Oct. 23, 1962 H. VOSSKUEHLER 3,059,295

COMPOSITE MOLD FOR CONTINUOUS CASTING

Filed May 26, 1959

Fig. 1

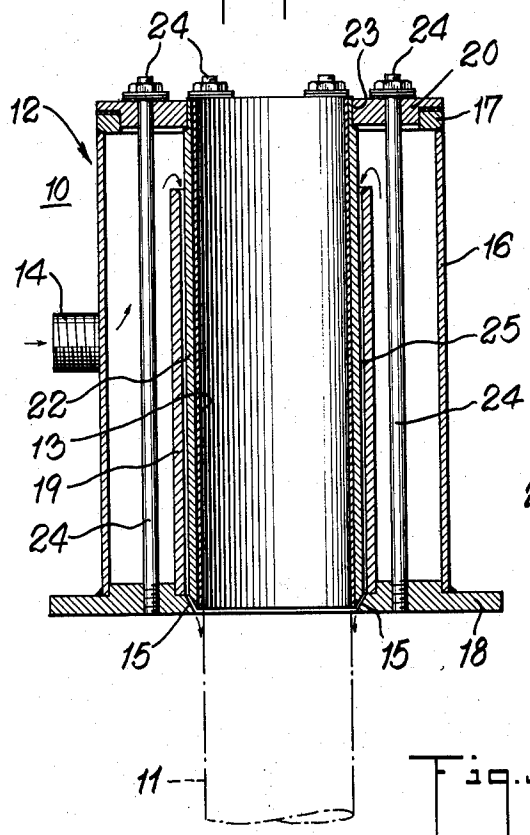


Fig. 3.

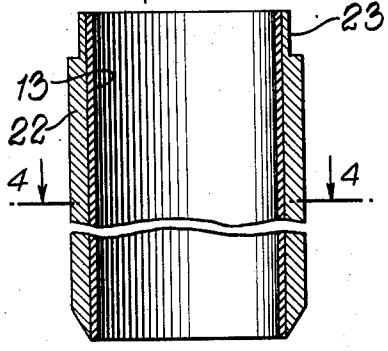


Fig. 4.

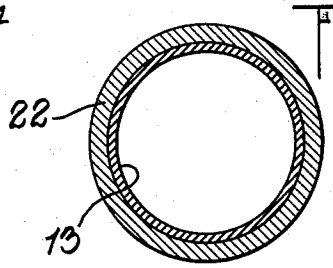
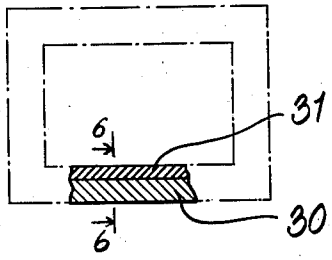


Fig. 5.



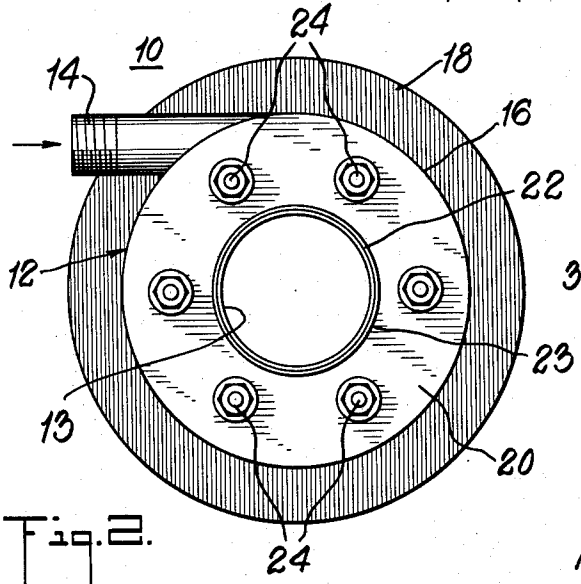


Fig. 2.

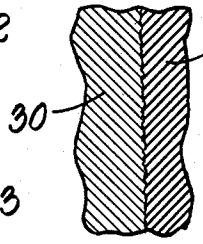


Fig. 6.

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COMPOSITE MOLD FOR CONTINUOUS CASTING

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7 Claims. (Cl. 22—57.2)

This invention relates to molds for continuously casting metals and more particularly to molds having a metal jacket and a graphite liner.

Considerable study has been given over the years to improving the heat transfer between the graphite liner and the metal jacket of molds for continuously casting metal. Under the temperature changes occurring in successive continuous casting cycles, there is a great tendency for the metal jacket and graphite liner to separate, destroying perfect solid-to-solid contact between their surfaces. Tests have shown that, if contact between the liner and jacket is reduced or destroyed, flow of heat is seriously impaired, inasmuch as even an extremely thin gap or gas layer possesses a remarkable heat-insulating capacity. For example, it can be shown that 0.001 of an inch of air space is equivalent to about 16 inches of copper and to about 5½ inches of graphite with respect to thermal conductivity.

