

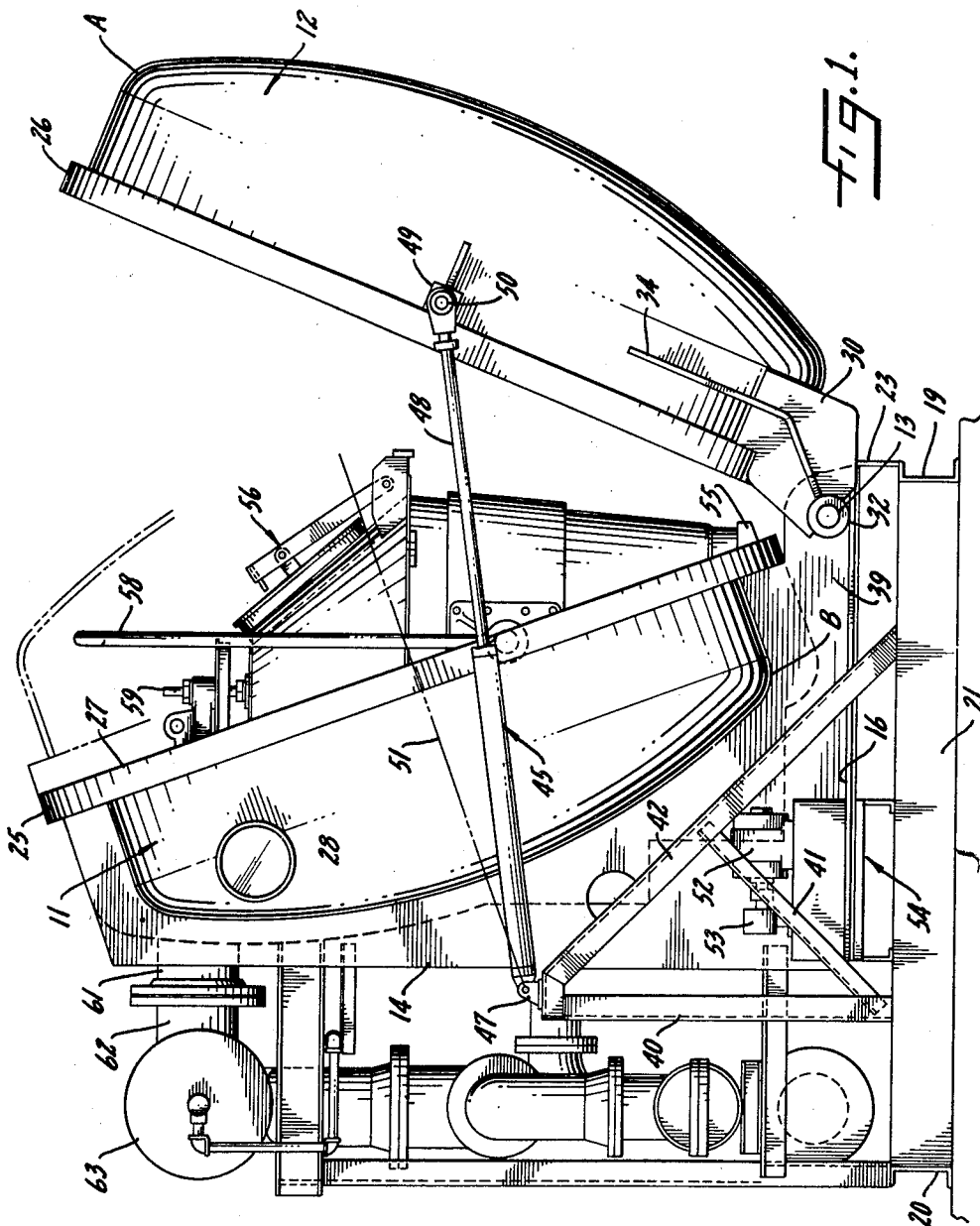
July 20, 1965

H. S. PHILBRICK, JR  
VACUUM DEGASSING SYSTEM

3,195,873

Filed March 27, 1961

3 Sheets-Sheet 1



INVENTOR.  
*Herbert S. Philbrick, Jr.*  
BY *Parker & Carter*  
*Attorneys.*

