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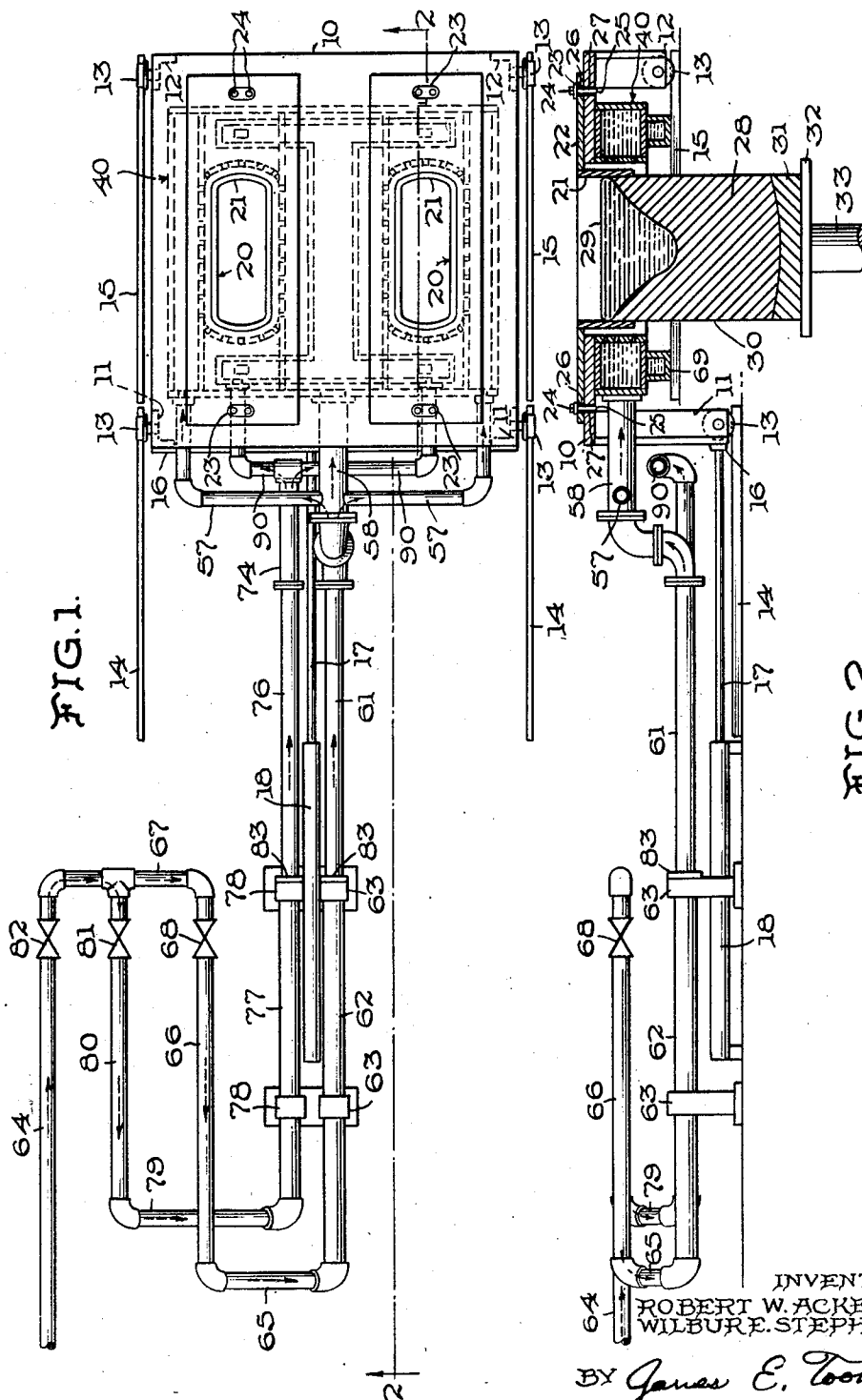
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2,789,328

APPARATUS FOR CASTING OF METALS

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2 Sheets-Sheet 1



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2 Sheets-Sheet 2

FIG. 3.

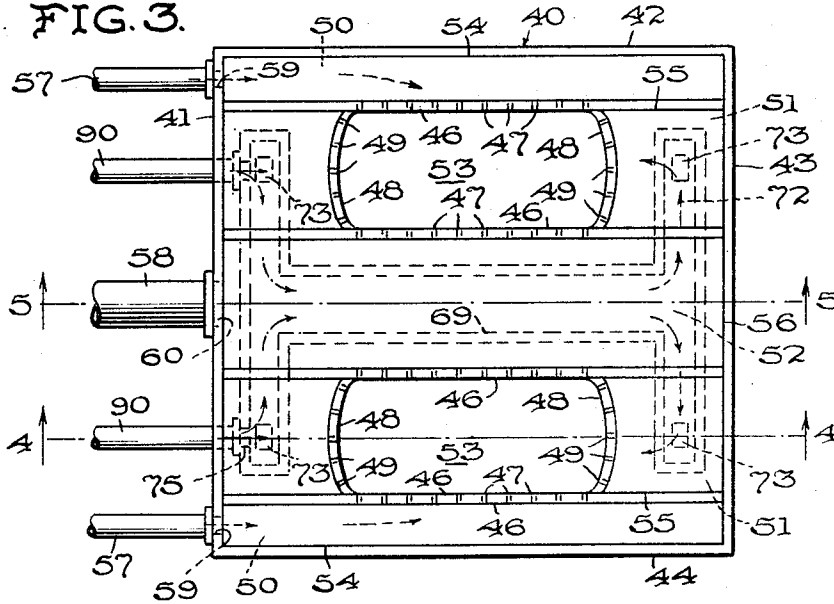


FIG. 4.

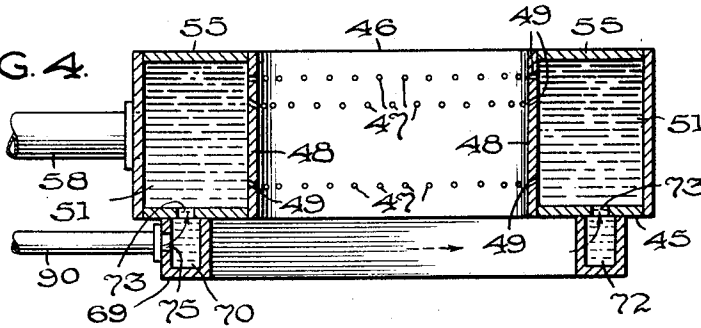
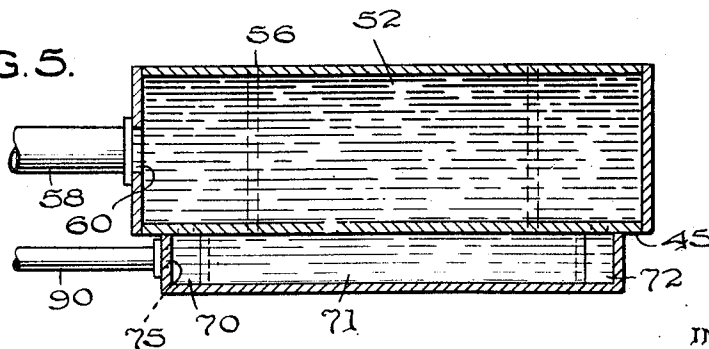


FIG. 5.



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APPARATUS FOR CASTING OF METALS

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This invention relates to the casting of metals. More particularly, this invention relates to apparatus for controlling the cooling of continuously cast ingots, billets and the like wherein the cross-sectional configuration of the casting is such, e. g. rectangular, square, or other angular shape, as to possess portions, e. g. corners, edges, etc., which normally are subjected to a more rapid rate of heat abstraction due to the greater casting surface area presented thereby as distinguished from portions of the casting located between such corners, edges, etc.

In the continuous casting of metals, including light metals such as aluminum and magnesium and alloys wherein these metals predominate, it is common practice to feed molten metal into one end of an open-ended mold wherein the molten metal is at least partially cooled therein to form an outer shell of solidified metal. The casting is continuously withdrawn by any suitable means from the opposite end of the mold while at the same time a supply of fluid coolant, e. g. water, is applied continuously to the casting as it emerges from the mold. The term "continuous" casting referred to herein is intended to include casting procedures which may be of a strictly continuous nature (in which the casting is cut to length without interruption of the casting procedure) or where the casting is of a semi-continuous nature; i. e. a casting of desired length may be cast, the flow of metal stopped, the casting removed and the procedure commenced anew.

In the casting of light metals, e. g. aluminum and aluminum alloys, one method and apparatus commonly used is that disclosed in the Ennor Patent No. 2,301,027 wherein the cooling is accomplished by means of a water spray directed around the periphery of the mold by spray means such as spray pipes or a spray box. Water jets impinge upon the outer surface of the mold and the embryo casting as it emerges from the mold. The amount of water applied is uniform about the periphery of the mold and casting. Although Ennor utilizes spray means for accomplishing cooling of the mold, other well known means may be used such as a cooling jacket which surrounds, and may form a part of, the mold. In such case, the coolant may not ultimately flow down onto the embryo casting and add to the coolant applied directly to the casting and it may be necessary to increase the volume of coolant applied directly to the casting.

While the application of uniform amounts of coolant directly to the embryo casting immediately upon emergence from the mold has served to promote rapid solidification of the metal and to improve metallurgical quality considerably, it has been found that in the casting of ingots, billets, or the like in shapes wherein the cross-sectional configuration is angular, e. g. rectangular, square, etc., those portions of the casting which present a greater surface area for heat abstraction per unit amount of metal, e. g. corners, edges, etc., cool at a faster rate than the remaining portions of the casting. This resultant non-uniform cooling or chilling of the casting may lead to one or more defects such as edge splits, corner cracks and bottom splits. Castings having a relatively large cross

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section are particularly susceptible to the occurrence of such defects due to non-uniform cooling.

Accordingly, it is the primary purpose and object of this invention to provide an improved apparatus for the continuous casting of metals. Another object of the invention is to provide an improved apparatus for accomplishing uniform cooling of ingots, billets, and the like of angular shape in the continuous casting thereof. A further object of the invention is to provide an improved apparatus for the continuous casting of ingots, billets and the like, particularly of light metals, of angular cross-sectional configurations, e. g. rectangular, square, etc. Further objects and advantages of the invention will become apparent from the following description of the invention.

Generally, the method of the invention consists in cooling the mold and emerging casting in a continuous casting process such that those portions of the casting, and complementary mold portions, which are normally subjected to a greater rate of heat abstraction, based on the surface area of the portion subjected to contact by coolant, e. g. corners, edges, etc., have less coolant applied thereto relative to the remaining portions of the casting, e. g. portions or points spaced from such corners, edges, etc. Such method of cooling application has given rise to a more uniform cooling of the casting around the entire periphery, and inwardly thereof, with the result of substantially reducing the occurrence of defects as hereinbefore enumerated. The apparatus of the invention for performing the method generally comprises a differential spray means for controlled application of coolant to the various portions of the casting surface. The spray means is composed of a plurality of spray chambers adapted to surround the entire periphery of the casting and adapted to contain coolant therein and discharge coolant therefrom onto the casting through a plurality of openings provided in each chamber. Provision is made for independent control of the pressure of the coolant in each chamber such that varying amounts of coolant can be applied to different portions of the casting surface, as desired.

The invention will be further described in the following detailed description of the accompanying drawings, wherein:

Figure 1 is a plan view of a presently preferred form of apparatus as applied in the casting of ingots of substantially rectangular cross-section;

Figure 2 is a side elevation, partly in section with parts removed for purpose of clarity, of the apparatus shown in Figure 1 and taken along line 2—2 of Figure 1;

Figure 3 is an enlarged plan view of the spray means shown in Figures 1 and 2 and more clearly shows the individual coolant containing chambers and means for supplying coolant thereto;

Figure 4 is a sectional view of the spray means taken along the line 4—4 of Figure 3, and

Figure 5 is a sectional view of the spray means taken along the line 5—5 of Figure 3.

With reference to Figures 1 and 2, plate member 10, which supports mold assembly 20 and spray means 40, is provided with legs 11, 11 and 12, 12. Although legs 12, 12 are shown as being shorter than legs 11, 11, the invention is not limited thereby. All of the legs could be the same length, if desired. The leg lengths, as shown, are preferred in that the amount of excavation to house the complete casting station is reduced.

At the bottom of each leg is provided a roller 13. Plate member 10, legs 11, 11 and 12, 12 and rollers 13 in effect provide a carriage for the mold and spray assembly. The rollers on legs 11, 11 are adapted to be in rolling contact with rails 14 and the rollers on legs 12, 12 are adapted to be in rolling contact with rails 15. A bar 16 is affixed at each end to the lower portion of legs 11, 11 and to bar 16

is affixed the outer end of piston rod 17 of a suitable hydraulic cylinder 18. The rollers 13, rails 14, 15 and hydraulic means 17, 18 are adapted to move the spray and mold assembly out of casting position, when desired, as will be described hereinafter.

The mold assembly 20 comprises an open-ended mold 21 and a supporting plate 22 to which the mold is suitably affixed, as by bolting or welding. Suitable means are provided for facilitating proper alignment of the mold with plate member 10 and spray means 40. One such means may comprise a member 23 provided at each end of plate 22. Member 23 is provided with a hole (not shown) at each end thereof adapted to receive therein the threaded portion of bolts 24 which are threaded into openings (not shown) provided in plate 22 for rigidly affixing member 23 to plate 22. Intermediate the ends of member 23 is a downwardly projecting pin 25 which passes through an opening 26 provided in plate 22. An aligned opening 27 is provided in plate member 10 for each opening 26 and which is adapted to receive pin 25. It will thus be seen that in assembling the molds with plate member 10 it is merely necessary to fit pins 25 into openings 27 in plate member 10.

Within the mold 21 and extending therebelow is an embryo casting 28 comprising a pool of molten metal 29 and solidified casting 30, the molten metal pool extending downwardly and forming a liquid crater or core within the casting. Molten metal is continuously poured into the mold by any of the means commonly used. The solidified portion of the casting rests upon a suitable bottom block 31 which block in turn rests upon a platform 32 against which bears the hydraulic piston rod 33.

The means of the invention for cooling the mold 21 and casting 28 comprises the spray box assembly 40. With particular reference to Figures 3, 4 and 5, it will be seen that the spray box generally comprises a receptacle made up of side members 41, 42, 43, and 44, which provide a frame means, and bottom member 45. Extending across the receptacle and running from top to bottom thereof are a plurality of partitions 46. The central portion of each partition 46, which is adapted to be adjacent a long side of a mold 21, is provided with a plurality of openings or spray holes 47 for exit of coolant. Extending between partitions 46 are a plurality of partitions 48, each of which is adapted to be adjacent an edge or short side of a mold 21. Partitions 48 are provided with a plurality of spray holes or openings 49 for exit of coolant. It will be seen that the partitions 46 and 48, together with sides 41, 42, 43, and 44 and bottom 45 define a plurality of chambers 50, 51 and 52, and also define openings 53 adapted to receive the molds 21 therein, the openings 53 being slightly larger in dimension than the external dimensions of molds 21. The chambers 50, 51 and 52 are enclosed by provision of top members 54, 55 and 56, respectively.

Means are provided for maintaining separate control of the amount of coolant applied to the long and short sides of the mold 21 and to the faces and edges of the embryo casting emerging therefrom. For purposes of describing this embodiment of the invention, as applied to rectangular or "sheet" ingots, the term "edges," as used herein, is defined as the relatively narrow longitudinally extending surfaces of the ingot as distinguished from the relatively wide ingot faces. The term "corner," as used herein, as defined as the point or place which joins an ingot edge to an ingot face.

Chambers 50 and 52 are those which contain the coolant for application to the long sides of the molds and ingot faces through spray holes or openings 47. To supply coolant to chambers 50 there are provided branch pipes 57 which connect to pipe 58. A suitable opening 59 is provided in the side 41 for passage of coolant from pipe 57 to chamber 50. For supplying coolant to chamber 52 pipe 58 is connected to side 41 and opening 60 is provided in side 41 for entrance of coolant into chamber 52. Pipe 58 is connected by suitable couplings to pipe 61 which is

adapted to slide into stationary pipe 62. Pipe 62 is rigidly supported by suitable clamps 63 which can be suitably mounted on the floor. Pipe 62 is connected to the main coolant supply pipe 64 by means of pipes 65, 66, and 67. In pipe 66 there is provided a suitable valve 68 for controlling the rate of flow of coolant into chambers 50 and 52 and, consequently, the amount of coolant being sprayed on the long sides of the mold and embryo ingot faces through spray holes 47.

Chambers 51 are those which contain the coolant for application to the short sides of the mold and ingot edges through spray holes or openings 49. To supply coolant to these chambers there is provided an H-shaped, open-top receptacle 69 which is suitably affixed as by welding, to the bottom 45 of the main receptacle, thereby providing chambers 70, 71 and 72. At each end of chambers 70 and 72 there is provided an opening 73 such that chambers 70 and 72 are in open communication with chambers 51. To supply coolant to chambers 51 there are provided branch pipes 90 which connect to pipe 74. A suitable opening 75 is provided in side 41 for passage of coolant from pipes 90 into chambers 51. Pipe 74 is connected by suitable couplings to pipe 76 which is adapted to slide into stationary pipe 77. Pipe 77 is rigidly supported by suitable clamps 78 which can be suitably mounted on the floor. Pipe 77 is connected to the main coolant supply pipe 64 by means of pipes 79 and 80. In pipe 80 there is provided a suitable valve 81 for controlling the rate of flow of coolant into chambers 51 and, consequently, the amount of coolant being sprayed on the short sides of the mold and embryo ingot edges through spray holes 49.

The main pipe 64 is provided with a suitable off-and-on valve 82 so that once the desired setting has been made to valves 68 and 81 for a given set of casting conditions the controlled coolant issuing from the spray box may be turned on or off, as desired, by merely actuating valve 82 and without necessitating readjustment of valves 68 and 81.

As mentioned hereinbefore, means are provided for moving the spray box and mold shell assembly out of casting position and these means included the use of legs 11 and 12, rollers 13 provided at the bottom of the legs, rails 14 and 15 upon which rollers 13 are adapted to move, a bar 16 affixed to legs 11, and a suitable hydraulic cylinder 18, the piston rod 17 of which is connected to bar 16. When it is desired to move the spray box and mold assembly out of operative position over the casting pit to permit the removal of previously formed castings, hydraulic cylinder 18 is actuated to cause piston rod 17 to move into the cylinder. Due to the fact that the outer end of the piston rod is affixed to bar 16, which in turn is affixed to legs 11 of the carriage for the spray box and mold assembly, the carriage and entire assembly will be moved to the left on rails 14 and 15 a sufficient distance to permit lifting means to pick up the castings. As the assembly moves to the left pipes 61 and 76 slide into stationary pipes 62 and 77, respectively. Suitable packing glands 83 are provided to prevent leakage of coolant at the sliding connections.

In operation of the instant apparatus, the hydraulic cylinder is actuated to move piston rod 17 to the right and thus move the carriage and spray box and mold assembly into operative position over the casting pit. The bottom block 31 is then raised by means of piston rod 33 into operative position at the bottom of mold 21. Thereafter, valve 82 in main line 64 is opened to permit coolant to pass through preset valves 68 and 81 and from there into the various chambers in the spray box assembly, as indicated by the arrows. After the coolant sprays are issuing from spray holes 47 and 49 molten metal is poured into the mold to form a molten metal head of desired height and then the piston rod 33 is slowly lowered at a predetermined rate. Due to the differential

spray box means, a predetermined amount of coolant per unit time and ingot area can be continuously applied to the long sides of the mold and ingot faces and a different predetermined amount applied to the short sides of the mold and ingot edges. Whenever it is desired to change the amount of coolant issuing from one set of chambers or the other this can be readily accomplished by adjustment of valve 68 and/or valve 81. When an ingot of desired length has been cast valve 82 in main line 64 will be turned to "off" position and the spray box and mold assembly moved out of operative position as described hereinabove.

Although the apparatus described above includes the use of two molds, it will be obvious that the invention is applicable to the casting of but a single ingot at a time or more than two ingots at a time by merely providing the necessary partitions and coolant chambers to provide for differential coolant application to the various ingot surfaces. It will also be obvious that rather than use a single spray box which provides coolant for both the mold and embryo casting a separate cooling means may be used for cooling the mold in the form of another spray box assembly or in the form of an enclosed system or coolant jacket where the differential cooling is accomplished by also controlling the rate of coolant flow into and out of the various chambers in the cooling jacket which could be integral with the mold. Additionally, the spray chambers could be in the form of pipe sections provided with the necessary spray openings.

The following is a specific illustrative example of the present invention as applied to the casting of 7075 aluminum alloy in 11" x 44" size ingots. The chemical composition of the alloy cast was 5.75% zinc, 2.60% magnesium, 1.65% copper, .30% iron, .20% chromium, .15% silicon, .10% manganese, balance aluminum.

Each mold was constructed of sheet aluminum alloy (1100) $\frac{1}{4}$ " thick. It was of substantially rectangular cross-section having rounded ends (short sides) and having a slight outward curvature on the long sides. The depth (vertical) was $7\frac{1}{2}$ ", length, (inside dimension) $44\frac{1}{4}$ " and width (inside dimension) $11\frac{1}{4}$ " adjacent the ends and running up to $11\frac{3}{4}$ " at the center. Radius of curvature of the ends was 10". Two such molds were used.

The spray box assembly was constructed of sheet steel. The annular space between the interior surface of the spray box and the mold was $\frac{3}{4}$ ". The upper row of spray holes 47 and 49 were $\frac{3}{32}$ " diameter, centered $\frac{1}{2}$ " apart, and directed horizontally. The next lower row of spray holes 47 and 49 were $\frac{3}{32}$ " diameter, centered $\frac{1}{2}$ " apart, directed downwardly at an angle of 20° from the horizontal, staggered with respect to the uppermost row of spray holes, and being located $\frac{3}{8}$ " therebelow. Lowermost row of spray holes 47 and 49 were $\frac{3}{32}$ " diameter, centered $\frac{1}{4}$ " apart, directed downwardly at an angle of 30° from the horizontal, and being located $\frac{3}{4}$ " below the uppermost row of spray holes.

The valves 68 and 81 were so adjusted that the coolant (water) issued from the spray holes 47 at the rate of 1.75 gallons per minute per linear inch of ingot width or mold surface and the coolant (water) issued from the spray holes 49 at the rate of 1 gallon per minute per linear inch of ingot thickness or mold surface.

The temperature of the molten metal delivered to the mold was about 1280° F. When the molten metal in the mold reached a level of about 2" above the bottom of the mold, lowering of the mold bottom block was commenced and continued at a rate of $2\frac{3}{4}$ " per minute. The molten metal level was gradually increased to a height of about $4\frac{1}{2}$ " above the bottom of the mold and then held at this level. After a standard length of ingot had been cast (about 106") pouring ceased and the ingot was lowered out of the mold. The coolant was turned off by turning valve 82 to "off", the spray box and mold as-

sembly moved out of operating position by actuation of hydraulic cylinder 18, and the ingots lifted from the casting pit by an overhead crane. The resultant ingots were free of cracks and splits.

By practice of the present invention involving the use of the different cooling apparatus and method as described herein, it has been possible to secure more uniform cooling of castings having an angular cross-section or shape and thereby reduce the occurrence of defects such as splits and cracks.

While the invention has been described with specific reference to casting ingots of rectangular or substantially rectangular cross-section, it is to be understood that it has application to the casting of metal into various angular cross-sectional shapes, e. g. square, etc. In the case of a square casting a separately controlled set of spray box chambers would be provided for the corners of the casting and another set of spray box chambers provided for the surfaces of the casting connecting the corners. While water has been referred to hereinabove as the coolant employed, other fluid coolants can be used so long as the requisite cooling effect is obtained. It is also to be noted that while the invention has been specifically illustrated with regard to the casting of aluminum alloys, it can be advantageously applied to the casting of other metals where similar problems exist.

It will be obvious that various modifications and alterations may be made in this invention without departing from the spirit and scope thereof and it is not to be taken as limited except by the appended claims herein.

What is claimed is:

1. In apparatus for the continuous casting of metal ingots of substantially rectangular cross-section comprising a mold, a spray box encircling said mold and adapted to spray a fluid coolant upon said mold and embryo ingot emerging therefrom, the improvement in spray box means comprising a horizontally disposed substantially rectangular frame means encircling the mold, a plurality of spaced partition means extending across and through the vertical extent of said frame and affixed thereto, the central portion of each partition adapted to be adjacent a long side of the mold and respective ingot face and being provided with a plurality of openings therein, a plurality of shorter partitions extending between and affixed to said first-mentioned partitions and extending through the vertical extent thereof, said second-mentioned partitions being spaced apart and inwardly from said frame, each of said second-mentioned partitions adapted to be adjacent a short side of the mold and respective ingot edge and being provided with a plurality of openings therein, the portions of said partitions being provided with openings therein defining a space wherein said mold is disposed, top and bottom means affixed to said frame and partitions and which, with said frame and partitions, define a plurality of spray chambers surrounding said space, means for providing said chambers with coolant comprising common conduit means connected in coolant flow relationship with the chambers for the short sides of the mold and respective ingot edges and common conduit means connected in coolant flow relationship with the chambers for the long sides of the mold and respective ingot faces, each of said common conduit means being provided with valve means for regulating the flow of coolant issuing from the respective spray chambers and for establishing different rates of coolant flow from adjacent chambers.

2. Apparatus according to claim 1 wherein said means for providing said chambers adjacent the short sides of the mold and respective ingot edges with coolant comprises a receptacle affixed to said bottom means and being in coolant flow relationship with said chambers and a conduit affixed to said receptacle and being in coolant flow relationship therewith.

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