July 14, 1964 N. KRUITHOFF 3,140,518

METHOD OF FORMING A CORE FOR CASTING A COPPER TRANSFORMER ELEMENT

Filed April 26, 1962 3 Sheets-Sheet 1

FIG. 1

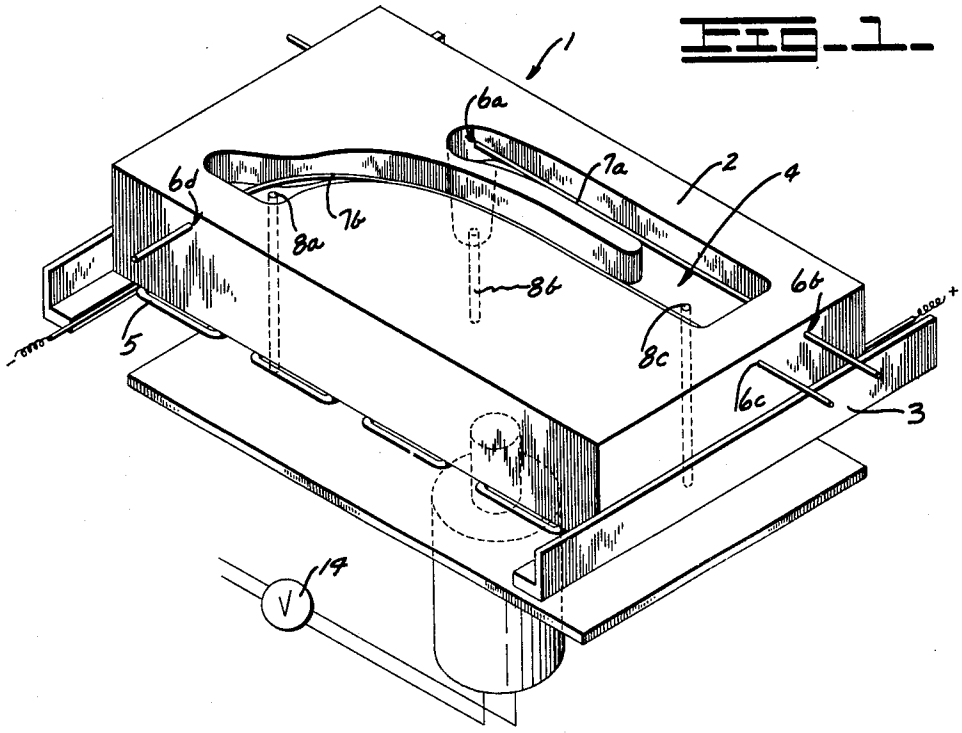
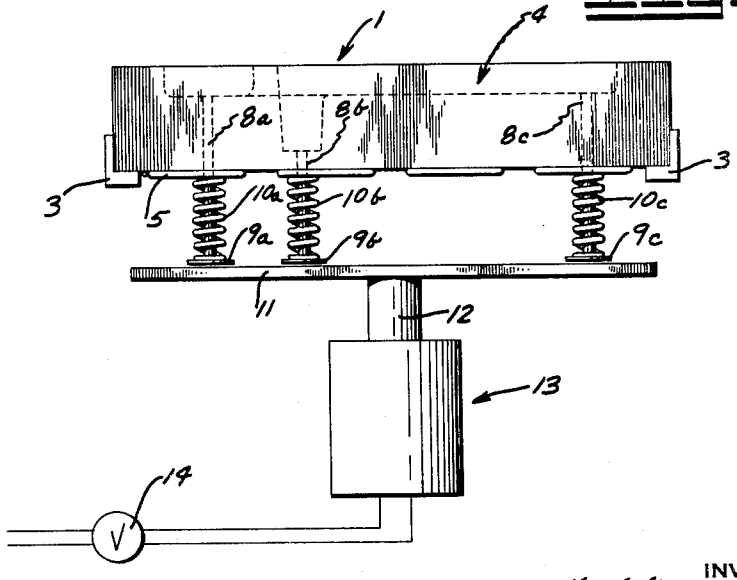


