

May 1, 1945.

S. RUBEN

2,375,178

VARIABLE ELECTRICAL RESISTOR

Filed Oct. 1, 1941

2 Sheets-Sheet 1

Fig. 1

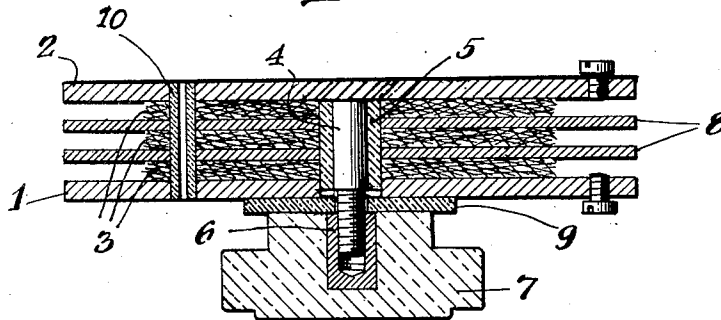
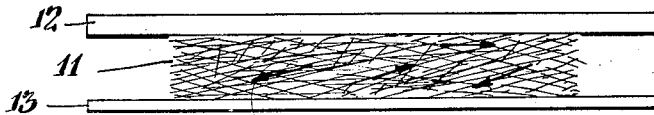


