US 20200354802A1

(19) United States
(12) Patent Application Publication
Green et al.
(10) Pub. No.: US 2020/0354802 A1
(43) Pub. Date: Nov. 12, 2020

(54) CONTROLLING OPERATION AND POSITION OF A LANCE AND NOZZLE ASSEMBLY IN A MOLTEN METAL BATH IN A VESSEL

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(21) Appl. No.: **16/760,376**

(22) PCT Filed: **Aug. 19, 2019**

(86) PCT No.: **PCT/US2019/047116**

§ 371 (c)(1),
(2) Date: **Apr. 29, 2020**

Related U.S. Application Data

(60) Provisional application No. 62/719,277, filed on Aug. 17, 2018.

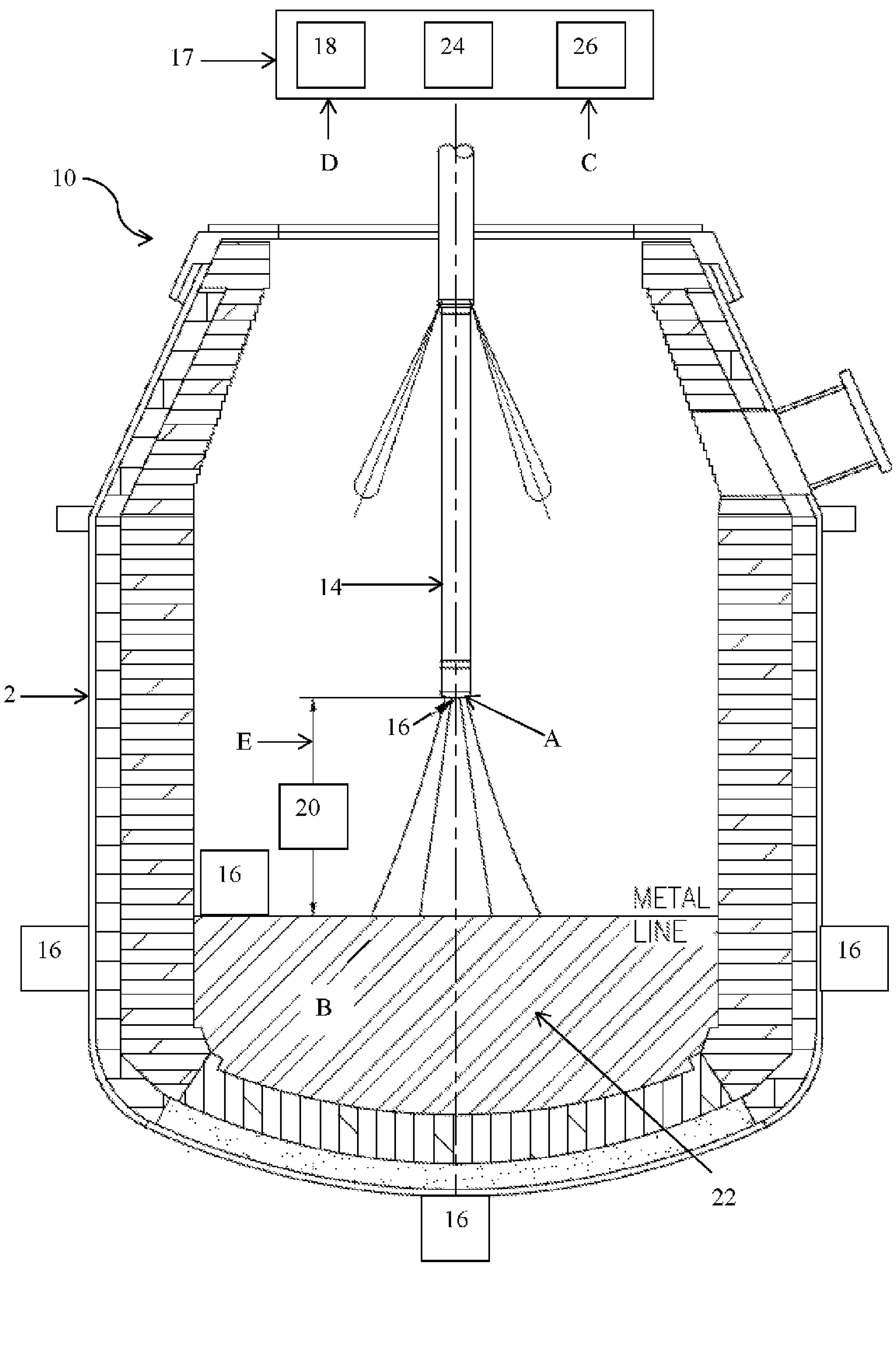
Publication Classification

(51) **Int. Cl.**
C21C 5/46 (2006.01)
C21C 5/32 (2006.01)

(52) **U.S. Cl.**
CPC ***C21C 5/462*** (2013.01); *C21C 2005/5288* (2013.01); ***C21C 5/32*** (2013.01); ***C21C 5/4673*** (2013.01)

(57) **ABSTRACT**

The present invention preferably comprises a system and method for operating and/or positioning a lance and nozzle assembly relative to a molten metal bath in a vessel. Specifically, at least one temperature sensor is provided proximate a tip of the lance and nozzle assembly and at least one temperature sensor is provided on or in the vessel. A processing unit is configured to receive at least one signal from each of the temperature sensors, process the signals to determine the active position of the lance and nozzle assembly relative to the metal bath, and move the lance and nozzle assembly to a preferred position the corresponds to a stage of operation in the vessel.



