

Sept. 1, 1964

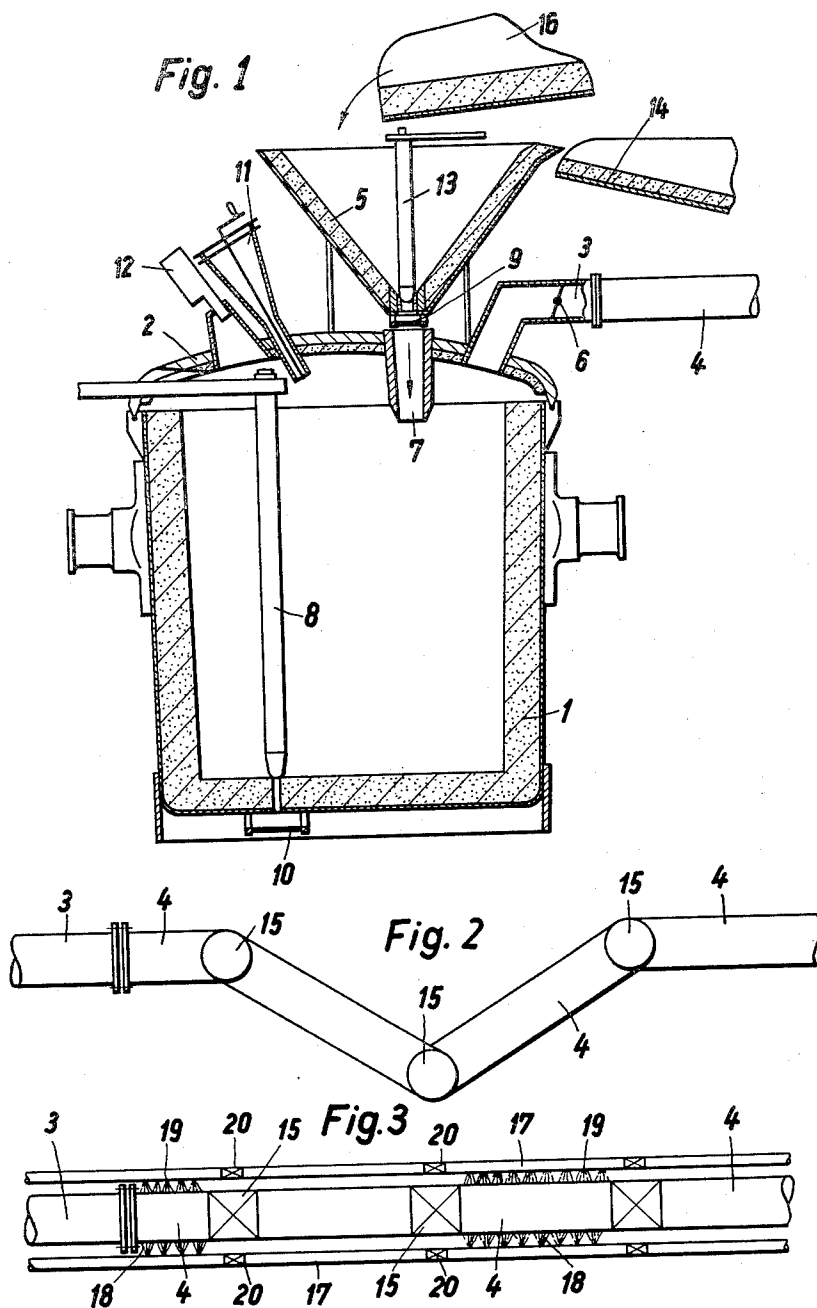
A. SICKBERT

3,146,503

DEGASIFICATION OF METAL

Filed Sept. 27, 1961

4 Sheets-Sheet 1



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4 Sheets-Sheet 2

