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[54] **APPARATUS FOR IMMERSING AND WITHDRAWING BATH EXAMINATION MEANS INTO AND FROM A MOLTEN BATH**

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[73] Assignee: **United States Steel Corporation**

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[52] **U.S. Cl.** .....**73/343 R,** 73/354, 73/DIG. 9, 136/234

[51] **Int. Cl.** **G01k 1/14**

[58] **Field of Search**.....73/354, 359, 344, 73/343 R, DIG. 9, 136/234

[56] **References Cited**

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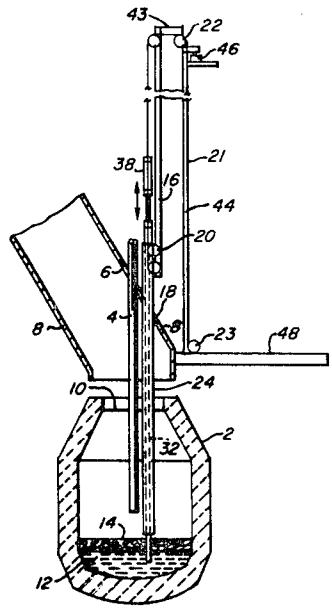
[57] **ABSTRACT**

Apparatus for immersing and withdrawing a sensor and a sample into and from a molten metal bath has a sensor and a sampler mounted on the lower end of a probe which is mounted for vertical movement inside a cooled jacket. The jacket is movable along a vertical runway which is pivoted from a service position to an operating position over the molten metal bath. The jacket is lowered along the runway to the surface of the bath and an air cylinder mounted on the jacket plunges the probe into the bath. When sensor readings and a sample are obtained, the air cylinder withdraws the probe back into the jacket where the protection and cooling effect of the jacket makes a liquidus arrest temperature for molten steel readily available. The jacket is then withdrawn from the bath and the runway pivoted back to the service position.

12 Claims, 5 Drawing Figures



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SHEET 1 OF 2

FIG. 5

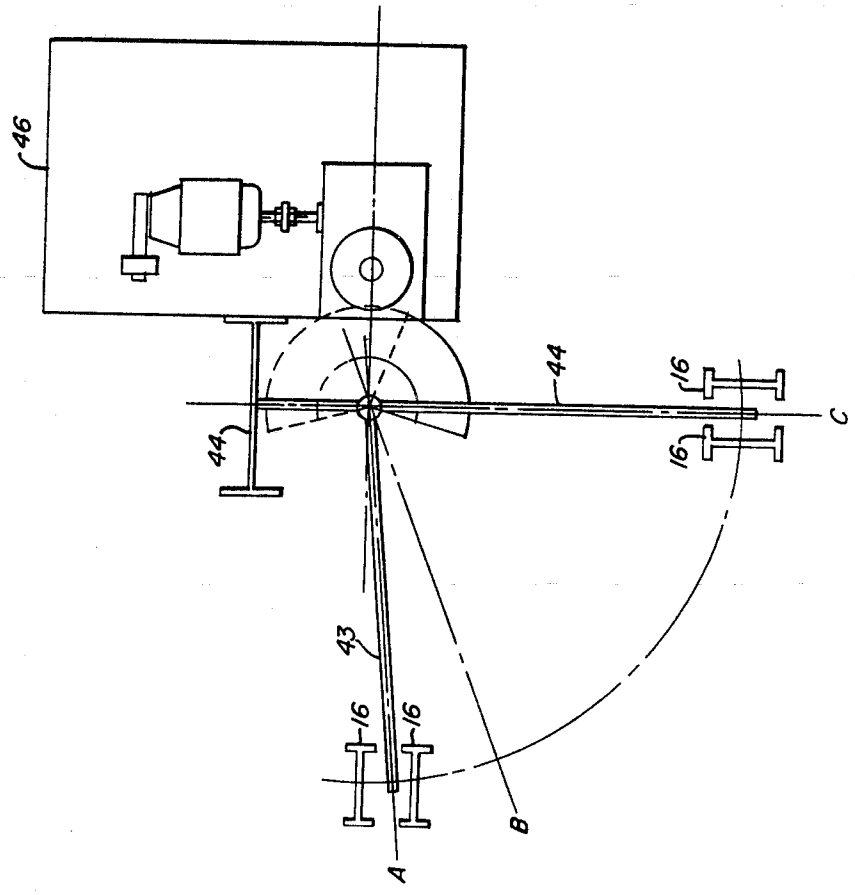

FIG. 1

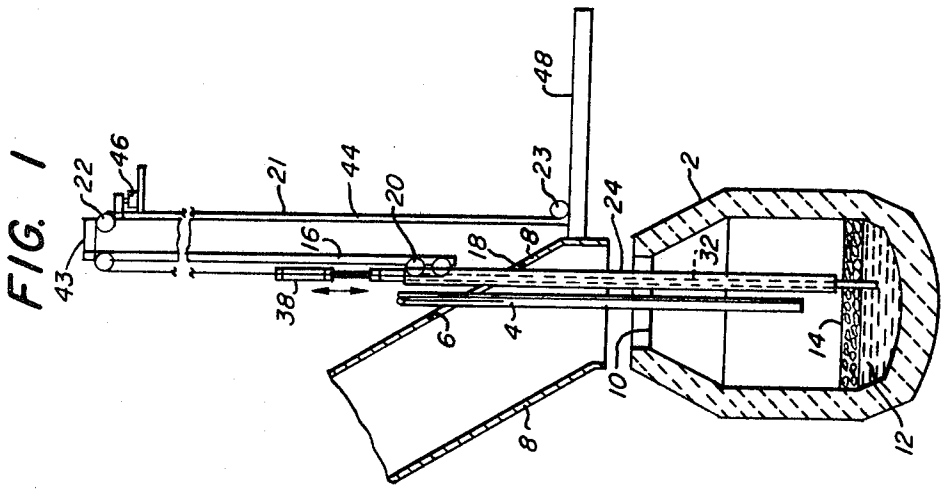

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FIG. 2

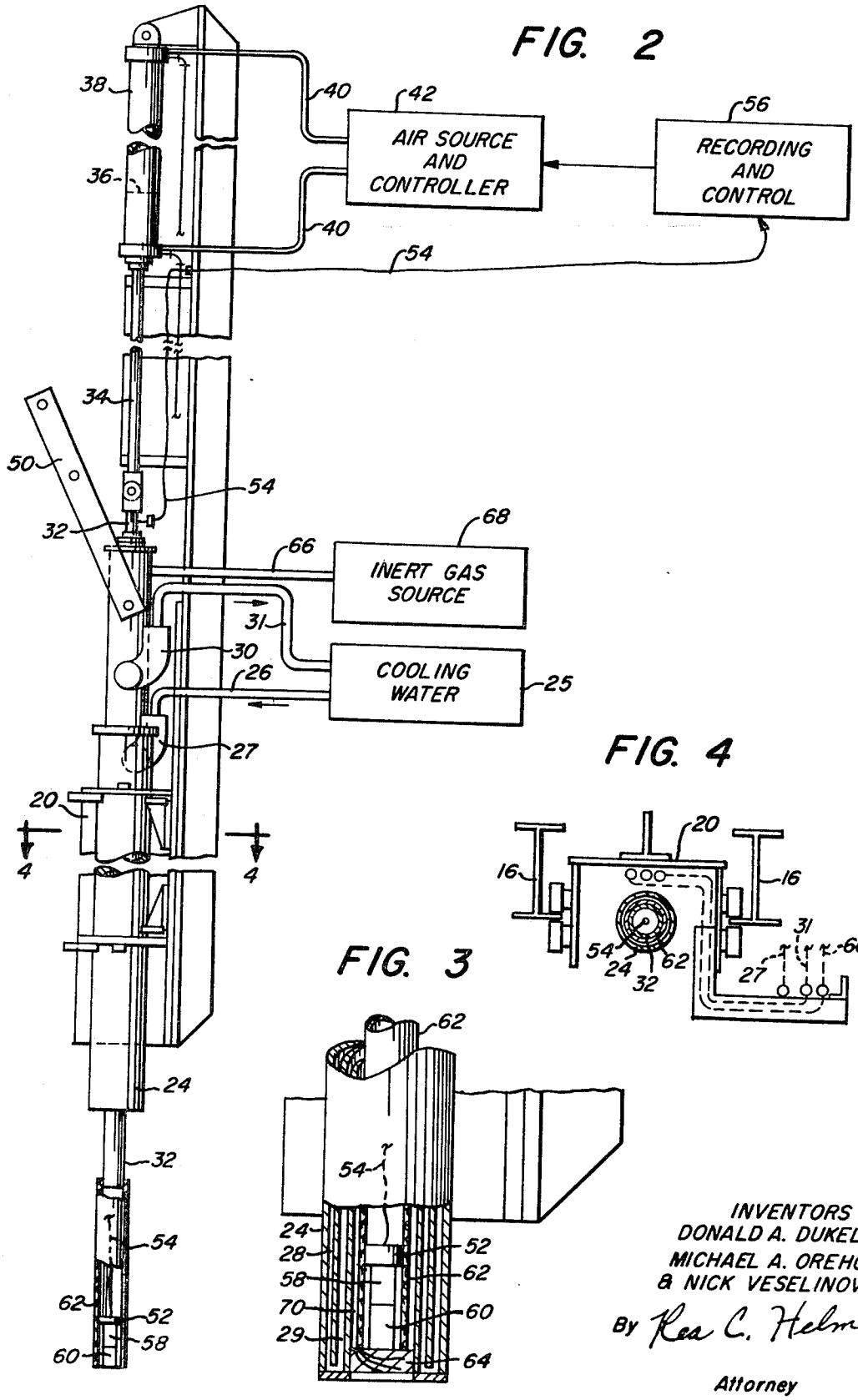

FIG. 4

FIG. 3

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APPARATUS FOR IMMERSING AND WITHDRAWING BATH EXAMINATION MEANS INTO AND FROM A MOLTEN BATH

This invention relates to apparatus for immersing bath examination means into a molten bath and withdrawing the bath examination means from the molten bath. More particularly, this invention relates to apparatus to obtain the liquidus arrest temperature, a sample, and other bath measurements in a steelmaking basic oxygen furnace.

Steelmaking by the basic oxygen process requires measuring the temperature of the steel at the expected end of the heat while temperature determination is desirable during the heat. In addition, a knowledge of composition is desirable during the heat and is required at the end of the heat. Since the process is relatively fast, these determinations must be made rapidly. The composition of the steel must be known prior to tapping so that any necessary corrections can be made in the furnace and the proper weights of alloy additions made in the ladle. The temperature of the steel must be corrected prior to tapping to avoid problems with casting in stationary molds or in continuous-casting molds.

While these measurements are required at the end point of the heat, it is obvious that in-process control would be improved if this same information were available at any time during the process and particularly a few minutes before the end point.

The conventional technique for obtaining a sample, measuring temperature or other bath sensor measurements requires that the oxygen lance be withdrawn from the furnace, the furnace rotated about 90° from the vertical and the measurements and the sampling performed manually. The furnace is then returned to its operating condition. This operation may require 3 minutes as a minimum and may require as long as 7 minutes when the slag is highly reactive and foamy, such as on high carbon heats. In addition, even after making an end point determination, it is not uncommon to re-blow as many as 50 percent of the heats because of incorrect carbon content or temperature at the end point.

It is therefore an object of our invention to provide apparatus for sampling a molten metal bath and cooling the sample before withdrawal from the vessel holding the metal.

Another object is to provide apparatus for sensing bath conditions and sampling without interrupting the blow.

Still another object is to provide apparatus for rapidly sampling and sensing bath conditions.

A still further object is to provide apparatus that simultaneously samples and senses bath conditions.

These and other objects of our invention will become more apparent after referring to the following specification and drawings in which:

FIG. 1 is a schematic illustration of a basic oxygen furnace with a general schematic representation of the essential feature of our apparatus.

FIG. 2 is a fragmentary side view of the carriage of our apparatus with the probe extended beyond the cooled jacket.

FIG. 3 is a fragmentary side view of the lower part of the carriage with the probe withdrawn into the cooled jacket.

FIG. 4 is a sectional view of the carriage along line IV—IV of FIG. 2 and showing the relation of the carriage to the runway.

FIG. 5 is a partial plan view showing the slew drive.

Referring now to the drawings, reference numeral 2 represents the vessel of a basic oxygen furnace. An oxygen lance 4 protrudes downward through an opening 6 in an exhaust hood 8 through the opening 10 of the vessel 2. A bath of molten steel 12 is covered by a layer of molten slag 14. This is a conventional basic oxygen steelmaking furnace.

The apparatus of our invention includes a vertical runway 16 mounted generally parallel to oxygen lance 4 and above a second opening 18 in the exhaust hood 8. A carriage 20 is adapted to move up and down on runway 16 by means of a conventional power driven drive mechanism shown as a cable 21 running over sheaves 22 and connected to carriage 20 and a floor mounted winch 23. Winch 23 could also be mounted on runway 16. The carriage could also be moved by other means and could include a counterbalance to lift the carriage to maximum height in the event of failure of any part of the drive mechanism. Attached to carriage 20 is a water-cooled jacket 24. A source of recirculating cooling water 25 has a flexible connection 26 to supply cooling water to an inlet 27 on jacket 24. Inlet 27 connects to an outer cooling passageway 28 in jacket 24. At the bottom of jacket 24, passageway 28 connects to an inner cooling passageway 29 inside jacket 24. Passageway 29 has an outlet 30 with a flexible connection 31 to return cooling water to source 25. A long hollow probe 32 is mounted inside jacket 24. The upper end of probe 32 is connected to one end of a push rod 34. The other end of push rod 34 is connected to a piston 36 in a double acting air cylinder 38 attached to carriage 20. Air lines 40 connect air cylinder 38 to an air source and controller 42. While an air cylinder is preferred for moving the probe in and out of the jacket, other drives, such as a hydraulic cylinder, a rack and pinion or a cable drive, could also be used. Runway 16 is pivotally supported by a bracket 43 from a runway support column 44 shown in FIG. 5 and partially shown in FIG. 1. A slew drive 46 pivots runway 16 about 90° to cover an operating position A of FIG. 5, a service position B of FIG. 5 where the carriage is over a work platform 48 and a park position C in FIG. 5. Bracket 43 and runway 16 are shown in FIG. 5 in both the operating and park position. Where space permits, the runway could be moved back and forth in, for example, a straight line path instead of pivoting around a support. It is not necessary that the runway be vertical as shown, but it should be directed towards the bath. A bail 50 is attached to jacket 24. The lower end of probe 32 has a socket 52 and electrical leads 54 leading from the socket 52 through the probe 32, out its upper end and then to a conventional recording and control apparatus 56. Attached to the lower end of the probe 32 and electrically connected in socket 52 to lines 54 is a conventional sampler 58, and a conventional thermocouple 60. The arrangement of a sensor and a sampler at the end of probe 32 is shown in simple block form in FIGS. 2 and 3 since this arrangement may vary depending upon the characteristics of the sampler and sensor. Other sensors, such as an oxygen content sensor, a carbon content sensor, a bath height sensor or a

slag height sensor, could be used in bath examination in addition to, or instead of, a thermocouple. The sampler may be for metal, for slag, or for both. The sampler 58 and thermocouple 60 are enclosed in a cardboard tube 62 attached to the end of probe 32. As shown, the end of jacket 24 is closed by a wooden plug 64, to protect the sampler 58 and thermocouple 60 from slag 14 upon entry of probe 32 into the metal bath 12.

The apparatus is prepared for use by the operator from service position B of work platform 48 where the desired sensors, such as thermocouple 60 and sampler 58, are attached to the extended probe 32. The operator then actuates controller 42 to withdrawn probe 32 into jacket 24. Where there may be a problem with slag 14 entering jacket 24, wooden plug 64 is inserted into the end of sleeve 24. The operator raises carriage 20 to its uppermost position with winch 23 and rotates runway 16 with slew drive 46 to working position A over opening 18 above vessel 2. He then lowers jacket 24 into vessel 2 so that the end of jacket 24 is just short of the level of slag 14 in vessel 2. In this position he actuates air controller 42 to supply air to the upper part of cylinder 38 knocking out plug 64 and plunging the end of probe 32 rapidly through slag 14 into molten metal bath 12.

The sensor 60 and the sampler 58 remain in the bath 12 for the time necessary to take temperature recordings on recorder 56, and collect a metal sample, typically 5 to 10 seconds. As soon as the sensings have been determined, he actuates air controller 42 to supply air to the lower part of cylinder 38, immediately withdrawing probe 32 back into jacket 24 thereby exposing the sensor and sampler to the protection and cooling effect of sleeve 24. This solidifies the sample rapidly enough that a liquidus arrest temperature is immediately available for a carbon content determination. As soon as sensor 60 and sampler 58 are inside jacket 24, he raises carriage 20 to take jacket 24 out of vessel 2, and then rotates runway 16 with slew drive 46 back to service position B where the sample is removed from probe 32 for spectrographic or other analysis, and sensor 60 and sampler 58 are replaced by new units. Carriage 20 is clear of vessel 2 in position C so that maintenance work may be performed.

While a wooden plug 64 has been shown as a method of preventing slag entry, FIGS. 2 and 3 show another method of preventing slag entry, whereby an inert gas, such as nitrogen or argon, is introduced into the space 70 between jacket 24 and probe 32 through a line 66 from a source 68 with sufficient pressure so that, as it exhausts from the bottom of the probe passed cardboard tube 62, it prevents slag entry. While an inert gas is preferred, other gases, such as air, could be used provided it would not provide a reaction to disturb the examinations being made or provide an undesirable reaction with the molten bath. Slag entry can also be prevented by a cap placed over the end of the jacket and dislodged by probe movement out of the jacket. The cap, as well as a substitute for the wooden plug, could be made of aluminum, steel, a refractory, cardboard, paperboard or any other material that will not react unfavorably with the bath and slag, and be readily meltable or otherwise disposable.

We claim:

1. Apparatus for immersing and withdrawing bath examination means into and from a molten metal bath comprising a molten metal bath, a runway, means mounted adjacent the bath for moving the runway between an operating position near the bath and a service position away from the bath, a cooled jacket mounted for movement on the runway, a probe mounted for movement inside the jacket, bath examination means mounted on one end of the probe, means for moving the probe and mounted bath examination means in and out of the end of the jacket next to the bath with the runway in the operating position, and means for moving the jacket between a first position away from the bath and a second position with said one end of the jacket just above the surface of the bath whereby in said second position the bath examination means is placed in position to begin bath examination when said one end of the probe is moved out of the jacket and into the bath.

2. Apparatus according to claim 1 which includes a vessel holding the molten metal bath and a generally vertical runway support column beside said vessel and in which the means for moving the runway includes means attaching the runway to the support column in a position spaced apart from and generally parallel to said support column and means for pivoting said runway about said support and in which said means for moving said jacket includes a carriage mounted for movement on the runway and upon which the jacket is mounted and means attached to said carriage for raising and lowering said carriage.

3. Apparatus according to claim 2 in which the means for raising and lowering the carriage is mounted on said runway.

4. Apparatus according to claim 2 in which the means for raising and lowering said carriage includes sheave means mounted on the upper end of said runway and said support column, winch means mounted adjacent said runway, and cable means connecting said carriage and said winch means and operating over said sheave means.

5. Apparatus according to claim 1 in which the means for moving said probe includes a cylinder mounted in fixed relationship to said jacket, a double acting piston in said cylinder, a push rod connecting said piston and the other end of said probe, and means connected to said cylinder for admitting compressed air to said cylinder to move said probe within said jacket.

6. Apparatus according to claim 1 which includes a layer of molten slag covering said metal and means for preventing slag entry into the probe.

7. Apparatus according to claim 6 in which said means for preventing slag entry includes a plug mounted in the end of said jacket towards said bath and dislodged by movement of said probe out of said jacket.

8. Apparatus according to claim 6 in which said probe is mounted in spaced relationship to said jacket to create a gas passageway between said probe and said jacket and which apparatus includes a source of pressurized gas connected to said passageway so that gas exhausts from the end of said jacket towards said bath to prevent slag entry.

9. Apparatus according to claim 8 in which said pressurized gas is an inert gas.

10. Apparatus according to claim 6 in which said means for preventing slag entry includes a cap surrounding the end of said jacket towards said bath and dislodged by movement of said probe out of said jacket.

11. Apparatus according to claim 1 which includes a source of cooling fluid, a first hollow passageway in said jacket with the end away from said bath connected to said source of cooling fluid, and a second hollow passageway concentric with said first hollow passageway with its end towards said bath connected to the end of the first hollow passageway towards said bath and the end of said second hollow passageway away from said bath connected to discharge said cooling fluid from said second hollow passageway.

12. Apparatus according to claim 1 in which said bath examination means includes a sampler and a bath condition sensor.

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