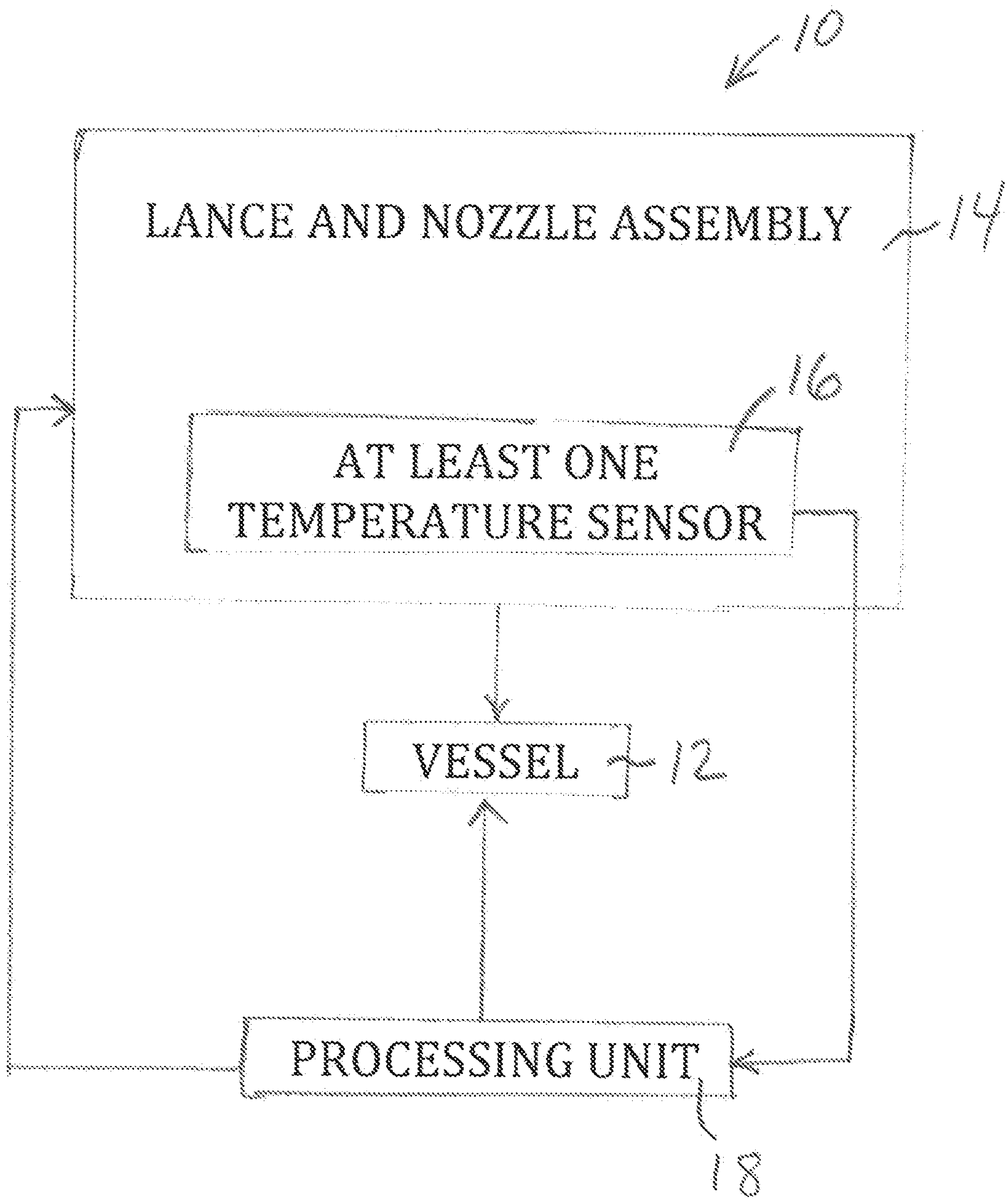

10
LANCE AND NOZZLE ASSEMBLY
14
16
AT LEAST ONE
TEMPERATURE SENSOR
VESSEL
12
PROCESSING UNIT
18

FIG. 1

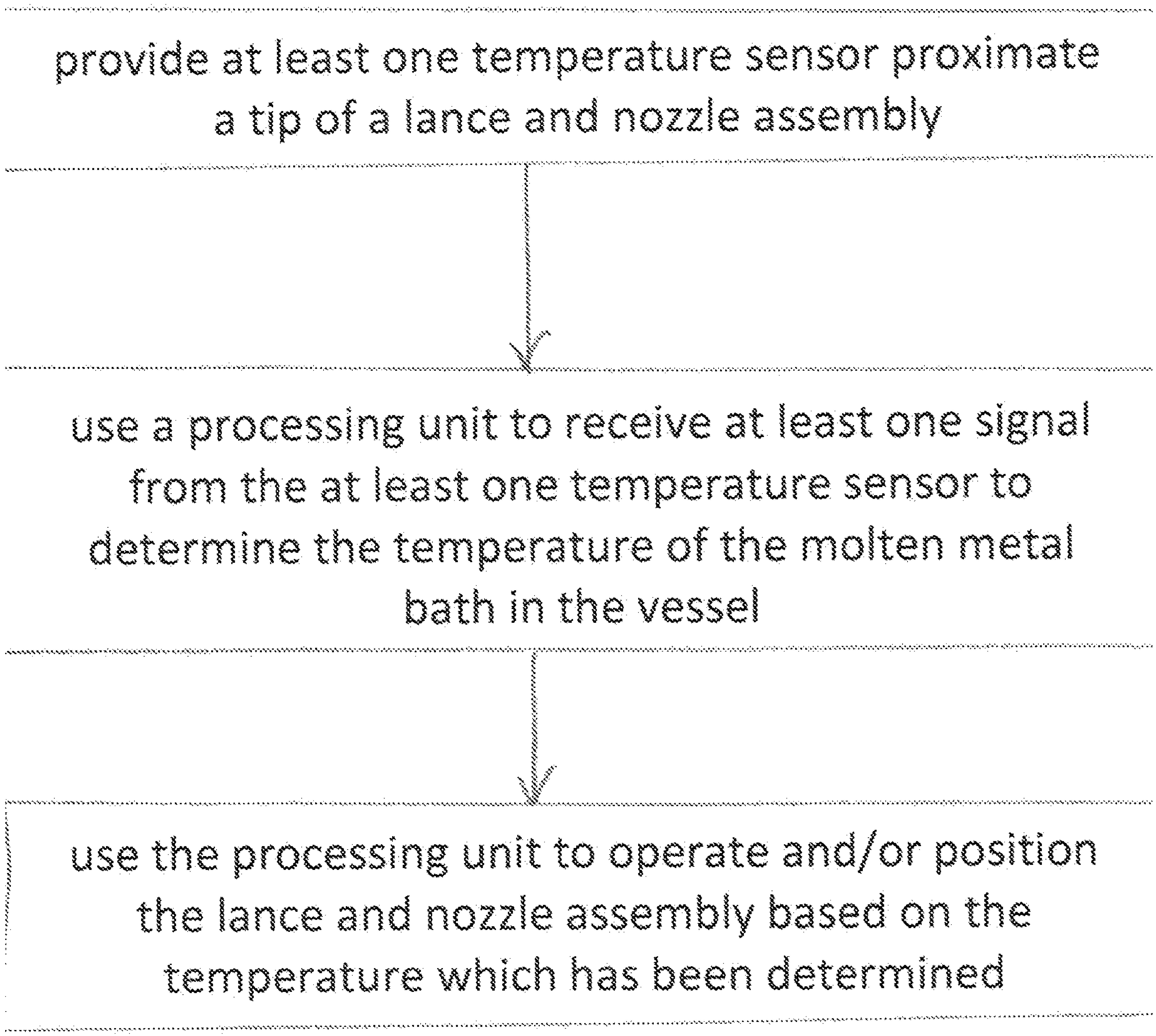

provide at least one temperature sensor proximate a tip of a lance and nozzle assembly
use a processing unit to receive at least one signal from the at least one temperature sensor to determine the temperature of the molten metal bath in the vessel
use the processing unit to operate and/or position the lance and nozzle assembly based on the temperature which has been determined

