

United States Patent

Harker et al.

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[54] CONDENSATE COLLECTION MEANS

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[51] Int. Cl. **C21c 7/00**

[58] Field of Search 164/50, 61, 250, 254; 266/19,
266/34 V, 34; 13/31; 118/49.1, 49.5

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[57]

ABSTRACT

Condensate collection means are described for use in a furnace for processing materials subject to vaporization wherein condensate is collected by means of a collector plate and one or more mesh structures positioned to condense the vapor. The one or more mesh structures allow vapor to first pass through to the collector plate but prevent solid pieces of condensate from falling back toward the vapor source.

5 Claims, 2 Drawing Figures

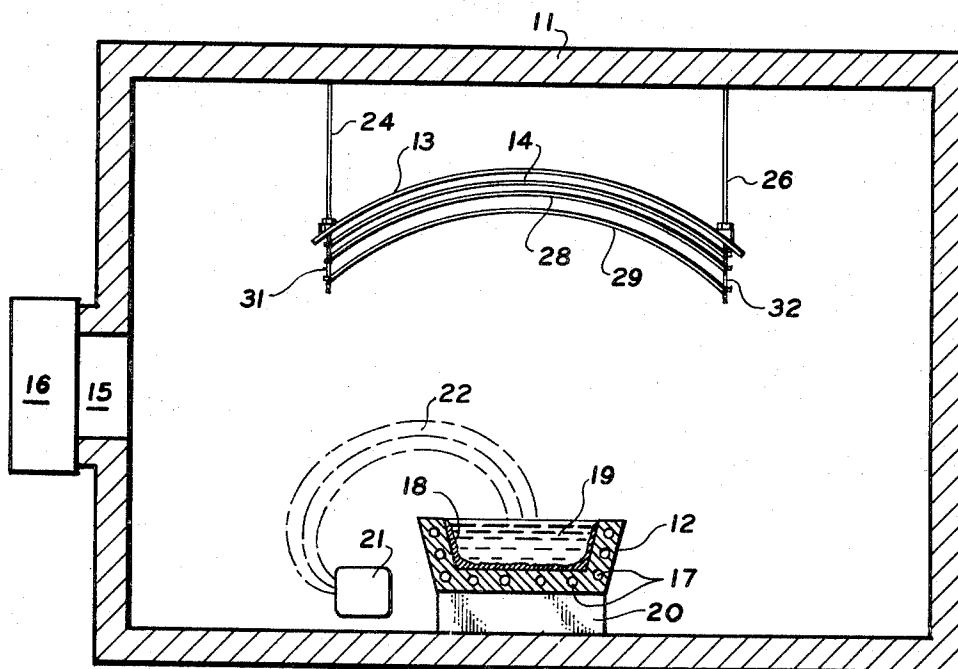


FIG. 1.

