

[54] **FOAMED METAL BODIES**

3,607,223 9/1971 Trihey 75/20 F

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FOREIGN PATENTS OR APPLICATIONS

260,414 11/1926 Great Britain 165/168
 615,147 10/1926 France 164/79

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 91,211, Nov. 19, 1970, abandoned, and Ser. No. 91,212, Nov. 19, 1970, abandoned.

[52] U.S. Cl. **165/168, 164/98, 164/108,**

164/112

[51] Int. Cl. **F28f 3/12**

[58] Field of Search 165/168; 164/98, 99, 79,
 164/112, 134; 237/69

References Cited

UNITED STATES PATENTS

2,552,810 5/1951 O'Neill 164/112

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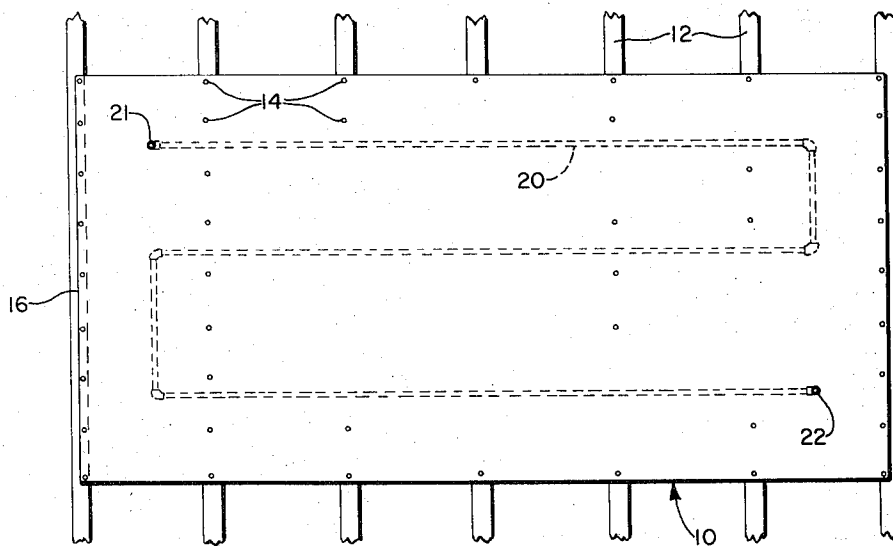
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[57]

ABSTRACT

A foamed metal panel has a tubular core embedded in it to conduct heating liquid or the like. The panel can also be reinforced with metal inserts such as blocks and plates at points of stress.

4 Claims, 2 Drawing Figures



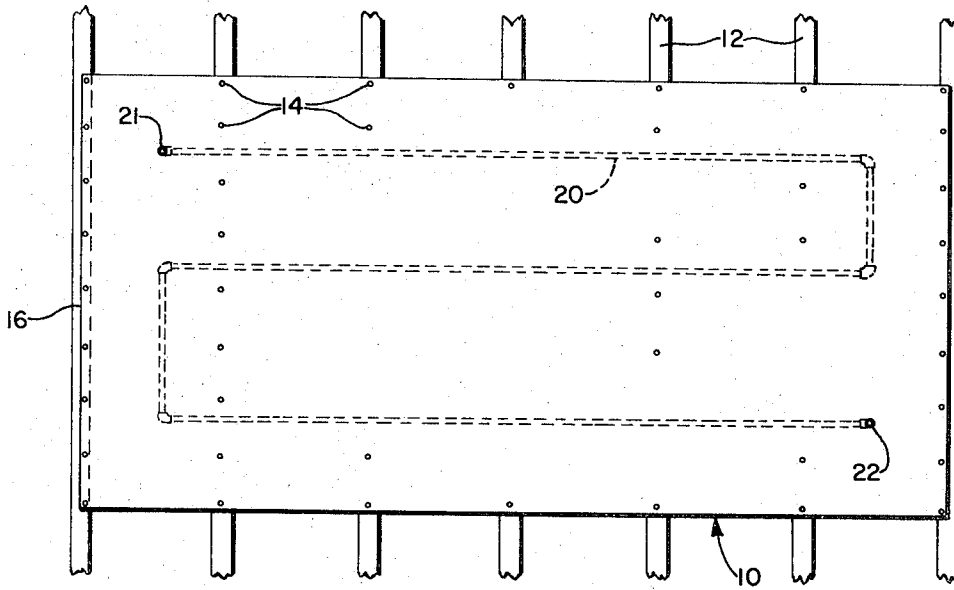


FIG. 1.

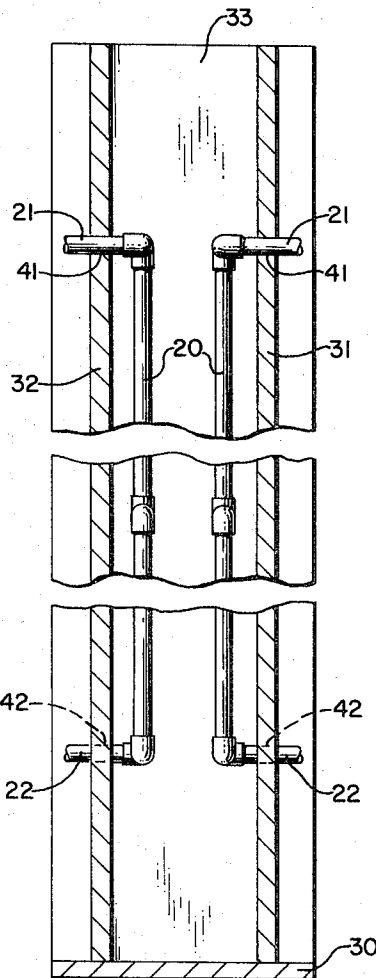


FIG. 2.

FOAMED METAL BODIES

CROSS REFERENCES TO RELATED APPLICATIONS

This application is a continuation-in-part of application Ser. Nos. 91,211 and now abandoned and 91,212 and now abandoned both filed on Nov. 19, 1970.

BACKGROUND OF THE INVENTION

Foamed metals are conventionally prepared in rectangular solids. Such bodies are satisfactory for many building or construction purposes. A need exists for foamed metal bodies having hollow cores therein capable of transmitting fluids therethrough, particularly

corrosive fluids. The present invention provides a composite unit of foamed metal and other metals or materials suitable for use in cooling and heating devices.

The instant invention also provides light-weight cooling vent units, heat exchange units, evaporative units, and building heating units.

The invention further provides a novel structural body suitable for use in the automobile industry as radiators and the like.

The present invention is also particularly suitable for providing an insulated fluid conducting means, particularly for carrying corrosive fluids.

SUMMARY OF THE INVENTION

The present invention relates to a foamed metal body having embedded in it a tubular core with a melting point greater than that of the foamed metal, and to a method of making such a body.

The foregoing as well as other aspects of the present invention will be more readily understood from the following description taken with the accompanying drawings in which:

FIG. 1 is a plan view of a foamed metal panel having an embedded tubular core, and showing the panel in a typical construction; and

FIG. 2 is a vertical sectional view showing an arrangement for making the panel of FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

According to the present invention a rectangular structural panel of foamed aluminum has embedded therein a conduit of a copper-base metal for a heating liquid, the conduit having an inlet end and an outlet end, both of said ends projecting out through one face of the panel.

Such a structural panel is particularly desirable for use as a flooring panel and can for example be made not more than 1 inch thick, and even thicknesses as little as three-fourth of an inch make suitable flooring. The heating conduit is preferably in the form of a single layer of conduit lengths to thus permit the use of conduits having a relatively large passageway cross-section.

FIG. 1 shows such a flooring panel 10 fastened directly to floor joists 12. This panel can be 8 feet long and 4 feet wide, as in conventional structural panels, and is readily nailed in place with headed nails 14. The panel can also be readily trimmed as with a saw if necessary, to make sure that an edge, as at 16, running parallel to a joist is located about the middle of the joist so

that an adjacent panel can also be secured to that joist.