July 20, 1965

H. S. PHILBRICK, JR  
VACUUM DEGASSING SYSTEM

3,195,873

Filed March 27, 1961

3 Sheets-Sheet 2

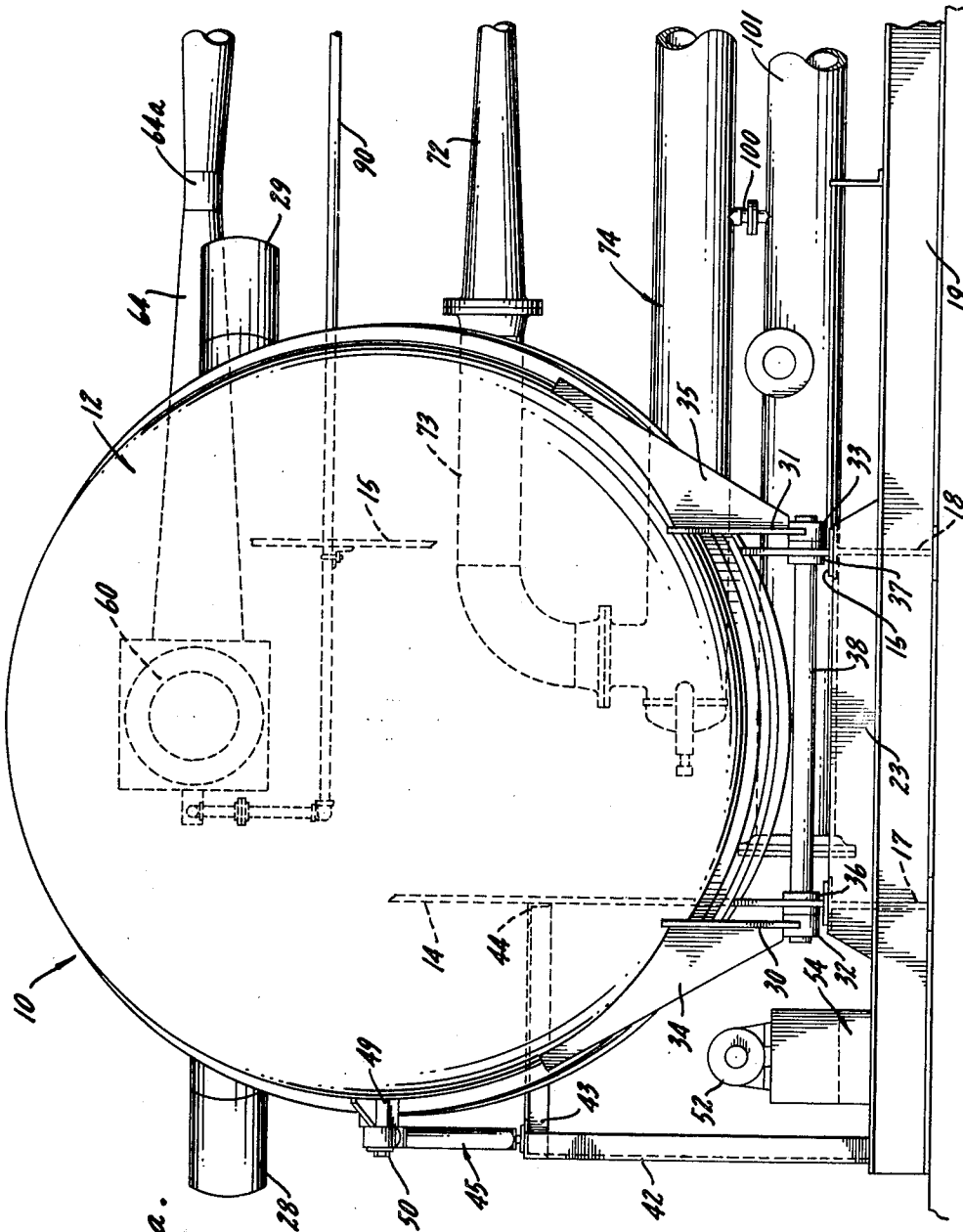


FIG. 2a.

INVENTOR.  
Herbert S. Philbrick, Jr.  
BY Parker & Carter  
Attorneys.

