

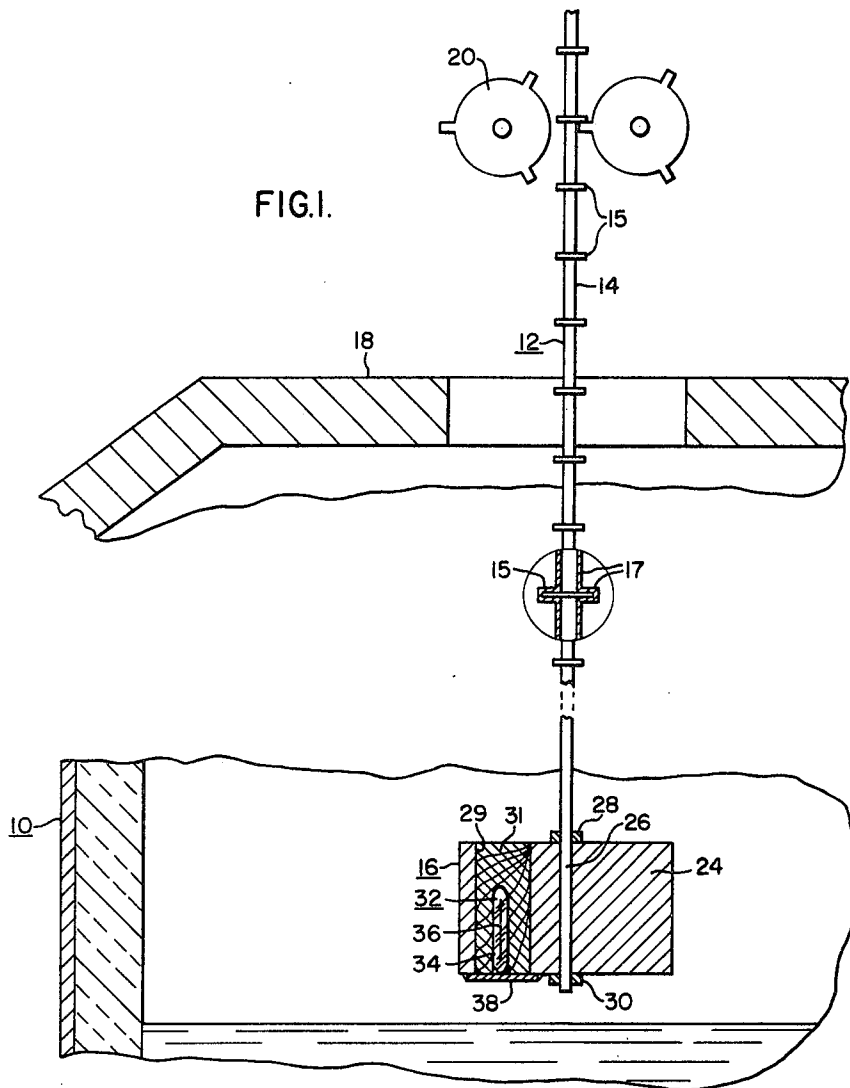
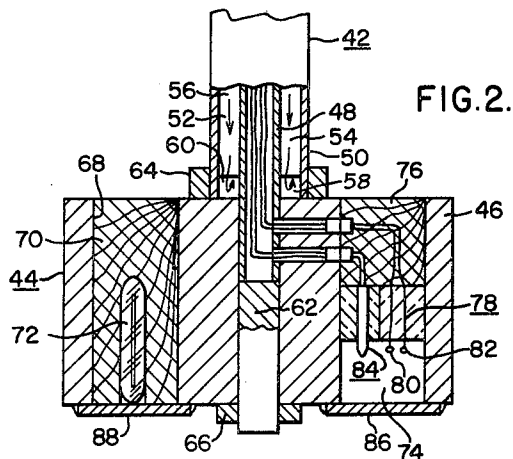
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N. R. CARLSON ET AL

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DIRECT SAMPLER FOR USE IN BASIC OXYGEN FURNACES AND THE LIKE

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INVENTORS
 Norman R. Carlson, James T. Carleton
 and Richard E. J. Putman
 BY *E. F. Rosovsky*
 ATTORNEY

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DIRECT SAMPLER FOR USE IN BASIC OXYGEN FURNACES AND THE LIKE

Norman R. Carlson, Export, Richard E. J. Putman, Penn Hills, and James T. Carleton, Pittsburgh, Pa., assignors to Westinghouse Electric Corporation, Pittsburgh, Pa., a corporation of Pennsylvania

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4 Claims

ABSTRACT OF THE DISCLOSURE

A molten metal sampling device. A water cooled lance-like member has a sampler carrying unit at its lower end and is operated in a basic oxygen furnace during the decarburizing oxygen blow to withdraw a bath sample. The sampler carrying unit also contains a contact pair operable to signify the sampling time.

CROSS-REFERENCE TO RELATED APPLICATIONS

The following copending patent applications assigned to the present assignee are related to the present application:

(1) Ser. No. 649,236 entitled Improved System and Method for Controlling Carbon Removal in a Basic Oxygen Furnace, filed by N. R. Carlson, J. T. Carleton and R. E. J. Putman on June 27, 1967.

(2) Ser. No. 649,231 entitled Improved System and Method for Controlling Phosphorus Removal in a Basic Oxygen Furnace, filed by N. R. Carlson on June 27, 1967.

BACKGROUND OF THE INVENTION

The present invention relates to bath sampler devices and more particularly to such devices which have utility in basic oxygen furnace or similar operating environments.

A direct sampler can form a basis for improved process control in metalmaking or other furnaces. For example, in basic oxygen steelmaking furnaces, actual as opposed to estimated levels of carbon and other elements in a bath can be determined from a sample analysis made possible by operation of a direct sampler during the decarburizing oxygen blow. As described in the above noted copending applications, the bath can then be steered more accurately and more efficiently by the furnace control system to the specified carbon and other end-point levels.

In order to maximize furnace productivity, it is desirable that bath sampling be effected during continuation of the active bath processing. Thus, as already indicated, it is desirable in the basic oxygen furnace that the bath sampling be effected during the decarburizing oxygen blow without requiring vessel rotation to the turndown position. To provide in process bath sampling in a basic oxygen furnace (BOF), the sampler must be able to withstand a flaming atmosphere of 3500° F. and immersion in molten steel and molten slag at 2900° F. for a period of at least about ½ minute. Further, the sampler must be withdrawn intact and the sample contained in the sampler must not be oxidized nor melted.

Post endpoint sampling procedures are typical in the prior art and particularly in the basic oxygen furnace prior art. Thus, after the process heat has been turned down or terminated, the vessel is rotated or opened for insertion of a sampling device typically in the form of an elongated spoon-like element. A sampling procedure of this type impairs furnace production efficiency, yet the spoon-like and similar sampler devices are not capable of use in the more efficient in process sampling procedures.

SUMMARY OF THE INVENTION

In accordance with the broad principles of the present invention, a sampler device comprises an elongated lowering mechanism preferably in the form of a lance-like member having a pin sampler carrying unit at its lower end. The pin sampler unit has adequate mass and appropriate physical form and physical properties to protect the pin sampler unit against basic oxygen furnace or similar high temperature environments. Preferably, the sampler unit also carries contact means operable to signify the sampling time and a thermocouple unit operable to generate a temperature signal.

It is therefore an object of the invention to provide a novel, efficient and economic sampler device operable to obtain bath samples in highly destructive environments such as those created in basic oxygen furnaces under decarburizing oxygen blow conditions.

An additional object of the invention is to provide a novel sampler device operable to obtain BOF bath samples without requiring BOF vessel turndown and thereby enabling improved BOF production efficiency.

Another object of the invention is to provide a novel sampler device which is operable to obtain a bath sample while producing a signal indicative of the sampling time.

A further object of the invention is to provide a novel sampler device which is operable to obtain a bath sample while producing a signal indicative of the bath temperature.

It is an additional object of the invention to provide a novel sampler device which is operable to obtain a bath sample while producing signals indicative of the sampling time and the bath temperature.

These and other objects of the invention will become more apparent upon consideration of the following detailed description along with the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1 shows a longitudinal section of a sampler device constructed in accordance with the principles of the invention.

FIG. 2 shows a longitudinal section of another lance-like sampler device constructed in accordance with the principles of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

More specifically, there is shown in FIGURE 1 a basic oxygen steelmaking furnace 10 and a sampler device 12 therefor including a lance-like and preferably relatively stiff lowering member 14 and a sample carrying unit 16 arranged in accordance with the principles of the invention. The lance member 14 in this case is formed from ribbed rod material such as a one-half inch diameter steel reinforcing rod having laterally projecting ribs 15. A suitably thick layer 17 of oblativ or burnable material is preferably coated on the rod 14 in order to achieve prolonged useful sampler device life.

By oblativ material it is meant to refer to an inert material or a reactive material which tends to burn away in a high temperature environment yet in doing so nonetheless provides thermal protection because heat is carried away with the products of burnup.

The rod 14 extends through a roof of a hood 18 of the BOF 10, and it is raised and lowered by operation of suitable drive means (not fully shown) such as motor driven cogged wheels 20 which, when rotated, interengage with the rod ribs 15 to raise or lower the rod 14.

The length of the rod 14 is adequate to enable the sampler carrying unit 16 to be disposed in the furnace bath. For example, the rod 14 may be about 50 feet long. As indicated in the previously noted copending applications, the sampler device 12 can be operatively controlled to obtain a

steel sample at a predetermined time point in the steel-making process. Thus, when a sample is to be retrieved, the drive means is activated to lower the rod 14 from its raised position until the sampled carrying unit 16 is adequately immersed into the metal bath. Shortly thereafter, the rod 14 is raised until the sampler carrying unit 16 is accessible from a platform or the like above the hood 18. The entire sampling operation can take place during the decarburizing oxygen blow (i.e., during operating conditions including full oxygen flow rate at lowered oxygen lance position).

The depth at which a sample is obtained in the bath can be relatively accurately controlled by controlled operation of the rod drive means. Depth control is particularly advantageous where chemical and temperature gradients are found to be characteristic of the baths being sampled thereby making it desirable to obtain samples at substantially the same depth or at equivalent depth points from bath to bath of operation.

The sampler carrying unit 16 includes a protective barrel member 24 which is made or cast from a material such as iron or steel and is provided with a central opening 26 through which the lower end of the rod 14 is extended. Collars 28 and 30 are located above and below the barrel 24 in conventional set screw or other suitable engagement with the rod 14 to secure the barrel 24 in place. The collars can have a thickness of about 1/2 inch to assure barrel securance to the rod 14 for a predetermined bath exposure time (such as an amount in excess of the time required for at least one sampling operation). Generally, the barrel 24 is provided with adequate size and mass to act as a protective vehicle for its contained elements under the extreme conditions encountered within the BOF 10. In a typical case the barrel 24 would have a diameter of 4 inches and a height of 6 inches. Preferably, the exposed barrel and collar surfaces are also coated with a layer of oblativ material for extended life. A suitable oblativ material for use in coating the barrel and rod surfaces would be a conventional sprayable refractory material such as that commonly used in the spray repair of dolomite and magnesite vessel linings.

The sampler carrying unit 16 also has an additional opening 29 within which a cylinder like enclosure 31 is disposed, and in turn a pin sampler 32 is disposed within the enclosure 31. The pin sampler 32 can be a commercially available type such as the kind marketed by Electro-Nite Engineering, Philadelphia, Pa. Accordingly, in this case the pin sampler 32 includes an evacuated glass tube 34 disposed in an opening from the lower side of the enclosure 31 and having an aluminum strip 36 contained therein. The enclosure 31 is formed from a suitable material such as wood to provide a convenient means for assembling and disassembling the pin sampler 32 in relation to the barrel member 24 while protecting the sampler 32 against molten material flow around the outside thereof.

A disk 38 is secured against the lower end of the enclosure 31 and over the barrel opening within which the pin sampler 32 is disposed. Securance of the disk 38 is by any suitable means such as by the use of a high temperature cement. The disk 38 is formed from suitable metal such as sheet steel and has a relatively small thickness such as 1/16 inch in order to allow time delayed entry of sample material from the steel bath into the sampler tube 34. Thus, as the rod 14 is lowered to move the sampler carrying unit 16 through the slag, the disk 38 begins to melt, and it continues to melt as the sampler carrying unit 16 is lowered into the molten steel. When the disk 38 is completely melted, molten steel causes the end of the pin sampler tube 34 to melt and steel flows by vacuum into the glass tube 34. Typically, the tube end piece is a low melting point glass to allow quick sample inflow. The sample is "killed" by the aluminum strip 36 in the tube, i.e., it is frozen without pin holes otherwise resulting from dissolved gaseous oxygen.

The rod 14 is then raised to withdraw the sampler carrying unit 16 from the bath, and the enclosure 31 and the pin sampler 32 are removed from the barrel member 24. The glass tube 34 is broken away from the steel sample which is then made available for analysis. A new enclosure 31 and a new pin sampler 32 and disk 38 are inserted in the barrel member 24 for taking the next sample. When the barrel member 24 is substantially expended, it is replaced with a new barrel member and secured to the rod 14 by means of new collars 28 and 30.

Samplings can be repeated until the structural integrity of the sampler device 12 or its rod 14 is no longer adequate, as determined in part by design factors such as materials and dimensions employed. Up to five or six or more samplings could typically be expected to be made with a sampler device of the type shown in FIGURE 1.

In FIG. 2, there is shown a more costly but more durable and more usefully operating embodiment of the invention. A sampler device 40 in this instance includes a water cooled lance-like lowering member 42 and a sampler carrying unit 44 having a barrel member 46 similar to the barrel member 24 of FIG. 1.

The lance member 42 includes an inner tube member 48 having a channel through which wires or cabling are extended. An outer tubular jacket member 50 is disposed about and supported in relation to the inner tube 48 by respective partition walls 52 and 54. Respective series connected supply and return channels 56 and 58 are thus formed between the members 48 and 50 for the flow of coolant such as water. Vertical movement of the lance member 42 is controlled by suitable means (not shown) such as a motor driven drum cable or a ratchet type drive. Flexible steel tubing or other piping (not shown) can be used to provide for coolant flow to and from the sampler lance member 42 as it undergoes vertical movement.

At the lower end of the lance member 42, the inner tube 48 is extended below the outer tube 50 for engagement with the barrel member 46 in a central opening therethrough. An end support wall 60 connects the lower end of the jacket member 50 to the inner tube member 48 and seals the coolant channels 56 and 58 from the exterior. Spaces provided between the bottoms of the partition walls 52 and 54 and the end wall 60 provide for coolant flow between the supply and return channels 56 and 58.

A side opening is provided through the wall of the inner tube member 48 at an environment protected location beneath the top surface of the barrel member 46 for the passage of the wires in the lance wiring channel to the barrel member 46. An end portion 62 of the inner tube member 48 is made solid to provide substantial sealing and protective separation of the wiring channel from the furnace environment.

Collars 64 and 66 are secured as by conventional set screw or other suitable engagement with the respective lance tube members 50 and 48 thereby rigidly attaching the sampler carrying unit 44 to the lance member 42. The thickness of the collars 64 and 66 is made adequate such as about 1/2 inch to assure collar survival over the barrel member life. Further, the barrel member 46, the lance member 42 and the collars 64 and 66 preferably have their exposed surfaces covered with an oblativ material for extended sampler device and sampler carrying unit lives.

In the embodiment of FIG. 2, an opening 68 is provided in the barrel member 46 for an enclosure 70 and a sampler tube 72 in a manner similar to the case of FIG. 1. Opening 74 is also provided for another wood or similar enclosure 76. On the bottom side of the enclosure 76, there are suitably supported within the barrel member opening 74 a timing signal generator such as an inexpensive contact fixture 78 having a pair of normally open contacts 80 and 82 and preferably also a thermocouple device 84, such as a commercially available dis-

posable unit containing a platinum/platinum-rhodium junction.

Four conductors are suitably extended from the thermocouple device 84 and the contact fixture 78 through the enclosure 76 to respective contacts which make sliding contact with respective contacts supported on an inner wall of the barrel member 46. The barrel member inner wall contacts in turn are connected with four wires which extend to the inmost barrel member opening and as previously described upwardly through the wiring channel in the sampler lance inner tube 48. Preferably the wires and other conductive paths in the thermocouple circuit are formed from compensated thermocouple lead wires or conductors.

The bottom of the thermocouple and contact opening 74 is enclosed by a disk 86 which is secured to the barrel member 46 as by a high temperature cement. The disk 86 is preferably substantially identical with the disk 88 which is secured across the bottom of the sampler tube 72 and the enclosure 70. The thickness of the disks 86 and 88 can, for example, be about $\frac{1}{16}$ inch.

During the sampling procedure, the substantially identical disks 86 and 88 reach a completely melted state at substantially the same time, and bath metal inflow into the opening 74 causes a thermocouple reading to be generated and further causes a conductive coupling between the contacts 80 and 82. The connected contacts 80 and 82 complete a circuit (not fully shown) thereby producing a timing signal which very accurately defines the process time point to which the sample in the sampler tube 72 and the temperature reading correspond. As indicated in the previously noted depending applications, such time information is important to end point chemistry control in the BOF. For example, without the timing contacts, erroneous identification of the sampling time point by as small a time span as 10 seconds or less can cause BOF end point carbon error by as much as two to three points or more depending on the rate of oxygen blow and the point in the process at which the sampling is made.

With the provision of a thermocouple reading by the sampler carrying unit 44, there is eliminated the need for a separate cabled thermocouple bomb device which is conventionally dropped into the BOF bath to generate a temperature reading before it is consumed by the hot environment in the furnace interior. The thermocouple signal can also be used as a timing signal, and in that event the device 84 provides both the temperature and the timing signalling functions and the timing signal generator 78 can be eliminated. However, it is preferred that the timing signal generator 78 be employed to generate a timing signal as previously described primarily because a thermocouple signal would generally variably lag a contact or other timing signal by as much as 3 to 5 seconds. Substantial economy is thus achieved with use of the sampler device of FIG. 2 in that only a thermocouple unit and its enclosure is expended at about $\frac{1}{40}$ the cost of a bomb each time a temperature reading is obtained. The barrel member 46 is expended after a number of uses but its cost per use is thus relatively low and further is allocable to both the function of obtaining a bath sample and the function of obtaining a temperature reading.

The sampler device 40 is operated in a manner similar to that described for the sampler device 12 of FIGURE 1. However, the enclosure 76 and the thermocouple unit 84 and the timing contact unit 78 as well as the enclosure 70 and the sampler tube 72 are replaced after each sampling. The barrel member 46 is replaced only as required (such as after every four to six uses or more). The sampler lance 42 is characterized with a relatively long operating life as a result of the positive cooling supplied for it.

Both described embodiments of the invention enable improved furnace productivity to be achieved. In the BOF application in particular, sampling can be obtained

without vessel turndown and without interruption of the steelmaking oxygen blow process.

The foregoing description has been presented only to illustrate the principles of the invention. Accordingly, it is desired that the invention not be limited by the embodiments described, but, rather, that it be accorded an interpretation consistent with the scope and spirit of its broad principles.

What is claimed is:

1. A sampler carrying member comprising a body member having adequate properties and mass and size to withstand basic oxygen furnace conditions as severe as decarburizing oxygen blow conditions for at least a predetermined exposure time sufficient to allow for bath sample retrieval, said body member having an opening therein, a sampler unit operable to accept a bath sample when a part of its external surface area is exposed to bath material, means for supporting and enclosing said sampler unit in said body member opening so as normally to protect the external surfaces of said sampler unit from exposure to the bath material, said sampler unit supporting and enclosing means including a meltable member secured in relation to said body member between said sampler unit surface part and the exterior, said body member having another opening therein, a timing signal unit operable to effect generation of a timing signal indicative of the point in time at which said timing signal unit is exposed to bath material, means for supporting and enclosing said timing signal unit in a part of said body member other opening so as normally to protect said timing signal unit from exposure to the bath material, said timing signal unit supporting and enclosing means including another meltable member secured in relation to said body member between said other opening part and the exterior, conductor means extending from said timing signal unit through said body member for transmitting the timing signal, both of said meltable members having adequate properties and mass and size to enable their survival for body member entry into the bath and to enable bath material inflow to said units after bath entry prior to consumption of said body member to an irretrievable state.

2. A sampler carrying member as set forth in claim 1 wherein said body member is a barrel-like member, said barrel member has an axial opening for receiving a supporting member, the first mentioned openings are located along respective axes substantially parallel to the axial barrel opening axis, said supporting and enclosing means includes respective removable thermally insulative members disposed in the first mentioned openings from one side thereof, said meltable members secured in relation to said barrel member across the other side of the first mentioned openings respectively.

3. A sampler device for use in a basic oxygen furnace or the like, said sampler device comprising a sampler carrying member having adequate properties and mass and size to withstand internal furnace conditions as severe as decarburizing oxygen blow conditions for at least a predetermined exposure time sufficient to allow for bath sample retrieval, an opening in said sampler carrying member, a sample unit operable to accept a bath sample when a part of its external surface area is exposed to bath material, means for supporting and enclosing said sampler unit in said sampler carrying member opening so as to protect the external surfaces of said sampler unit from exposure to the bath material during carrying member entry into the bath and so as to enable bath material inflow to said sampler unit after bath entry, said sampler carrying unit having another opening, a timing signal unit operable to effect generation of a timing signal representative of the point in time at which said timing signal unit is exposed to the bath material, means for supporting and enclosing said timing signal unit in a part of said carrying member other opening so as to protect said timing signal unit from exposure to the bath material during car-

rying member entry into the bath and so as to enable bath material inflow to said timing signal unit at substantially the same time as bath material inflows to said sampler unit, a thermocouple unit for generating a signal representing bath temperature when exposed to bath material, means for supporting and enclosing said thermocouple unit in said carrying member other opening part so as to protect said thermocouple unit from exposure to the bath material during carrying member entry into the bath and so as to enable bath material inflow to said thermocouple unit, an elongated lance-like member having an end portion movable between the furnace interior bath region and a region remote therefrom, means for establishing and maintaining coolant flow within said lance member during sampler device operation, means for securing said sampler carrying member to said elongated member end portion, conductor means extending from said timing signal unit through said sampler carrying member for transmitting the timing signal, conductor means extending from said thermocouple unit through said sampler carrying member for transmitting the thermocouple signal, and means forming an interior and longitudinal cooled channel within said lance member for passage of wiring to said conductor means.

4. A sampler device for use in a basic oxygen furnace or the like, said sampler device comprising a sampler carrying member having adequate properties and mass and size to withstand internal furnace conditions as severe as decarburizing oxygen blow conditions for at least a predetermined exposure time sufficient to allow for bath sample retrieval, an opening in said sampler carrying member, a sampler unit operable to accept a bath sample when a part of its external surface area is exposed to bath material, means for supporting and enclosing said sampler unit in said sampler carrying member opening so as to protect the external surfaces of said sampler unit from exposure to the bath material during carrying member entry into the bath and so as to enable bath material inflow to said sampler unit after bath entry, said sampler carrying member having another opening, a timing contact unit for generating a timing signal, means for sup-

porting and enclosing said timing unit in a part of said carrying member other opening so as to protect said unit from exposure to the bath material during carrying member entry into the bath and so as to enable bath material inflow to said unit after bath entry, conductor means extending from said unit through said sampler carrying member for transmitting the timing signal, an elongated lance-like member having an end portion movable between the furnace interior bath region and a region remote therefrom, means for thermally protecting said lance member against internal furnace conditions as severe as decarburizing oxygen blow conditions to an extent sufficient to allow repeated use of said lance member in obtaining bath samples, said protecting means including means for establishing and maintaining coolant flow within said lance member during sampler operations, means forming an interior and longitudinal cooled channel within said lance member for passage of wiring to said timing signal conductor means, means for securing said sampler carrying member to said lance member end portion, and means for driving said lance member into and out of the furnace interior so as to control the position of said sampler carrying member.

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S. CLEMENT SWISHER, Primary Examiner

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