrical unit of the class described which comprises as an essential part of its make-up a base member of unglazed porcelain material substantially impervious to moisture and ordinary acids, and a uniform substantially homogeneous appropriately attenuated coating of dry graphite carried thereon constituting the electrical resistance element of the unit.

In testimony whereof, I have signed my name to this specification this 31st day of January, 1928.

GEORGE A. WELLS.