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[54] **PROCESS FOR REFINING METAL MELTS**

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[51] **Int. Cl.** **C21c 5/32**

[58] **Field of Search** 75/60, 59, 62

[56] **References Cited**

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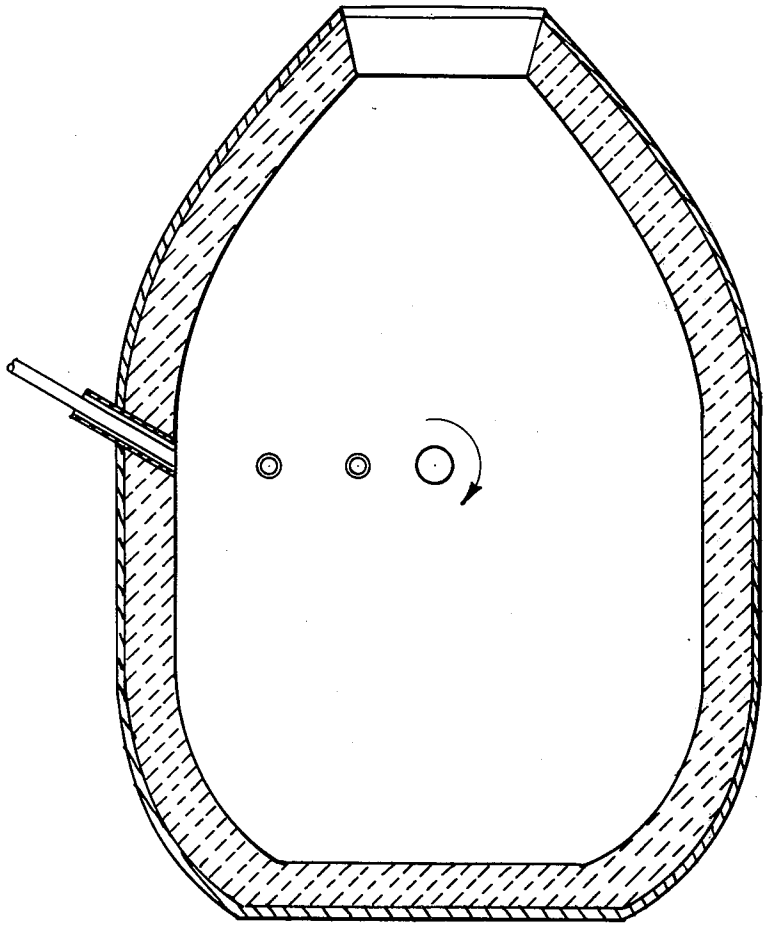
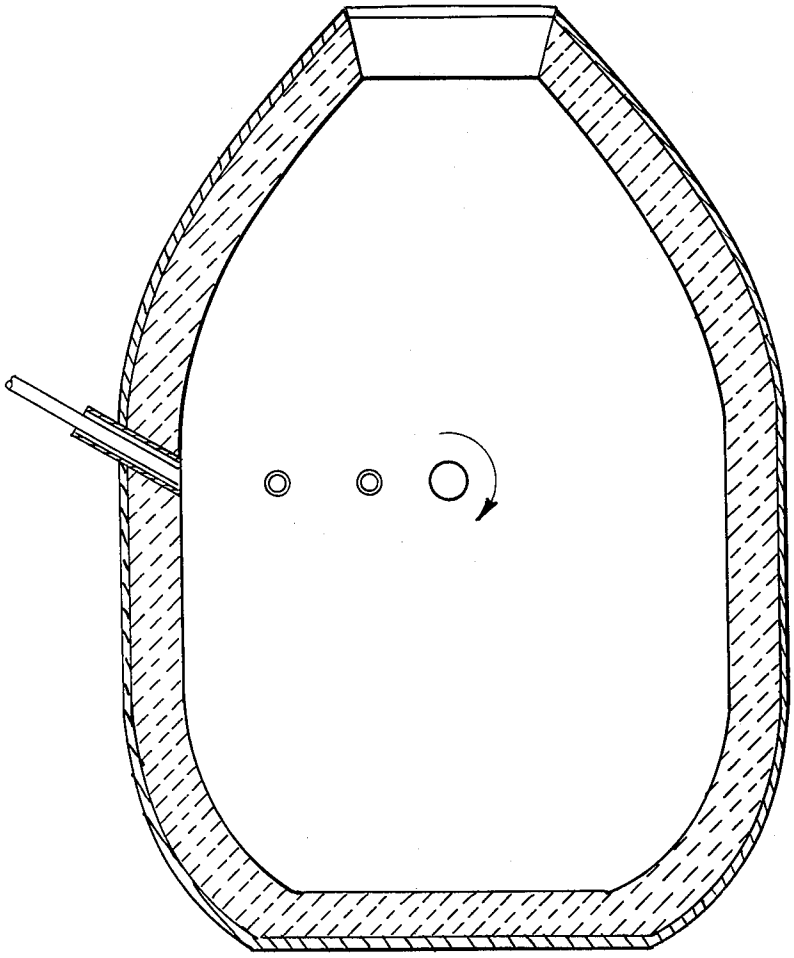
[57] **ABSTRACT**

