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3,262,190

METHOD FOR THE PRODUCTION OF METALLIC HEAT TRANSFER BODIES

Original Filed July 10, 1961

FIG. 1

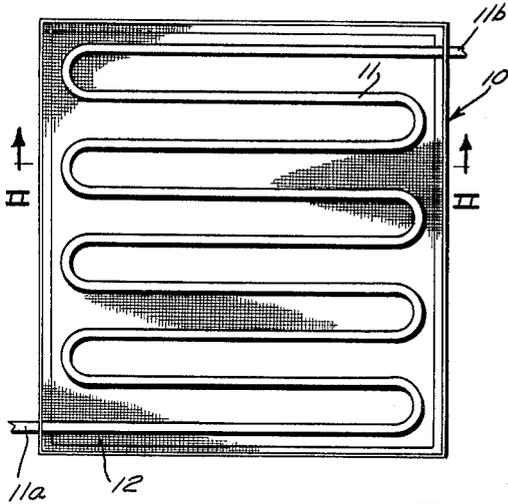


FIG. 2

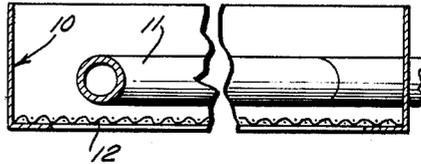


FIG. 3

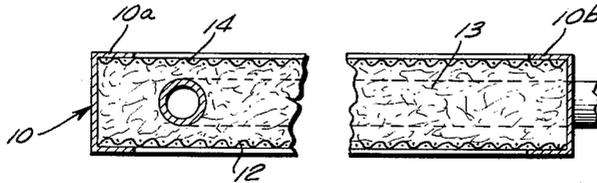


FIG. 4

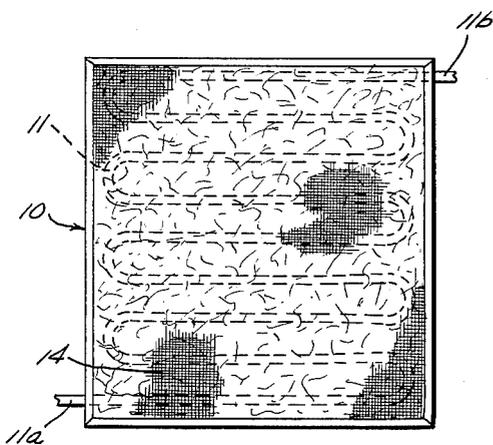
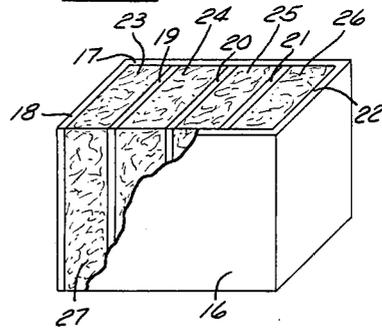


FIG. 5



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METHOD FOR THE PRODUCTION OF METALLIC HEAT TRANSFER BODIES

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5 Claims. (Cl. 29—157.3)

This application is a division of our copending application Serial No. 122,844 filed July 10, 1961.

The present invention is directed to improved heat transfer systems of the type employed, for example, in automobile radiators, heaters, refrigerators, and air conditioning systems. The heat transfer systems of the present invention are specifically designed to replace the conventional fin and tube structures now commonly employed as heat exchange elements.

The manufacture of fin and tube type heat exchangers is usually accomplished by an assembly of blanked and stacked fins strung over serpentine heat transfer tubes. While such assemblies are reasonably efficient heat transfer systems, they are rather difficult to assemble and consequently are relatively expensive to manufacture.

The present invention employs techniques of the new field of fiber metallurgy in building up a heat transfer system consisting basically of a heat transfer element having relatively short, heat conductive fibers of metal bonded to the surface of the heat transfer element and bonded to each other along their areas of contact. This structure results in an improved heat transfer system because of the very large surface to volume character of the metal fibers. The improved heat transfer system is also capable of being automated more completely than present methods and therefore provides a cheaper manufacturing cost by virtue of reduced labor cost.

Fiber metallurgy concerns itself with the manufacture and use of metallic fibers, that is, metallic elements whose length is considerably greater than any dimension in cross-section but is not so long as to constitute a continuous filament. As a general rule, the fiber has a ratio of at least 10 to 1 between its length and its mean dimension in cross-section. In the case of a circular fiber, the mean dimension is the diameter, while in the case of a rectangular fiber, the mean dimension is one-half the sum of the short side and the long side of the rectangle.

