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METHOD OF INJECTING GASES INTO STEEL MELTS

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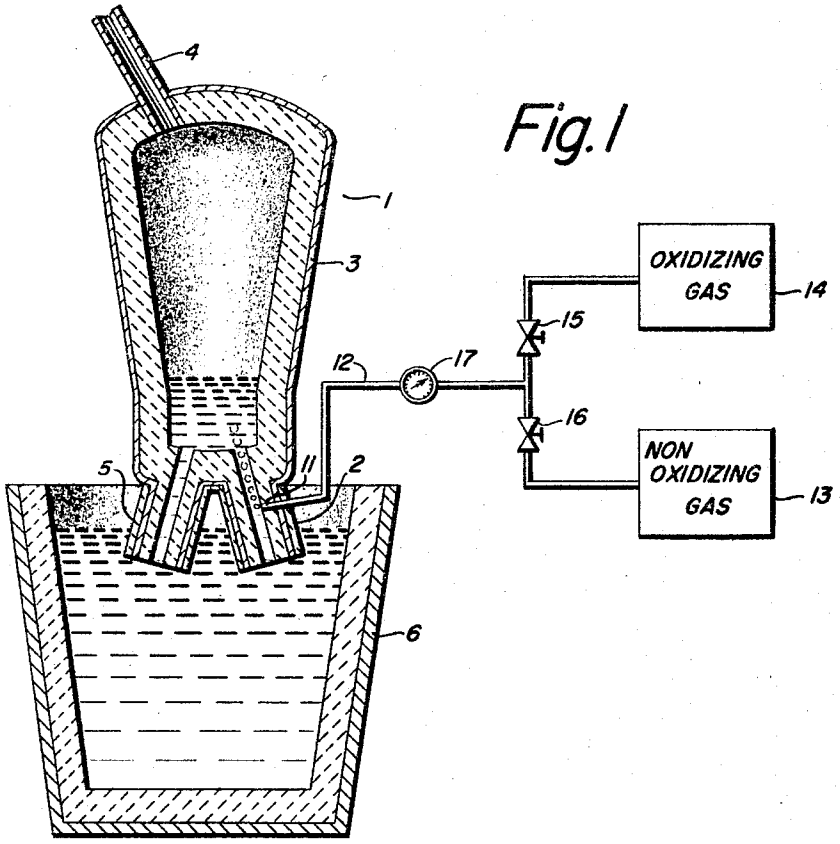


Fig. 1

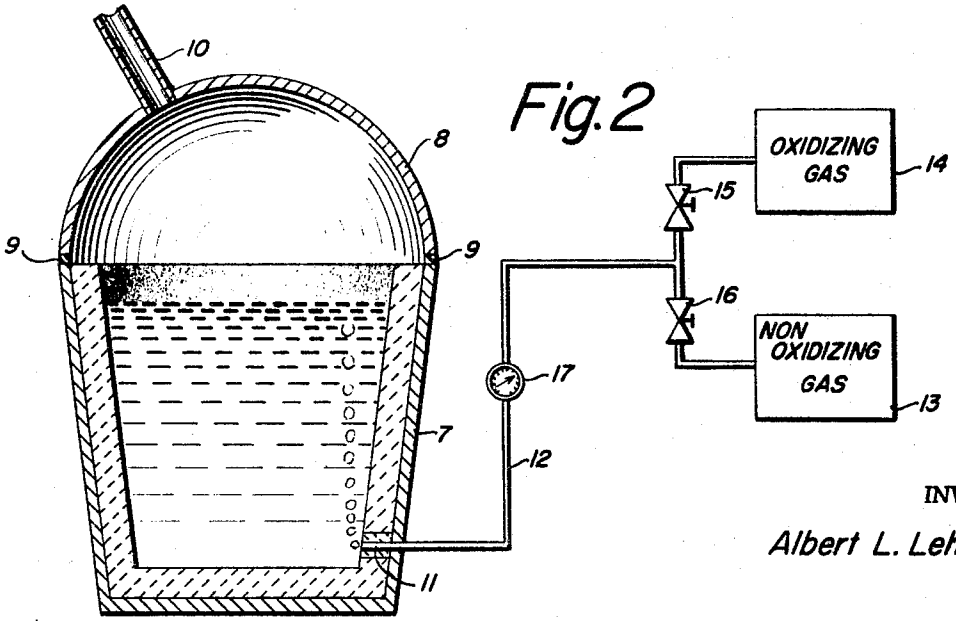


Fig. 2

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METHOD OF INJECTING GASES INTO STEEL MELTS

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This invention relates to the injection of gases beneath the surface of molten metal. It relates particularly to the injection of gases into metallurgical apparatus used for the vacuum degassing of molten metals such as steel.

Vacuum degassing processes and apparatus have been developed which depend for their operation on the injection of relatively small amounts of gas below the surface of the metal to be treated to bring about the transportation or agitation of the molten metal so that deleterious gases dissolved in the molten metal may be removed by vacuum pumps. In such processes and apparatus the gas used for the transportation or agitation of the molten metal bubbles into the melt from the tip of a conduit leading from a high pressure source of gas. In most instances, the gas chosen is a non-oxidizing gas, preferably an inert gas.

Frequently, the tip of the conduit in contact with the molten metal becomes partially and sometimes completely plugged by accretions of solidified metal which tend to form about the tip due to the cooling effect of the incoming gas. This is especially true when relatively small diameter tips are used. As the flow of the incoming gas becomes retarded by these accretions, the transportation or agitation of the molten metal in the vacuum degassing apparatus is also retarded. If the flow of the incoming gas ultimately stops, the flow of molten metal also will stop. It is important, therefore, in these processes, that the flow of the incoming gas be relatively constant and carefully controlled.

In order to attempt to maintain a continuous flow of gas into the molten metal, it has been necessary, prior to my invention, to use either a plurality of injection ports, or a porous refractory tip or an oversize tip on the gas conduit.

A plurality of injection ports has been tried in order to permit the gas to enter the melt from a number of separate points. If one or more of the ports becomes plugged or stopped up, the gas will continue to flow from the remaining ports. However, this technique often results in an uneven distribution of the gas, and requires the necessity of separate gas conduits leading to each port.

Porous refractory tips containing hundreds of tiny passages through which the gas could diffuse into the molten metal were sometimes used on the end of the gas conduit. However, in many cases, the gas diffused much too slowly to be effective either because the passages were too small or that they quickly filled with solidified metal. It was also necessary to replace this refractory tip at very short intervals.

Oversize injection tips were tried without success. It was reasoned that a large diameter tip on the gas conduit would still permit a sufficient flow of gas even when partially plugged. Not only did this technique waste gas but it also increased the load on the vacuum pumps. More important was that complete blockages could still occur which would stop the degassing process altogether. Furthermore, in many cases, the gas flow before any partial stoppage occurred was too large for the degassing apparatus to operate properly.

It is therefore an object of my invention to provide a method of maintaining a relatively constant controllable flow of gas beneath the surface of a bath of molten metal.

It is a further object of my invention to provide a method of keeping the tip of a conduit in contact with molten metal constantly open.

It is a still further object of my invention to provide a method of removing accretions of molten metal which might form about the tip of gas conduit in contact with molten metal.

The foregoing objects, and other objects and the means whereby they are accomplished we have found can be attained by intermittently adding to the flow of gas a small amount of oxidizing gas to melt any accretions of metal that may form about the tip of the conduit.

FIGURE 1 is a sectional view of a form of vacuum degassing apparatus for degassing molten metal in a ladle or other similar vessel.

FIGURE 2 is a sectional view of another form of vacuum degassing apparatus for degassing molten metal in a covered ladle-like vessel.

Referring to the drawings more in detail, FIGURE 1 shows vacuum degassing apparatus **1** of the "gas lifter" type in which molten metal is lifted up conduit or leg **2** into vacuum chamber **3** from vessel **6** by injecting relatively small quantities of a gas into leg **2**. The metal is degassed in vacuum chamber **3** with the deleterious gases dissolved in the molten metal being removed by exhaust pipe **4**. The metal then discharges down conduit or leg **5**. The vacuum degassing apparatus **1** is shown in FIGURE 1 in position for degassing molten metal in a ladle **6**, although such apparatus can be used to degas metal in other vessels, such as furnaces, as well.