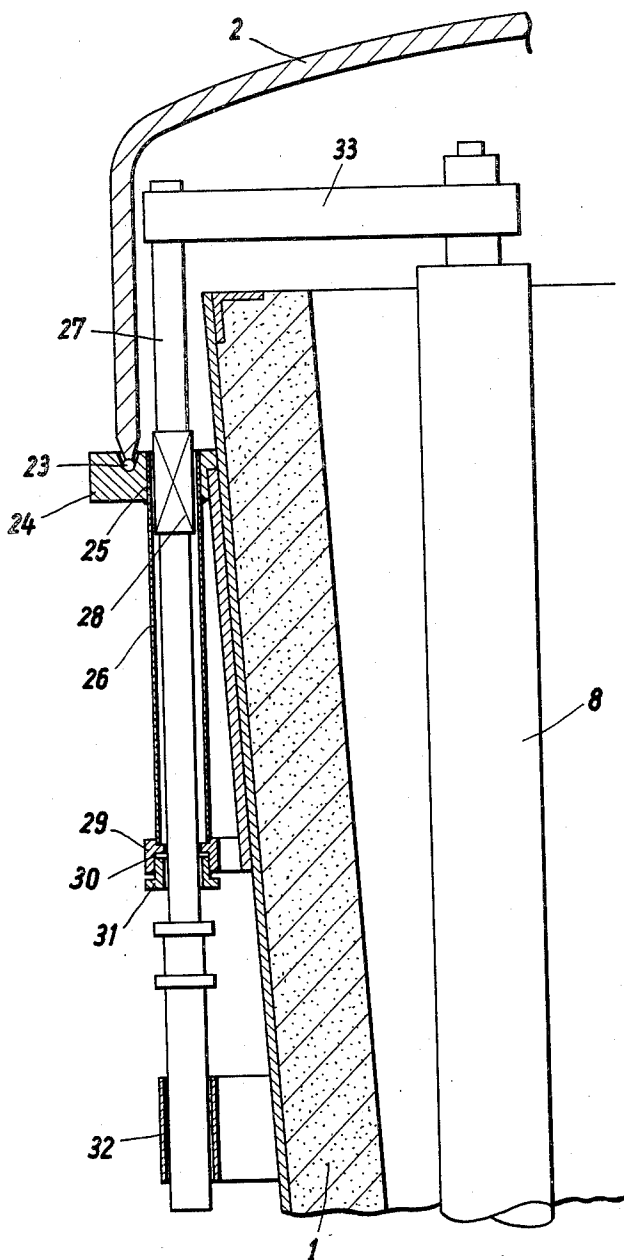


Fig. 4

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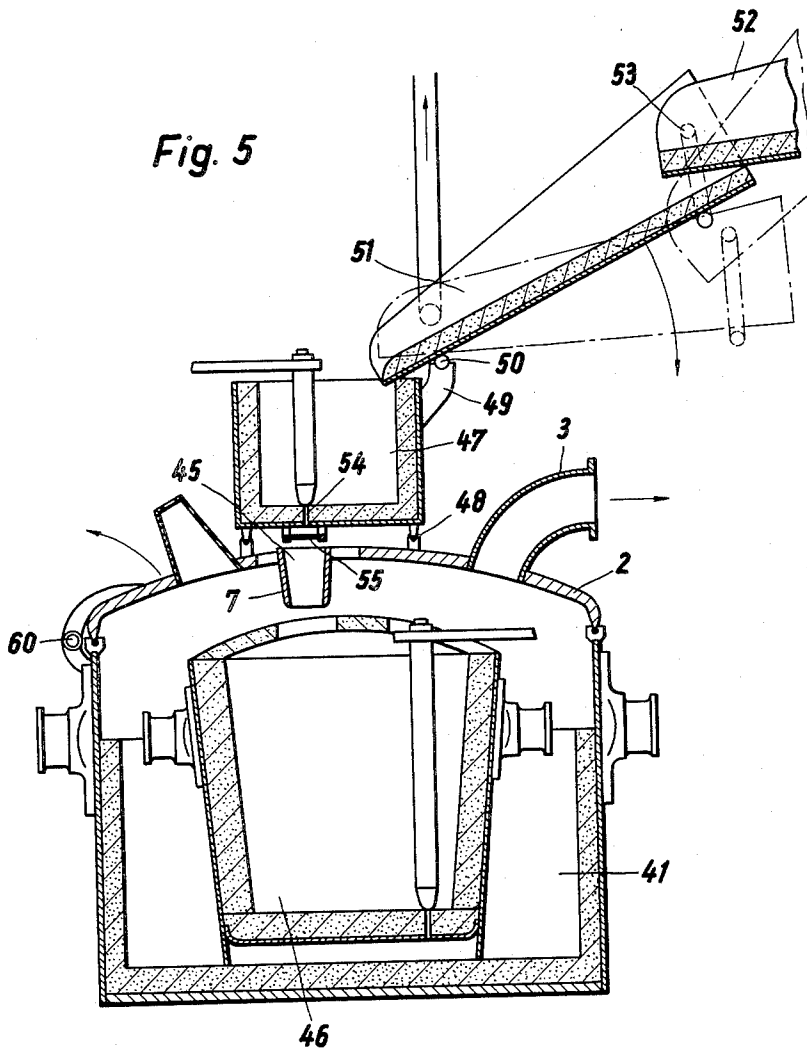
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4 Sheets-Sheet 3