Various efforts have been made in the past to improve the heat transfer between the copper jacket and the graphite liner. For example, in Wieland Patent No. 2,871,530, the graphite liner of a billet mold is placed within the jacket with a severe compression fit. The compression fit may be obtained either by pressing an oversize graphite tube into the metal jacket, or by shrinking a heated metal jacket onto the graphite liner.

In Wieland Patent No. 2,835,940 intimate thermal contact between the graphite liner and metal jacket of a cake mold is obtained by making the jacket and liner of separate pieces. The jacket pieces are connected by articulated joints so arranged that the jacket may warp or distort under the temperature variations of continuous casting. The liner is in the form of relatively thin, separate plates which are so mounted that they may freely follow the changes in shape of the jacket, thereby to maintain good thermal relationship between the liner and jacket.

The above prior practices have, in general, given excellent performance when used for the purposes intended, but have certain limitations for other purposes. For example, the compression fit is useful mainly with cylindical molds and is not especially adapted for rectangular or cake molds. Furthermore, with both types of mold there is a tendency for thermal relationship between jacket and liner to deteriorate after prolonged use, with consequent loss in efficiency of heat transfer.

The present invention seeks to overcome the above-mentioned disadvantages by adhering a metal layer integrally to the graphite liner so as to intimately bond the metal jacket to the graphite; and thus form a metal-to-graphite contact which can be separated only by destroying the mold. The metal layer may be applied to the graphite in various ways, depending upon results desired; for example, the metal layer may be applied by spraying molten metal onto the surface of the graphite, or by dipping the graphite liner into molten metal. However, it is preferred to adhere the metal to the graphite liner by electroplating. The invention is applicable to molds of different cross-sections including circular and rectangular, but it is particularly advantageous for rectangular molds where it is difficult, if not impossible, in many cases to unite liner and jacket by a severe compression fit.

The mold according to the present invention increases the heat flow from the molten metal being cast to the cooling medium applied to the jacket and thus permits an increase in casting rate, resulting in improved grain structure and surface characteristics of the metal which is being continuously cast.

Other objects and features of the invention will be more apparent from the following description when considered with the following drawings, in which:

FIG. 1 is a longitudinal cross-section through a preferred form of circular mold according to the invention;

FIG. 2 is a plan view of FIG. 1;

FIG. 3 is an enlarged detail showing the graphite liner and the inner shell of the jacket which is plated onto the liner;

FIG. 4 is a transverse section taken on the line 4—4 of FIG. 3;

FIG. 5 is a transverse section, somewhat diagrammatically illustrating application of the invention to a mold of oblong cross-section;

FIG. 6 is a section, on the line 6—6 of FIG. 5, illustrating very diagrammatically, the interlocking bond between graphite liner and metal jacket.

In the accompanying drawings and in the description forming part of this specification, certain specific disclosure of the invention is made for purposes of explanation, but it will be understood that the details may be modified in various respects without departure from the broad aspect of the invention.

Referring to the drawings and more particularly to FIGS. 1 to 4, one preferred form of mold will now be described. The mold **10** comprises a metal jacket **12** and graphite liner **13**. Cooling water is applied to inlet **14** and withdrawn at annular outlet **15**. The cast product is indicated diagrammatically by **11**; the cooling water issuing from annular outlet **15** impinges upon the cast product **11**, as indicated. It will be understood that this mold may be mounted and used in a manner similar to the mold shown in the above-mentioned Wieland Patent No. 2,871,530.

The jacket **12** comprises two assemblies connected together by through bolts **24**. The first assembly comprises an upper ring **17** and a lower supporting plate **18** connected by outer cylindrical shell **16**. A well **19** is seated in an annular shoulder at the inner edge of the plate **18**.

The second assembly comprises inner shell **22** having an upper shoulder **23** to which is suitably connected an upper plate **20**. The graphite liner **13** is bonded to and supported by inner shell **22** in a manner insuring excellent heat transfer as discussed more at length hereinafter. The through bolts **24** are anchored in the bottom plate **18** and passed through upper plate **20**. Upper nuts are applied to bolts **24** for suitably clamping the assemblies together. The parts of each assembly are connected in any suitable way.

It will be noted that the inner shell **22** is spaced from well **19** and also from bottom plate **18**; the latter spacing provides the annular outlet **15**. The well **19** provides a space **25** of reduced cross-section to promote increased flow of cooling liquid to overcome any film effect against inner shell **22**. The discharge **15** is made smaller than inlet **14** so as to insure completely filling the jacket with water. The tangential connection of the inlet **14** further assists in providing improved cooling.

A preferred method of adhering the inner shell to the graphite liner will now be described. Any well-known electroplating process may be used, which will bond the metal to the graphite in an intimate manner. For example, the following process, sometimes referred to as the Elmore process, may be used. The graphite sleeve is placed in an electrolytic bath containing a copper electrolyte with the axis of the liner horizontal. The upper part of the liner projects out of the bath, the lower part of the liner is immersed in the bath. As the electro-

deposition proceeds, the graphite tube is rotated, and as the copper is deposited on the outside surface of the tube, the surface is pressed by an agate stone which is reciprocated lengthwise of the liner axis. This polishes and packs the electro-deposited copper, preventing sprouts, needles and other projections, providing a smooth, hard, dense layer, making the deposited metal of the order of three times harder than ordinary electrolytic copper, and substantially more dense than ordinary electrolytic copper.

It will be understood that any conventional means may be provided to prevent electro-deposition on surfaces where no deposit is wanted; or, if desired, the entire liner, both inside and out, may be coated with metal and the metal afterwards removed from the inside and other places where no metal deposit is wanted. In any event, after the electro-deposition, the copper inner shell **22** is machined to the shape shown.

Instead of starting the electrolytic deposition with a graphite tube, a solid graphite rod may be used on which the copper may be deposited in the manner described above. After copper is deposited to the desired thickness, the solid rod may be bored to form a graphite cylinder.

Instead of the Elmore process, any other process may be used, which will electro-deposit a dense, hard copper coat on the outside surface of the graphite. For example, the well-known Cowper-Coles process may be used; here the cylindrical graphite cathode may be disposed vertically and completely immersed in the electrolytic bath. Electro-deposition may be carried out while the cathode rotates at extremely high speed.

The liner may be made of any grade or quality of graphite, including materials containing graphite, such as graphite-coated carbons which are suitable for casting the metal it is desired to continuously cast. The jacket also may be made of any metal or alloy, but it is preferred to use copper for electro-deposition. It will be understood that the electrolytic process causes the copper ions to enter the pores of the graphite depositing below the surface and forming an adhering coat which is anchored and keyed to the graphite; this metal coat can be separated from the graphite only by destruction of the graphite. The bond is of such nature that the copper layer cannot be separated from the graphite by stripping.

The invention is applicable to a wide variation of dimensions. For example, the continuously cast billets may be from three to six inches in diameter, the electro-deposited copper layer may be five mm. in thickness (0.02″), and the graphite liner may be two mm. in thickness (0.008″). These are given by way of examples and not in any limiting sense. An important advantage of the plating operation is that the graphite liner may be made extremely thin after the metal is bonded to it since its adherence to the copper jacket obviates any necessity for the graphite to be self-supporting after the metal jacket is deposited.

Referring now to FIG. 5, the invention is shown applied to a cake mold having plane walls; the inner metal shell is

denoted by **30** and the graphite liner by **31**. The jacket in this form may follow the construction of the jacket shown in the Wieland Patent No. 2,835,940, except that the plates forming the inner jacket shell are formed by plating metal onto the graphite liner plates. In FIG. 6 the interface between metal jacket **30** and graphite liner **31** is deliberately exaggerated to illustrate the tight interlocking bond between these members.

Thus a mold is provided in which the graphite liner and metal jacket are intimately bonded together. This intimate bond eliminates air gaps, and also makes possible use of an extremely thin layer of graphite. The efficiency of the bond is not limited to any particular cross-section of mold. The intimacy of the bond is just as effective in the case of a plane surface, as used in cake molds, as it is in the case of a cylindrical surface, as used in billet molds. The improved efficiency of heat transfer from liner to jacket makes possible continuous casting at high rates of speed, at the same time obtaining improved internal and external characteristics in the cast product.

While certain novel features have been disclosed and are pointed out in the annexed claims, it will be understood that various omissions, substitutions and changes may be made by those skilled in the art without departing from the spirit of the invention.

What is claimed is:

1. In a system for continuously casting metal, a mold comprising a metal supporting jacket adapted to be cooled by fluid and a graphite liner defining a mold cavity within said jacket, characterized in that the metal jacket is plated onto the graphite liner to form a massive built-up metal coat.

2. The system according to claim 1, in which the jacket and liner are circular and cylindrical.

3. The system according to claim 1, in which the jacket and liner have flat walls.

4. The system according to claim 1, in which the metal jacket comprises densified and hardened electrolytically deposited metal.

5. The system according to claim 1, in which the metal jacket is applied to the graphite liner by spraying.

6. The system according to claim 1 in which the metal jacket is applied by dipping the graphite liner in molten metal.

7. The system according to claim 1, in which the graphite liner is so thin as to require adherence to the jacket for support.

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