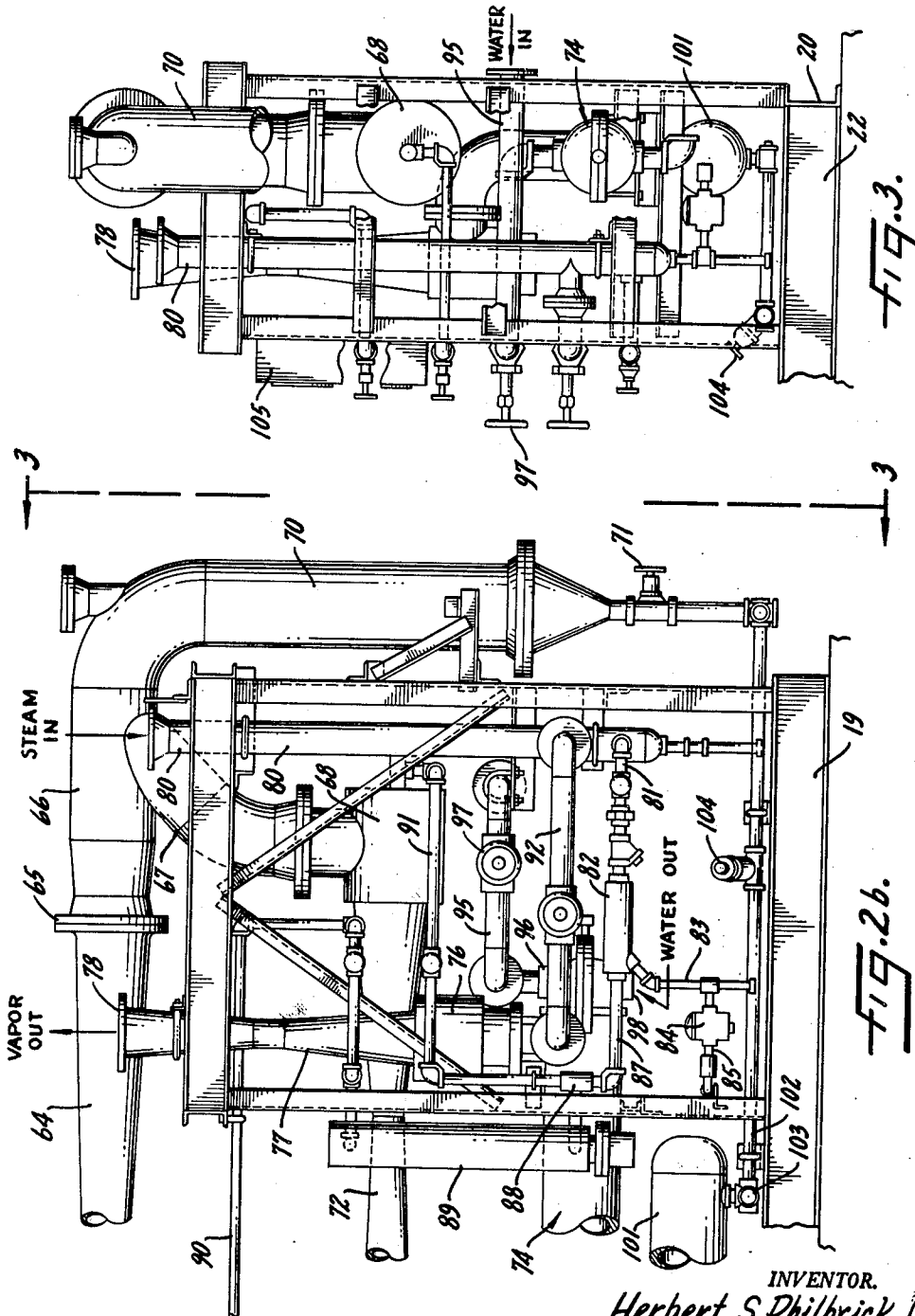
July 20, 1965

H. S. PHILBRICK, JR  
VACUUM DEGASSING SYSTEM

3,195,873

Filed March 27, 1961

3 Sheets-Sheet 3



INVENTOR.  
*Herbert S. Philbrick, Jr.*  
BY *Parker & Carter*  
Attorneys.

1

2

3,195,873

## VACUUM DEGASSING SYSTEM

Herbert S. Philbrick, Jr., Chicago, Ill., assignor to John  
Mohr and Sons, Chicago, Ill., a corporation of Illinois  
Filed Mar. 27, 1961, Ser. No. 98,381  
8 Claims. (Cl. 266—34)

This invention relates generally to metallurgical vacuum degassing systems, and particularly to a vacuum tank and condenser system especially adapted for vacuum degassing of relatively small heats of molten metal.

