Feb. 5, 1963 L. SIMONSON ET AL 3,076,241

GRAPHITE MOLD CASTING SYSTEM

Filed June 22, 1959

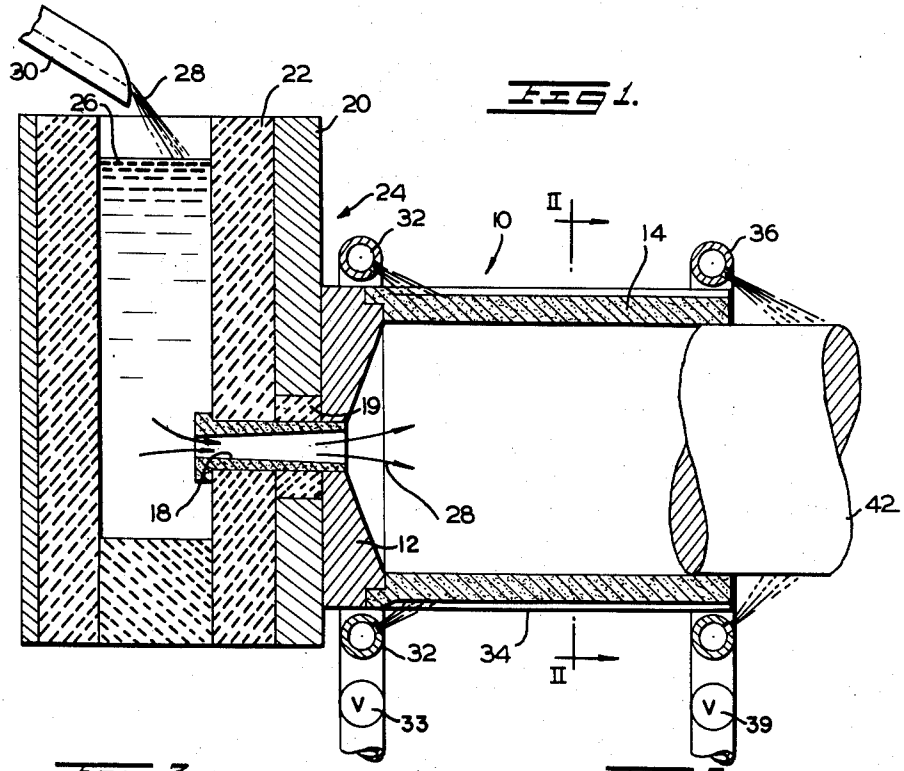


Fig 1.

Fig 2.

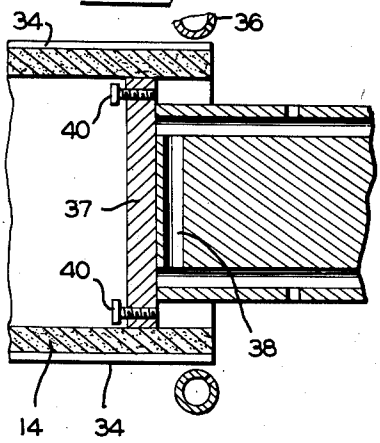
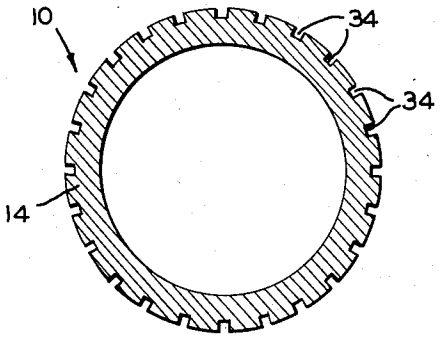


Fig 3.



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United States Patent Office 3,076,241 Patented Feb. 5, 1963

3,076,241

GRAPHITE MOLD CASTING SYSTEM

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Filed June 22, 1959, Ser. No. 821,856
4 Claims. (Cl. 22—200.1)

This invention relates to continuous casting of metal, and especially to horizontal casting of aluminum and its alloys through water-cooled graphite molds.

A large proportion of all aluminum produced, whether alloyed or substantially pure, is continuously cast from molten metal into ingots preliminary to subsequent conventional operations, such as rolling and extruding. This process conventionally requires a mold shell in the form of a hollow sleeve, means to spray or circulate water against the outside of the mold shell in order to chill the molten metal in the mold shell, and means to spray water directly against the ingot emerging from the mold shell. A highly heat-conductive material is desirable for the mold shell, and aluminum itself is usually employed to make mold shells for continuously casting molten aluminum. While an aluminum mold shell is excellent for conducting heat, it tends to stick to the metal being chilled by contact with the mold shell, and various lubricants are used to prevent such sticking, which mars the ingot surface and can cause other troubles. A single application of lubricant at the beginning of a casting cycle is not always enough to last until the end of the casting cycle, and this problem is magnified when attempts are made to change from vertical casting, which is the most frequently used method, to horizontal casting, which offers a relatively unlimited opportunity to make long, uninterrupted continuous castings. Supplying additional lubricating oil during the casting operation requires special attention and care, and consequently efforts have long been made to develop mold shells made of graphite, which is self-lubricating and yet has relatively high heat conductivity. Unfortunately, graphite is somewhat porous, especially in the regular commercial grades, and consequently water sprayed directly on a graphite mold and absorbed into the graphite will break up the graphite shell as the absorbed water vaporizes under influence of heat from molten metal in the mold. This has led to designs where a direct water spray on the graphite mold is either omitted altogether, which requires modification of the basic casting principles, or an outer metal covering is added, with resultant complications of construction and interference with heat conductivity. In either case, the self-lubricating advantages of the graphite are offset by disadvantages stemming from its porosity and brittleness, and graphite mold shells have found very limited acceptance in the aluminum industry.

The present invention provides means and method of employing graphite molds efficiently in continuous casting of metals, especially aluminum and its alloys. Water is applied directly to the graphite of the mold shells to chill the molten metal therein, and long uninterrupted horizontal casting operations can be completed without adding any supplemental lubricant after the casting operation begins.

For a better understanding of the invention and its other objects and advantages, reference is now made to the accompanying drawings, in which there are shown, for purposes of illustration only, certain present preferred embodiments of the invention. In the drawings:

FIG. 1 is a vertical sectional view through continuous casting apparatus embodying the invention;

FIG. 2 is a section on the line II—II in FIG. 1; and

FIG. 3 is a vertical sectional view, in reduced scale, showing the outer end of the mold shell shown in FIG. 1, with the starter block therein before casting begins.

Referring now more particularly to the drawings, the continuous casting apparatus shown in FIG. 1 comprises a mold base member 12 formed of an insulating material, preferably the mixture of asbestos fiber and inorganic cementitious binder sold under the trademark "Marinite" (Johns-Manville Sales Corporation), and a graphite mold shell 14 in the form of a cylindrical sleeve secured at one end to the base 12. The graphite of the shell 14 is ideally as dense as possible, but the partially porous graphite of the grade commercially sold for use in electric anodes has proved entirely satisfactory for the purpose. The interior surface of the base 12 surrounded by the shell 14 is cupped toward the open end of the shell 14, in the form of a shallow cone. A graphite feeder tube 18 extends horizontally through a central opening in the mold base 12, and through the still outer wall 20 and insulating liner 22 of a feeder box 24, to connect a molten metal pool 26 in the interior of the box 24 with the interior of mold shell 14. A ring 19 of insulating material ("Marinite") separates tube 18 from metal wall 20. The upper end of box 24 is open, and molten metal 28 is fed into it from a feeder trough 30 extending from a holding furnace (not shown). The rate of flow of the metal 28 can be controlled satisfactorily by conventional valve means (not shown) controlling the outlet of the holding furnace.

While graphite has a relatively high coefficient of thermal conduction, it is substantially less conductive of heat than the aluminum mold shells conventionally used in vertical casting. In addition, water sprayed against a horizontally-extending mold shell tends to flow around the shell toward its lower side, rather than toward the exit end of the shell where the ingot is emerging, and this tends to interfere with proper distribution of cooling water around the mold shell. These problems are dealt with in accordance with the present invention by locating a spray ring 32 around the base member 12, with the spray outlet directed toward substantially the whole outside surface of the shell 14, and by forming grooves 34 in the outer surface of the shell 14 in a direction parallel to its central axis. This has the effect of increasing the outer surface of the shell 14 exposed to the water sprayed from the ring 32, thereby increasing the cooling effect of this spray, and at the same time grooves 34 help to guide the spray water horizontally toward the outer end of the shell 14, and thus oppose the tendency of the spray water to flow downwardly around the sides of the shell 14 instead of flowing toward its exit and where the ingot 42 is emerging. A second spray ring 36 is located adjacent to the exit end of the shell 14, to spray cooling water directly on the emerging ingot.

At the start of a new casting operation, the interior surfaces of the mold base 12 and shell 14 are swabbed out with a lubricating grease, such as tallow, and then a gas tube having a burner at the end is inserted down into the feed box 24 and the burner flame is directed through the tube 14 into the mold cavity. This flame is preferably maintained until the graphite tube 18 becomes visibly red hot, in order to make sure that the incoming molten metal does not freeze prematurely, and that the heat of the flame has driven off the volatile components of the grease and any other volatiles which may be unintentionally present, thereby minimizing the risk of explosions. The preheating also heats the graphite mold so that it is free of absorbed water and will not be subjected to much thermal shock when casting begins. A starter block 37 is then inserted a short distance into the open end of the mold shell 14, to block the initially entering molten metal, and

this starter block is internally cooled by a flow of water through passages 38 inside of the block to prevent the block from expanding excessively when the molten metal initially comes in contact with it, with possible resultant injury to the mold shell 14. The chilled starter block 37 helps to initiate the freezing of the incoming molten metal at the start of the casting operations, and bolts 40 extending from the starter block become embedded in the metal and serve to pull the ingot 42 away from the mold during the casting operation. The gate of the holding furnace is then opened, and the molten metal 28 is permitted to flow down the trough 30 into the box 24. When the level of the molten metal in the box 24 rises above the level of the tube 18 to the level of the top of the shell 14, it is clear that the mold cavity has been filled with molten metal, and movement of the starter block out of the mold is begun. Up to this time, spray rings 32 and 36 are shut off by valve means 33 and 39, but when the starter block begins to move, both spray rings are turned on and the continuous casting operation begins. It is important to observe that the molten metal heats the shell 14 to a temperature several hundred degrees Fahrenheit above the boiling point of water, and consequently the spray from the ring 32 is unable to soak into the graphite of the shell 14, in spite of the fact that the graphite is partially porous. This prevents injury to the graphite, and makes it possible to use the same mold shell repeatedly for many casting operations.

The starter block 37 is mounted on a carriage (not shown), and is drawn horizontally away from the mold to withdraw the ingot 42 as it emerges from the mold. A series of supporting rollers (not shown) support the weight of the ingot extending between the mold and the starter block. The casting operation can be continued until the end of the prepared line of travel of the starter block has been almost reached, at which point the flow from the holding furnace is shut off, and the remaining metal in the box 24 is used up in completing the trailing end of the ingot. The water sprays are then turned off, and the ingot removed. The ingot can be cut into as many pieces as desired after completion of its casting, or, by means of a traveling saw, during casting. After removal of the ingot, the carriage with the starter block can be returned, and the operation repeated. For convenience and economy, several ingots can be cast simultaneously parallel to each other.

Mold shells 14 of various diameters have been successfully used to produce cylindrical ingots of corresponding diameters for extrusion purposes, made of various aluminum alloys suitable for extrusions. For example, 2¼ inch diameter and 2 11/16 inch diameter ingots of R–11 aluminum alloy (in which the significant alloying elements are about 11% silicon, 0.75% manganese, 0.75% magnesium and 1.75% copper), 3 inch, 3½ inch, 4 7/16 inch, 5⅛ inch, 6 inch, and 8 inch diameter ingots of 6063 aluminum alloy; 4 7/16 inch, 5⅛ inch, and 6 inch diameter of 6061 aluminum alloy and 6062 aluminum alloy; and 5⅛ inch diameter of 3003 aluminum alloy. The mold shell 14 can also be formed with other cross sectional shapes, such as square or rectangular, and cast with the longest cross-sectional dimension of the ingot extending either horizontally or vertically, for various purposes other than extrusions, such as rolling operations. In the case of rectangular mold shells, the narrower opposite sides (up to about 3 inches) are preferably left ungrooved. For example, ingots of square cross section measuring 1¾ inch along each side have been successfully cast of 5056 aluminum alloy, and ingots measuring 2 inches by 28 inches in cross section have been successfully cast of 1235 aluminum alloy; and ingots of 7½ inches by 30½ inches cross section have been successfully cast of 1100 alloy and 3003 aluminum alloy. In the case of the round and rectangular graphite mold shells mentioned above, the mold lengths varied from about 3½ to 10 inches in length (measured parallel to the central axis from the juncture with the outer end). These are representative examples, but other examples of larger or smaller cross sectional dimensions and lengths, and employing other alloys, can also be cast, using the casting system of the invention.

In the examples given above, the interior diameter of the feed pipe 18 was about ¾ inch in all cases, and the casting speeds ranged from about 4 to 6 inches per minute (e.g., when casting 6063 alloy in a graphite mold shell of 8 inch internal diameter and 8 inch length) to about 25 inches per minute (e.g., when casting R–11 alloy in a graphite mold shell of 2 11/16 inch internal diameter and 6 inch length). While these casting speeds are typical, greater or less casting speeds can be used. The casting temperatures were the same as those used for casting the same alloys by conventional direct chill vertical continuous casting methods. The head of molten metal 26 above the tube 18 was about 8 to 14 inches, depending generally on the size of the ingot, but larger and somewhat smaller heads can be used. The ingots cast were about 80 feet long, but this was governed by the travel of the carriage at the end of the ingot, rather than by any limitation of the casting method.

The ingots in the above examples were characterized by smooth, bright surfaces, and were of such good quality that scalping was unnecessary for most purposes, including extrusion and rolling. For example, a 2 x 28 inch slab of 1235 alloy (about 99.35% aluminum) was cast at a rate of 4½ inches per minute from a graphite mold shell of the invention, and rolled down to 0.004 inch foil of good quality, without scalping the slab after casting, and without encountering any blistering.

While the casting system of the invention has been illustrated by reference to aluminum and aluminum alloys, it is also adaptable to the casting of other metals, such as magnesium, copper, zinc and alloys of each of these metals.

While present preferred embodiments of the invention have been illustrated and described, it will be understood that the invention is not limited thereto but may be otherwise variously embodied and practiced within the scope of the following claims.

We claim:

1. In the method of continuously casting metal through a mold shell made of graphite capable of absorbing water, the steps of initiating the casting of the metal by the steps of inserting a starter block into the open exit end of the mold shell, internally cooling said starter block while filling the mold shell with molten metal up to the starter block, and commencing to spray water directly against the outer graphite surface of the mold shell only after it the outer graphite surface of the mold shell only after it has been filled with molten metal and has been heated to a temperature greatly in excess of the boiling point of water.

2. In the method of continuously casting metal through a mold shell made of graphite capable of absorbing water, the steps of initiating the casting of the metal by the steps of inserting a starter block into the open exit end of the mold shell, internally cooling said starter block while filling the mold shell with molten metal up to the starter block, commencing to spray water directly against the outer graphite surface of the mold shell only after it has been filled with molten metal and has been heated to a temperature greatly in excess of the boiling point of water, and immediately after such spray commences commencing to withdraw the starter block from the mold shell.

3. In the method of continuously casting metal through a mold shell made of graphite capable of absorbing water, the steps of initiating the casting of the metal by the steps of internally greasing the mold shell, preheating the mold shell to drive off the volatile components of the grease, inserting a starter block into the open exit end of the mold shell, internally cooling said starter block while filling the mold shell with molten metal up to the starter block, and commencing to spray water directly against the outer

graphite surface of the mold shell only after it has been filled with molten metal and has been heated to a temperature greatly in excess of the boiling point of water.

4. In the method of continuously casting aluminum alloy through a mold shell made of graphite capable of absorbing water, the steps of initiating the casting of the aluminum alloy by the steps of inserting a starter block into the open exit end of the mold shell, internally cooling said starter block while filling the mold shell with molten aluminum alloy up to the starter block, and commencing to spray water directly against the outer graphite surface of the mold shell only after it has been filled with molten aluminum alloy and has been heated to a temperature greatly in excess of the boiling point of water.

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