United States Patent

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[33] **Great Britain**
[31] **18,505/68**

[54] **TREATMENT OF MOLTEN MATERIAL**
9 Claims, 6 Drawing Figs.

[52] **U.S. Cl.** ..... **266/34 R,** 18/2.5 R, 222/149, 241/39
[51] **Int. Cl.** **C21c 7/00**
[50] **Field of Search** ..... 18/2.5 M, 2.4, 2.5 R, 2.6, 2.7; 266/34, 15, 34 A, 34 T, 34 V, 38; 241/164, 165, 166, 167, 169; 75/51, 52, 59, 60, 61, 93; 222/148, 149, 196, 198, 226, 342, 345; 164/66

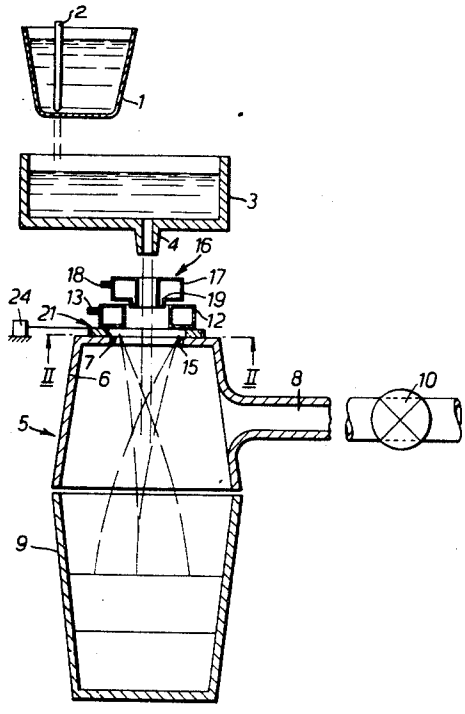
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ABSTRACT: The invention is directed to means for removing accretions from the gas discharge nozzle or nozzles of apparatus for treating molten materials in which a freely falling stream of the molten material is shattered by a flow of gas directed at the stream. The accretion-removing means may comprise scrapers movable either continuously or intermittently across the face of the orifices of the or each gas discharge nozzles. Alternatively, the accretions may be removed or may be prevented from forming by a high-frequency vibrator connected to the gas discharge device.



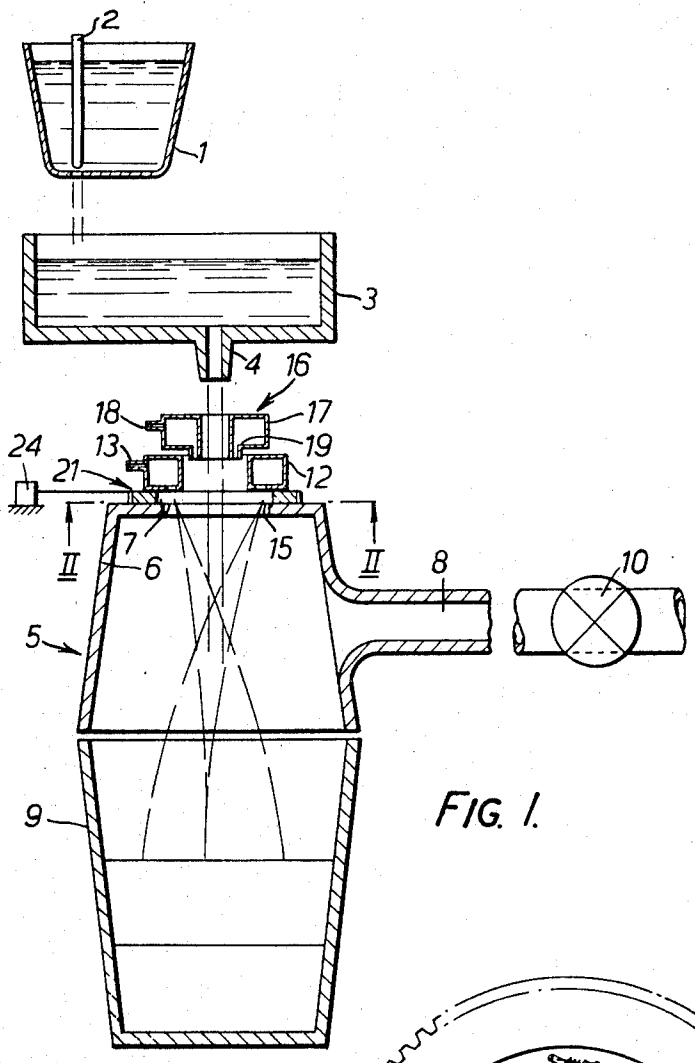


FIG. 1.