A process for refining metal melts in a refractory vessel which comprises: blowing at least one stream of oxygen and a surrounding fluid stream of a protective fluid Medium, downwardly towards the surface of a metal melt to be refined, said streams being blown through dual tube tuyeres mounted in the masonry of said vessel and discharging a downwardly inclined stream onto the top surface of the metal melt in said vessel.

10 Claims, 1 Drawing Figure





PROCESS FOR REFINING METAL MELTS

This invention relates to a process for the refining of metal melts, and particularly to the refining of pig iron to produce steel, by a process in which oxidizing gases, preferably pure oxygen, are surrounded by a liquid or gaseous protective medium and blown upon the metal bath. The refining gas supply tuyeres usually consist of two concentric tubes, the refining gas being supplied through the central tube and the liquid or gaseous protective medium being made to pass through the annular spacing between the two tubes, and these tuyeres are inserted through the refractory masonry into the refining vessel, without requiring cooling by means of a circulatory cooling system.

The use of pure oxygen for refining metal melts is now widespread in industry. Thus pure oxygen as the refining gas is increasingly being used in the refining of pig iron to produce steel. A decisive step in the application of pure oxygen as a refining medium in the steelmaking industry was taken approximately **15** years ago with the introduction of the top oxygen-blowing process. In this process, a water-cooled lance is directed through the converter mouth onto a pig iron melt in the converter and oxygen is blown onto the melt. In addition to the many advantages deriving from the use of pure oxygen as the refining gas such as the favorable thermal economics allowing a higher proportion of scrap than the usual Thomas process and the omission of ballast gases such as nitrogen during air-refining, the top oxygen blowing process does suffer from technical drawbacks. Among these are the following:

The high temperature at the focus of the oxygen lance produces increased iron evaporation and contamination of product as well as undesired formation of brown smoke and increased iron content in the slag. Furthermore the top blowing process requires a large investment in buildings and facilities. These are mainly for the water-cooled lances, the equipment required to move the latter, and not least by the required elevation of the steel workshops. The latter is required so that the lance may be removed upwards from the converter prior to tapping, for which the converter will be tilted.

In addition to the oxygen top blowing method, another process for refining pig iron to steel in which oxygen is supplied to the melt underneath the bath surface has gained industrial significance in the past two years. In this process as described in the U.S. Pat. No. **3,706,549** and in German Auslegeschriften Nos. **1,583,968** and **1,758,816**; the refining oxygen is supplied to the melt together with a protective medium. Use is made of tuyere arrangements that may be constructed of two concentric tubes which are made to pass through the refractory masonry and into the refining vessel underneath the bath surface. Oxygen flows through the center tube and the protective medium flows through the annular space between the tubes, where such a concentric arrangement is used. Gaseous and/or liquid hydrocarbons are preferably used as the protective media. Thus crude benzol, propane, butane, natural gas or coke oven gas have been used. The amounts of protective media with respect to the refining oxygen are relatively small and may amount to **7%** in volume when natural gas is used and **3%** in volume when propane is used.

The protective medium prevents premature backburning of the tuyeres and an even burn-off of tuyeres

and of the surrounding refractory masonry is achieved. By contrast, it has been found that those tuyere pipes transmitting only oxygen burn back in funnel-shape very quickly and may cause converter breakdown during refining of a single melt. This has prevented industrial application of pure oxygen refining, without protective media. Oxygen used together with a properly metered amount of protective medium will cause an average wear in the tuyeres and in the refractory material of about **3** mm/melt. For instance by providing a **40** ton converter with a bottom masonry approximately **1** meter thick and with **8** tuyeres with **18** mm ID oxygen supply tubes, a converter life of **200** to **300** melts has been obtained. The life of the refractory masonry of the converter mantle is approximately double that of the converter bottom and therefore the bottom must be changed once during a converter campaign.

If oxygen is blow into a melt below the bath surface, there is danger that the blast will blow through the metal bath and emerge from the bath top surface. This danger increases as the height of the melt above the tuyeres decreases, with increasing tuyere diameter when the oxygen pressure remains constant and with increase in oxygen pressure when the tuyere diameter remains constant. In order to prevent such penetration of the metal bath by the oxygen jet, definite relations between oxygen pressure, tuyere diameter and filling height must be observed. Thus for steel refining converter with a total capacity of **40** tons and with an oxygen gauge pressure of **15** atmospheres, the maximum diameter of the oxygen supply tubes should amount to about **20** mm. A maximum tuyere diameter of about **30** mm is obtained for a converter capacity of **200** tons and the same oxygen pressure.

The customary total time of refining is about **10** minutes. In order to supply during this time the required amount of about **1,200** n^3/min. STP of oxygen for a **200** ton converter, approximately **20** tuyeres with the indicated diameters of about **30** mm will be required.

Although possessing decisive advantages during the blowing in of oxygen below the bath surface as contrasted with the top blowing oxygen process, for instance the reduction of iron losses, the lowering of the iron oxide content in the refining slag, quieter blowing, omission of recirculating cooling systems for the tuyeres and lesser elevations of steel work shops, there are nevertheless several technical drawbacks also associated with blowing in of oxygen below the bath surface. Such drawbacks in particular are the minimum number of tuyeres based on the relationship between filling height, tuyere diameters and blowing pressures, and the somewhat premature wear of the refractory masonry in the area of the tuyeres requiring changing this masonry region, for instance the converter bottom, during the converter campaign.

The present invention is directed to the provision of a process for the refining of metal melts which will combine the advantages of the known refining processes in which oxygen is blown by means of a water-cooled lance on the metal bath with the known refining process in which oxygen is introduced into a converter below the bath surface, in such manner that a new process will be obtained that does not suffer from the drawbacks of either of these known oxygen refining processes.

As shown in the single FIGURE of drawings, in the present invention tuyeres for the supply of oxygen and

protective medium are installed above the bath surface in the refractory lining of the converter mantle. It has been surprisingly discovered that tuyere-assemblies such as those which are being used for introducing oxygen and protective media underneath the bath surface when installed above the bath surface in the converter mantle masonry will burn back evenly together with the masonry and not, as had been expected on account of experience, at a rate approximately twice the rate of wear of the masonry in the tuyere region. For a refractory lining **500** mm thick in the converter mantle, durabilities from **500** to **800** melts have been achieved, which amounts to an average burn-off rate of about **0.5** to **1** mm/melt for the tuyeres. By installing the tuyeres for supplying oxygen and protective media above the bath surface, a technically simple and very reliable oxygen top blowing process has been achieved. The number of tuyeres no longer is limited as is the case when oxygen supply tuyeres and oxygen introduction occur underneath the bath surface, and tuyere diameters may be substantially enlarged. As an example, a single tuyere transmitting all the oxygen may be used for a **200** ton converter. The diameter of the oxygen supply tube amounts to approximately **130** mm. It was found suitable, however, to distribute the oxygen over several tuyeres. This procedure is advantageous since even if one tuyere breaks down, the melt may be refined to the end by means of the other tuyeres, and in addition the wear of the refractory lining may be advantageously controlled in such manner. As an illustration, operating with four tuyeres with approximate **65** mm ID's in said **200** ton converter was found to be practical.

In theory the arrangement of the tuyeres in the converter mantle may be effected at any height above the bath level. However the range from about **10** to **100** cm above the bath surface was found to be particularly advantageous in practice.

