Dec. 2, 1958 F. W. VAUGHN ET AL 2,862,265

CONTINUOUS CASTING MOLD

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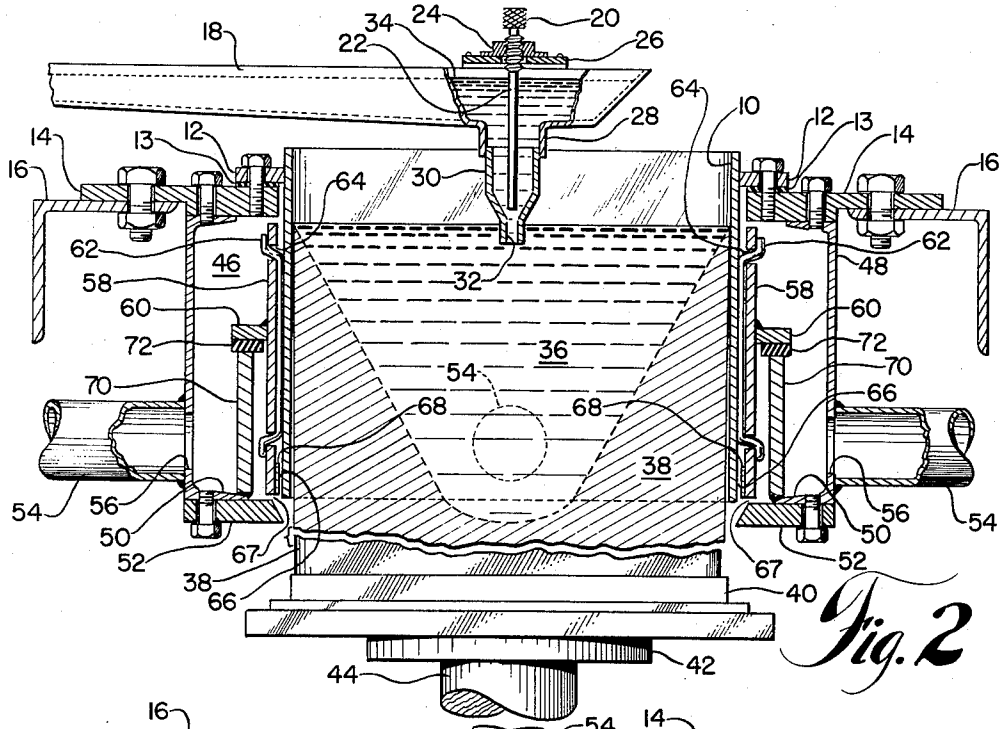


