

Nov. 28, 1967

O. B. ATKIN

3,354,936

CONTINUOUS CASTING PROCESS

Filed May 26, 1965

FIG. 1

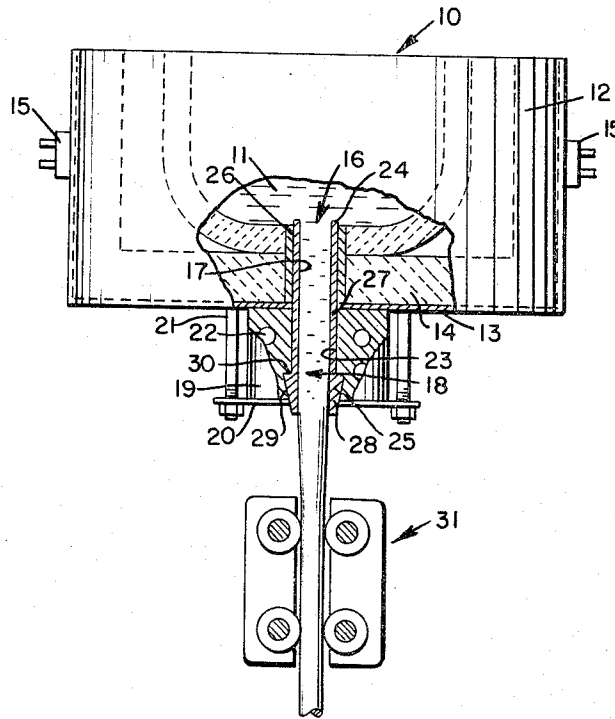
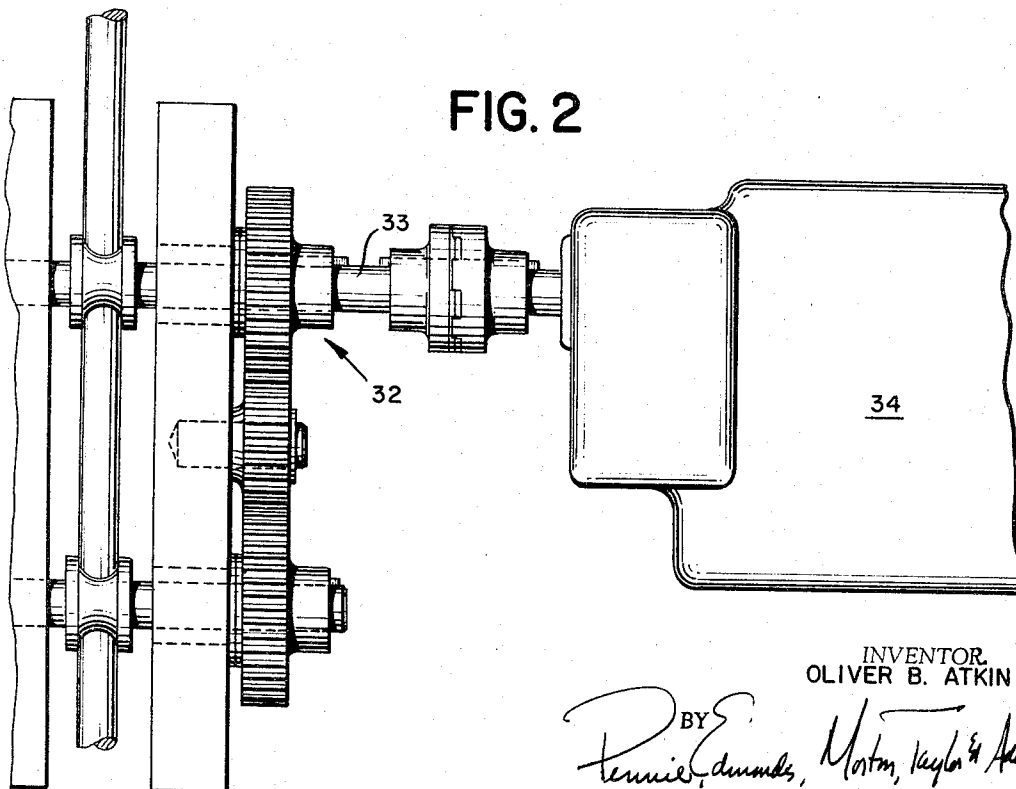


FIG. 2



INVENTOR
OLIVER B. ATKIN

BY *Pennie, Edmunds, Morton, Taylor & Adams*

ATTORNEYS

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CONTINUOUS CASTING PROCESS

Oliver B. Atkin, Hamden, Conn., assignor to Anaconda American Brass Company, a corporation of Connecticut
Filed May 26, 1965, Ser. No. 459,040
2 Claims. (Cl. 164—82)

ABSTRACT OF THE DISCLOSURE

A continuous casting process for preventing harmful surface deposits on castings commonly produced during the continuous casting of copper metal alloys having as one element a metal of a higher vapor pressure than copper wherein the metal having the high vapor pressure distills from the surface of the hot metal shape after solidification and condenses on the surface of the mold. In this process the metal shape is withdrawn in a first direction toward the exit end of the mold and is then cylindrically stopped and reversed to reabsorb the condensed metal on the reversed portion of the metal shape which is brought into juxtaposition with the condensed metal.

This invention relates to a continuous casting process, and more particularly, it relates to the prevention of harmful surface deposits on castings produced by the continuous casting of metal alloys having as one element a metal of relatively high vapor pressure which is segregated from the metal during casting and periodically reabsorbed on the surface of the metal shape.

In the continuous casting of metal alloys, particularly copper alloys, there occurs a troublesome segregation of certain metals from the surface of the casting which become deposited on the mold wall and are reabsorbed on the surface of the metal in a discontinuous pattern. This surface discontinuity is harmful in that it forms brittle spots on the casting. One theory on the mechanism by which the segregation of metal and subsequent reabsorption on the surface of the cast metal occurs is described in Metals Technology, volume 8, No. 2, in an article by Daniel R. Hull entitled, "Some Practical Observations on Inverse Segregations."

Attempts have heretofore been made in an effort to eliminate the surface discontinuities; one such process is described in U.S. Patent No. 2,740,177 and relates to intermittent withdrawal of a metal casting for the purpose of maintaining molten metal stationary with respect to a mold in a chill zone until the outer surface of the metal is frozen into a shell to prevent "bleeding" of metal constituents to the surface of the casting and freezing on the outer surface shell. I have found that this method does not completely solve certain surface discontinuities on the casting.

The operation of continuously casting metal shapes is initiated by pouring molten metal into a crucible of an assembly for maintaining the metal in its molten state. The crucible has an outlet, usually in the bottom, and has a mold in which the molten metal is shaped and solidified connected to the crucible outlet. The mold is usually open at both of its ends, and as the molten metal solidifies into the metal shape defined by the mold, it contracts away from the walls of the mold and, therefore, can be linearly withdrawn from the mold on a continuous basis.

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Because the molten metal contracts away from the walls of the mold as soon as it solidifies, a separation is formed between the walls of the mold and the metal shape. I have discovered that in the continuous casting of copper alloys for example, after the liquid metal has solidified in the mold during continuous casting, certain alloying elements, for example zinc, tin and lead, distill from the surface of the hot solidified casting because of their relatively high vapor pressure, and this metallic vapor condenses on the surface of the cold mold in the separation formed by the contraction of the metal shape. This condensed metal builds up to the point where it touches the solidified casting where it is reabsorbed as a ring of zinc-rich, tin-rich or lead-rich material on the surface of the casting. In one example, when casting with a 70% Cu-30% Zn alloy, localized ring portions formed by reabsorption of segregated zinc contained 30% Cu and 70% Zn; these local portions were very low in hot strength and ductility and the surface was easily broken along these portions and prolonged casting, say 20 minutes, will cause rods to break apart along the portions which reabsorbed the zinc.

I have found that by stopping and reversing the withdrawal of the casting periodically for a fraction of the time the casting is withdrawn, the build-up of condensed metallic vapor on the mold in the separation between the metal shape and the mold is reabsorbed by the casting long before it can accumulate and become harmful.

Broadly stated, the invention is a method of continuous casting metal shapes wherein molten metal is fed through a chilled mold, solidified within the mold and contracted away from the walls of the mold while being continuously fed therethrough. The improvement is in casting alloys which are alloyed with metals of differing vapor pressures so that the metal having the higher vapor pressure distills from the surface of the hot metal shape after solidification and condenses on the surface of the mold within the separation. The process is characterized by withdrawing the metal shape in a first direction toward the exit end of the mold and cyclically stopping and reversing the casting direction of the metal shape for a fraction of the time period of withdrawal, reabsorbing the condensed metal onto the reversed portion of the metal shape which is brought into juxtaposition with the condensed metal, and withdrawing the metal shape in the first direction again.

A preferred embodiment of the invention is described hereinbelow with reference to the drawing wherein:

FIG. 1 is a side elevation partly in section of continuous casting apparatus; and

FIG. 2 is an enlarged fragmentary side elevation of apparatus for withdrawing the metal shape being cast and cyclically reversing the direction of withdrawal.

The continuous casting apparatus shown in the drawing consists of a crucible 10 which is shown substantially filled with molten metal 11. The crucible is mounted within a holding furnace assembly 12 which is constructed of an outer metal sheet 13 and is lined with a heat insulating material 14. A plurality of burners 15 extend through the side walls of the holding furnace 12 at spaced intervals to supply the necessary heat to the crucible to keep the metal molten.

At the bottom of the crucible 10 is a crucible outlet 16 which leads into an elongated annular furnace opening 17. The annular opening extends through the insulating

material 14 and the outer sheet 13 at the bottom of the holding furnace assembly 12.

A cooling zone 18 below the crucible outlet is defined in part by a copper cooling block 19 which is supported on a plate 20, and the plate in turn is supported on a pair of threaded bolts 21 which depend from the bottom of the holding furnace assembly 12. The cooling block has a plurality of water passages 22 formed therein so that a coolant such as cold water can be circulated through the block to maintain it cooled during operation. An annular cooling block opening 23 extends axially and completely through the cooling block in co-axial alignment with the crucible outlet 16 and the annular furnace opening 17.

Positioned with its marginal inlet end 24 within the crucible outlet and extending through the annular furnace opening 17 and through the annular cooling block opening 23 and in co-axial alignment with the crucible outlet is a graphite mold 25. The mold is held in place in the crucible outlet 16 and the annular furnace opening 17 by a deposit of refractory cement 26. As shown, the inlet end 24 of the mold extends above the bottom of the crucible slightly for the reason that this extension will insure that the metal flowing into the mold will not be partially cooled by the crucible bottom; this is particularly important at the start. An intermediate portion 27 of the graphite mold is within the cooling zone and its marginal outlet end 28 extends outwardly from the bottom of the cooling block. The cooling block 19 surrounds a major length of the intermediate portion 27 of the graphite mold and is in heat exchange relationship therewith. At the marginal outlet end 28 of the mold is an outwardly flared portion 29 which seats in an annular recess 30 provided in the cooling block to retain the mold in the block against longitudinal displacement in the direction of travel of the metal shape passing therethrough. Spaced from the outlet end of the graphite mold are a set of rollers 31 which are powered to withdraw the metal shape from the mold.

In FIG. 2 the rollers 31 are shown connected to a common gear arrangement 32 for rotating the rollers together at the same speed and one of the gears is connected to a shaft 33 which is coupled with a reversible motor 34 for driving the rolls in either direction. Motor 34 can have a suitable gear reducer attached to it so that the rollers can be driven in either direction at the relatively slow speeds required for withdrawal of the metal shape.

In continuous casting, the molten metal is maintained in crucible 10 and the metal is gravity fed through the crucible outlet 16 into the mold 25 where it is cooled and solidified. The mold is kept cold by the cooling block, and as the metal solidifies it solidifies first on the outermost surface and continues to solidify progressively inward. Upon initial solidification the metal shape will contract away from the walls of the mold leaving a separation between the cast metal shape and the mold walls. It is theorized that upon initially breaking contact with the cool walls of the mold, there is a tendency for the metal shape repeatedly to expand in contact or near contact with the cooled walls of the mold again, at which position the metal shape contracts once again. There is a point at which substantial solidification has occurred leaving a separation between the metal shape and the walls of the mold.

