Sept. 3, 1968 F. HARDERS ET AL 3,399,715

METHOD FOR THE CONTINUOUS CASTING OF METAL

Filed Sept. 3, 1965 2 Sheets-Sheet 1

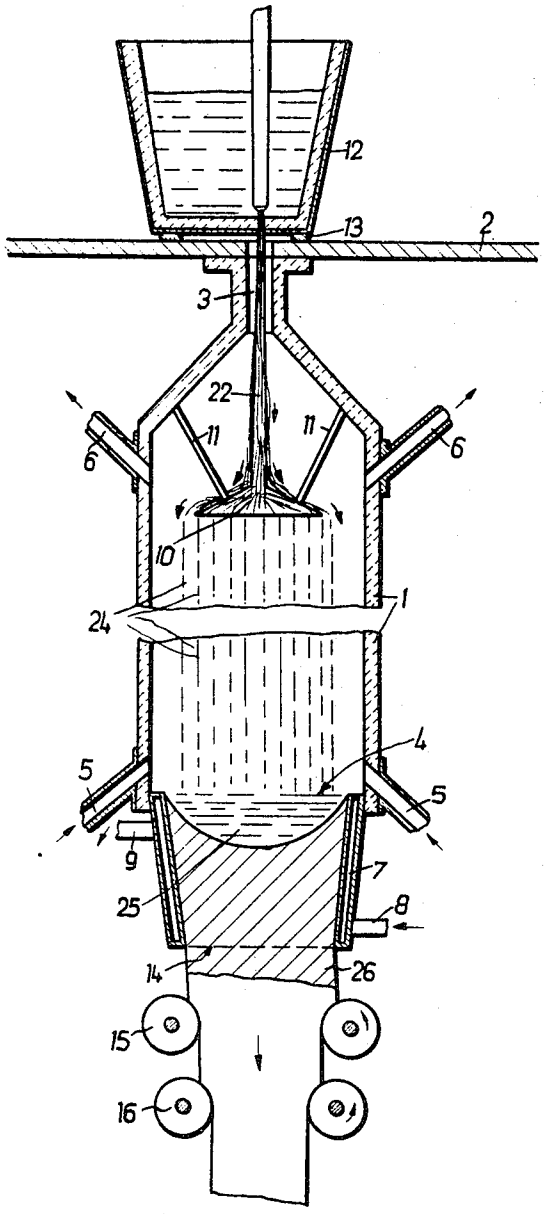


Fig. 1

METHOD FOR THE CONTINUOUS CASTING OF METAL

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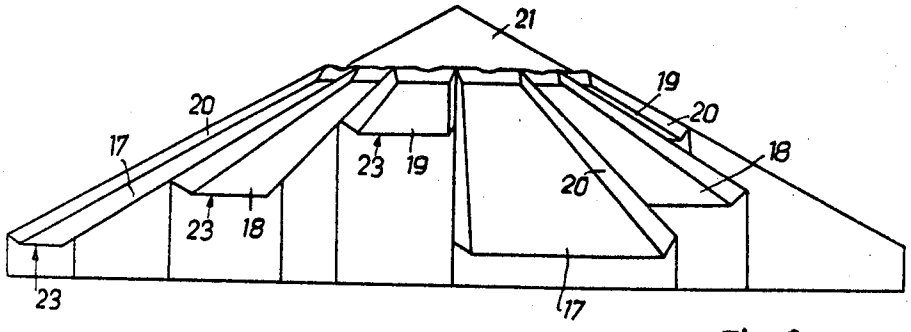


Fig. 2

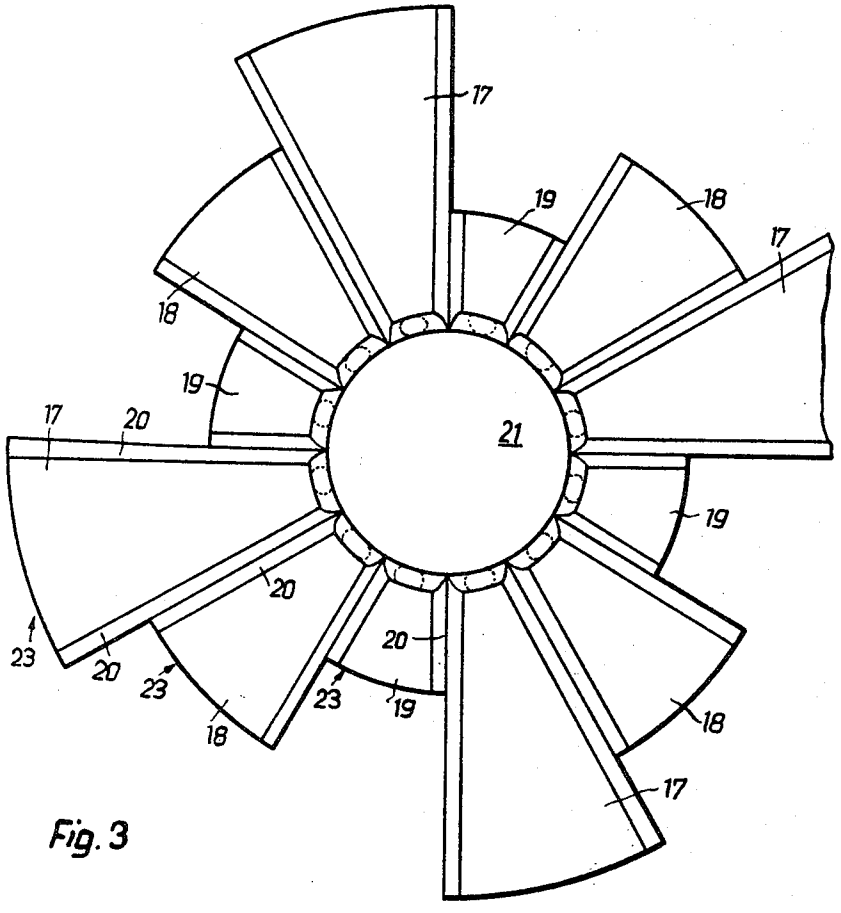


Fig. 3

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METHOD FOR THE CONTINUOUS CASTING OF METAL

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ABSTRACT OF THE DISCLOSURE

Method for continuous casting of metal by passage through a vertical chamber wherein solidification of cooling takes place includes dispersing the molten metal on introduction to the cooling chamber so that it falls as droplets, circulating a gaseous coolant through the falling stream of droplets within the tower so as to cool the droplets, reuniting the cooled droplets at the lower end of the chamber, and subjecting the resultant mass to pressure so as to complete solidification.

This invention relates to the casting of metal by a continuous method.

In a continuous casting, the temperature distribution when measured at different points of its cross-section is so irregular that it is impossible to roll it with the aid of the same heat. On the contrary, the casting must be cut up and re-heated before rolling and in this respect, the continuous casting method has no advantage over ingot casting.

The method of this invention which seeks to obviate this disadvantage has in common with the known continuous casting methods the feature that molten metal is poured into a cooling tower or other chamber from which it passes out at the bottom in the form of a partly solidified bar.

According to the present invention the molten metal on introduction to the cooling chamber or housing is dispersed into individual droplets and these droplets are cooled by a current of gas and combined into a bar at the mouth of the container, the bar being thereupon compressed. By being subdivided into droplets, on cooling of the latter, practically the same temperature is obtained at all points on the cross-section of the metal bar obtained on resolidification.

Having regard to temperature distribution, a bar produced in this manner has substantially the same properties as a heated ingot and can therefore be directly subjected to further processing.

Moreover, after passing out from the cooling tower, a bar having these properties can be deflected along a horizontal path i.e. out of the vertical, with a substantially smaller radius of curvature than is possible in the case of continuous casting. This results from the material being in a plastic condition which considerably facilitates every type of deformation. The furnaces previously required for re-heating can be dispensed with and the compressed bar can be transferred directly in a continuous movement to a rolling mill, without being divided up.

The method is especially applicable to the continuous casting of steel. In this case the coolant gas is advantageously one which reacts only slightly or not at all with the surface of the steel droplets. Suitable gases have been found to be blast furnace gas, optionally with additions of carbon monoxide and/or hydrogen, as well as water gas, and partly oxidised natural gas. Hydrogen, or a gas

which contains large quantities of hydrogen, in addition to carbon monoxide is particularly advantageous for cooling because owing to its high thermal conductivity hydrogen permits particularly rapid and intensive cooling of the droplets of steel. In addition, hydrogen has the advantageous property that although during the cooling of the droplets it dissolves to a certain extent in the latter, as a rule it subsequently separates almost completely from the solid steel.

Blast furnace gas is suitable for cooling the droplets particularly if its high nitrogen content does not result in either any noteworthy absorption of nitrogen, as in the case of unkilled steel, or if absorption of nitrogen is not harmful, as in the case of basic converter steel. Blast furnace gas has the advantage of being cheaper than the above-mentioned gases.

In the case of the continuous casting of steel it is advisable for the degree of cooling of the steel droplets in the cooling tower to be so controlled that, depending on the size of the drops, about 2 to 20% of the mass solidifies. It is then advisable for the melt to be broken up into droplets of a size between 0.3 and 10.0 mm., preferably between 1.0 and 6.0 mm., which can be achieved through suitable shaping of the distributor device effecting dispersal and breaking up of the molten metal and by suitable proportioning of the quantity of steel fed per minute. If cooling is effected with a gas not containing hydrogen, the upper limit of droplet size should be of the order of 3.0 mm., while in the case of hydrogen or a cooling gas containing hydrogen the upper limit may be 6.0 mm. With this size and when the above-mentioned cooling gases are used, there is practically no contamination of the steel by oxygen (oxidation) or possibly nitrogen. Unkilled and killed steels may be cast in this manner.

An apparatus suitable for carrying out the method of this invention comprises a cooling tower having at its upper end an inlet for introduction of the melt, a distributor or dispersing device disposed beneath said inlet and composed of refractory material, on to which the melt falls and so arranged that the melt is broken up into individual currents made up of small particles or droplets of molten metal and a discharge outlet at or in passage through which the droplets from the individual currents are re-united to form a compact mass together with connections for cooling gas pipes. The distributor device may consist of a conical deflector the narrow end of which faces the inlet opening and which is sub-divided into sectors having different radial lengths. When a cone of this type is used, it is advisable for the quantity of melt introduced to be such as to provide a layer thickness over the surface of the cone not appreciably in excess of 4 mm.

One embodiment of the invention is diagrammatically illustrated in the accompanying drawings, in which:

FIGURE 1 is a longitudinal vertical section of an apparatus suitable for carrying out the method of this invention,

FIGURE 2 is a view in elevation, on an enlarged scale of a distributor device such as is used in the apparatus shown in FIGURE 1,

FIGURE 3 a plan view of the distributor device of FIGURE 2.

Referring to FIGURE 1 the apparatus comprises a relatively wide cylindrical housing **1** which functions as the cooling tower in the sense originally referred to hereinabove, the tower having at its upper end a relatively narrow inlet opening **3**, and at its lower end a wide discharge opening **4**, the width of which is a multiple of that of the top opening.

Leading into the housing **1** adjacent its lower end are

a number of pipes **5** for the entry of a cooling gas, which discharges through corresponding pipes **6**. A relatively short chamber or continuous casting mold **7** is connected to the bottom opening **4** for operation as a cooling jacket, for which purpose it has a hollow wall **7'** into which water enters at **8** and passes out again at **9**.

Molten metal is fed to the housing **1** from a ladle **12** traversable over a platform **2** so that it can be run into position above the opening **3**, an annular seal **13** if necessary being provided between the platform and the ladle when the latter has been brought into position. Beneath the mouth **14** of the continuous casting mold **7**, are independent sets **15** and **16** of rollers.

In alignment with and beneath the opening **3** is a conical diverter plate **10** having its lateral area facing upwards and supported by struts **11**. The plate **10**, which forms the initially mentioned distributor is composed of refractory material.

In the embodiment illustrated in FIGURES 2 and 3 the cone forming the distributor **10** is divided into a large number of sectors of different radial lengths, a total of **12** such sectors being provided in the example illustrated and having three different lengths, the longest sectors being designated at **17**, those of medium length at **18** and the shortest sectors at **19**. Each sector is bounded along its radial sides by rims or beads **20**, which together with the surface of the sector form a channel. The beads **20** extend from outside to inside as far as the edge of a smooth conical surface **21**.

In operation the ladle **12** is brought into position over the opening **3** and after the seal **13** has been made the ladle is opened to allow a casting jet **22** to flow into the container **1** where it impinges on the distributor disc **10**. The effect of the disc **10** is to distribute the metal over the individual sectors **17**, **18**, and **19** and thereby divide it into **12** individual currents, which flow down in a thin layer outwards and over the perimeter **23**.

The speed of pouring is controlled, preferably being selected so that the metal layers are not thicker than 4 mm. Under the action of surface tension, the layers at the edge of the distributor break up into drops, which fall through the cooling tower as a broad current or curtain **24**.

The cooling gas entering the housing at **5** and leaving at **6** flows in counter-current and under the action of the gas, the drops, which are cooled more or less intensively according to size, collect partly as a pool **25** of still liquid and partly in the plastic state beneath the opening **4**, before finally passing out of the hopper **7** as a solid mass or bar **26**. The cooling action due to the hopper merely serves the purpose of effecting the complete solidification of a thin edge layer of the still uncompressed bar.

The bar **26** consists of drops which at their solidified surfaces become welded to one another. In passage between the two pairs of rolls **15** and **16**, the bar is compressed and has imparted to it the shape of a flat slab. Cavities existing between the drops are closed after this deformation and the gas contained in them passes out in an upwards direction. The bar can then be deflected through 90° and subjected to further processing in a horizontal direction. Further shaping is possible and can readily be performed when the bar is to be rolled out into a sheet. In this case a continuous flow through the subsequent shaping rolls is possible without the bar having to be cut up into individual portions.

It is also possible however to produce billet material and sections if the plastic bar passing out of the hopper **7** is at the outset compressed in two directions perpendicular to one another. The bar can then again be deflected into the horizontal and subjected to further processing. Because of its great plasticity, fewer roll passes are necessary for the profiling than in the case of deformation in the solid condition.

It is known that in order to obtain a homogeneous grain structure in solid steel a degree of deformation in the

solid condition of at least 5 to 6 is necessary. For a sheet having a final thickness of say 10 mm. this means that it may be deformed in the plastic condition to a thickness of 6 cm. Maintenance of the plastic condition is merely a question of removing heat. It has been found that with a fraction of 20% of solid material and 80% of liquid substance in the bar passing out of the cooling jacket **7**, and in the case of the conversion of the bar into sheet, the plastic deformation must be completed within a period not substantially exceeding two minutes.

A suitable size of cooling tower has for example a diameter of about 1 metre and a height of 4 metres. Having regard to the time required by the drops to fall, the minimum height should generally be 3 metres. In the upward direction the height is limited by the speed of impingement of the drops.

The casting of killed open hearth steel containing 0.25% of carbon, 0.3% of silicon, 0.05% of phosphorus and 0.05% of sulphur will be described as an example. The steel is poured into the container **1** from a ladle having a capacity of 80 tons at a speed of 5 tons per minute. Through the action of the distributor **10**, drops of a size between 0.8 and 5 mm. will be produced. The cooling gas used can contain 20% of blast furnace gas and 80% of a natural gas partly oxidised with oxygen, thus consisting of 2% of carbon dioxide, 33% of carbon monoxide, 54% of hydrogen, remainder nitrogen. The gas is blown in at room temperature. The gas consumption amounts to 240 normal cubic metres per minute and the outlet temperature amounts to about 1000° C. The solidification amounts on the average to 20%.

It may be added that other forms of distributor may be used, for example an annular slot or nozzle in which the steel is divided up by a sharp gas current, or a sieve-like structure or else a refractory spray.

What we claim is:

1. A method for the continuous casting of metal by passage through a vertical chamber wherein solidification by cooling takes place, said method comprising the steps of:

(i) dispersing the molten metal on introduction to the cooling chamber so that it falls as droplets,

(ii) circulating a gaseous coolant, through the falling stream of droplets within the tower so as to cool the droplets so they are partly solidified,

(iii) reuniting the cooled droplets at the lower end of the chamber, and

(iv) subjecting the resultant mass to pressure to complete solidification.

2. A method for the continuous casting of steel which comprises the steps of:

(i) feeding the molten metal into the upper end of a vertical chamber,

(ii) dispersing the molten metal so that it falls as droplets,

(iii) circulating a coolant gas through the falling stream of droplets so as to cool the droplets so they are partly solidified,

(iv) reuniting the cooled droplets at the lower end of the chamber, and

(v) subjecting the resultant mass to pressure to complete solidification.

3. The method claimed in claim **2** in which the coolant gas is selected from carbon monoxide, hydrogen or a mixture of carbon monoxide and hydrogen.

4. A method as claimed in claim **2** in which blast furnace gas is used as the gaseous coolant.

5. The method claimed in claim **2**, wherein dispersal of the molten metal is so controlled as to divide it into droplets of a size within the range 0.3–10.0 mm.

6. A method as claimed in claim **5**, wherein the droplet size is within the range 1.0–6.0 mm.

7. A method according to claim **1** wherein the dispersal is effected by directing a jet of the molten metal at a

controlled rate of flow onto a distributing plate to produce a surface layer thickness not exceeding 4.0 mm. over the surface area of the distributing plate.

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