A copper tube 20 is embedded in the panel and has two ends 21, 22 turned downwardly and projecting through the lower face of the panel. Those ends can be connected to a conventional hot water home heating circuit so that the heating water circulates through tube 20. By reason of the intimate contact between the tube and the foamed metal of panel 10 the heat from the heating water is rapidly and efficiently distributed throughout the panel. Both copper and aluminum have very high thermal conductivities, and with such metals the convolutions of tube 20 can be located relatively far apart in the panel and less tubing is necessary. Thus tubing having a three-eighths inch internal diameter can be as much as 15 inches apart if desired. The tubing is preferably kept at least about 8 or 10 inches from the edges of the panel to allow the panel to be trimmed along any or all of its edges.

The nails 14 can have their heads driven into the upper surface of the metal foam, so that they do not penetrate. This leaves a flat panel top suitable for receiving coatings such as a plastic cover layer over which a rug or other floor covering can be secured if desired. As with standard flooring, the edges of the panel that run perpendicular to the joists can be tongue-and-groove.

The metal foam of the panels is preferably made sufficiently porous so that the location of tube 20 can be observed from the upper face of the panel and the securing nails accordingly located where they do not damage the tubing. Thus with aluminum foam having a density of about 35 pounds per cubic foot a copper tube 20 will have its outline fairly reliably evident where the top of the tube is not more than about one-fourth inch below the upper face of the panel. The tube can also be located closer to that face if desired. By arranging the tube so it is closer to the upper face than the lower face of the panel, the heat distribution can be made to favor heating the space above the panel as against the space below the panel. Also instead of mounting the panel directly on the floor joists 12 it can be mounted on a sheet of insulation or ordinary sub-flooring, or the lower panel face can be coated with thermally insulating plastic or the like, to also favor heating upwardly as against downwardly.

A single panel may easily be enough to provide all the home heating necessary for a small room such as a bathroom or a small kitchen. For larger rooms two or more heating panels can be provided either immediately adjacent each other or in spaced locations. In any of these constructions the remainder of the floor around the heating panels can be filled with additional panels of foamed aluminum that do not contain tubing.

A feature of the foregoing floor construction is that it provides a floor surface which is extremely fire resistant and yet simple to build. This is something the building industry has long needed inasmuch as fire-resistant wall and ceiling constructions are more or less standard but the only good fire resistant floors have been concrete floors which are too expensive to provide in individual homes.

The foamed metal panels of the present invention are also simple to secure in place by cementing, if desired. Thus a layer of cement can be brushed onto the upper surfaces of the joists 12, after which panel 10 can be

lowered in place over the cement-carrying joist surfaces. Unevennesses in level of the top surfaces of the joists 12 can be compensated for by the insertion of shims in any space that appears between the lower face of panel 10 and the upper face of joist 12. Each shim can carry a top layer of cement to make sure that it is adhered to the panel as well as to the joist.

Panel 10 can be made by molding the foamed aluminum around the tube 20. FIG. 2 shows such a molding arrangement in which the mold is formed from bottom plate 30, two side plates 31, 32, and two edge plates of which only one, 33, is shown in the figure. Each side plate 31, 32 has a number of openings 41, 42, which receive the ends 21, 22 of a tube 20 fitted into these openings before the mold plates are assembled. A tube so fitted will remain in place, as shown in FIG. 2, but if desired additional supports can be provided such as by use of a length of copper wire looped under a portion of the tube with the ends of wire extending up over the top edge of the mold.

Molten aluminum containing a foaming agent can then be poured into the mold and the foaming completed, and the product cooled as described in U.S. Pat. No. 2,979,392 or in other suitable manner. The mold plates can be made of metal such as carbon steel that is not wet by molten aluminum under molding conditions. Prior to pouring the molten aluminum into the mold, the interior sides of the mold plates are coated with a "ladle wash" (an iron oxide slurry). The ladle wash is applied before each molding operation. After the molding is completed the mold is taken apart, the foamed block removed from the mold sides and sawn in two to make two panels of the type shown in FIG. 1.

