United States Patent

Boron et al.

[15] **3,685,359**

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[54] **EXPENDABLE LANCE**

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[21] Appl. No.: **637,687**

[52] **U.S. Cl.**.....**73/354,** 73/DIG. 9, 73/17 R, 136/234

[51] **Int. Cl.**.....**G01n 25/06,** G01k 13/12

[58] **Field of Search**.....73/359, 343, 354, 421, 425, 73/425.4, 17 R, DIG. 9; 136/231, 234, 242

[56] **References Cited**

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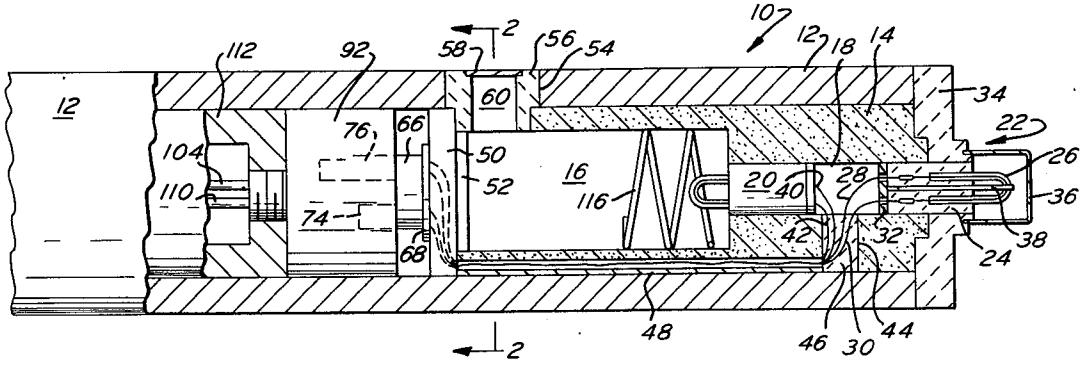
[57] **ABSTRACT**

An expendable lance is provided which is adapted to be inserted into a bath of molten metal to ascertain the temperature of the molten metal, detect phase change, and to retrieve a sample of the bath.

15 Claims, 5 Drawing Figures



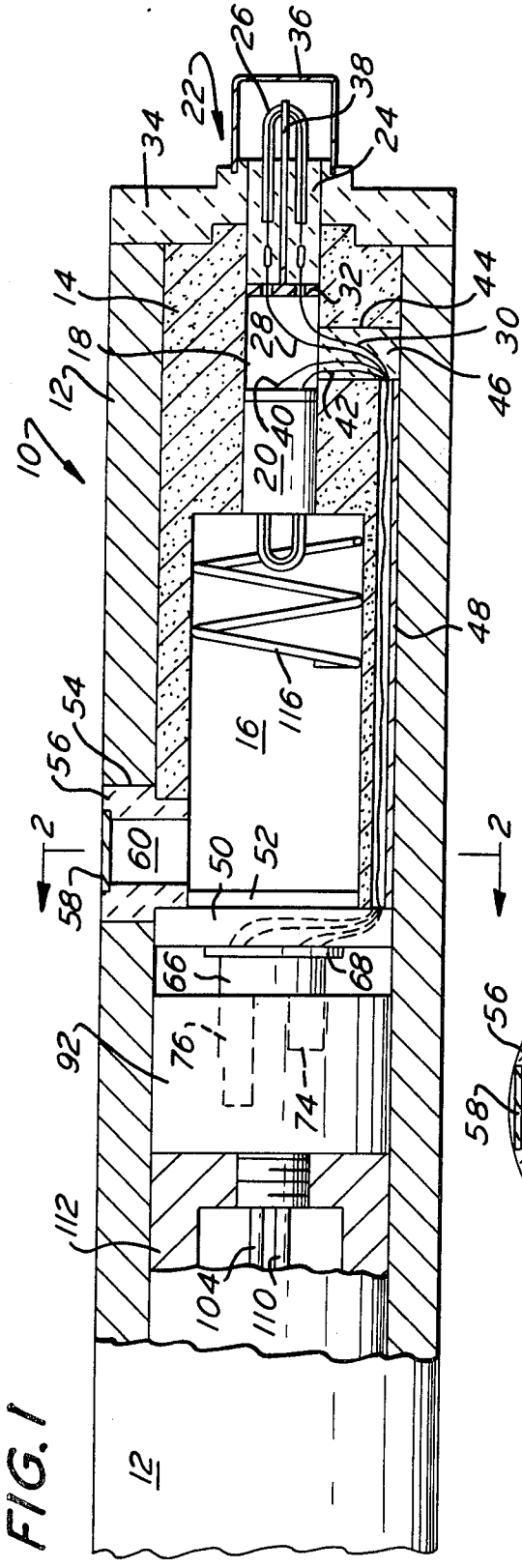


FIG. 1

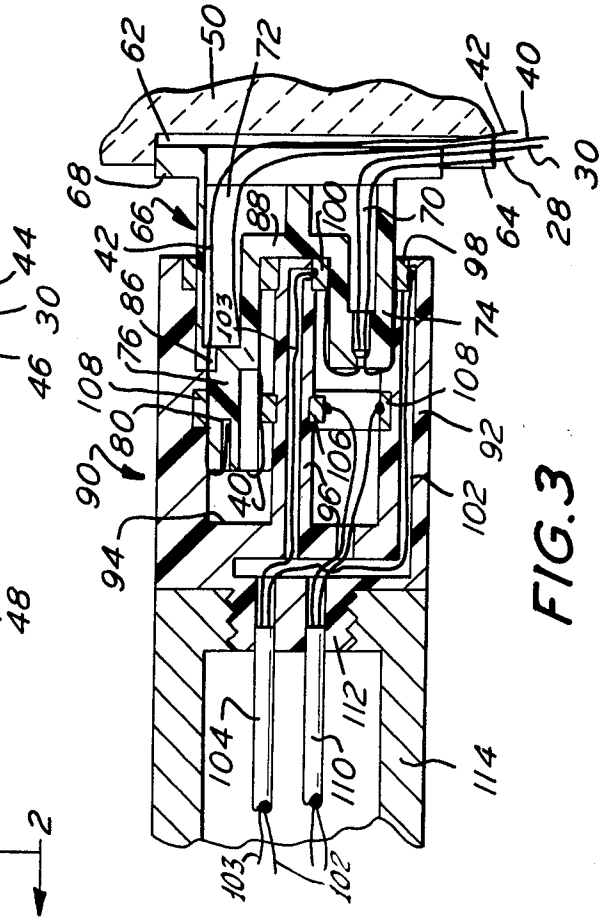


FIG. 3

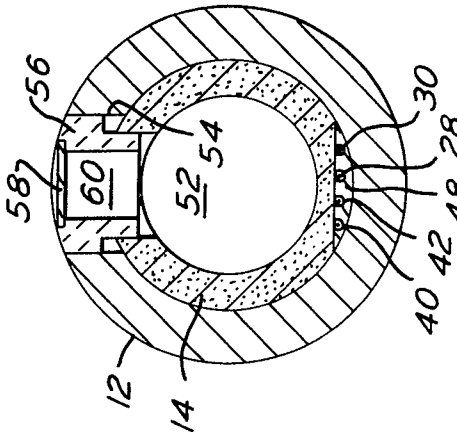


FIG. 2

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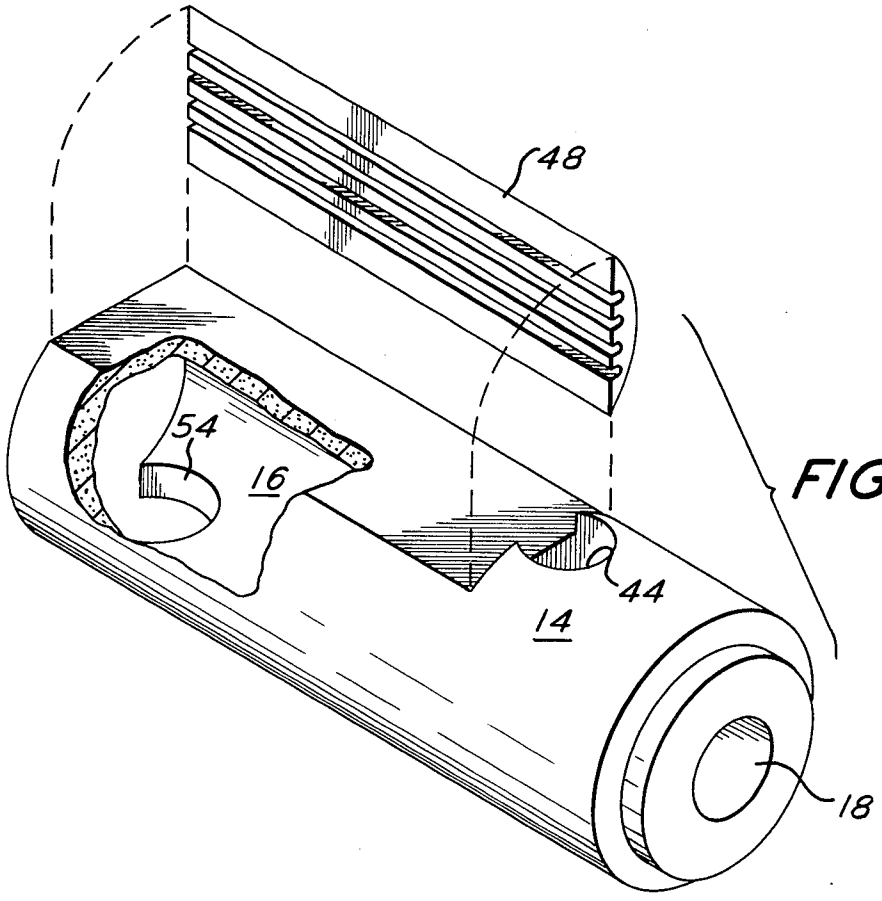

FIG. 4

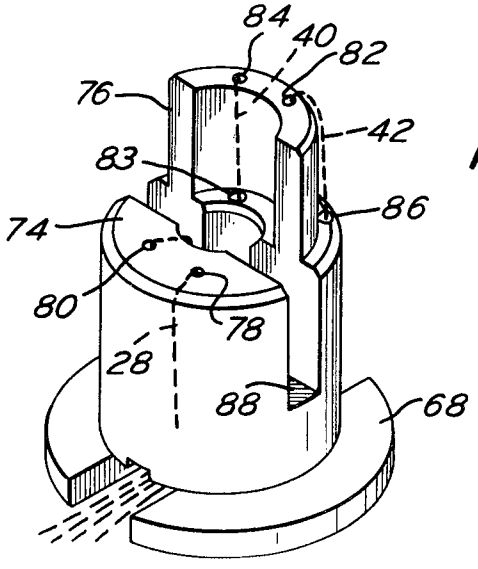

FIG. 5

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EXPENDABLE LANCE

This invention is directed to an expendable lance which may be inserted into a bath of molten metal and simultaneously accomplish a plurality of objects. The bath temperature is adapted to be detected by means of a thermocouple at the immersion end of the expendable lance. The lance is provided with structure to detect a phase change known as a liquidus arrest test to obtain the percent equivalent value of a desired constituent such as carbon, silicon, etc. The lance is also constructed in a manner so as to retrieve a specimen of the molten metal for laboratory analysis.

The lance of the present invention is preferably constructed of a lightweight expendable tube made from a heat resistant material such as cardboard. Cardboard lances for supporting thermocouples, per se, are old as per U.S. Pat. No. 3,038,951. Expendable devices for detecting phase change facilitating ascertainment of the liquidus arrest value are known and have been used for many years. For example, see U. S. Pat. No. 3,267,732. As per U.S. Pat. No. 3,267,732 the expendable phase change detector device is in the form of a cup-shaped mold having thermocouples extending thereinto. The cup-shaped mold is supported on a base and molten metal is poured thereinto from a ladle or the like.

The present invention eliminates the necessity for utilizing a cup-shaped mold and support which are to be positioned on the floor or other support surfaces. The present invention facilitates obtaining a reading on a chart while the lance is disposed in the bath of molten metal. When the bath of molten metal is in a basic oxygen furnace, it is not possible to obtain a small sample of the molten metal in a ladle for pouring into a cup-shaped mold as per U.S. Pat. No. 3,267,732. Thus, in one sense the present invention facilitates obtaining readings indicative of liquidus arrest values in environments which the cup-shaped molds of U.S. Pat. No. 3,267,732 cannot be utilized. Further, this desirable aspect of the present invention is accomplished automatically pursuant to immersion of the lance into the bath for purposes of ascertaining the temperature of the molten metal in the bath.

The present invention also includes provision for retrieving a sample of the bath. The samples to be retrieved enters the lance through a destructible portion of the lance and enters a mold. The temperature sensing means for use in obtaining readings on the liquidus arrest value are structurally interrelated with said mold and the values obtained are predicated on the sample retrieved. As indicated above, the entire lance is expendable. Access of the sample is obtained by sawing off a section of the lance. Other ways of obtaining the specimen from within the lance will suggest themselves to those skilled in the art. The specimens obtained are used to ascertain one or more of the constituents of the molten metal, such as gas content (oxygen,nitrogen, hydrogen, etc.) as well as the percentages of the various constituents of the molten metal.

It is an object of the present invention to provide a novel expendable lance for immersion into a bath of molten metal.

It is another object of the present invention to provide a novel expendable lance adapted to be immersed in molten metal for simultaneously ascertaining the temperature of the molten metal and a liquidus arrest value.

It is another object of the present invention to provide a novel expendable lance for immersion into molten metal to obtain a temperature of the molten metal, liquidus arrest value for the molten metal, together with a specimen of the molten metal which will be permitted to solidify within the lance.

It is another object of the present invention to provide an expendable lance for ascertaining the temperature of a molten bath of steel, while obtaining additional information with respect to the nature of the steel.

Other objects will appear hereinafter.

For the purpose of illustrating the invention, there is shown in the drawings a form which is presently preferred; it being understood, however, that this invention is not limited to the precise arrangements and instrumentalities shown.

FIG. **1** is a partial longitudinal section of a portion of a lance in accordance with the present invention.

FIG. **2** is a sectional view taken along the line **2—2** in FIG. **1**.

FIG. **3** is an enlarged detail view of the non-directional coupling between the lance and the lance holder.

FIG. **4** is a perspective view of the sand mold and lead wire guide.

FIG. **5** is a perspective view of the contactor block.

Referring to the drawing in detail, wherein like numerals indicate like elements, there is shown in FIG. **1** a portion of an expendable lance in accordance with the present invention designated generally as **10**. The lance **10** includes an expendable tube **12** made from a lightweight heat-resistant material such as cardboard. A body structure **14** is fixedly secured within and adjacent one end of the tube **12**. Body structure **14** is preferably comprised of a monolithic mass of non-metallic molded material such as sand. Body structure **14** is preferably open at both ends and has an axially disposed chamber **16** communicating with an axially disposed bore **18** of smaller diameter.

First and second identical thermocouple units **20** and **22** are mounted in bore **18** but extending in opposite directions. Units **20** and **22** are identical. Hence, only unit **22** will be described in detail.

The thermocouple unit **22** comprises a heat resistant body **24** made from any convenient material such as ceramic. Thermocouple wires are connected together to form a hot junction at the bight of a U-shaped tube **26**. The thermocouple wires may be platinum and platinum-rhodium. The thermocouple wires are, within the body **24**, connected to suitable lead wires **28** and **30**.

The material from which the lead wires **28** and **30** are made is well known to those skilled in the art. The lead wires **28** and **30** extend through a plastic base **32** on the body **24**. Body **24** is supported within the bore **18** so that it partially projects beyond the end face of the body **14** so that a ceramic header **34** may be joined thereto. Header **34** overlies the adjacent end face of the body structure **14** and the end face of the tube **12**. An expendable metallic cap **36** is imbedded in the header **34**. Cap **36** protects the U-shaped tube during passage through slag. The U-shaped tube **26** is properly positioned with respect to the base **32** by means of a post **38** integral at one end with the base **32**. The other end of the post embraces the U-shaped tube at the bight portion thereof. No such post is provided in unit **20**.

Except as mentioned above, the thermocouple units 20 and 22 are identical. The hot junction of the thermocouple wires on unit 22 project forwardly of the immersion end of the tube 12 so that the temperature of the molten metal may be ascertained. The hot junction of the thermocouple wires on unit 20 project into the chamber 16 so that a reading may be ascertained measuring thermal arrest or phase change temperatures of a sample of the molten metal as the molten solidifies within chamber 16. The units 20 and 22 are preferably preassembled and adhesively joined to the body structure 14 within the bore 18 and illustrated in FIG. 1. The lead wires for unit 20 are designated as 40 and 42.

The body structure 14 is formed with a hole 44 in a side wall thereof communicating with bore 18 between the units 20 and 22. The lead wires 28, 30, 40 and 42 extend outwardly through the hole 44. Thereafter, the hole 44 is filled with a ceramic material 46.

As shown more clearly in FIGS. 2 and 4, the body structure 14 is provided with a flat surface on one side. A lead wire guide 48 made from an electrically non-conductive material such as a ceramic overlies the flat surface and forms a continuation of the peripheral surface of the body structure 14. Longitudinally extending slots or notches are provided on the guide 48. Each of the lead wires 28, 30, 40 and 42 extends along one of the notches.

As shown more clearly in FIG. 1, the left hand end of the body structure 14 is closed by a plug 50 having a boss 52 which enters the chamber 16. Plug 50 is preferably made from an electrically non-conductive material such as a ceramic. As shown more clearly in FIGS. 1 and 2, the tube 12 is provided with a hole 54 which extends radially inwardly. A ceramic tube 56 is mounted within the hole 54 and communicates directly with chamber 16. A heat destructible cover 58 closes the passage 60 in tube 56. Cover 58 may be made from any desirable low melting metal such as copper, low carbon steel, etc.

The surface of the plug 50 opposite from the boss 52 is provided with a recess circular in configuration and having an extension 64. Extension 64 extends to the periphery of the plug in line with the guide 48 for accommodating the lead wires 28, 30, 40 and 42. The lead wires extend into a hollow contact connector 66. Connector 66 has a base 68 supported within recess 62 on plug 50.

The connector 66 is preferably made from an electrically non-conductive material capable of being made inexpensively. We prefer to make the connector 66 from a polymeric plastic material such as polypropylene and preferred to injection mold the connector. As will be made clear hereinafter, the connector 66 is constructed in a manner so as to provide exposed contacts extending in an axial direction and adapted to mate with a non-directional female contact connector. A non-directional connector is one which does not require any particular orientation in order to effect a connection between the proper contacts on the male and female connectors.

As shown more clearly in FIGS. 3 and 5, the base 68 on the connector 66 is provided with a slot in line with extension 64 so that the lead wires may extend up into the connector. Lead wires 28 and 30 extend into one arcuate chamber 70 and lead wires 40 and 42 extend into an oppositely disposed arcuate chamber 72. The body of the connector 66 includes two arcuate projections. Arcuate projection 74 is substantially coextensive with chamber 70 and projection 76 is substantially coextensive with chamber 72. Projection 76 is substantially longer than projection 74.

The end face of projection 74 is provided with apertures 78 and 80 which are arcuately spaced and communicate with chamber 70. Lead wire 28 extends through aperture 78 and is bent so as to extend axially along the outer periphery of projection 74. Lead wire 30 extends through aperture 80 and is bent so as to extend axially along the inner periphery of projection 74.

The end face of projection 76 is also provided with a pair of arcuately disposed apertures which are designated as 82 and 84. The apertures 78–84 are equally spaced from the longitudinal axis of contact connector 66. Passage 83 communicates with chamber 72. Apertures 82 and 84 are blind as shown more clearly in FIG. 3. A passage 86 is provided at the outer peripheral surface of projection 76 so as to communicate with chamber 72. Lead wire 40 extends through passage 83 and extends along the inner peripheral surface of projection 76 in an axial direction and then into aperture 84. Lead wire 42 extends through chamber 72, passage 86, along the outer peripheral surface of projection 76 in an axial direction and is bent so as to have its end extend into aperture 82. The arcuate surfaces on the inner periphery of projections 74 and 76 define a socket having its lower end defined by a wall 88. The connector 66 is adapted to extend into a female connector designated generally as 90. Connector 90 may be made from a lightweight electrically non-conductive material such as a polymeric plastic.

The female connector 90 includes a cylindrical wall 92 having a bottom wall 94 so as to be generally cup-shaped. A center post 96, concentric with wall 92, extends axially from the bottom wall 94. Post 96 is adapted to be received in the socket of the male connector 66.

The male connector 66 is adapted to telescope into the annular space between the outer periphery of post 96 and inner periphery of cylindrical wall 92. On its inner periphery, the wall 92 is provided with a ring-shaped surface on contact 98 which engages lead wire 28. On its outer periphery, post 96 adjacent its free end is provided with a ring-shaped contact 100. A surface on contact 100 engages lead wire 30.

Contact 98 is connected to one end of a wire 102 extending through a passage in wall 92. One end of a wire 103 is connected to contact 100 with the remainder of the wire extending through an axial passage in post 96. These wires are part of cable 104 which extends rearwardly to a recorder.

A ring-shaped contact 106 is fixedly secured to the outer periphery of post 96 intermediate the ends of post 96. A ring-shaped contact 108 is fixedly secured to the inner periphery of wall 92 so as to circumscribe contact 106. A surface on contact 106 engages a free end of lead wire 40. A surface on contact 108 engages a portion of lead wire 42. Wires are connected to the contacts 106 and 108 and extend through the connector 90 to a cable 110.

The bottom wall 94 of the connector 90 is provided with an axially extending boss 112 threadedly secured to a metal pipe 114. Pipe 114 may be considered a

lance holder. Pipe **114** and female connector **90** are non-expendable. Cable **110** extends to a recorder. A commercially available switching device having a built-in timer may be utilized to sequentially couple the cables **104** and **110** to the recorder so that readings are obtained sequentially on the temperature of the molten metal and the carbon equivalent value.

The lance of the present invention is utilized as follows:

The pipe **114** may be 6 or 8 feet long and terminates in a handle, not shown. The lance **10** may be of varying lengths between 2 and 5 feet. A lance **10** is telescoped over the end of pipe **114** until the female connector **90** is coupled to the male connector **66** as shown in FIG. **3**. In view of the construction of connectors, no particular orientation is needed so as to assure proper engagement between the respective contacts.

Thereafter, the end of lance **10**, while supported by the pipe **114**, is immersed into a bath of molten metal such as steel.

Within 3 or 4 seconds, a temperature reading is obtained by the temperature sensing unit **22**. Manually or automatically, the single recorder will then be switched over to cable **110**. If desired, two separate recorders can be used. Thereafter, a reading will be obtained indicating the liquidus arrest value. Simultaneously, cover **58** will have melted or otherwise disintegrated so as to permit the molten steel to enter chamber **16**. If the molten metal is steel, it is often desirable to place a deoxidizing material such as aluminum wire **116** in the chamber **16**. The deoxidizing material may assume shapes other than wire. The molten metal will substantially fill the chamber **16**. The heat insulating properties of the tube **12** and the body structure **14** will facilitate solidification of the specimen to be retrieved and supported within chamber **16**.

The lance is then removed from the molten bath after having been immersed for a period of approximately 6 to 10 seconds. Thereafter, the lance **10** is removed from the end of the pipe **114**. The solidified specimen within chamber **16** is retrieved in any convenient manner such as by sawing the lance **10** in the general area of chamber **16**. After the specimen is retrieved, the remainder of the lance is discarded.

It will thus be seen that the lance **10** of the present invention facilitates obtaining two measurement values with respect to the bath as well as a specimen of the bath for further laboratory analysis. These desirable characteristics of the bath are ascertained substantially simultaneously by use of a single expendable lance. The sloppy and inconvenient method of ladling a specimen of the bath into a mold is eliminated as well as permitting liquidus arrest values to be obtained with respect to a bath disposed within a furnace. The latter object was not attainable heretofore in the manner of a lance as described above.

The present invention may be embodied in other specific forms without departing from the spirit or essential attributes thereof and, accordingly, reference should be made to the appended claims, rather than to the foregoing specification as indicating the scope of the invention.

We claim:

1. An expendable lance for immersion into a bath of molten metal comprising an expendable tube, a hollow body structure in said tube adjacent one end of the tube adapted to be immersed in a bath, said body structure having a chamber therein, said chamber having first and second ends with the first end being closer to said one end of said tube, a first temperature sensing unit projecting from said one end of the tube for sensing the temperature of a bath of molten metal, a second temperature sensing unit, said second unit being inside the tube and coupled to said body structure so as to have its temperature sensing portion exposed to and adjacent said first end of said chamber, means adjacent said second end of the chamber defining a passage so that molten metal may flow radially into said chamber at the second end thereof and surround the temperature sensing portion of said second unit, and a heat destructible member sealing said passage, said heat destructible member being of a type so as to be destroyed by the bath of molten metal after said one end has been immersed into the bath of molten metal, said chamber facilitating a means for retrieving the specimen of the bath of molten metal.

2. A lance in accordance with claim **1** including a non-directional connector within said tube, a pair of lead wires extending from each of the temperature sensing units to said connector and having axially extending contact portions supported by said connector, whereby readings may be obtained from each sensing unit.

3. A lance in accordance with claim **1** wherein each of said temperature sensing units are supported by said body structure and extend in opposite directions.

4. A lance in accordance with claim **1** wherein said temperature sensing units are identical and are coaxial with respect to said tube.

5. A lance in accordance with claim **1** wherein said means defining a passage to permit entry of molten metal into said chamber includes a radial hole in said tube, and a liner for said hole made from a ceramic material.

6. An expendable lance comprising an expendable tube, a first temperature sensing unit supported by said tube adjacent one end for ascertaining the temperature of a bath of molten metal, means having a chamber therein and disposed within said tube adjacent said one end for retrieving a sample of the bath of molten metal whose temperature is to be ascertained by said unit, a second temperature sensing unit in said tube supported between said first unit and the chamber for ascertaining the liquidus arrest value of the sample at one end of the chamber as the sample solidifies in said chamber, and radial passage means for permitting introduction of a liquid sample directly into the other end of said chamber.

7. A lance in accordance with claim **6** wherein said means for retrieving a sample includes a body structure made from a monolithic mass of heat resistant, non-metallic material and in which is disposed said chamber, each of said temperature sensing units being supported by said body structure, and a heat destructible member closing said passage means.

8. A lance in accordance with claim **6** including a connector supporting contact portions of lead wires extending from said temperature sensing units, said contact portions being supported by said connector for coupling to two sets of contacts, each set of contacts having a pair of contact surfaces.

9. A lance in accordance with claim **8** wherein said chamber is axially disposed between said first temperature sensing unit and said connector.

10. An expendable lance comprising an expendable cardboard tube, a hollow body structure made from a material tending to retard cooling of molten metal so as to allow detection of thermal arrest in the molten metal, said body structure being supported within said tube adjacent an immersion end and having a chamber, a radial passage through said tube positioned so as to facilitate introduction of molten metal into said chamber, a heat destructible cover closing said passage, said body structure supporting identical first and second thermocouple units back-to-back, said first thermocouple unit projecting beyond the immersion end of said tube to facilitate obtaining a temperature reading indicative of the temperature of the bath of molten metal, said second unit extending in an opposite direction from said first unit and having its temperature sensing portion disposed within said chamber, a non-directional connector within said tube adjacent said body structure, lead wires extending from each thermocouple unit to said connector, said connector supporting portions of said lead wires in a position so that contact portions of the lead wires associated with the thermocouple units may be separately mated with contacts adapted to communicate a signal to a recorder.

11. A lance in accordance with claim **10** including a lance holder telescoped within said tube, said lance holder supporting a female connector adapted to mate with said first-mentioned connector, said female connector having two sets of contacts, each set of contacts mating with the contact portions of the lead wires associated with one of the thermocouple units.

12. An expendable lance comprising an expendable cardboard tube, a hollow body structure made from a ceramic material, said body structure being supported within said tube adjacent one end thereof, said body structure having a chamber therein, said chamber having first and second ends with the first end being closer to said one end of said tube, said body structure and tube each having a radial passage, said passages being aligned with one another so that molten metal may enter said chamber adjacent the second end thereof through said passages, a heat destructible cover on said tube blocking entry of molten material into said chamber, an expendable thermocouple unit supported by said body structure at said first end with the hot junction thereof positioned to facilitate obtaining a temperature reading indicative of the temperature of the molten metal, at least a portion of said unit being disposed between said one end of said tube and said chamber, and a non-directional connector within said tube and supported by said body structure, said connector supporting portions of wires in a position so that contact portions of the wires may be separately mated with contacts adapted to communicate a signal to a recorder, with said chamber being disposed between said connector and said thermocouple unit.

13. A lance in accordance with claim **12** including a second expendable thermocouple unit supported by said body structure between said chamber and said one end of said tube, said second thermocouple unit having a sensing junction positioned beyond said one end of said tube.

14. A lance in accordance with claim **12** wherein said body structure includes longitudinally extending grooves adjacent its outer periphery with conductors from said thermocouple unit extending through said grooves to said connector.

15. An expendable lance comprising an expendable cardboard tube, a hollow body structure made from a heat resistant material, said body structure being supported by said tube adjacent one end thereof, said body structure having a chamber therein for retrieving a specimen of metal, said body structure having first and second closed ends, said body structure having a radial passage so that molten metal may enter said chamber radially adjacent the second end thereof through said passage, a heat destructible cover blocking entry of molten material into said chamber, an expendable thermocouple unit supported by said body structure at said first end with the hot junction thereof positioned to facilitate obtaining a temperature reading indicative of the temperature of the molten metal in said chamber, an electrical connector within said tube and supported adjacent said second end of said body structure, said connector supporting portions of wires in a position so that contact portions of the wires may be separately mated with contacts adapted to communicate a signal to a recorder, with said chamber being disposed between said connector and said first end of said body structure.

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