FIG. 2



INVENTOR
Neal Kruithoff

BY
Bruce and Benneveld
ATTORNEYS

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METHOD OF FORMING A CORE FOR CASTING A COPPER TRANSFORMER ELEMENT

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FIG-3

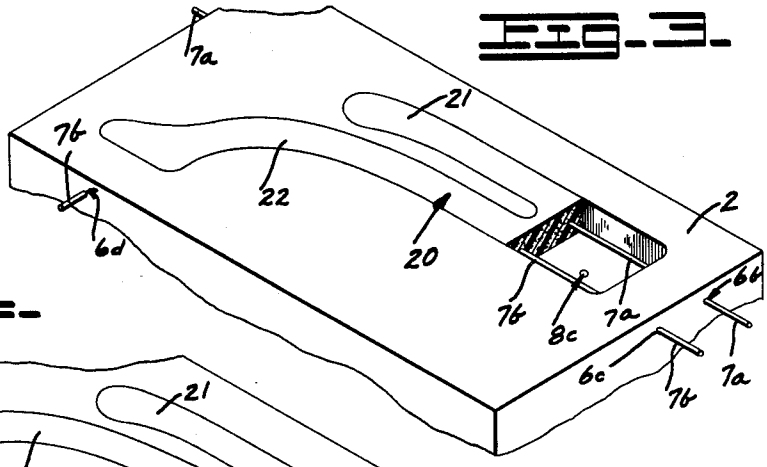


FIG-4

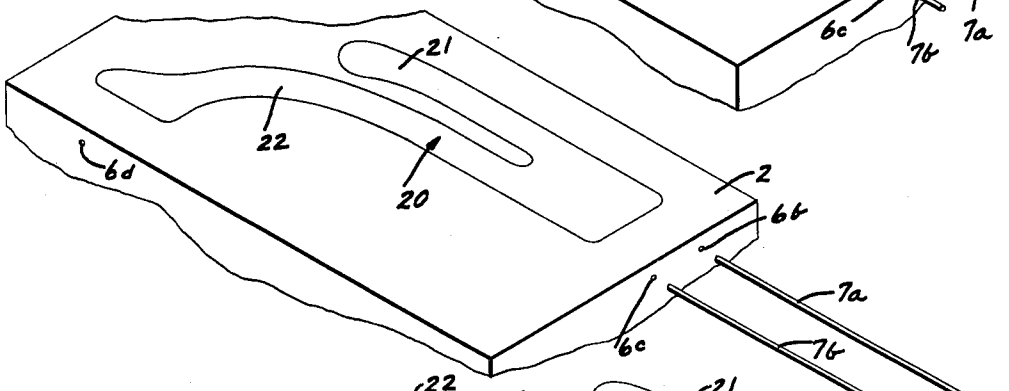


FIG-5

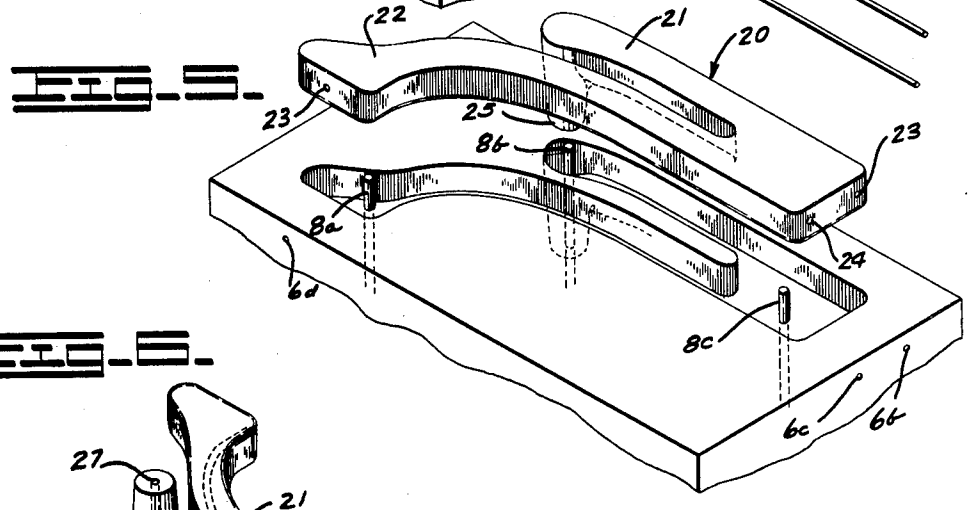
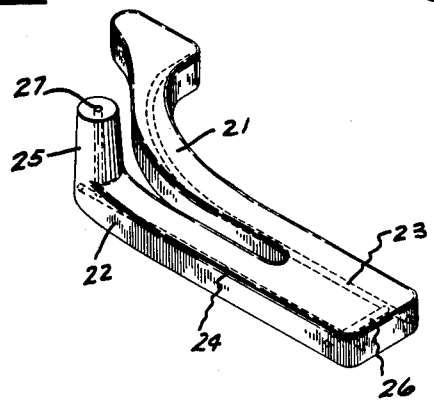