After solidification, when casting with an alloy having at least one element with a relatively high vapor pressure, the metal distills out from the surface of the metal shape and the metal vapor condenses on the cold walls of the mold where it accumulates until reabsorbed on the surface of metal shape, usually in the form of a brittle surface defect. Examples of the alloys which experience this segregation of a metal during casting are copper alloys which are rich in zinc, tin, lead, or even sulfur or tellurium.

According to my method, the metal shape is withdrawn in a first direction toward the exit end of the mold in its normal casting direction for a time period which, dependent upon the alloy being cast, causes some amount of condensation of metallic vapor on the mold wall within the separation but not such an accumulation as will be harmful to the metal casting if reabsorbed on its surface. This time period must be determined empirically, based upon each alloy being cast and the degree of vapor distillation which takes place for a given length of time. The essential feature of the method is, however, that the metal shape is stopped and simultaneously reversed so that a portion of the freshly cast metal shape is brought in juxtaposition with the condensed metal on the mold wall and reabsorption of the condensed metal on the reversed portion on the metal shape takes place. It is theorized that upon reversal of the metal shape the reversed surface portion will contact the condensed metal and thereby become reabsorbed. This theory is based upon the assumption that the reversed portion is expanded to a slightly larger diameter and upon reversal will contact the condensed metal. By cyclically stopping and reversing the casting direction of the metal shape for a small fraction of the time period of withdrawal, the amount of reabsorbed metal is not harmful to the metal shape cast. The reversal is easily accomplished by an arrangement of standard parts as shown in FIG. 2.

The mold is preferably made of a graphite which has been treated to render it substantially non-porous. Other condense materials can be used provided the distilled metal cannot penetrate the material and they have good thermal conductivity, good rigidity and low thermal expansion. These graphite molds are also characterized by the property that they are not wet by copper alloys and therefore are particularly preferred when this method is used for the casting of copper alloys. It is thought that if the mold can be wet by the alloy (e.g. a metal mold) this periodic reversal of the metal shape will tend to impart physical defects on the surface of the metal shape during reversal.

In one example, a copper alloy containing 87% copper and 13% zinc was cast at a rate of 13" per minute. It was withdrawn in the casting direction for a time period of 3 seconds, and it was stopped and reversed for a time period of 1 second. This cyclical stopping and reversing effected about $\frac{1}{16}$ " reversal of the metal casting and this was sufficient to reabsorb the condensed zone from the cold mold wall.

In another example a copper alloy containing 90% copper and 10% tin was cast at a rate of 15" per minute. With this alloy a 20-second time period in the casting direction and a 1 second stopping and reversal period was sufficient to absorb the condensed tin before any harmful accumulations took place.

In a third example a copper alloy containing about 99% copper, 1% lead and .10% boron was cast at a rate of 15" per minute with a time period of 10 seconds in the direction of casting and 1 second for stopping and reversal. This effectively removed the condensed lead from the mold walls and reabsorbed it on the surface without causing harmful surface defects.

I claim:

1. In a method of continuously casting metal shapes wherein molten metal is fed through a chilled mold, solidified within the mold and contracted away from the walls of the mold while being continuously fed there-through, the improvement comprising casting copper metal alloys which are alloyed with metals having a higher vapor pressure than copper so that the metal having the higher vapor pressure distills from the surface of the hot metal shape after solidification and condenses on the surface of the mold within the separation formed by

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said contraction, said mold surface characterized by not being wet by the alloy being cast, withdrawing the metal shape in a first direction toward the exit end of the mold, cyclically stopping and reversing the casting direction of the metal shape for a fraction of the time period of withdrawal, reabsorbing the condensed metal onto the reversed portion of the metal shape which is brought into juxtaposition with the condensed metal, and with drawing the metal shape in said first direction again.

2. A method according to claim 1 characterized by 10

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said high vapor pressure metal being selected from the group consisting of lead, tin or zinc.

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J. SPENCER OVERHOLSER, *Primary Examiner*.

R. D. BALDWIN, *Assistant Examiner*.