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4 Sheets-Sheet 4

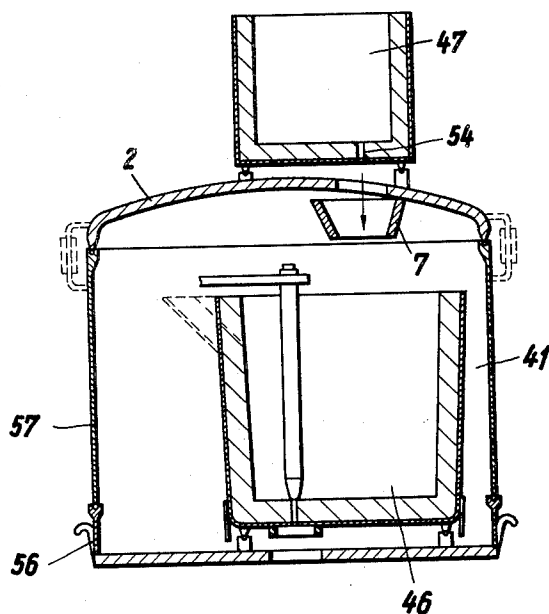


Fig. 6

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3,146,503

DEGASIFICATION OF METAL

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6 Claims. (Cl. 22-85)

The present invention relates to the degasification of metal, for example steel.

Methods have been previously proposed for degassing metal such as steel in which the molten metal is passed to a degassing device in a transport ladle, said degassing device consisting of a vacuum chamber and a charging ladle which is fitted vacuum-tight onto the chamber.

In one known method of this kind steel is electrically heated in the charging ladle and then flows through the outlet of this ladle into a casting ladle inside a vacuum chamber (see U.S. patent specification 2,253,421). If it is not desirable to heat the charging ladle electrically the loss of temperature incurred during the period of degassing has to be made up for by a considerable superheating of the melt in the furnace. When applying different degassing processes where reduced pressure is used it is also necessary to account for the loss of temperature by additional heating. The longer the melt stays in these containers before it is finally cast in moulds the higher the loss of temperature will be. These necessary and unavoidable excess temperatures require an additional furnace time (heating time), they cause an increased wear of the refractory lining and prolong the duration of the process prior to the casting operation.

The present invention is based on the fact that the otherwise necessary high superheating of the melt can be avoided to a large extent. It is moreover based on the realisation that the lower the content of deoxidizing agent in the steel the quicker and more complete the degassing process will be. Furthermore a process has already been proposed whereby a jet of unkilld steel which is subdivided into little drops is introduced into a vacuum. It was found that it is possible, when carrying out this process in a certain way, to obtain steel the properties of which are such that it can be cast into satisfactory castings at that stage already without any further treatment.

According to one form of the present invention there is provided a process for degassing metal under vacuum which comprises melting the metal without applying a vacuum, conveying the molten metal from a tapping device to a relatively small feeding device mounted vacuum tight on a vacuum chamber and allowing the molten metal to pass from the feeding device into the vacuum chamber wherein the molten metal is subjected to a stream degassing operation. The process is applied with advantage to steel. The relatively small feed device may be funnel shaped.

According to another form of the present invention there is provided an apparatus for carrying out the process, which comprises a tapping device cooperating with a relatively small feeding device mounted vacuum tight on a vacuum chamber, the vacuum chamber being evacuable by evacuating means. The vacuum chamber may be so designed as to serve both as vacuum chamber and as tapping ladle.