FIG-6



INVENTOR
Neal Kruithoff
BY
Price and Heneveld
ATTORNEYS

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METHOD OF FORMING A CORE FOR CASTING A COPPER TRANSFORMER ELEMENT

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FIG. 7.

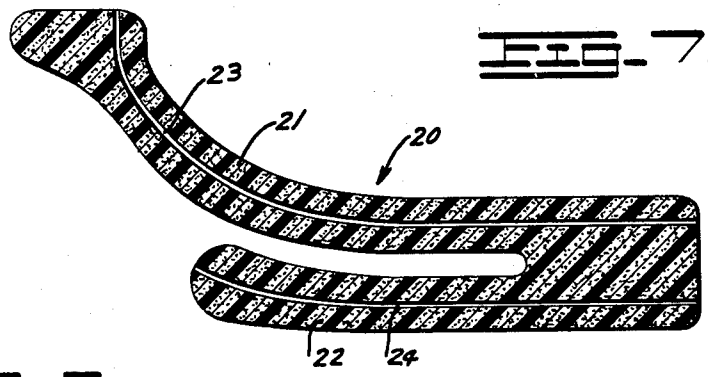


FIG. 8.

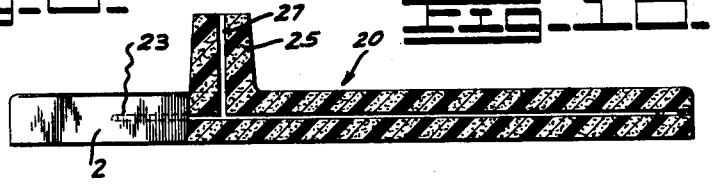
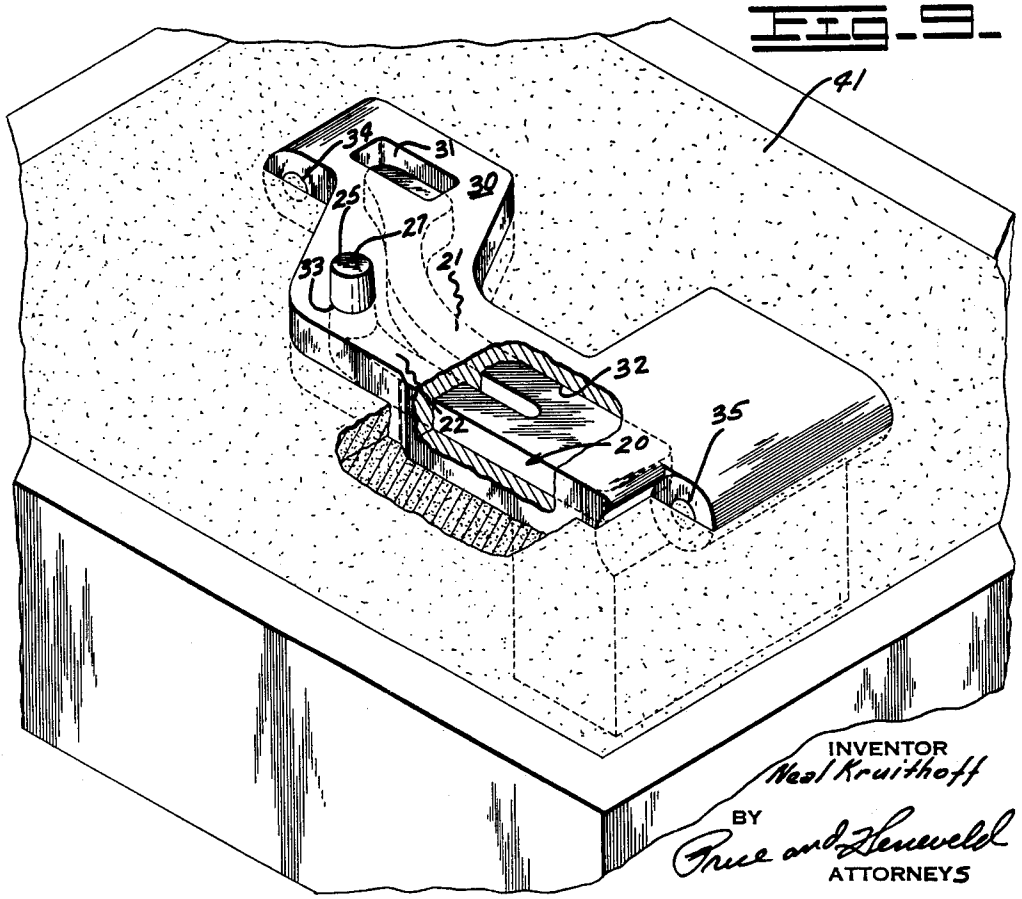