It is now generally recognized that the quality of steel can be greatly improved by removing the included deleterious gases it contains when it leaves the melting furnace. The most deleterious gas is probably hydrogen although it is also desirable to reduce the nitrogen and oxygen content as much as possible. One of the best modes of reducing the included gas content is to subject the molten metal to a high vacuum. The high vacuum enables the included gases, because of their greater internal gas pressure, to migrate to the surface where they may be drawn off through the vacuum system.

Various systems for vacuum degassing molten metal are known in the art. In order to obtain the high vacuums needed to effectively degas, steam ejector pumps are often used. A steam ejector system requires a cooling medium to condense the motive steam for the steam ejectors and the entrained gases drawn off from the vacuum tank in order to function in the most efficient manner and with a minimum consumption of motive steam.

The most commonly employed cooling systems are direct contact systems. Until the development of the present invention these systems utilized either a water column or a pump working on a column of water of a height less than atmospheric pressure. In each system there is generally direct physical contact between the "vacuum circuit" and the cooling water circuit, and as a result there are disadvantages to both systems. In the first instance, exceedingly high head room was required. Since a column of water requires a 34 foot head, a total of anywhere from 40–50 feet is required. In the second instance, the head room is reduced but a mechanical pump must be used to keep the head below a level at which cooling water will enter the vacuum system. Should water enter the vacuum system, there is always the result that a very serious explosion can occur. Should the pump ever fail, the results can be disastrous. Also, mechanical pumps frequently become a source of air leaks into the vacuum system and this serves to destroy or reduce the effectiveness of the process.

High head room and safety hazards are not the only drawbacks to the present systems. In many instances, vacuum degassing cannot be carried out because the time required to operate the system is so long that the permissible temperature drop of the metal to be degassed is exceeded. In addition, most present vacuum degassing systems are only capable of handling large heats of molten metal, on the order of 10 tons and above, and consequently they entail a relatively large physical installation, high equipment and installation costs, and are rather complicated to operate.

Accordingly, a primary object of this invention is to provide a vacuum degassing system capable of handling relatively small heats of molten metal on the order of the size found in foundries whereby included deleterious gases such as hydrogen, nitrogen, and oxygen can be removed.

Another object is to provide a vacuum degassing system especially adapted for small heats of molten metal in which the degassing can be carried out within permissible temperature drop limitations.

Yet another object is to provide a vacuum degassing system for small heats of molten metal in which the cooling water system is physically separated from the vapor system whereby the danger of explosion due to backup of cooling water into the vacuum system is substantially eliminated.

Yet a further object is to provide a vacuum degassing system which is small, requires little head room, is low in equipment and installation costs, and extremely simple to operate.

Another object is to provide a vacuum tank and system for degassing relatively small ladles of molten metal at pressures on the order of about one-half millimeter of mercury.

Another object is to provide a vacuum tank which can be quickly opened and closed to receive and discharge a ladle of molten metal.

Yet another object is to provide a vacuum tank in which a ladle can be placed therein from either above or from the side thus eliminating the time required for ladle placement.

Yet a further object is to provide a vacuum tank in which lift and swing devices are eliminated thus speeding up the process by considerably reducing the equipment handling time.

Other objects and advantages will become apparent from a reading of the following description of the invention.

The invention is illustrated more or less diagrammatically in the accompanying drawings wherein:

FIGURE 1 is a side view of the system showing a ladle positioned within the vacuum tank;

FIGURE 2, which consists of FIGURES 2a and 2b, is a front view illustrating particularly the steam, water, and vapor circuits; and

FIGURE 3 is a right side view taken substantially along the line 3—3 of FIGURE 2.

Like reference numerals will be used to describe like parts throughout the following description of the drawings.

The vacuum tank and its opening and closing mechanism is illustrated best in FIGURES 1 and 2. The tank, which is indicated generally at 10, consists of a left and right half 11, 12, which are pivoted about a horizontal pivot 13. The left half 11 is supported by a pair of braces or supports fabricated from plates 14, 15. The braces are welded to foot plates 16, 16 which in turn rests upon a pair of I-beams 17, 18. A framework consisting of longitudinal channels 19, 20 and cross channels 21, 22 form an exterior framework for structure to be hereinafter described. A trapezoid shaped front plate is indicated at 23.

Left half 11 of the tank is formed roughly in the shape of one-half of a clam shell. The circular edge of the tank half terminates in a flange 25 which mates with a corresponding figure 26 on right half 12. When the halves are together as illustrated in FIGURE 2, a parting line is formed at 27. The abutting faces of flanges 25, 26 are recessed to receive an O-ring seal, or other suitable sealing means (not shown) to provide an air-tight joint when the tank is closed.

A pair of windows or ports 28, 29 open into the stationary tank half so that the condition of the molten metal in the ladle can be checked during the degassing operation.

Right half 12 is substantially complementary in general outlines to the left half 11. A pair of vertical brackets 30, 31 having collars 32, 33 at their lower ends respectively are welded along their upper edges to the exterior of tank half 12. A pair of side or wing brackets 34, 35 are welded along their inner edges to brackets 30, 31 respectively and along their upper edges to the exterior of the tank to provide additional reinforcement.

3

Each saddle or support 14, 15 has a forwardly extending portion 39 which is welded along its bottom edge to foot plate 16. The outer end of each forward portion 39 is apertured to receive a collar 36, 37 which is aligned with collars 32, 33 carried by the right half 12. A pivot rod 38 is received within the four aligned collars.

A cylinder support framework is welded to the end channel 21 and support 14 to provide a base for the tank opening cylinder. The framework consists essentially of a plurality of side L-beams 40, 41, 42 welded together as illustrated in FIGURE 2 and a cross member 43. The inner end of cross member 43 is welded by means of a short brace 44 to the left or outside of support 14.

A hydraulic cylinder for opening and closing the vacuum tank is indicated generally at 45. The cylinder is pivoted at its rear end to an ear 47 welded to the upper flange of the cross brace 43. Extensible and retractable piston rod 48 extends outwardly to a trunnion 49 on right vacuum tank half 12. The piston rod is pivoted to the trunnion about an axis 50. In FIGURE 1 the cylinder is shown in its completely open or extended position. The position of the cylinder when the tank is closed is indicated by the line 51. The parts are so proportioned that when the tank is closed the hydraulic cylinder will be substantially perpendicular to the parting line 27 and even during its most extended position the cylinder is still roughly perpendicular to the parting line.

A motor 52 and a fluid pump 53 having a reversing valve (not shown) supply hydraulic fluid to cylinder 45 to open and close the tanks through hydraulic lines (not shown). The motor and pump are supported on a small platform 54.

A platform 55 within the tank supports a ladle 56 or any other suitable molten metal container. In this instance a small ladle having a capacity on the order of from 1-5 tons is illustrated. The ladle includes a bale or hanger 58 and a stopper rod rigging assembly 59 which extend considerably above the top of the closed ladle. When the tank is closed, it will be seen from the dotted line position of right half 12 that there is ample clearance for any conventional ladle structure. The extremities of the left half 11 are indicated in dotted lines in FIGURE 1.

The vacuum or vapor system consists essentially of a circuit into which steam from a plurality of jets is injected. The path of gas removal from the chamber to atmosphere is substantially as follows.

Stationary half 11 of the tank is apertured at 60 and connected by a pair of short conduits 61, 62 to a jet chamber 63. The jet chamber is essentially tubular as can be best seen by looking at the left half of FIGURE 1. The first stage of the vacuum circuit is formed by a gradually inwardly and then outwardly tapering pipe 64 which is connected as at 65 to a short straight run 66. The tapering portions of the pipe form a venturi ahead of which is located a steam jet as will be explained hereafter. The withdrawn vapors then pass downwardly through a short connector 67 into a second jet chamber 68. Run 66 opens into a dust separator or dirt catcher 70 which is closed at its lower end by valve 71. In operation heavy particles will continue on past connector 67 and collect in the bottom of separator 70 where they can be subsequently blown out by manipulation of valve 71.

The second stage 72 of the steam ejector begins at jet chamber 68 and extends forwardly to a connection 73 which connects the second stage to a surface condenser indicated generally at 74. Second stage 72 includes a venturi similar to the first stage.

The vapor then passes through the condenser and upwardly to a third jet chamber 76 to which is connected the third stage 77. The discharge end of third stage 77, which also contains a venturi, may be connected by any suitable piping (not shown) to atmosphere at outlet 78.

