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MOLD FOR HEAT CURING THERMOSETTING RESINS

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Fig. 1.

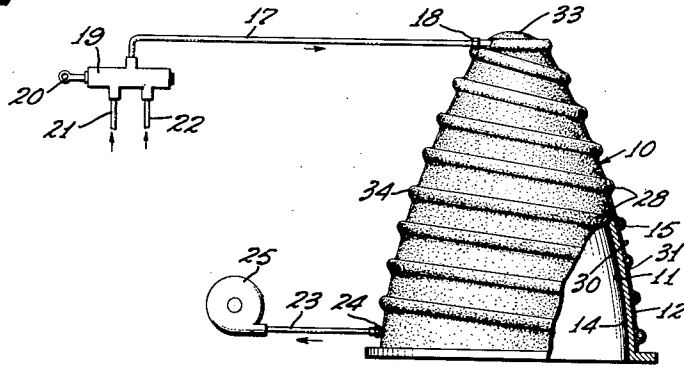


Fig. 4.

Fig. 2.

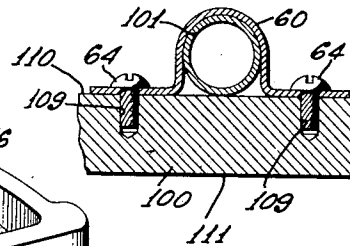
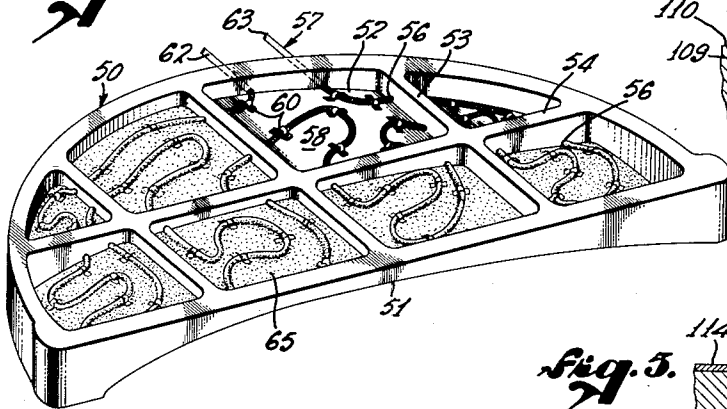


Fig. 5.

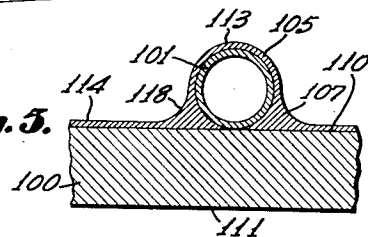


Fig. 3.

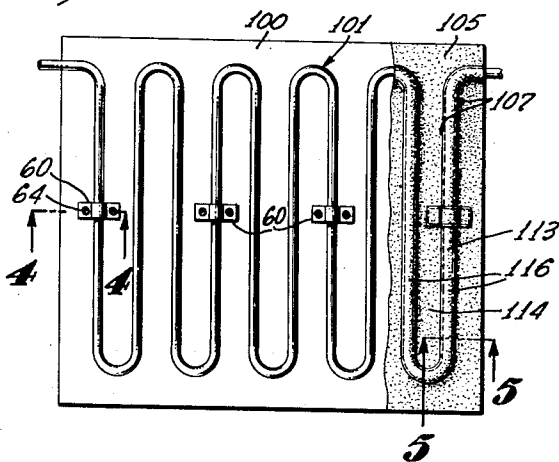
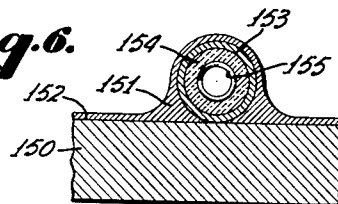


Fig. 6.



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MOLD FOR HEAT CURING THERMOSETTING
RESINS

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6 Claims. (Cl. 18—38)

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This invention relates to heat exchangers. More particularly, specific application of the invention has been made for molds for fusible or thermo-setting materials such as plastics and is likewise suitable for certain metals, commonly molded.