According to a further form of this invention there is provided a tapping ladle comprising a stopper device, guiding means for controlling the movement of the stopper, and a vacuum-tight cover, the tapping ladle being designed to serve both as tapping ladle and as a vacuum chamber.

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The size of the said relatively small feeding device is kept as small as possible so that it cannot absorb much heat. Furthermore only its lower part need be constantly filled with molten metal. When tapping the metal which may be melted in an electric furnace, the outflow rate of the melt is adjusted to correspond to the volume of the said feeding device and its discharge opening. Preferably the molten metal passes through the feeding device quickly. If the pump capacity is sufficient the discharge opening of the feeding device can be left open, as the pump will quickly enough create the necessary vacuum after the discharge opening has been sealed off by the molten metal. But if desired the discharge opening can be provided with a temporary sealing device, for example a meltable membrane, a valve, for instance a slide valve and/or a stopper rod.

The feeding device is fitted vacuum-tight on the top of the vacuum chamber. This top of the vacuum chamber should have an opening under the discharge opening of the feeding device.

The vacuum chamber may be so designed as to serve both as vacuum chamber and as a tapping ladle. Thus a suitable ladle having a vacuum-tight cover may be constructed so that a vacuum can be created within the ladle. However, if desired, the vacuum chamber may contain a tapping ladle.

If the tapping ladle is fitted with a stopper device, sealing means may be provided underneath the stopper device. When using such a ladle it is advisable to provide an anti-splash device between the bottom of the relatively small feeding device and the vacuum chamber, the anti-splash device passing through the top of the vacuum chamber. The anti-splash device serves to protect the ladle stopper device from damage by the inflowing molten metal.

It is also advisable in one embodiment of this invention to cover the ladle contained in a vacuum chamber with a heat insulation slab which is provided with an opening for the inflowing molten metal and which slab should remain on the ladle until a subsequent casting operation is finished.

In another embodiment of this invention, instead of using the cover for sealing the tapping ladle directly it can however, also be used for sealing the vacuum chamber into which the ladle is placed.

In one preferred embodiment, the apparatus to be used consists essentially of a tapping ladle, fitted with a nozzle or a stopper device, which ladle is constructed as a vacuum-tight chamber and is provided with a vacuum-tight closing cover. It is expedient to provide the cover with a connecting tube to connect with a vacuum suction pipe. Furthermore a relatively small feeding device which is preferably constructed as a feed hopper is arranged on the cover of the vacuum chamber. Preferably this relatively small feeding device is detachable and may be fitted onto the cover with the necessary sealing devices.

In another preferred embodiment, the apparatus consists essentially of a vacuum chamber for receiving the tapping ladle and which is fitted with a vacuum-tight cover. Furthermore it consists of a preferably detachable, relatively small feeding device and as tapping device, a chute cooperating with the feeding device with the tapping furnace, or as tapping device a transport device for transporting the molten metal from a tapping furnace to the feeding device during the tapping operation.

Preferably the vacuum chamber is adapted to be transportable and for this purpose is preferably provided with for example supporting journals for engagement with the casting crane, or is so constructed to be readily movable. It is expedient here for example to have flexible connecting tubes and/or flexible suction pipes which con-

sist preferably of swivel joint or ball-and-socket joint like links.

If necessary, especially when treating unkilld steel, the pipes connecting the vacuum chamber with the pumping unit are cooled appropriately during the tapping operation, preferably by means of compressed air pipes which run along the suction pipe and the outlet orifices of which are directed towards the suction pipe.

The present invention also provides for the possibility of using one pumping unit for two vacuum treatments if treatment during the tapping operation as well as during the subsequent casting operation in moulds, e.g. ingot moulds, ceramic moulds or continuous casting moulds, is to be effected under vacuum. For this purpose a further suction tube can branch off the pumping unit or off the pipe leading to the degassing device. One or more of such pipes as well as one or more connecting members may be provided with shut-off means, so that such a pipe or connecting member can be switched to the particular device where the vacuum is needed.

When the tapping operation is completed the metal, e.g. steel, can be cast into moulds for instance ingot moulds or continuous casting moulds which are in the presence of air, a protective gas or under vacuum. Furthermore a deoxidizing or alloying agent may be added to the molten metal before, during or after the degassing operation. When treating steel this can be tapped either unkilld, partly deoxidized, or completely deoxidized. This can apply to other metals also.