FIG. 2

FIG. 3

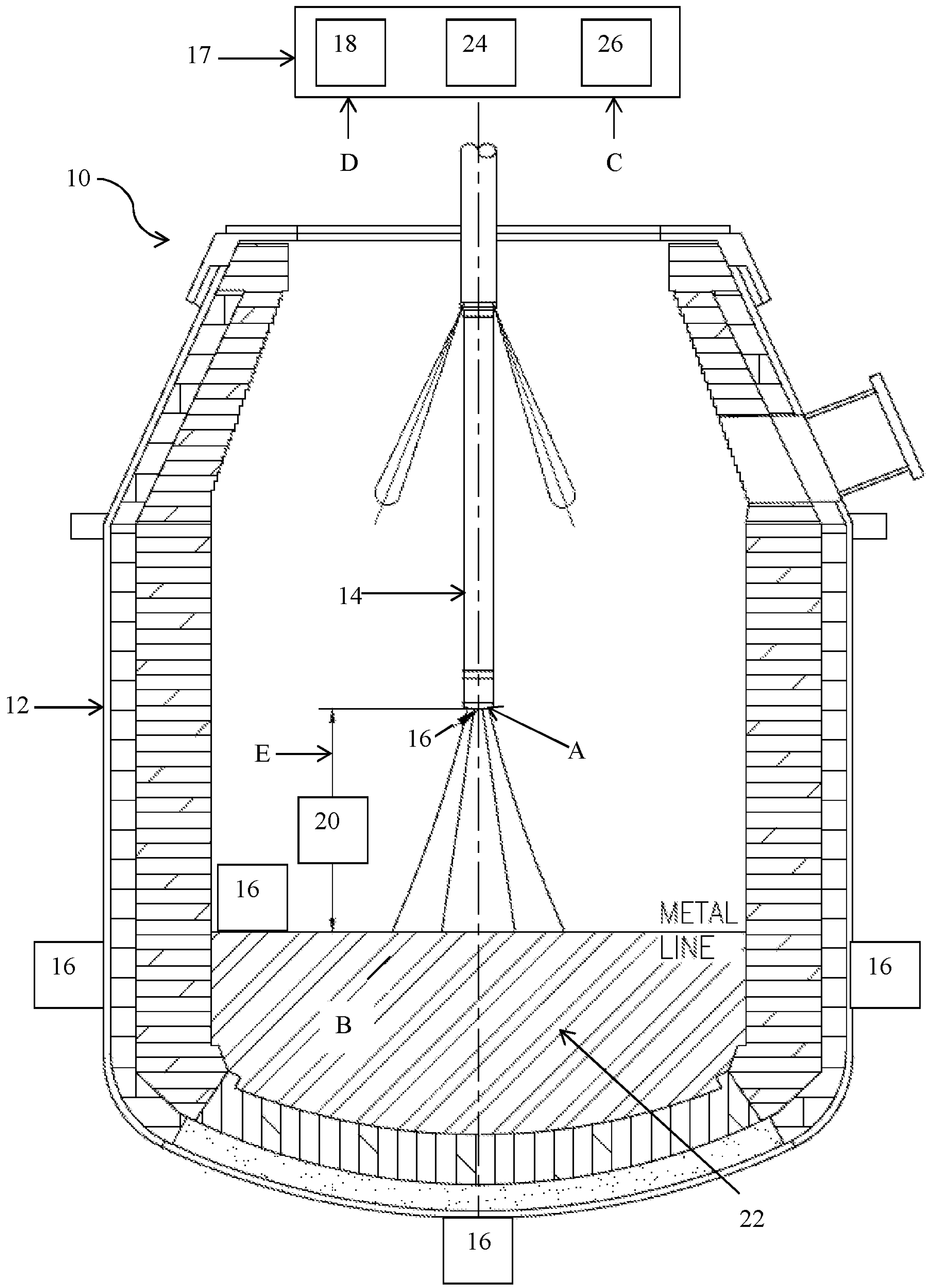
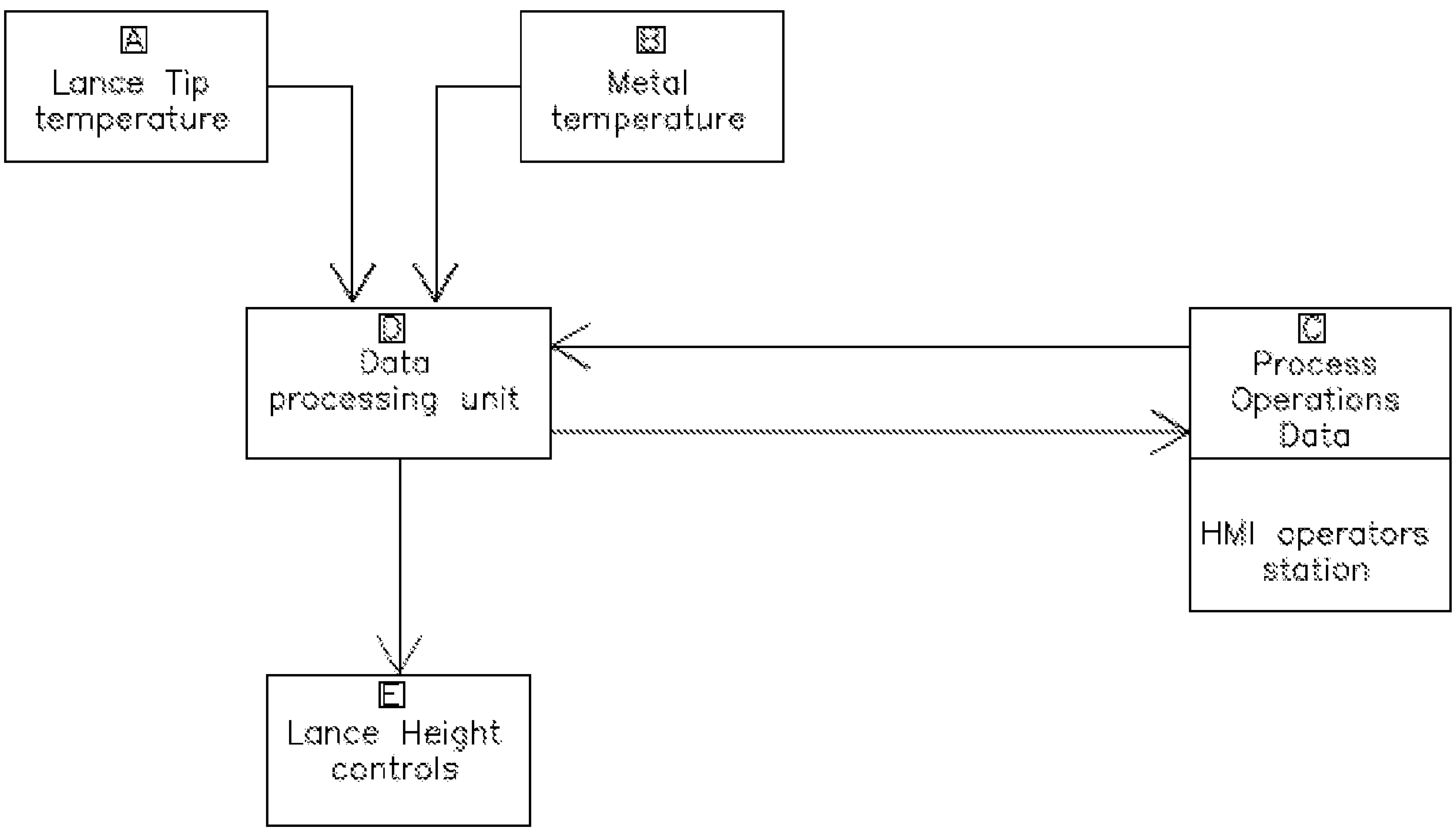


FIGURE 4


A
Lance Tip temperature
B
Metal temperature
D
Data processing unit
C
Process Operations Data
HMI operators station
E
Lance Height controls

CONTROLLING OPERATION AND POSITION OF A LANCE AND NOZZLE ASSEMBLY IN A MOLTEN METAL BATH IN A VESSEL

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Patent Application No. 62/719,277 filed in the United States Patent and Trademark Office on Aug. 17, 2018.

FIELD OF THE INVENTION

[0002] The present invention generally relates to vessels for melting metal. More specifically, it relates to systems and methods for controlling the operation and/or positioning of a lance and nozzle assembly relative to a molten metal bath in such a vessel.

BACKGROUND OF THE INVENTION

[0003] In the steel industry, the Basic Oxygen Furnace (BOF) is the primary steelmaking vessel in a steel mill. A general goal in the industry is to improve quality control while also reducing production time and cost. However, a common impedance to being able to achieve that goal is the inability to determine, in real time, the temperature of the molten steel bath inside a BOF. As a result of lacking real time, accurate temperature data, target temperatures and chemistries are often missed. Failure to achieve the target temperatures and chemistries during the metal melting process can result in inefficiencies and may even result in having to reinitiate the heating process, resulting in significant economic impact. This lack of ability to determine temperature in real time results in a lack of efficiency that not only applies to BOF's in the steel industry, but also to electric arc furnaces (EAF's) as well as induction furnaces.

[0004] A BOF operates at very high temperatures. As a result, using temperature sensors inside the BOF to take temperature readings is not typically feasible. Furthermore, to the extent that using temperature sensors inside the BOF has been attempted, the high temperatures at which the BOF operates tend to substantially impact the life of the sensors.

