Nov. 28, 1967 A. JACKSON, JR 3,354,937

PROCESS AND APPARATUS FOR CONTINUOUS CASTING

Filed May 14, 1965

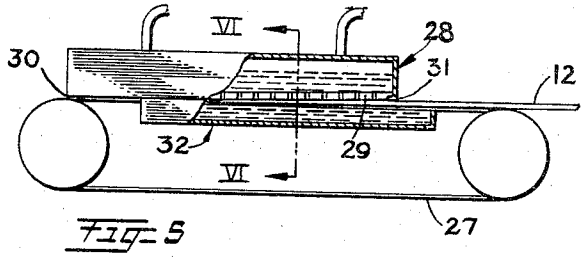


Fig. 5

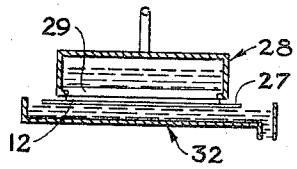


Fig. 6

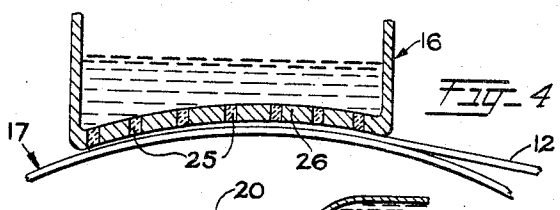


Fig. 4

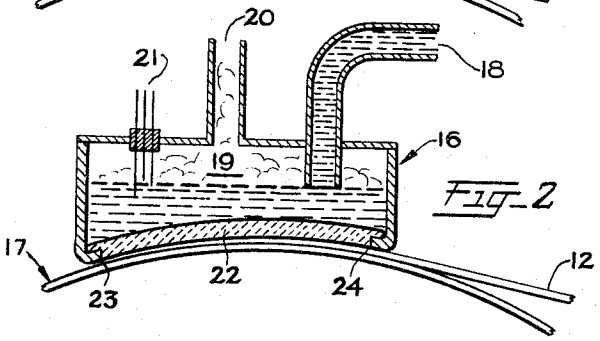


Fig. 2

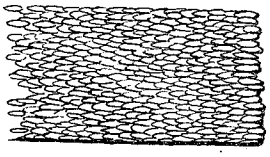


Fig. 3a

Fig. 3b

Fig. 3c

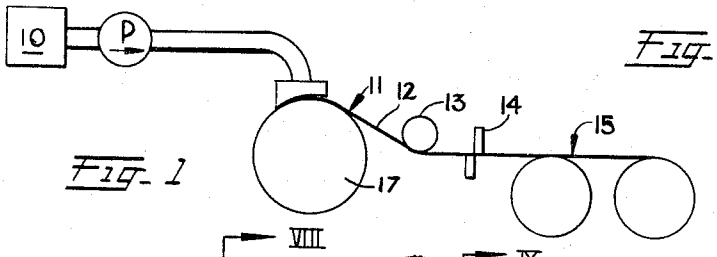


Fig. 1

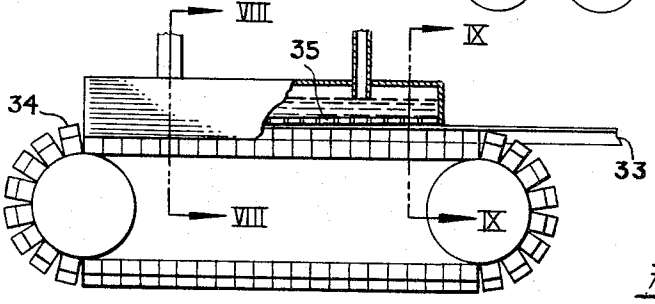


Fig. 7

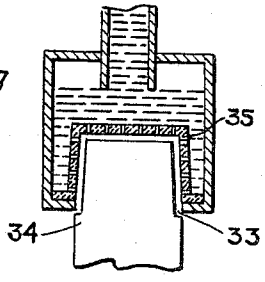


Fig. 8

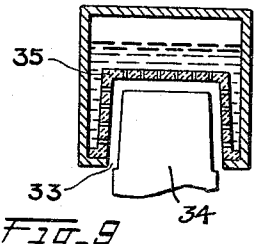


Fig. 9

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PROCESS AND APPARATUS FOR CONTINUOUS CASTING

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9 Claims. (Cl. 164—87)