If steel is tapped in its unkilld state the degassing will be particularly effective. Until now it was rather dangerous to transport completely unkilld steel in the tapping ladle because the steel would very easily boil up in the ladle. According to the present process, however, even completely unkilld steel can generally be transported without any appreciable danger.

In a preferred embodiment of the process, the steel which is to be degassed by vacuum treatment is melted in known manner, for example in an electric or open-hearth furnace, or in a converter. The steel may flow from the furnace in a deoxidized, partly deoxidized or unkilld state; the deoxidizing agent or agents can be added through a feeding device (vacuum-tight sluice). If desired, one or more alloys such as titanium, niobium, boron, aluminium, can also be introduced. If the steel is tapped in its unkilld state the degassing operation will be particularly effective, because a greater part of the deoxidizing process takes place over the deoxidizing gaseous phase CO of the carbon when the molten metal is introduced into the vacuum chamber. It is known that this reaction is supported if the inflowing jet is subdivided into small drops which provide a large reaction surface. The deoxidizing and/or alloying agent(s) can be added before or during or after the vacuum treatment. Deoxidizing and/or alloying agents can also be added to the molten metal when casting it into moulds or ingot moulds afterwards.

In another embodiment of this invention, a chute is used to connect the tap hole of the melting furnace with the upper edge of the relatively small feeding device. This chute may be provided with a suspension device so that it can be lowered according to the degree the chute is lowered. The part of the chute that is nearest to the feeding device may rest on an anti-frictional guiding device which may be mounted on or near the feeding device.

If it is not desirable to use a tapping chute the vacuum chamber may be mounted on a crane or fitted with wheels in order to adjust and control the distance between the furnace tap hole and the relatively small feeding device during the tapping operation.

In the case of a vacuum tapping ladle which is designed to have a stopper device, e.g. stopper rod, it is of particular importance that the bearing for the stopper device, e.g. stopper rod, is made vacuum-tight.

In a preferred embodiment of this invention a vacuum-tight casing is provided for the guide rod for the stopper rod along the outside wall of the ladle. At the top this casing is connected vacuum-tight in a bore in a flange, which flange is needed with such ladles for the sealing against the cover of the ladle. The lower end of the casing is provided with a vacuum sealing device which encloses the guide rod, which in turn has a circular cross-section. Preferably the sealing device is designed as a packing box. It is expedient to use a particularly soft packing gland. During the vacuum treatment in the tapping ladle the sealing device is tightly screwed onto the soft gland by means of a cap nut, and has to be loosened before starting the casting operation to permit an easier movement of the rod.

In a further embodiment of this invention the suction pipe between the vacuum pumping unit and the vacuum chamber of vacuum tapping ladle may be cooled. In certain cases this cooling may be limited to the vicinity of the tapping ladle. Cooling is particularly expedient when treating steel, and especially when treating unkilld steel.

According to one embodiment of this invention the cooling effect is achieved by means of pipes which blow air onto the suction pipe, the air being supplied by nozzles. In the case of flexible lines these pipes are appropriately fitted along the lines. In the case of lines with swivel joint or ball-and-socket joint-like parts the pipes for the cooling agent can be correspondingly flexible and follow the bends of the flexible suction tube.

According to another embodiment of this invention the same pumping unit can be used for the first vacuum treatment after the tapping as well as for a subsequent or all subsequent degassing operations. The need for such subsequent degassing operations which are preferably carried out at lower rates of pressure arises particularly in the case of casting from the vacuum tapping ladle. As the larger portion of the gas has been removed during the vacuum treatment after the tapping operation it is possible and very advantageous to apply a particularly low pressure when vacuum casting from the tapping vacuum ladle, so that the pressure is well below that used previously in the vacuum tapping ladle.

The present invention can be carried out in several different ways.

If only one line (flexible) is used this line can be provided with a connecting member which can be connected with both the vacuum tapping ladle and the vacuum feeding device.

However it is also possible to provide a second suction pipe to the vacuum feeding device which branches off from the pumping unit or from the suction pipe of the pumping unit which leads to the vacuum tapping ladle.

In the latter case, a possibility has to be provided for switching the suction pipes on and off individually, which can for example be achieved by means of a vacuum-tight shut-off valve which is fitted in each of the suction pipes. This advantageous mode of operation constitutes an essential simplification of the dual degassing process—the first of which is carried out after the tapping and the second during the subsequent casting process from the tapping ladle into moulds, ingot moulds or continuous casting moulds, under vacuum.

With respect to the above mentioned possibility of applying a continuous casting method after the degassing process the following has to be noted in the case when unkilld or partly deoxidized steel is used.

In an embodiment of this invention the unkilld or partly deoxidized steel flowing from the melting device into the tapping ladle which is designed as a vacuum chamber, can be subjected to low pressure during the tapping operation, after which the ladle can be used as a casting device for continuous casting. This method allows the thickness of the non-segregated surface zone to

be determined by adjusting the pressure accordingly. The casting into slabs, billets or bars is effected in a known way in the presence of air or protective gas and preferably with the aid of a tundish. In most cases the pressure will be adjusted so as to allow for a considerably large unsegregated zone to remain inside the slab, billet or bar. If desired the process can be controlled so that the casting solidifies practically unsegregated across its whole cross-section.

This method described immediately above offers the particular advantage of heat economy. Despite an additional operation—the evacuation—no substantial loss of heat is incurred as compared with the conventional continuous casting methods. Furthermore this treatment makes it possible to adjust differences in quality between the individual melts which usually occur in continuous production and to improve the overall quality which results in a uniform quality of the slab, billet or bar and of the finished products made therefrom, e.g. strip or wire.

The accompanying drawings show various embodiments of the this invention.

FIG. 1 shows in diagrammatic sectional elevation an apparatus comprising a tapping vacuum ladle, i.e. a device in which a vacuum is created only within the ladle;

FIG. 2 shows diagrammatically in side elevation a flexible line between the vacuum chamber and the pumping unit (not shown);

FIG. 3 shows diagrammatically in plan view a cooling device for the flexible line according to FIG. 2;

FIG. 4 shows in diagrammatic sectional elevation an apparatus comprising a vacuum-tight stopper guiding means for a vacuum tapping operation according to FIG. 1;

FIG. 5 shows in diagrammatic sectional elevation an apparatus comprising a tapping ladle inserted and enclosed by a vacuum chamber; and

FIG. 6 shows in diagrammatic sectional elevation a modification of the apparatus illustrated by FIG. 5.

Referring to FIG. 1, a tapping ladle 1 which is designed as a vacuum-tight chamber has a vacuum-tight cover 2 which is provided with a connecting tubular elbow 3 to connect the cover 2 with suction pipe 4. Connecting elbow 3 is also provided with a valve 6. Connecting elbow 3 and/or suction pipe 4 is/are made of a flexible material and is/are preferably fitted with swivel joint or ball-and-socket joint like links 15 (according to FIG. 2). Arranged on cover 2 is a relatively small funnel-shaped feeding device 5, the stopper rod 13 of which is optional. Under the discharge opening of the feeding device 5 a sealing device 9 is fitted which can be removed when the melt is introduced. Underneath the outlet of the feeding device 5 an anti-splash device 7 is provided which protects the stopper device 8 from damage. A sealing device 10 is fitted under stopper device 8. Furthermore a feeding means 11 is provided for the addition of an alloying or deoxidizing agent and a TV camera 12 to permit control of the degassing operation. The feeding device 5 is connected to an overflow chute 14, especially for slag.

The flexible connection according to FIG. 2 is not shown in FIG. 1. It is needed for example during the tapping operation when it allows the apparatus to follow the movements of a tapping chute 16. According to FIG. 2 the flexible pipe consists of tubular members 4 which are connected by links 15, in this case swivel joints.

After the completion of the tapping operation the cover 2 can be removed, and the casting operation can be effected in the usual way. It is however, also possible to disconnect the connection with the pumping unit, then remove the whole apparatus and proceed with the casting operation with the cover still on.

Whereas FIG. 2 is a side view of the flexible pipe, FIG. 3 shows the same pipe in a plan view. According to FIG. 3 pipes 17 are disposed along tubular mem-

bers 4 of the flexible suction line, and a cooling agent 18 can be blown onto the tubular members 4 of the suction line through openings 19. The cooling pipes 17 are also provided with links 20 so that they can follow the movement of tubular members 4 and links 15.

