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PROCESS AND APPARATUS FOR DEGASSING OF FLUID METALS

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FIG. 1

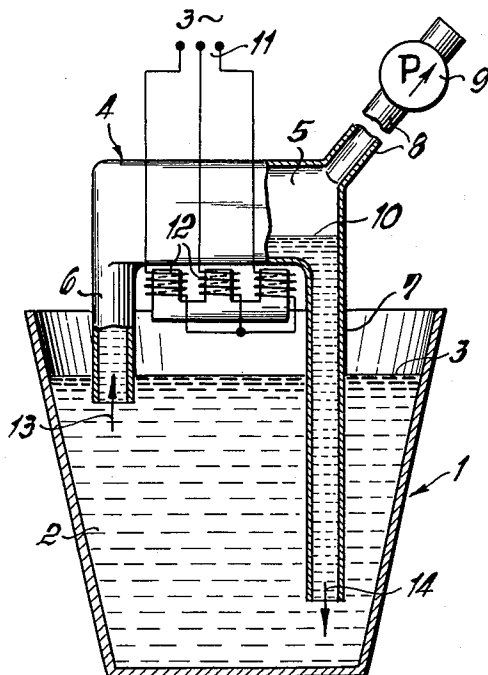
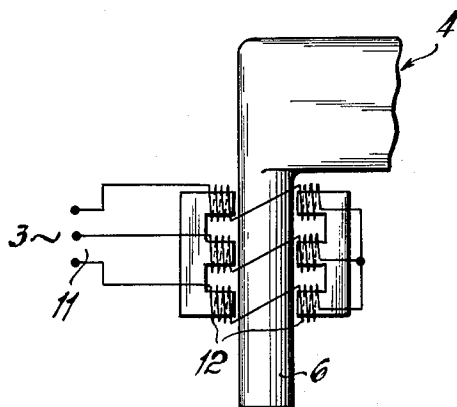


FIG. 2



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PROCESS AND APPARATUS FOR DEGASSING OF FLUID METALS

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2 Claims. (Cl. 266—34)

This application is a continuation-in-part of my application Serial No. 854,119, filed Nov. 19, 1959, now abandoned, for "Vacuum Degassing of Fluid Metals."

The present invention relates to a process and to an apparatus for degassing of fluid metals, and more particularly to degassing of molten metals by treatment at sub-atmospheric pressures.

It is already known to expel harmful gases from molten metals by passing such metals through an evacuated chamber in which the gases are withdrawn to improve the quality of the metal. In accordance with a process of which I have knowledge at this time, molten metal is caused to circulate from a casting ladle, through a vacuum chamber, and back to the casting ladle under the influence of a gaseous carrier which is being injected into the path of molten metal in a direction to entrain it toward the vacuum chamber. A serious drawback of this process is that the gaseous carrier must be separated from molten metal together with such gases which were entrapped in the metal prior to its contact with the carrier; therefore, the devices which evacuate gases from the chamber consume too much energy. Also, the gaseous carrier is normally an inert gas, such as argon, and the use of this gas in connection with the treatment of molten metal adds to the overall cost of the operation. Moreover, unless the gaseous carrier is heated in advance, it reduces the temperature of molten metal which is undesirable in most degassing operations.

It is also known to subject molten metal to the stirring action of a magnetic field produced by a single-phase current so that stirring will result in expulsion of some of the entrapped gases. However, this method is rather unsatisfactory because the energy requirements of the apparatus are very high and because the degassing action is not as effective as if the mass of metal is caused to pass through an evacuated chamber.

Accordingly, it is an important object of my invention to provide a very simple apparatus for degassing molten metals by vacuum treatment and to construct the apparatus in such a way that it can insure complete or highly satisfactory evacuation of gases with consumption of little energy and without appreciable cooling of molten metal.

Another object of the invention is to provide an apparatus of the just outlined characteristics which is constructed and assembled in such a way that the means which causes molten metal to circulate through an evacuated chamber is not exposed to excessive heat and that such means may actually heat molten metal on its way from the casting ladle through the evacuated chamber and back to the ladle.

A further object of the instant invention is to provide an apparatus for vacuum degassing of molten metals which occupies little space, which may be combined with nearly all types of existing casting ladles or other forms of receptacles for molten metal, which may operate with suction producing devices of small capacity, and which may be connected to commercially available sources of electrical energy without necessitating any converting means or similar expensive equipment.

An additional object of the invention is to provide a novel arrangement which is utilized in an apparatus of the

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above outlined characteristics to cause circulation of molten metal through an evacuated chamber.

Still another object of my invention is to provide a process for degassing molten metal, particularly steel, according to which large quantities of molten metal may be degassed within exceptionally short periods of time and in a continuous operation.

