April 30, 1963 R. W. TURNBULL **3,087,233**

PERVIOUS METAL FIBER MATERIAL AND METHOD OF MAKING THE SAME

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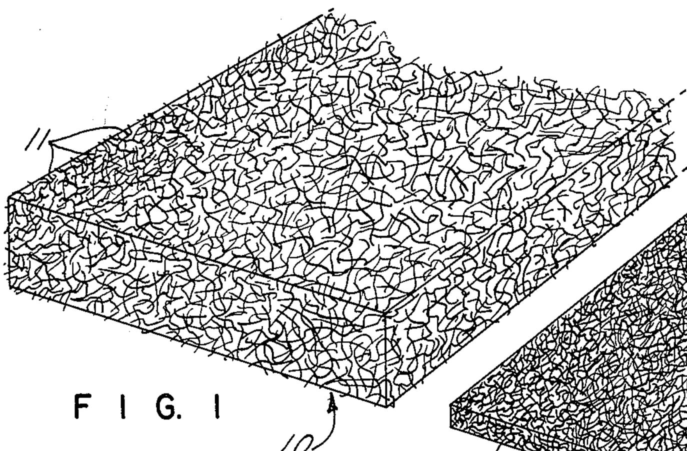
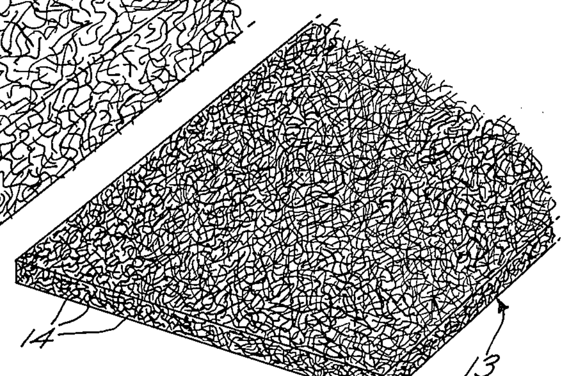
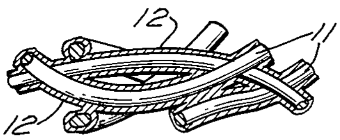


F I G. 1





F I G. 3

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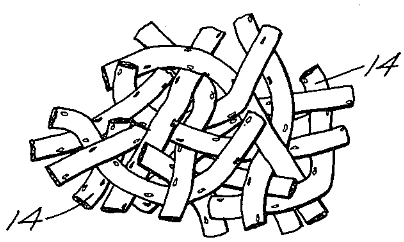
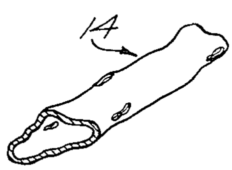
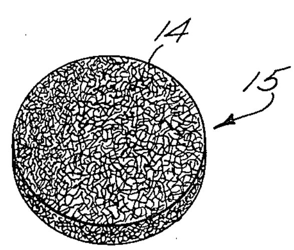




F I G. 4

F I G. 5



F I G. 6

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PERVIOUS METAL FIBER MATERIAL AND METHOD OF MAKING THE SAME

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This invention relates to a pervious material formed of fine metal fibers and to the method of making the same.

Articles formed of metal fibers are well-known and have been used for years. One example of the same is steel wool which is used for scouring purposes and as a filter.

The individual fibers forming such prior metal fiber articles are much larger in diameter or thickness than the very fine metal fibers contemplated by the present invention. This is because such metal fibers have been produced heretofore by a cutting or tearing operation or a drawing operation, and these operations do not produce fibers having the degree of fineness herein contemplated.

An important object of the present invention is to produce a metal fiber filter that is capable of removing all solids more than a few microns in size from the fluid being filtered. The steel wool and other metal fiber materials available heretofore are too coarse to produce this high degree of filtration.

The fine metal fibers herein contemplated are produced by using fine organic carrier strands, such as natural or synthetic fibers or filaments, and depositing on these strands a thin metal jacket of iron, nickel, copper or the like by a gas plating operation that is now well-known. Apparatus for gas plating glass fibers and other objects is disclosed in patents now owned or controlled by the Union Carbide Corporation.