FIGURE 2 shows another type of vacuum degassing apparatus. The molten metal to be degassed is contained in ladle-like vessel **7** which is provided with a removable cover **8** joined to vessel **7** in an air-tight manner by seals **9**. The deleterious gases given off by the molten metal during the degassing process are removed by exhaust pipe **10**. Relatively small quantities of gas are injected into the molten metal through one or more points in the sides of vessel **7**, which in bubbling up to the surface of the metal as shown in FIGURE 2, agitate or stir the melt, so that all portions thereof are exposed to the vacuum at the surface of the melt.

In both types of apparatus the gas is preferably injected into the melt from a relatively small diameter injection tube **11** forming the discharge end of gas conduits **12**. As shown in FIGURES 1 and 2, the injection tube **11** is usually embedded in the refractory lining of the vacuum degassing apparatus. Gas conduits **12** lead to a high pressure source of gas **13** used to "lift" the molten metal as shown in FIGURE 1, or to "agitate" the molten metal as shown in FIGURE 2. When the molten metal is steel, the gas normally used for these purposes is a non-oxidizing gas, preferably an inert gas such as argon. However, occasionally it is desired to bring about a chemical reaction in the vacuum degassing apparatus, in which case a reactive gas can be used.

My invention generally comprises connecting a high pressure source of a highly oxidizing gas **14**, such as oxygen, in parallel with non-oxidizing gas source **13** at a pressure lower than gas source **14** by means of valves **15** and **16**. A pressure gage **17**, designed to measure back pressure, is inserted in conduits **12** between injection tubes **11** and gas sources **13** and **14**. Valve **16** is normally open. As long as the flow of non-oxidizing gas from gas source **13** through conduit **12**, and injection tube **11**, is unimpeded, no back pressure will be recorded by gage **17**. However, as soon as accretions of solidified metal begin to form around the tip of injection tube **11**, the back pressure in conduit **12** will rise and be recorded on gage **17**. Valve **15** is then opened manually or automatically for a very short period of time, at most only several seconds,

to permit a small quantity of highly oxidizing gas to be carried to the tip of injection tube **11**, where it immediately melts or burns away the solidified metal accretions. The amount of oxidizing gas so injected is insufficient to seriously erode the injection tube and is insufficient to cause any appreciable oxidation of the molten metal.

In using this method with vacuum degassing apparatus of the type shown in FIGURE 1, argon gas to lift the molten metal was injected into the molten metal in leg **2** from an injection tube **11** of ¼" diameter at a flow rate of about 2 to 9 standard cubic feet per minute at a gas pressure measured at source **13** of about 100 p.s.i. Whenever a back pressure was detected on gage **17**, valve **15** was opened manually for about 1 to 3 seconds, permitting approximately one standard cubic foot of oxygen gas at a gas pressure of about 180 p.s.i. measured at source **14** to flow to the tip of injection tube **11**. Immediately thereafter the back pressure in conduit **12**, as recorded by gage **17**, returned to zero indicating that the tip of injection tube **11** was again free of accretions or solidified metal, and the non-oxidizing gas was again flowing freely.

It can be seen that this simple but highly effective method of keeping an injection tube in contact with molten metal constantly open permits one to maintain a substantially constant and accurately controlled flow of gas at all times for the agitation or transportation of molten metals in metallurgical apparatus.

As many embodiments of the invention are possible without departing from the scope thereof, it is to be understood that all matter set forth or shown in the accompanying drawings is to be interpreted as illustrative and not limiting.

I claim:

1. A method of keeping the tip of a injection tube in contact with molten metal constantly open comprising maintaining a continual flow of non-oxidizing gas through said tube and intermittently adding to said flow of non-oxidizing gas, small quantities of an oxidizing gas sufficient to melt any accretions of metal that may have formed around the tip of said tube.

2. The method of claim **1** wherein the non-oxidizing gas is one of the inert gases.

3. The method of claim **1** wherein the oxidizing gas is substantially pure oxygen gas.

4. The method of claim **1** wherein the oxidizing gas is added to the flow of non-oxidizing gas only when the back pressure of said non-oxidizing gas in the tube rises above a predetermined limit.

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