Fig. 2

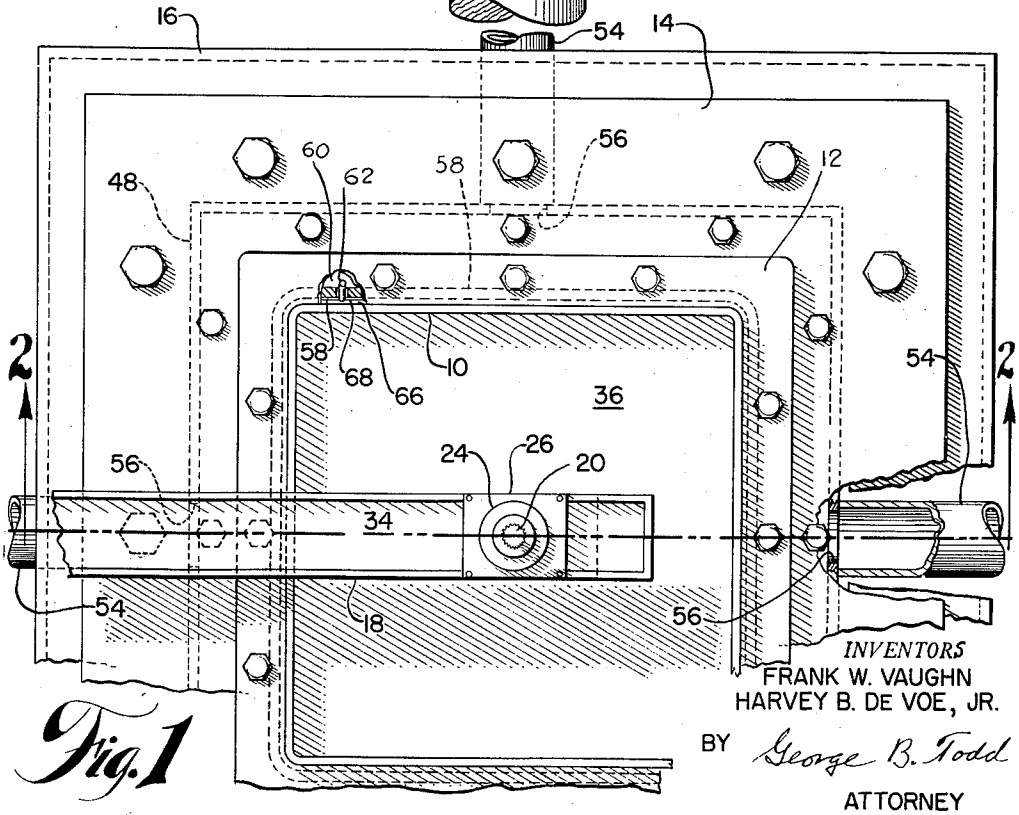


Fig. 1

INVENTORS
FRANK W. VAUGHN
HARVEY B. DE VOE, JR.
BY George B. Todd
ATTORNEY

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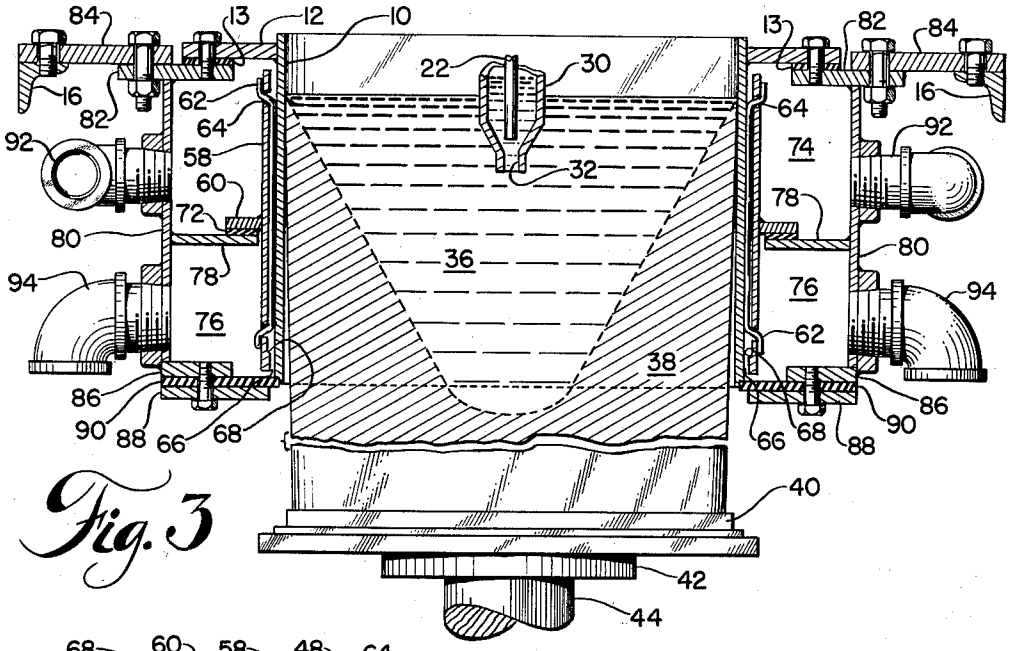