The carrier strands may vary extensively in length and range from a fraction of an inch to one or more inches long. These strands are deposited in a randomly disposed mat or batt either before or after they are gas plated.

The individual carrier strands may have such jacket deposited thereon by running continuous organic strands through a gas plating device. However, it is preferable, in most cases, to form a mat or batt of such organic strands and then subject this mat of strands to the gas plating operation so as to deposit a thin metal jacket on each individual strand. The metal jackets thus formed may be submicron or low micron in wall thickness.

Next, this mat of plated strands is heated or otherwise treated so as to decompose the carrier strands without destroying the metal jackets formed on such strands. What remains after the organic carrier strands are destroyed are the thin metal jackets disposed at random to each other in the form of a relatively open mat or batt. The mat may then be compressed more or less to flatten or partly flatten these metal jackets and crowd them together to form a pervious metal material of the desired density and pore structure.

As a final step, it may be desirable to sinter this fibrous mass so as to bond the metal fibers together to prevent fiber migration and form a firm metal sheet.

The porous or pervious metal fiber mass thus produced may be used as a catalysis or self-lubricating bearing member or in other fields where this very fine pore structure is desired, but it is particularly well adapted for use as a filter to filter either liquids or gases to remove all solids over a few microns in size.

The above and other features of the present invention and method of making the material will be further understood from the following description when read in connection with the accompanying drawing, wherein:

FIG. 1 is a perspective view of the mat or batt formed of textile fibers or strands.

FIG. 2 on a greatly enlarged scale shows a few of the strands of FIG. 1 after a thin metal jacket has been deposited on each strand.

FIG. 3 is a perspective view of a porous metal sheet formed by metal coating the strands of FIG. 1 and then decomposing these carrier strands, and compressing the remaining metal jackets.

FIG. 4 is a greatly enlarged perspective view of part of the porous metal sheet of FIG. 3.

FIG. 5 is a further enlarged view on one of the collapsed metal jackets of FIG. 4, and

FIG. 6 is a perspective view of a filter disc or catalysis cut from the sheet of FIG. 3.

The mat or batt shown in FIG. 1 may be given any desired thickness, width and length found desirable. This mat is designated by the numeral **10** and is made up of the fine fibers, filaments or strands **11**. It is important that these strands, which are frequently hereinafter called "carrier strands," be formed of organic fibers or filaments that can be substantially completely decomposed by heat as hereinafter described.

Such strands **11** may be natural fibers, such as cotton or synthetic fibers, such as extruded viscose filaments. These extruded filaments should be cut or broken to relatively short lengths measuring anywhere from a fraction of an inch to an inch or more in length, so that they can be blown or otherwise deposited one on top of the other at random to each other to form the mat **10** of the desired size and thickness. If the mat **10** is formed of cotton fibers they will tend to interlock which is desirable. If this mat is formed of synthetic fibers, such fibers should preferably be pre-crimped so that they will interlock one with the other in the mat **10**. The carrier strands **11** are preferably fine strands for a reason to be given.

The individual strands **11** have deposited thereon thin metal jackets **12**. Such jackets can be deposited on continuous lengths of synthetic filaments by passing these filaments through a gaseous metal coating chamber, such as disclosed in the patents above referred to, and then the coated filaments can be cut into short lengths and deposited one on top of the other at random to each other as shown in FIG. 2.

However, it is preferable to form the mat **10** of organic randomly disposed fibers **11** as above described, and then metal coat the carrier strand **11** throughout the mat **10** by a gaseous metal depositing operation which will now be described. Such coating operation serves to cover each fiber in the mat with a thin metal jacket, and these jackets may be less than one micron to a few microns in wall thickness. If cotton fibers that are non-circular in cross section are used as the carrier strands, the jackets deposited thereon will likewise be non-circular in cross section, whereas, if round, extruded filaments are the carrier strands, the metal jackets will be round in cross section.

