May 23, 1933. L. L. HOWARD ET AL 1,910,391

RESISTOR

Filed Dec. 13, 1929

Fig. 1.

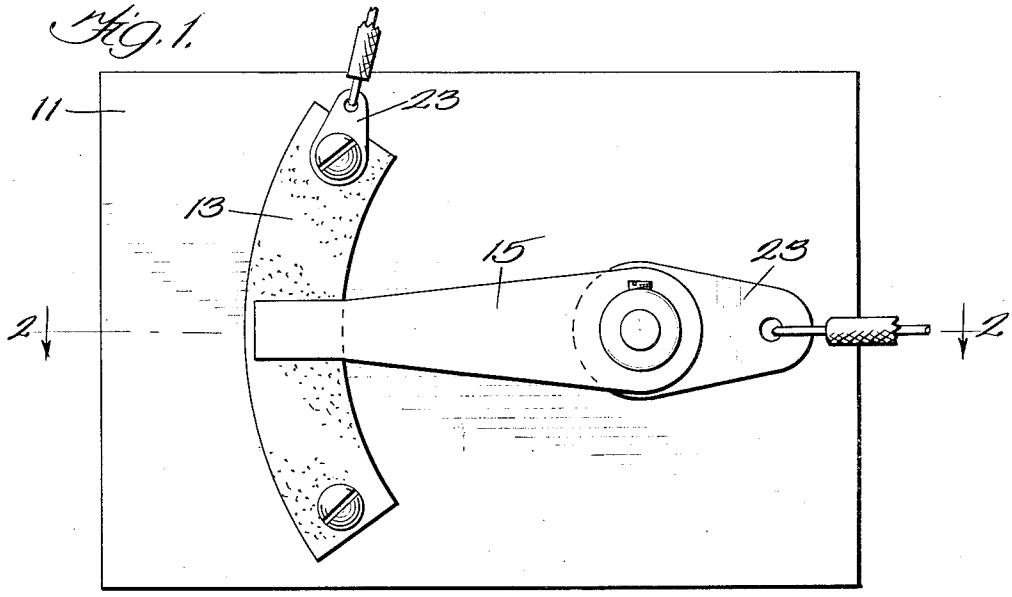


Fig. 2.

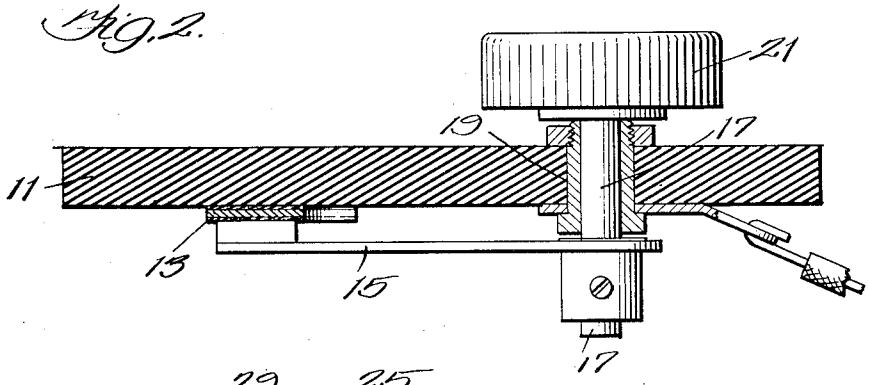
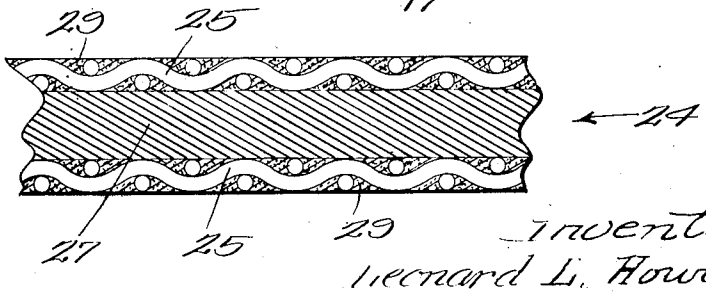


Fig. 3.



Inventors
Leonard L. Howard
Arthur H. Haroldson
By Cheever, Cox + Moore Attys.

Patented May 23, 1933

1,910,391

UNITED STATES PATENT OFFICE

LEONARD L. HOWARD AND ARTHUR H. HAROLDSON, OF VALPARAISO, INDIANA, ASSIGNORS, BY MESNE ASSIGNMENTS, TO CONTINENTAL DIAMOND FIBRE COMPANY, OF NEWARK, DELAWARE, A CORPORATION OF DELAWARE

RESISTOR

Application filed December 13, 1929. Serial No. 413,714.

