Feb. 1, 1966 N. E. LINDSTRAND ETAL 3,232,343

RADIATOR AND RELATED METHODS

Filed Nov. 26, 1963 2 Sheets-Sheet 1

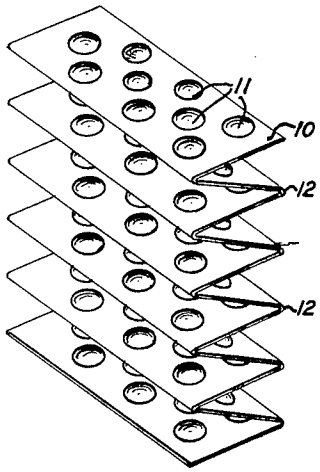


FIG. 1

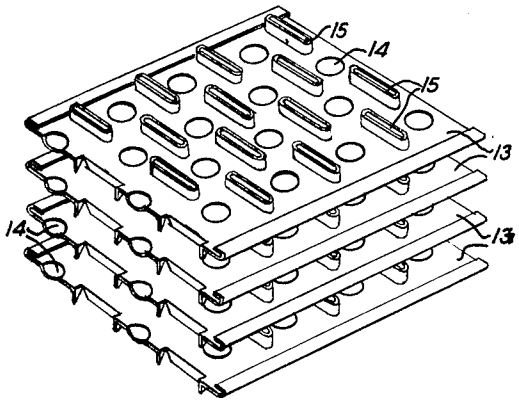


FIG. 2

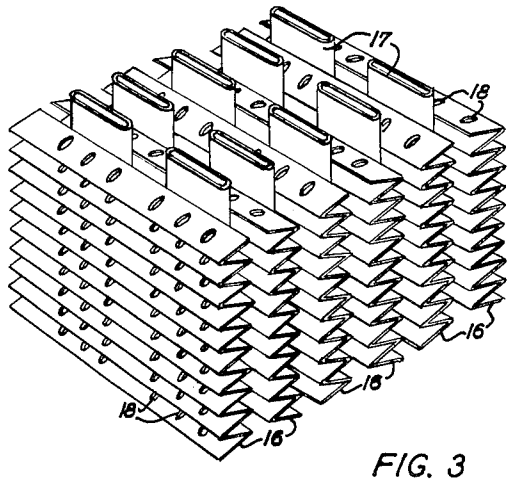


FIG. 3

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RADIATOR AND RELATED METHODS

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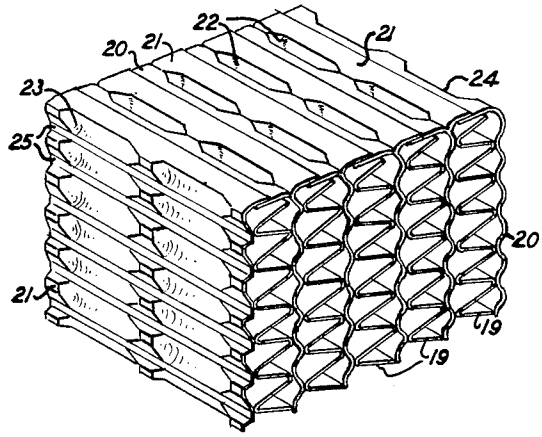


