Feb. 12, 1929. 1,702,062

D. SONKIN

RESISTANCE UNIT

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Fig 1

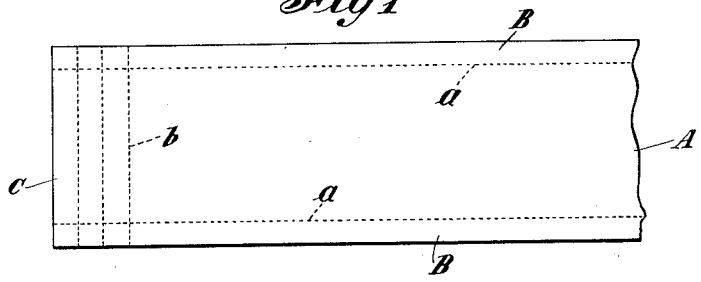


Fig 2

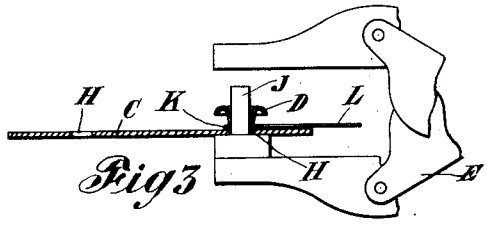


Fig 3

Fig 4

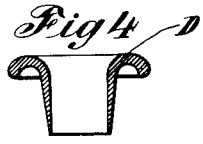
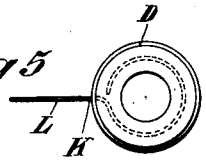


Fig 5



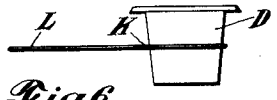
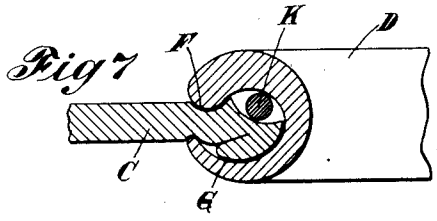


Fig 6

Fig 7



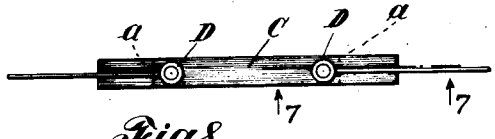


Fig 8

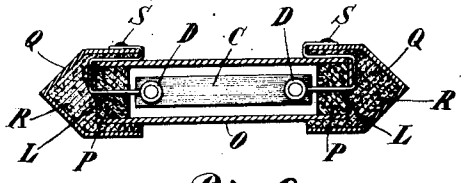


Fig 9

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D. SONKIN

RESISTANCE UNIT

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Fig 11

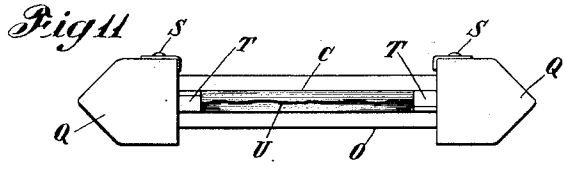


Fig 12

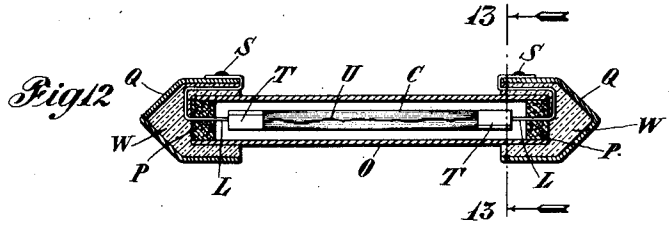


Fig 14

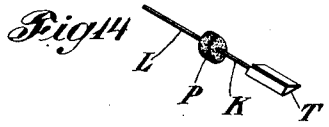


Fig 13

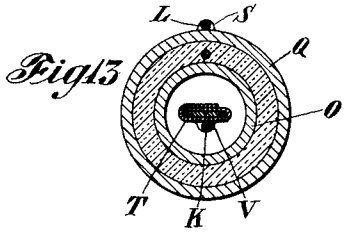
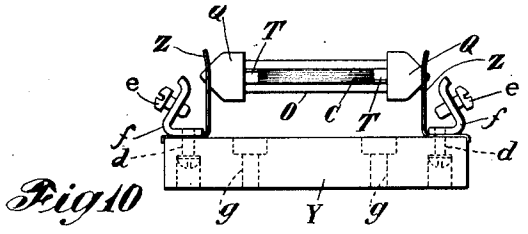


