Sept. 18, 1973 A. DIENER ET AL 3,759,700

PROCESS OF REFINING METAL MELTS BY SUPERSONIC OXYGEN BLOW

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FIG. 1

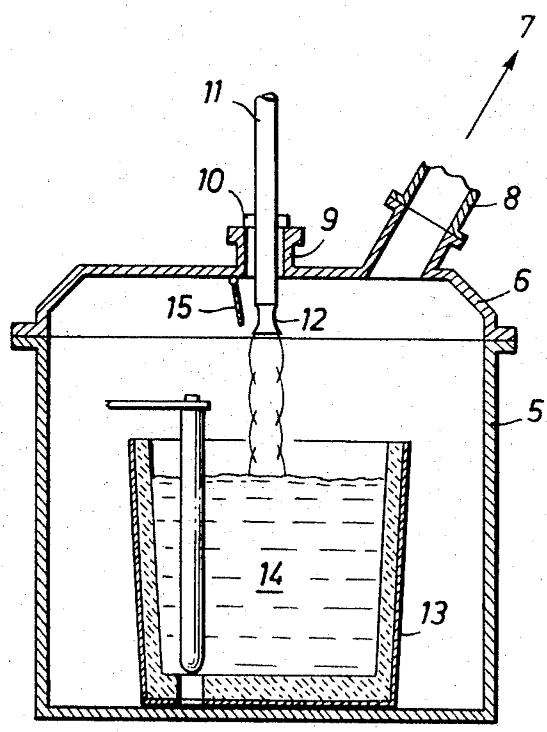

FIG. 2

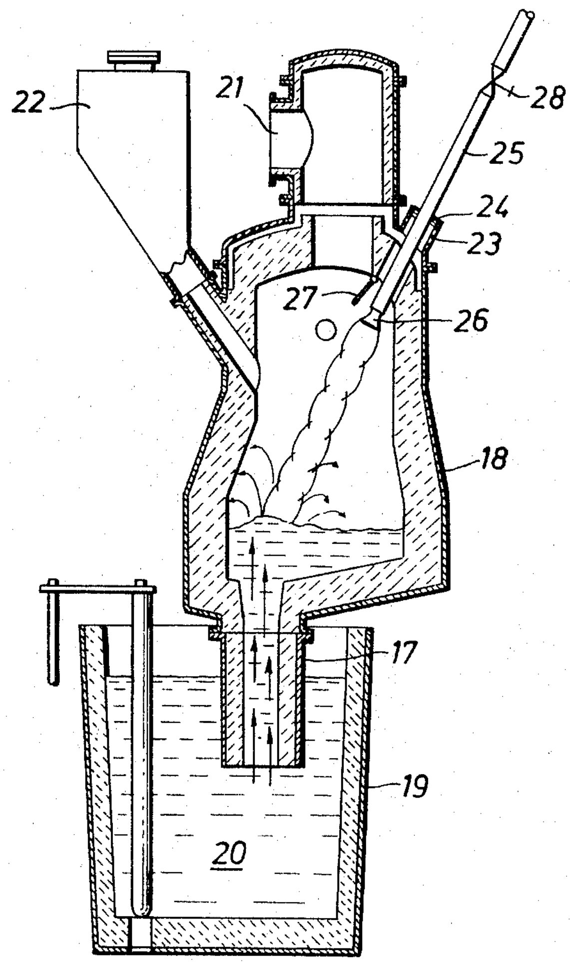

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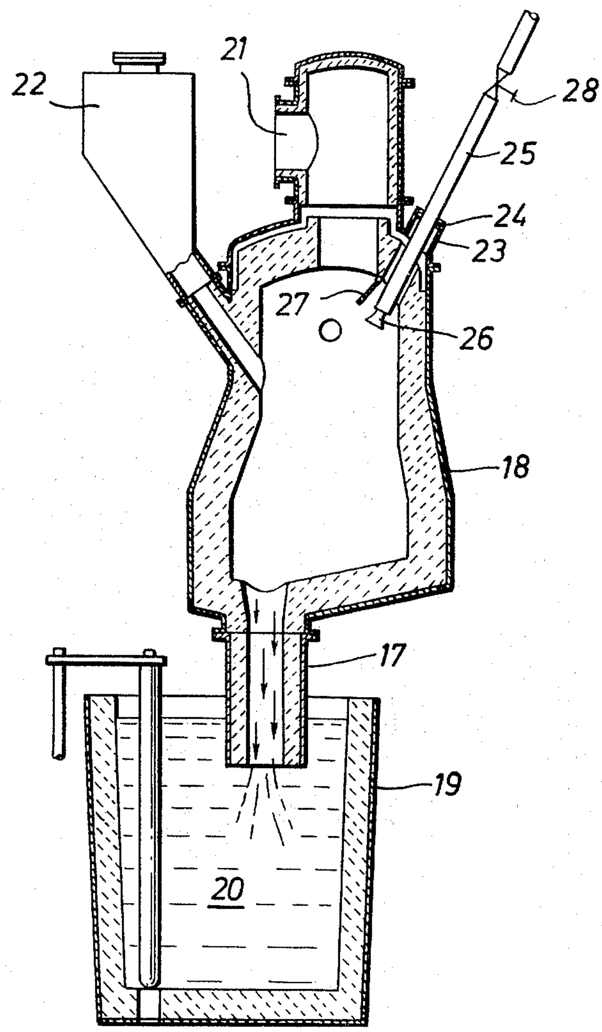
FIG. 3



