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ELECTRICAL HEATER AND METHOD OF MAKING SAME

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FIG. 1

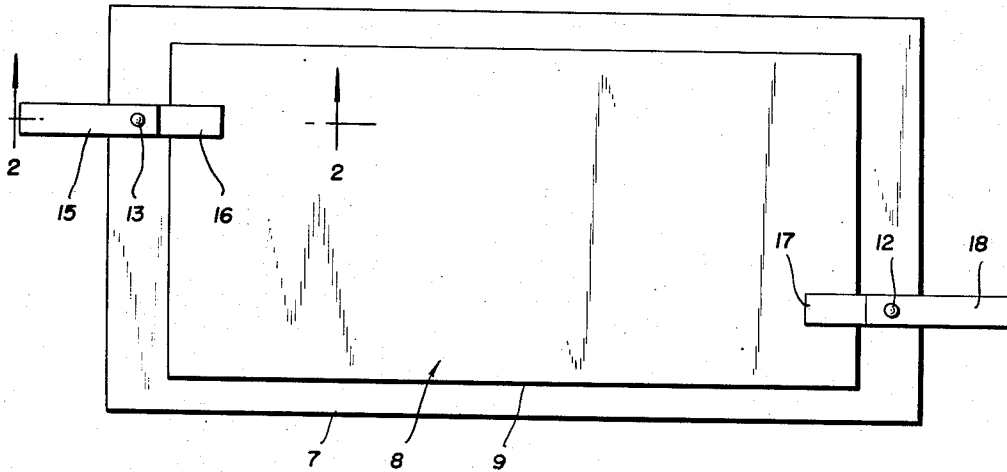
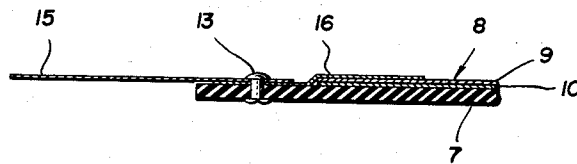


FIG. 2



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ELECTRICAL HEATER AND METHOD OF
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12 Claims. (Cl. 117-65)

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This invention relates generally to electrical resistors and more particularly it relates to electrical heating elements or conductors and the process of forming such heating elements or conductors.

Conventional electrical heaters comprise carbon or wire resistors or those of the type commonly known as "Calrod." Heating elements of these types have a relatively limited exposed area for transmitting or transferring heat in that usually they consist of wire wound on a form or mandrel, whereby a large percentage of the area of the wire is not in direct contact with the atmosphere. In the case of "Calrod" heating elements, for example, the length of the element itself is limited and its area exposed to the air is again limited because of its relatively short length. Since the useful area of conventional heating elements is limited it follows that they must operate at an exceedingly high temperature and, therefore, emit excessive infra-red energy. In certain applications, infra-red emission in large quantities is not desirable. For example, in heating aerial photographic equipment, excessive radiation may have undesirable effects on the photographic film.

Conventional electrical heating elements have a further disadvantage in that they are relatively unstable with respect to age, ambient temperature, operating temperature, and humidity. In many applications it is imperative that temperatures be maintained within precise limits and, therefore, stability is an important characteristic of electrical heating elements.

In some applications, electrical heating elements may be exposed to hydro-carbons such as oils, gasoline, acids, or to abrasive effects. Wire resistors, for example, which are either not insulated or are provided with relatively thin coatings of insulation are not resistive to these various materials and conditions.

Conventional electrical heating elements are usually so constructed that it is relatively difficult to form the element for the purpose of providing a predetermined electrical resistance. Usually the only variable is length or cross-sectional area of the electrical conductor. A further disadvantage is excessive weight especially in equipment designed for use in airplanes. Also in airplane use it is desirable to arrange a heating element in close proximity to the particular device which it is desired to heat. This becomes difficult when heating elements are operated at exceedingly high temperatures.

Accordingly the principal object of this inven-

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tion is to provide an electrical heating element having a maximum exposed area in proportion to cross-sectional area.

Another object of this invention is to provide an electrical heating element adapted to occupy the minimum volumetric space in proportion to its exposed heating area.

A further object of this invention is to provide an electrical heating element which may be operated at relatively low temperature.

Still another object of this invention is to provide an electrical heating element having a relatively high rate of energy transfer at a relatively low operating temperature.