The molding can also be modified so as to make the foamed block thicker and then sawing it into three or more panels of which only the outer two panels have the embedded cores. Alternatively only one panel can be molded at a time, or one core-carrying panel in a plural-panel block.

Foamed aluminum having discrete cells therein may be produced by a variety of methods. They may be produced by expanding molten metal amalgams (British Pat. No. 206,797; U.S. Pat. Nos. 2,434,775; 2,533,016); by incorporating quartz, microballoons in the molten metal and optionally heating to expand the gas (Chemical Engineering News, June 11, 1962, Page 37); by the use of heavy metal hydride blowing agents, particularly the hydrides of titanium or zirconium (U.S. Pat. Nos. 2,393,906; 2,751,289; 2,895,819; 2,937,938; 2,974,034; 2,979,392; 2,983,597); by volatilizing organic materials during cooling of the melt (e.g., camphor as in U.S. Pat. No. 2,155,651); by volatilizing inorganics other than metal hydrides (ammonium chloride, U.S. Pat. No. 1,642,348; magnesium carbonate, calcium hydroxide, carbonitrate, U.S. Pat. No. 642,349; calcium carbonate, U.S. Pat. No. 2,191,658; ammonium bicarbonate, U.S. Pat. No. 2,671,955; cadmium or magnesium carbonate, U.S. Pat. No. 2,935,396); and by pellet metallurgical techniques (magnesium carbonate growing of magnesium metal, U.S. Pat. No. 2,935,396). Other processes involving blowing molten metal with a suitable gas generating agent such as lithium hydride, titanium hydride, zirconium hydride and the like. Air properly entrained in a molten metal may also be used in preparing such foam. Where a blowing agent such as a metal hydride is used,

viscosity control and/or strengthening additives may be used in the molten metal during the foaming process to help control the foam density pore uniformity and provide optimum strength. Representative examples of suitable processes for preparing foamed metal are found in U.S. Pat. Nos. 3,297,431, 3,300,296, 3,305,902 and British Pat. No. 1,287,994.

The tube 20 can be made of a copper or copper-base alloy such as bronze, brass and the like, where these alloys have melting points higher than that required for foaming aluminum. By aluminum is meant substantially pure aluminum as well as aluminum alloys containing 80% or more and preferably 90% or more of aluminum. The following aluminum alloys are examples of useful alloys for preparing the foamed metal bodies of the present invention:

Alloy

7075 (1.6% Cu, 2.5% Mg, 0.3% Cr, 5.6% Zn, remainder Al)

2024 (4.5% Cu, 0.6% Mn, 1.5% Mg, remainder Al)

5086 (0.45% Mn, 4.0% Mg, 0.1% Cr, remainder Al)

6063 (0.4% Si, 0.7% Mg, remainder Al)

Almag 35 (6-8% Mg in Al)

1000 series Al (99.6% minimum Al)

2011 (5.5% Cu, 0.5% Pb, 0.5% Bi, remainder Al)

2218 (4.0% Cu, 1.5% Mg, 2% Ni, remainder Al)

3005 (1.2% Mg, 0.4% Mg, remainder Al)

4032 (12.2% Si, 0.9% Cu, 1.1% Mg, 0.9% Ni, remainder Al)

4043 (5% Si, 95% Al)

8280 (1.5% Si, 1.0% Cu, 0.5% Ni, remainder Al)

Magnalium — 70% Al, 30% Mg

The foamed metals used in the present construction may be prepared by processes known in the art.

The density of the foamed aluminum may vary over a wide range. Generally, foamed aluminum having a density of less than about 50 pcf can be used. Foams ranging from 5 to 35 pcf are preferred; densities ranging below about 27 pcf are more preferred; and a foam density ranging from about 8 to about 27 pcf is most preferred.

The tubular cores may be suspended in the foamed metal mold by any convenient means. For example, the core may be suspended or held in place in the mold by wires. It may also be supported by the mold itself, by spacers secured to or resting against a mold wall, or by shelves or recesses in the mold or otherwise physically attached to the mold. The configuration, size and shape of the core will in large determine the particular type of suspension to be chosen.

If fluids are to be transported or moved through the tubular body encapsulated in the foamed metal, the body will be held in place in the mold so that fluid communication can be readily obtained in the finished product. For example, openings in the tubular body will extend through the encapsulation to a desired degree.

The panels of the present invention are also suitable for interior panels of a freezing compartment with foamed metal. The tubular core is for this purpose connected so as to receive the freon or other coolants used in the evaporator of the refrigeration system.

The instant invention may also be used for constructing wall panels or the like, wherein steam or other suitable heating fluids may be transferred through tubular

bodies encapsulated in the foamed metal. Thus the panel 10 of FIG. 1 makes a good roof covering that collects solar heat which is transmitted to avenues of a liquid circulated through tube 20, to a panel within a home where it serves to heat the home. A roof panel of this kind can be much thinner than three-fourth inch.

Where the foamed aluminum panels are subject to excessive stresses they can be reinforced as by embedded blocks or the like. The tube 20 in the panel of FIG. 1 also acts as a reinforcement, particularly where the tube is made of thickwalled hard brass or bronze, or of steel. Also by placing a length of such a tube under longitudinal tension in the mold and then releasing that tension after the molded panel has solidified and cooled somewhat, the panel is placed under some internal compression that further strengthens it. The effect of such internal compression is increased when the tensioned tube length has flanges at each end that engage the surrounding metal foam.

Reinforcing blocks or plates may also be embedded in the foamed metal at desired stress locations for facilitating the joining of panels, as for example to make a cargo container or other box-like structure from the panels, or to strengthen tongue-and-groove interengagements between panels. Such embedded bodies can extend to the surface of the panel where the bodies are used to receive fasteners such as screws, bolts or rivets or other desired hardware. Hinges and handles can thus be applied as well as locks or catches.

The reinforcing bodies can be of metals such as copper, brass, steel or titanium, that have melting points higher than that of the aluminum foamed. Where these bodies are to extend to the surface of the final panel, they can be secured to the mold surface, as by screws or the like that penetrate through the mold plate and threadedly engage the body, preferably at a threaded opening provided for receiving a fastener in the completed panel. Reinforcing bodies that do not extend to the panel's surface can be held in the mold by wires, shelves, spacers, or the like, as in the case of the tubing.

The foamed panels can also be reinforced by distributing in the foamed metal some reinforcing fibers. Such fibers can be made of metal such as brass, bronze, cop-

per, steel, titanium, or they can be made of carbon or other inorganic materials that withstand the temperatures produced during the foaming operation. It is preferred that the fibers be at least about one-half inch long, although even fiber lengths of one-fourth inch are helpful.

Although copper is the preferred material for the conduits of this invention, other suitable materials having a higher melting point than that of the foamed metal comprising the panel or body. Some examples of these materials are zirconium, tantalum, titanium, steel and alloys of these materials. Other examples are carbides, borides, nitrides, graphite, silicon, zirconia and refractory or ceramic materials.

The foregoing disclosure and description of the invention is illustrative and explanatory thereof and various changes in the size, shape and materials as well as in the details of the described construction, may be made within the scope of the appended claims without departing from the spirit of the invention.

What is claimed is:

1. A rectangular structural panel of foamed aluminum having discrete cells therein, having a density less than about 50 pounds per cubic foot and having embedded therein a copper-base conduit for a heating liquid, the conduit having an inlet and an outlet end, both of said ends projecting out through one face of the panel.

2. The combination of claim 1 in which the panel is not more than about 1 inch thick and the conduit is in the form of a single layer.

3. A rectangular structural panel of heat conducting foamed aluminum having discrete cells therein and having embedded therein a copper-base conduit for a heating liquid, the conduit having an inlet and an outlet end, both of said ends projecting out through one face of the panel, and reinforcing blocks or plates embedded in the foamed metal at desired stress locations for strengthening the panel or facilitating the joining of one panel to another panel.

4. The panel of claim 3, wherein said reinforcing blocks or plates extend to the surface of the panel for receiving fasteners or other desired hardware.

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