FIG. 4 shows an embodiment of a vacuum-tight guiding means for the stopper rod of a tapping vacuum ladle 1. This ladle is provided with a cover 2 which rests in a sealing member 23 in a flange 24. This flange 24 has a bore 25 into which the casing 26 of the stopper rod guiding rod 27 is fitted in a vacuum-tight manner. The cross-section of the portion of rod 27 near flange 24 is angular, but it changes and becomes circular near point 28. At the lower end of casing 26 a packing box 29 is connected vacuum-tight with the casing 26 by means of a soft packing 30 and a cap nut 31. The guiding rod 27 is fitted with another guiding means 32. As usual the guide rod 27 is connected with a crosshead 33 which in turn is connected with stopper rod 8.

FIG. 5 shows an apparatus in which a tapping ladle 46 is inserted into a vacuum chamber 41 which is provided with a cover 2.

In this case the cover 2 is hinged to the vacuum chamber 41 by means of joint 60 so that it can be moved back when the chamber 41 is opened. Furthermore a feed opening 45 is provided in the cover 2 with an anti-splash device 7. A relatively small feeding device 47 is fastened onto the cover 2 in a vacuum-tight manner at 48. The feeding device 47 is also provided with a bracket 49 which has a guiding means 50 for a connecting chute 51. This connecting chute is connected to tapping spout 52 by means of links 53 so that it can be lowered to the position shown in chain dotted lines in accordance with the lowering of the tapping spout. The connecting tube for the suction pipe is denoted 3.

FIG. 6 represents a vacuum chamber 41 which consists of a base plate 56, a centrepiece 57 and a cover 2. In this case a feeding device 47 is sealed neither by a stopper above the outlet 54 nor by a sealing device beneath the outlet 54. Consequently the first charge of molten steel that enters the feeding device 47 has to seal off the outlet 54 before a very efficient pumping unit starts operating and evacuates the container 41.

It is also possible to design a vacuum chamber, the centrepiece 57 and the cover 2 of which constitute one unit, so that a sealing device is only needed at the base plate 56.

It may be mentioned here that especially when degassing unkill steel the anti-splash device referred to in the particular description and illustrated in the drawings may be formed as a double-walled tube in case of damage by the molten steel to the inner wall.

It is possible to combine the degasification with a desulphurizing treatment. Known desulphurizing means, such as a mixture of lime and fluorspar, may be added into the tapping ladle before and/or during tapping. F.i., a steel having a sulphur content of 0.015% was treated with a mixture of 4 parts lime and 1 part fluorspar in a quantity of 2% of the steel weight. The final sulphur content was 0.003%.

What I claim and desire to secure by Letters Patent is:

1. In a tapping ladle provided with a discharge opening through its bottom and having an axially movable stopper rod for control of the discharge opening, in combination therewith, the improvement which comprises a sealing flange surrounding said ladle, a cover removably positioned in vacuum-tight engagement with said sealing flange, a tube extending alongside said ladle through said flange, an axially movable control rod extending through said tube into said cover, a cross member connecting said control rod and said stopper rod and a sealing member forming a vacuum-tight sliding seal between said control rod and tube.

2. Improvement according to claim 1 in which said

tube and control rod have corresponding non-circular adjacent cross-sectional areas to allow a sliding non-rotating fit therebetween.

3. Improvement according to claim 2 in which the portion of said tube extending through said flange has a non-circular cross-sectional shape and the adjacent portion of said control rod has a correspondingly shaped cross-sectional shape. 5

4. Improvement according to claim 3 in which said sealing member is a packing gland positioned at the lower end of said tube. 10

5. Improvement according to claim 1, in which said sealing member is a packing gland positioned at the lower end of said tube.

6. Improvement according to claim 1, said sealing member including a packing box fixedly secured with respect to the tube, packing material within the packing box, and a cap nut adjustable between a first position in which the packing material tightly grips the 15

control rod assuring a vacuum-tight seal and a second position permitting movement of the control rod to actuate the stopper rod.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,146,503

September 1, 1964

Adolf Sickbert

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 4, line 18, for "of vacuum" read -- or vacuum --.

Signed and sealed this 9th day of February 1965.

(SEAL)

Attest:

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Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents