United States Patent [19]

Bennett

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[45] **Apr. 17, 1973**

[54] **LANCE WITH DISTANCE MEASURING SUB-SYSTEM**

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[52] **U.S. Cl.** .....**266/34 LM,** 343/12 R

[51] **Int. Cl.** **C21c 7/00,** G01s 9/04

[58] **Field of Search** .....343/12 R; 266/34 LM

[56] **References Cited**

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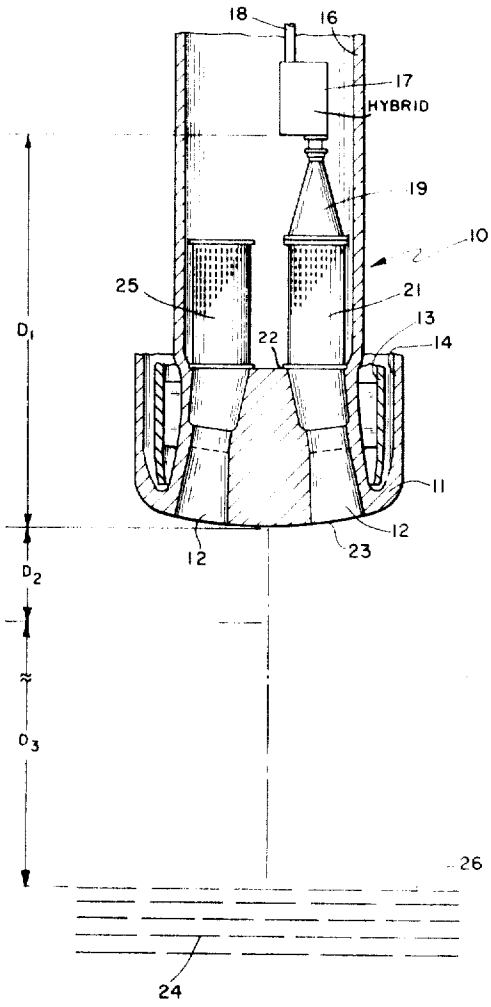
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[57] **ABSTRACT**

The invention is directed to an assembly which includes in combination a lance for supplying a gas to a nozzle in combination with radar-type means for determining the distance between the nozzle and a reflecting surface spaced from the nozzle. In the preferred embodiment, the assembly comprises an oxygen lance for a basic oxygen furnace which includes means for determining the distance between the lance and the surface of the charge in the furnace.

6 Claims, 3 Drawing Figures

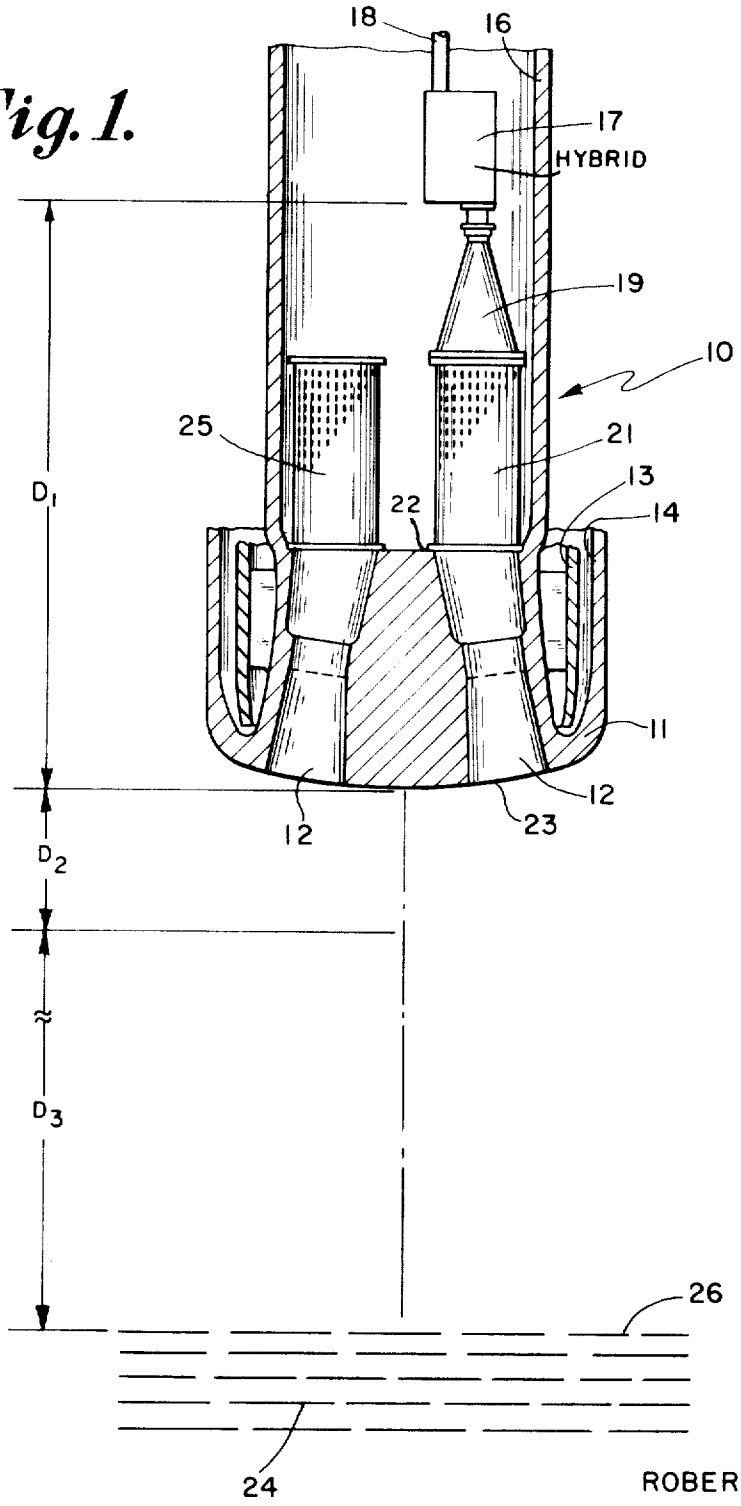


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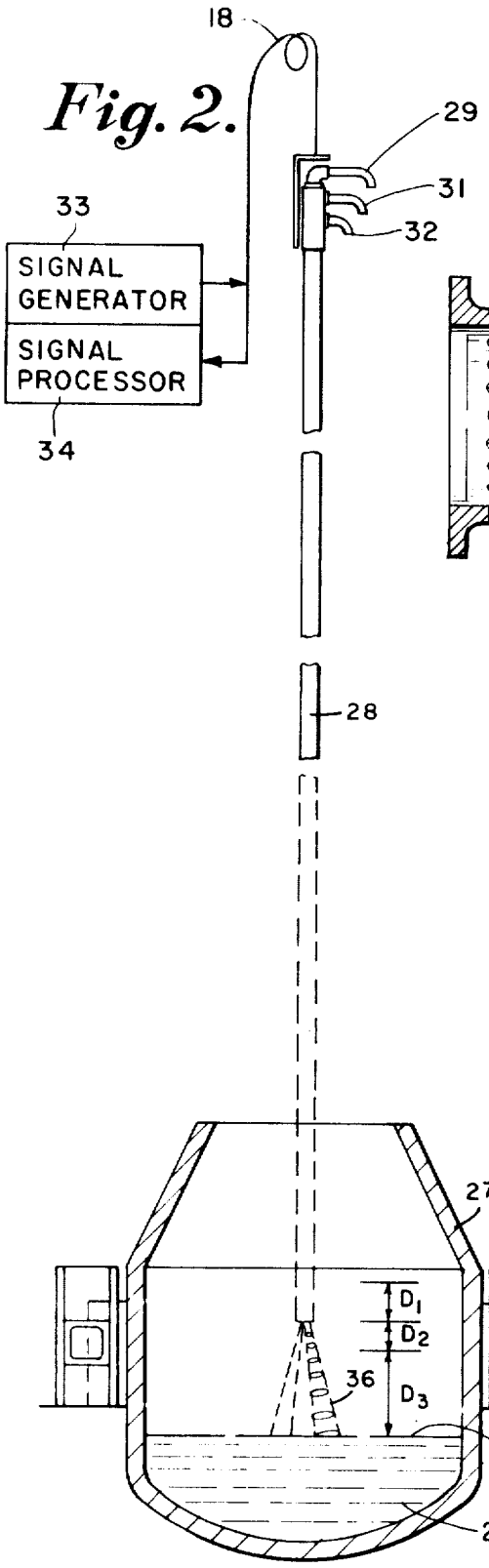
Fig. 1.



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Fig. 2.