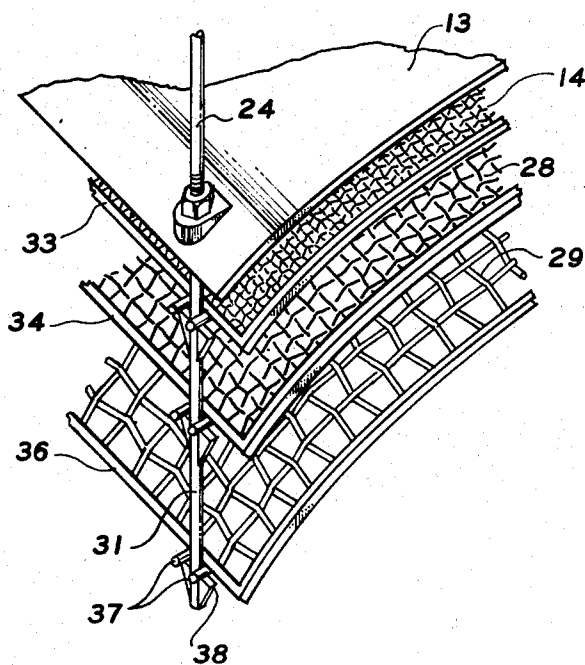
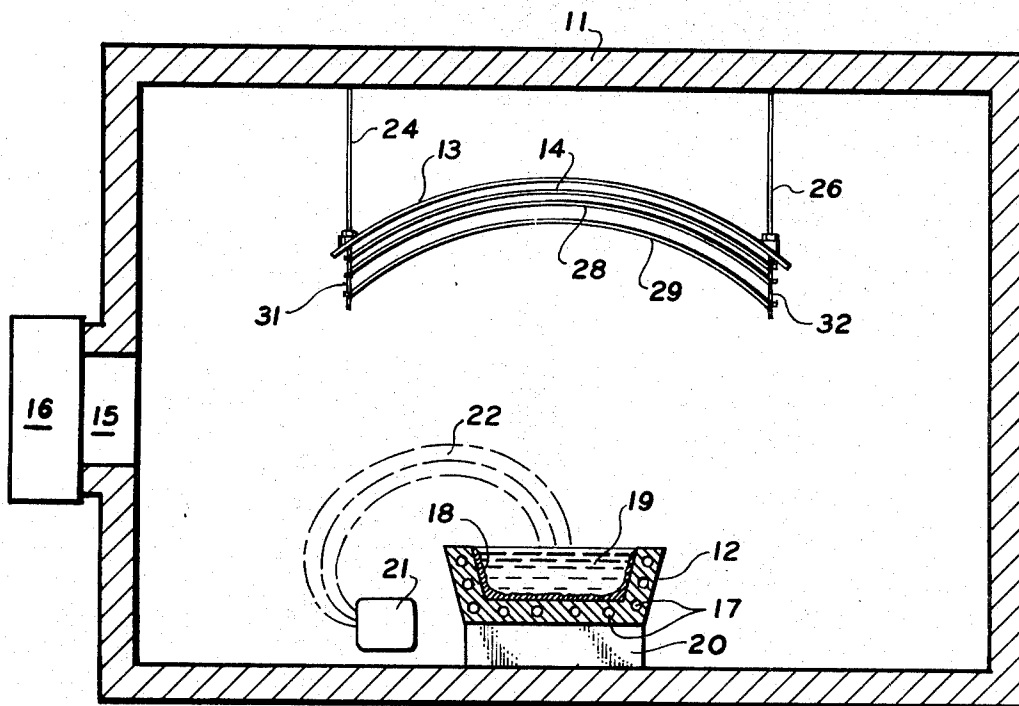


FIG. 2.

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CONDENSATE COLLECTION MEANS

This invention relates generally to the processing of materials subject to vaporization and, more particularly, to means for collecting condensate in a furnace for processing materials subject to vaporization.

In the processing of materials such as molten metals or alloys, especially in vacuum, high vapor pressure constituents often leave the liquid-gas interface of the melt and condense on nearby furnace elements such as shields, furnace walls, structural components and refractories. Where evaporation rates are high, for example 0.005 inch to 0.150 inch thick condensate per hour per unit area, there is a tendency for the condensate building up on such nearby elements to peel off and drop downwardly. Structures positioned above the molten material, where vapor flow is usually heaviest, are particularly prone to releasing flakes of condensate which fall back toward the molten material. In addition, shields for electrical leads or other parts, located in the path of lower angle vapor may also coat with condensate and, if close to the melt, produce a flaking problem.

Solid pieces of condensate falling from various elements within a furnace can produce serious problems. For example, undesired volatiles which are evaporated from the molten material being processed may be unintentionally returned to the molten material in the form of solid pieces or flakes of condensate falling from furnace elements to thereby contaminate the molten material. Moreover, where electron beams are utilized to heat the molten material, solid pieces of ferromagnetic condensate falling from nearby furnace elements may result in a shorting out of electron guns and a detrimental altering of the electron beam deflection magnetics (the magnetic fields utilized to direct and focus the electron beams).

Accordingly, it is an object of the present invention to provide condensate collection means for use in a furnace for processing materials subject to vaporization.

Another object of the invention is to provide means for collecting condensate in a vacuum furnace and preventing such condensate from peeling and falling back toward material being processed.

A further object of the invention is to provide means in a furnace for processing materials subject to vaporization, which means prevent contamination of purified materials due to falling condensate.

It is another object of the invention to provide means in an electron beam furnace for processing materials subject to vaporization, which means prevent interference with the production, direction and focusing of the electron beams due to falling condensate.

Other objects of the invention will become apparent to those skilled in the art from the following description, taken in connection with the accompanying drawing wherein:

FIG. 1 is a schematic illustration of a vacuum furnace incorporating the invention; and

FIG. 2 is a perspective view of a portion of the condensate collection means, utilized in the vacuum furnace of FIG. 1.

Very generally, the invention is for use in an enclosure 11 having means 12 therein for containing the vaporizable material being processed. The invention includes a collection plate 13 for collecting condensate,

such collection plate being positioned in the vapor flow above or to the side of the containing means. At least one mesh structure 14 is positioned between the collection plate and the containing means. The mesh structure is sufficiently porous to allow vapor to pass through to the collection plate and is sufficiently fine as to prevent passage of solid pieces of condensate of significant size falling from the collection plate.

Referring now particularly to FIG. 1, a vacuum furnace for use with the invention is illustrated schematically. It is to be understood, however, that the invention is useful in any type of furnace wherein the presence of vapor may cause a flaking problem. The illustrated furnace includes an air-tight enclosure or tank 11 having a port 15 through which the enclosure is evacuated by means of a vacuum pump 16. The actual configuration of the enclosure or tank 11 depends upon the particular process employed therein and it therefore may take any of a variety of forms. Typically, the inside of such an enclosure includes various items such as structural bracing, supports for the heating and metal containing elements, viewing windows, vapor barriers, etc. Many of these elements are subject to the condensation of vapor thereon.

In the illustrated embodiment, the means for containing the molten material for processing comprise a crucible 12 having a plurality of coolant passages 17 therein for the circulation of a coolant. The crucible may be made of copper and the circulated coolant may be water. Cooling of the crucible forms a skull 18 of solidified molten material between the molten material 19 and the crucible. This maintains the purity of the molten material and prevents erosion of the crucible. The crucible is supported in the furnace by means of a suitable support 20.

The molten material 19 in the crucible 12 is heated by means of an electron beam gun 21. The electron beam gun produces a beam 22 of electrons which is directed through an arcuate path by a suitable magnetic deflection system, not illustrated, to strike the surface of the molten material 19. An electron beam gun and magnetic deflection system capable of producing such a result is shown and described in U.S. Pat. No. 3,177,535 assigned to the assignee of the present invention.

In the illustrated embodiment, the material 19 is processed in the crucible 12, which is relatively shallow, in order that various occluded gases and volatile impurities may be drawn off by the vacuum. Typical vacuum conditions are one Torr or less pressure. Although the illustrated embodiment employs a crucible, the invention is equally applicable to other types of processing wherein other types of equipment are utilized. For example, in any process in which molten metal is heated and is contained by any suitable means such as a hearth, tundish, launder, or, as illustrated, a crucible, volatile materials may be evolved from the melt which will condense on various structures within the furnace. Also, in cases where metal is intentionally vaporized for condensation on and coating a substrate (not shown) positioned above the melt, vapor which misses the substrate being coated may result in a flaking problem as described. Moreover, although the illustrated means of heating utilizes the energy of an electron beam, the invention is applicable to other means of heating such as induction or resistance heating.

As previously mentioned, in many cases where molten material is processed, especially in a vacuum, high vapor pressure constituents leave the liquid-gas interface of the melt and condense on nearby furnace elements such as shields, tank walls, furnace structures and refractories. In many processes, a high evaporation rate occurs, such as 0.005 inch to 0.150 inch thick condensate per hour per unit area directly above or near the melt. The internal elements of the furnace may be in a position where vapor condenses thereon. When the condensate builds up sufficiently, there may be a tendency for the condensate to peel from the nearby structure and solid pieces or flakes of the condensate may fall back toward the molten material. When solid pieces of the material fall back into the melt, this may produce undesired contamination of the molten material. Moreover, where, as in the illustrated embodiment, electron beams are utilized to heat the molten material, solid pieces of condensate may fall on elements of the electron beam gun casing shorting. Additionally, the presence of pieces of ferromagnetic condensate falling through the magnetic deflecting fields for the electron beam may produce undesired variation.