Fig. 3

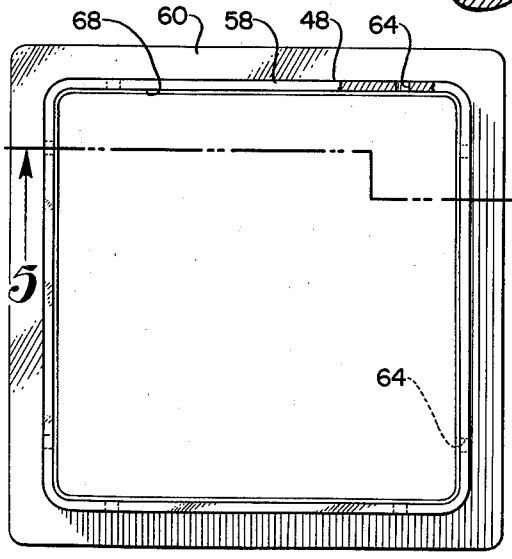


Fig. 4

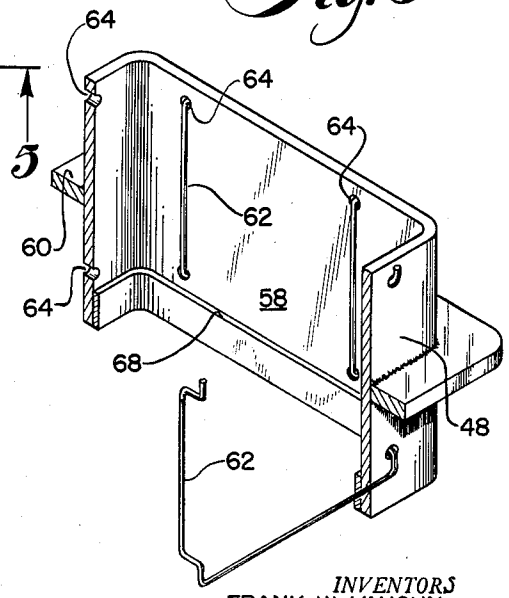


Fig. 5

INVENTORS
FRANK W. VAUGHN
HARVEY B. DE VOE, JR.

BY George B. Todd

ATTORNEY

United States Patent Office 2,862,265
Patented Dec. 2, 1958

2,862,265

CONTINUOUS CASTING MOLD

Frank W. Vaughn, Alexandria, Va., and Harvey B. De Voe, Jr., Massena, N. Y., assignors to Aluminum Company of America, Pittsburgh, Pa., a corporation of Pennsylvania

Application December 10, 1956, Serial No. 627,379

5 Claims. (Cl. 22—57.2)

This invention relates to the casting of ingots in bottomless molds by the continuous casting process and it more particularly relates to a device for directing cooling liquid over the surface of the mold.

In the continuous casting process the molten metal is fed into the top of an open end mold and solidified metal is withdrawn from the bottom of the mold. To secure a rapid solidification of the metal, the mold must be drastically chilled and this is generally accomplished by flooding the external surface of the mold with a liquid coolant such as water. To facilitate the rapid transfer of heat from the freezing metal to the coolant, the mold is usually made with a thin wall and a good heat conductive material is employed such as copper or aluminum or alloys thereof. Because the mold has thin walls, it is convenient to refer to it as being a mold shell. The mold shell and descending ingot may be chilled by projecting a copious amount of water against the shell over that portion of the external surface which corresponds to the inside of the mold in contact with or in close proximity to molten metal and the forming ingot. Where this means of cooling is employed, it is a common practice to allow the water to run down from the mold onto the surface of the ingot emerging therefrom. In place of such an open cooling system, the mold shell may be surrounded by a chamber through which the coolant is circulated. One modification of the cooling chamber arrangement has been proposed which consists of providing openings in the bottom of the chamber whereby a portion of the circulated coolant drops upon the ingot as it descends from the mold. In the foregoing mold cooling practices a relatively large volume of coolant is employed at a relatively low pressure.

In operation it has been found that where perforated pipes or nozzles are used, the openings occasionally become plugged with a resultant non-uniform cooling of the mold and, therefore, with adverse effect upon the ingot formed therein. In the case of jacketed molds, the transfer of heat from mold shell to the liquid coolant is sometimes impeded because of the accmulation of gas or vapor bubbles on the surface of the mold and the failure of the stream of water passing through the cooling jacket to sweep away the bubbles. An increase in the pressure and volume of the coolant supplied to the jackets does not necessarily overcome that condition or produce a corresponding increase in the chilling effect because of increased difficulty in obtaining a uniform distribution of the incoming coolant over the mold surface. Moreover, the use of a larger volume of coolant requires that additional means must be provided for handling the coolant discharged from the cooling chamber.

Our invention is directed to increasing the chilling efficiency of the coolant and creating conditions favorable to a higher rate of withdrawal of the ingot from the mold. One of the objects of our invention is to provide a device in association with a jacketed continuous casting mold which directs the coolant over the mold surface. Another object is to provide means within the cooling chamber surrounding a continuous casting mold to increase the flow of coolant over the mold surface without loss in uniformity of cooling effect. Still another object is to provide a device in the cooling chamber surrounding a continuous casting mold which is self-adjusting within limits and yet maintains a minimum width of passageway for the coolant to pass over the mold surface.