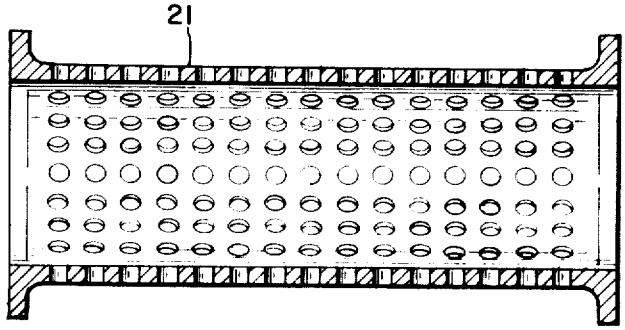


Fig. 3.

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LANCE WITH DISTANCE MEASURING SUB-SYSTEM

There are a number of materials processes, typically metallurgical processes, wherein a gas is blown into a molten bath comprising the materials charge, at high velocity from a lance. The basic oxygen steel making process is by far the most prominent example.

In virtually every lance application the position of the lance relative to the charge bath is an important process variable. Position accuracies of ½ to 1 inch are sought. It is also hypothesized that materials processing may be improved if the lance position can be continuously adjusted during processes. At the present time, the lance position, or height as it is called, is adjusted only at the beginning of a gas blow.

In the basic oxygen process, an oxygen lance supplies oxygen under pressure to one or more nozzles located at the tip of the lance. The nozzles are located in a tip at the end of the lance located in the furnace and spaced from the charge bath. Oxygen, during a blow, leaves a nozzle opening as a supersonic effluent and impinges against the charge in the furnace. The distance between the nozzle and the charge, in this case the height of the nozzle opening, is a critical processing parameter.

The lance is 70 feet long. Heretofore, the spacing between the nozzle and the charge was determined at the top of the lance, 70 feet from the tip, by the location of a pointer in relation to a scale. This system does not provide for variation in the length of the cable supporting the lance and variations in length in the lance due to temperature differences.

Further, the pointer-scale system does not take into account the turbulence within the furnace, which turbulence causes variations in the distance between the nozzle opening and the charge. The net result is a not too efficient system. A capability for measuring the distance of the nozzle opening from the charge continuously, to the nearest half inch to one inch is the design objective.

Heretofore, attempts have been made to measure the critical distance by attaching devices to the outside of the lance. Optical devices proved ineffective because the charge surface is obscured by smoke and dirt, and molten particles. Radar-type measuring instruments mounted external to the lance are also ineffective for the lack of stable reference with respect to the nozzle opening.

It is an object of the invention to provide a lance system which incorporates means for accurately measuring the distance between the lance tip, nozzle opening in the tip, and a charge surface.

Other objects of the invention are to provide in the foregoing described lance system (1) radar-type distance measuring sub-system, (2) means for using a nozzle as an antenna, (3) signal generating means located in the proximetry of the nozzle for reducing bandwidth requirements and for eliminating ambiguous readings, and (4) electromagnetic wave coupling means overlying the nozzle opening having means for providing an unimpeded flow of gas to the nozzle.

It is another object of the invention to provide a lance system with a distance measuring sub-assembly that avoids the limitations and disadvantages of prior art systems in a relatively simple and reliable manner.

It is another object of the invention to provide a lance system with an electromagnetic wave distance measuring sub-assembly containing a perforated wave guide section for coupling the nozzle to a signal generator means without impeding gas flow.

In accordance with the measuring a lance assembly with an electromagnetic wave sub-assembly for meansuring the spacing of the lance in relation to a reflecting surface comprises a gas carrying lance terminating in a tip having at least one nozzle passage having an exterior opening. The lance assembly includes a transmitter and receiver located in the lance proximate to the nozzle passage. A coupling means is provided for carrying signals to and from said nozzle passage from the transmitter and receiver. The nozzle passage and the nozzle opening act as an antenna. Signal generating and signal processing means are coupled to the transmitter and receiver.

The novel features that are considered characteristic of the invention are set forth in the appended claims; the invention itself, however, both as to its organization and method of operation, together with additional objects and advantages thereof, will best be understood from the following description of a specific embodiment when read in conjunction with the accompanying drawings, in which:

FIG. 1 is a partial cross-section of representation of the lance assembly showing the structural details of the transmitter-receiver, the coupling (transition) means, and the antenna-oxygen nozzle. The nozzle is also shown in a space relationship with respect to a reflecting surface.

FIG. 2 is a schematic representation of a basic oxygen furnace with an oxygen lance in its operating position, and

FIG. 3 is a perforated cylindrical member which forms part of the electromagnetic wave coupling means.