FIG. 10.



FIG. 9.



INVENTOR
Neal Kruithoff
BY
Bruce and Lenewald
ATTORNEYS

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3,140,518

METHOD OF FORMING A CORE FOR CASTING A COPPER TRANSFORMER ELEMENT

Neal Kruithoff, 444 Lakeside Drive NE., Grand Rapids, Mich.

Filed Apr. 26, 1962, Ser. No. 191,684
4 Claims. (Cl. 22—194)

This invention relates to a method of forming a cast copper transformer component, and more particularly to an electrical conducting, copper transformer component having an elongated cooling passageway therein and relatively thin walls around the passageway.

This is a continuation-in-part of my application, Serial No. 803,680, filed April 2, 1959, and entitled Method of Casting and Core Utilized Therein, now abandoned.

Casting articles from copper (this term includes alloys where copper is the dominant metal), so as to provide an elongated passageway with a thin wall between the passageway and the outer surface of the article, is extremely difficult. The casting of such articles has plagued the industry for some time. A particular article in this category of articles is a copper lug used in water cooled welding transformers. Although casting the lug with a suitable water passageway has been desired since the very conception of such lugs, no satisfactory method had been devised before this invention. The practice has been to cast a solid lug and then drill bores through the lug at different angles plugging the ends of the bores to provide the proper water passageway. Obviously, such procedure is time consuming, costly and the resultant passageways have not been completely satisfactory.

Manufacturers of welding transformers requiring lugs of these types, including the assignee of the present invention, have engaged a number of well-known and highly reputable foundries, large and small, to develop a method of casting the lug with the water passageway already in it. To my knowledge, all foundries failed to produce a satisfactory lug because of several reasons. First, if certain conventional packed sand cores having a binder are used to produce this lug, blowouts occur by reason of the molten metal striking the core material and binder which forms gases which blow through the thin wall of the article being cast before the metal freezes. When casting copper, the amount and duration of gas formation is exceptionally troublesome over the unusually long cooling period of the molten copper. Even when a few of the castings using prior methods were not blown, the electrical conductivity of the wall around the passageways was so low as to unduly limit the operating capacity of a welding transformer using the castings as components. Moreover, cores which might not form this gas, such as metal, cannot be used in forming elongated passageways, especially if they are tortuous, since their removal is impossible after the article is cast. Further, some types of core material, such as oil sand, do not have the strength to be suspended in the cavity of the mold by props.

As a consequence, outstanding foundries have admitted to the assignee of the present invention their inability to cast thin walled copper articles, and thus have been unable to supply the thousands of transformer components constantly needed by the assignee herein. Prior attempts of conducting gases away from the casting, such as those taught in Patents Nos. 2,268,676 to Shanley; and 1,207,495 to Butz are known. These are simply not capable of forming the assignee's water cooled transformer components. According to one method, loose sand must be mixed with linseed oil and packed very tightly to hold its shape. The linseed oil creates volumes and volumes of gases when vaporized and reacted upon by the hot copper. Moreover, the gases cannot readily escape to passageways through tightly packed sand. Further, the escape passageways are very unreliable because the sand tends to cave in and plug them. The use of tubular metal inserts in a core is completely unsatisfactory for electrically conducting copper transformer components since the metal would move around in the water cooling passageways and prevent proper cooling.