Our present invention relates in general to electrical apparatus and has more particular reference to a novel resistance material, the material of our invention being well adapted for use in precision rheostats and other resistance units used in electric circuits, and being especially well fitted for use in radio apparatus where inexpensive but accurate resistance control of electric circuits is important.

Heretofore, it has been customary to form resistance units from strips of conducting material such as copper or aluminum wire, carbon blocks, and the like, the resistance being varied if necessary by means of a slide contactor or similar device arranged to move along the block or strip of conducting material in order to change the length and/or the cross sectional area of the conducting material included in the circuit. Where metals are employed it is usual to arrange the conductor as an elongated coil to conserve space, the resistance increasing in proportion to the length of wire traversed by the contactor and/or inversely in proportion to the cross sectional area.

Resistance units made of metallic materials are subject to several disadvantages. Wire resistance units have the disadvantage of being costly to manufacture since they are made from relatively expensive materials and require a number of assembly operations to produce the finished product.

A further disadvantage of resistance units provided heretofore resides in the fact that most metals corrode, are effected by moisture and do not provide constant resistance when effected by heat such as is frequently generated in electric circuits.

Among the chief disadvantages inherent to resistors provided in the past, however, is one which has heretofore not been well appreciated, since the disadvantage resides in an inherent limitation or lack of a desirable characteristic which is present in all known resistance materials. Every material at present used in resistors has a constant or practically constant conductivity characteristic, that is to say, a piece of any given resistance material will have the same conductivity per unit of length and cross sectional area as any other piece of the same material providing the temperature, pressure and other external conditions are the same. Even a variation of such external conditions will not change the conductivity of a given material to any great extent. The foregoing fact presents a very specific and practical limitation to the use of the known resistance materials in resistors, to wit, the size of a resistor for any given purpose will be determined in large measure by the resistance material used, and the purpose of our present invention is to provide a composite resistance material which can be made up with extreme accuracy to have any desired conductivity between zero conductivity (i. e., maximum resistance providing an insulator) and infinity conductivity (i. e., minimum resistance providing a perfect conductor of electricity).

Among the other objects of our invention is to provide a novel resistance material which is inexpensive to manufacture, which may be moulded and/or punched to any desired size, shape or configuration with a minimum of effort and manufacturing operation, and which, if desired, may be moulded directly into its supporting base or panel.

Another important object is to provide a resistance material of readily mouldable material which can consequently be easily made into any desired size and shape and in which the conductivity or resistance characteristic of the finished material can be varied at will and accurately controlled and determined during the manufacture of the material.

Still another object of the invention is to produce a composite resistance material from a well known binder and a finely divided conducting material which can be produced by pulverizing scrap conductor material which would otherwise be discarded as useless. In this way, scrap copper, carbon, etc., comprising the waste products of several industries, can be made useful.

Yet a further important object is to expand the scope of the thermo-plastic (i. e., heat hardening material) and laminating industry generally and of the heat hardening

resins in particular by producing a new resistance material, having desirable and advantageous characteristics, through the addition of a cheap, powdery by-product, comprising a conducting material such as powdered copper or other powdered metal or electrical conducting non-metal such as carbon in any of its powdery or powdered forms, to a suitable heat curable resin.

Our present invention also embraces the method of controlling the conductivity of our resistance material during the manufacture thereof by varying the relative proportion of the ingredients, and includes the novel method of making a resistor by mixing or folding a conducting material into a non-conducting or insulating material and then sustaining the mixture in a desired form as by solidifying the same.

Numerous other objects and advantages of our invention will be apparent as it is more fully understood from the following description which, taken in connection with the accompanying drawing, discloses a specific embodiment of our invention for the purpose of illustrating and explaining the same.

Referring to the drawing:

Figure 1 is a plan view of a variable slide contact rheostat assembly embodying a resistance material made in accordance with the teachings of our invention.

Figure 2 is a sectional view taken substantially along the line 2—2 in Fig. 1.

Figure 3 is an enlarged section showing the internal construction of the resistance material embodied in the rheostat shown in Fig. 1.

To illustrate our invention, we have shown on the drawing a rheostat comprising a panel 11 forming a supporting base or frame of non-conducting material, to which is suitably mounted a resistance unit 13. The resistance unit may be secured in place by any convenient fastening means. It may be glued or secured to the base-board by any suitable adhesive or, since the base-board and the resistance unit may both be made from heat curable moldable material, as will be hereinafter more fully described, the resistance unit may be molded directly into the panel if desired. The configuration and construction of the base and resistance unit is of course optional and depends largely upon convenience and expediency.