A further object of the invention is to provide a process of the just outlined characteristics according to which molten metal may be heated while it is caused to circulate through the evacuated chamber and according to which no additional gases must be introduced into molten metal in order to bring about circulatory movements thereof.

With the above objects in view, one feature of the invention resides in the provision of a process for degassing gas-containing molten metal in an evacuated chamber which is located above the level of molten metal. The process comprises the steps of establishing two separate paths through which the metal may communicate with the evacuated chamber whereby the metal rises in these paths in a fully automatic way due to pressure differential existing between said level and the chamber, and subjecting the risen metal to the action of a low-frequency rotating magnetic field so as to bring about circulation of metal upwardly through one of the paths, through the evacuated chamber where the metal is degassed, and downwardly through the other path.

The rotating magnetic field is produced by an electromagnetic arrangement which is preferably located entirely outside of the bath of molten metal and which comprises a source of polyphase alternating electrical energy and winding means adjacent to at least one of the aforementioned paths and/or to the evacuated chamber. The forces produced by the rotating magnetic field preferably act in the direction in which the metal circulates. A very important advantage of a low-frequency rotating magnetic field is that it can generate forces which can act directly on the body of molten metal in order to bring about circulation of metal in an endless path. Such forces cannot be generated by a magnetic field which is produced by direct current or by single-phase alternating current.

Mass-produced steels are degassed in the ladle or in the chill mold.

The novel features which are considered as characteristic of the invention are set forth in particular in the appended claims. The improved degassing apparatus itself, however, both as to its construction and its method of operation, together with additional features and advantages thereof, will be best understood from the following detailed description of certain specific embodiments with reference to the accompanying drawings, in which:

FIG. 1 is a vertical section through a degassing apparatus which embodies one form of the invention; and

FIG. 2 is a fragmentary elevational view of a modified degassing apparatus.

Referring now in greater detail to the drawings, and first to FIG. 1, there is shown a degassing apparatus which comprises a receptacle here shown as a fixed ladle 1 which contains a bath of molten metal 2, e.g., steel. The upper level 3 of the bath is maintained at atmospheric pressure. The apparatus further comprises a housing 4 which defines an evacuated chamber 5 and which is connected with two downwardly extending pipes 6, 7. Each of these pipes communicates with the chamber 5 and each thereof has a lower end which dips into the bath 2 at a different level. The housing is further connected with a conduit 8 which leads to the low-pressure side of a suction producing pump 9 serving as a means for withdrawing gases from the chamber 5 whereby the metal rises in a fully automatic way and fills the chamber up to a level 10.

The means for causing molten metal to circulate in an endless path including the separate paths defined by the pipes 6, 7, the path defined by the receptacle 1 and the path defined by the housing 4 includes an electromagnetic arrangement which is located entirely outside of the body of molten metal. The arrangement comprises a source 11 of low-frequency polyphase alternating electrical energy which is connected in circuit with a winding 12, and this winding is outwardly adjacent to the housing 4. When the circuit of the winding 12 is completed, the mass of molten metal which has risen into the chamber 5 is caused to circulate in the aforementioned endless path by flowing upwardly through the path defined by the pipe 6 (arrow 13), through the chamber 5 where it is degassed under the action of the pump 9, thereupon downwardly through the path defined by the pipe 7 (arrow 14), and back into the receptacle 1.

FIG. 2 illustrates a portion of a modified degassing apparatus wherein the winding 12 surrounds the pipe 6. Of course, it is equally possible to provide an additional winding around the pipe 7 and/or to provide the winding of FIG. 2 in addition to the winding of FIG. 1.

The exact level of molten metal in the chamber 5 (see the numeral 10) depends on the action of the pump 9. The electromagnetic arrangement 11, 12 acts not unlike a circulating pump, and the physical laws on which the operation of my improved apparatus is based are the same as in the transmission of forces to the rotor of an asynchronous polyphase alternating current motor. The circulating body of metal is analogous to the rotor while the stator winding which produces the rotating magnetic field corresponds to the stators of a similarly phased motor. As a rule, the winding 12 is cooled by compressed air or water and, if necessary, the winding may be protected from heat which is being radiated from the bath. The rotating magnetic field merely brings about circulatory movement of the bath; the work necessary to cause molten metal to rise into the suction chamber 5 is performed by the suction producing pump 9.

In accordance with my process, the flow of molten metal through the evacuated chamber 5 is continuous so that the entire contents of the receptacle 1 are degassed within a short period of time. Furthermore, a portion of the energy produced by the rotating magnetic field is converted into heat so that the degassing operation actually results in inductive heating of the bath. By proper selection of electrical and geometric parameters, it is possible to avoid heat losses and to carry out the operation without necessitating additional heating of molten metal.

The reason for utilizing pipes of different lengths (i.e., pipes whose lower ends dip into the bath at different levels and preferably at a considerable distance from each other) is that such arrangement prevents freshly degassed metal from entering the pipe 6. In other words, by utilizing pipes which dip into molten metal at different levels, the degassing operation may be completed within exceptionally short periods of time because the likelihood of circulating the one and the same batch of molten metal is reduced to a minimum.

Since the effect of forces which the rotating magnetic field exerts upon the circulating metal is greater at lower frequencies, the method of my invention may be carried out by operating at mains frequency, for example, with a 50-cycle polyphase supply, so that I need not resort to frequency converters and all phases of an existing polyphase supply are uniformly loaded.

In summation, it can be said that the apparatus of my invention exhibits the following advantages:

It may be operated with little supervision and its operation is continuous so that the time necessary for degassing a given batch of molten metal is reduced to a minimum with attendant savings in heat energy because the length of intervals during which the metal is likely to cool is very short. The circulating mass of molten metal is subjected to inductive heating which compensates for at least

some temperature losses; the electromagnetic arrangement may operate at mains frequency; batches of newly degassed material are separated from non-degassed batches to speed up the degassing operation; the evacuating chamber need not be moved toward or away from the receptacle or vice versa so that the construction of the apparatus is simplified; and a small suction producing pump is sufficient to degasify large batches of molten metal within short periods of time.

Moreover, since the operation of my apparatus is based on the recognition that the means (pump 9) for causing molten metal to rise into the evacuated chamber 5 may be entirely independent of the means (11, 12) which causes the metal to circulate in an endless path, the circulation producing means may be mounted at a point where it is best protected from radiation heat and where it is readily accessible for inspection. In other words, all component parts of the circulation producing means may be located externally of and need not be in contact with molten metal. The lower the frequency of the rotating magnetic field the deeper its energy enters the interior of the molten metal and the more evenly the forces are distributed within the molten metal. That is why a low-frequency rotating magnetic field will exert greater forces on the molten metal than a higher-frequency rotating magnetic field.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can, by applying current knowledge, readily adapt it for various applications without omitting features that, from the standpoint of prior art, fairly constitute essential characteristics of the generic and specific aspects of this invention and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the following claims.

What is claimed as new and desired to be secured by Letters Patent is:

1. An apparatus for degassing molten metal comprising a receptacle having a bottom wall and adapted to contain a bath of molten metal having an upper level; an elongated housing defining a chamber which is disposed above said receptacle, said housing having a pair of opposite ends; a pair of pipes communicating at the upper ends thereof with said chamber respectively at said opposite ends of said housing and extending downwardly from said chamber so as to dip into molten metal in said receptacle, said pipes having lower ends spaced transversely and vertically from each other to communicate with the bath respectively adjacent said upper level thereof and adjacent said bottom wall of said receptacle; suction producing means connected with said housing the reduce the pressure in said chamber to cause molten metal to rise from said receptacle into said chamber; and an electromagnetic arrangement for producing a low frequency rotating magnetic field effective to cause molten metal to flow in an endless path from said receptacle through one of said pipes, through said chamber, through the other pipe, and back to said receptacle whereby the metal is degassed by flowing through said chamber, said arrangement comprising a source of polyphase alternating electric energy and a plurality of separate electromagnetic means arranged adjacent to said path and spaced from each other along portions of said path and electrically connected to the source of alternating current to produce a rotating field moving in direction of said path.

2. An apparatus for degassing molten metal comprising a receptacle having a bottom wall and adapted to contain a bath of molten metal having an upper level; a housing defining a chamber which is disposed above said receptacle, said housing having a pair of opposite sides; a pair of pipes communicating at the upper ends thereof with said chamber respectively at said opposite sides of said housing and extending downwardly from said chamber so as to dip into molten metal in said receptacle, said pipes having lower end spaced from each other to each

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communicate with the bath at a level intermediate said upper level thereof and said bottom wall of said receptacle; suction producing means connected with said housing to reduce the pressure in said chamber to cause molten metal to rise from said receptacle into said chamber; and an electromagnetic arrangement for producing a low frequency magnetic field effective to cause molten metal to flow in an endless path from said receptacle through one of said pipes, through said chamber, through the other pipe, and back to said receptacle whereby the metal is degassed by flowing through said chamber, said arrangement comprising a source of polyphase alternating electric energy and a plurality of separate electromagnetic means arranged adjacent to said path and spaced from each other along portions of said path and electrically connected to the source of alternating current to produce a rotating field moving in direction of said path.

nected to the source of alternating current to produce a rotating field moving in direction of said path.

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