FIG. 4

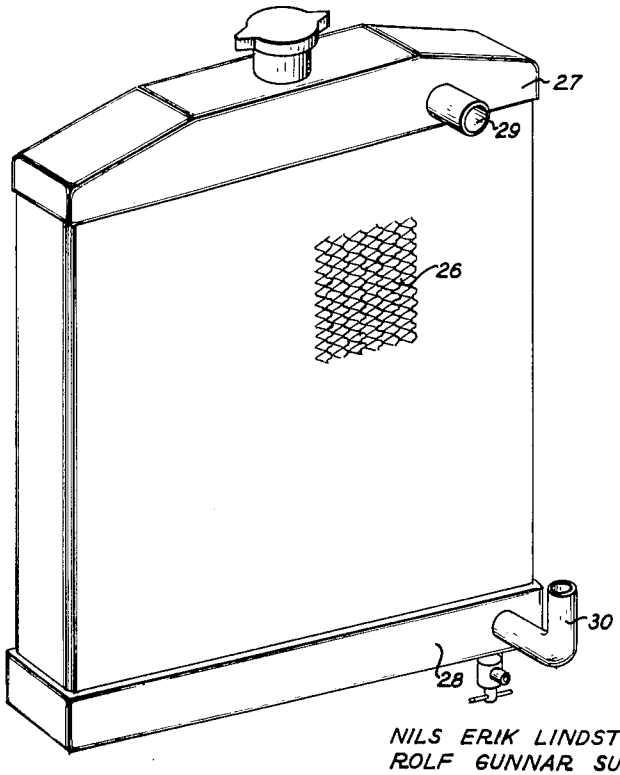


FIG. 5

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RADIATOR AND RELATED METHODS

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2 Claims. (Cl. 165—148)

This invention relates to improved radiators and to improved methods for manufacturing radiators with improved characteristics, as well as to methods for providing improved alloys for use in radiator structures and the like.

It is an object of the invention to provide an improved radiator construction, especially suitable for use in the automobile industry, such structure being of relatively reduced weight without suffering any loss of cooling efficiency.

It is a further object of the invention to provide an improved radiator construction fabricated of a material having a thermal conductivity comparable to known structures, while having an improved tensile strength and ductility.

It is a further object of the invention to provide an improved method of manufacturing radiator structures by providing sufficient tensile strength and ductility to permit making, for example, air fins with bosses and slits to increase turbulence without affecting the other desirable characteristics of the radiator structure.

It is still another object of the invention to provide improved techniques to enable the reduction of the gauge of air fins and the like without causing a loss of strength.

Yet another object of the invention is to provide improved techniques which avoid the cracking of the radiator structure material during manufacturing processes.

Still another object of the invention is to provide improved techniques in accordance with which there will be no grain size change or change of directional properties during manufacturing processes.

In the manufacturing of radiator structures according to preferred techniques attempts are made to increase cooling capacity per unit weight by making elements of the radiator structure with detents or bumps and/or slits which tend to weaken the structure and tend to complicate the manufacturing processes by changing tensile strength and ductility characteristics as well as the heat conductivity of the materials employed.

It is known to add elements to the pure copper which generally constitutes the material employed in an effort to provide sufficient tensile strength to enable the material to be processed as aforesaid.

Such components usually result in a reduced thermal conductivity and as well in a reduced ductility. The material employed, therefore, readily cracks as it is being shaped.

It has now been found, according to the invention, that small quantities of cadmium added to deoxidized copper will give an unexpected high tensile strength to the material and that this high tensile strength will survive soldering processes as components of a radiator structure are joined to one another, such as when air fins are soldered to water tubes and the like.

As stated above a basic requirement for obtaining a satisfactory result in making the alloy according to the invention is to have deoxidized copper. Investigations to this end have proved that a satisfactory alloy is obtained by using solely cadmium as a deoxidizer. The cadmium content of the alloy should then amount to .1 to .3% by

weight. However, an improved result is obtained according to the invention by using cadmium and phosphorous in combination as deoxidizers.

It has also proved that a similar result can be obtained by using cadmium and lithium in combination as deoxidizers.

Some typical alloys are the following:

(1) Copper and .2% by weight of cadmium

(2) Copper and .2% by weight of cadmium and an addition of .005 to .010% by weight of phosphorous.

(3) Copper and .2% by weight of cadmium and an addition of .010 to .020% by weight of lithium.

According to the invention, an alloy is formed of deoxidized copper and .05 to 2% by weight of cadmium, the amount of cadmium preferably employed being within the range of .1 to .3% by weight.