The steam circuit is illustrated best in FIGURES 2 and 3. Steam enters the system from a suitable source (not shown) through inlet header 80. A portion of the steam

4

is diverted through steam line 81 for the first and second stages of the ejector system. This portion of the steam passes through a steam-water separator 82 which removes the moisture from the steam. Separator 82 is connected by line 83 to steam trap 84. Condensate from separator 82 is collected in steam trap 84 and discharged at intervals into condensate line 85.

From the separator the steam passes by line 87 to a junction T 88. A portion of the steam is diverted at T 88 through an electric heater 89 which adds heat to the steam to compensate for the temperature drop that occurs before the steam enters the ejector. This portion of the steam then passes by line 90 over to the first jet chamber 60 where it is admitted to the first stage 61 of the ejector system. It will be understood that the particular placement of the nozzle of the steam jet will vary somewhat with the design of any particular plant, but usually the jet nozzle will open immediately upstream from the constriction 64a in the first stage. Electric heater 89 adds superheat to the steam going to the first stage ejector. This is necessary for the satisfactory operation of the ejector. Approximately 20 degrees F. to 60 degrees F. is the desired amount of superheat.

The balance of the steam which was not diverted to the first stage at the junction 88 passes upwardly through line 91 to the second jet chamber 68. Again, the exact location of the steam jet nozzle in the ejector will depend somewhat on the design of the particular plant.

That portion of the steam which was not diverted to line 81 is diverted through line 92 to the third jet chamber 76. In a three-stage system the third stage will often require a greater quantity of steam than the first and second stages combined, and accordingly line 92 is larger than line 81.

Suitable valves for shutting off any portion or all of the steam designed for each of the three stages are provided. Since their function is well understood, they are not further described.

The cooling water system is illustrated best in FIGURES 2 and 3. Water enters the system from a suitable source (not shown) through pipe 95. The water passes to the inlet 96 of condenser 74 after passing through a main shut-off valve 97. The internal structure of the condenser 74 is not material to this invention and accordingly is not further described in detail. Suffice it to say that the arrangement is such that the cooling water will flow counter-current to the flow of vapor throughout at least a portion of the path of travel of the vapor through the condenser. The cooling water leaves the condenser through outlet 98 which may be connected to any suitable discharge or return line, not shown.

One of the most unique features of the invention is the provision for handling condensate from the vapor circuit. The vapor passing through the surface condenser has water vapor entrained in it. This water vapor is condensed in the condenser 74 and flows to discharge pipe 100. Pipe 100 opens into a condensate tank 101 which in turn is connected into a discharge line 102 and discharged to atmosphere through valve 104 at the end of cycle, and after atmospheric pressure has been restored to evacuating system. A valve 104 between clean-out valve 103 and valve 71 permits the condensate from the dirt separator 70 to be removed from the system without draining the condensate tank 101 at the same time. By opening valves 71, 103 and 104 simultaneously, the dirt from the separator and condensate from the tank can be drained together.

The use and operation of the invention are as follows:

A small ladle of molten metal is transferred from the melting furnace to the clam shell vacuum tank of FIGURE 1. The ladle may be placed on the platform 55 within the tank from above or alternately, the ladle may be swung in and downwardly from the side. This, of course, is possible because the maw formed by the two clam shell halves is wide enough to permit the ladle to

5

come in sideways, at least from about the mid-portion of the tank upwardly. This particular feature is of great advantage in installations in which head room is at a premium.

As soon as the ladle is placed on platform 55 suitable conventional valve mechanisms associated with hydraulic closing cylinder 45 are actuated to close and seal the clam shell tank. As the right portion 12 of the chamber moves from its disengaged solid line position in FIGURE 1 to its engaged, dotted line position in FIGURE 1, it passes through its balance position. It will also be obvious to those skilled in the art that the entire range of movement of right portion 12 is closely adjacent the balance position since the illustrated solid line positions of portions 11 and 12 are the positions of maximum displacement from one another. As soon as the two flanges 25, 26 make contact and a seal is formed, the vacuum system is turned on and the interior of the tank evacuated. The atmosphere within the tank and, subsequently, the included gases drawn off from the molten metal leave the chamber through the vapor circuit which consists essentially of three stages, 64, 72 and 77 of a steam ejector system. Steam for each of the individual stages is supplied through the steam circuit from header 30 to the venturies at the mid-portion of each stage.

