Mar. 13, 1923. 1,448,681

E. R. STOEKLE

ELECTRICAL RESISTANCE

Filed Sept. 11, 1922

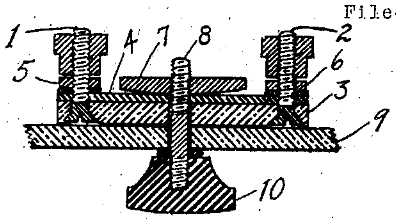

FIG. 1.

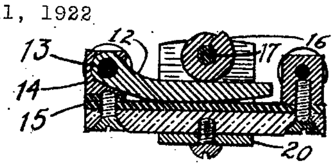

FIG. 3.

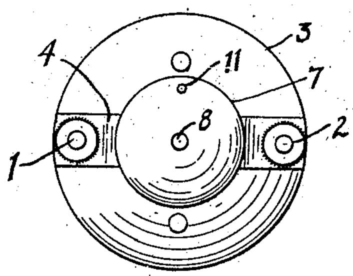

FIG. 2.

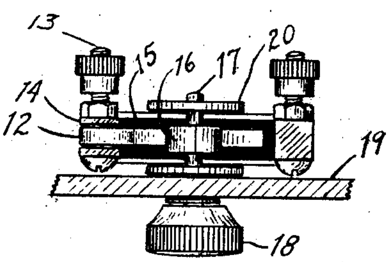

FIG. 4.

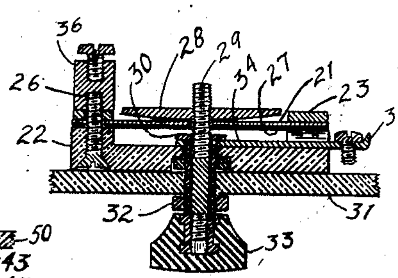

FIG. 5.

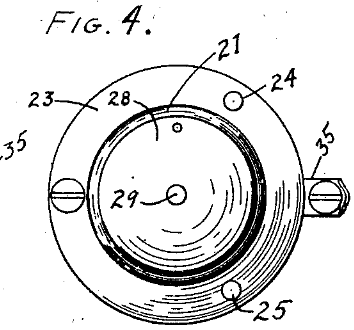

FIG. 6

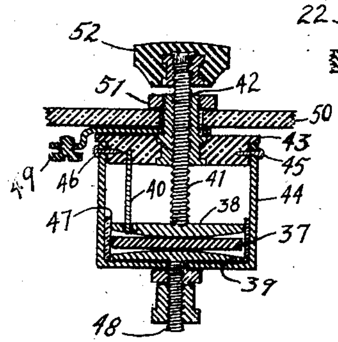

FIG. 7.

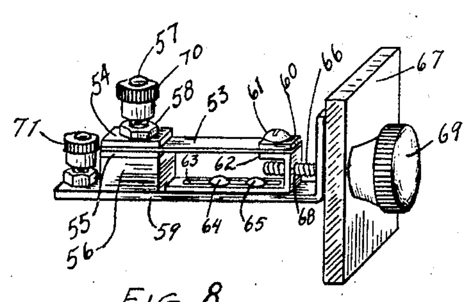

FIG. 8.

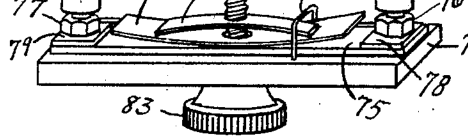

FIG. 9.

Inventor:

Erwin R. Stoekle

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UNITED STATES PATENT OFFICE.

ERWIN R. STOEKLE, OF MILWAUKEE, WISCONSIN.

ELECTRICAL RESISTANCE.

Application filed September 11, 1922. Serial No. 587,395.

To all whom it may concern:

Be it known that I, ERWIN R. STOEKLE, a citizen of the United States, residing at Milwaukee, in the county of Milwaukee and State of Wisconsin, have invented new and useful Improvements in Electrical Resistances, of which the following is a full, clear, concise, and exact description, reference being had to the accompanying drawings, forming a part of this specification.

This invention relates to improvements in electrical resistances particularly of an adjustable type. The adjustable resistance devices described below are particularly designed to furnish certain control elements in wireless apparatus, but the novel methods of varying the resistance herein described are also adapted to other applications in which the electrical current in a circuit is to be varied.

One application of this new electrical resistance is in the construction of so called grid-leaks for the vacuum tubes used in wireless communication. Such grid-leaks have a resistance of the order of one megohm and are often constructed by connecting two terminals with a pencil line drawn on insulating material such as bakelite. It is however, desirable to have such resistances conveniently adjustable and existing types are neither convenient to adjust nor permanent in character.

One object of this invention is to provide an improved electrical resistor made of a resistance material which is elastically deformable so that the resistance may be varied by changing the configuration of the resistor by the application of mechanical stress.

Another object is to provide an improved electrical resistor made of a highly resilient electrical resistance material whose specific resistance can be made of any desired value over wide limits by adjusting the proportions of the constituents of the composition comprising the resistor.

Another object is to provide an electrical resistance device employing a resistor of the above nature which can be conveniently regulated over any desired range.

Another object is to provide an improved electrical resistance of relatively large magnitude whose value can be regulated in infinitesimal steps from a fraction of a megohm up to several megohms.

Another object is to provide an improved variable electrical resistance whose magnitude may be changed at will by varying the length and cross-section of the current path through an elastically yielding resistor, by the application of pressure to an electrode in contact with the resistor; this method of varying resistance being an improvement over the usual sliding contact methods in that a more intimate contact is maintained between the resistor and the variably contacting electrode, and also in that the abrasion of the resistor due to sliding a contact upon its surface is obviated.

Another object is to provide an improved variable grid-leak whose value can be varied at will and which has a more permanent character than the grid-leaks now commonly used.

Other objects and novel features of this resistance will appear from the following description and the accompanying drawings, Figures 1 to 9.

Figure 1 shows in cross-section a simple and preferred form of the resistance device in which regulation of the resistance is accomplished by regulating the length of the path of the current.

Figure 2 shows a plan view of this construction.

Figure 3 shows a cross-section of another construction in which the length of the path of the current is varied in a somewhat different manner.

Figure 4 shows a plan view of this construction.

Figure 5 shows a cross section of a device in which the flow of current is radially through the resistor element and in which the resistance may be adjusted by varying both the length and cross section of the current path.

Figure 6 shows a plan view of this device.

Figure 7 shows a cross section of another construction in which the resistance is varied by compressing the resistor and by changing the cross section and length of the current path.

Figure 8 shows in perspective view a construction in which the resistance is varied by changing the tension on the resistor.

Figure 9 is a perspective view of another construction in which the resistance is varied by varying the length of the current path.

Referring to the Fig. 1 the terminal screws 1 and 2 are attached to an insulating base 3 of hard rubber or bakelite. The resistor element 4 is in the form of a flat strip or slab of the elastically resilient resistance material and is clamped to the insulating base by means of the nuts 5 and 6 on the terminal screws 1 and 2. A disc shaped metal button 7 having its lower surface convex, is threaded to a shaft 8 which extends rotatably through a hole in the resistor, insulating base and mounting panel 9. The exterior end of the shaft 8 has fastened to it an insulating operating knob 10. The rotation of the shaft 8 by means of the knob 10 draws the button 7 downward so that its convex surface makes contact over a greater area of the resistor 4, thereby shunting more of the current from the resistor through the metallic button and decreasing the length of the path of the current through the resistor.

Referring to the Fig. 2, the pin 11 is fastened in the insulating base and extends slidably through a hole in the button 7. This pin serves to prevent the rotation of the button when the threaded shaft 8 is rotated.

The resistor element 4, (Figs. 1 and 2) in its simplest form may consist of a flat strip of rubber extending between the two binding posts, and having a conducting path on its surface which may be formed by a pencil mark or layer of conducting ink. A preferable method of forming a more permanent conducting surface on the rubber was found to be as follows: Lampblack or very finely divided carbon is mixed with a solution of rubber in carbon disulphide or other suitable solvent, in such proportions as will give the desired specific resistance to the mixture. This mixture when applied to the clean surface of the rubber will upon drying, form a strongly adhering electrically conducting layer.

The resistor may also be made of a slab of a composition of rubber and some finely divided conducting material, such as carbon. This composition may be made by mixing a finely divided conducting material such as lampblack with unvulcanized rubber in such proportions as will give the desired electrical conductivity to the resultant product. The mixture may then be formed into the desired shape and vulcanized to give it the required resiliency.

Figures 3 and 4 show a cross section and plan view respectively, of another method of varying the length of the path of the current. In the Figure 3 the metallic arm 12 is pivoted at one of the terminals 14 by means of a pivot 13. The lower curved surface of the arm 12 rests against the surface of the resistor 15. A cam 16 bears upon the upper surface of the arm 12 and is rotatable by means of a shaft 17 and an operating knob 18—Fig. 4. A right-handed rotation of the cam 16 moves the arm 12 down so that a greater extent of the surface of the resistor 15 is brought into contact with the lower curved surface of the arm, thus shortening the path of the current through the resistor, a minimum path being attained when the entire under surface of the arm 12 is in contact with the resistor 15. In this construction the total change in the resistance is accomplished in less than one revolution of the operating knob 18.

Figure 4 shows a plan view of this resistance device and the manner of mounting it on the panel 18. In this view the contact arm is shown at 12. The cam 16 is shown fastened to the shaft 17 which extends through the bracket 20 and the panel 19.

Figures 5 and 6 show a cross-section and plan view respectively, of a form of the device in which the resistor 21 is a circular disc or diaphragm clamped to the insulating base 22 by means of the metallic ring 23 and the screws 24, 25 and 26.

The disc shaped resistor may consist of rubber with an electrically conducting surface layer applied in the manner described above, or it may consist of a disc of the above described composition of rubber and carbon. It may also consist of a layer of a yielding electrically conducting material backed by an elastic diaphragm consisting of a thin disc of mica or other insulating material as shown at 27 in Fig. 5. Such a composite resistor has been constructed by superposing a layer of asbestos impregnated with carbon upon a disc of mica.

The metal disc 28 has its lower convex surface in contact with the conducting surface of the resistor. A threaded shaft 29 engages with a tapped hole in the disc 28 and passes rotatably through a bushing 30 which fastens the base to the panel 31 by means of the nut 32. The exterior end of the shaft 29 has fastened to it the operating knob 33. Electrical connection from the binding post 35 to the disc 28 is made by means of the metal strip 34, the bushing 30 and the shaft 29. The binding post 36 is electrically connected to the ring 23 as shown.

The path of the current through the resistor is thus seen to be radially from the disc 28 to the ring 23. A right-handed rotation of the knob 33 draws the disc 28 toward the diaphragm resistor thus flexing the latter and bringing a greater surface of the convex face of 28 into contact with the conducting surface of the resistor 21. This flexure of the resistor not only shortens the path of the current from the disc 28 to the ring 23 but also increases its average cross-sectional area. Both of these changes in the geometry of the current path result in a decrease in the resistance, the minimum resistance being attained when contact has been established between the resistor 21 and the convex surface of the disc 28 to the outer edge of the latter.

Figure 7 shows a cross-section of a device employing an elastically deformable resistor in which the magnitude of the resistance is changed by compressing the resistor and by varying the cross section and the length of the current path. In this figure the resistor 37 should preferably be made entirely of the rubber-carbon composition described above, so that the current in this case is conducted through the volume of the resistor. The circular metallic button 38 has its lower convex surface bearing upon the upper surface of the resistor. The lower button 39 upon which the resistor rests may have its upper surface either plain or preferably also slightly convex. The upper button is prevented from rotating by means of the guide pin 40 upon which it is free to slide. A threaded shaft 41 extends through the tapped insert 42 moulded in the insulating cover 43 of the metallic cylindrical shell 44. The pins 45 and 46 fasten the cover 43 to the shell 44.

The end of the shaft 41 bears in a slight recess upon the upper surface of the button 38, and is free to rotate with respect to the button 38. The resistor 37 and button 38 are insulated from the metallic container 44 by means of the cylindric insulating shell 47.

Electrical contact is made to the button 39 by means of the binding post 48 and the button 38 is connected to the binding post 49 by means of the insert 42 and the shaft 41. The device is mounted on the panel 50 by means of the threaded insert 42 which extends through the panel and is clamped by the nut 51.

The operation of the above construction is as follows:

The path of the current through the resistance material is from the contact of the button 38 with the upper surface of the resistor to the contact of button 39 with its lower surface. It is obvious that a right-handed rotation of the operating knob 52 will compress the resistor 37 and thus increase the area of contact of the buttons 38 and 39 with resistor. Since in this construction the length of the current path is very short compared to the diameter of its cross section an increase in the contact area will produce a very marked change in the resistance between the buttons 38 and 39.

It is also obvious that the distance between the contact buttons 38 and 39 will be decreased upon compressing the resistor and therefore the length of the current path will be decreased. Both the increase in contact area and the decrease in the length of current path will operate to diminish the resistance between the buttons 38 and 39 when the resistor is compressed. Conversely a relaxation of the compression of the resistor by a left-handed rotation of the operating knob 52 will operate to increase the resistance.

Figure 8 shows another device for regulating resistance by means of this new elastically deformable resistance material. In this figure the resistor 53 consists of a band of the elastic resistance material one end of which is clamped between the metal blocks 54 and 55 which are secured to a block of insulating material 56 by means of the screw 57 and nut 58. This block is mounted on a metallic bracket 59 from which it insulates the terminal 57.

The other end of the resistor strip 53 is clamped by means of the metal piece 60 and screw 61 to a member 62 which is held in a slidable relation to the bracket 59 by means of the slot 63 through which the rivets 64 and 65 pass. The threaded shaft 66 passes freely through the panel 67 and the bracket 59 and engages a threaded hole 68 in the slidable member 62. An operating knob 69 is fastened to the exterior end of the shaft 66. The binding posts 70 and 71 serve to make electrical connections to the ends of the resistor strip.

The operation of this device is as follows.

A right-handed rotation of the knob 69 applies tension to the strip of resistance material whereby its resistance is increased. Conversely a left-handed rotation of the knob relaxes the tension whereby the resistance is decreased. In this manner continuous variations of the resistance between the terminals 70 and 71 can be accomplished by rotating the knob 69.

Referring to the Fig. 9, the terminal screws 72 and 73 pass through the insulating base 74, and clamp the resistor 75 to the base by means of the nuts 76 and 77 and the contact plates 78 and 79.

A bent flexible contact strip 80 has its convex surface bearing upon the surface of the resistor 75 as shown. A second bent member 81 is threaded to the shaft 82 and has its ends bearing slidably upon the surface of the member 80 as shown. The shaft 82 passes rotatably through the member 80, the resistor 75 and the base 74. An operating knob 83 is fastened to the exterior end of the shaft 82 and serves to rotate the latter. A stirrup 84 holds the members 80 and 81 in alignment and prevents them from rotating when the shaft 82 is turned.

A right-handed rotation of the knob 83 draws the member 81 toward member 80, thereby flexing the latter and bringing it into contact with the resistor 75 along a greater length of the latter. This shortens the path of the current through the resistor, thereby decreasing the resistance between the terminals 72 and 73. A left-handed rotation of knob 83 relieves the flexure of 80 thus decreasing its contact with 74 and increasing the resistance.

Other methods of accomplishing a change in the resistance of this novel resilient resistance material and other uses of its peculiar properties will be apparent to those skilled in the art. The above specifications describe devices employing typical methods of accomplishing this resistance change, and other devices employing the novel resistors described above will be made the subject of separate patent applications.

What I claim as new and desire to secure by Letters Patent is:

1. An elastically deformable electrical resistor consisting of a finely divided conducting material imbedded in a relatively nonconducting matrix of an elastically deformable substance, and means for making electrical connections to said resistor.

2. An elastically deformable electrical resistor consisting of finely divided carbon imbedded in a matrix of rubber or gutta percha, and means for making electrical contacts with said resistor.

3. A variable electrical resistance comprising a resistor of finely divided conducting material such as carbon imbedded in and distributed throughout the volume of said resistor; suitable terminals for said resistor; and means for applying mechanical stress to said resistor, whereby its electrical resistance may be varied.

4. An electrical resistor comprising an elastically deformable insulating base; an electrically conductive layer applied upon the surface of said base; and suitable terminals for making electrical connections to said conductive layer.

5. An electrical resistor comprising an elastically deformable insulating base; an electrically conductive layer applied upon the surface of said base; suitable terminals for making electrical connections to said conductive layer; and means for varying the resistance of said resistor by the application of mechanical stress thereto.

6. An electrical resistor comprising a resilient base of rubber; an elastic layer of electrically conductive material such as a mixture of finely divided carbon with rubber, applied to the surface of said base; and suitable terminals for making electrical connections with said layer of conductive material.

7. A variable electrical resistance comprising a strip of resilient material such as rubber, an electrically conductive elastic layer upon the surface of said strip; terminals for making electrical connection with said layer; a metallic contact member having a convex surface in contact with said conductive layer, and means for pressing said convex surface of said contact member into variable contact with said conductive layer whereby the electrical resistance between said terminals is varied.

8. A variable electrical resistance comprising a thin disc of insulating material such as a disc of mica supported at its edges; an electrically conductive elastically yielding layer upon the surface of said disc; an insulating base supporting said disc; a metallic ring clamping said disc at its outer edge to said base and making electrical contact with said conductive layer; an electrode having a convex surface adjacent said electrically conductive surface layer; and means for flexing said disc and bringing said conductive surface into variable contact with said convex surface of said adjacent electrode, whereby the electrical resistance between said electrode and said metallic ring at the outer edges of said conductive surface may be varied.

9. A variable electrical resistance comprising an elastically deformable electrical resistor in the form of a strip; terminals making electrical contact with the ends of said strip; a contact shoe pivoted to and in electrical connection with one of said terminals and having a convex surface in contact with the surface of said resistor; and means for varying the contact pressure between the said contact shoe and said resistor whereby contact is made along a variable length of said resistor and its resistance thereby varied.

10. A variable electrical resistance comprising an elastically deformable resistor in the form of a short cylinder; contact members having convex surfaces in contact with the ends of said resistor; means for moving said contact members with respect to each other whereby said resistor may be variably compressed between said contact members, and the resistance between said contact members varied.

11. A variable electrical resistance comprising a convex lens shaped elastically deformable resistor; electrodes making contact with the convex surfaces of said resistor; means for variably compressing said resistor between said electrodes, whereby the area of contact of said electrodes with said resistor may be varied, and the resistance between said electrodes varied.

12. A variable electrical resistance comprising a resistor of an elastically yielding conducting material; terminals for establishing electrical connection to said resistor; a contact element having a convex surface bearing upon the surface of said resistor; and means for varying the pressure between said contact element and said resistor whereby a variable area of contact between said contact element and said resistor is accomplished.

13. A variable electrical resistance comprising an elastically deformable resistor; suitable terminals for making electrical connection to said resistor, and means for varying the tension on said resistor whereby its resistance may be varied.

14. A variable electrical resistance comprising a strip of rubber; a conductive layer upon the surface of said strip; terminals for establishing electrical connection to said conductive layer; and means for varying the tension on said strip whereby the resistance between said terminals is varied.

15. A variable electrical resistance comprising an elastically yielding resistor such as a strip of asbestos impregnated with an electrically conducting material such as a chemically precipitated metal; an insulating base to which said resistor is fastened; terminals for making electrical connections to the ends of said resistor; a flexible contact member in the form of a curved strip having its convex surface adjacent the surface of said resistor; means for flexing said contact strip and for pressing its convex surface into variable contact with said resistor, whereby the electrical resistance between said terminals is varied.

16. An electrical resistance comprising a resistor in the form of a strip of woven fabric impregnated with a conducting material such as finely divided carbon; an insulating base to which said resistor is fastened; terminals for making electrical connections to the ends of said resistor; a flexible contact member in the form of a curved strip having its convex surface adjacent the surface of said resistor; means for flexing said contact member thus pressing its convex surface into variable contact with said resistor, whereby the electrical resistance between said terminals is varied.

17. An electrical resistance comprising a resistor in the form of an electrically conducting sheet; a flexible curved contact member having its convex surface adjacent one surface of said resistor; a second contact member having a surface adjacent to the opposite surface of said resistor; suitable terminals for making electrical connections to said contact members, and controllable means for flexing said curved contact member by the application of pressure thereto, whereby a variable compression is applied to said resistor and a variable area of intimate contact established between the surfaces of said contact members and said resistor, thus varying the resistance between said terminals.

18. An electrical resistance comprising a resistor in the form of a strip of woven fabric impregnated with a conducting material such as finely divided carbon; a bent flexible contact member having its convex surface adjacent one surface of said resistor; a second contact member adjacent the opposite surface of said resistor; suitable terminals for making electrical connections to said contact members, and means for applying pressure to said bent flexible contact member whereby the latter is flexed and its convex surface brought into variable area of contact with said resistor thus varying the resistance between said contact members.

19. An electrical resistance comprising a resistor in the form of a sheet; a curved flexible contact member having its convex surface adjacent one surface of said resistor; a second contact member having a surface adjacent the opposite surface of said resistor; suitable electrical connections to said contact members; a compression member bearing upon the ends of said flexible contact member; a screw engaging said compression member, whereby pressure may be exerted upon said flexible member thus changing its area of contact with said resistor and also changing the contact pressure upon said resistor, both of said changes effecting a change of resistance between said contact members.

In witness whereof, I have hereunto subscribed my name.

ERWIN R. STOEKLE.