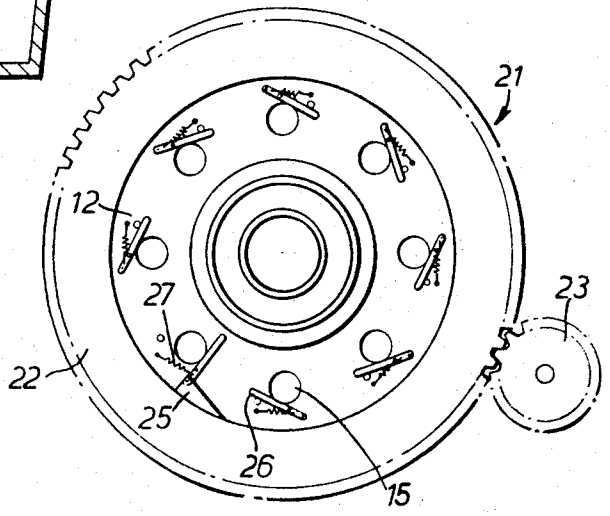


FIG. 2.

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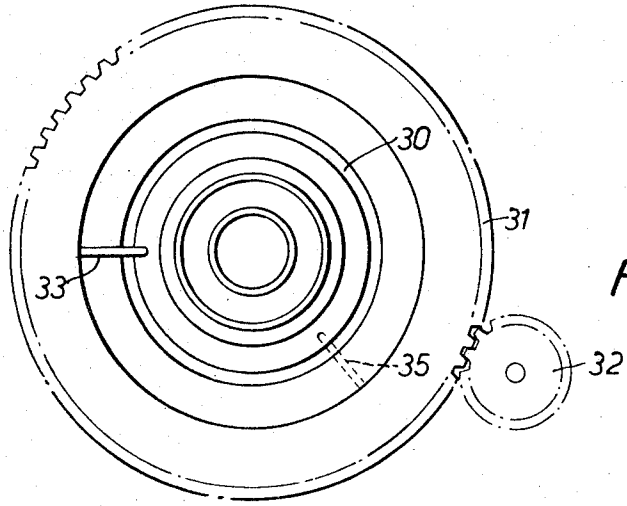


FIG. 3.

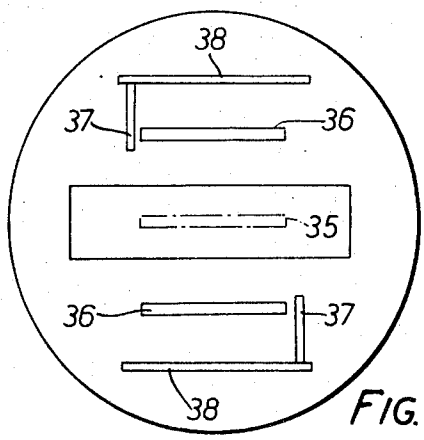


FIG. 4.

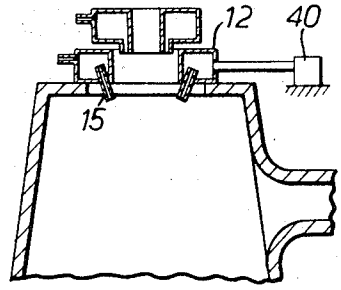


FIG. 5.

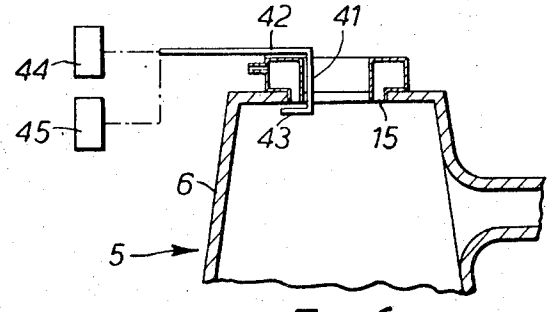


FIG. 6.

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TREATMENT OF MOLTEN MATERIAL

This invention relates to apparatus for carrying out processes for treating molten material of the kind in which a freely falling stream of molten material is shattered by a blast of fluid directed against the stream.

One example of such a process is the spray refining process in which a stream of molten metal falling freely under the influence of gravity is formed into droplets by the action of a jet or jets of gas capable of reacting with impurities in the molten metal; an example of the spray refining process in which ferrous metal is refined by the action of oxidizing gas issuing from a gas discharge device is described in United Kingdom Pat. specification No. 949,610. The oxidizing gas may be, for example, oxygen, air or air enriched with oxygen.

During prolonged operation of the spray refining process, buildup of material containing iron oxide, lime and silica has occurred around the outlet orifices of the gas jets. It is believed that this material buildup is caused by fine droplets of molten material freezing due to the relatively low temperatures at the orifices resulting from rapid expansion of the oxidizing gas as it issues under pressure from the orifices.

The material buildup forms cone-shaped accretions dependent from the undersurface of the gas discharge device and disposed around the periphery of such outlet orifice; the accretions may project to a substantial distance and may cause partial interference and deflection of the oxidizing gas jets. Such interference and deflection can lead to inefficient shattering of the molten metal stream and subsequent poor removal of impurities.

According to the present invention there is provided apparatus for carrying out a process for treating molten material, comprising a reaction vessel, means for feeding molten material into the reaction vessel as a freely falling stream, a gas discharge device having orifice means operable to produce a gas flow directed towards the path of the molten material to shatter the stream thereof, and means operable substantially to clear or to maintain clear of accretions the orifice means of the gas discharge device.

The invention will now be described by way of example only with reference to the accompanying diagrammatic drawings, in which:

FIG. 1 illustrates a cross section of apparatus in accordance with the invention;

FIG. 2 is a plan view to an enlarged scale taken along line II—II of FIG. 1 showing apparatus in accordance with the invention mounted on the undersurface of a gas discharge device of the apparatus;

FIGS. 3 and 4 are plan views similar to that shown in FIG. 2 of further embodiments of apparatus in accordance with the invention, and

FIGS. 5 and 6 are part cross sections of views of alternative apparatus in accordance with the invention.

Referring now to FIG. 1 of the drawings, there is shown a transfer ladle 1 having a flow control stopper 2 for controlling the rate of flow of molten metal, e.g. ferrous metal, to a tundish 3 having a refractory outlet nozzle 4.

Positioned beneath the tundish is a reaction vessel 5 which comprises a hood 6 having a central aperture 7 and a waste gas offtake 8, and a receiving vessel 9 positioned beneath the hood 6. As extractor fan 10 is located in the offtake 8, which is shown as having a single inlet but may comprise a plurality of inlets spaced about the hood.

Located above the hood 6 is an annular oxidizing gas discharge device comprising a header 12 having an inlet 13 and a plurality of outlet nozzles 15 having orifices which are orientated so as to direct jets of oxidizing gas downwardly and inwardly. The jets intersect the path of the stream of molten metal discharged by the tundish nozzle 4 inside the hood 6.

A flux discharge device 16 is mounted above the gas discharge device and comprises an annular manifold 17 having an inlet 18 and outlets 19 to discharge a curtain of fluxing agent around the molten metal stream. The inlet 18 is coupled to a source of gas-entrained flux.

Apparatus for clearing material buildup from around the oxidizing gas nozzles is indicated at 21; the apparatus is illustrated in more detail in FIG. 2. The apparatus comprises a rotatable collar 22 mounted between the upper surface of the hood 6 and the undersurface of the gas discharge device, and coaxial with a circle passing through the center of each gas discharge orifice 15. The collar is driven through gearing 23 by a drive motor 24 (FIG. 1) and has mounted on its inner circumference an inwardly extending cam surface 25 which is so shaped and positioned as to cooperate with the radially outer ends of spring-loaded pivotably mounted scraping members 26, one of which is mounted adjacent the orifice of each oxidizing gas nozzle. The end of each member 26 remote from the collar 22 is movable against the action of a spring 27 across the orifice of the adjacent oxidizing gas nozzle upon deflection of the member by contact with the cam surface. The members 26 may be blades or bars of toughened steel.

In operation, molten material in the tundish 1 will fall from the nozzle 4 as a coherent stream at a rate determined by the head in the tundish. The freely falling stream, together with flux discharged from the outlets 19, is shattered by and intimately mixed with jets of oxidizing gas discharged from the orifices 15 of the gas discharge device. The impurities in the molten metal react with the oxidizing gas and refined particulate metal is collected in the receiving vessel.

In order to remove material buildup from around the peripheries of the orifices 15 of the gas discharge nozzles, the collar 22 is rotated either continuously or intermittently by the drive motor 24 during operation of the refining apparatus. The cam surface 25 contacts, in turn, the ends of scraper members 26 which are moved by the cam surface against the action of their springs across the face of the adjacent gas discharge orifice. Once the cam surface is moved out of contact with a scraper member 26, the spring loading of the member returns the member to its original position. In an alternative embodiment, the members 26 are not moved across the orifices of the nozzles 15, but merely to positions in close proximity to the boundaries of the nozzles so as to strike one side of each accretion which results in removal of the material buildup.

As described in accordance with FIGS. 1 and 2, the gas discharge device comprises a plurality of individual gas discharge nozzles. In FIG. 3 there is illustrated apparatus for clearing material buildup from around the orifice of a single annular orifice 30 from which a convergent annular jet of oxidizing gas is discharged to intersect the path of the molten metal stream. The apparatus comprises a rotatable collar 31 mounted coaxial to the orifice 30. The collar is driven through gearing 32 and has a scraper member 33 extending radially inwardly from the inner circumference of the collar. The member 33 is dimensioned to extend across the orifice and is operable to clear the boundaries of the orifice of material buildup.

As the member 33 is rotated about the undersurface of the gas discharge device, accretion may buildup along its trailing edge which will lead to excessive blockage of the annular nozzle 30. In order to remove any such accretion, a further scraper member 35 (shown in broken line in FIG. 3) may be provided which extends radially inwardly from the inner circumference of a rotatable collar (not shown) mounted coaxial with collar 31 and driven intermittently by variable speed drive means (not shown) at speeds greater and less, respectively, than that of the collar 31; the arrangement is such that the member 35 sequentially moves forwardly relative to the member 33 to a position at which it strikes and removes any accretion formed on the trailing edge of member 33, and then rearwardly relative to the member 33 to a position at which the member 33 strikes and removes any accretion formed on the trailing edge of member 35.

In the embodiments described in accordance with FIGS. 1 to 3, the tundish nozzle 4 is of generally circular cross section and the oxidizing gas is directed at the molten metal stream from an annular gas discharge nozzle or an annular array of such nozzles. In the embodiment illustrated in FIG. 4, the

tundish nozzle 35 is of generally rectangular cross section at outlet and the oxidizing gas discharge device comprises two nozzles 36 of generally rectangular cross section, one disposed adjacent each longitudinally extending side of the molten metal stream. Mounted adjacent the longitudinal extent of each nozzle 36 is an inwardly extending scraper member 37 movable by drive means along a track 38. Each scraper member 37 is positioned so as to lie outside the extent of the orifice of the adjacent nozzle 36 while not in operation, and dimensioned so as to move across and along the longitudinal extent of the nozzle when operated by the drive means. Whereas two oxidizing gas nozzles are shown, it is to be understood that only one such nozzle may be provided. Furthermore, the cross-sectional shape of the tundish nozzle and associated gas discharge nozzle or nozzles may alternatively be of elliptical or any other form having a major axis several times greater than the minor axis.

In the foregoing embodiments, material buildup is cleared by scraper members moved in relation to the orifice of the or each gas discharge nozzle. In an alternative embodiment illustrated in FIG. 5, a vibrator unit 40 is coupled to the gas discharge device. The unit is operable continuously or intermittently during operation of the refining process to cause high-frequency vibration of the gas discharge device to prevent or remove material buildup from around the boundary of the or each oxidizing gas discharge orifice.