We have discovered that the foregoing objects and others can be achieved by providing a sleeve within the cooling chamber surrounding the mold shell which is spaced but a short distance from the shell and which extends over at least that portion of the mold shell wherein the molten metal and the freezing ingot are located. Space is left at the top and bottom of the sleeve within the chamber for the coolant to enter and leave the narrow passageway between the sleeve and mold shell but all of the coolant entering the chamber must go through the passageway before it is discharged from the chamber. By means of this arrangement it has been found that a relatively high velocity sheath of coolant is produced which passes over the mold surface. The high velocity is obtained without increasing the pressure of the coolant supplied to the chamber. As a matter of fact, a relatively low pressure supply can be conveniently employed and still secure the necessary rapid flow of coolant over the surface of the mold shell. The rapidly moving stream of coolant effectively chills the mold and prevents the accumulation of any gas or vapor bubbles on the surface of the mold. Also, by reason of the more effective chilling of the mold, it is sometimes possible to increase the rate at which the ingot is withdrawn from the mold. We have found that the rapidly moving stream of coolant provides a uniform chilling around the entire periphery of the mold and that the sleeve prevents any direct impingement of the coolant upon the mold surface as it enters the cooling chamber. The sleeve is not rigidly attached to either the mold or the surrounding chamber but is held in place by hydraulic pressure within the chamber and separate elongated spacer elements between the sleeve and the mold which maintain a passageway of predetermined minimum width. The self adjustment of the sleeve within the cooling chamber eliminates a tedious and painstaking positioning which would be necessary if the sleeve were rigidly supported and it also permits a certain degree of response to any change in shape or alignment of the mold such as occasioned by warpage of the mold.

The above features and others will become clearer through reference to the accompanying figures wherein

Fig. 1 is a top plan view of a continuous casting unit including a metal transfer trough;

Fig. 2 is a side elevation, partially in section, taken on line 2—2 of Fig. 1;

Fig. 3 is a side elevation of a modification of the apparatus shown in Fig. 2;

Fig. 4 is a top view of the sleeve element seen in Fig 2, and

Fig. 5 is a vertical section of Fig. 4 taken on line 5—5.

Referring to Fig. 1, the mold shell **10** is supported on table **14** by the flange **12** attached to the mold. The table in turn is connected to the main frame **16**. Molten metal **34** is delivered from a source, not shown, to the transfer trough **18** from which it descends into the mold and forms pool **36**. Control of the metal flow is effected by a manually operated valve supported by threaded block **24** which in turn is mounted on bracket **26**, the handle

of the valve appearing at **20**. The vertical wall of the water chamber below the table is shown in dotted lines at **48** together with pipes **54** which supply water to the chamber. Sleeve **58**, described below, surrounds the mold **10** and is spaced therefrom by wires **62**.

More details of the apparatus are apparent in the sectional view in Fig. 2. The transfer trough **18**, carrying molten metal **34**, is provided with a downspout flange **28** and a nipple **30** secured thereto having a bottom discharge port **32**. The metal flow control valve consists of stem **22** having a threaded portion which engages complementary threads in supporting block **24** mounted on bracket **26**. By turning the valve stem the lower end is adjusted with respect to the discharge port thus controlling the volume of metal entering the mold. A pool of molten metal **36** is maintained at a susbtantially constant level once the pouring operation has commenced. The metal freezes inwardly from the mold wall forming a crater-like cavity and eventually the completely solidified ingot **38**. The ingot rests upon mold bottom **40** carried on platform **42** that is raised and lowered by the hydraulic ram arm **44**. The ram is situated in a pit, not shown, into which the ingot descends and from which it is hoisted upon completion of the casting operation.

The water chamber **46**, which completely surrounds the mold shell and extends over substantially the entire height of the mold, has an outer vertical wall **48**, conveniently made of a channel member, and a bottom portion **50**. Bolted to the bottom **50** is a deflector plate **52** having a bevelled edge for directing the water dropping from the water chamber against the ingot descending from the mold. To prevent escape of water from the top of the chamber, a gasket **13** is provided between flange **12** and table **14**. Water is supplied to the chamber through pipes **54** and openings **56** in the channel member **48**.