ABSTRACT OF THE DISCLOSURE

The present invention relates to a process and apparatus for casting molten metal and the like into the form of sheets, plates or shapes by discharging the molten metal through orifices in an orifice plate, whose outlet ends conform to a path, the orifices being distributed both longitudinally and laterally along the path, and bringing a moving heat extracting surface maintained at a temperature below the fusion temperature of the metal into close contiguous relationship to said path, the earlier metal deposited on the heat extracting surface serving as a heat extracting surface as it passes contiguous to subsequent orifices. In the preferred form the rate of progression of the heat extracting surface is greater than the rate in which the molten metal flows through the orifices.

The present invention relates to a process and apparatus for continuous casting of molten metal and similar material.

A purpose of the invention is to improve techniques for continuous casting of relatively wide bands in thin sections, as for example, to produce sheet, plate and shapes.

A further purpose is to improve the microstructure of thin continuous cast metals and the like.

A still further purpose is to pour molten metal and similar materials through a plurality of orifices into a progressively widening space between a pour hearth from which the metal is poured and a cooled crystallizer and preferably to progress the crystallizer at a speed greater than that at which the metal is poured through the orifices in the direction of widening of the space so as to elongate metal crystals in the direction of progression and deposit successively the increments or dashes of solidifying metal, first on the crystallizer and then, as the operation progresses, on the recently deposited metal crystals, while retaining the continuous cast section so thin that it can be rapidly quenched by heat drawn through the crystallizer.

A further purpose is to progress the crystallizer transverse to the exit ends of the orifices from the pour hearth so as to wipe the newly depositing crystals across the crystals just formed and to obtain a firm inter-crystallization bond.

Further purposes appear in the specification and in the claims.

The invention relates not only to the process but also to the apparatus and product produced by the process.

In the drawings I have chosen to illustrate a few only of the numerous embodiments in which the invention may appear, selecting the forms shown from the standpoints of convenience in illustration, satisfactory operation, and clear demonstration of the principles involved.

FIGURE 1 is a diagrammatic side elevation of a plan for continuous casting in accordance with the present invention.

FIGURE 2 is an enlarged fragmentary diagrammatic vertical section through a pour hearth and crystallizer of the invention, corresponding, for example, to a portion of FIGURE 1 sectioned in the plane of the paper.

FIGURE 3*a* is a diagrammatic plan view of a continuous casting according to the invention.

FIGURE 3*b* is a fragmentary side elevation of a continuous casting according to the invention looking from the side into the space between the pour hearth and the crystallizer.

FIGURE 3*c* is a diagrammatic front view of the continuous casting according to the invention, the casting moving toward the observer.

FIGURE 4 is a view similar to FIGURE 2 showing a variation.

FIGURE 5 is a side elevation, partly in longitudinal section showing a modification of the invention.

FIGURE 6 is a section on the line VI—VI of FIGURE 5.

FIGURE 7 is a side elevation, partly in longitudinal section, of a further variation of the invention.

FIGURE 8 is a section of FIGURE 7 on the line VIII—VIII.

FIGURE 9 is a section on the line IX—IX of FIGURE 7.

Describing in illustration but not in limitaton and referring to the drawings:

Recently continuous casting has received much attention from the steel industry because of the many economies which result from bypassing the usual batch operation of teeming molten metal into ingot molds, handling the ingot molds, and incurring scrap losses by cropping the ingots to eliminate "pipe," gas cavities and segregation. One of the important contributions of the present invention is that continuous methods can be substituted for batch handling, making the quality of the product more controllable and increasing the efficiency to lower the cost.