United States Patent Office

3,759,700
Patented Sept. 18, 1973

3,759,700

PROCESS OF REFINING METAL MELTS BY SUPERSONIC OXYGEN BLOW

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Filed Jan. 22, 1970, Ser. No. 4,917
Claims priority, application Germany, Jan. 20, 1969, P 19 04 442.9
Int. Cl. C21c 7/00
U.S. Cl. 75—60 2 Claims

ABSTRACT OF THE DISCLOSURE

In a process of refining metal melts, particularly iron melts and steel melts, oxygen is blown at supersonic velocity from an oxygen lance, preferably fitted with a Laval nozzle, onto the surface of the melt which is contained in a vacuum chamber under greatly reduced pressure. The oxygen jet must be in the form of a cohesive stream of oxygen which substantially wholly impinges on the surface of the melt in the vacuum chamber without first breaking up and being dispersed in the chamber.

This invention relates to a process for refining molten metals, particularly iron melts and steel melts, in which for example the carbon content and/or the content of other undesired elements in the metal is reduced. The invention also relates to apparatus for carrying out the process.

It is known to accelerate the removal of carbon from steel melts at reduced pressure by adding solid oxides, for example fine-grained ores, rolling mill scale or other metal oxides. However, the addition of solid oxygen carriers involves several disadvantages. In the first place the heat required for dissolving the solid oxygen carrier is taken from the metal melt. Secondly, before the undesired elements in the melt, for example the carbon, can be oxidized, the solid oxygen carrier first has to be reduced, and this decreases the free enthalpy of the entire reaction. Moreover the oxides which it is practical to use for this purpose, particularly the ores, contain a number of elements which have deleterious effects on the properties of the steel melt being refined.

Also known are processes for refining steels at reduced pressure, in which gases are blown into the melt from underneath. For example German patent specification (Auslegeschrift) 1,216,904 describes a process for degassing a melt at greatly reduced pressure, in which the melt flows through a vacuum chamber situated above the body of melt which it is desired to degas. The molten metal is introduced into the vacuum chamber through an inlet pipe by means of a conveying gas. In the vacuum lift degassing process, the vacuum vessel is arranged to move up and down to discharge degassed portions of the melt and draw in fresh portions of melt for degassing, the vessel being connected to the melt by a length of pipe whose lower end dips into the melt. In this process it is known to introduce the melt through the inlet pipe by means of a conveying gas.

The vacuum processes which use conveying gases must necessarily use either inert gases or at least gases which are slow to react as the conveying gas, because this gas serves merely to lift the molten metal in the inlet pipe. In these processes it is not possible to introduce pure oxygen as the conveying gas because the reaction of the pure oxygen with the molten metal, and with the other elements present in the melt, would be so violent that the refractory lining of the inlet pipe would be rapidly destroyed. The destruction of the refractory lining would be accelerated by the ferrous oxide which is produced

when pure oxygen is introduced into an iron melt or into a steel melt. Ferrous oxide destroys a refractory lining very rapidly.

According to the present invention, in a process of refining metal melts, particularly iron melts and steel melts, oxygen is blown at supersonic velocity onto the surface of a melt under reduced pressure in a vacuum chamber. With such a process pure oxygen can be introduced into the melt in a vacuum chamber so that the resulting high heat of reaction of the oxidation reaction is utilized and high alloy melts can be produced, without the disadvantages mentioned earlier. At supersonic velocity the oxygen jet forms a cohesive narrow column of flowing gas which does not escape through the vacuum pump before reacting with the metal melt. Consequently, the oxygen reacts practically completely with the easily oxidized substances in the metal melt, for example with the carbon in an iron or steel melt.

Preferably, the pressure of the oxygen jet at the point it enters the vacuum chamber is below, but not too far below, the internal pressure in the vacuum chamber, otherwise there would result a very short supersonic jet which would break down at the first node by shock compression to give a useless subsonic jet. Provided that the pressure in the oxygen jet at the nozzle outlet is not too different from the pressure in the vacuum vessel there is formed an elongated supersonic jet which is stable through several nodes. If the pressure in the jet at the nozzle outlet is much higher than the pressure in the vacuum vessel, the jet bursts just after leaving the nozzle, and becomes useless.

In accordance with a further feature of the invention apparatus for performing a process according to the invention comprises a vacuum chamber, means for evacuating the chamber, and an oxygen lance which projects into the chamber and which is capable of directing a jet of oxygen at supersonic velocity onto the surface of a melt which in operation is contained in the chamber.