[0005] There are a few temperature measuring approaches that have been attempted in the industry and have resulted in at least some measure of success. These approaches include the following: using a bomb thermocouple (i.e., temperature sensor); using a spring loaded thermocouple disposed in the tip of a lance; using an infrared camera to sense the temperature of the tip of a lance or the bath itself; and using a thermocouple installed in a tuyere (i.e., an air nozzle which is used to blow air into the molten bath in the BOF). While these approaches do provide for the measurement of temperature, the measurements that are taken are basically just a snapshot—a single temperature measurement taken at a specific point in time. Because the temperature of the molten metal bath in a BOF varies greatly with stratification of the level (height) of the bath and proximity to the heating element, none of these approaches effectively provide accurate temperature data with regard to the overall bath inside the BOF.

[0006] Generally speaking, each steel mill develops their own BOF process control strategies in an attempt to improve quality control while concurrently reducing production time and cost. In most facilities, static models are used to determine the amount of oxygen to be blown into the bath in the vessel and the charge to be applied to the furnace, based on initial and final heat information. While these models have improved the operators' chances of achieving the desired endpoint, they do not provide real time process information and therefore target temperatures and chemistries can still be missed. Failure to achieve the desired endpoint condition can be attributed to errors in model input conditions (e.g. the unknown composition of the scrap, uncertainties in hot metal temperature and chemistry, etc.) as well as the inability of the model itself to accurately represent the physics of the conversion process. Changes in furnace volume can also result in distance variations between the tip of the lance and the top surface of the molten metal bath—a phenomenon that affects bath stirring characteristics and carbon oxidization rates. Alleviating the missed endpoint condition requires corrective action, either while the steel remains in the BOF or during subsequent ladle treatment. Unfortunately, either corrective action translates to additional operating cost.

[0007] Because of the challenging environment in the BOF, it has been difficult to implement process sensors in this environment that can provide meaningful data over long sensor lifetimes. One of the primary objectives for requiring a temperature measurement is to rapidly and accurately measure the end-point melt temperature for quick tap operations. Gaining access to the melt surface through the slag layer represents the primary challenge associated with accurate endpoint temperature measurement.

[0008] One method is to install a temperature sensing device through a tuyere. This type of sensing device is adequate at the beginning of the life of the sensor, but quickly begins to deteriorate. A second type of temperature sensing device is an infrared camera located in the roof, sidewall or lance tip. The slag layer on top of the steel requires a high pressure gas to part it, and the resulting splashing of the slag creates difficulty in obtaining an accurate measurement.

[0009] As a matter of course, some molten metal is always left in the bottom of the BOF, between heats, to improve melting efficiency. After every heat, some of this metal and slag freezes, building a thickness on the bottom of the furnace. After a number of heats, this thickness builds substantially enough to warrant adjusting the height of the lance relative to the bath. If the lance is too low or too close to the bath, the tip can overheat or the lance can ingest slag that can plug the orifices. On the other hand, if the lance is too high, the oxygen will not penetrate the slag. To determine the height of the lance above a bath, some furnace operators measure the buildup using a system that uses lasers to calculate the available volume of vessel. This is an expensive and time-consuming process. Other operators place a disposable rod on the end of a lance, insert the lance to operating position, remove the lance and measure the length of melted rod to determine the actual distance to the bath. This method involves exposing personnel to unsafe conditions.

SUMMARY OF THE INVENTION

[0010] An objective of an embodiment of the present invention is to provide an improved system and method for controlling the operation and/or positioning of a lance and nozzle assembly with regard to a molten metal bath in a vessel.

[0011] Another objective of an embodiment of the present invention is to provide a system and method for continuously detecting and monitoring the temperature of a molten metal bath in a vessel.

[0012] Briefly, a preferred embodiment of the present invention provides a system and method for measuring and monitoring the temperature of a molten metal bath in a vessel, such as a BOF, and based on those temperatures, amend the position of a lance and nozzle assembly relative to the height of the molten metal bath. Specifically, at least one temperature sensor is disposed proximate the tip of a lance and nozzle assembly in order to continuously measure and monitor the temperature at the tip of the lance. Another temperature sensor may be placed in a position to measure the temperature of molten metal bath. Preferably, the at least one temperature sensor is configured to provide at least one signal to a processing unit (such as a control center), and the processing unit is configured to process the at least one signal and determine the temperature of the molten metal bath. The at least one temperature sensor can be either hard wired to the processing unit, or the at least one temperature sensor can be configured to wirelessly transmit the signals to the processing unit. Regardless, the system can be used to continuously monitor the temperature of the lance tip and/or molten metal bath over time. Moreover, the control center may be configured to operate and/or position the lance and nozzle assembly relative to the molten metal bath, based on signals received and processed by the control center via the at least one temperature sensor. It is contemplated that a single sensor, such as an infrared sensor, may measure the temperature of both the lance tip and the molten metal bath in order to carry out the systems and methods of this invention.

[0013] A preferred embodiment of the present invention comprises:

[0014] a system for operating and/or positioning a lance and nozzle assembly relative to a molten metal bath in a vessel, the system comprising:

[0015] at least one temperature sensor proximate a tip of the lance and nozzle assembly; and

[0016] a processing unit configured to receive at least one signal from the at least one temperature sensor, process said at least one signal to determine the temperature of the molten metal bath in the vessel, and operate and/or position the lance and nozzle assembly based on the temperature which has been determined by the processing unit based on the at least one signal which has been received by the at least one temperature sensor.

[0017] Another preferred embodiment of the present invention comprises:

[0018] a method for operating and/or positioning a lance and nozzle assembly relative to a molten metal bath in a vessel, the method comprising:

[0019] providing a first temperature sensor proximate to a tip of the lance and nozzle assembly, wherein the sensor is housed by the lance and nozzle assembly, wherein the first temperature sensor is configured to detect a temperature of the tip of the lance and nozzle assembly, and wherein the temperature is converted to tip temperature data;

[0020] providing a second temperature sensor on or within the vessel, wherein the second temperature sensor is configured to detect a temperature of the molten metal bath, and wherein the temperature is converted to bath temperature data;

[0021] sending the tip temperature data and the bath temperature data to a processing unit;

[0022] exchanging information between the processing unit and a process operations data module, wherein the information comprises the tip temperature data, the bath temperature data, and process operations data;

[0023] mapping the tip temperature data and bath temperature data to a corresponding active elevation of the lance and nozzle assembly;

[0024] comparing the active elevation to a preferred elevation of the lance and nozzle assembly;

[0025] moving the lance and nozzle assembly from the active elevation to the preferred elevation.

BRIEF DESCRIPTION OF THE DRAWINGS

[0026] The organization and manner of the structure and operation of the invention, together with further objects and advantages thereof, may best be understood by reference to the following description taken in connection with the accompanying drawings wherein like reference numerals identify like elements in which:

[0027] FIG. **1** is a block diagram of a system provided in accordance with a first embodiment of the present invention; and

[0028] FIG. **2** is a block diagram of a method using the system shown in FIG. **1**, provided in accordance with an embodiment of the present invention.

[0029] FIG. **3** is a diagram of a system provided in accordance with an embodiment of the present invention.

[0030] FIG. **4** is a flow chart describing steps of a method provided in accordance with an embodiment of the present invention.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0031] While this invention may be susceptible to embodiment in different forms, there are shown in the drawings and will be described herein in detail, specific embodiments with the understanding that the present disclosure is to be considered an exemplification of the principles of the invention, and is not intended to limit the invention to that as illustrated.

[0032] FIG. **1** is a block diagram of a system **10** provided in accordance with a first embodiment of the present invention. As shown, the system **10** comprises a vessel **12**, such as a BOF, for use in a metal making process. The vessel **12** may comprise multiple layers of refractory material, such as fire brick, alumina, silica, etc., as well as one or more internal insulating layers, such as gunite or other shotcrete material. Regardless of the exact structure of the vessel **12**, during the metal making process, the vessel **12** contains a molten metal bath **22** that is thermally processed as is customary in the industry.

[0033] As shown in FIG. **1**, the system **10** provides that a lance and nozzle assembly **14** comprising at least one temperature sensor **16** is disposed about the vessel **12**. The at least one temperature sensor **16** is configured to provide at least one signal to a PLC or processing unit (such as a control center) **18**, and the processing unit **18** is configured to process that at least one signal received from the at least one temperature sensor **16** and determine the temperature of the molten metal bath **22** inside the vessel **12**.

[0034] The at least one temperature sensor **16** can be either hard wired to the processing unit **18** (such as via hardwire, a fiber optic conductor, etc.), or the at least one temperature sensor **16** can be configured to wirelessly transmit the at least one signal to the processing unit **18** (such as via laser signals, a radio signal, etc.). Regardless, the system **10** can be used to continuously monitor the temperature of the molten metal bath **22** in the vessel **12** over time, and based on the temperature that has been detected, the processing unit **18** can change one or more operating conditions, during production, to arrive at the desired endpoint. The same temperature sensor **16** may also be effectively used, by the processing unit **18**, to confirm that the conversion process has reached the desired endpoint condition. In some preferred embodiments, as will be described below, a sensor **16** is located at the tip of the lance and nozzle assembly **14** for detecting a temperature of the lance **14** tip and another sensor **16** is positioned near the molten metal bath **22** for detection of a temperature thereof. In either case, the utility of the real-time sensor (i.e., the at least one temperature sensor **16** and processing unit **18**) is its ability to minimize the time and cost required to produce steel.

[0035] The temperature of the slag itself can be measured with the at least one temperature sensor **16** located in the lance and nozzle assembly **14** and the melt temperature inferred from this measurement. This temperature probe reading the inside of the copper tip can be a spring loaded thermocouple, or an IR camera. The time-resolved radiance from the slag and combustion of gases can be correlated to the temperature of the bath. The operating temperature profile exhibits a peak near the start of the heat and falls rapidly to a minimum approximately 250 seconds into the heat. From that point, the radiance gradually rises, while concurrently exhibiting local minima and maxima associated with: 1) variations in combustion activity below the lance; 2) addition of ore, lime, and stone throughout the heat; and 3) changes in lance height.

[0036] Since radiance is coupled with the heat release rate within the combustion zone, the data effectively received (by the processing unit **18** via the at least temperature sensor **16**) provides feed-back information for modified lance practice and/or the time and rates of flux addition to arrive at a more uniform radiance level and greater integrated heat release rates at early times in the conversion process.

[0037] Tip sensor measurements (measurement of the temperature of a tip of the lance and nozzle assembly **12** taken by the processing unit **18** via the at least one temperature sensor **16**) may also provide an indicator of end point bath carbon content. Based on empirical evaluation of data, it has been determined that measurements pertinent to bath carbon content are consequential only after the heat has progressed for approximately 1000 seconds or more. From this time forward, the radiance exhibits an initial maximum, followed by a decrease to a local minimum, rising again to a local maximum. For many heats, within 50 seconds after the second local maximum or 100 seconds of the local minimum, the carbon endpoint is reached. From a process control perspective, it is preferable to obtain bath carbon content information as soon as feasible before reaching the endpoint to allow time for process correction, if necessary. However, failing this approach, a thermally measured endpoint carbon measurement would also be useful.

[0038] Preferably, the processing unit **18** is configured to effectively use the at least one temperature sensor **16** in the lance and nozzle assembly **14** to calibrate the temperature of the lance while the lance is in a known position relative to the bath. Using the at least one temperature sensor **16**, the relative position of the lance and nozzle assembly **12** relative to the bath can be determined by the processing unit **18**, indirectly without having to take further measurements, make additional calculations, or exposing anyone to a risk in safety.

[0039] Providing at least one temperature sensor **16** in the lance and nozzle assembly **14** effectively provides a view into the vessel that can be used by the processing unit **18** to decrease process time and energy as well as positioning of the lance. With all the information that is typically collected, furnace owners still have operators manually make operational decisions thereby losing consistency between operators. The purpose of the present invention is to automate the real time data being collected with automated control of the lancing operations. This is done by sending data signals from the at least one temperature sensor **16** to the processing unit **18** via hardwire, fiber optic conductor, laser signals, radio signal, etc. The at least one temperature sensor **16** and the processing unit **18** collectively function to permit analysis of certain bath conditions which might be metallurgical, relate to sound and light, or be pyrometric, etc. This data is received and analyzed by the processing unit **18**, and the resulting analysis causes commands to be sent to the lance carriage controls and oxygen valve stand for the beneficiation of the process.

[0040] The arrangement may be utilized with any gas lance or oxygen-oil or oxygen fuel burner lance where some form of sensor or information gathering means is to be incorporated. Preferably, a central tube of the lance and nozzle assembly provides a safe and yet effective construction and shielding means for the cable conductor. The arrangement may also be utilized with any signal or information transmittal method, such as but not limited to light usage or fiber optic transfer medium as well as the transmittal of an electrical signal by cable. The ability to measure the bath temperature in real-time allows the operator to see what the bath is doing over time, instead of relying upon single-point measurements taken, for example, with a thermocouple. This capability can be used to prevent overshoots, reduce processing time and optimize energy usage. Real-time temperature monitoring gives valuable insight into the transient behavior of the bath, thereby ensuring the ability of the measurement to accurately represent the bath as a whole. It provides a safe and economic manner in which the desired result may be achieved. It further automates the control of the oxygen blow and lance position ensuring consistency in operation between operators.

[0041] The present invention is directed to a combination of a lance and nozzle assembly for supplying gas to a basic oxygen furnace. The lance and nozzle include an arrangement to accommodate a temperature sensing device or unit which is adapted to transmit signals providing information in connection with the refractory or contents of the bath contained within the vessel. The arrangement includes a signal transmission by, for example, hard wire or radio transmission to a processing **18**, such as a PLC, located in a control center. This PLC interprets the data to provide automatic control for operating or positioning the lance and nozzle assembly.

[0042] FIG. **2** is block diagram of a method using the system shown in FIG. **1**, in accordance with an embodiment of the present invention, and is self-explanatory given the description hereinabove.

[0043] FIG. **3** is a diagram of a preferred embodiment of the present invention. System **10** preferably comprises vessel **12**, lance and nozzle assembly **14**, at least one temperature sensor **16**, control suite **17**, processing unit **18**, elevation **20**, molten metal bath **22**, lance elevation control **24**, and process operations data module **26**. As shown, the one or more temperatures sensors **16** may be located in various positions about the system **10**, including at the tip of the lance and nozzle assembly **14**, a probing mechanism within the vessel **12**, or outside the vessel **12** such as in sensor systems comprising ultrasonic transceivers. In a preferred embodiment of the present invention, the system **10** comprises a sensor **16** at the tip of the lance and nozzle assembly **14**, and a second sensor **16**, preferably in a different location such as in the vessel **12** or outside the vessel **12**, configured to measure the temperature of the molten metal bath **22**.

[0044] FIG. **4** is a flow diagram of a preferred embodiment of the present invention. The flow diagram is designated with boxed reference letters that are also provided in FIG. **3** to help explain where those steps in FIG. **4** will typically occur in system **10**. The locations of these designations in FIG. **3** are exemplary and non-limiting. As shown in FIGS. **3** and **4**, the present invention comprises a method for operating and/or positioning lance and nozzle assembly **14** relative to the molten metal bath **22** in vessel **12**, the method comprising the steps of:

[0045] A: collecting tip temperature data via sensor **16** at the tip of the lance and nozzle assembly **14**, wherein such data is provided to processing unit **18**;

[0046] B: collecting bath temperature data via sensor(s) **16**, such as that provided in one or more locations other than the lance and nozzle assembly **14**, for the molten metal bath **22** in the vessel **12**, wherein such data is provided to processing unit **18**;

[0047] C: obtaining in process operations data module **26** process operations and parameters data from primary and sub systems of system **10**, wherein the process operations and parameters data of the process operations data module **26** and data of processing unit **18** may be exchanged between unit **18** and module **26** either unidirectionally or bidirectionally;

[0048] D: providing information to lance elevation control **24** based on a comparison of data received by processing unit **18** against stored data;

[0049] E: amending the elevation position of the lance and nozzle assembly **14** in relation to the bath **22**.

[0050] Mechanisms for obtaining tip temperature data from the tip of lance and nozzle assembly **14** include various means and methods, such as Op-T Temp, pyrometer, thermocouple, infrared temperature sensors, and resistance temperature detectors.

[0051] Mechanisms for obtaining bath temperature data from the metal bath **22** include continuous bath measurement, manual measurement, manual measurement, automated measurement, ultrasonic measurement, and probing.

[0052] The temperature data obtained at steps A and B are preferably mapped to a calculated lance and nozzle assembly **14** elevations **20** via an algorithm as such elevations **20** relating to an operating range at Step C. The operating ranges preferably correspond to a particular processing step in the metal making process of the vessel **12**. Step C may comprise a feedback loop, and process operations data module **26** may be connected to and/or informed by an operator's station. Data comprising module **26**, including process operations data, may include data from the primary and sub systems of the vessel **12**, including anti-slop systems as well as normal operations practices input provided by operators at human machine interfaces.

[0053] At step D, the data processing unit **18** preferably calculates the lance and nozzle assembly **14** elevation **20** and amends the elevation **20** based on the temperature readings in the operating range at Step C. This step comprises the lance elevation control **24**, which receives input from the processing unit **18**. The elevation **20** is preferably the distance between the lance and nozzle assembly **14** tip and the surface of the molten metal bath **22**.

[0054] Step E can be effectuated by various means including automated controls and manual operation controls as prompted by the lance elevation control **24**.

[0055] Ideally, the present invention will maintain the elevation **20** at an optimal level depending on the operational stage of the vessel **12**.

[0056] If the temperatures reach a critical level where the lance **14** is calculated by the system **10** processing unit **18** to be too close to the bath **22** the lance **14** can be alarmed for manual adjustment override, or it can be programmed to automatically adjust to a proper lance **14** height **20** to prevent damaging or dunking the lance **14** tip in relation to the steel bath **22**.

[0057] Any of steps A-E can comprise a wired or wireless transmission of data.

[0058] It is contemplated that additional steps may be deployed the method described herein. The process described herein may be automated, manual, or semi-automated.

[0059] While specific embodiments of the invention have been shown and described, it is envisioned that those skilled in the art may devise various modifications without departing from the spirit and scope of the present invention.

1. A method for operating and/or positioning a lance and nozzle assembly relative to a molten metal bath in a vessel, the method comprising:

providing a first temperature sensor proximate to a tip of the lance and nozzle assembly, wherein the first temperature sensor is housed by the lance and nozzle assembly, wherein the first temperature sensor is configured to detect a temperature of the tip of the lance and nozzle assembly, and wherein the temperature is converted to tip temperature data;

providing a second temperature sensor on or within the vessel, wherein the second temperature sensor is configured to detect a temperature of the molten metal bath, and wherein the temperature is converted to bath temperature data;

transmitting the tip temperature data and the bath temperature data to a processing unit;

exchanging information between the processing unit and a process operations data module, wherein the information comprises the tip temperature data, the bath temperature data, and process operations data;

mapping the tip temperature data and the bath temperature data to a corresponding active elevation of the lance and nozzle assembly;

comparing the active elevation to a preferred elevation of the lance and nozzle assembly; and

moving the lance and nozzle assembly from the active elevation to the preferred elevation.

2. A system for operating and/or positioning a lance and nozzle assembly relative to a molten metal bath in a vessel, the system comprising:

a lance and nozzle assembly having a first elevation in a vessel comprising a molten metal bath;

a first temperature sensor proximate to a tip of the lance and nozzle assembly, wherein the first temperature sensor is housed by the lance and nozzle assembly, wherein the first temperature sensor is configured to detect a temperature of the tip of the lance and nozzle assembly, and wherein the temperature is converted to tip temperature data;

a second temperature sensor on or within the vessel, wherein the second temperature sensor is configured to detect a temperature of the molten metal bath, and wherein the temperature is converted to bath temperature data;

a processing unit configured to receive and exchange data, wherein the data comprise the tip temperature data and the bath temperature data;

a process operations data module, wherein the module is configured to exchange data with the processing unit;

a lance elevation control, wherein the lance elevation control is configured to receive data from the processing unit, and wherein the lance elevation control is configured to move the lance and nozzle assembly from the first elevation to a second elevation.

3. A method of operating and/or positioning a lance and nozzle assembly relative to a molten metal bath in a vessel, the method comprising:

providing at least one temperature sensor proximate a tip of a lance and nozzle assembly;

using a processing unit to receive at least one signal from the at least one temperature sensor to determine the temperature of the molten metal bath in the vessel; and

using the processing unit to operate and/or position the lance and nozzle assembly based on the temperature which has been determined by the processing unit based on the at least one signal which has been received by the at least one temperature sensor.

4. The method of claim **1**, wherein the first temperature sensor is a thermocouple, an infrared camera, a pyrometer, or a resistance temperature detector.

5. The method of claim **1**, wherein the second temperature sensor comprises an ultrasonic transceiver.

6. The method of claim **1**, wherein at least one of the tip temperature data and the bath temperature data is wirelessly transmitted to the processing unit.

7. The method of claim **1**, wherein the moving the lance and nozzle assembly from the active elevation to the preferred elevation is automated to prevent dunking of the tip of the lance and nozzle assembly into the molten metal bath.

8. The system of claim **2**, wherein the first temperature sensor is a thermocouple, an infrared camera, a pyrometer, or a resistance temperature detector.

9. The system of claim **2**, wherein the second temperature sensor comprises an ultrasonic transceiver.

10. The system of claim **2**, wherein at least one of the tip temperature data and the bath temperature data is wirelessly transmitted to the processing unit.

11. The system of claim **2**, wherein the lance elevation control is automated to prevent dunking of the tip of the lance and nozzle assembly into the molten metal bath.

12. The method of claim **3**, wherein the first temperature sensor is a thermocouple, an infrared camera, a pyrometer, or a resistance temperature detector.

13. The method of claim **3**, wherein at least one of the tip temperature data and the bath temperature data is wirelessly transmitted to the processing unit.

14. The method of claim **3**, wherein the operating and/or positioning of the lance and nozzle assembly further comprising moving the lance and nozzle assembly from an active elevation to a preferred elevation.

15. The method of claim **3**,

wherein the first temperature sensor is housed by the lance and nozzle assembly, wherein the first temperature sensor is configured to detect a temperature of the tip of the lance and nozzle assembly, and wherein the temperature is converted to tip temperature data comprising the at least one signal; and

further comprising the steps of:

providing a second temperature sensor on or within the vessel, wherein the second temperature sensor is configured to detect a temperature of the molten metal bath, and wherein the temperature is converted to bath temperature data comprising a second signal;

transmitting the at least one signal and the second signal to the processing unit;

exchanging information between the processing unit and a process operations data module, wherein the information comprises the tip temperature data, the bath temperature data, and process operations data;

mapping the tip temperature data and the bath temperature data to a corresponding active elevation of the lance and nozzle assembly;

comparing the active elevation to a preferred elevation of the lance and nozzle assembly; and

moving the lance and nozzle assembly from the active elevation to the preferred elevation.

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