United States Patent

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[54] **CONTINUOUS CASTING PROCESS**
7 Claims, 3 Drawing Figs.

[52] **U.S. Cl.** **164/73,** 164/82
[51] **Int. Cl.** **B22d 11/10**
[50] **Field of Search** 164/66, 73, 82, 156, 268, 281

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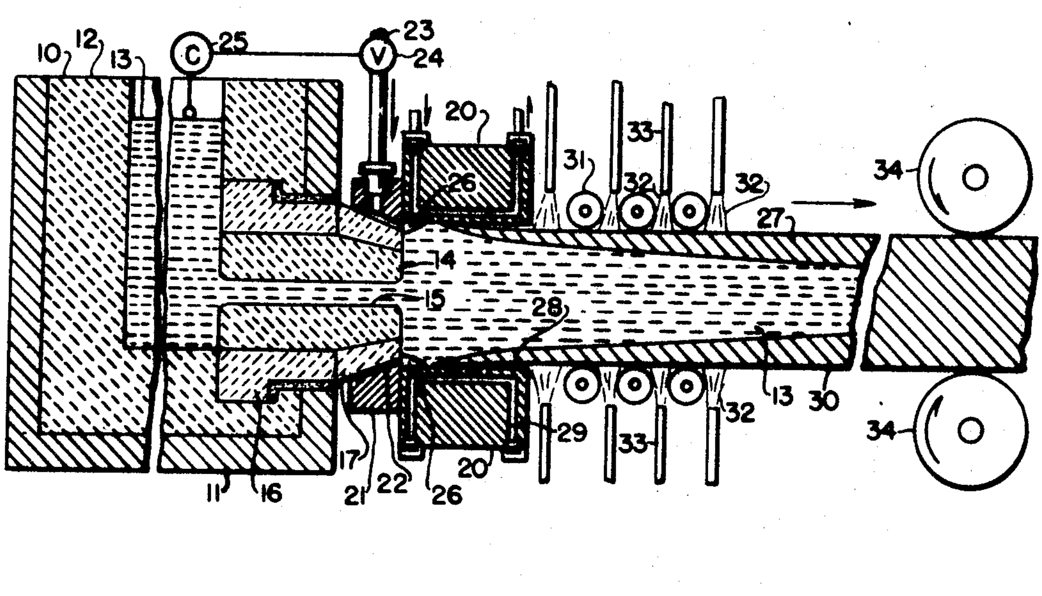
ABSTRACT: In continuous casting wherein molten metal to be continuously cast flows from a casting nozzle into a cooled mold from which a billet with at least an outer shell solidified is withdrawn, a gas is injected under pressure about the casting nozzle into the mold to form a gas pocket about the casting nozzle in molten metal within the mold, the gas escaping between the forming billet and the mold.



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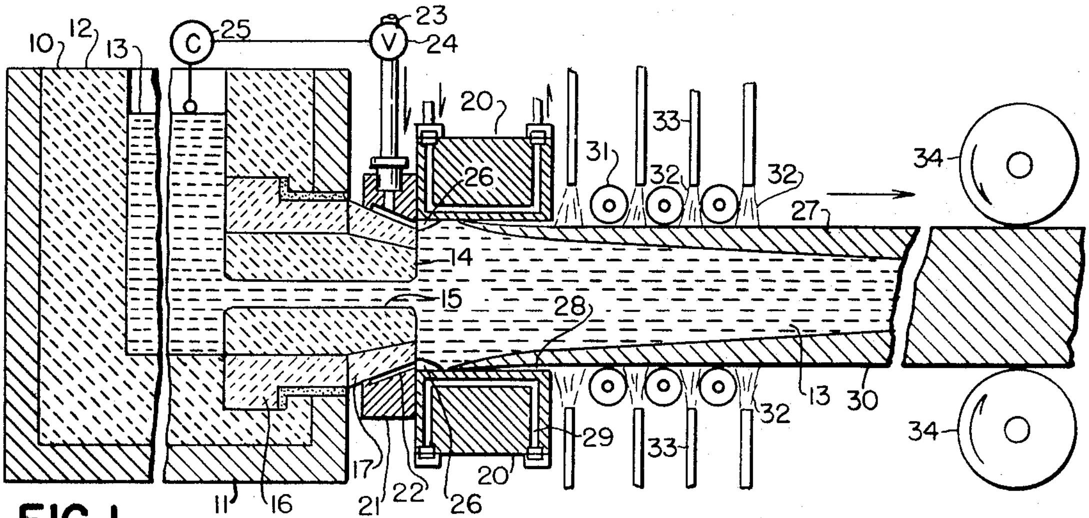

FIG. 1

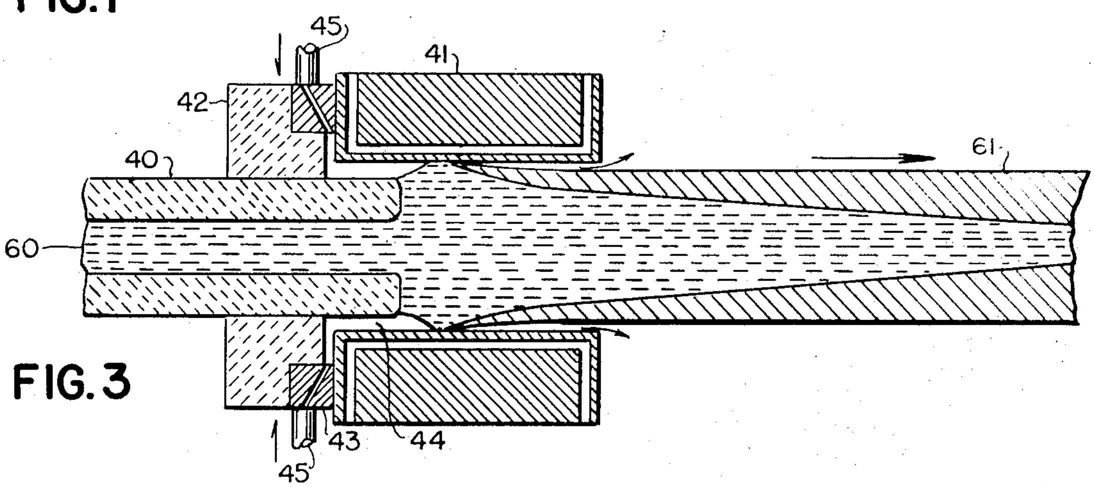

FIG. 3

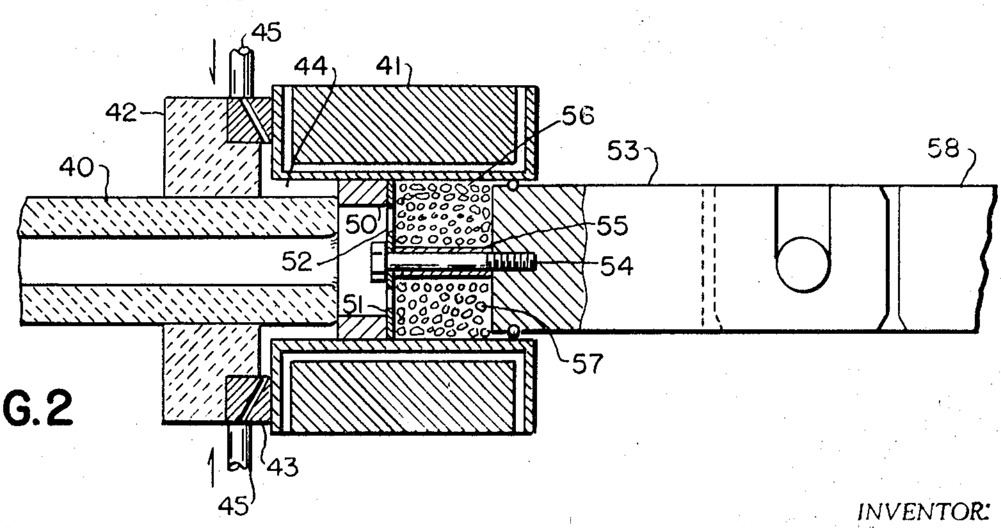

FIG. 2

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CONTINUOUS CASTING PROCESS

This application is a continuation of an application of the same inventor, Ser. No. 628,348, filed Apr. 4, 1967, now abandoned, titled CONTINUOUS CASTING PROCESS AND APPARATUS.

BACKGROUND OF THE INVENTION

Many problems are inherent in the continuous casting of metals, particularly steel. One problem solved by this invention results from the fact that, in a horizontal continuous casting machine, the cool surface of the mold is in contact with a refractory surface of the casting nozzle. This causes liquid steel to solidify and form a bridge between the solidified shell of the billet being cast and the nozzle. This bridging tears out portions of the refractory nozzle in contact with solidified steel to damage and destroy the apparatus in short order. This invention solves this problem and, for the first time, should allow a horizontal continuous casting machine for steel to be built and operated.