When metallic fibers of the character described are suitably deposited by any of a variety of methods to be described later, they assume a random three dimensional distribution which provides a uniform porosity, and remarkable strength to porosity ratios. The strength characteristics of the fibers arise from providing metal-to-metal bonds between the fibers along their areas of contact. Such metal-to-metal bonds may be provided, for example, by sintering the fibers at an appropriate sintering temperature, or by employing pre-coated fibers having a coating of a brazing material thereon and then heating the fibers to a temperature sufficient to melt the brazing material without melting the fibers, causing the molten brazing material to eventually solidify at the points of contact between the fibers and bond them together.

The unique strength to porosity ratio, the ability to produce extremely porous materials, and the very large surface to volume character of the deposited fiber mass are properties which adapt such fiber metallurgy structures to the field of heat transfer elements.

Accordingly, an object of the present invention is to provide a method for the production of an improved heat transfer system utilizing a highly porous heat transfer means.

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Another object of the invention is to provide a method for the production of a highly porous felted heat transfer element for use in heat transfer systems.

Still another object of the invention is to provide an improved method for assembling a heat exchange device.

Another object of the invention is to provide a method for the manufacture of heat transfer elements which is more readily adaptable to automation and is less expensive than methods presently used in the manufacture of fin and tube type heat transfer elements.

A further description of the present invention will be made in conjunction with the attached sheet of drawings in which:

FIGURE 1 is a plan view of the heat transfer assembly in an early stage of formation;

FIGURE 2 is a cross-sectional view taken substantially along the line II—II of FIGURE 1;

FIGURE 3 is a view similar to FIGURE 2 but illustrating the heat transfer assembly with the metallic fibers incorporated therein and bonded together;

FIGURE 4 is a plan view of the finished assembly; and

FIGURE 5 is a view in perspective of a modified form of the invention.

As shown in the drawings:

In FIGURE 1, reference numeral 10 indicates generally an open support frame consisting of sheet metal or the like. The frame 10 carries a conventional serpentine type tube 11 consisting of copper or the like and having its ends 11a and 11b secured to the frame 10. A relatively coarse metal screen 12 is fastened to one side of the frame 10 to rigidify the frame 10 and also to serve as a collector for the metal fibers which are subsequently deposited over and about the tube 11.

Relatively small, heat conductive fibers are then deposited in the form of a felt over the tube 11 so that the tube is completely immersed within a mat 13 of fibers, as best illustrated in FIGURE 3.

While copper fibers are preferred for the mat because of their excellent heat transfer characteristics, it should be appreciated that other types of metallic fibers can also be employed. It should also be apparent that the fibers can be deposited about the tube 11 in any of a variety of manners. The simplest consists in simply dropping the fibers by gravity onto and around the tube 11, using the screen 12 as a collector. In order that the metallic fibers have a substantial amount of mobility during the felting, it is advisable to employ fibers which have lengths not in excess of two inches, and preferably not in excess of one inch. Particularly good results have been achieved by employing fibers in the range from one quarter to three quarters inch in length.

Another procedure for depositing the fiber mat 13 about the tube 11 consists in suspending the metallic fibers in a liquid medium such as oil or glycerine, agitating the fibers in suspension so that a uniform slurry is produced, and then pouring the slurry over the tube 11 so that the suspending medium drains out through the screen 12, leaving a randomly oriented felt of fibers about the tube 11.

Still another technique which can be employed consists in suspending the short length fibers in an air stream under a slight positive pressure, and blowing the fibers onto and about the tube 11 until a mat of sufficient thickness is built up.

By any of these means of deposition, the porous, randomly oriented mat of fibers can be produced about the tube 11. The best results, the porosity of the mat should be at least 50%, while it may be as high as 95%.

After the fiber mat 13 has been incorporated about the tube 11, a second screen 14 may be secured across the face of the frame 10 to further rigidify the structure

without significantly increasing its resistance to air flow. As illustrated in FIGURE 3, the upper ends 10a and 10b of the frame 10 may be bent over to provide areas for fastening the screen 14 to the frame 10.