Referring to FIG. 2 of the Drawings, there is shown a schematic representation of a basic oxygen furnace **27** containing a charge **24** with a reflecting surface **26**. A lance **28** is shown in its operational position within the furnace **27**. Typically, a lance is 70 feet long. Oxygen is coupled to the lance via pipe **29**. Cooling water is inserted and removed through pipes **31** and **32**.

A coaxial cable **18** is shown coupling the lance to the signal generator **33** and signal processor **34** in a remote position from the lance. A radiated signal from the nozzle of the lance to the reflecting surface **26** is depicted at **36**.

A signal generator **33** and signal processor **34** are coupled through a coaxial cable **18** to a transmitter-receiver **17** located within the lance (See FIG. 1). A component known as a hybrid acts as a transmitter and receiver. Its process function will be explained hereinafter.

Refer to FIG. 1 of the Drawings. It is a cross-sectional representation of the lower end of a typical basic oxygen lance **10**. The lance is terminated in a tip **11** containing a plurality of nozzle **12** through which a gas,in this case, oxygen, flows at supersonic speeds and impacts through a nozzle opening **23** on the charge **24**.

Gas is supplied to the nozzles **12** by a pipe **16** which is coupled to the oxygen supply pipe **29** previously described in connection with FIG. 2.

A pair of concentric tubes **13** and **14** are coupled to pipes **31** and **32** (FIG. 2) and are provided to supply and remove cooling water from the tip **11**.

Continuing in connection with FIG. 1, the hybrid 17 is coupled to the entrance 22 of one of the nozzles 12 by means of a transition section 19 and a cylindrical section 21. The cylindrical section 21 is perforated and more fully depicted in FIG. 3.

A second perforated section 25 is shown in combination with the other left nozzle 12. This is provided purely for aerodynamic reasons to balance the forces caused by the flow of oxygen. The perforated cylinder 25 forms a part of the electromagnetic distance measuring sub-assembly.

The spacing of the hybrid 17 with reference to the nozzle opening 23 and the distances to be measured from the nozzle opening 23 to the reflecting surface 26 are critical parameters. The distance separating the hybrid 17 and the nozzle opening 23 is designated D_1 in FIG. 1 and 2. The smallest separation to be measured between the nozzle opening 23 and the reflecting surface 26 is designated D_2. The symbol D_3 represents the distance between the smallest distance to be measured by the lance system and the longest distance to be measured. In short, it represents the operating distance variation encountered by the lance.

The distance measuring sub-assembly may be either a short pulsed or a CW system. With regard to the latter, it may be a linear FM–CW system or a sign wave FM–CW system. The foregoing systems are merely preferred for the basic oxygen process but not exclusive. Other conventional radar-type systems may be applicable in basic oxygen or other metallurgical processes employing a lance.

For purposes of this discussion, a linear FM–CW system will be described. The operation of the distance measuring sub-assembly is, briefly, as follows: A linear FM–CW signal is generated in the signal generator 33 and coupled to the hybrid 17 by way of a coaxial cable 18. The hybrid 17 couples the signal to the transitional section 19. The signal passes in sequence through the cylindrical section 21 and the nozzle 12. It becomes a radiated signal 36 (see FIG. 2) after it leaves the nozzle opening 23. The radiated signal 36 impinges on the reflecting surface 26 where a portion of the radiated signal is re-reflected back into the nozzle opening 23, the nozzle 12, the cylindrical section 21 and the transitional section 19 to the hybrid 17. The hybrid assembly 17 may contain a crystal detector (not shown) which converts the signal to an audio signal. In this case, the audio signal leaves the hybrid via cable 18, and is coupled to the signal processor 34 where it is processed to provide a distance measurement.

The detector may be located at the signal processor if a favorable signal-to-noise ratio can be maintained. Where the crystal detector is located in the signal processor, the hybrid 17 functions as follows. A small portion of the transmitted signal is deliberately leaked into the receiver section of hybrid 17 and is carried to the signal processor 34, as is a true received signal. The signal processor 34, more appropriately the detector in the signal processor, operates on the transmitted and received signal to generate the audio signal representing the distance measured.

The signal processing is typically that of a linear FM system. The transmitted signal leaving the hybrid 17 causes a first reflection back through the receiver to the signal processor from the nozzle opening 23. The nozzle opening 23 represents a discontinuity that generates a small reflection signal back to the signal processor 34. This first reflected signal from the nozzle opening 23 represents the reference from which all distances are computed.