Fig 10



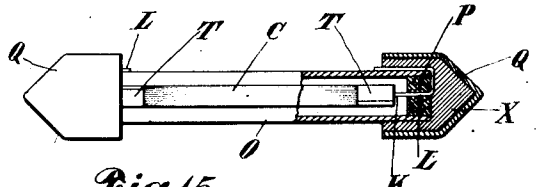


Fig 15

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Patented Feb. 12, 1929. 1,702,062

UNITED STATES PATENT OFFICE.

DAVID SONKIN, OF NEW YORK, N. Y., ASSIGNOR TO RADIO CORPORATION OF AMERICA, A CORPORATION OF DELAWARE.

RESISTANCE UNIT.

Application filed October 23, 1920. Serial No. 418,958.

This invention relates to resistance units, and more especially to a high resistance element particularly suitable for use in a unit for resistance type amplifiers, or as a grid leak for radio vacuum tubes in various forms of vacuum tube apparatus, although the invention is not limited to these uses and may be employed in any apparatus in which it is found suitable.

The primary object of the invention is to secure a high resistance, of the order of two megohms for instance, which is small and compact, simple in construction, of low cost, and reliable and stable in operation whether in radio work or line telegraphy, telephony, or land or submarine cables.

Illustrative examples of various preferred forms of the resistance element and resistance unit are shown in the accompanying drawings, in which,

Fig. 1 is a face view of a portion of a large strip or piece of prepared resistance material before cutting;

Fig. 2 is an enlarged face view of a small resistance strip or element before attachment of the contacts;

Fig. 3 is a side view partly in section and partly broken away showing the method of attaching contacts to the element in the form of eyelet pieces by means of a punch or tool;

Fig. 4 is an enlarged detail longitudinal sectional view of an eyelet piece before clamping;

Fig. 5 is a detail top plan view of an eyelet piece with connector or leading-in wire engaging the same;

Fig. 6 is a detail elevation of Fig. 5;

Fig. 7 is an enlarged detail sectional elevation of a portion of a resistance element and an eyelet partly broken away and clamped to the element, this view being taken on line 7—7 of Fig. 8;

Fig. 8 is a plan view of a resistance strip or element after the attachment of the contacts;

Fig. 9 is an enlarged longitudinal sectional view of a complete resistance unit containing a resistance strip or element;

Fig. 10 is a full size side elevation of a modified form of resistance unit in a mounting, which is also adapted to receive and hold the form of unit shown in Fig. 9;

Fig. 11 is an enlarged side view of the form of resistance unit shown in Fig. 10;

Fig. 12 is a longitudinal sectional view of the resistance unit shown in Fig. 11;

Fig. 13 is a transverse sectional view of Fig. 12 on the line 13—13 looking in the direction of the arrows;

Fig. 14 is a detail perspective view of a plug and contact for the unit shown in Figs. 11 and 12; and

Fig. 15 is an enlarged side view partly broken away and partly in longitudinal section showing a modification of Fig. 12.

By way of example, my invention will be described in detail with reference to a preferred form of high resistance unit in accordance with the invention. As shown in the drawings, this comprises a capsule or cartridge type of device having a high resistance strip or element within a tubular container, preferably of suitable insulating material such as glass, and terminal caps are provided at the ends of the container. The completed unit is adapted to be removably held in convenient manner in a spring mounting as shown of actual size in Fig. 10. Any desired number of such resistance units may be mounted side by side or in any other suitable arrangement and connected in circuit as desired.

Among the important features of the invention are the composition of the resistance film to be placed upon a strip of material and the method of preparing the resistance strip or element.

A liquid composition of the nature of carbon, such as lamp-black, fine graphite or high calcined petroleum coke suspended in glue, gum, gelatine, or glutinous vegetable juices and the like, or in general, a mixture of finely divided carbon and a liquid of suitable consistency to hold the carbon in suspension, is a suitable composition for the resistance film. I have found that waterproof india ink for drawing purposes satisfactorily fulfills the requirements of my invention and is a ready and convenient source of supply of such prepared material. The india ink may be used alone or in combination with finely divided graphite such as is commercially known as grade H graphite, a suitable proportion be-

ing six parts of india ink to one part of graphite thoroughly mixed together. The body or base of the resistance strip or element, which is conveniently formed of thin insulating material, such as paper, should preferably be relatively non-absorbent and have a smooth surface, as the character of the paper has a determining effect on the resistance values. I have found that bristol board, such as is used for Patent Office drawings, is particularly satisfactory, although I do not limit myself to this material. The smooth surface of such bristol board takes the composition or ink well, does not permit it to be absorbed by the sub-surface fibres, and when dry produces a satisfactory film. Of the various thicknesses of bristol board obtainable, three ply quality is found most satisfactory for my purposes.

In preparing the film, a large strip or sheet of bristol board, which may conveniently be about eight to ten inches long and about two inches wide, a portion of which is indicated in Fig. 1 at A, is coated preferably on both sides with the mixture of india ink and graphite dust, for example, in the following manner: The two inch strip A is tacked down or otherwise held upon a plane surface, and a moderate amount of india ink solution is taken upon a 1-½ inch flat varnish brush, preferably a camel's hair brush, of good quality, so that hair marks are not left on the surface. A single, firm, longitudinal stroke is made the entire length of the strip A. This is followed by a series of transverse strokes, always beginning from the same edge and lapping each stroke over the previous one a little. A second lengthwise stroke is then taken, which is also followed by a series of transverse strokes as before. In this manner every portion of the paper is traversed at least four times and by this procedure an even film is obtained. The only time that the brush is dipped is previous to the initial stroke. When the surface has dried the strip is turned over, and the same procedure repeated on the other side. In the complete process, four coats have been provided on each side. The strip when dry has an even surface along its entire length save for quarter inch belts B on the outside edges indicated in approximate extent by the dotted lines *a*. The main belt between the dotted lines *a* is usable for resistance, whereas the portions B are not suitable for this purpose.

The size and dimensions of the original strip A, the number of coats applied and the method of application may be varied according to the results desired. In any case the object sought is to produce a thin conductive film which is as uniform and even as possible. The film applied to each side in the manner described has a thickness of approximately one to two thousandths of an inch and may be varied over a wide range. However, for practical reasons it is undesirable to have a film of greater thickness than of the order of one or two thousandths of an inch, or its equivalent, in a resistance of less than 100,000 to 50,000 ohms roughly speaking.

When thoroughly dry, the prepared paper A is cut transversely into strips C along the dotted lines *b*. For preparing the form of device shown in Figs. 2 to 9 inclusive, these resistance strips or elements should preferably be about 5/16 inches wide, and each strip has a usable film about 1-1/2 inches long with imperfect end portions about 1/4 inch long as indicated in Fig. 2.

The small resistance strips or elements are now ready for the attachment of suitable contacts and incorporation in a complete resistance unit. One practical and simple means of making an efficient contact to the film is by using eyelets, and I have found that the eyelet known as the "solidhead" eyelet, is a satisfactory device which does not damage the film. This is important, because damage to the film may raise the resistance. These "solidhead" eyelets D shown in the figures are made of special material and are fastened in place by a pair of pliers (shown at E, Fig. 3) which forms them so that curved and rounded surfaces F and G bear upon the coated paper as shown in Fig. 7. All cracking of the film is avoided by this means, and good contact to the film is made.

It is difficult to estimate the exact number of coats of ink solution and the size of strip or element necessary to give a definite required resistance, but by variations of the length or width of the strips, or the number of coats or composition of the coating material, variations may be secured over considerable range. I have found that for a resistance of two megohms for instance, a film consisting of four coats per side of the composition set forth, on strips of the size hereinbefore stated is about correct. However, the safest way is to measure the resistance between eyelet contacts of a sample strip, and if the resistance is too low, the long edges of the strip may be trimmed down, or a sample may be made up with slightly greater distance between the centers of the eyelets. Having obtained a sample of the required resistance element, the remainder of the piece of bristol board A may be cut up and resistance elements made in accordance with the sample in quantity production, each one being preferably tested. In every case the distance between the outer rim of the eyelet D and the long edge of the strip C should preferably be at least 3/64 of an inch in order to avoid breaking the paper at the eyelet.

In clamping the eyelets D to the strip C, a hole H is punched in the strip, for example, about 1/2 inch in from the end of the strip, and the strip is left on the stud J of the pliers E as shown in Fig. 3. The eyelet D is placed

over the stud J, and a bare stranded copper wire K, which may consist of four strands of #30 B. & S. gage, is wound around the eyelet as shown in detail in Figs. 5 and 6, leaving the long free end L for the connector or leading-in wire. The eyelet D is then clamped with a firm pressure, but not violently, in order to avoid breaking the bristol board, until the eyelet is flattened into the form shown in enlarged sectional detail view in Fig. 7. As there indicated, the material of the eyelet D is curled and clamped around and in contact with the wire connector K. A second eyelet D with its connector K, is clamped the desired distance, about 5/8 of an inch center to center, away from the first eyelet on the strip C, and the superfluous paper is then cut off substantially at the dotted lines *a*, leaving a unit about one inch in length. The strip with the eyelets in place is shown in Fig. 8.

The advantage of the method described of attaching the connectors or leading-in wires K to the eyelets, resides in the fact that soldering the wires directly to the eyelets is avoided, because soldering results in damage by heating, to the resistance film in the neighborhood of the eyelet.

It is to be noted in connection with Fig. 7 that there is an absence of any break in the film surface, which is an advantage of this particular type of contact; the contact between the film, leading-in wire K and eyelet D is positive and over the entire available surface; and the film of ink solution appears upon the surface of the bristol board at the crimped portions.

The complete resistance strip or element constructed as described is now ready to be put into a container as shown in Fig. 9, which may consist of glass tubing O cut to the proper length for a unit of the desired size. Cork plugs P are preferably put over the connectors or leading-in wires K of the resistance strip and these plugs P are inserted in the ends of the tube O, and preferably trimmed off close to the glass, care being taken not to nick or scratch the leading-wires K of the resistance strip and these plugs P are inserted in the ends of the tube O, and preferably trimmed off close to the glass, care being taken not to nick or scratch the leading-in wires.

Cap terminals Q preferably made of copper or brass of the desired thickness and preferably nickel plates are then placed over the ends of the tube O and are held in position with a suitable sealing compound, as for instance, plaster of Paris R as indicated in Fig. 9. To prevent moisture of plaster of Paris from entering the tube O, the ends of the cork plugs P are preferably painted with beeswax before putting on the caps Q. To prevent the beeswax from melting when the lead-in wires K are soldered to the caps at S, the soldering is preferably done before and not after sealing; that is, the cap Q is soldered onto the leading-in wire K a suitable distance, about ½ inch from the cork plug P, beeswax is spread over the ends of the plugs, plaster of Paris is put into the caps, and the caps and leads are sealed in place over the ends of the tube O.

The resulting product is a reliable unit resistance of compact and stable form. The resistance film on the strip or element C in some respects acts as a carbon compression, because if one side only of the paper strip is coated, I have found that the resistance decreases when the paper is bent so that the film particles are compressed and the resistance increased when the particles are put under tension. This occurrence makes it highly desirable to coat both sides of the paper, in order that bending of the strip when it is placed in the glass container O shall not produce considerable variation.

Figs. 11 to 14 inclusive illustrate a modification of a resistance unit in which a different form of contact for the resistance strip or element is employed. In this modification, strips T of thin copper are carefully wrapped around the ends of the resistance strips C and clamped tightly to the strip to obtain good contact. Care should be taken that the edges of the contact strips T do not cut into the thin resistance film, which might disturb its continuity and considerably increase the previously measured value of resistance. One way of balancing for this loss is to lead pencil the ends of the resistance strip prior to attaching the metallic contacts T and make connection on the penciled parts. Furthermore, after the contacts T are in place at each end and the resistance measured, if the resistance is too high, it may be reduced by adding a small pencil mark shown at U in Figs. 11 and 12 on the coated paper, in order to adjust the resistance of the element to the proper value of two megohms or such other value as desired.

In assembling the resistance unit shown in Figs. 11 to 14, the connectors or leading-in wires K are first soldered at V (Fig. 13) to the clips or contacts T, and the clips are clamped to the ends of the coated bristol board resistance strip C. One cork plug P is suitably pierced and slipped over the end L of one connector or leading-in wire K, and this assembly is inserted in the glass tube C, the other plug P is then pierced and slipped over wire L at the other end and brought down into the end of the tube O. The wires L are bent back around the ends of the tube as shown and the cap terminals Q are sealed in place over the ends of the tube, in this instance by sealing wax W if desired. In Fig. 15 another modification is shown substantially similar to that described in connection with Figs. 11, to 14, except that the cap terminals Q are

filled with melted Wood's metal X and are thus held in position on the ends of the tube O. In this case contact is made between the wires L and the cap terminals Q through the conducting agency of the Wood's metal.

The form of mounting shown in Fig. 10 is suitable for any of the forms of resistance units illustrated and described. It consists of an insulating base Y having spring contact arms Z spaced the desired distance apart and held in position by the screws *d*. Screw binding posts *e* carried by small brackets *f* are suitably mounted at the bases of the arms Z and held in position by the screws *d*. The insulating base Y is also preferably provided with socket holes *g* to receive suitable fastening devices for securing the mounting to a support.

I claim and desire to obtain by Letters Patent the following:

1. A grid leak for vacuum tubes consisting of a container of insulating material, a high resistance element within said container, contacts carried by said element, insulating plugs for said container, connectors for said contacts extending through said plugs and metallic cap terminals secured over the ends of said container in contact with said connectors.

2. A grid leak for vacuum tubes consisting of a container, a resistance element within the container, comprising a strip of non-absorbent insulating material, a film of carbon upon the surface of said paper, means for sealing the ends of said container, metallic cap terminals for the ends of said container and connectors electrically connecting the resistance element with the said cap terminals.

3. A grid leak for vacuum tubes consisting of a container, a resistance element within the container, comprising a strip of non-absorbent insulating material, a film upon said surface formed from a liquid composition of finely divided suspended carbonaceous material, metallic cap terminals sealed over the ends of said container and connectors electrically connecting the resistance element with the said cap terminals.

4. A grid leak for vacuum tubes consisting of a container, a resistance element within the container, comprising a strip of non-absorbent paper, a film upon the surface of said strip formed from india ink, metallic cap terminals sealed over the ends of said container, and connectors electrically connecting the resistance element with the said cap terminals.

5. A resistance element comprising a support of insulating material having a thin adherent film of conductive material thereon, and a terminal in the form of a hollow rivet extending through the support and film for establishing electrical contact with the film.

6. A high resistance element comprising a support of insulating material having a thin adherent film of conducting carbonaceous material thereon and a hollow rivet extending through said support and film for establishing electrical contact with the film.

7. A high resistance element comprising a support of insulating material having a thin adherent film of conducting material thereon, a hollow rivet extending through said support and film, and a conductor coiled around said rivet, said rivet being compressed to establish intimate contact between said conductor and film.

8. A grid leak comprising a high resistance element, an insulated container for said element, means within said container for supporting said element at spaced intervals in said container, conductors extending through said supporting means, and fusible metal tips over the ends of said container contacting with said conductors.

9. A grid leak comprising a high resistance element, an insulated open-ended container for said element, cork plugs in the ends of said container adapted to support said element, and conductive terminals over the ends of said container.

10. A high resistance element for electrical circuits comprising a support of hard-surfaced and highly polished non-absorbent paper and a dry film of a glutinous carbon containing substance coating the surface thereof.

11. A process of preparing a high resistance element which consists in applying a coating of uniform thickness of a glutinous carbon containing fluid to a hard-surfaced highly polished non-absorbent paper, and drying the coating to produce an adherent high resistance conducting film of carbon containing material on the surface of said paper.

12. A grid leak comprising a high resistance element, an insulated container for said element, means within said container for supporting said element at spaced intervals in said container, end caps over the ends of said container, and low fusible material between the ends of said container and said caps, said low fusible material being adapted to secure said element in position and to seal the ends of said container.

13. A grid leak comprising a high resistance element, an insulated container for said element, means at the ends of said container for supporting said element at spaced intervals from the walls of said container by means of conducting member extending from the ends of said resistance element and through said supporting means, a cap over each end of said container, and low fusible material between the ends of said container and element support and said cap, said material being adapted to seal the ends of said container and to provide a contact surface for said projecting conducting members.

14. A grid leak comprising a high resist-

ance element, an insulated open-ended container for said element, cork plugs mounted in the ends of said container, conducting members extending from the ends of said resistance element and projecting through and beyond said cork plugs in the ends of said container, a conducting cap at each end of said container, and a low fusible material between the ends of said container and said cap, said material being adapted to seal, the ends of said container and to provide contact between said projecting conducting members and said cap.

DAVID SONKIN.