After the mat has been built up, the complete assembly is treated to provide metal-to-metal bonds between the tube 11 and the fibers, as well as between the fibers themselves. This is most conveniently done by passing the entire assembly into a sintering furnace and holding the assembly within the furnace, in the presence of a reducing or a non-oxidizing atmosphere until the metal-to-metal bonds are produced. Generally, the sintering temperature will be on the order of two-thirds of the melting temperature of the metal involved, expressed in degrees Kelvin.

After sintering, the metal fibers are secured by metallurgical bonds to the surface of the tube 11 and are similarly secured to adjoining fibers at their areas of contact. Some sintering of fibers also occurs to the material of the opposed screens 12 and 14, resulting in the production of a completely porous but substantially rigid heat transfer assembly.

As previously indicated, another method of securing the metal-to-metal bonds consists in pre-coating the metal fibers with a brazing compound, such as a low melting alloy, and then heating the assembly to a temperature sufficient to melt the brazing compound without melting the fibers or the tube 11. When the molten material has solidified, it forms metal bonds at the areas along which the fibers contact the surface of the tube 11, and also along those areas at which the fibers contact each other.

A modified form of the invention is illustrated in FIGURE 5 of the drawings. In this form, the heat exchanger is composed of a pair of opposed side plates 16 and 17 spaced from each other by means of sheet metal separators 18, 19, 20, 21 and 22, thereby providing a series of compartments 23, 24, 25 and 26. Metal fibers 27 are disposed in each compartment thus provided, the fibers 27 being bonded to each other (by sintering, brazing, or the like) and also being bonded to the walls of the compartment which they abut. With the illustrated structure, a hot fluid can be introduced through the fibrous masses in compartments 23 and 25 and a cooling fluid through compartments 24 and 26 in countercurrent flow to the hot fluids in the adjoining compartments, and thereby provide efficient heat exchange between the fluid streams.

The fiber mat possesses excellent heat transfer properties from the bonds between the fibers and the tubing, and between the fibers themselves. The very high porosities achieved by the felting process permits the easy passage of air or gases through the felted body. The heat transfer is therefore by conduction through the wall of the tubing from the fluid circulated through the tubing, through the high specific surface fiber network by conduction, and finally to the forced permeating gas by convection and radiation.

It should be evident that various modifications can be made to the described embodiments without departing from the scope of the present invention.

We claim as our invention:

1. The method of making a heat transfer assembly which comprises positioning a heat transfer element in spaced relation to a foraminous surface, dispersing heat conductive metal fibers in three dimensional random orientation to fill up the space between said heat transfer element and said foraminous surface, and thereafter metallurgically bonding said fibers to said heat transfer element, to said foraminous surface, and to themselves.

2. The method of making a heat transfer assembly which comprises positioning a heat transfer element in spaced relation to a foraminous surface, dispersing heat conductive metal fibers in three dimensional random orientation to fill up the space between said heat transfer element and said foraminous surface, said fibers having lengths not in excess of two inches and having lengths at least 10 times their mean dimension in cross-section, and thereafter metallurgically bonding said fibers to said heat transfer element, to said foraminous surface, and to themselves.

3. The method of making a heat transfer assembly which comprises positioning a heat transfer element in spaced relation to a foraminous surface, dispersing heat conductive metal fibers in three dimensional random orientation to fill up the space between said heat transfer element and said foraminous surface, and thereafter sintering said fibers to said heat transfer element, to said foraminous surface, and to themselves.

4. The method of making a heat transfer assembly which comprises positioning a heat transfer element in spaced relation to a foraminous surface, dispersing heat conductive metal fibers in three dimensional random orientation to fill up the space between said heat transfer element and said foraminous surface, each of said fibers having a length not in excess of two inches and having a length at least 10 times its mean dimension in cross-section, and thereafter sintering said fibers to said heat transfer element, to said foraminous surface, and to themselves.

5. The method of making a heat transfer assembly which comprises positioning a heat transfer element in spaced relation to a foraminous surface, dispersing heat conductive metal fibers in three dimensional random orientation to fill up the space between said heat transfer element and said foraminous surface, and thereafter metallurgically bonding said fibers to said heat transfer element, to said foraminous surface, and to themselves to form a mat of felted fibers having a porosity of at least 50%.

References Cited by the Examiner

UNITED STATES PATENTS

1,893,330	1/1933	Jones	113—118 XR
2,401,797	6/1946	Rasmusson	165
3,062,509	11/1962	Mulder	29—157.3
3,127,668	4/1964	Troy	29—419 XR

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