The present invention is concerned primarily with the type of continuous casting in which a rather wide strip, plate, sheet or shape of metal or similar material is sought to be obtained.

In the commercially used continuous casting processes for steel and other metals, as far as I am aware, when wide sections are obtained they are relatively thick. For example, continuous casting of steel may produce slabs up to 48 inches wide and about 4 inches thick. Unieux in France has produced continuously cast strips about 14 inches wide and 1⅝ inches thick. Even in this case, however, a great deal of hot rolling is required before sheet gages can be obtained. A few selected alloys of aluminum can be continuously cast in relatively wide strips which are as thin as ¼ inch, although other aluminum alloys are continuously cast in thicknesses of ⅜ inch to ½ inch. In order to produce sheet, it is still necessary to hot roll.

Another difficulty with commercially used processes of continuous casting of wide bands is that the microstructure is often undesirable. Large grains result and segregation of impurities occurs, so that extensive reduction by rolling is necessary to produce metal sheet of suitable properties, regardless of the thickness desired.

A still further problem particularly in the case of continuous casting of steel is that a poor surface results compared to pressure casting.

The installations require a considerable amount of capital investment, in order to be economical they must be of large minimum capacity, and they are relatively inflexible as to changing the size, quantity, and alloy composition of the metal being cast.

The present invention is applicable to continuous casting of metals and similar materials including steel, both of plain carbon and alloy grades, and also to continuous casting of numerous other metals and alloys including copper base, aluminum base, nickel base, lead base, magnesium base, tin base, and the like.

Metal for the process can be drawn from any desired source, and passed into a pour hearth or pre-conditioning or distribution box which is specially designed as set forth below. From the pour hearth the metal is deposited on the crystallizer, which in its simplest form may be an internally cooled copper drum rotating on a generally horizontal axis. The metal from the pour hearth first solidifies on the surface of the crystallizer and is withdrawn in a thin sheet, plate or shape of predetermined thickness.

In the simplest embodiment of the invention, the sheet or other continuous casting thus produced can be utilized without any further processing, other than cutting to size and the like. However, it is usually desirable to cold roll the sheet, whether it be of steel or of a non-ferrous metal, so as to increase the mechanical properties, improve the surface finish and produce a more precise gage thickness. It will therefore be evident that the continuous casting of the invention will be suitably cast in a thick enough section so that it can be satisfactorily reduced by rolling.

One of the great advantages of the present invention is that there is not any large pool of molten metal undergoing solidification at a given time, in which dendrites might form or gross segregation could occur.

The cast product is of fine grain structure and faults and impurities are widely and uniformly distributed, instead of becoming localized and causing stress concentration and since the continuous casting in accordance with the invention is relatively simple and hot rolling is not essential, the capital investment required to produce an integrated plant is much less than in the case of other processes. The invention may therefore be employed by manufacturers who are seeking to produce sheet, or the like, for internal use in their own plants, as well as by small emerging nations, and dealers in metal scrap. This is true because the process and apparatus of the invention are economical for operation at relatively small volume levels. The direct labor cost is much less per ton of metal processed, and since the invention is applicable for high volume production, it is economical for large producers to abandon present processes in favor of the new process. One of the advantages of the present invention is that the equipment is very adaptable to permit modification in the size of the continuous casting and its composition.

An important aspect of the present invention is that the molten metal to be cast is poured or distributed through a large number of small orifices or openings onto a crystallizer or heat sink so that the amount of molten metal from which heat is being extracted to produce solidification at a given moment is relatively small and distributed over a wide area of the crystallizer. Also in the present invention the difference in temperature between the crystallizer and the molten metal just prior to crystallization is so great that solidification is practically instantaneous, providing in effect a quenching action, which assures fine grain size and uniformly dispersed impurities and faults. At the initial point at which continuous casting begins, the crystallizer surface is actually in contact with the molten metal being solidified, and therefore there is metallic conduction through the crystallizer (in a simple case a water-cooled rotating copper drum) to solidify a first layer of crystals. As the crystallizer advances, the next molten metal to be solidified encounters the layer of just crystallized metal, which is in effect then the crystallizer. If as in the prior art there were no orifices forming the barrier laterally between various sources of molten metal being crystallized, a large volume of molten metal would come in contact with the crystallizer, and the temperature differential between the molten metal and the solidified crystals would be very small. Thus, unlike the present invention, there was in the prior art slow crystallization, segregation of impurities, and very slow cooling of subsequent increments of molten metal in the case of steel where the conductivity is relatively low as compared to copper or aluminum.