Still another object of this invention is to provide an electrical heating element characterized by a certain amount of resilience which permits the element to be wrapped around the surface of the heated object.

A still further object of this invention is to provide an electrical heating element which is stable with respect to age, ambient temperature, operating temperature, and humidity.

Another object of this invention is to provide an electrical heating element, the electrical resistance of which may easily be adjusted during its formation.

Another object of this invention is to provide an electrical heating element which is resistant to abrasion, hydro-carbons, and acids.

Still another object of this invention is to provide an electrical heating element having minimum infra-red radiation with respect to rate of transfer of energy.

A still further object of this invention is to provide a process of forming an electrical conducting material adapted to comply with the foregoing objects of this invention.

In accordance with this invention, there is provided an electrical conductor comprising a sheet of insulating material having a coating of a dried mixture of two different conductive materials, each of which has an electrical resistance differing from the other.

Another feature of this invention comprises an electrical heating element, including a sheet of insulating material and a coating of a dried mixture of colloidal graphite and a colloidal metal selected from a group including gold, silver, or aluminum.

Further in accordance with this invention, there is provided a process of forming an electrical conducting material comprising the steps of mixing colloidal graphite in a vehicle, mixing a colloidal metal in a vehicle, said metal

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being selected from a group including gold, silver, or aluminum, combining these two mixtures, applying a first film of said mixtures to a non-conductive base material, drying said film, applying a second film over the first film, and drying the second film.

For a better understanding of the invention, together with other and further objects thereof, reference is made to the following description, taken in connection with the accompanying drawings, and its scope will be pointed out in the appended claims.

In the accompanying drawings:

Figure 1 of the drawings is a top plan view of an electrical heating element as provided by this invention.

Figure 2 of the drawings is an enlarged, partial, cross section taken on line 2—2 of Figure 1.

In accordance with this invention there is provided an electrical heating element consisting of a relatively flexible sheet of insulating material 7 on which is superimposed in sheet form an electrical conductor 8. The electrical conductor 8 consists of an outer coating 9 and an under coating 10. Each of these coatings may be of the order of .001" to .00125" in thickness. The composition and formation of these coatings will be described subsequently. Electrical terminals are provided by means of metallic terminal strips 15 and 18 which may be connected in conventional manner to a source of electrical potential. The terminal strips 15 and 18 may be electrically connected to the conductor 8 by providing conductive films 16 and 17. These films may comprise silver painted or printed on the surface of conductor 8 and the surface of insulating sheet 7. The terminal strips 15 and 18 may be fixed in intimate contact with the films 16 and 17 by riveting the terminal strips by means of rivets 12 and 13.

Each layer 9 and 10 of electrical conductor 8 is composed of a material consisting of, for example, colloidal graphite and colloidal silver, the preferred mixture being 33% graphite and 66% silver. This mixture may be varied from these percentages to a mixture of 50% graphite and 50% silver for the purpose of obtaining a composition having the desired electrical resistance. For example, variation of the proportions of the above materials will provide an electrical conductor having a resistance varying from .25 to 100 ohms when the conductor has dimensions of .002" thickness by 1" in width and 1½" in length. The following table shows the resistances of other well known electrical resistance materials.

Colloidal graphite dispersions—75 to 150 ohms for films approximately .002" th. x 1" wd. x 1½" lg.

Colloidal carbon black dispersions—125 to 200 ohms for films approximately .002" th. x 1" wd. x 1½" lg.

Resistance wire—100 to 600 ohms/mil. ft.

Solid carbon blocks—.0015 ohm/in. cube.

Solid graphite blocks—.0003 ohm/in. cube.

Carborundum (sintered) approx.—.1 ohm/cent. cube.

This material is used for extremely high temperatures.

From the foregoing it is apparent that a much wider variation in resistance is obtainable in accordance with applicant's invention than has heretofore been obtainable with conventional materials.

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It is desirable that the materials should include graphite and a metal selected from the class including silver, gold, and aluminum, all of which are characterized by their ability to be reduced to extremely small particles such as those found in colloidal mixtures. It has been found that aluminum is the least satisfactory of these materials as it is relatively unstable with comparison to gold or silver. Boneblack can be substituted for graphite, but for many applications it is found that it is not reducible to particles of sufficiently small size.

The process of preparing the conductor 8 consists in mixing, for example, colloidal graphite in alcohol at high speed, mixing colloidal silver in alcohol at high speed, and then mixing these two mixtures to obtain a thorough mixture. Alcohol is provided in a quantity sufficient to permit the application to insulating sheet 7 of a film of approximately .001" in thickness to .00125" in thickness.

A first film of approximately .001" in thickness may be applied to insulating sheet 7 and then dried at a temperature of approximately 200° F. A second film of the same thickness may then be applied over the first film and dried at approximately 200° F. until the second film loses its sheen. The drying temperature may then be increased at the rate of approximately 40° per hour until a temperature ranging from a minimum of 350° F. to a maximum of 550° F. is attained. If it is desired to hold the final drying temperature at 350° F., the drying process should be continued for a period of four hours; but if the temperature is raised to 550° F., the drying period is continued only for one and one-half hours. For temperatures within the range of 350° F. to 550° F., the drying period may be adjusted accordingly.

It is found necessary to dry the films at elevated temperatures in order to stabilize the electrical resistances. Without such heat treatment, it is found that the electrical resistance varies with ambient and operating temperatures. It is believed that the electrical resistance is stabilized by reason of the fact that heat treatment draws the particles of graphite and silver or other metal into more intimate contact with one another. It is also found, however, that excessive heat burns these particles and destroys their intimate electrical contact. Accordingly, experiment shows that the practical limits of temperature are 350° F. to 550° F. If, for example, the drying temperature is permitted to exceed 650° F. it causes burning of the graphite and an increase in the electrical resistance of the conductor.

It is preferred to apply the conducting material to the sheet 7 in two or more coats thereby to provide efficient drying and to prevent cracking of the film. Also by applying successive films, any desired over all thickness may be obtained thereby to obtain a relatively low electrical resistance.

Experimental use of the electrical heating element described herein proves that the conductor is stable as to age, ambient temperature, operating temperature, and humidity. It is resistant to oil, hydro-carbons, and acids or abrasion and is resilient, thereby permitting the heating element to be wrapped about a curved surface without danger of cracking or change of electrical resistance.

The size of the sheet 7 and the heating element 8 is found to be substantially unlimited and may be adjusted to the requirements of a particular heating problem. For example, in aerial

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photographic equipment, it is possible to heat a container of almost any size which may be found in such equipment. It is also found that infra-red radiation of such a heating element is limited to such an extent that it does not have any damaging effect on photographic film.

While there has been described what is at present considered the preferred embodiment of the invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention, and it is, therefore, aimed in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the invention.

I claim:

1. An electrical heating element comprising a flexible sheet of insulating heat-resistant material and a film of a dried mixture consisting of colloidal graphite and colloidal silver fixedly adhered to said sheet, said mixture being stabilized against change in resistance as a result of changes in ambient temperature.

2. The process of forming an electrical heating element consisting of the steps of mixing colloidal graphite in volatile alcohol at high speed, mixing colloidal silver with volatile alcohol at high speed, combining 33% to 50% graphite mixture with 66% to 50% silver mixture, applying a film consisting of said combined mixtures approximately .001" to .00125" in thickness to a heat-resistant non-conductive base material, adhering said film to said base material without the use of any adhesive composition by drying said film at approximately 200° F. until it loses its sheen, increasing said drying temperature at the rate of 40° per hour to a range of 350° F. to 550° F. and holding said temperature range of 350° F. to 550° F. for a period varying from four hours to one and one-half hours.

3. The process of forming an electrical heating element comprising the steps of mixing colloidal graphite in volatile alcohol at high speed, mixing colloidal silver with volatile alcohol at high speed, combining said mixtures, applying a film consisting of said combined mixtures approximately .001" to .00125" in thickness to a non-conductive heat-resistant base material, adhering said film to said base material by drying said film at approximately 200° F., increasing said drying temperature to a range of 350° F. to 550° F. and holding said temperature range of 350° F. to 550° F. for a period varying from four hours to one and one-half hours.

4. The process of forming an electrical heating element comprising the steps of mixing colloidal graphite in a volatile vehicle at high speed, mixing a colloidal metal with a volatile vehicle at high speed, said metal being of the group consisting of gold, silver, and aluminum, combining 33% to 50% graphite mixture with 66% to 50% metal mixture, applying a film consisting of said combined mixtures to a non-conductive heat-resistant base material, adhering said film to said base material by drying said film, said drying being performed at a predetermined temperature for a given period of time which will stabilize the electrical resistance of said film against resistance changes occurring as the result of changes in ambient temperature.