According to the invention, an alloy is formed of copper which is deoxidized by adding .005 to .015% by weight of phosphorous and .05 to 2% by weight of cadmium, the amount of cadmium preferably employed being within the range of .1 to .3% by weight.

According to the invention, an alloy is formed of copper which is deoxidized by adding .01 to .02% by weight of lithium and .05 to 2% by weight of cadmium, the amount of cadmium preferably employed being within the range of .1 to .3% by weight.

According to the invention, the alloy may be rolled into thin strips or foil having a thickness of about .01 mm. to .15 mm.

The strips or foil thus formed may be bent to any suitable form for constituting a component of a radiator structure and are found to have sufficient tensile strength and ductility to permit any conventional operation to be performed thereon. Moreover, the total weight of the radiator structure can be significantly reduced without any significant loss of cooling capacity. More specifically, it has been found that a reduction in weight of about 20% causes a loss of cooling capacity of less than about 5%.

Some preferred embodiments of the invention in which the aforesaid alloy may preferably be employed are illustrated in the accompanying drawing in which:

FIGURE 1 illustrates in perspective view a component of a radiator structure according to the invention;

FIGURE 2 illustrates in perspective view a honeycomb structure employing the alloy of the invention; and

FIGURE 3 illustrates a second honeycomb structure embodying the alloy of the invention.

FIGURE 4 illustrates a third embodiment of a honeycomb structure employing the alloy of the invention.

FIGURE 5 illustrates in a perspective view of radiator construction, especially suitable for use in the automobile industry, with a honeycomb structure employing the alloy of the invention.

The radiator structure component illustrated in FIGURE 1 comprises generally a sheet 10 having a generally zig-zag form and in the face of which are provided a multitude of embossments or dents 11. Said sheeting or foil 10 has a multitude of fold lines 12 and is intended to be incorporated into a honeycomb structure as will be shown in greater detail hereinafter.

The bumps of FIGURE 1 are intended to create a turbulence which enhances the cooling efficiency of the structure. It will be appreciated, however, that these embossments, as well as the multitude of fold lines, require a material with superior tensile strength and ductility to avoid problems during mass production of such components.

The honeycomb radiator structure of FIGURE 2 comprises a plurality of sheets 13, having a multitude of bumps or dents 14 therein, the sheets 13 being spaced in horizontal disposition and having passed therethrough

a plurality of vertical water tubes **15** welded or soldered thereto, the tubes **15** having a flattened cross-section in this embodiment of the invention.

In assembling such a structure it may be found that when conventional techniques are employed the soldering or welding tends to cause a grain structure change or growth which is to be avoided if the strength of the overall structure is to be retained. It is an object of the invention to avoid this grain size change so that optimum structural strength can be realized.

In the embodiment of FIGURE 3, a honeycomb structure comprising a plurality of elements **16** is illustrated, there being included in the structure a plurality of vertically disposed water pipes **17** welded thereto. The zigzag structures are provided with a multitude of slots **18**, the purpose of which is to increase the radiating surface area of the structure and to create a turbulence to increase the cooling efficiency of the device.

In the embodiment of FIGURE 4, a honeycomb structure comprising a plurality of elements **19** is illustrated, there being included in the structure between adjacent elements vertical pairs of corrugated partitions **20**, **21** lying close to each other to form flow passages **22** between them. Said pairs of partitions are mutually the image of each other and in addition to the wave-like corrugations they are also provided with elongated embossments **23** and **24**. Pairs of such embossments **23** and **24** are arranged in vertical rows which communicate with each other via intervening grooves **25** so as to form the passageways referred to above.

FIGURE 5 illustrates a radiator for the automobile industry incorporating as indicated by reference numeral **26** a honeycomb structure employing the alloy of the invention. In this figure reference numeral **27** designates the upper header and **28** the lower header mutually connected through the pipes **15** and **17** respectively or the passages **22** and further connected, respectively, to the engine block via pipe connections **29** and **30** in a conventional way.