There is still a great advantage in the present invention even in the case of copper and aluminum, although the difficulty to be overcome is not as pronounced in this case as it is with steel.

In the invention a suitable source of molten metal such as a pour hearth has leading from it a multiplicity of small orifices, the initial ones of which are located almost in touching relationship to the crystallizer. In order to simplify the description, reference will first be made to what happens at a single such orifice.

Molten metal pours or flows through this orifice at a rate controlled by a number of factors, of which the following are examples:

(1) The pressure on this molten metal due to its specific gravity and head, and any positive pressure, such as gas pressure, pump pressure or vibration under which the molten metal is supplied.

(2) The size, shape and length of the orifice.

(3) The viscosity of the molten metal determined by its fluidity at the particular temperature.

(4) The interaction at the surface between the molten metal and the wall of the orifice.

As the molten metal passes slowly from the source through the exit end of the orifice, it is moving generally transverse to the surface of the crystallizer, and it instantaneously freezes on encountering the crytsallizer surface. This is true because there is a small amount of metal being solidified compared to a large heat extraction surface of the water-cooled copper surface or other crystallizer, and also because there is a wide temperature differential between the cooling surface of the crystallizer and the molten metal. The moving surface of the crystallizer preferably moves adjacent to the orifice at a linear velocity faster than the velocity of the molten metal as it passes through the orifice so that increments or dashes of metal are broken off and carried forward by the crystallizer. This also provides sufficient speed of withdrawal of the molten metal from the orifice so that metal in the orifice will not freeze and block or damage the orifice.

On the downstream side of the first orifices there are of course a multiplicity of other orifices. For the purpose of discussion a single one of these downstream orifices will be considered. This time the exit end of the orifice is spaced slightly further from the surface of the crystallizer so that the already crystallized increment or dash of metal from the first orifice passes adjacent thereto, and a second increment or dash of molten metal is frozen on top of the first and overlaps the space between two of the first increments or dashes, and at the same time is smeared or elongated in the direction of progression.

It will be evident that from the standpoint of metal issuing through this second orifice, the crystallizing surface consists both of the crystallizer itself and also the increment or dash of metal which has previously been solidified, which has a part in removing the heat from the metal coming through the second orifice. Since the surface of the increment or dash of metal already frozen has had its temperature reduced almost to that of the surface of the water-cooled crystallizer, the differential in temperature is still almost as great as that encountered by the first increment or dash of molten metal and this new molten metal likewise solidifies instantaneously.

Actually there are many other orifices in the downstream direction of movement of the continuous casting, and orifice after orifice discharges its molten metal on the crystals previously solidified, gradually building up the thickness of the continuously cast sheet or other element.

It will be evident that the subsequent orifices in the downstream direction are progressively spaced a greater and greater distance from the surface of the crystallizer in order to accommodate the thickening section of the continuous casting, and are in practice shifted slightly laterally so that they are not all in a straight line but are staggered.