Considerable effort was expended on this serious problem by the applicant herein after everyone of the several foundries asked, admitted defeat. This effort resulted in the present invention which is believed by the assignee herein, the world's largest manufacturer of welding transformers, to be a major advance in the transformer field.

This invention finally solves these problems which have plagued the industry for some time. The object of this invention is to provide a method of casting a copper article having an elongated passageway.

Another object of this invention is to provide a method of casting an electrically conducting copper transformer compenent having optimum cooling with an elongated water passageway surrounded by a thin wall between the passageway and the outer surface of the article.

It is thus a specific object of this invention to provide a method of casting non-ferrous transformer components, especially of copper, wherein (1) optimum cooling, (2) high electrical conductivity, and (3) high casting reliability with a low scrap rate are simultaneously achieved in a relatively inexpensive manner.

Other objects of this invention will become obvious to those skilled in the foundry art by reading the following description in conjunction with the accompanying drawings wherein:

FIG. 1 is a top perspective view of the apparatus for forming the core of this invention.

FIG. 2 is a side elevational view of the apparatus of FIG. 1, for forming the core of this invention.

FIG. 3 is a fragmentary, top perspective view of the apparatus of FIGS. 1 and 2 having a core therein and partially cut away to illustrate one step of the method of this invention.

FIG. 4 is a fragmentary, top perspective view of the apparatus of FIGS. 1 and 2 having a core formed therein illustrating another step of the method of this invention.

FIG. 5 is a fragmentary, top perspective view of the apparatus of FIGS. 1 and 2 showing a core, formed by such apparatus, being ejected from the core box.

FIG. 6 is a perspective view of the finished core of this invention.

FIG. 7 is a cross-sectional plane view of the core of this invention formed by the apparatus of FIGS. 1 and 2 but not quite completely finished.

FIG. 8 is a side elevational, partially sectioned view of the finished core of FIG. 6.

FIG. 9 is a fragmentary, perspective of one part of a mold having a casting therein formed in accordance with the method of this invention. The casting is partially cut away to show the core therein forming the passageway.

FIG. 10 is a fragmentary, sectional, plan view of one end of the finished core of FIGS. 6 and 8.

Briefly, the method of this invention relates to casting a copper transformer component with an elongated water cooling passageway therein. In this method, a mold is formed having a cavity conforming to the shape of the article or component to be casted. In this cavity is a highly porous core having a low gas-forming propensity, and arranged essentially corresponding in shape to the passageway desired in the article, and enabling gaseous flow to a central gas duct. The core is formed by mixing a dry core sand with a thermosetting binder such as phenolic binder to form a porous, binder-impregnated mass, embedding elongated elements in the mass by arranging them in a cavity into which the core mass material

is to be poured, heating the core material in the cavity to cure the binder, and withdrawing the elongated elements when the resin is cured sufficiently to cause said core to be self supporting to form gas ducts communicating with the ports in the cured, rigid core. A vent is provided in the mold to afford communication between the gas duct and the ambient air. Next, molten copper is poured into the mold and around the porous core. The small amount of gas created around and in the core during the pouring of the molten copper readily permeates the core and escapes to the ambient air.

It was found that this novel method, time after time, achieves a far superior, water coolable copper transformer component without blown out walls.

Throughout this application the word "passageway" is used to described passages or openings formed in the castings by the method and core of this invention. This term means any such openings or passages requiring the method of this invention and the core to prevent blowouts.

Another term used throughout this application is "dry core sand." By this is meant a fairly coarse sand free from clay, the sand being mixed with a binder which holds the particles of the sand together in a porous structure to retain the shape of the core. This type of core material is distinguished from metal and green sand.

Referring to the drawings, reference numeral **1**, FIGS. 1 and 2, denotes the core forming apparatus including the core box **2** supported by the support frame **3**. The core box is constructed of a heat conductive material such as steel in which a cavity **4** is cut conforming to the shape of the core to be made by the apparatus. The core box **2** is heated by the heating elements **5**.

The core box has openings **6***a*, **6***b*, **6***c* and **6***d* properly positioned for receiving the wires **7***a* and **7***b* in the central portion of the cavity **4**.

