

Feb. 16, 1954

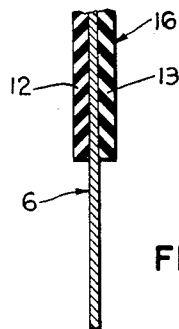
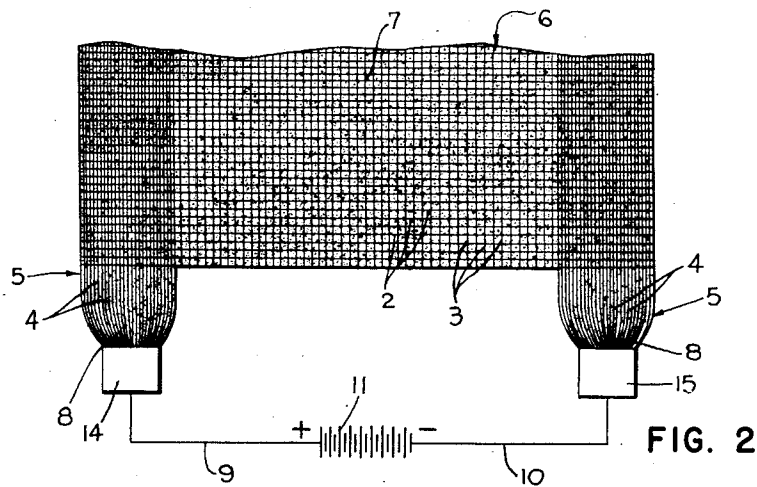
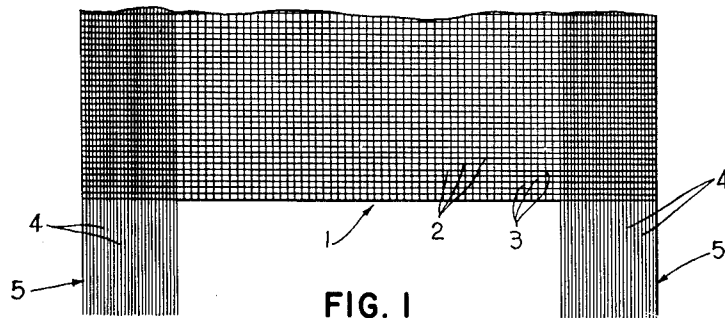
C. J. FORD

2,669,646

ELECTRICALLY CONDUCTIVE MATERIAL

Filed Jan. 20, 1950

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

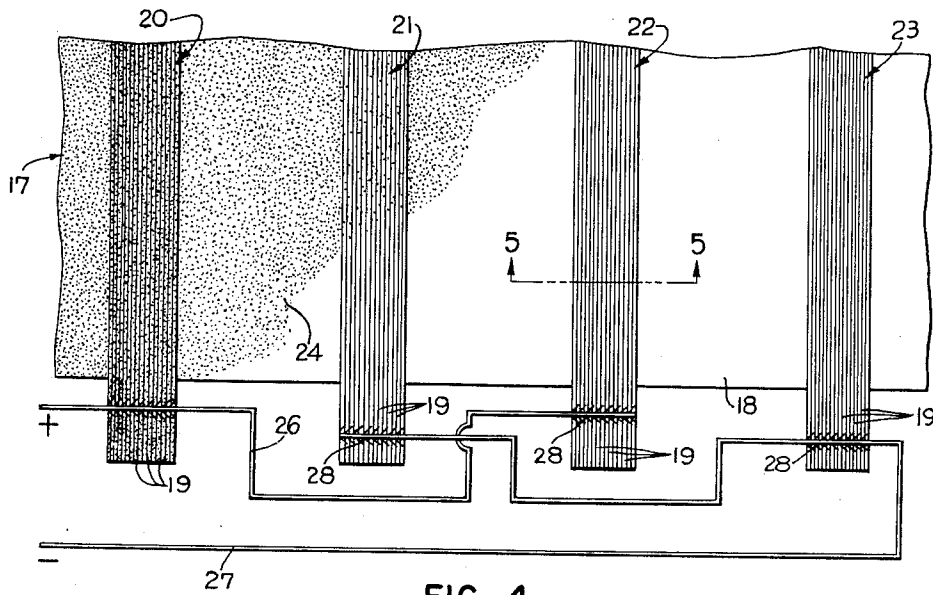


FIG. 4

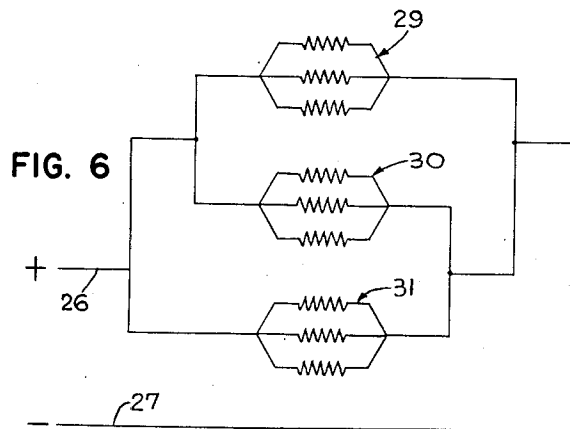


FIG. 6

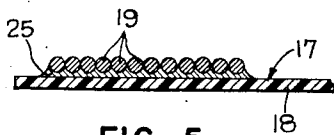


FIG. 5

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ELECTRICALLY CONDUCTIVE MATERIAL

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Application January 20, 1950, Serial No. 139,551

1 Claim. (Cl. 219—46)

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The present invention relates to an improved form of electrically conductive material and the method of making the same. More particularly, the invention is concerned with a composite form of electrically conductive material embodying integrally formed conductors therein.

An electrically conductive material of the type with which the teachings of the present invention are advantageously employed is any flexible material such, for example, as a thin plastic film or sheet, woven fabric, and the like on which a thin continuous deposit or coating has been formed rendering the normally non-conducting material capable of carrying an electrical current. A cloth fabric woven from threads of natural or synthetic origin or from a mixture of both is particularly well suited to such use and electrically conductive properties can be readily imparted to it in the manner suggested above.

One of the problems frequently encountered in the use of such electrically conductive flexible material, however, has been the difficulty experienced in satisfactorily securing electrical conductors or connections to the electrically conductive material itself.

Such connections, while they can be accomplished by soldering or brazing, are exceedingly bulky and susceptible to parting or breaking, especially where the connections are subjected in the normal use of the electrically conductive flexible material to vibrations of high frequency. Conditions of this nature are found, for example, in the use of such treated material in the fabrication of de-icing equipment for aircraft and the like. This represents only one of many such uses for the material possessing comparable conditions affecting the security of electrical connections thereto.

It is, therefore, an object of the present invention to obviate any and all such difficulties as are encountered in the provision of a secure electrical connection to the fabric by an improved method of forming the flexible material itself.

It is a further object of the present invention to provide an electrically conductive material in which the strands comprising the electrical conductors are intimately secured to or formed integrally with the material itself, thereby producing a completely homogeneous product.

Other objects and advantages of the invention will become apparent as the following description of one specific application of the inventive concept proceeds.

Fig. 1 represents a partial plan view of a segment of a composite cloth fabric of the type

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employed to advantage in the practice of the present invention. Fig. 2 illustrates the composite fabric of Fig. 1 to which a coating of an electrically conductive material and a dressing has been applied with an electrical circuit shown diagrammatically. Fig. 3 is a fragmentary enlarged cross section of an article, for example, a heating element comprising a core of material such as that shown in Fig. 2 and exposed laminae of insulating material. Fig. 4 shows a plastic film having metallic conductors attached and coated with an electrically conductive material. Fig. 5 is an enlarged cross section of the article shown in Fig. 4 and taken along the line 5—5 therein. Fig. 6 is a diagrammatic representation of an electrical circuit especially adapted to use with the article illustrated in Fig. 4.

In Fig. 1 of the drawings, the reference numeral 1 identifies a composite structure or fabric. The composite fabric 1 is made up of a plurality of weft or woof threads 2 extending transversely of the material and a plurality of warp threads 3 extending in a longitudinal direction or normal to the woof. At or adjacent the edges of the composite fabric 1, a plurality of metal wires or strands of electrically conductive material such, for example, as the metal wires 4 are substituted for certain of the warp threads so as to provide a distinct area, strip, or selvage 5 in the body of the fabric.

It will be readily understood that the metal wires 4 may extend in either direction and, moreover, may be arranged together in spaced groups or areas, each advantageously including a plurality of strands, throughout the body of the material depending upon the use to which the composite fabric 1 is to be put. Moreover, the metal strands or wires 4 can be sewn or otherwise secured to the fabric in restricted areas thereof. In any event, it should be understood that the use of the strip or selvage 5 adjacent the edge of the composite fabric 1 is found to be advantageous for certain specific uses to which the material is to be put, but is by no means restrictive of the invention.

The core 6 illustrated in Fig. 2 represents the composite fabric 1 to which a sheath or coating 7 has been applied. This sheath or coating embodies an electrically conductive substance which is intimately bonded to the woof and warp threads 2 and 3, as well as to the metal wires 4 so as to form a homogeneous covering over the entire width of the composite fabric, but not necessarily filling the voids in the fabric. The wires 4 forming the selvage portion 5 of the composite fabric

1 are adapted to be compacted, twisted, or gathered together in the manner indicated by the reference numeral 8 so as to provide a satisfactory connection for the electrical conductors 9 and 10 between which is disposed a source of electrical energy such, for example, as the battery 11. The clips 14 and 15 may advantageously be employed to facilitate the connection of the conductors 9 and 10 to the ends of the individual groups or gathers 8 of the wires 4 at the ends of the selvage portions 5.

The electrically conductive substance used in the coating 7 applied to the composite fabric 1 may take any of several forms. It may take the form of a chemically deposited metallic substance, such as metallic silver deposited from a silver nitrate solution. A coating 7 of copper or other suitable electrically conductive metals may be formed on the components of the composite fabric 1 by an electrochemical or plating process. It is essential that a substantially continuous sheath or coating be formed over the composite fabric 1 so as to insure a uniform particle-to-particle contact over the entire surface of the fabric. Other external dressings may be applied over the coating 7.

The completed core 6 is particularly well suited to incorporation in a laminated structure in which the core is completely enclosed in sheaths of suitable insulating and moisture resistant material 12 and 13 as indicated in Fig. 3. These sheaths of insulating material 12 and 13 may advantageously be relatively thin layers of vulcanized or unvulcanized rubber which, in the latter instance, are subsequently vulcanized. This construction is particularly well adapted to be affixed by a suitable bonding agent to a surface, such, for example, as that of a propeller or the wing surfaces of an airplane. Electrical current then supplied to the core 6 of the completed structure 16 serves to facilitate the removal of ice collecting upon exposed surface.

In Figs. 4, 5, and 6 is shown another type of flexible material, in this instance, a thin plastic film or sheet. The reference numeral 17 generally identifies the composite structure. The composite structure 17 embodies a plastic sheet 18 which carries a plurality of continuous electrically conducting strands or wires 19 arranged in a plurality of spaced mutually parallel groups 20, 21, 22, 23, the whole being covered with a uniform coating 24 of an electrically conductive substance such, for example, as a metal of the class including silver, gold, copper, and the like or their alloys.

The individual wires 19, which must be exposed, are advantageously secured to the plastic sheet 18 as by means of a thin layer 25 of an adhesive or bonding agent after which the whole is coated as indicated in Fig. 4. The electrical conductors 26 and 27 soldered or brazed, as at 28, to the exposed ends of the several wires 19 serve to complete the unit. The completed composite structure 17 is readily sheathed or incorporated in a laminated structure in the same manner as the fabric unit 1 (see Fig. 3) to form a heating element or other type of electrical unit.

With a composite structure of the type illus-

trated in Fig. 4 of the drawings, the several groups 20, 21, 22, and 23 set up a complex electrical circuit diagrammatically illustrated in Fig. 6. In other words, the plastic sheet 18 of the composite structure 17 with the coating 24 comprises a plate resistor in cooperation with the several groups 20, 21, 22, and 23 of wires 19. Thus, a series of mutually parallel circuits is formed involving the several groups 20, 21, 22, and 23, as shown in Fig. 6.

The several cooperating groups 20 and 21, 21 and 22, 22 and 23 represent individual mutually parallel resistances. The resistance circuit 29 represents that set up on the coated plastic sheet 18 between the cooperating groups 20 and 21 of the wires 19. The resistance 30 represents the completed circuit across the coated plastic sheet 18 between the groups 21 and 22. Similarly, the resistance 31 represents the completed circuit across the coated plastic sheet between groups 22 and 23 of wires 19.

Many other highly advantageous uses of the material will readily suggest themselves to those skilled in the art such, for example, as heating wall panels, enclosures for oil tanks to insure elevated temperatures of the contents, heated clothing, and many other similar uses. It will be understood that while certain representative embodiments and details have been shown for the purpose of illustrating the invention, it will be apparent to those skilled in this art that various changes and modifications may be made therein without departing from the spirit or scope of the invention.

I claim:

An electrically conductive material comprising a woven fabric of normally non-conductive warp and wool threads with certain of the warp threads in at least two spaced mutually parallel areas of the fabric adjacent the edges thereof being replaced by substantially continuous fine wires having electrically conductive properties to form a composite fabric with integrally formed strips of metal therein; and a uniform coating of an electrically conductive metal extending over both the non-conductive threads and the conductive wires in the composite fabric.

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References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
940,151	Heath	Nov. 16, 1909
1,989,282	Kimble	Jan. 29, 1935
2,205,543	Rideau et al.	June 25, 1940
2,274,840	Marick et al.	Mar. 3, 1942
2,327,756	Adamson	Aug. 24, 1943
2,386,095	Edgar et al.	Oct. 2, 1945
2,406,367	Griffith et al.	Aug. 27, 1946
2,473,183	Watson	June 14, 1949
2,503,457	Speir et al.	Apr. 11, 1950
2,559,077	Johnson et al.	July 3, 1951
2,631,219	Suchy	Mar. 10, 1953

FOREIGN PATENTS

Number	Country	Date
581,212	Great Britain	Oct. 4, 1946