The inclination angle of the tuyeres as measured from the horizontal tuyere position in the direction of the bath surface may also fluctuate within limits, the range from **10°** to **60°** having been found to be suitable. When mounting tuyeres in the converter mantle, the inclination angle of the tuyeres should be increased as their height above the bath surface increases.

Further, tuyeres have been mounted at several different heights above the bath surface. A preferred arrangement utilizes tuyeres located in two tuyere planes. First the tuyeres in the more elevated plane with respect to the bath surface are utilized in a new converter, and after approximately half a campaign, the tuyeres in the lower-lying plane are utilized. The tuyere supply holes in the masonry that are not being used were plugged with refractory tamping clay or similar substances. The bath level in the converter decreases appreciably as the wear of the refractory masonry increases while the metal charge remains the same, and this procedure with two planes of tuyeres provides the advantage of blowing oxygen from nearly the same height onto the melt during the entire converter campaign.

In order to minimize ejections and splashes from the converter during the refining process, an array of tuyeres was utilized in which the impinging gas jet imparted a rotational impulse to the metal melt. This is achieved, not by directing the tuyeres along the converter longitudinal axis, but rather by turning all of them away and outward from such line — from the

converter wall to the converter longitudinal axis — by approximately **10°** to **50°**. In other words, the tuyeres were so arrayed that the impinging gas jets effected a rotational motion of the metal melt in the same direction.

A further measure for improving blowing consists in loading the oxygen stream with fine-grained slag-forming agents, in particular with lime. Besides the simplification achieved from the addition of slag-forming agents to the converter, the use of a lime-loaded oxygen stream makes it possible to refine for instance a pig iron melt to steel in about **10** minutes without any kind of ejection. Loading the oxygen stream with lime dust has proved particularly useful when refining low-phosphorus pig iron. The lime dust loading should be varied during the entire refining period. Experience shows that the ejection behavior during the refining of low-phosphorus pig-iron will markedly vary as a function of the silicon content of the melt, and therefore it was found advantageous to appreciably increase the lime-loading during the first half of the silicon removal and to reduce it as the silicon in the melt is removed.

The sense of the invention further includes operating the tuyeres for introduction of oxygen with protective media not only in refining veessels such as the various types of steel-making converters, but also in the refining by means of metallurgical furnaces such as electric and Simens-Martin furnaces. In addition the process of the invention has been applied to pre-refining and to post-refining in transportation vessels for metal melts with good results. Furthermore, the invention has been successfully applied to continuous steel making. In this installation the tuyeres were obliquely arranged in a groove-like furnace in order to stir the metal melt evenly.

The protective fluids which have been used in the practice of the present invention include those described in U.S. Pat. No. **3,706,549** and German Auslegeschriften Nos. **1,583,968** and **1,758,616** noted above. Particularly preferred fluids are hydrocarbons, especially straight chain alkanes with fewer than five carbon atoms in the chain, e.g., methane (natural gas) or propane.

We claim:

1. A process for refining metal melts in a refractory vessel which comprises:

blowing at least one stream of oxygen and a fluid stream of a protective fluid medium surrounding said oxygen, downwardly towards the surface of a metal melt to be refined, said streams being blown through dual tube tuyeres mounted in the masonry of said vessel above the surface of the metal melt to be refined and discharging a downwardly inclined stream of oxygen surrounded by a protective fluid medium onto the top surface of the metal melt in said vessel to refine said metal melt.

2. The process of claim **1** wherein the relative proportions of the oxygen and the protective fluid medium are such that the wear of the tuyeres is approximately equal to the wear of the masonry in which they are mounted.

3. The process according to claim **1** wherein the fluid stream blown at the melt causes the melt to rotate around the longitudinal axis of the converter.

4. The process according to claim **1** wherein lime is added to the oxygen stream before it is blown at the melt.

5. The process according to claim 1 wherein the oxygen and the protective fluid medium are blown upon a flowing stream of metal.

6. The process of claim 1 wherein the metal melt to be refined is pig iron.

7. The process of claim 1 wherein the protective fluid medium is a hydrocarbon.

8. The process of claim 7 wherein the hydrocarbon comprises a straight chain alkane with fewer than five

carbon atoms in the chain.

9. The process according to claim 7 wherein the oxygen and the protective fluid medium are blown-in in several planes.

10. The process according to claim 7 wherein the oxygen and the protective fluid medium are blown-in in several directions.

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