The signal returning from the reflecting surface 26, as is typical in all linear FM–CW systems, will generate within the hybrid an audio signal having a frequency different from the audio signal reflected from the nozzle opening 23. The signal reflected may be synthesized in the signal processor, since the distance from the hybrid to the nozzle surface 23 is known and remains fixed. The signal processor computes the distance between the nozzle opening 23 and the reflecting surface 26 on the basis of, or the equivalence of, the difference in frequency between the two reflected signals.

A number of combinations of lances and electromagnetic wave subassemblies were tried and found to be unsatisfactory. For example, the electromagnetic passage was mounted on the top of the lance and the transmitted signal passed to the nozzle by using the center oxygen tube or an additional tube as a wave guide. This was found to be unsatisfactory. A coaxial coupling between an exterior transmitter-receiver and an antenna-oxygen lance proved equally inoperative, as a practical matter.

In each case where the hybrid was mounted outside the lance, a number of distructive problems were noted.

Even when the hybrid 17 was located in the lance, difficulties were encountered until it was determined that the distance from the hybrid 17 to the nozzle opening 23 needed to be less than the shortest distance to be measured, namely D_2.

By using a modulation index for the FM–CW system of a least 200, interference from signals in the low audio frequency range such as amplifier $1/f$ noise microphonics and 60 cycle power line interference was eliminated. An upper value of modulation index of 500 was selected to keep the bandwidth requirements within economic and easily manageable range. The modulation index represents the number of times the transmitter sweeps through the FM frequency band per second.

While it is possible to construct a separate and distinct antenna within the lance oxygen pipe 16 an election was made to use an existing oxygen nozzle 12 as the antenna. Accordingly, it was necessary to provide a coupling for both the electromagnetic wave signals and the passage of oxygen from the center pipe 16 to the nozzle 12.

In this connection a perforated cylinder 21 coupling was designed and utilized in the manner shown in FIGS. 1 and 3. The perforations in the cylinder 21 should be smaller than 0.1 of the wavelength at the operating frequency. The degree of containment of an electromagnetic wave in a perforated cylinder can be estimated in accordance with procedures described by W.W. Mumford in his article on "Some Technical Aspects of Microwave Radiation Hazzards" I.R.E. Proceedings, Vol. 49, February 1961, pp. 445.

The complementary cylinder 25 associated with the second oxygen nozzle passage shown in FIG. 1 is provided for dynamic stability and flow balance and may be eliminated if the perforated cylinder 21 causes no measurable interference with the normal flow of oxygen.

The various features and advantages of the invention are thought to be clear from the foregoing description. Various other features and advantages not specifically enumerated will undoubtedly occur to those versed in the art, as likewise will many variations and modifications of the preferred embodiment illustrated, all of which may be achieved without departing from the spirit and scope of the invention as defined by the following claims.

I claim:

1. A lance assembly with an electromagnetic wave sub-assembly for measuring the spacing of the lance in relation to a reflecting surface of a materials processing charge comprising:

a fluid carrying lance terminating in at least one nozzle having a nozzle opening;

transmitter and receiver means located in the lance proximate said nozzle opening;

coupling means for carrying signals to and from said nozzle from said transmitter and receiver, said nozzle and nozzle opening acting as an antenna; and

signal generating and signal processing means coupled to said transmitter and receiver.

2. A lance assembly as defined in claim 1 in which the distance from said transmitter and receiver to the nozzle opening is D_1 and the distance from said nozzle opening to the reflecting surface is in the range of D_2 to $D_2 + D_3$, where D_1 is smaller than D_2.

3. A lance assembly as defined in claim 1 in which lance is an oxygen lance for a basic oxygen furnace, said transmitter and receiver are located in the oxygen supply pipe, and said antenna is an otherwise conventional oxygen nozzle.

4. A lance assembly as defined in claim 3 in which said coupling overlies the nozzle and includes means for providing unimpeded oxygen flow to said antenna-oxygen nozzle.

5. A lance assembly as defined in claim 4 in which said coupling includes a perforated cylinder interconnecting the oxygen supply pipe and said antenna-oxygen nozzle.

6. A lance as defined in claim 4 in which said transmitter modulation index is 200–500.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,727,897 Dated April 17, 1973

Inventor(s) Robert George Bennett

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

Column 2, line 4, "measuring" should read -- invention, --;

lines 5 and 6, "meansuring" should read

-- measuring --.

Signed and sealed this 8th day of January 1974.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

RENE D. TEGTMEYER
Acting Commissioner of Patents

FORM PO-1050 (10-69)

USCOMM-DC 60376-P69
* U.S. GOVERNMENT PRINTING OFFICE : 1969 O—366-334.

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