It is intended by the instant invention to eliminate the old-fashioned method of heating molds in open ovens prior to the molding operation, or in the course thereof, and also to eliminate the complicated cast molds having fluid passages formed in the bodies thereof. Prior art molds and heat exchangers, particularly suited to molding operations, have either been massive and cumbersome requiring relatively elaborate fabricating techniques, or, on the other hand, required transportation, regardless of their size, from a station at which initial operations were performed to an oven in which thermo-setting casting materials were cured. Chilling of prior art molds generally requires removal from the oven for subjection to a refrigerant, cold water bath, etc.

Economy and facility of production of molds incorporating heat-exchange construction are of importance, but of hardly less significance is the efficiency of the heat exchanger itself, its adaptability to variant environments or forms, and its convenience in use. In each and all of these respects it is intended by the instant invention to improve over the prior art means and methods of making and using heat exchangers in general and heat exchangers for the molding art in particular.

It is therefore among the objects of this invention, broadly, to provide a new and improved heat-exchanger construction.

More specifically, it is an object of the invention to provide a new and improved construction adapted for the efficient and effective manufacture and use of molds designed for the production of articles of manufacture wherein a heating phase, or a cooling phase, or both are employed.

Other general objects of the invention are: The provision of a new and improved heat-exchanging apparatus for a prefabricated mold of any desired configuration, the resultant construction:

- (a) occupying a minimum of space,
- (b) contributing a relatively insignificant weight factor,
- (c) being facile of use,
- (d) being adaptable to mass production methods,
- (e) Saving time in the productive process both during utilization of the heat exchanger and during application of the same as to a mold or the like for use, and
- (f) having unusual versatility in use and in application.

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Other more specific objects of the invention also include without limitation, provision of:

- (a) a new and improved refrigerating and/or heating conduit connection to and for heating and/or refrigerating a vessel, a space-heating, or a refrigerating, panel,

(b) improved means for bonding a conduit for the desired purpose described to a member whose temperature is to be controlled,

- (c) new and improved means for temporarily positioning a conduit means preliminary to fixing the same in place in the desired manner and for the desired purpose intended, and

(d) a new and improved versatile means for producing a complete thermal dispersion of optimum efficacy between a refrigerating or heating element, whether electrical, fluid, or chemical, and a vessel, mold, or panel, or the like, the temperature of which is to be governed.

It is, moreover, among the objects of the invention to provide improvements over prior art devices heretofore contemplated for generally similar purposes including rapidly and efficiently elevating the temperature of a member, maintaining said member at such desired temperature with uniformity of effectiveness, rapidly changing such temperature through the agency of the heat exchanger and without the necessity of transporting the subject member from one station to another or bringing it under the influence of external atmospheric or similar environmental influences, and all interfering to a minimum possible extent with the other uses and procedures surrounding the intended use of the subject equipment and material, as the application of molding pressures thereto.

With these and other objects in view, the invention consists in the construction, arrangement and combination of the various parts of the device whereby the objects contemplated are attained, as hereinafter set forth, pointed out in the appended claims, and illustrated in the accompanying drawings.

In the drawings:

Figure 1 is an elevational view, parts being cut away, of a conical shaped mold embodying this invention.

Figure 2 is a perspective view of a slightly concave mold member embodying this invention.

Figure 3 is a plan view of a flat, heat-exchange panel or mold embodying this invention.

Figure 4 is a detailed sectional view taken as on a line 4—4 of Figure 3.

Figure 5 is a similar detailed view taken as on a line 5—5 of Figure 3.

Figure 6 is a view like Figures 4 and 5 of another further modified heat-exchanger construction embodying this invention employing an electrical heating element.

Referring more particularly to the drawings, a

substantially cone-shaped female mold or die member generally designated by the numeral 10 may be selected for illustrating this invention. Such mold member 10 may, as is conventional, comprise an interior surface 11 conforming to the external shape of an object to be molded, and an external surface 12 defining therebetween a wall 14 preferably of uniform thickness throughout and preferably formed of any suitable heat-transmitting metal substance such as aluminum, steel, nickel, copper, etc.

Directly against the exterior surface 12, a preferably tube-type conduit is applied. The conduit may be of a single continuous length or of several runs interconnected by headers in parallel or reticulate fashion.

In Figure 1, the conduit takes the shape of a helical coil of copper or other tubing 15 and is spirally wound about the wall 14 of the mold member, preferably in continuous contiguity with the external wall surface 12.

A coil inlet for a fluid refrigerant or heating agent may comprise the pipe 17 fitted as with a threaded union 18. The inlet pipe 17 is connected as to a valve 19 having a handle 20 by means of which the inlet pipe 17 may selectively receive, as from a pipe 21 connected with a source of steam or the like agent for heating the coil 15, or to a pipe 22 connected to a source of cold water or refrigerant for chilling said coil 15.

An outlet pipe 23 may be similarly secured as by another union 24 to an opposite end of the coil 15 to permit the circulation of the steam or water from the coil 15 to a pump 25 for re-heating, cooling, recirculation, or disposal. Any fluid remaining in the coil can be evacuated by the pump.

Between adjacent loops 28 of the coil 15 a coating of metal 30 is sprayed and deposited upon and in coherent relationship to the external surface 12 of the mold wall and in a manner to form fillets 31 in the corners between the adjoining surfaces of the wall 14 and the tubing 15. The sprayed coat may comprise zinc, aluminum, copper or any other sprayable metal of good heat conductivity. The metal spray is produced by blowing the fused metal from an electric or acetylene torch in accordance with known metal spraying methods.

The coating 30 thus formed is preferably, though not essentially, also continuous over the entire external surface of the coil and of the mold including the upper end 33 of the mold as well as the outermost surface portions 34 of the tubing. Thereby in effect, a blanket of conductive material may be distributed over the entire exterior mold surface in intimate relationship with the tubing or conduit and also with the external mold surface 12.

The fillets 31 are built up adjacent the areas of proximity of the coils and the molds to provide a direct, intimate and effective bond for optimum thermal dispersion between the tubing and the mold. It is the fillet thickness, as shown hereinafter, that is critical.

In the others, as well as in the instant embodiment, it has been found that the mold and tubing may be exposed to the room temperature and atmosphere during the heating and/or cooling process. If desired, however, a layer of insulative material may be applied to the exterior surface of the mold and tubing for retaining any heat otherwise lost through convection and radiation.

Referring now to the form of Figure 2, a mold member 50 may comprise a concave or other suit-

ably shaped interior surface 51 of a cast metal wall 52 preferably of uniform thickness throughout and having reinforcing ribs 53 transversely and 54 longitudinally thereof. Optionally, the wall 52 and the reinforcing ribs 53 and 54 are cast integrally. In any event, they should be formed with holes 56 in order that a metal conduit 57, preferably of a flexible variety, formed with or without radiating fins, may be more readily wound in a sinuous route over the exterior surface 58 of the mold wall 52. After passing the conduit 57 through the several openings 56 in a manner to most effectively comprehend the exterior surface 58 of the mold, any suitable straps 60 may be provided for holding the conduit against the mold surface 58.

Thereupon, or at a prior stage if desired, the external surface 58 and the conduit 57 are thoroughly sand blasted, or otherwise etched, roughened, and cleaned to insure the most coherent contact of the sprayed metal with the mold and tubing surfaces.

The metal coating being then applied primarily in the fillet region and also if desired over the surface of the conduits and the outside surface of the mold by standard metal spray process, as heretofore stated, fills up the corners between the conduits and the adjoining surface of the mold and may cover as well the exposed surface of the conduits and the entire external surface of the mold. It is important to note that the fillet forms a direct heat conductive bond between the coil and the mold. The coating in other areas, as over the tubing surfaces and between adjacent coils, may be omitted with somewhat of a loss in total conductive efficiency, or a narrow ribbon normally made by the spray may, alone, be left. The mold itself is conductive in either event.

The ends 62 and 63 of the conduits may then be connected to a source of steam or other heating element, or cold water or other refrigerating element, or both, as heretofore stated.

The straps 60 may be secured in any desired fashion to the wall 52, but in order to avoid distortion of the tubing or the inner mold surface 51 by welding or similar processes supplying any undue amount of heat, securements such as screws 64 may be inserted in a well-known manner into holes drilled into the outer side 58 of the mold wall 52.

If the mold can be laid flat so that no tendency will exist for the conduit to move out of a preset position, the straps or the like 60 may be dispensed with and the metal coating 65 directly applied by spraying, as aforesaid, over the outer surface of the mold and, primarily, in the form of fillets between the conduit and the mold. The sprayed metal will then alone hold the tubing in place.

As illustrated in Figures 3, 4, and 5, any suitable heat exchanger, such as a panel 100, whether curved, right-lined, square, round, or other geometric shape, may be provided with zig-zagging coils 101. Preliminarily, these may be secured in place as by straps 60, held in place as by screws 64.

The surface of the tubing comprising the coils 101, as well as the adjacent surface of the panel 100, is again sand-blasted, or otherwise scoured, roughened, and cleaned. A metal 105 is then sprayed, as aforesaid, forming a coating over the panel 100 on one or both sides thereof including the surfaces of the coils 101. Fillets 107 may likewise be formed between the conduit comprising

the coils and the adjacent surface of the heat exchanger panel 100, as heretofore stated.

The connection of the screws 64 to the panel 100, as by means of holes 109 drilled partly through the same, may be seen most clearly in Figure 4 where the exterior or upper surface of the panel is designated by the numeral 110 and the inner or bottom surface is designated by the numeral 111. By reference to Figures 3 and 4, it will be apparent that the metal covering 105 preferably forms a continuous coating over the coils 101 as at the top surface 113 thereof and also in the area 114 between adjacent coil loops 116.

In this, as in the other embodiments, the fillets 107 may, but need not, be as deep as illustrated and the surface 113 of said fillets may have a straight or curved profile in cross-sectional view. If desired, the fillets may be relatively shallow, the coating thickness in the deepest portion of the fillets being only equal to or slightly greater than that at the top 113 of the conduit or in the area 114 between adjacent loops thereof, but the rate of conductivity will be less than with a thicker fillet, other things being equal.

In Figure 6 another further modified form of construction embodying this invention comprises a panel, wall, or other member 150, corresponding to any of the previous embodiments heretofore described, including a fillet 151 of sprayed metal coherent to one surface 152. A conduit 153 similarly disposed over the surface 152 to those heretofore described, contains a refractory material 154 separating the conduit 153 from an electrical heating element 155. By such construction, the member 150 may be heated electrically in lieu of the fluid-heating element or agent contemplated for the previously described embodiments of the invention.

It will be apparent that in lieu of the fluid or electrical conduit 155, chemically produced heat, as by exothermic reaction, or cold, as by endothermic reaction, may perform a similar heating or refrigerating function.

It has been found that by the utilization of the instant invention, the metal spray is adequate to retain the conduit in position on the outer surface of the mold, or the like, and, what is even more important, the coating of sprayed metal effects a complete dispersion of heat or cold passing through the conduit or originating therein.

Tests have been made to determine the relative advantages of various forms of metal utilized for the spray or otherwise deposited covering, as well as to compare the relative efficiency of the instant invention with prior molds and practices. Some of these follow:

Example No. 1

A mold utilizing a steam coil was used to make a part comprising a fiber glass matrix impregnated with "Selectron," an unsaturated polyester resin. One-half inch nominal size copper tubing in a continuous helical-type coil 21 feet in length was secured by straps and screws to an aluminum mold of one-half inch wall thickness. The total weight of the mold was 250 pounds. The same, being of only one female half, was formed in the general shape of a hemisphere approximately 12 inches in radius and comprising only a female part having an approximate length and width of 32 inches, respectively, and a total surface area of approximately 10 square feet. Molding pressure was applied by a flexible vacuum bag.

The coils were approximately 4 inches apart between centers on only the convex side of the mold where they were subjected to a thorough sand blasting and thereafter spray coated with zinc by means of a metal spray gun to a thickness between the coils of approximately one-sixteenth of an inch and with a fillet thickness from side to side of the tubing of approximately one-fourth of an inch.

When subjected to sixty pounds of steam pressure within the coil, maintaining a temperature equivalent to approximately 260 degrees Fahrenheit therein, the mold was brought up to a curing temperature of approximately 200 to 210 degrees Fahrenheit in approximately nine minutes, and the resin was completely cured in a total time, beginning at room temperature, of approximately 35 minutes.

The same hemisphere subjected to the same general environment but cured in an oven required approximately 25 minutes to come up to the curing temperature at an oven temperature of approximately 260 degrees Fahrenheit, and approximately 30 minutes at an oven temperature of 225 degrees Fahrenheit. The total curing time in the oven at the former temperature, 260 degrees Fahrenheit, was approximately one hour.

Example No. 2

A mold utilizing a steam coil was used to make a part comprising a fiber glass matrix impregnated with "Selectron." Flexible bronze tubing in a continuous coil 30 feet in length was secured by straps and screws to an aluminum mold. The coil was of one-half inch nominal tubing size. The mold wall thickness was three-fourths of an inch. Total weight of the mold was 200 pounds. The mold was formed in the shape of a quarter-shell 16 inches deep having an approximate length and width of 20 and 14 inches, respectively, and a total surface area of approximately seven square feet.

The coils were arranged four inches apart and secured to the external surfaces of both the male and female halves of the mold where they were subjected to a thorough sand blasting and thereafter coated with aluminum by means of a metal spray gun to a thickness between the coils of approximately one-sixteenth of an inch and with a fillet thickness of approximately one-fourth of an inch.

When subjected to sixty pounds of steam pressure within the coil, the mold was again brought up to a curing temperature of approximately 200 to 210 degrees Fahrenheit in approximately 10 minutes and the resin was again cured in a total time, beginning at room temperature, of approximately 25 minutes.

The same molded product required 90 minutes curing time in an oven at an oven temperature of 260 degrees Fahrenheit.

Example No. 3

A mold utilizing a steam coil was used to make a part comprising a fiber glass matrix impregnated with "Selectron." Bronze flexible tubing in a continuous coil 74 feet in length was secured by straps and screws to an aluminum mold. The coil was of one-half inch nominal tubing size. The mold wall thickness was three-fourths of an inch. Total weight of the mold was 440 pounds. The mold was formed in the shape of a half tear-drop approximately 13 inches deep, and having an approximate length of 80 inches and width of 28 inches, respectively, and a total surface area of approximately 21 square feet.

The coils were arranged four inches apart and secured to the external surface of both the male and female halves of the mold where they were subjected to a thorough sand blasting and thereafter coated with zinc by means of a metal spray gun to a thickness between the coils of approximately one-sixteenth of an inch and with a fillet thickness of three-eighths of an inch.

When subjected to sixty pounds of steam pressure within the coil, the mold was brought up to a curing temperature of approximately 200 degrees Fahrenheit in approximately 10 minutes and the resin was cured in a total time, beginning at room temperature, of approximately 40 minutes.

The total curing time in an oven at the 260° Fahrenheit temperature was approximately 90 minutes.

Example No. 4

A mold utilizing a steam coil was used to make a part comprising "Paraplex," an unsaturated polyester resin. Copper tubing in a continuous coil 110 feet in length was secured by welded straps to a nickel mold. The coil was of three-eighths inch nominal tubing size. The mold wall thickness was five-sixteenths of an inch. Total weight of the mold was 300 pounds. The mold was of only one piece and was formed in the shape of a parabola 28 inches deep having an approximate length of 49 inches and width of 42 inches, respectively, and a total surface area of approximately 38 square feet. Molding pressure was applied by means of a flexible diaphragm pulled into place by a vacuum.

The coils were arranged two inches apart and secured to only the convex external surface of the female mold where they were subjected to a thorough sand blasting and thereafter coated with zinc by means of a metal spray gun to a thickness between the coils of approximately one-sixteenth of an inch and with a fillet thickness of approximately one-fourth to three-sixteenths of an inch. When subjected to sixty pounds of steam pressure within the coil, the mold was brought up to a curing temperature of approximately 200 to 210 degrees Fahrenheit in approximately 10 minutes and the resin was cured in a total time, beginning at room temperature, of 30 minutes.

The total curing time in an oven at an oven temperature of 260° Fahrenheit was approximately 130 minutes.

Example No. 5

A mold utilizing a steam coil was used to make a part comprising a fiber glass matrix impregnated with "Selectron." Bronze flexible tubing in a continuous coil 90 feet in length was secured by straps and screws to an aluminum mold. The coil was of one-half inch nominal tubing size. The mold wall thickness was one-half inch. Total weight of the mold was 1480 pounds. The mold, of only one piece, was formed in the shape of an airplane fin 34 inches deep having an approximate length of 78 inches and width of 16 inches, respectively, and a total surface area of approximately 32 square feet.

The coils were arranged four inches apart on the outer side of the mold and secured thereto whereupon they were subjected to a thorough sand blasting and thereafter coated with zinc by means of a metal spray gun to a thickness between the coils of approximately one-sixteenth of an inch and with a fillet whose thickness was approximately one-fourth of an inch. When

subjected to sixty pounds of steam pressure within the coil, the mold was brought up to a curing temperature of approximately 200 degrees Fahrenheit in approximately 10 minutes and the resin was completely cured in a total time, beginning at room temperature, of 70 minutes.

The total curing time in an oven at the 260° Fahrenheit temperature was approximately 150 minutes.

In each of the above examples the packed molds required 25 minutes at an oven temperature of approximately 260° Fahrenheit and 30 minutes at an oven temperature of 225° Fahrenheit to come up to a desired molding temperature of 200°-210° Fahrenheit.

The figures given, though based on direct observation, are approximate.

Thus, it has been experimentally determined that steam-carrying coils secured by sprayed metal to the exterior surface of a mold, after thoroughly sand blasting the mold and the conduit, are in general controlled by the thickness of the fillet and character of the metals employed in the mold, the coils, and the deposited metal uniting the two. Speedier heat conductivity is also a function of decreasing mold thickness, increasing tubing size and more proximate coil spacing. When coils otherwise similar in size and material are spaced relatively closely apart over the surface of the mold, curing temperatures are achieved more rapidly. Spacially uniform mold temperatures are obtained once the mold has been heated to a desired temperature. The above examples are illustrative of a satisfactory group of working conditions successfully used in fabrication of air frame parts for airplanes. Polymerization was uniform and entirely satisfactory.

Copper has been found best for spraying purposes as a coating from the standpoint of heat conductivity, corresponding in this respect to the high heat conductivity of this substance. However, zinc was found to spray approximately three times as fast as copper and has therefore been preferred. Aluminum has also been used to advantage. This designation of particular metals is intended, however, merely as illustrative.

The thickness of the coating built up on the coil and adjacent surfaces does not appear critical. With any given materials, however, best results are obtained when the fillet connection between the tubing and the mold is thickest. Excellent results are accomplished when the fillet thickness from side to side of the tubing is equal to at least one-half of the diameter of the tubing in accordance with the following table:

Tubing Size	Fillet Width	Fillet Thickness
Inches	Inches	Inches
$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{8}$
$\frac{3}{8}$	$\frac{3}{8}$ - $\frac{1}{2}$	$\frac{3}{16}$
$\frac{1}{2}$	$\frac{1}{2}$ -1	$\frac{1}{4}$
$\frac{3}{4}$	1-1 $\frac{1}{4}$	$\frac{3}{8}$

Greater conductivity is of course obtained with heavier fillets but from a practical and commercial standpoint such are not always required.

In addition to the above-enumerated plastics on which satisfactory results have been obtained by the instant process, "Laminac," an unsaturated polyester resin containing a catalyst such as benzoyl peroxide; "Vibrin," an unsaturated polyester with cross-linking monomer, likewise

containing a catalyst such as benzoyl peroxide; "Marco," an unsaturated polyester resin containing a catalyst such as benzoyl peroxide; and "Thalid," a polyester resin containing a catalyst such as benzoyl peroxide.

Another decided advantage of the instant invention is that the mold may be used in place upon the workshop floor and need not be transported from place to place. Thus, connections to the coils for heating or chilling the same circumvent otherwise required movement of the mold from station to station during various stages of packing the mold, compressing the same, if required, heating and chilling, etc.

This invention features the provision of new and improved structure and means for making a thermal bond and for conduction of heat or cold from a circulating coil or its equivalent to the exterior surface and hence to the body of a mold or other subject member. The means employed contemplate first a thorough cleansing and roughening of the subject surfaces followed by metal spraying to form a relatively wide area of contact between a heating coil or the like and a subject surface, particularly at and immediately adjacent the line of contact between such coil and such surface.

Other means of depositing a metal coating have been contemplated including electro-plating and while such other procedures are possible, they are generally too slow to be commercially practical, while direct painting, as with a brush, of metallic binding agents, achieves a less satisfactory thermal dispersion and an inferior metal-to-metal contact than herein contemplated.

Metal spraying is herein referred to. It is not required, however, that metal coils or metal molds or the like be used. Any substance capable of carrying a heating or refrigerating agent can be used, such as plastic or even rubber, provided they are capable of union with the other member (coil or panel) by a metal spray process as herein referred to.

As noted, the invention may be used for heat exchangers in general, including, without limitation, vessels for cooking, around which coils may be wound, coil construction for refrigerators or freezers, for space heaters, radiating panels, and the like.

Although the invention has been herein shown and described in what is conceived to be the most practical and preferred method and embodiment, it is recognized that departures may be made therefrom within the scope of the invention, which is not to be limited to the details disclosed herein but is to be accorded the full scope of the claims so as to embrace any and all equivalent structures and methods.

The invention having been herein described, what I claim as new and desire to secure by Letters Patent is:

1. A mold for heat curing thermosetting resins and the like, said mold having an inner surface of a configuration conforming to that of the article to be molded and an outer surface of generally similar configuration to that of said inner surface, metal tubing engaged in intimate line contact with said outer surface, said tubing being bent in a suitable configuration to substantially uniformly overlie said outer surface with portions of the tubing substantially uniformly spaced apart and distributed over the area of said outer surface, means securing said tubing to said outer surface at spaced intervals along the length thereof to hold the same in contact with said

outer surface, heat conducting metal in the inter-spaces between said tubing and said outer surface along the respective sides of the line of contact of said tubing with said outer surface, said heat conducting metal thus forming fillets for transferring heat from said tubing to said mold, and a layer of heat conducting metal of substantially uniform thickness covering the portions of the tubing and said outer surface which is not engaged by said fillets.

2. A mold for heat curing thermosetting resins and the like, said mold comprising a sheet of heat conducting material of substantially uniform thickness having an inner surface of a configuration conforming to that of the article to be molded, relatively thin-walled metal tubing engaged in intimate line contact with the outer surface of said sheet, said tubing being bent in a suitable configuration to substantially uniformly overlie said outer surface with portions of the tubing substantially uniformly spaced apart and distributed over the area of said outer surface, means securing said tubing to said outer surface at spaced intervals along the length thereof to hold the same in firm line contact with said outer surface, heat conducting metal in the inter-spaces between said tubing and said outer surface along the respective sides of the line of contact of said tubing with said outer surface, said heat conducting metal thus forming fillets for transferring heat from said tubing to said mold, and a continuous layer of heat conducting metal of substantially uniform thickness covering and fused to the otherwise exposed portions of the tubing and said outer surface and fillets, said layer being of a thickness of the same order of magnitude as the thickness of said tubing wall.

3. A mold, as defined in claim 1, wherein the tubing has a diameter of $\frac{3}{8}$ of an inch to $\frac{1}{2}$ inch and adjacent portions of the tubing are spaced apart 2 inches to 4 inches over the outer surface of the mold.

4. A mold, as defined in claim 1, wherein the tubing is $\frac{3}{8}$ to $\frac{1}{2}$ inch in diameter, and the width of the fillet between the tubing and the outer surface of the mold is $\frac{1}{8}$ of an inch to $\frac{1}{4}$ inch in width, and the thickness of the layer of heat conducting metal covering the tubing and the outer surface of the mold is about $\frac{1}{16}$ of an inch.

5. A mold, as defined in claim 1, in which the tubing is copper and the heat conducting metal forming the fillets and layer of covering material is zinc.

6. A mold for heat curing thermosetting resins and the like, said mold having an inner surface of a configuration conforming to that of the article to be molded and an outer surface of generally similar configuration to that of said inner surface, metal tubing engaged in intimate line contact with said outer surface, said tubing being bent in a suitable configuration to substantially uniformly overlie said outer surface with portions of the tubing substantially uniformly spaced apart and distributed over the area of said outer surface, means securing said tubing to said outer surface at spaced intervals along the length thereof to hold the same in contact with said outer surface, heat conducting metal in the inter-spaces between said tubing and said outer surface along the respective sides of the line of contact of said tubing with said outer surface, said heat conducting metal thus forming fillets for transferring heat from said tubing to said mold, and a layer of heat conducting metal of substantially uniform thickness covering exposed

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portions of the tubing and the outer surface of said fillets.

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