The vapors in the vapor circuit, which includes both the gases withdrawn from the tank and the steam, passes into a surface condenser 74 after passing through two stages of the steam ejector. Since condenser 74 is a surface condenser and cooling water is separated from the vapors by suitable piping, there is no physical contact between condenser tubes and the vapors circulating around the outside of the tube. The vapor passes through the third stage 77 of the steam ejector system after leaving the surface condenser 74 and is discharged to atmosphere through outlet 78.

The only water in the vacuum or vapor circuit is that which condenses from the steam jets ahead of the condenser. This is so small a quantity that it is feasible to collect it in the drain tank 101 under vacuum during the cycle and then dump the condensate at the end of the cycle. The amount of condensate may be relatively small, say on the order of 1 gallon per minute. This quantity could be pumped out continuously but this would introduce a mechanical arrangement which is subject to failure. Drain tank 101 can be made large enough to adequately take care of a number of degassing cycles and is fool-proof as far as mechanical leakage is concerned. This particular set up is very practical for a short cycle, such as on the order of 5-15 minutes as would be employed in small ladle degassing.

By contrast, the amount of cooling water needed in this system may be on the order of 100 gallons per minute. This large gallonage of course never comes in contact with the vapor and the vapor circuit. By arranging the condenser and drain tank as shown, the over-all height of the system is kept at a minimum and the condensing portion of the circuits, which in the prior art was the most contributing factor to high head room requirements, is entirely eliminated. In this system, any back-up of cooling water will merely cause a disruption in the cooling water circuit. Since the cooling water circuit is physically separated from the vapor circuit, no explosion can occur.

A typical example of the functioning of this system may be illustrated as follows.

In actual operation, a ladle containing something over a ton of molten metal has been degassed in a total cycle time of about 5-6 minutes. Allowing approximately one minute of pump down-time leaves a total treatment period of around 3-4 minutes. During the degassing of the ladle above referred to, the absolute pressure in the tank and first stage was approximately 4-6 millimeters of mercury, the vacuum in the second stage was in the neighborhood of 25-35 millimeters of mercury and the discharge pres-

6

sure in the third stage was 760 millimeters. The temperature of the cooling water in the surface condenser was on the order of about 80 degrees F. The optimum pressures and temperatures of steam will vary from installation to installation. The amount of heat supplied and duration of time in which the heater 89 is turned on will also vary from installation to installation.

The two halves of the clam shell tank are so oriented that the maximum height of the tank is utilized. Thus, the tank is slightly tipped to one side so that the longest dimension of the ladle assembly, in this case the ladle rigging, will lie along a line passing through point A of right half 12 and point B of left half 11. The distance between A and B is, of course, considerably greater than the barrel diameter of the tank. This feature is of considerable advantage in this type of installation because pump down-time is directly related to the size of the tank. By utilizing the smallest possible tank, it is possible to reduce the pump down-time to an absolute minimum.

It will be understood that the clam shell vacuum tank is utilizable with or without the particular condensing system illustrated. The main purpose of any condensing system is to increase the capacity of the vacuum system. The later ejector stages do require larger quantities of steam. By removing the steam from the earlier stages as condensate there is more capacity left to remove air and other vapors from the vacuum tank. This, however, may increase operating costs due to the cost of cooling water and it may be feasible on some small setups to dispense with the condenser.

When considering the invention as a combination of the vacuum tank with a low head room surface condensing system, it should also be understood that modifications may be made in the condensing system piping. In other words a single stage steam ejector or four or more stages might be utilized, depending upon the desired operating characteristics.

Suitable controls with gauges and other indicating instruments may be collected together at a convenient point such as a control panel indicated at 105 in the right side of FIGURE 2. In view of the fact that the particular controls for the piping system shown are not considered to be essential to an understanding of the invention, they have been omitted for purposes of clarity.

While a preferred embodiment has been illustrated and described and several variations described, it should be understood that the scope of the invention is not to be so limited by the description. Instead it is the intent to limit the invention only by the scope of the following appended claims.