Extending upwardly through the bottom of the core box **1** at selected points below the cavity **4** are ejector pegs **8***a*, **8***b* and **8***c*. These pegs have the heads **9***a*, **9***b* and **9***c* at their lower ends and the springs **10***a*, **10***b* and **10***c* circumventing them respectively for biasing the pegs downwardly.

Below the heads of the pegs **8***a*, **8***b* and **8***c* is an actuating mechanism for pushing them upwardly. This mechanism includes the ejector platform **11** actuated by the piston rod **12** of the fluid motor **13** which is controlled by the valve **14**. It should be obvious from the above description that after a core is formed in the core box **2** it can be ejected upwardly by the pegs **8***a*, **8***b* and **8***c* actuated by the ejector platform **11** and fluid motor **13**. This entire operation will be described hereinafter.

Before describing the steps in making the core by the apparatus shown and described, it is desirable to first describe the core material perferably used in the method. This material broadly is a dry sand made from a fairly coarse sand free from clay, the sand being mixed, impregnated, or coated with a thermo-setting binder. The coarse sand is not packed but retains a porous characteristic. The preferred sand is a silica sand and the preferred binder is a thermosetting phenolic resin, such as phenol formaldehyde. Other similar thermosetting resins such as urea or melamine formaldehyde may also be used. One such core material is sold in the trade as "10–4576 Acme Resin Bond Sand" sold by the Acme Resin Company of Chicago, Illinois. This core material is made by coating silica sand with a thermosetting liquid phenolic resin, semi-cured to a thermoplastic state, and then drying it so that in its final form it is a powdery material which will fill the cavity **4** of the core box **2** and completely surround the wires **7***a* and **7***b*. This material is characterized by being a thermosetting material after curing. Upon application of heat it will set and form a coalesced mass constituting a rigid core sufficiently strong to be supported in the cavity of the mold by props. It is further characterized by uniformly dispersed sand particles having a resin matrix whereby it is highly gas porous

permitting gas formed around and in the core by reason of the molten copper striking the core to permeate the core as well be described hereinafter. This core material is further characterized by being capable of retaining its shape and gas porosity at the melting temperature of the metal used for the casting so long as it is not subjected to any substantial shock. However, the material does break down losing the strong linkage between the sand particles permitting the material to be disintegrated when subjected to any substantial shock. The purpose for these characteristics will be described hereinafter. A material of this type, namely phenol formaldehyde, is disclosed in Letters Patent Nos. 2,706,163 and 2,706,188 although this application is not limited thereto.

The core is formed by first arranging the wires **7***a* and **7***b* in the central portion of the cavity **4**. This is easily performed by inserting the wire **7***a* through the openings **6***a* and **6***b* positioning it in the center of one section of the cavity **4**. The other wire, **7***b*, is inserted through the openings **6***c* and **6***d* positioning it in the center of the other section of the cavity. The core is then heated by heating elements **5**.

After the core box is heated to the proper temperature, approximately 450 degrees F. for the Acme resin bond sand referred to above, and with the ejector mechanism in the down position as shown in FIG. 2, that is, with the pegs **8***a*, **8***b* and **8***c* located flush with the floor of the cavity **4**, the cavity is filled with the core material. The heated core box immediately starts to set the core material and after having set for a very short time, about 30 seconds at 450° F., the excess core material from the top of the core box is wiped off making the top of the core flush with the core box, and the wires are withdrawn, the wires being withdrawn before the core material is completely set perferably at a time when the material immediately around the wires is in a semi-plastic state which will permit the withdrawal of the wire without the duct being formed by the wires closing in by reason of the plasticity. The state of the material immediately around the wires, when they are withdrawn, can be compared to the semiplastic state of a synthetic resin article being extruded which, although not in a solid form, retains its shape and immediately after being extruded permanently sets.

After the wires are withdrawn, the curing of the thermosetting core is continued at 450° F. by the heat from the core box until a rigid core member is formed in which member the sand particles are held together by the thermoset synthetic resin binder. The total curing time at 450° F. is preferably about 1 minute. It has been found that the withdrawal of the wires must be done as soon as the core material has cured enough to be self supporting and the sand particles are all adhered together by the resin matrix so that the passageways will not cave in, and that they must be withdrawn before the material completely cures to its final rigid state. If the core material becomes too rigid, it has been found that the wires can barely be withdrawn, and only with great effort, often with damage to the core. The 30 second period after the curing begins til the withdrawal will of course vary slightly with different binders and with varying thickness cores due to different curing times and temperatures, heat transmission variations, and the like. With the phenolic resin used, the total curing time should not substantially exceed 1 minute at 450° F. or else charring of the resin begins. The temperature of about 450° F. has also been found to be quite important for the specific phenol formaldehyde resin used as set forth above. Here again, this can conceivably vary somewhat with different resin binders.

The next step is to raise the ejector mechanism by turning the valve **14** to a position which will actuate the fluid motor **13** causing the piston rod **12** and ejector platform **11** to rise pushing the pegs **8***a*, **8***b* and **8***c* upwardly against the bias of the springs **10***a*, **10***b* and **10***c*. Peg **8***a* located at the end of one section of the core, peg **8***b* at

the end of the other section, and peg 8c located at the juncture between the two sections lift the core upwardly as illustrated by FIG. 5 permitting it to be removed.

The resultant product from the apparatus of FIGS. 1 and 2 is shown in FIG. 7. This particular core **20** includes the two elongated sections **21** and **22** each of which have a gas duct **23** and **24**, respectively. Section **22** has a protrusion **25** (FIG. 8) provided for the purpose of extending through the wall of the article to be cast providing a gas exhaust port as will be described.

The next step in finishing the core is to drill the two gas ducts **26** and **27**. Gas duct **26** provides communication between the two gas ducts **23** and **24** and gas duct **27** extends through the protrusion **25** providing escape of the gas from inside the cast article. The ends of gas ducts **23, 24** and **26** are then plugged as illustrated by FIGS. 8 and 10. This completes the core which has one continuous gas duct running through the central portion of the elongated sections and terminating at the protrusion **25**. The completed core as shown in FIGS. 6 and 8 is now ready for use in the method of this invention.

FIG. 9 shows an example of a cast article made in accordance with the casting method of this invention using the novel core previously described. This cast article is a lug specifically adapted for use in a water cooled transformer. In this type of transformer the heat generated by the current is so great that it is necessary to circulate water through the respective parts of the welding apparatus. For this purpose, it is necessary that the cross section of the water passageway be as large as possible to produce the most efficient dissipation of the heat. In the past, these passageways have been formed by drilling bores through a solid cast lug, which method is more costly and the dissipation of heat less efficient because of a smaller cross section of the water passageway.

The casting denoted by reference numeral **30** is a copper article shaped as shown having an inner face with an opening **31** for receiving one end of a water cooled secondary loop. Water flows through opening **31**, passageway **32** formed by the core and then through the opening port **33** formed by the protrusion **25** of the core. Openings **34** and **35** for support bolts are formed at the ends of the lugs by conventional cores.

The molding apparatus used in the casting method of this invention is conventional. It comprises a conventional flask **40** in which the mold **41** is formed. As well-known, the flask comprises two parts, a drag and a cope, one located above the other. A cavity is formed in the adjacent faces of the mold in the drag and the cope by a conventional pattern plate placed between the drag and the cope. Compression of the sand on each side of the pattern plate forms the cavity conforming in shape to the article to be cast.

The drag and the cope are separated and the core is arranged in the center of the cavity between these two parts. This is accomplished by props which ultimately disintegrate when the molten metal is poured around the core.

In accordance with this invention, a vent opening (not shown) is provided through one of the mold parts. This vent opening communicates with the end **27** of the gas duct of the core permitting any gas created in the pouring step to escape to the ambient air around the flask.

Having arranged a core inside the cavity between the drag and cope molds and having provided the vent extending through the mold, the apparatus is ready for pouring. The molten metal is poured through an opening provided in the mold so that it surrounds the core and occupies the cavity in the mold. The molten metal upon striking the core creates a gas which permeates the core and enters the gas ducts. This gas passes through the pores of the core and into the gas ducts, out of the end duct **27** and through the vent opening in the mold, thus preventing any blowout which occurs in conventional methods of casting.

In venting this gas from the core inside the cast article, it is possible in accordance with this invention to produce a copper article having an elongated passageway with thin walls, and having a high electrical conductivity. Heretofore this has been impossible although the foundry industry at large has attempted to accomplish it for sometime.