In accordance with the invention, a structure for capturing the condensate and preventing it from falling back in solid form toward the melt is employed. The structure includes the collection plate 13 which, in the illustrated embodiment, forms a partially cylindrical canopy over the melt 19 and is suspended by and bolted to a plurality of supports, two of which 24 and 26 are shown, from the roof of the enclosure 11. Depending upon the particular furnace configuration, the collection plate may be positioned in different orientations from that illustrated, for example, at about 45° and toward one side of the molten material rather than directly over it. The collection plate material and thickness is not critical to the invention, but the collection plate should be sufficiently stiff to maintain its rigidity under operating conditions. This should take into account the fact, as will be explained, that the collection plate may be used to support other elements and also that the collection plate will become coated with condensate and therefore become heavier. Typically ¼ to ½ inch mild steel plate will maintain its position within plus or minus one-fourth inch during most operating conditions where its overall area is about 30 to 50 square feet. Less area requires less thickness. For example, 16 gauge material may be satisfactory for areas of the order of 1 to 10 square feet. Preferably, the collection plate is imperforate, but this is not critical if it is otherwise capable of condensing a sufficient amount of vapor. Under some circumstances, a portion of the furnace wall itself may serve satisfactorily as the collection plate.

Three mesh structures 14, 28 and 29, substantially coextensive with the surface of the collection plate 13 facing the source of vapor, are supported on struts, two of which 31 and 32 are shown, extending downwardly from the collection plate 13. The mesh structures, which are not necessarily woven but of any suitably perforate construction, are of decreasing fineness towards the crucible 12, that is, the mesh structure 14 is finer than the mesh structure 28, and the mesh structure 28 is finer than the mesh structure 29. In one satisfactory form of the invention, the mesh structure

14 comprises a woven wire screen of either welded or galvanized construction spaced ¼ inch to 2 inches from the collection plate 13. Such a mesh structure may be fabricated from 10 gauge or finer wire and may have a separation of ¼ inch to ½ inch between wires. The second mesh structure 28 may be spaced 1 inch to 1½ inches off the mesh structure 14 and may be of similar construction having 1 inch to 1½ inches spacing between 10 gauge or finer wire strands. In the illustrated embodiment, the third mesh structure 29 may be spaced 1 inch to 2 inches off the mesh structure 28 and may be of 3 gauge wire or finer with a separation between wires of about 2 inches.

As may be seen in FIG. 2, the mesh structures 14, 28 and 29 may be held in frames 33, 34 and 36, respectively. The structures may be supported on the struts 31 and 32 in any suitable manner, for example, the projections 37 and stops 38 as illustrated.

Under operating conditions, the volatile materials which first leave the molten material 19 pass through the mesh structures 29, 28 and 14 and condense on the collection plate 13. Solid pieces of the condensed material on the collection plate falling therefrom are captured between the collection plate and the mesh structure 14. As processing continues, condensation on the mesh structure 14 eventually plugs that structure preventing further condensation on the collection plate 13. However, condensation has been occurring on the mesh structure 28 and, when condensate builds up sufficiently on the mesh structure 14 as to peel or flake off, solid pieces or flakes of condensate are prevented from falling through by the mesh structure 28. Eventually, when the mesh structure 28 is plugged by condensate and begins to peel or flake, condensate build up on the mesh structure 29 is sufficient to prevent pieces or flakes from falling toward the melt.

Processes of short duration (several minutes to an hour), which typically result in thin, flaky condensate, are of no problem since the collection plate 13 and the first mesh structure 14 are effective in trapping this type of condensate, preventing flakes from falling back toward the crucible 13. At the other extreme, thick heavy condensates resulting from processes running from 10 to 20 hours are effectively trapped by the second and third mesh structures 28 and 29.

Dependent upon the length of the process and the types of materials being processed, it may be possible to utilize only a single mesh structure rather than three, as in the illustrated embodiment. Moreover, some circumstances may enable the use of two mesh structures or require more than three mesh structures, depending upon processing conditions. Thus, the nature of the process and the type of material being processed determine the porosity and gauge of the mesh structure utilized, as well as the number thereof. The examples previously set forth are typically satisfactory for the processing of most metals and alloys for runs of 10 to 20 hours.

Basically, the first mesh structure should be sufficiently porous to allow vapor to initially pass through to the collection plate, and should be sufficiently fine as to prevent passage of solid pieces of condensate of significant size falling from the collection plate. By significant size, it is meant those pieces of a size which would cause an intolerable contamination of the melt or an in-

tolerable variation in the magnetics or a shorting or the electron beam gun. Very tiny flakes, which are not typical but which may fall and pass through the mesh structure or structures may be tolerable and therefore are insignificant.

After a period of operation, the mesh structures become plugged with condensate, the more fine mesh structures becoming plugged first. The fineness of the first mesh structure 14 is selected as described above. The other mesh structures are selected to become sufficiently fine after a period of operation, due to condensation, as to prevent passage of flakes of significant size once condensate begins flaking off the immediately adjacent plugged mesh structure toward the collection plate. As condensate builds up on the wires of a mesh structure, typically in a columnar or needle shaped pattern or grain growth for most metals, the open spaces between the wires become smaller to prevent passage of flakes.

It may therefore be seen that the invention provides condensate collection means for use in a furnace for processing material subject to vaporization. The invention provides a very low cost and efficient means of dealing with heavy condensates and thereby is extremely useful where high vapor pressure constituents are present in the molten material, particularly during lengthy processing runs. The invention is of particular advantage in vacuum furnaces where purification of material or coating of substrates is desired or where electron beam heating is utilized.

Various modifications of the invention in addition to those shown and described herein will become apparent to those skilled in the art from the foregoing description and accompanying drawings. Such modifications are intended to fall within the scope of the appendant claims.

We claim:

1. For use in a furnace for processing materials subject to vaporization, condensate collecting means comprising, a collection plate for collecting condensate having a surface adapted for positioning in the path of vapor, and at least one mesh structure positioned adjacent said surface and substantially coextensive therewith for positioning in the path of vapor, said mesh structure being sufficiently porous to suitably allow vapor to pass through to said collection plate and being sufficiently fine as to prevent passage of solid pieces of condensate of significant size falling from said collection plate.

2. For use in a furnace for processing materials sub-

ject to vaporization, condensate collecting means comprising, a collection plate for collecting condensate having a surface adapted for positioning in the path of vapor, a plurality of mesh structures positioned at spaced intervals from said surface substantially coextensive therewith for positioning in the path of vapor, said mesh structure being sufficiently porous to suitably allow vapor to pass through to said collection plate and being sufficiently fine as to prevent passage of solid pieces of condensate of significant size falling from said collection plate, said mesh structure being of decreasing fineness away from said collection plate.

3. Means according to claim 2 including a first mesh structure generally parallel to said collection plate and spaced from $\frac{1}{4}$ to 2 inches therefrom, said first mesh structure being comprised of a woven wire screen of 10 gauge or finer wire having a spacing between wires of from $\frac{1}{8}$ to $\frac{1}{2}$ inch, and including a second mesh structure generally parallel to said first mesh structure and spaced from 1 to $1\frac{1}{2}$ inches therefrom, said second mesh structure being comprised of a woven wire screen of 10 gauge or finer wire having a spacing between wires of from 1 inch to $1\frac{1}{2}$ inches.

4. Means according to claim 3 including a third mesh structure generally parallel to said second mesh structure and spaced from $\frac{1}{4}$ to 2 inches therefrom, said third mesh structure being of 3 gauge or finer wire having a spacing between wires of about 2 inches.

5. For use in a furnace for processing materials subject to vaporization, condensate collecting means comprising, a collection plate for collecting condensate having a surface adapted for positioning in the path of vapor, a first mesh structure positioned adjacent said surface and substantially coextensive therewith for positioning in the path of vapor, said first mesh structure being sufficiently porous to suitably allow vapor to pass through to said collection plate and being sufficiently fine as to prevent passage of solid pieces of condensate of significant size falling from said collection plate, a second mesh structure positioned on the opposite side of said first mesh structure from said collection plate, said second mesh structure being more porous than said first mesh structure to continue to allow vapor to pass through after said first mesh structure becomes plugged with condensate, said second mesh structure being sufficiently fine due to build up of condensate thereon at the time said first mesh structure becomes plugged as to prevent passage of solid pieces of condensate of significant size falling from said first mesh structure.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,690,635

Dated September 12, 1972

Inventor(s) Howard R. Harker and Geoffrey H. Humberstone

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

The co-inventor is Geoffrey H. Humberstone.

The Assignee is Airco, Inc.

In Column 2, line 66, "geam" should be --beam--

In Column 3, line 21, "casing" should be --causing--
" " " , line 26, "form" should be --from--

In Column 4, lines 35 and 36, there should be a hyphen (-) between "build" and "up"

In Column 5, line 1, the second "or" should be --of--
" " " , line 17, "or" should be --of--

Signed and sealed this 13th day of March 1973.

(SEAL)
Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents