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Schladitz

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[54] **POROUS, ELECTRICALLY CONDUCTIVE MEMBER**

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[51] **Int. Cl.** **B44d 1/20**, C23c 13/00

[58] **Field of Search** 117/228, 107.2, 119, 117/4, 98, 93; 29/419

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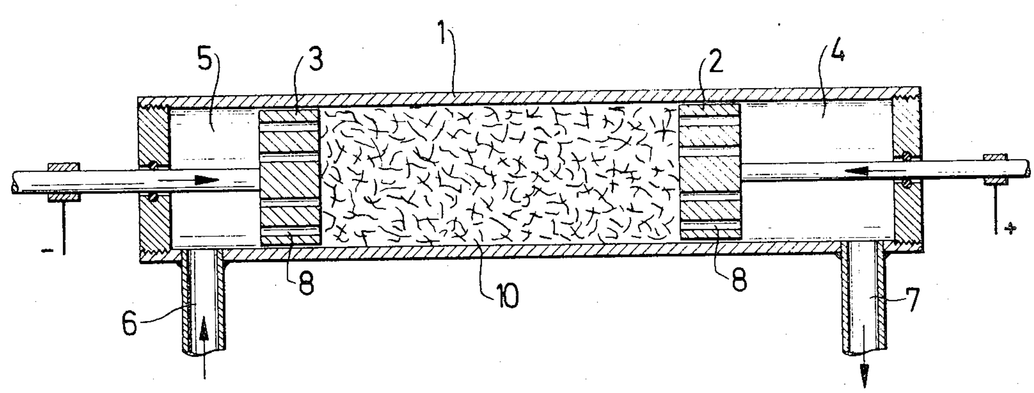
[57] **ABSTRACT**

A porous electrically conductive member particularly suitable for forming an electrical heating element is formed by coating thin filaments with electrically conductive metal, cutting them into short lengths or fibres and piling the fibres into a felt-like mass. This is made into a cohesive element preferably by further metal deposition which adds another coating to make the fibres adhere at their points of contact, although sintering or other methods can be used.

2 Claims, 1 Drawing Figure



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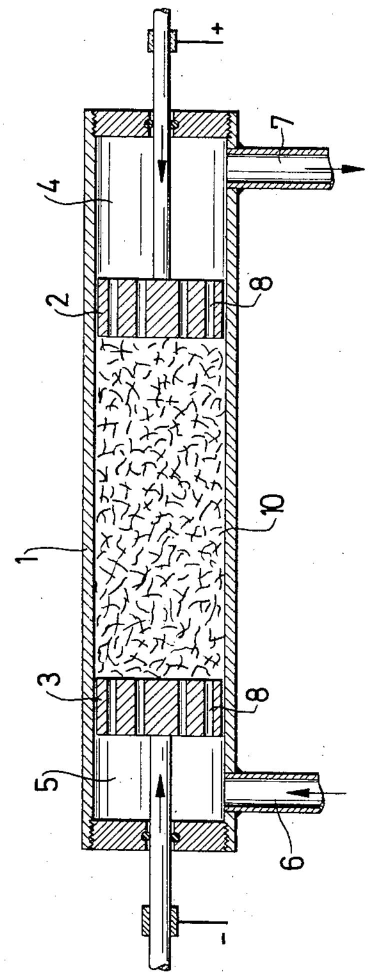

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POROUS, ELECTRICALLY CONDUCTIVE MEMBER

The invention relates to porous electrically conductive members, particularly ones suitable for forming electrical heating elements for the rapid heating of gases, liquids, vapours or aerosols. Such members consist of a felt-like structure with a great number of oblong, interlocked particles which are interconnected by a metal at their points of contact.

In known heating elements of this kind these particles consist of hairs, needles, rods or crystal whiskers with a diameter of under 10 μm or of lamellar particles with a thickness of under 1 μm. These particles can be metallic or they can consist of a thread-like nonconductor, such as aluminum oxide, quartz, glass or some organic synthetic material, and a conductive metal coating. It is very often of particular importance that the selected material has high heat resistance so that, even at temperatures of about 1,000° C, the strength properties will not be appreciably affected. As far as the production of such felt-like heating elements is concerned it is also of importance that the thread -like nonconductor can be provided with a conducitive metal coating in the most economical manner. Furthermore it has been shown that an even fibre cross section is essential to ensure homogeneous heating of the medium in question. The base material which has to be metallized is also desirably as cheap as possible.

Known metallized hair, thread-shaped or lamellar particles meet these requirements only partially. Nonmetallic whiskers of aluminium oxide with high heat resistance are still too expensive for industrial application in felt-like heating elements. Though these whiskers have a very great length-diameter ratio of the order of about 10,000:1 and more, this represents, however, at a diameter of 1 micron, a length of only about 10 mm which renders the economical production of a metal coating difficult.

It is the object of this invention to provide a porous, electrically conductive member which can be produced cheaply and which is distinguished by high heat resistance and a low specific weight.

According to one aspect of the invention there is provided a porous, electrically conductive member compsising a felt-like mass of oblong, interlocked particles interconnected by a metal at their points of contact, said particles consisting of graphitic carbon fibres on the surface of which a metal has been deposited by the thermal decomposition of a metal compound in the gaseous phase.

It is generally known that carbon filaments are produced by the carbonization, at comparatively low temperatures, of natural or synthetic filaments which consist of a carbon compound, such as cotton filaments or polyacrylonitrile filaments. For increased stresses these carbon filaments can be converted into crystalline graphite at a temperature of about 2,500° C. Carbon filaments of this kind are referred to as graphitic carbon filaments. Carbon filaments have high heat resistance, up to about 3,000° C, high specific strength and a low specific weight and they are obtained as yarn in any length since the starting material, for instance polyacrylonitrile filaments or cotton filaments, can be produced as a continuous or twisted filament. For this reason it is possible to metallize the carbon filaments at high speed (several m/sec) in a continuous process, either individually or, in a more economical way, in a hank of several thousand single filaments. After the metallization the hank can be cut up into the desired lengths which are then felted, the single filaments being interconnected by a metal at their points of contact. Polyacrylonitrile filaments are produced by means of a drawing die and consequently have an absolutely even fibre cross section. The carbon filaments which are obtained through the carbonization of these filaments accordingly also have an even cross section.

A carbonyl of the metals chrominum, nickel, tungsten, molybdenum or a mixture of such carbonyls is preferably used for the coating of the carbon filaments. It is generally known that metal carbonyls have the property that they decompose in metal and carbon dioxide at a certain temperature. Thus the metals can be deposited in finely crystalline form on the surface of the carbon filaments to give a very adhesive, coherent coating which can be connected in an electrically conductive manner with the coatings of adjacent carbon filaments. This connection can be established through sintering, through additional depositing of metal in the gaseous phase to cause metallic bonding at the points of contact of the various metal-coated carbon filaments, through high frequency-induction heating to fuse the various filaments, through electron beam welding, through ultrasonic sealing, or through laser beam heating for example. For extreme conditions, for instance for the heating of reactive liquids, it is possible to cause a reaction of the metal coating with the material of the carbon filament. If for instance a carbon filament is coated with tungsten and if this coated filament is heated to a temperature exceeding 1,000° C, tungsten carbide — which is distinguished by its exceptional hardness and chemical resistance — is formed through the known reaction of tungsten with carbon.

Some specific examples relating to the production of the object according to the invention will now be described, by way of example, with reference to the accompanying drawings, in which the single figure is a diagrammatic axial section of

EXAMPLE 1

Carbon filaments with a diameter of between 0.1 and 10 micron are twisted or spun in order to obtain a continuous yarn and raised to the decomposition temperature of nickel carbonyl which lies between 100 and 160° C, by high frequency heating for example. The heated filaments are then passed through an enclosed space into which a mixture of 90 percent argon and 10 percent nickel carbonyl vapour is introduced. The nickel carbonyl is decomposed on the heated filaments into nickel and CO, whereby a coherent coating of nickel is formed round each individual filament. The thickness of the coating depends upon the retention time of the filaments in the reaction chamber, namely upon the rate of passage assuming there to be continuous flow through the chamber. It amounts for instance to 0.1 to 0.5 micron. The filaments which have been metal-coated in this way are still not coherent and they are now cut up into staple fibres which will be gathered by known measures, for instance by an air-sifting method into a loose pile. This loose pile is introduced into the central part of a cylinder **1**, referring now to the drawing, between two pistons **2** and **3** which can be moved towards each other. The sides of pistons **2** and **3** which are not facing each other and the ends of the cylinder **1** define chambers **4** and **5**. The cylindrical chamber **5** provided with a feedpipe **6** for a mixture of nickel carbonyl vapour and an inert gas, and a discharge pipe **7** leads from the cylindrical chamber **4** for undecomposed residual gases as well as for the CO which is produced by the decomposition of the nickel carbonyl. The pistons **2** and **3** are provided with through bores **8**. At least the facing sides of these two pistons are electrically conductive and can be connected to a source of current. After the introduction of the pile **10** between the pistons **2** and **3** the latter are moved towards each other until the desired porosity of the pile is attained. The pistons **2** and **3** are then connected with the source of current and the pile is heated by the direct passage of current to the decomposition temperature of the carbonyl which is used. A mixture of 90 percent argon and 10 percent nickel carbonyl vapour is now fed through the pipe **6** into the chamber **5** this passes through the bores **8** in the piston **3** into the pile **10** where the nickel carbonyl is decomposed and nickel atoms are deposited on the metal coated filaments and on the points of contact of the filaments, whereby a good electrically conductive connection between the filaments will be established. This second coating can attain a thickness of 0.1 to 2 micron. As far as this process is concerned, it is essential that the pressure which is exerted by the pistons **2** and **3** on the pile **10** is maintained during the subsequent metallizing process, since the metallized carbon filaments will otherwise tend to move away from each other in view of their high modulus of elasticity.

EXAMPLE 2

Carbon filaments are provided with a nickel coating in the manner proviously described. The continuous filaments are then cut up into lengths of about 1 cm and these staple fibres are gathered in the shape of a loose pile by pouring them into a mould or by allowing them to be precipitated from a liquid. The short lengths of fibres are compacted until the desired porosity is attained and are then submitted to a caking process by heating to approximately 600°– 1,000° C over a period of about 30 minutes. It will be understood that as far as this second method is concerned the thickness of the metal coating of the continuous carbon filaments should exceed that of the first example, since at the subsequent joining of the individual filaments by a sintering process a second metal deposit on the filaments does not take place.

Such porous, electrically conductive members are particularly suitable as heating elements for the rapid heating of gas vapours, aerosols and liquids. It is possible to convert with these heating elements, for example, liquid hydrocarbons into vapours within fractions of seconds. A jet of hot gases, for instance of argon, with a temperature of 1,300° C can be produced which can be used for hard-soldering, welding or flash welding. Although these elements are principally intended and suitable for applications where great demands on the heat resistance are made, they are also suitable as hot or cold electrodes for electrochemical processes, fuel cells or as secondary cells. The low specific weight is of particular importance in this connection.

I claim:

1. A process for the production of a porous, electrically conductive member comprising the steps of:

obtaining carbon filaments by the carbonization of natural or synthetic filaments consisting of a carbon compound; heating said carbon filaments to the decomposition temperature of a metal carbonyl; exposing the heated filaments to an atmosphere containing metal carbonyl vapour until their surfaces are coated with metal; cutting up the metallized carbon filaments into staple fibres; compacting a loose pile of such fibres to the desired porosity for said member; and heating said compacted pile by direct passage of electrical current to the decomposition temperature of a metal carbonyl, passing metal carbonyl vapor through said compacted and heated pile while the compression pressure is maintained to deposit metal uniformly on the fibers and at their points of contact thereby to interconnect them.

2. A process as claimed in claim **1**, wherein the carbon filaments are heated after the metal coating to a temperature at which a chemical reaction between the metal of the coating and the carbon takes place.

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