Fig. 2

WITHOUT COMPRESSION



ELECTRODE EXTENDING OVER ENTIRE CONTACTING
SURFACE OF IMPREGNATED GLASS MAT

Fig. 3

WITH COMPRESSION



SHORT PATHS ON COMPRESSION DUE TO PARALLEL
PATHS ON CONTACTING OF FIBRES TOGETHER

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2 Sheets-Sheet 2

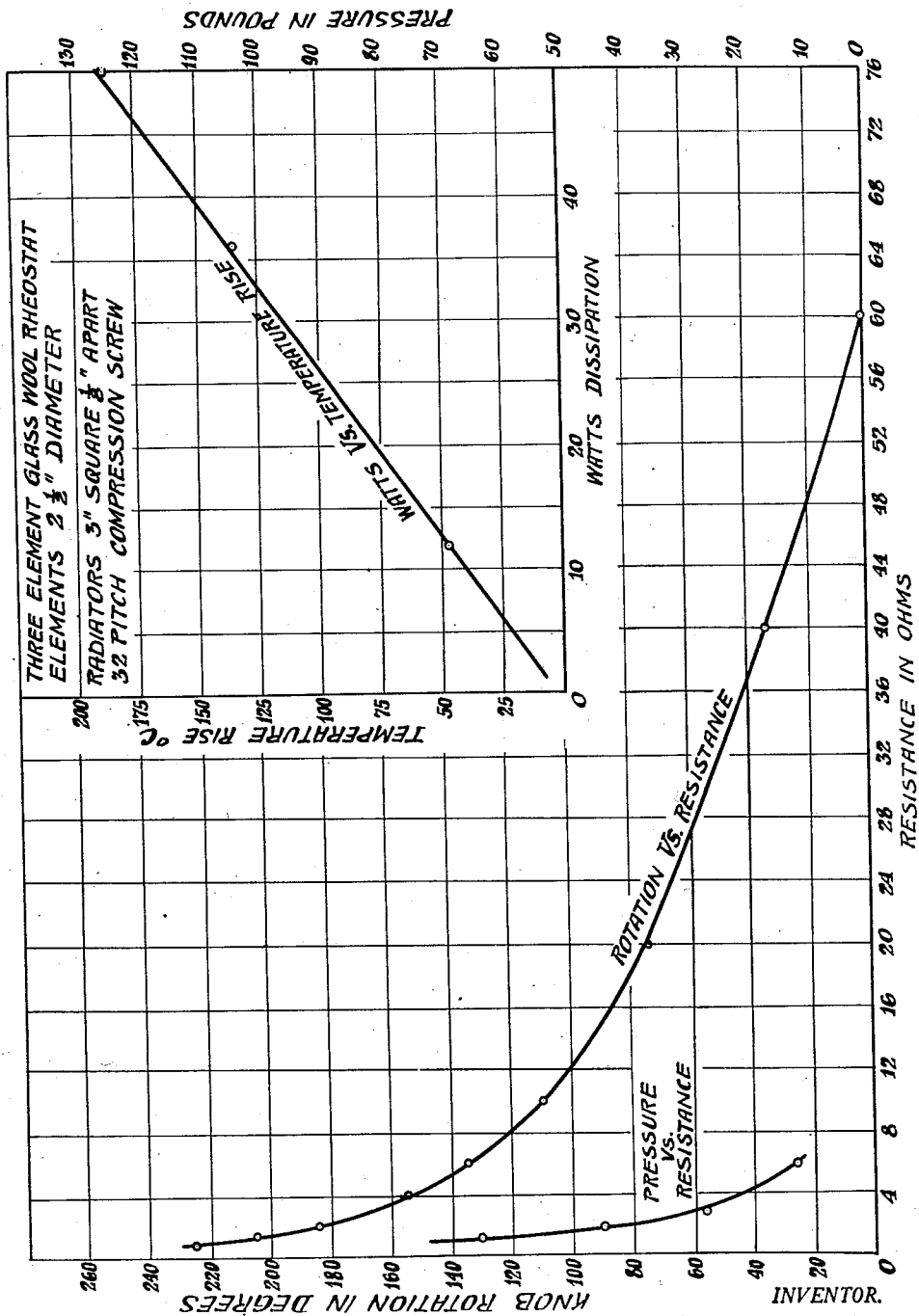


Fig. 4

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VARIABLE ELECTRICAL RESISTOR

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3 Claims. (Cl. 201—50)

This invention relates to variable electrical resistors.

An object of the invention is the provision of a variable resistor of new and improved construction which can be conveniently and economically manufactured, which is stable and which can be used to replace variable wire wound resistors of the prior art as well as variable resistors of the carbon pile type.

A further object is the provision of an improved variable resistor of the compression type.

Other objects will be apparent from the disclosure and from the drawings, Fig. 1 of which is a view partly in section, of a variable resistance device made according to this invention; Fig. 2 is a detail of one section of the resistance element not under compression; Fig. 3 is a detail of the same section of the resistance element under compression and Fig. 4 is a graph illustrating the performance of the resistor in respect to pressure versus resistance, rotation versus resistance and temperature rise watt dissipation.

The art discloses two general types of variable resistors. One is the wire wound type utilizing the variation in resistance obtained by contacting the resistance element at various points along its length by a conductor in the form of a rotating sliding contact, or by bringing out connections from various points to the resistor element, contact to which is made by a sliding arm contact or lever. Variable resistance elements of this type are also made utilizing a carbon base resistor instead of wire. The other type is the compression type which functions by reason of the contact resistance variation between materials having negative pressure resistance coefficients such as carbon or which function by the compression of a mixture of powder or flake carbon or graphite with an insulating material such as mica powder.

Each of these types has an inherent limitation, that is, inability to directly dissipate its heat without a high temperature gradient from the hottest portion to the heat radiating surfaces.

The resistor of this invention allows the dissipation of heat more effectively from the resistor element and permits the construction of units having a much higher power capacity with volume. Also it allows the construction of a resistor having a much longer life than the present compression type due to the fact that unlike the carbon compression types which lose their initial range due to the change in contacting surface, the units of this invention by virtue of their construction are stable in operation and

may be adjusted or repeatedly compressed at the same pressures with approximately the same resistance values.

Another factor of importance with the present resistor is that a large resistance range can be obtained with a small angular change of the control pressure.

The invention comprises the impregnation into and onto the fibres of a glass mat or cloth of a resistor material such as colloidal graphite, and the heating up of the impregnated glass mat to the point where the resistance material is firmly and permanently bonded to the glass. The preferred impregnating material is colloidal graphite. Other resistor materials such as platinum may be used, in which case the glass mat is impregnated with a platinum chloride solution and then baked to the required temperature, such as 350° C., thus bringing about decomposition of the chloride and deposition of a thin platinum film. It is also possible to utilize a very thin deposit of nickel as the resistance material by heating the glass mat to 250° C. in a nickel carbonyl atmosphere.

In carrying out the invention, the glass fibre mat, preferably about 20 mils thick, and containing a large number of thin glass fibres, is placed in a container in which is a solution of 20% by weight of colloidal graphite (Aquadag). The aquadag is in an aqueous solution to which a small amount of ammonium hydroxide has been added to insure colloidal suspension (1 c. c. of 28% NH_4OH per liter of water). A low pressure is applied to allow the air between the fibres to be exhausted and after a period of about fifteen minutes the glass fibre mat having thereon a deposit of colloidal graphite is taken out of the impregnating solution and passed through a rubber roller under pressure so as to eliminate excess material. It is then baked for thirty minutes at a temperature of about 300° C. As a result of this baking the colloidal graphite is firmly bonded to the glass fibres and the glass mat may be then punched into discs or squares with mounting holes of a size dependent upon the application. By variation of the colloidal graphite content various ranges of initial resistance values can be obtained.

For some applications an ammonium shellac solution in the order of 5% of the graphite content may be added. This is a clear red solution completely miscible with the colloid. It decomposes during the baking, adds to the bonding of the graphite to the glass and increases the resistance to water vapor effects.

In the construction of the variable resistance units electrodes of good heat conductivity are positioned on both sides of the resistor discs, preferably at the minimum pressure required to secure good contact. The resistivity is high due to the long resistance paths along the fibres. When compressed the various fibres are brought together to provide an increasing number of multiple paths (due to contacting together of the fibres) which lowers the resistance in proportion to pressure.

In order to illustrate the construction of a typical unit and the performance of such a unit, reference is made to the drawings.

In Fig. 1 is shown a variable resistance device of this invention in which the resilient spring-like glass fibre mat resistor element 3, separated by brass heat-radiating plates 8, is contacted by end plates 1 and 2 of $\frac{1}{8}$ " thickness aluminum or brass. A ceramic tube 10, is riveted to the back end plate 1, serving as a guide and to keep the plates from rotating. Centrally located ceramic tube 5 is placed on thread screw 6, which is attached to the back end plate 1. At the thread end the knob 7 containing a threaded metal insert 6 and further insulated from the end plates by glazed ceramic washer 9 is used to apply the pressure to the resistor elements. This glazed washer also reduces the turning friction of the knob.

By the use of spacer washers of various thickness to increase the space between the radiator plates the amount of heat radiation and loss can be regulated.

In the unit described, the radiator plates have an area 3" square and are maintained $\frac{1}{8}$ " apart by use of spacer washers. The impregnated glass mat resistor elements are 2 $\frac{1}{2}$ " in diameter and a 32 pitch compression screw has been used in order to regulate the operation.

In Fig. 2 is shown a detail of one of the resistor sections of the device. The impregnated glass mat 11 is shown housed between contactor plate 12 and 13. The mat is not under operating pressure and the long current path length can be noted.

In Fig. 3 the same resistance section can be shown under compression and it is obvious that the current path has become much shortened due to parallel paths and contacting together of the fibres 11a.

The graph of Fig. 4 illustrates the operating characteristics of a resistor built according to the design illustrated in Fig. 1.

The three curves, pressure against resistance, rotation against resistance and watts against temperature rise are self explanatory and illustrate the wide range of utility of the device.

The variable resistance device of this invention allows a wide range of control, inasmuch as the sections may be connected in series, in parallel or in series parallel, and still have a control throughout the entire range of adjustment. This is not possible with wire wound variable resistors or compression type resistors.

Having described my invention what I claim as new and desire to secure by Letters Patent, is:

1. The method of making an electric resistance element which comprises immersing a resilient glass fibre mat containing a large number of criss-crossing thin glass fibres in an aqueous ammoniacal suspension of colloidal graphite to deposit colloidal graphite on said fibres, removing said mat from said suspension and extracting excess liquid therefrom and then baking said mat to bond said colloidal graphite thereto.

2. The method of making an electric resistance element which comprises immersing a resilient glass fibre mat containing a large number of criss-crossing thin glass fibres in an aqueous ammoniacal suspension of colloidal graphite to deposit colloidal graphite on said fibres, removing said mat from said suspension and extracting excess liquid therefrom and then baking said mat to bond said colloidal graphite thereto, and then inserting said mat between parallel plate electrodes in contact therewith.

3. The method of making an electric resistance element which comprises immersing a resilient glass fibre mat containing a large number of criss-crossing thin glass fibres in an aqueous ammonium resin solution containing a suspension of colloidal graphite, to thereby deposit colloidal graphite and resin on said fibres, removing said mat from said suspension and extracting excess liquid therefrom and then baking said mat to decompose said resin and bond said graphite to said glass fibres.

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