Horizontal continuous casting machines for steel, heretofore not feasible, should be far less costly than the vertical machines now used because molten metal will not have to be lifted to great heights and structures will not have to be provided to support the vertical casting machine high above the working floor.

Another problem in vertical, curved mold continuous casting machines involves lubrication of the mold. Excessive lubrication is often required in these conventional machines as much of the lubricant may be burned up before reaching the mold walls where it is required. This excessive lubrication causes "pinhole porosity" in steel so produced which results in an inferior product.

As is well known, in conventional continuous casting machines solidification of liquid metal occurs within the first few inches of contact with the mold wall. However, conventional vertical continuous casting machines require molds of considerably greater length than these few inches to accommodate variations in the liquid metal level therein as flow rates from a tundish have not yet been controlled with accuracy. This excessive length of mold does not extract heat from the still liquid core of the billet being continuously cast because the solidified shell of the billet shrinks and draws away from the cooled mold wall so that only inadequate heat transfer takes place. Further, in conventional vertical continuous casting machines, casting speed is determined by metal flow through the casting nozzle which, in turn, is determined by casting nozzle diameter and the height of the liquid metal in the tundish. Thus, in conventional machines, withdrawal speed must be adjusted to compensate for nozzle erosion and changes in the head of metal in the tundish.

Additionally, conventional continuous casting machines have their molds oscillated to increase rubbing velocity and thus reduce friction to prevent solidified metal from gripping the mold.

SUMMARY OF THE INVENTION

This invention, in a continuous casting machine, introduces a gas under pressure around a casting nozzle to form an annular pocket in the molten metal. This pocket of gas, which is a relatively poor conductor of heat and which has comparatively small heat absorbing potentials, effectively insulates the molten metal leaving the casting nozzle to eliminate the destructive bridging hereinbefore described. Since bridging and the resulting destruction of the refractory casting nozzle is eliminated by this invention, it makes possible, for the first time, the horizontal continuous casting of metal, particularly steel.

Since bridging is no longer a problem and may be eliminated by this invention, withdrawal speed of an ingot or billet being continuously cast may be used to determine and control flow through the casting nozzle in both horizontal and vertical machines. Because this invention allows the speed of casting to be regulated, consecutive heats of metal may be more easily poured through a machine as the timing of consecutive heats is less critical with the rate of casting now being controllable. Since this invention only requires short mold lengths as there need by no molten metal level fluctuation therein, maximum heat transfer or cooling may be accomplished sooner by means of sprays beyond the shorter mold length.

This invention allows the more efficient lubrication of a continuous casting machine in that a lubricant may be introduced with the gas to flow between the ingot or billet and the mold wall. In some cases the gas itself may serve as a lubricant. The more efficient lubrication thus provided may eliminate the need to oscillate continuous casting molds to reduce friction. For this and other reasons, this invention may be applied to both horizontal and vertical continuous casting machines.

Many other advantages resulting from this invention will become apparent from the following descriptions.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a longitudinal, vertical section through a horizontal continuous casting machine according to this invention with a portion of the tundish and the continuously cast billet broken away;

FIG. 2 is a longitudinal vertical section through a fragment of a modified casting nozzle and a mold showing a starting apparatus positioned therein for horizontal continuous casting; and

FIG. 3 is a longitudinal vertical section through the continuous casting machine elements of FIG. 2 casting a billet therein.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

As shown in FIG. 1, a tundish **10** has a steel shell **11** lined with a refractory **12**. Molten metal, particularly steel, **13** is delivered into tundish **10** from any convenient source (not shown). A casting nozzle **14** of refractory material contains a channel **15** therethrough and is mounted in tundish **10** by mean of a nozzle block **16**. The outer end of casting nozzle **14** is surrounded by an insulating ring **17** of refractory material such as pyrolytic graphite or the like. Adjacent to mold **20** about the insulating ring **17** there is disposed a copper adapter ring **21** containing an inner annular gas injection channel **22**.

A gas which is to be injected into mold **20** is delivered from any suitable source (not shown) through pipe **23**. Pressure and thereby flow of this gas is regulated by a valve **24** which adjusts gas flow in pipe **23**. As one example of this invention, a conventional sensing device **25** may respond to the level of molten metal **13** in tundish **10** to set valve **24** to increase gas flow for a greater head of metal.

In a horizontal continuous casting machine as shown in FIG. 1, the injected gas forms an annular pocket **26** about the end of casting nozzle **14**. Directly beyond pocket **26**, molten metal **13** contacts mold **20** to solidify and form the solid shell **27**. A shell **27** of steel contracts on forming to shrink away from the inner walls **28** of mold **20**. Mold **20**, as in conventional continuous casting machines, is cooled by water or any other suitable fluid circulated in channels **29**.

On emerging from mold **20**, the billet **30** passes between the support rollers **31** and receives cooling sprays **32** from nozzles **33**. Such sprays **32** are usually of water. Withdrawal rollers **34** pull the billet **30** from mold **20** and may be used to determine casting speed. Maximum casting speed is determined by the upper limit of the flow of molten steel through a given channel **15** of a casting nozzle **14**. Slower casting speeds may be obtained by the slower withdrawal of billet **30** from the mold **20** as the annular gas pocket **26** prevents bridging and thus prevents any resulting destruction of the refractory casting nozzle **14**.

Many gases may be used in the practice of this invention such as nitrogen, air, propane, and the like. For a lubricant, powdered graphite, high-temperature silicon, oils such as rapeseed or cranbee, may be injected as a powder or spray with the gas. The gas pressure for horizontal continuous casting according to this invention should be less than 150 pounds per square inch for steel. The gas may perhaps also be injected in another form, such as oil or water, which would flash into a gas in the mold. Since the injected gas is an insulator rather than a coolant, it may be preheated if desired. The gas inlet pressure required to form the pocket **26** may be varied according to the hydrostatic pressure of the head of molten metal **13**.

This invention better lubricates the mold **20** in that it rapidly forces a lubricant to the area of solidification in the mold. The metal in contact with the mold wall at and beyond the area of solidification is not uniform and smooth so that the surface roughness of the forming billet allows the gas to readily escape from the open end of mold **20** between mold **20** and billet **30**. Square, round, rectangular, or other billets **30** may be formed according to this invention.

FIGS. **2** and **3** show a casting nozzle **40** which projects into a cooled mold **41**. A clearance **44** is formed between the outer surface of nozzle **40** and mold **41**. A refractory adapter **42** and a gas injection seal **43** are provided to inject gas from tubes **45** into the clearance **44**. The startup device of FIG. **2** has an asbestos ring **50** fixed to plate **51**. Plate **51** contains apertures **52** and is fixed to the starting head **53** a spaced distance away by means of bolt **54** and spacer **55** to form a chamber **56** containing scrap metal **57** to chill and solidify molten steel entering chamber **56** through apertures **52**. The starting bar **58** is connected to head **53** and passes between withdrawal rollers (not shown) as in FIG. **1**.

Gas is injected through tubes **45** and the starting head **53** is withdrawn as molten steel is flowed through casting nozzle **40** from an attached tundish (not shown). This molten steel **60** is cooled in mold **41** to form the billet **61**. While FIG. **3** shows a horizontal continuous casting operation in progress, this invention may just as easily be applied to vertical machines to prevent bridging and allow increased casting speed and control of the casting speed by control of the billet withdrawal rate. Support rollers and cooling sprays may be provided although they are not shown in FIGS. **2** and **3**.

While this invention has been shown and described in the best forms known, it will nevertheless be understood that these are merely exemplary and that modifications may be made without departing from the spirit and scope of the invention except as it may be more limited in the appended claims.

What is claimed is:

1. A process for continuous horizontal casting comprising the steps of flowing molten material to a substantially horizontal refractory casting nozzle discharging into a substantially horizontal open-ended cooled mold having a sidewall structure which is laterally spaced from said nozzle, and introducing a gas around the distal end of the casting nozzle under such pressure that the gas displaces the meniscus of the molten metal to form a pocket in the molten material around the end of the nozzle, and prevents formation of a solid bridge between the solidified shell of the billet being cast and the nozzle.

2. The process according to claim **1**, wherein the process is the continuous casting of steel.

3. The process according to claim **1**, wherein the gas escapes between the forming billet and the mold.

4. The process according to claim **1**, including the additional step of controlling the rate of flow of molten steel through the casting nozzle and the rate of formation of the billet by controlling the rate of withdrawal of the billet and from the mold.

5. The process according to claim **1**, wherein a lubricant is introduced with the gas into the mold.

6. The process according to claim **1**, wherein said gas is introduced at a pressure under 150 pounds per square inch.

7. The process according to claim **1**, wherein a reservoir of molten metal is connected to said nozzle, and there is provided the additional step of regulating the pressure of the gas to form said pocket in proportion to the head of metal in the reservoir.

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