To enable the unusual configurations necessary to radiator structures of the aforesaid type, the invention contemplates the use of a special alloy. This special alloy involves the combining with deoxidized copper of .05 to 2% by weight of cadium, the amount of cadmium employed preferably lying within the range of .1 to .3% by weight.

As has been indicated above, the alloy of the invention may be rolled into thin strips or foil with a thickness of about .10 mm. to .15 mm., this material having sufficient tensile strength and ductility to enable any of the aforesaid configurations to be manufactured with ease without changing the directional characteristics thereof and without resulting in a change of grain size during manufacture.

The reduced gauge permissible with the alloy of the invention permits a significant reduction in weight of the radiator structure without a corresponding decrease in thermal capacity. The invention, moreover, avoids the defects of the additives previously employed in that it helps rather than harms the thermal conductivity and ductility of the resulting alloy and avoids cracking when the alloy is formed into the peculiar shapes required for radiator structures.

It will be appreciated that upon formation of the above alloy it is then rolled into thin strips or foil and is then formed with embossments, dents or slits or by being bent by means of rotating or stamping tools, during which process the material can be bent to suitable sizes to which will be soldered or welded suitable tubes or flow passages serving for accommodating a cooling fluid.

The alloy of the invention provides that the material will have the same strength and elongation in all direactions in order to avoid hairline cracks and the like when the material is formed.

An additional very important advantage of the invention is that it has a higher softening temperature. This permits the use of increased soldering temperatures without any loss in strength and therefore substantially reduces the soldering time for radiator structures. This contributes materially to minimizing costs and contributes substantially to mass production technique.

In summary the invention according to one aspect thereof, relates to a method of improving the properties of copper for use in a radiator, which method comprises alloying deoxidized copper with .05 to 2% by weight of cadmium, the copper constituting from about 98 to 99.95% of the remainder. Preferably the amount of cadimium is restricted to .1 to .3% by weight and the resulting alloy is preferably rolled into a strip of about .10 mm. to .15 mm.

According to another aspect of the invention, it relates to a method of improving a radiator design adapted for employing copper sheeting of minimum determinable thickness, the method of the invention comprising alloying cadmium with deoxidized copper and using a sheeting of the resulting alloy at less than said determinable thickness.

According to still another aspect of the invention, there is contemplated a method of improving the tensile strength and ductility of copper while maintaining the heat conductivity properties thereof by alloying deoxidized copper with .05 to 2% by weight of cadmium, rolling the resulting alloy into a strip and forming a radiator part out of said strip such as by forming embossments, dents or slits therein, as has been described above.

In accordance with still another aspect of the invention, there is contemplated a method of minimizing the weight of a radiator while maintaining the strength thereof by forming the radiator from a sheeting of the aforedescribed alloy.

Other aspects of the invention relate to honeycomb structures formed of the above-noted alloy and/or the use of and provision of articles of manufacture comprising a sheet of an alloy of deoxidized copper and cadmium preferably in combination with phosphorus or lithium in the above-described proportions.

There will now be obvious to those skilled in the art many modifications and variations of the structures and methods set forth above. These modifications and variations will not depart from the scope of the invention if defined by the following claims.

What is claimed is:

1. A radiator structure comprising means for conveying a fluid medium, and a honeycomb structure in said means in heat exchange relation therewith, said honeycomb structure including an assembly of relatively thin spaced copper elements of a thickness of .01 to .15 mm. defining parallel air passages, each element being of an alloy consisting of deoxidized copper with 0.05 to 2% by weight of cadmium and 0.005 to 0.015% by weight of phosporus.

2. A radiator structure comprising means for conveying a fluid medium, and a honeycomb structure in said means in heat exchange relation therewith, said honeycomb structure including an assembly of relatively thin spaced copper elements of a thickness of .01 to .15 mm. defining parallel air passages, each element being of an alloy consisting of deoxidized copper with 0.05 to 2% by weight of cadmium and 0.01 to 0.02% by weight of lithium.

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