As previously stated, the core **20** is made up of material which when heated to the extreme temperatures of the molten metal is burned destroying the linkage between the particles. At these extreme temperatures, the core is capable of retaining its shape so long as it is not subjected to shock and until the molten metal has frozen. However, when the article is separated from the mold by conventional apparatus such as shakers, the core material will disintegrate and fall apart and is capable of being shaken out of the passageway **32** formed by the core. This permits casting an article with a passageway which is tortuous or any shape desired.

The advantages of this invention should be obvious from the above description and, therefore, it is considered unnecessary to reiterate them. Briefly, this invention produces a method of casting, a novel core for use in such method, and a method for making the core, all of which are novel and have solved problems long existing in the art.

Having described by invention, it should become obvious that although I have shown preferred embodiments, modifications and alterations are possible within the broadest spirit of this invention and as a result, such modifications and alterations should be considered to be included unless the claims by their language expressly state otherwise.

I claim:

1. A method of forming a copper transformer component having a curved cooling passageway therein, comprising the steps of: providing a mold having a cavity conforming to the shape of the component to be cast; forming a core by mixing sand with a binder resin capable of being cured to a thermosetting state, forming the mixture into an uncompacted shape, with an elongated curved, wire-type element poistioned therein, curing said resin to its thermosetting state and withdrawing said element from said core when partially cured sufficiently to be self supporting to form a gas duct having firm, non-sagging, non-crumbling, and yet porous walls; then heating said core further to completely cure said core to a rigid state; arranging said core in the cavity of said mold; said cured core being characterized by high gas porosity, strength, and capability of retaining its shape and gas porosity at the melting temperature of copper; said core essentially corresponding to the shape of said passageway; providing an air vent in said mold to communicate between said gas duct and ambient air; pouring molten copper in said cavity around said core; and cooling and solidifying said molten copper while simultaneously venting gases created around and in said core through the pores, gas ducts, and to the atmosphere.

2. A method of forming a copper article having a curved passageway therein, comprising the steps of: providing a mold having a cavity conforming to the shape of the article to be cast; forming a core by mixing sand with a binder resin capable of being cured to a thermosetting state, forming the mixture into an uncompacted shape with an elongated curved, wire-type element positioned therein, curing said resin to its thermosetting state and withdrawing said element from said core when partially cured sufficiently to be self supporting to form a gas duct having firm non-sagging, non-crumbling and yet porous walls; then heating said core further to completely cure said core to a rigid state; arranging said core in the cavity of said mold; said cured core being characterized by high gas porosity, strength, and capability of retaining its shape and gas porosity at the melting temperature of copper; said core essentially corresponding to the shape of said passageway; providing an air vent in said mold to com-

municate between said gas duct and ambient air; pouring molten copper in said cavity around said core; and cooling and solidifying said molten copper while simultaneously venting gases created around and in said core through the pores, gas ducts, and to the atmosphere.

3. A method of making a gas conducting, complexly configurated core for casting non-ferrous articles, comprising the steps of: providing a core box having a cavity corresponding in shape to the core to be made; arranging at least one elongated wire-type member in a curved fashion along the central portions of and extending to the edges of said cavity in conformity with the complex configuration of said cavity; filling said cavity around said elongated member with an uncompacted and thus porous mixture of dry sand and phenolic resin binder; heating said core mixture in said core box to partially cure said phenolic resin to a semi-plastic, self sustaining, non-crumbling state whereby said elongated member may be readily withdrawn without sagging of said core material; withdrawing said elongated member to leave a duct in the core; and then heating said core mixture further to completely cure said core to a rigid state.

4. A method of making a gas conducting complexly

configurated core for casting non-ferrous articles, comprising the steps of: providing a core box having a cavity corresopnding in shape to the core to be made; arranging at least one slender, wire-type elongated member in a curved fashion along the central portions of and extending to the edges of said cavity; filling said cavity around said elongated member with an uncompacted and thus porous mixture of dry sand and thermosetting resin binder; heating said core mixture to partially cure said resin to a self sustaining non-crumbling state whereby said core material will not sag when said elongated member is withdrawn; withdrawing said elongated member to leave a duct in the core; and then heating said core mixture further to completely cure said core to a rigid state.

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