In each of the embodiments illustrated in FIGS. 1 to 4, the material clearing device 21 is located between the oxidizing gas discharge device and the upper surface of the hood 6; the scraper members of the device 21 are therefore positioned above the reaction zone within the vessel 5. In the embodiment illustrated in FIG. 6, a scraper member 42 is shown comprising a shaped hollow rod having a portion 41 which extends downwardly into the hood 6 of the reaction vessel 5 and a portion 43 which extends radially outwardly from the portion 41 to a position in which it lies between adjacent oxidizing gas orifices 15. A drive motor 44 is coupled to the member 42 to move the rod portion 43 across the face of one or more of the oxidizing gas orifices. One or more such members 42 may be provided. Since the rod portions 41 and 43 extend into the hood 6, the hollow member 42 is cooled by cooling fluid fed to the member from conveying means illustrated diagrammatically at 45. It will be appreciated that each of the material clearing devices illustrated in FIGS. 1 to 4 could also be cooled, e.g., water cooled.

Results of a trial carried out in which material buildup was removed in situ are compared in the following tables with results of a trial in which material buildup was not removed. The two trials were carried out under similar operating conditions, the oxidizing gas input rates and velocities to the gas discharge device being identical.

Table 1—Trial in which material buildup was removed in situ:

	Carbon	Silicon	Manganese
Molten ferrous metal analysis	4.10%	2.15%	0.96%
Produce steel analysis	0.21%	0.05	0.08%

Table 2—Trial in which material buildup was not removed.

	Carbon	Silicon	Manganese
Molten ferrous metal analysis	4.10%	2.15%	0.96%
Product steel analysis	2.65%	0.70%	0.62%

It will be seen from the above tables that more efficient usage of oxidizing gas occurred in the trial outlined in Table 1.

Whereas the invention has been described with reference to apparatus for refining molten metal, in particular ferrous metal, it is to be understood that the apparatus can be used for the treatment of materials other than molten metal, for example, metalliferous materials.

We claim:

1. Apparatus for carrying out a process for treating molten material, comprising a reaction vessel, a container having an outlet of generally circular cross section for feeding molten material into the reaction vessel as a freely falling stream, a gas discharge device having an array of discharge orifices circumferentially arranged about the path of the stream of molten material and operable to produce a gas flow directed towards the path of the molten material to shatter the stream thereof, and accretion-clearing means comprising a member positioned adjacent each orifice and means for moving each said member into accretion-removing relationship with the adjacent orifice.

2. Apparatus according to claim 1, wherein each said member is arranged to be moved intermittently across the face of the adjacent orifice.

3. Apparatus according to claim 2, wherein said members are pivotally mounted in relation to the gas discharge device, and wherein said means for moving each said member comprises a cam surface movable into contact with an outwardly extending end portion of each said member.

4. Apparatus according to claim 3, wherein the cam surface is formed on the radially inner circumference of a collar rotatable by drive means about the array of discharge orifices.

5. Apparatus for carrying out a process for treating molten material, comprising a reaction vessel, a container having an outlet of generally circular cross section for feeding molten material into the reaction vessel as a freely falling stream, a gas discharge device having an annular orifice circumferentially arranged about the path of the stream of molten material and operable to produce a gas flow directed towards the path of the molten material to shatter the stream thereof, and accretion clearing means comprising a member carried by a rotatable collar mounted coaxial to the annular orifice, which member extends across the radial extent of the annular orifice.

6. Apparatus for carrying out a process for treating molten material, comprising a reaction vessel, a container having an outlet of generally rectangular cross section for feeding molten material into the reaction vessel as a freely falling stream, a gas discharge device having elongate orifice means extending along at least one longitudinally extending side of the path of the stream of molten material and operable to produce a gas flow directed towards the path of the molten material to shatter the stream thereof, and means operable substantially to clear or to maintain clear of accretions the elongate orifice means of the gas discharge device.

7. Apparatus according to claim 5, wherein the accretion clearing means comprises a member movable along a path parallel to the longitudinal sides of the path of molten material and extending across the lateral extent of the or each orifice.

8. Apparatus for carrying out a process for treating molten material, comprising a reaction vessel, means for feeding molten material into the reaction vessel as a freely falling stream, a gas discharge device having at least one orifice operable to produce a gas flow directed towards the path of the molten material to shatter the stream thereof, and means operable substantially to clear or to maintain clear of accretions said at least one orifice, said accretion clearing means comprising a member positioned adjacent said at least one orifice and means for moving said member into accretion-removing relationship with said at least one orifice.

9. Apparatus according to claim 8 further comprising high-frequency vibrator means connected to said gas discharge device.

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