A slide finger 15 having a free end contacting a surface of the resistance unit 13 is mounted for rotation at its other end to a shaft 17, journalled in a bushing 19, which in turn is mounted in a perforation formed in the base 11. The shaft is provided with an operating handle or knob 21 whereby the position of the slide finger 15 may be adjusted. Terminals 23 are provided whereby the slide finger and resistance unit may be connected in an electrical circuit. The form and construction of the resistance varying means (i. e., the slide finger and associated items) is of course optional and also depends largely upon convenience and expediency.

The resistance unit 13 comprises a formed block or strip of electrical non-conducting or insulating material in which a quantity of a suitable finely divided conductor of electricity is uniformly mixed throughout the block. We prefer to form the resistance unit from a thermo-plastic (heat hardening or curable) material such as the reaction product of phenol and formaldehyde, which is a thermo-plastic material capable of being hardened and solidified under heat and pressure but which, in its unreacted state, before the application of heat and pressure is a fluid resinous material. Of course it is not essential that a heat hardening material be employed, and in fact any insulating material which will carry the conducting material uniformly distributed therein may be used, and there are of course numerous heat curable materials other than the reaction product of phenol and formaldehyde which we may use as the nonconducting base for our resistance material. Among these is the reaction product of glycerol and phthalic anhydride. In fact, we may form our resistance unit from any convenient insulating material which will carry the conducting material in suspension therein.

In forming the resistance unit, we mix into the insulating base or carrier material, a quantity of any suitable conductor of electricity in finely divided amorphous or powdery condition. We find that carbon in any of its forms, and reduced to a fine powder, is well adapted for this purpose, and on account of its cheapness, we prefer to use either lamp black or graphite as the electrical conductor material. Pulverized metallic conductors may also be employed, and cheap scrap pieces of conducting material such as copper, aluminum, etc. may be pulverized and used to advantage to reduce the cost of the final product. The powdered conducting material may be mixed with the insulating material in various proportions in order to vary the conductivity and resistance per unit of length in the resulting material, it being apparent that where a high percentage of conducting material is used, the resulting material will have a relatively low electrical resistance per unit of length while a resistor having a relatively low amount of conducting material will have relatively high resistance per unit of length. By properly controlling the ratio of conducting to nonconducting material during manufacture, a material is attained, having any desired resistance and conductivity characteristics ranging between the insulating characteristics of the nonconducting ingredient and the conducting characteristics of the conducting material ingredient.

While any suitable nonconductor which is capable of carrying the conducting material uniformly distributed therein may be used as the base of our material, we prefer to use a heat hardening resin because this type of material is well known in the laminating industry and because it has certain inherent advantages over other types of material which may be employed. Heat curable materials in their unstable forms are fluid so that the conducting material can be easily mixed or folded into the heat curable material which is relatively heavy and viscous and will hold the finely divided conducting material well until finally hardened. Then when the conducting material is uniformly mixed throughout the heat curable carrier, the same can be quickly solidified and made self sustaining so that the distribution of the conducting material will not thereafter vary throughout the finished material.

It is within the contemplation of our invention also to add an inert filler to the mixture before the same is rendered self sustaining as by curing the heat hardening resin. The filler may be any suitable nonconductor of electricity and is added for the purpose of providing mechanical strength and also to replace some of the more expensive heat curable insulating materials.

Such fillers as wood flour, sawdust and other fibrous and nonfibrous materials such as pulverized mica, absestos, cotton and the like may be used, and the filler may take the form of fabricated sheets of material such as paper, or woven materials such as cloth, etc., may be used as a filler and to strengthen the product.

Heat curable material, as is well known, may be molded in any desired form so that it is possible to directly produce the resistance unit 13 by configurating a quantity of the conducting and nonconducting material mixture either with or without the filler in a suitable mold. However, we prefer to make the resistance unit by pre-forming a composite board 24 comprising strips or sheets 25 of the filler, preferably in the form of fibrous fabric sheets impregnated uniformly with the mixture 29 of the heat curable resin and the powdered conducting material. The impregnated sheets may then be stacked together and solidified under heat and pressure to form a hard, water resistant board, as is well known in the laminating art. From such a board, the resistance unit 13 may be formed as by machining, punching, stamping or the like.

Any suitable fibrous sheet material such as paper, canvas, linen, cambric, flannel fabric, silk fabric, cheesecloth, broadcloth, et cetera, may be used for the sheets 25.

In order to meet various industrial demands, the board 24 may be made entirely from fibrous sheets 25 which have been impregnated with the resin and lamp black mixture 29, or the board may be formed by alternating the sheets 25 with sheets 27 impregnated with the resin alone, or the board may be made by simply facing a stack of sheets 27, impregnated only with the heat hardening resin, with a sheet 25 impregnated with the heat hardening resin and powdered conducting material mixture as shown in Fig. 3 of the drawing. It is obvious also that the number of sheets required to make a board depends upon the individual thickness of the sheets and upon the thickness of the finished article.

When graphite is used as the conducting material, there is a tendency for the graphite particles to slip or ooze from position in the product during the heat and pressure which is applied in order to finally cure the resin. In order to prevent excessive oozing during the pressing operation and the consequent displacement of graphite in the product, we find that a pre-heating or partial curing of the resin without pressure is desirable. This may be accomplished by heating the impregnated sheets to a predetermined temperature before they are stacked and finally cured in the heated presses, as is well known in the industry.

The new conducting material which we have invented is relatively inexpensive to manufacture and can be turned out in large quantities at low cost. Resistance units made from this material have constant conductivity and resistance under all normal operating conditions, and can be made in production quantities to an accurate predetermined standard of resistance which standard may be varied at will during the manufacture of the material, according to whatever resistance characteristic is needed in the finished product. The actual resistance of any given unit can also be regulated during its manufacture by reducing or increasing the ratio of the conducting material, to wit, graphite or lamp black, to the other materials (resin and filler) comprising the finished product.

The new material also is resistant to heat, moisture, oils, and other solvents. It is rigid and will not become easily broken in service. The new material also having the conductor material in it rather than on it provides an extremely substantial article which will not easily wear out in service and which consequently provides good rugged operating characteristics.

It is thought that the invention and numerous of its attendant advantages will be fully understood from the foregoing description, and it is obvious that numerous changes may be made in the form, construction, and arrangement of the various parts without departing from the spirit and scope of the invention or sacrificing any of its ma-

terial advantages, the form hereinbefore described being of a preferred embodiment for purposes of illustration.

We claim:

1. A resistance material comprising a fibrous strip impregnated with a reaction product of phenol and formaldehyde and having a finely divided conducting material scattered uniformly throughout the strip.

2. A resistance material comprising a fibrous strip impregnated with a reaction product of phenol and formaldehyde and having amorphous carbon distributed uniformly throughout the strip.

3. A resistance unit comprising a fabric strip impregnated with a product of phenol and formaldehyde having graphite scattered uniformly through the strip.

4. A resistance unit comprising a laminated strip including a layer of fibrous material impregnated with a heat curable resin in its finally reacted state and having carbon in a finely divided state mixed uniformly throughout the resin.

5. A resistance unit comprising a laminated strip including a layer of fibrous material impregnated with the reaction product of phenol and formaldehyde in its finally reacted state, and having graphite scattered throughout the resin.

6. A resistance unit comprising a laminated strip of heat hardened material, including a layer of fibrous fabric impregnated with a heat hardened resin with which an amorphous conducting material is mixed.

7. A resistance unit comprising a laminated strip of heat hardened material faced with a layer of fibrous fabric impregnated with a heat hardened resin with which an amorphous conducting material is mixed.

8. A resistance unit comprising a laminated strip formed of fibrous fabric layers and a heat hardened resin, at least the surface layer of which includes a conductor in amorphous condition, uniformly scattered throughout the layer.

9. The method of making resistance material, which consists in uniformly mixing a measured quantity of a conducting material into a predetermined quantity of a heat curable resin in fluid state, impregnating a fibrous strip with said mixture so that the mixture has substantially uniform density in the strip, and finally heat hardening the heat curable resin without varying the amount of conducting material therein.

10. A resistance material comprising a woven fabric strip impregnated with a heat curable resin in its cured state and having a finely divided conducting material uniformly distributed throughout the heat curable resin.

11. A resistance material comprising a woven fabric strip impregnated with a heat curable resin in its cured state and having amorphous carbon uniformly distributed throughout the heat curable resin.

12. A resistance material comprising a fibrous strip impregnated with a reaction product of a heat-curable resin in its cured state, and having a finely divided conducting material scattered throughout the strip.

13. The method of making resistance material which consists in uniformly mixing a measured quantity of a conducting material with a predetermined quantity of a reaction product of phenol and formaldehyde in fluid state, impregnating a fibrous strip with said mixture so that the mixture has substantial uniform density in the strip and finally heat hardening the reaction product without varying the amount of conducting materal therein.

In witness whereof, we have hereunder subscribed our names.

LEONARD L. HOWARD.
ARTHUR H. HAROLDSON.