The procedure for metal coating the carrier strands **11** as they lay in the mat or batt **10** consists in suspending the organic fiber mat **10**, **11** in a chamber with windows transparent to infra-red radiation, purging the chamber with an inert gas such as CO_2 or N_2, heating the mat to above the decomposition temperature of the plating vapor by external infra-red radiators, then admitting the plating gas mixed with a carrier gas such as N_2 or H_2 until such time as the desired thickness of plate has deposited on the fibers **11**. The plating gas may be any metal bearing gas or volatile liquid such as iron or nickel carbonyl whose decomposition temperature is below the decomposition temperature of the organic fibers. In this way a jacket **12** of the desired thickness is deposited on the carrier strands **11**.

The mat is then heated in an inert or reducing atmosphere, such as N_2 or H_2 to a temperature high enough to anneal the metal and decompose the organic fibers **11**. This will leave the jackets **12** as empty tubes. In the case of nickel on cellulose, this can be done between 1400–1500° F., which is well below the melting point of nickel. The mat is then cooled to room temperature and compressed to the desired thickness and density to thereby provide a pervious metal mat made up of partly or substantially flattened metal tubes. This compressed metal mat is shown in FIG. 3 and is designated by the numeral **13**. The mat is formed entirely of the hollow metal jackets **14**. These jackets which may be from a fraction of an inch to an inch or more long are frequently herein called, "metal fibers."

Since the primary purpose of the present invention is to provide a porous metal material having exceptionally fine pore structure, the carrier strands **11** should be fine in diameter or cross section, and the metal jackets deposited on such fibers should be very thin, say not more than a few microns thick.

After the pervious metal sheet **13** formed of the more or less flattened metal jackets **14** is produced as just described, and the fibers are sintered one to the other to retain them in place, porous discs such as shown in FIG. 6 and indicated by **15** may be cut therefrom, or this pervious sheet **13** may be otherwise used. Another use of the porous metal sheet **13** would be to pleat the sheet and form this pleated material into a cylinder for use as a high temperature metal filter of very fine pore structure capable of removing all solids from a fluid more than a few microns in size.

If desired, the porous metal sheet **13** may be strengthened by applying to one or both faces of the sheet **13** a suitable woven metal cloth (not shown). The metal sheet **13** could be sintered to such wire cloth in a reducing atmosphere at a time and temperature found suitable for the particular metal and fiber size involved. The reinforced porous metal sheet or filter media can then be formed to any desired shape.

It will be seen from the foregoing that by forming a pervious metal material as herein contemplated, so that the same is made up of very fine metal jackets, a metal sheet having extremely fine pore structure is provided.

Having thus described my invention, what I claim and desire to protect by Letters Patent is:

1. The method of making a pervious metal material, which comprises forming a mass of randomly disposed long slender interlocked organic carrier strands, depositing on the individual strands a thin metal jacket, then destroying said strands in the mass without destroying their metal jacket, and then compressing these randomly disposed empty metal jackets to flatten them and form a compact pervious mass of such interlocked jackets.

2. The method of making a pervious metal material, which comprises forming a mass of randomly disposed long slender interlocked organic carrier strands, depositing on the individual strands a thin metal jacket, then destroying said strands in the mass without destroying their metal jacket, and then compressing these randomly disposed empty metal jackets to flatten them and sintering one to the other to form a compact pervious mass of such jackets.

3. The method of making a metal filter material which comprises forming a mass of randomly disposed long slender interlocked organic carrier strands, depositing on the individual strands a thin metal jacket, then destroying said strands in the mass without destroying their metal jackets, and then compressing these randomly disposed empty metal jackets to flatten them and form a compact pervious mass of such interlocked jackets.

4. A pervious mass of metal material comprising a plurality of randomly disposed long slender interlocked fibers consisting of hollow plated metal jackets, said jackets being in a distorted and flattened condition and sintered together at their points of contact, the wall thickness of said jackets being between one micron and a few microns.

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