5. The process of forming an electrical conducting material comprising the steps of mixing colloidal graphite in a volatile vehicle at high speed, mixing a colloidal metal with a volatile

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vehicle at high speed, said metal being of the group consisting of gold, silver, and aluminum, combining said mixtures, applying a film consisting of said combined mixtures to a non-conductive heat-resistant base material, drying said film, applying a second film over said first film also consisting of said combined mixtures, and drying said second film.

6. An electrical heating element comprising a flexible sheet of heat-resistant insulating material which serves as a reinforcing base, and a continuous layer consisting of 33% to 50% of colloidal graphite and 66% to 50% of colloidal metal of the group consisting of silver, gold, and aluminum adheringly superimposed on one side of said sheet, said layer providing a surface which will radiate heat when electrical power is coupled thereto, said layer and said base constituting a single sheet-like unit which may be flexed to follow a contour of predetermined curvature, said colloidal graphite and colloidal metal being arranged in such electrical contact with each other so as to provide an electrical heating element of predetermined stable resistance which will produce a wall of heat containing substantially no infra-red radiation, the mixture constituting said layer being stabilized against changes in electrical resistance as a result of changes in ambient temperature.

7. An electrical heating element comprising a flexible sheet of heat-resistant insulating material which serves as a reinforcing base, and a continuous layer consisting of mixed colloidal graphite and colloidal metal of the group consisting of silver, gold, and aluminum, adheringly superimposed upon one side of said sheet, said layer providing a surface which will radiate heat when electrical power is coupled thereto, said layer and said base constituting a single sheet-like unit which may be flexed to follow a contour of predetermined curvature, said colloidal graphite and colloidal metal being arranged in such electrical contact with each other so as to provide an electrical heating element of poor electrical conductivity but of predetermined stable resistance which will produce a wall of heat containing substantially no infra-red radiation, the mixture constituting said layer being stabilized against changes in electrical resistance as a result of changes in ambient temperature.

8. An electrical heating element comprising a flexible sheet of heat-resistant insulating material which serves as a reinforcing base, and a continuous layer consisting of 33% to 50% of colloidal graphite and 66% to 50% of colloidal metal of the group consisting of silver, gold and aluminum adheringly superimposed on one side of said sheet, said layer comprising a surface which will radiate heat when electrical power is coupled thereto, said layer and said base constituting a single sheet-like unit which may be flexed to follow a contour of predetermined curvature, said colloidal graphite and colloidal metal being uniformly arranged on said sheet in such electrical contact with each other so as to provide an electrical heating element of poor electrical conductivity but of predetermined stable resistance which will produce a wall of heat containing substantially no infra-red radiation, the mixture constituting said layer being stabilized against changes in electrical resistance as a result of changes in ambient temperature.

9. An electrical heating element comprising a flexible sheet of insulating heat-resistant material and a film of dried mixture consisting of

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colloidal graphite and a colloidal metal, said metal being of the group consisting of gold, silver and aluminum, said mixture being fixedly adhered to said sheet and stabilized against changes in resistance as a result of changes in ambient or operating temperatures.

10. An electrical heating element comprising a body of insulating heat-resistant material and a film of dried mixture consisting of colloidal graphite and a colloidal metal, said metal being of the group consisting of gold, silver and aluminum, said mixture being fixedly adhered to said body and stabilized against change in resistance as a result of changes in ambient and operating temperatures.

11. An electrical heating element comprising a body of insulating heat-resistant material and a film of a dried mixture consisting of conductive colloidal carbon and a colloidal metal, said carbon being of the group consisting of bone black, graphite and carbon black, said metal being of the group consisting of gold, silver and aluminum, said mixture being fixedly adhered to said body and stabilized against change in resistance as a result of changes in ambient temperature.

12. The process of forming an electrical heating element comprising the steps of mixing con-

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ductive colloidal carbon and a colloidal metal in a volatile liquid vehicle, said metal being of the group consisting of gold, silver and aluminum, applying a film of uniform thickness consisting of said mixture to a non-conductive heat-resistant base material and drying said film so as to remove all traces of said vehicle and to adhere the resultant dried mixture to said base material, said drying being performed at a given temperature for a given period of time which will serve to stabilize the electrical resistance of said film against resistance changes occurring as a result of changes in ambient temperatures.

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