In order to obtain the desired oxygen jet, i.e. a cohesive narrow column of flowing oxygen, the outlet opening at the end of the lance is preferably constructed as a Laval nozzle. Also, the lance is preferably arranged so that it can be retracted into the connection through which it passes into the vacuum chamber, and there is a member which is movable to close the mouth of the connection when the lance is retracted so that the outlet end of the lance is protected when not in use. This protects the end of the lance, especially when this is a Laval nozzle, from spattered metal and slag.

Two examples of apparatus by which a process in accordance with the invention can be performed, and one example of such a process will now be described with reference to the accompanying drawings, in which:

FIG. 1 is a vertical section through one example comprising a vacuum enclosure in which there rests a pan containing a metal melt;

FIG. 2 is a vertical section through the second example showing a vacuum lifting vessel having a lower suction pipe dipping into a metal melt in a pan, the figure showing the apparatus during the refining of a portion of the melt; and,

FIG. 3 is a similar view to FIG. 2, but shows the apparatus during discharging of the refined portion of the melt back into the pan.

The apparatus shown in FIG. 1 consists of a vacuum enclosure **5** closed by a gas-tight cover **6** fitted with a connection **8** leading to a vacuum pump **7** (not shown). The cover **6** also has a connection **9** with a stuffing box seal **10** through which there passes, in a gas-tight but axially slidable fashion, an oxygen lance **11**. The outlet opening of the oxygen lance **11** is in the form of a Laval nozzle **12**, which causes the oxygen which issues from the lance to form a narrow, cohesive jet. Beneath the nozzle **12** of the oxygen lance **11** there is a pan **13** containing the metal melt **14** which is being processed. When the lance **11** is not in use it is retracted upwards into the neck of the connection **9** and covered over by a flap **15**, for protection against spattered metal and slag. This is particularly to protect the Laval nozzle **12**.

In the apparatus represented in FIGS. 2 and 3 a vacuum lifting vessel **18** has a lower suction pipe **17** which dips into a metal melt **20** contained in a pan **19**. The vacuum vessel **18** is connected by a connection **21** to a vacuum pump, not shown in the drawing, and also has an inlet connected to a feed device **22** for introducing alloy substances into the melt. The upper end of the vacuum vessel **18** is equipped with a lance connection **23** containing a stuffing box seal **24** through which an oxygen lance **25** passes in a gas-tight but axially slidable fashion. The lance **25** has its outlet opening in the form of a Laval nozzle **26**. The vacuum lifting vessel **18** is also equipped with an internal flap **27** for protecting the nozzle **26** of the oxygen lance **25** when the lance is retracted and not in use. The arrangement illustrated in FIGS. 2 and 3 is operated intermittently, that is to say oxygen is blown only during the degassing part of the process, which is the period when a portion of the melt **20** is being lifted under vacuum, and degassed, in the degassing vessel **18**. This arrangement during this part of the process is represented in FIG. 2. On the other hand, no oxygen is blown when the degassed and refined portion of melt is run down again into the pan **19**, as is represented in FIG. 3. To provide control of the oxygen blow, the lance **25** has a shut-off valve **28**, which can if desired be controlled by the lifting mechanism for the vacuum vessel **18**, the vessel being lifted in order to cause the degassed portion of the melt to run back into the pan **19**.

In one example of a process in accordance with the invention carried out with apparatus of the kind shown in FIGS. 2 and 3, a steel melt containing 0.3% carbon, 16% chromium and 8% nickel was refined in vacuo at a pan temperature of 1650° C., the amount of carbon in the melt being reduced to 0.03% with practically no slagging of the chromium. It should be noted that at this temperature the oxygen dissolved in the melt could not have reduced the amount of carbon to less than 0.25%. The oxygen blow lance **25** had a Laval nozzle with an aperture ratio of $F^*-/F=0.08$, and through this pure oxygen was blown from an oxygen supply pipe containing oxygen at a pressure of 3 atmospheres gauge. This arrangement provided a supersonic oxygen jet with a pressure of 15 torr at the nozzle outlet, this pressure being less than the pressure prevailing in the vacuum vessel **18** which was 20 torr. With this arrangement the supersonic jet took the form of a cohesive narrow jet directed onto the portion of the melt in the vessel **18** and this rapidly caused the removal of carbon from the melt. To reach the final very low carbon content of 0.03% approximately 4 kg. of oxygen per ton of steel refined was blown.

We claim:

1. A process of refining metal melts, particularly iron and steel melts, in a vacuum chamber, including the steps of supplying at least a portion of said melt to said vacuum chamber, reducing the pressure in said chamber, and blowing from a Laval nozzle onto the surface of said melt in said vacuum chamber a narrow cohesive jet of oxygen at supersonic velocity which substantially entirely impinges on the surface of the melt, and controlling said blowing whereby the pressure of said oxygen jet at the point where said jet enters said vacuum chamber is about 25% lower than said pressure in said vacuum chamber.

2. A process as claimed in claim **1**, wherein a steel melt containing chromium is refined.

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U.S. Cl. X.R.

75—49; 266—34 L, 34 Y