Returning now to a consideration of the first orifice, it will be evident that another orifice is spaced laterally beside the first orifice, and in fact there are at any point longitudinally of the axis of the crystallizer drum a large number of orifices extending width-wise of the sheet. One method of spacing the orifices is shown in U.S. Patent No. 2,993,492. However, it will be evident that the wall of the pour hearth which contains the orifices may be formed with orifice therein such as drilled titanium diboride primarily for aluminum or boron nitride primarily for steel or may be of a foraminous material, such as a porous alumina plate primarily for steel, a porous carbon plate such as a porous graphite plate primarily for aluminum, a porous plate of another refractory such as magnesia, or a heat resistant screen of a suitable high melting point metal or alloy or refractory fiber cloth which is resistant to corrosion by the melt, for example tungsten in a particular case. The porous materials are readily available in the prior art and provide a large number of random orifices which are generally directed transverse to the surface of the crystallizer. See U.S. Patent 3,006,473 describing porous carbon (graphite) for filtering aluminum.

It will be evident that each fresh drop of molten metal passing one of the orifices encounters a cold surface of freshly solidified metal. Because of the fresh solidification, the nascent surface of the crystals are uncontaminated and will readily bond to a new drop of molten metal, and at the same time the surface has such a great difference in temperature from that of the molten metal that the freezing is almost instantaneous. If the particular metal is especially subject to contamination by gas for example from the atmosphere, a suitable enclosure or protecting medium may be used, or the apparatus can be operated in an enclosure under vaccuum.

This process differs from other processes where the fresh solidified material which is in contact with the next increment of molten metal prior to its solidification are almost the same temperature. In the prior art this condition promotes slow cooling, large grains and a dendritic growth across the thickness of the molten metal, in the most damaging direction. No such dendritic structure occurs in the present invention. Furthermore, since the new process permits solidification to take place completely in a multiplicity of increments or dashes, the impurities and defects are confined to the particular crystals which are forming and cannot segregate into large pockets which will create zones of weakness.

Furthermore, the present invention prevents internal stress from building up to a large over-all internal stress level since that can relax as the individual increments solidify.

For example, if a 4-foot wide sheet of molten metal is forming at one time in a very thin section, the shrinkage on solidification will create such stress that there could be a series of longitudinal splits formed. If any such shrinkage cracks develop in the present invention they will be extremely small and numerous and will be welded by the next increment of molten metal deposited by a subsequent orifice so that no permanent damage is done.

One of the advantages of the present invention is that the instantaneous solidification and the absence of hot working makes it possible to continuously cast alloys which, because they separate on slow cooling, or embrittle during hot working, or are hot short, have not previously been continuously cast in sheet form.

The drawings show by way of example several different embodiments of the invention in diagrammatic form.

FIGURE 1 is a plant lay-out which takes molten metal from a furnace **10** through a suitable launder under gravity, gas pressure, or pumping to a casting station **11** to be described more fully. From the casting station a continuously cast sheet, strip or shape **12** issues, guided by a roller **13** to a flying shear **14** and then to a coiling station **15** which is merely intended as an indication of any suitable permanent distributing point. The coiling station consists of two coils as well known in the art which are used alternatively, and automatically. The flying shear likewise is automatic to cut off the desired lengths of sheet or the like.

If desired the sheet can pass through leveling rollers well known in the art between the flying shear and the coiling station.

The casting station is the heart of the present invention and will be described more fully by reference first to FIGURE 2.

The molten metal enters through the launder **18** to a suitable pour hearth, tundish, or distribution or preconditioning box **16** which is located above the top of a crystallizer, in this case a cooling drum, **17**. In this particular embodiment the cooling drum may conveniently be of the order of 48 inches in diameter and 18 inches wide, having an outer shell of copper suitably one-half inch thick for maximum heat conductivity.

The cooling drum is cooled on the interior by water in a manner well known in the art, the water being preferably held at a temperature of about 200 degrees Fahrenheit. Other suitable cooling media may be used if desired. If the entry temperature of the water is about 68 degrees Fahrenheit, each gallon of water will provide approximately 1,000 B.t.u.'s of cooling. The pour hearth is preferably a closed box as shown in which molten metal, for example aluminum, is fed in sufficient volume through the launder **18** at a temperature for example of 1300 degrees Fahrenheit to maintain a 3-inch head of molten metal in the pour hearth. Prior to introducing the aluminum into the pour hearth it is preferably filtered and degassed such as by the process disclosed in U.S. Patent No. 3,172,757. Overlying the molten metal is argon or another suitable protecting gas **19**, maintained under a positive pressure of 8 ounce per square foot gauge and introduced through gas inlet **20**.

A suitable level controller **21** of well-known character serves to maintain a 3-inch head of molten aluminum between maximum and minimum levels. The bottom of the pour hearth is formed of a layer suitably of carbon (graphite) **22** which is porous and is cut to form a lower surface which is slightly relieved with respect to the surface of rotation of the outside of the drum as later explained. The orifice plate **22** in the particular embodiment is desirably about 12 inches wide and 12 inches long, made of porous carbon (graphite) grade 25, which may be obtained from National Carbon Company Division of Union Carbide Company. The porosity is 48 percent and it has an average pore diameter of 0.0047 inch and an average permeability of 90 gallons of water per square foot per minute per one inch thickness at a water temperature of 70 degrees Fahrenheit and under a pressure differential of 5 pounds per square inch gauge.

Using the orifice plate as just described, a 3-inch head of molten aluminum under a positive gas pressure of 8 ounces per square foot gauge will deposit or pour about 33⅓ pounds of molten aluminum through the porous plate per minute.

The exit end of the first orifice in the direction of motion are almost in touching engagement with the crystallizer surface and between the first and the last orifices in the direction of flow the bottom surface of the orifice plate is curved on a radius equal to the drum radius but about an axis which is suitably displaced with respect to the drum axis so that at **24** at the exit end the orifice plate is spaced from the drum a distance equal to or slightly greater than the thickness of the emerging continuously cast sheet or the like **12**. In the particular illustration, the porous plate **22** is adjusted to produce an aluminum sheet having a width of about 12 inches and a thickness of about 0.012 inch. This is a convenient thickness for subsequent cold rolling down to a sheet

0.003 inch thick useful for manufacturing aluminum foil containers for frozen food and the like.

Since molten aluminum liberates 330 B.t.u.'s per pound in solidifying and cooling from its molten temperature of 1300 degrees Fahrenheit down to 200 degrees Fahrenheit, it is necessary to extract 660,000 B.t.u.'s per hour in order to cast one ton of molten aluminum per hour. Under the previously assumed conditions, this will require a minimum of 660 gallons of water per hour and the aluminum is withdrawn at a speed of 196 feet per minute or 3.3 feet per second.

Since the thickness of the continuously cast sheet or the like is so small, it offers practically no resistance to heat extraction, and the intimate contact of the sheet with the crystallizer gives good heat transfer which is believed to be in excess of 2000 B.t.u.'s per hour per square foot per degree Fahrenheit. Also, the conductivity of the metal of the crystallizer, where it is copper, is so great that a very high heat transfer rate occurs through the drum wall and the cooling medium.

Solidification shrinkage of the aluminum will normally cause a 12-inch width to narrow by approximately ⅛ inch. Since, however, the aluminum sheet is so thin that the shrinkage force will not build up high internal stresses, they can be readily relieved by forming microscopic cracks in the thin material which are instantaneously welded by fresh aluminum supplied by later orifices as the sheet progresses forward beneath the porous plate. The feed rate, of course, must be fast enough to prevent solidification from progressing into the pores of the bottom plate itself. The result is that the grains are elongated or smeared longitudinally as shown in the plan view, FIGURE 3*a*, in the side view, FIGURE 3*b*, and in the end view, FIGURE 3*c*. The sheet is made up of a multiplicity of layers both widthwise and in thickness. Although the heat is being withdrawn from the crystallizer beneath the sheet, the grain structure does not progress across the sheet in a manner which would impair the mechanical properties but the grains are elongated longitudinally as they would normally be in rolling.

It will be evident that the porosity of the orifice plate at the bottom of the pour hearth and the pressure on the metal by virtue of its own head, and from the gaseous pressure, make it possible to determine the feed rate and from the feed rate, the rate of progression of the crystallizer is determined since the crystallizer must progress fast enough to prevent solidification of the crystals in the orifices. Also, the feed rate can be controlled by a series of cyclic pulses of pressure on the molten metal as created by a vibrator or otherwise.

Likewise the area of the orifice plate may be made quite large so that a large area for heat extraction is provided. This is of special importance in ferrous metallurgy where a ferrous alloy is being continuously cast which has relatively poor heat conductivity.

FIGURE 4 shows the bottom of a modified distribution box or pour hearth, omitting the structure above. Instead of making the bottom of the distribution box of a large porous plate, the bottom is made of non-porous material such as refractory or metal with porous orifice bars **25** filling slots in the bottom. In the case of aluminum, the orifice bars may be of porous graphite with impervious material **26** in between so as to spread the distribution of the molten metal over a large surface area.

In the case of continuous casting a steel sheet 48 inches wide and 0.090 inch thick, at a speed of 200 feet per minute, the amount of steel or hot band being cast is 52 tons per hour. Since the heat extracted from the molten steel in cooling from its melting temperature down to approximately room temperature is 650 B.t.u.'s per pound it would be necessary to extract approximately 1,000,000 B.t.u.'s per minute and this necessitates as a minimum more than 1,000 gallons of cooling water per minute. Using a conservative rate of heat transfer at the casting station of 300 B.t.u.'s per hour per square foot per degree Fahrenheit, it is evident that in crystallizing steel down to the temperature of the water from 2680 degrees Fahrenheit, the temperature of the molten steel, the orifice plate should be 4 feet wide and 21 feet long or longer. The orifice plate could be shorter because the value of 300 B.t.u.'s per hour per square foot per degree Fahrenheit is believed to be conservative and also it is not necessary to quench the steel in the apparatus to a temperature as low as that of the cooling water. However, ignoring these factors it will be seen that a drum in this case would be of excessively large diameter.

For this purpose therefore a modified form of crystallizer is used as shown in FIGURES 5 and 6. An endless carbon steel belt **27** is progressed over suitable pulleys under a pour hearth or distribution box **28** which has an orifice plate **29** forming the bottom thereof, the orifice plate having a plurality of transverse slots filled with porous material suitably refractory such as porous alumina which under a particular pressure differential will permit 52 tons of molten metal per hour to pass therethrough. Preferably, the molten steel is vacuum degassed by any of the well-known processes prior to being introduced into the pour hearth. The orifice plate is tilted about an axis **30** so that at this point it almost touches the surface of the crystallizers **27**, whereas at the other end **31** it is spaced from the endless band or crystallizer **27** by a thickness equal to or slightly greater than the thickness of the emerging continuously cast sheet or the like **12**. On the opposite side of the metal band from the orifice plate there is provided an elongated water tank **32** having cooling water in contact with the crystallizer. This is best seen in FIGURE 6. Such a water bed metallic plate cooler is well known in the art and is of the type commercially available from Sandvik Steel, Inc., 1702 Nevins Road, Fair Lawn, N.J.

The above described process also lends itself to castings well known in the industry as metal "shapes," such as tubes, channels, beams, rails, and the like, as well as plates. For example in FIGURES 7, 8 and 9 a channel **33** is being continuously cast onto properly shaped metal mold blocks **34** which form the crystallizer and are linked together by an endless chain passing over suitable sprockets underneath a suitably shaped orifice plate **35**, which conforms to the principles of the present invention. It will be evident that the orifice plate is just slightly larger than a mating size where the deposit of the continuous casting starts and greatly enlarges relative to the size of the mold block **34** at the outlet side so that it is the same as or slightly larger than the thickness of the channel **33** being cast. The mold block is suitably cooled by cooling apparatus conveniently as shown in FIGURE 5 which has been omitted for convenience in illustration.

Where a closed shape like a tube is being formed it will be understood that it may be formed direct or the continuous casting **33** may be formed so that its abutting edges later adjoin and are united as by seam welding as well known in the art.

While generally the crystallizer moves and the pour hearth is relatively stationary (although it may be vibrated), it may be desirable in some cases to have the hearth move and the crystallizer stationary. Also, the reference to continuous casting is meant to also cover processes where the pour hearth and crystallizer reciprocate relative to one another. For example, in making heavy plates or shapes it will sometimes be desirable to have the crystallizer move back and forth under the pour hearth to build up the thickness. In this example, the space between the hearth and crystallizer would usually be gradually increased as the thickness of the plate or shape is increased.

In view of my invention and disclosure variations and modifications to meet individual whim or particular need will doubtless become evident to others skilled in the art to obtain all or part of the benefits of my invention without copying the process, structures and product shown,

and I therefore claim all such insofar as they fall within the reasonable spirit and scope of my claims.

Having thus described my invention what I claim as new and desire to secure by Letters Patent is:

1. A process of casting molten metal and the like into solid form, comprising the steps of passing molten metal and the like through a plurality of small orifices, the orifices having outlet ends which are disposed along a path, the orifices being distributed longitudinally of the path and also transversely of the path, relatively moving a heat extracting surface maintaned at a temperature below the fushion temperature of such metal and the like in close contiguous relationship to the path and to the outlets of the orifices so that the molten metal and the like is cooled along the path with said heat extracting surface, and passing the heat from the metal and the like being deposited at a more downstream point along the path through previously deposited solid metal to said heat extracting surface, said orifices and the relative movement of the heat extracting surface causing elongation of the crystals of molten metal and the like deposited.

2. A process of continuously casting metal, which comprises cooling a heat transfer surface to extract heat, advancing said heat transfer surface along a path, pouring molten metal through a plurality of constricted channels substantially normal to the heat transfer surface at a rate sufficient to prevent solidification of molten metal in said channels, said channels being space longitudinally of and also laterally of said path of advance of the heat transfer surface, from the ends of said channels at a more rearward position with respect to said path depositing small increments of metal through a short distance on said heat transfer surface, from the ends of said channels at a more forward position with respect to said path depositing small increments of metal through a short distance on said metal previously deposited and cooling them through said previously deposited metal and said heat transfer surface, the ends of said channels at the more downstream positions being more remote from the heat transfer surface than the ends of said channels at the more upstream positions to accommodate the increasing thickness of the casting.

3. A process of claim 2, which comprises elongating the crystals of metal in the direction of advance of the crystallizer as the continuous casting forms.

4. A process of claim 2, in which the crystallizer advances at a rate greater than the rate at which the molten metal flows through the orifices.

5. In mechanism for continuous casting, a pour hearth having an orifice plate provided with a plurality of orifices through which molten metal can be poured, the orifices having outlet ends, a crystallizer having a surface disposed generally normal to flow of metal through the orifices, the crystallizer being located immediately adjacent to the outlet ends of the orifices, means for extracting heat from the crystallizer to solidify molten metal as it flows through the orifices into space between the outlet ends and the crystallizer, and means for progressing the crystallizer at a rate sufficient to prevent molten metal from solidifying in the orifices, the outlet ends of the orifices being distributed in the orifice plate in spaced relation both longitudinally of the direction of progression and laterally of the direction of progression of the crystallizer, the space between the outlet ends of the orifices and the crystallizer approximating the thickness of a continuous casting.

6. A mechanism of claim 5, in which the outlet ends of the orifices located opposite more downstream positions in the direction of the progression of the crystallizer are more remote from the crystallizer than the ends of the orifices opposite the crystallizer at more upstream positions in the direction of progression of the crystallizer.

7. A mechanism of claim 5, in which the orifice plate and orifices comprise porous refractory.

8. A mechanism of claim 5, in which the crystallizer is straight in cross section transverse to the direction of advance.

9. A mechanism of claim 5, in which the crystallizer and the pour hearth in cross section are non-straight and form a shape, whereby the continuous casting comes out in the form of a shape.

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