I claim:

1. A vacuum tank for use in degassing molten metal, said tank including a first and second tank half, said first and second halves forming, by themselves, a vacuum tank of a size sufficient to receive a container of molten metal, said halves being substantially symmetrically shaped and opening along a parting line formed approximately at the major dimension of the tank, at least one of said tank halves being pivotable about a generally horizontal axis into sealing engagement with the other tank half, means supporting the tank with its parting line disposed generally vertically to thereby form an upwardly, outwardly diverging opening for the reception of a container for molten metal when the tank halves are in an open position, a fluid operated cylinder and piston means, said cylinder and piston means being pivotally connected to a stationary support structure and the movable half of the tank, said cylinder and piston means being so positioned as to lie substantially perpendicular to the parting line throughout the extension and retraction of the cylinder and piston means, a support structure for a container of molten metal within the tank, and a vacuum connection opening into the tank.

2. The vacuum tank of claim 1 further characterized in that the two halves of the vacuum tank are of substan-

tially uniform diameter a substantial distance on each side of the parting line, one of said halves being supported in a stationary support structure, the parting line of the tank being canted slightly from the vertical so that a container of molten metal, when placed on the support structure within the tank, will lie substantially along the longest dimension of the tank.

3. A vacuum chamber, said chamber including, in combination,

two portions,

said portions being movable relative to one another from a closed position in which they are in engagement to an open position in which they are disengaged, and

means for supporting one of said portions,

means for moving the other of said portions along a path, the ends of which correspond to engaged and disengaged positions of said other portions, all points of said path being at least adjacent the balance position of said other portion, said portions, when opened, forming a generally vertically axised opening.

4. The vacuum chamber of claim 3 further characterized in that the said other portion moves along a path of travel which includes its balance position.

5. The vacuum chamber of claim 3 further characterized in that the means for relatively moving the portions from engaged to disengaged positions includes means for applying an opening and closing force to the other portion which is substantially perpendicular to the parting surface on the said other portion throughout the entire path of travel of the said other portion.

6. The vacuum chamber of claim 5 further characterized in that the means for applying an opening and closing force to said other portion includes a fluid cylinder assembly,

one end of said assembly being operatively connected to said other portion of the vacuum chamber,

said fluid cylinder assembly being substantially perpendicular to the parting surface of the said other portion throughout the entire path of travel of the said other portion as it moves from an engaged to a disengaged position.

7. A vacuum system for degassing relatively small heats of molten metal, said system including a vapor circuit connected to a vacuum tank, said vapor circuit having at least a pair of steam ejector vacuum stages connected in series, a surface condenser, the upstream end of the first stage being constructed and arranged to be connected to

the vacuum tank to be evacuated, the downstream end of one of the stages discharging into the surface condenser, said condenser having cooling water tubes therein so constructed and arranged that the vapor flow through the condenser runs counter to a substantial length of the water tubes, said water tubes maintaining the vapor system physically separated from the cooling water system, a condensate tank and a connection between said surface condenser and condensate tank whereby condensate from the condenser may be drained to the condensate tank, a vapor outlet from the condenser, and at least one additional vacuum stage connected to the condenser outlet,

said vacuum tank being composed of two halves which open about a generally vertically axised parting line slightly canted from the perpendicular, means supporting one of the tank halves whereby the other tank half may move with respect to it, the diameter at the parting line being substantially greater than the diameter perpendicular to said parting line whereby said halves, when in an open position, form an upwardly, outwardly diverging opening suitable for reception of a container of molten metal from either the side or above.

8. The vacuum system of claim 7 further characterized in that one of the tank halves is stationary and the other is pivotable about a generally horizontal axis and further including fluid actuated means constructed and arranged to apply an opening force to the movable tank half in a direction substantially perpendicular to the parting line throughout at least a portion of the opening movement of said movable tank half.

#### References Cited by the Examiner

##### UNITED STATES PATENTS

|           |      |          |         |
|-----------|------|----------|---------|
| 651,000   | 6/00 | Webster  | 183—2.5 |
| 1,907,050 | 5/33 | Elliott  | 183—2.5 |
| 2,093,666 | 9/37 | Vogt     | 266—34  |
| 2,734,240 | 2/56 | Southern | 266—34  |
| 2,852,246 | 9/58 | Janco    | 266—34  |

##### OTHER REFERENCES

Bussard et al., German printed application, 1,041,218, 10/58.

MORRIS O. WOLK, *Primary Examiner*.

R. K. WINDHAM, *Examiner*.