Within the chamber and close to the mold shell **10** is sleeve **58** which extends around the entire periphery of the mold shell and is opposite that portion of the shell which holds the liquid and the solid metal. In this manner this portion of the mold shell is effectively chilled through the functioning of the sleeve as described below. The sleeve is supported upon an inner chamber wall member **70**, which is shorter than the outer wall member **48**, through welded sleeve flange **60** intermediate the top and bottom of the sleeve with gasket **72** positioned between the flange and the upper edge of member **70** to substantially eliminate leakage of any water from the water chamber. The inner wall member **70**, which may be in the form of a narrow plate section, is welded to the base of the water chamber thus forming a chamber having integral side walls and base. In addition to serving as a support for the sleeve, the member **70** also acts as a baffle to the incoming stream of water from the pipes. In mounting the member **70** on chamber base **50**, sufficient space should be left between it and the sleeve to accommodate the bent ends of the spacer elements and not interfere with the lateral movement or adjustment of the sleeve.

To provide the proper spacing of sleeve from the mold shell separate elonagted spacer elements, such as wires **62**, are employed. In the case of a rectangular mold at least two wires should be placed on each side but for circular or polygonally shaped molds enough wires or spacer elements must be used to maintain a minimum predetermined spacing between the mold and sleeve. The vertically positioned spacer wires **62** are initially bent into the shape of a flat U, the ends passed through holes **64** near the top and bottom of the sleeve and then bent at right angles to hold the spacer element in place. If desired the spacer elements may consist of a single wire as shown in Fig. 5, running from one vertical element to the other. It will be appreciated that other shapes of spacer elements may be employed providing they are relatively thin and in contact with such a small area of

the mold as not to interfere with chilling of the mold shell. It is obvious that the axis of the spacing elements should be parallel to the stream of coolant and offer a minimum obstruction to the flow of the liquid. The shape of the sleeve in Fig. 2 and the location of the wire holes are seen more clearly in Figs. 4 and 5. The sleeve **58** is spaced from the mold over at least a major portion of its height by a distance approximately equal to the diameter of the wire thereby providing a thin substantially uniform pasageway around the entire mold shell. Although the spacing elements may be continuous bodies as illustrated they may also be in sections, one directly above the other, or in a staggered arrangement. The length of the spacing elements and their arrangement is a matter of choice depending upon the size of the sleeve.

Under some conditions it is desirable to reduce the rate of flow of coolant through the passageway between the sleeve and mold shell. This can be accomplished by providing a relatively narrow band at the base of the sleeve as indicated at **68**. The band may be of any thickness as long as the passageway between the sleeve and the mold is of sufficient width to permit a continuous flow of liquid and the rate of flow above the constricted region is not reduced to such a level as to impair chilling of the mold shell. A reduction in width of the passageway by as much as 50% can be effected without loss in cooling efficiency above the constriction.

The sleeve **58** should be terminated short of the bottom of the cooling chamber and the bottom edge of the mold shell thereby allowing the coolant to pass under the lower edge of the sleeve. In the arrangement in Fig. 2 the space **67** between the lower edge of the sleeve and the deflector plate **52** also serves to permit escape of any water which may accumulate between the sleeve and inner chamber wall **70**. It is important in any case that the sleeve extend almost to the bottom edge of the mold shell to insure cooling of the shell with the rapidly flowing sheath of coolant.

The sleeve is maintained in sealing relationship to the gasket **72** and inner wall member **70** by the exertion of hydraulic pressure against the sleeve and the supporting flange **60**. Moreover, the hydraulic pressure permits a degree of self-adjustment of the sleeve that would not occur in a rigid connection between the flange **60** and wall **70**.

In the modification of the apparatus shown in Fig. 3, the water is not discharged from the cooling chamber onto the ingot, instead it leaves the chamber through a pipe. In this arrangement of mold and cooling chamber, the mold is supported by flange **12** which is bolted to top flange **82** rigidly attached to the outer vertical chamber wall member **80**. A gasket **13** between the two flanges prevents any leakage of water. The top flange **82** is also bolted to the mold table **14** and the latter is supported on a main frame **16**. The cooling chamber is divided into two parts, an upper portion **74** and a lower portion **76**, the two being separated by a horizontal wall **78** and the supporting flange **60** attached to the sleeve **58**. The bottom of the lower portion is formed from integrally attached flange **86** and bottom plate **88** bolted thereto with gasket **90** between the two members which extends beyond them to engage the lower edge of the mold shell and thus establish a water tight seal. A rigid connection can be made between the bottom of the chamber and the lower edge of the mold but this makes assembly and disassembly of the mold unit more difficult and is therefore less satisfactory from the standpoint of maintenance. The water is supplied to the upper portion through pipe **92** and it is discharged from the lower portion of the chamber through pipe **94**. A gasket **72** is provided between flange **60** and dividing wall **78** to seal the upper portion of the chamber from the lower portion and thus force all of the water entering the upper portion **74** to pass through the narrow passageway between the sleeve and the mold before

leaving the lower portion **76**. The sleeve is spaced from the mold with wires as described above and a raised rim portion **68** may be provided at the bottom of the sleeve. Other kinds of spacing elements may be employed and they may be in sections arranged as desired as has been mentioned above.

It is a characteristic of our cooling system that all of the coolant, except for leakage losses, enters a chamber and is compelled to pass through the narrow space between the sleeve and mold shell before being discharged. Moreover, the coolant need not be under a high pressure, it having been found that a pressure within the chamber of less than 1 lb. per sq. in. is sufficient to provide the desired flow. The pressure in any case must be positive, that is, above atmospheric pressure.

It will be appreciated that although the mold described above is square, the invention is applicable to rectangular, polygonal and circular molds. Also, the length of the mold may vary but generally those of the short type such as employed in the direct chilling process are preferred.

As an example of a suitable mold and cooling chamber of the type shown in Figs. 1 and 2 the mold may consist of a ¼" thick plate of aluminum alloy and may be approximately 12" square and have a height of approximately 7½". The sleeve element may likewise consist of a ¼" thick aluminum alloy plate and have an aluminum alloy flange welded thereto intermediate the top and bottom of the sleeve. The spacer wires employed may be approximately ⅛" in diameter so that the passageway between the sleeve and the mold shell over the major portion of the sleeve height will be approximately ⅛" in width. The wires should be made of aluminum, preferably, to minimize corrosion. The raised band **68** may be approximately 1/16" in thickness and 1" in height thus reducing the width of the passageway to about 1/16". The cooling chamber adapted to serve the foregoing mold may be about 6" in height and about 2" in width. In the case of the mold and chamber seen in Fig. 3, the mold and chamber may be about 10" in height and the chamber approximately 3" in width.

To effect the desired cooling of the mold the water can be supplied at a rate of about 80 gallons per minute under a relatively low pressure of less than one lb. per sq. in. Within the ⅛" wide passageway between the sleeve and mold shell it will have a velocity of approximately 240 feet per minute at this pressure. However, at the reduced section of the passageway at the bottom of the sleeve the velocity will be increased to about 480 feet per minute. It is, therefore, evident that a high velocity stream of water effectively wipes the mold surface and removes any steam bubbles which might tend to develop. Under these conditions it has been possible to increase the rate of lowering the ingot by as much as 1" per minute over the normal lowering rate.

To cast a light metal ingot in the apparatus described above, the mold bottom **40** is moved up into the mold shell, the water chamber filled and circulation of water commenced. Molten metal is gradually fed to the mold and a pool of metal created which is maintained at substantially a constant level after the casting operation has started. The molten metal freezes from both the bottom and the sides of the mold cavity. When a sufficient amount of metal has frozen the mold bottom is lowered with the embryo ingot resting thereon. The pouring and chilling operations are continued until the desired length of ingot has been obtained whereupon they are stopped and the ingot removed. To secure a sound uniform ingot, the chilling of the mold walls must be uniform. The closely spaced sleeve described above accomplishes this result.

Although the apparatus has been described in connection with the casting of ingots it can also be used where a metal layer is to be cast upon a central core. Thus, a core in the form of an ingot or wrought article, of suitably smaller transverse dimensions than the mold may be passed through the mold and molten metal cast against it which when frozen provides the desired layer or cladding. The molten layer must be chilled in the same manner as an ingot to produce a sound uniform cast layer.

It will be appreciated that the size and shape of the ingot may vary, the larger ingots being lowered from the mold at a lower rate than ingots of relatively small cross section because of the greater amount of heat which must be extracted from the larger mass of molten used in forming the large ingots.

The apparatus for casting the molds can be used in casting many metals but it has proved to be most successful in casting the light metals, aluminum, magnesium and the alloys wherein these elements constitute the major portion of the alloy composition.

Having thus described our invention and certain embodiments thereof, we claim:

1. In a continuous casting mold unit, an open ended mold and means for cooling said mold, said means comprising a liquid coolant-containing chamber completely surrounding said mold and extending over substantially the entire length thereof, said chamber having inner and outer walls, the mold itself constituting at least a portion of the inner wall, means for supplying liquid coolant to said chamber and self adjusting means within said chamber for directing the coolant over the surface of the mold at a relatively high velocity, said coolant-directing means comprising a movable sleeve around the entire mold and parallel thereto, said sleeve being opposite at least that portion of the mold which contains the molten and solidified metal and of a length less than that of the cooling chamber, said sleeve also being supported intermediate the top and bottom thereof with freedom for limited lateral movement and spaced from the top and bottom of the chamber, and flexible separate spacing elements mounted at intervals around said sleeve on the side facing the mold, which elements when in contact with the mold define the minimum width of a narrow passageway between said sleeve and mold over at least the major length of the sleeve, said spacing elements consisting of thin elongated members detachable from the sleeve and mounted on said sleeve in a direction such that their axes are parallel to the direction of the flow of coolant through the passageway between the sleeve and mold, the upper end of said passageway being in communication with the upper portion of the coolant chamber whereby all of the coolant entering the chamber enters the passageway and is discharged therefrom after passage over the mold surface.

2. In a continuous casting mold unit, an open ended mold and means for cooling said mold, said means comprising a liquid coolant-containing chamber completely surrounding said mold and extending over substantially the entire length thereof, said chamber having inner and outer walls, the mold itself constituting at least a portion of the inner wall, means for supplying liquid coolant to said chamber and self adjusting means within said chamber for directing the coolant over the surface of the mold at a relatively high velocity, said coolant directing means comprising a movable sleeve around the entire mold and parallel thereto, said sleeve being opposite at least that portion of the mold which contains molten and solidified metal and of a length less than that of the cooling chamber, a peripheral flange integrally joined to said sleeve on the side facing the outer chamber wall, said flange being located intermediate the top and bottom of said sleeve, said flange resting upon and in compressive sealing relationship to a portion of the chamber wall extending into the chamber and toward said flange, said flange and sleeve being laterally movable with respect to the chamber wall extension, said flange in cooperation with said chamber

wall extension providing a complete substantially liquid-tight barrier to escape of coolant from the chamber, said sleeve having flexible separate spacing elements mounted at intervals around it on the side facing the mold which elements when in contact with the mold define the minimum width of a narrow passageway between the sleeve and the mold, said spacing elements consisting of thin elongated members detachable from the sleeve and mounted thereon in a direction such that their axes are parallel to the direction of the flow of coolant through the passageway between the sleeve and mold.

3. In a continuous casting mold unit, an open ended mold and means for cooling said mold, said means comprising a liquid coolant-containing chamber completely surrounding said mold and extending over substantially the entire length thereof, said chamber having inner and outer walls, the mold itself constituting at least a portion of the inner wall, means for supplying liquid coolant to said chamber and self adjusting means within said chamber for directing the coolant over the surface of the mold at a relatively high velocity, said coolant-directing means comprising a movable sleeve around the entire mold and parallel thereto, said sleeve being opposite at least that portion of the mold which contains the molten and solidified metal and of a length less than that of the cooling chamber, said sleeve also being supported intermediate the top and bottom thereof with freedom for limited lateral movement and spaced from the top and bottom of the chamber, and flexible separate spacing elements mounted at intervals around said sleeve on the side facing the mold, which elements when in contact with the mold define the minimum width of a narrow passageway between said sleeve and mold over at least the major length of the sleeve, said spacing elements consisting of thin elongated members detachable from the sleeve and mounted on said sleeve in a direction such that their axes are parallel to the direction of the flow of coolant through the passageway between the mold and sleeve, the portion of the sleeve below the spacing members being thicker and consisting of a band of uniform width and thickness on the side of the sleeve facing the mold, said band serving to reduce the width of the passageway and increasing the velocity of the coolant passing the band as compared to the velocity above the constricted region, the upper end of said passageway being in communication with the upper portion of the coolant chamber whereby all of the coolant entering the chamber enters the passageway and is discharged therefrom after passage over the mold surface.

4. In a continuous casting mold unit, an open ended mold and means for cooling said mold, said means comprising a liquid coolant-containing chamber completely surrounding said mold and extending over substantially the entire length thereof, said chamber having inner and outer walls, the mold itself constituting the inner wall, a vertical wall portion shorter than the outer wall intermediate the mold and outer wall, but parallel to said outer wall, means for supplying liquid coolant to said chamber and self adjusting means within said chamber for directing the coolant over the surface of the mold at a relatively high velocity, said coolant-directing means comprising a movable sleeve around the entire mold and parallel thereto, said sleeve being opposite at least that portion of the mold which contains liquid and solidified metal and of a length less than that of the cooling chamber, said sleeve having spacing elements mounted on the side facing the mold, said elements being mounted at intervals on the sleeve and when in contact with the mold define the minimum width of a narrow passageway between said sleeve and mold, said spacing elements consisting of thin elongated members detachable from the sleeve and mounted thereon in a direction such that their axes are parallel to the direction of the flow of coolant through the passageway between the sleeve and mold, said sleeve being supported by a peripheral flange integrally joined thereto on the side facing the outer chamber wall intermediate the top and bottom of the sleeve, said flange resting upon and in sealing relationship to the short vertical chamber wall intermediate the mold and outer chamber wall, with a yieldable sealing element between said flange and the top edge of the short vertical wall, said flange and said short wall serving as a barrier to the escape of coolant from the chamber, the portion of the sleeve below the peripheral flange being in contact with the coolant traversing the passageway and spaced from the said short vertical chamber wall, the passageway between the sleeve and mold terminating at the lower edge of the sleeve and the coolant being discharged therefrom and directed against the solidified metal body descending from the mold.

5. In a continuous casting mold unit, an open ended mold and means for cooling said mold, said means comprising a liquid coolant-containing chamber completely surrounding said mold and extending over substantially the entire length thereof, said chamber having inner and outer walls, the mold itself constituting the inner wall, said chamber being divided into upper and lower portions by a horizontal wall in cooperation with a flange supporting coolant directing means, means for supplying coolant to the upper portion of the chamber and means for receiving coolant discharged from the lower chamber portion, self adjusting means within both of said chambers for directing the coolant over the surface of the mold at a relatively high velocity, said coolant-directing means comprising a movable sleeve around the entire mold and parallel thereto, said sleeve being opposite at least that portion of the mold which contains liquid and solidified metal and of a length less than that of the cooling chamber, said sleeve having flexible separate spacing elements mounted thereon at intervals on the side facing the mold which when in contact with the mold define the minimum width of a narrow passageway between the sleeve and mold, said spacing elements consisting of thin elongated members detachable from the sleeve and mounted thereon in a direction such that their axes are parallel to the direction of the flow of coolant through the passageway between the sleeve and mold, said sleeve having a peripheral flange integrally joined thereto on the side facing the outer chamber wall and intermediate the top and bottom of the sleeve, said flange resting upon and in sealing relationsip to the horizontal wall dividing the cooling chamber into upper and lower portions, a yieldable sealing element being provided between said flange and said horizontal wall, the flange and horizontal wall together serving as a barrier to escape of coolant from the upper to the lower portions of the cooling chamber except through the passageway between the sleeve and mold, the passageway at both top and bottom being in communication, respectively, with the upper and lower portions of the cooling chamber whereby all of the coolant entering the upper portion of the chamber enters the passageway and the coolant discharged from the passageway is discharged into the lower portion of the cooling chamber.

References Cited in the file of this patent

UNITED STATES PATENTS

1,503,479	Coats	Aug. 5, 1924
2,187,720	Williams	Jan. 23, 1940
2,590,311	Harter et al.	Mar. 25, 1952
2,613,411	Rossi	Oct. 14, 1952

FOREIGN PATENTS

835,790	Germany	Apr. 3, 1952
932,085	Germany	Aug. 22, 1955