

Nov. 21, 1967

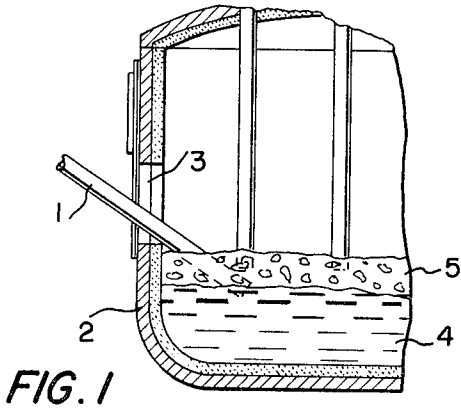
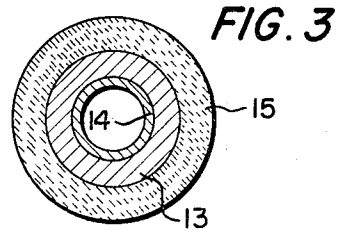
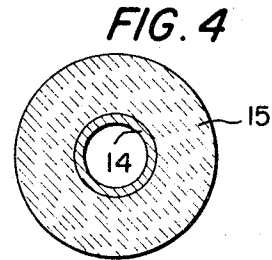
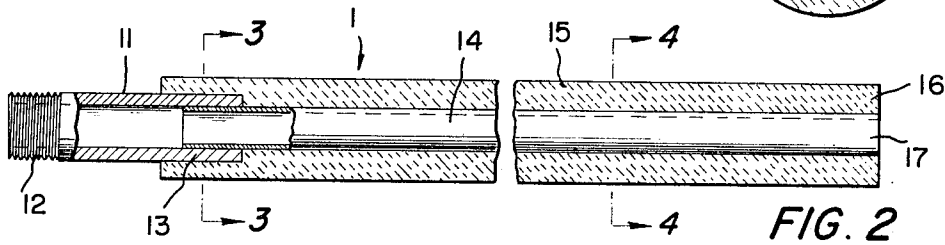
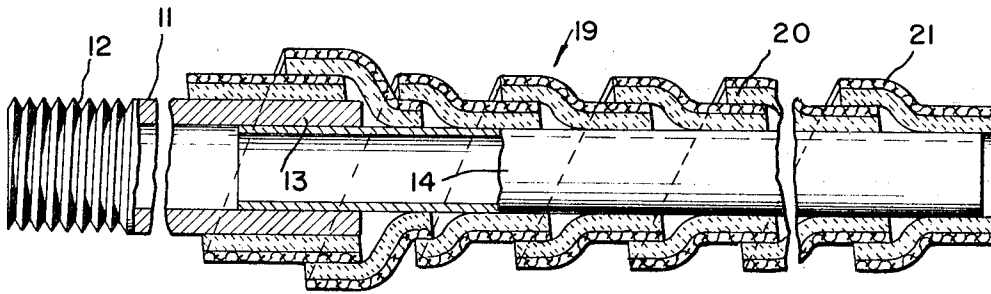
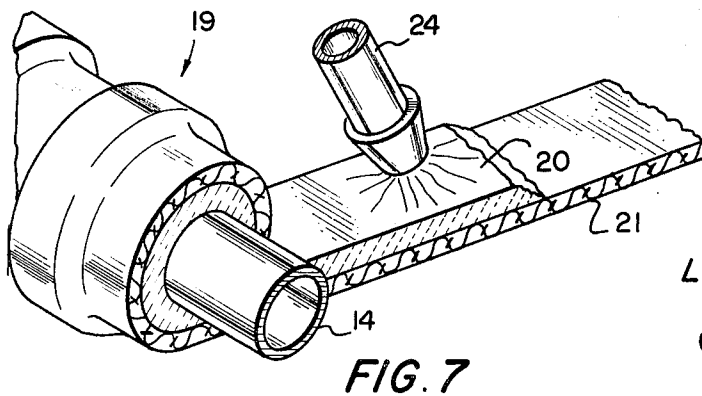
L. E. NORBURN

3,353,808

REFRACTORY COATED OXYGEN LANCE

Filed Feb. 23, 1965

3 Sheets-Sheet 1



INVENTOR
LOUIS E. NORBURN
BY
David W. Tibbott
ATTORNEY

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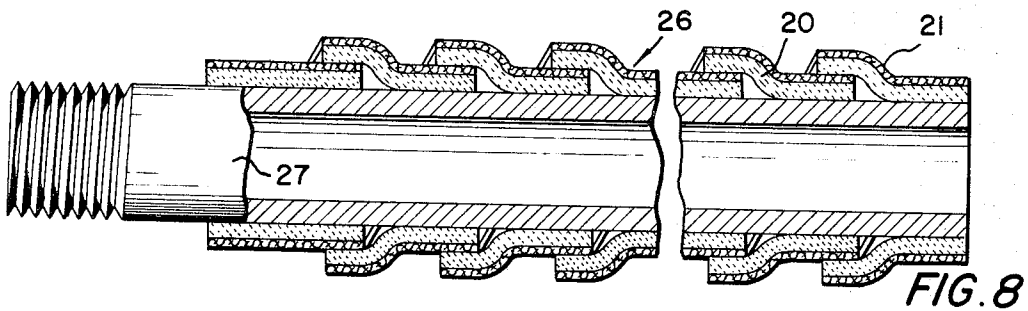
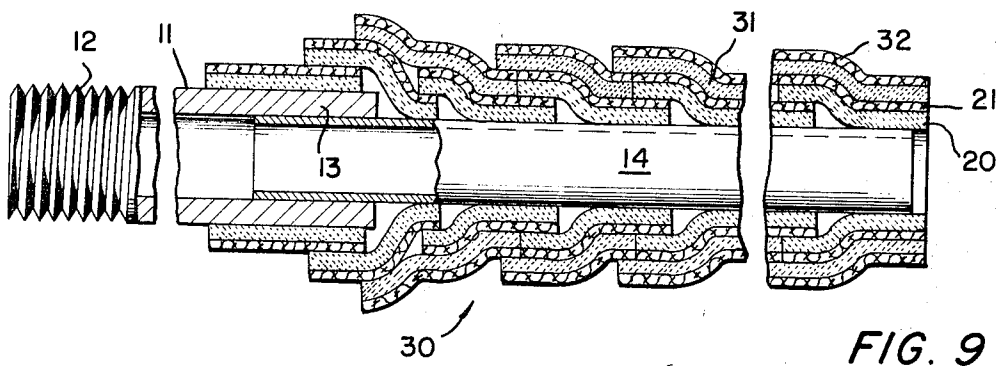
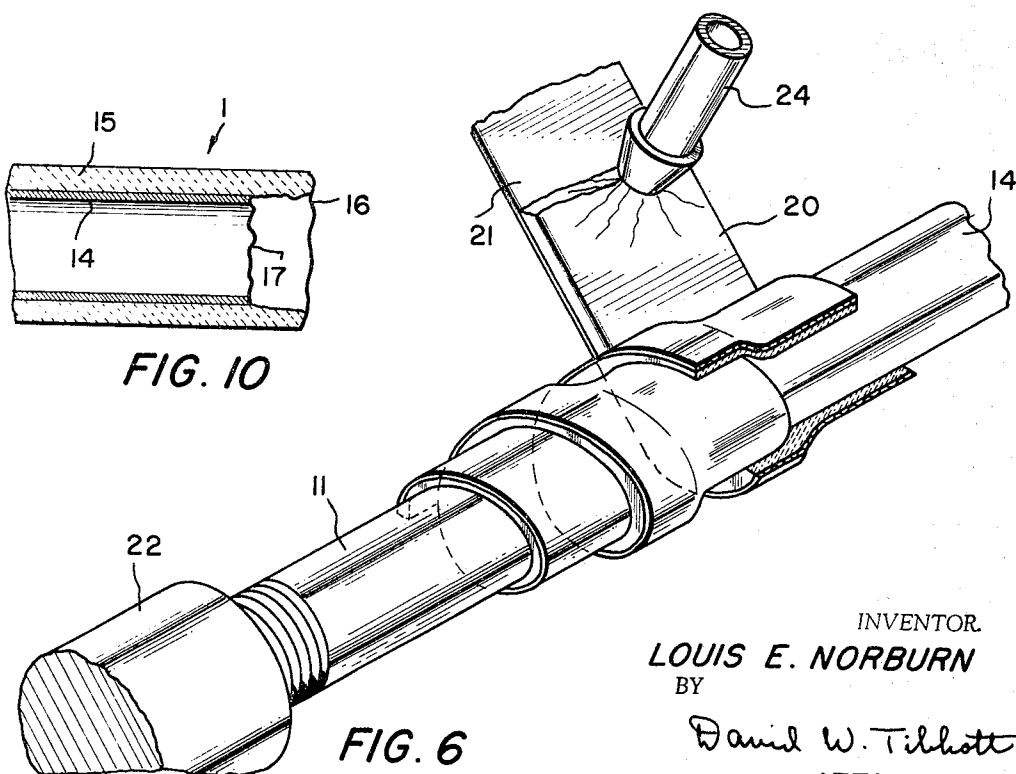
L. E. NORBURN

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3 Sheets-Sheet 2



INVENTOR
LOUIS E. NORBURN
BY

David W. Tibbott
ATTORNEY

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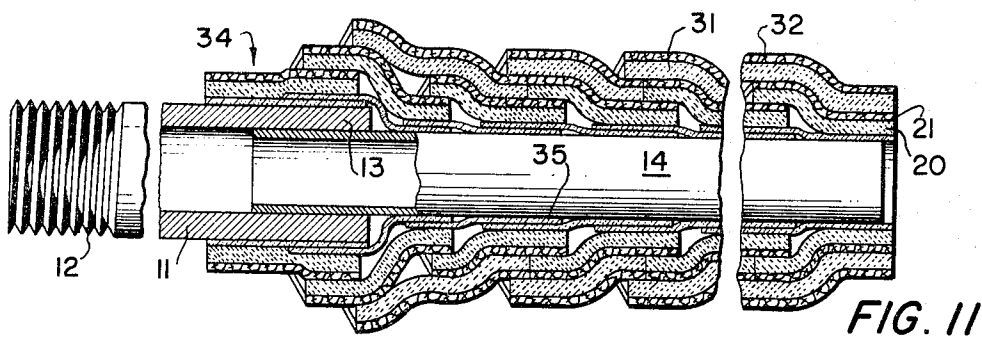
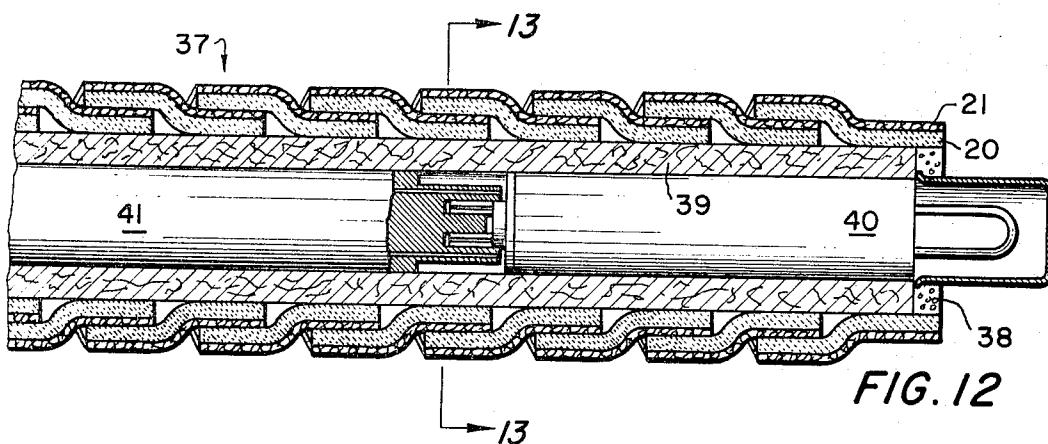
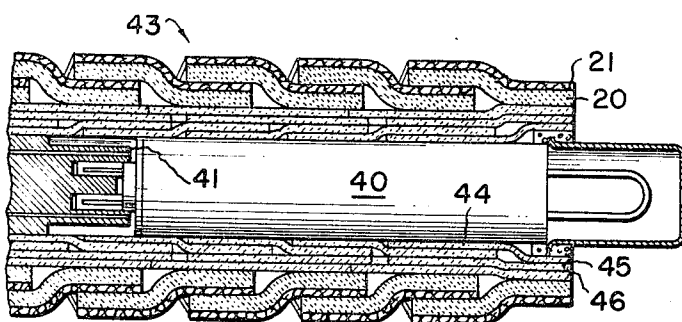
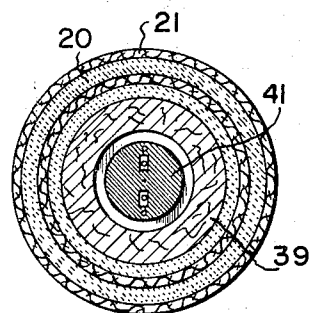
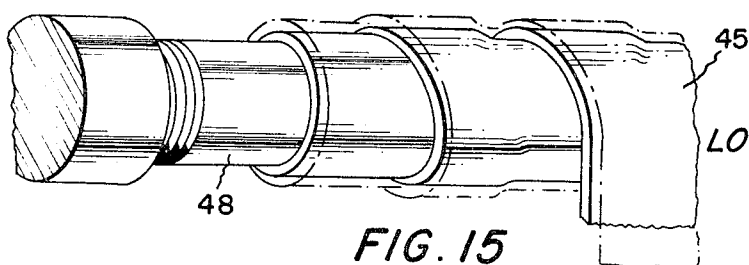
L. E. NORBURN

3,353,808

REFRACTORY COATED OXYGEN LANCE

Filed Feb. 23, 1965

3 Sheets-Sheet 3



INVENTOR
LOUIS E. NORBURN

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3,353,808
REFRACTORY COATED OXYGEN LANCE
Louis E. Norburn, P.O. Box 817,
Danville, Va. 24541
Filed Feb. 23, 1965, Ser. No. 439,498
4 Claims. (Cl. 266—34)

ABSTRACT OF THE DISCLOSURE

A construction of oxygen lance or thermocouple adapted to be inserted into a molten metal bath and including a tubular core covered with a refractory coating. The core can be a short length of thick pipe attached to a longer length of thin wall tubing with the refractory coating reinforcing the tubing to prevent its bending. The refractory coating is either molded around the core or deposited on a flexible strip which is wrapped in spiral overlapping relationship around the core. The core can be covered with a coating of resin impregnated asbestos located beneath the refractory coating.

This application is a continuation-in-part of my patent application, Ser. No. 371,351, filed June 1, 1964. This invention relates generally to the art of steel making and particularly to an elongated tube useful for insertion into a bath of molten metal to serve various purposes, such as injecting gas into the bath or measuring its temperature.

It is conventional to inject oxygen into a molten bath in a steel-making furnace such as an electric arc furnace or an open hearth furnace. In some cases, this is carried out using a water-cooled lance having a nozzle located a short distance above the molten bath so that the lance does not contact the bath. In other cases, the open end of the lance is immersed in the molten bath. When the lance end is immersed in the molten bath, it is subject to very high temperatures and to contact with various corrosive constituents in the bath which cause it to be rapidly eroded. To date, no satisfactory way has been found to prevent this erosion.

Heretofore, lances adapted for immersion in a molten bath have been of several types, all of which are expected to be rapidly eroded or burned away at the immersed end during use. One prior type of lance comprises a plurality of sections of bare black iron pipe attached together end to end. Another type of lance uses sections of black iron pipe with the end section covered with a plurality of molded ceramic rings slipped loosely over the pipe. When bare black iron pipe is used, the pipe is burned up relatively rapidly due to the lack of protection. When ceramic rings are placed on the pipe to protect it, the pipe burns slower but is more difficult to insert into and to remove from the furnace due to the added weight of the ceramic rings at the end of the lance. Furthermore, the ceramic rings cannot be used more than once because they crack and break while cooling after being used in a furnace.

One principal object of this invention is to provide an elongated tube structure that can be used as a lance which substantially overcomes or minimizes the foregoing problems.

Various tube structures have been used in the past to house temperature measuring devices, such as thermocouples, for insertion into molten baths to take the temperature of the bath. Normally, the tube is designed as a removable member since it is partly burned away during a single immersion in the molten bath. The outer tube should offer adequate protection to the temperature measuring device, while in the molten bath, since the temperature measuring device is too expensive to be thrown away after a single use. Conventional tubes used for this purpose do

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not give sufficient protection to their contents so that the temperature measuring devices are often damaged by the molten bath.

Another important object of this invention is to provide an elongated tube structure which can be used to house a temperature measuring apparatus for insertion into a molten bath and which provides adequate protection to the temperature measuring apparatus while in the molten bath.

The invention is described in connection with the accompanying drawings wherein:

FIG. 1 is a fragmentary vertical section schematically representing an electric arc steel-making furnace with an oxygen lance extending through the furnace charging door;

FIG. 2 is an axial section of one embodiment of an oxygen lance;

FIG. 3 is a section taken on line 3—3 of FIG. 2;

FIG. 4 is a section taken on line 4—4 of FIG. 2;

FIG. 5 is an axial section of another embodiment of lance;

FIG. 6 is a fragmentary, perspective view illustrating the wrapping of the lance of FIG. 5;

FIG. 7 is a fragmentary, perspective view taken from another angle illustrating the wrapping of the lance shown in FIG. 5;

FIG. 8 is an axial section of a third embodiment of lance;

FIG. 9 is an axial section of a fourth embodiment of lance;

FIG. 10 is a fragmentary, axial section illustrating the condition or shape of the discharge end of the lance of FIG. 2 after it has become eroded or partly burned away during normal use of the lance;

FIG. 11 is an axial section of a fifth embodiment of lance;

FIG. 12 is a fragmentary axial section of the front end of a temperature measuring tube for use in a steel furnace;

FIG. 13 is a section taken on line 13—13 of FIG. 12;

FIG. 14 is a fragmentary axial section of the front end of a second embodiment of a temperature measuring device; and

FIG. 15 is a fragmentary perspective view illustrating the winding on a mandrel of the core shown in FIG. 14.

The use of an oxygen lance 1 for making steel is illustrated in FIG. 1. The lance 1 is inserted into an electric arc steel furnace 2 through a charging door 3 and disposed with its end immersed in a bath 4 of molten steel. The bath 4 includes a layer 5 of slag floating on top of the bath. Oxygen is fed through the lance 1 at about 100 p.s.i. and discharged from the lance end into the bath 4 below its surface. The oxygen combines with carbon and other undesirable constituents in the bath 4 to form oxides which either pass off as gases or accumulate as slag. Eventually, a sufficient amount of the undesirable constituents are removed or eliminated for the remainder of the bath to comprise the desired type of steel. The main advantage of using the oxygen lance is that it greatly speeds up the steel making process so that the capacity of a furnace can be substantially increased. The same lance can be also used for injecting other materials into a steel furnace, such as powdered lime, graphite, carbon, alloying elements, etc.

The lance 1 illustrated in FIGS. 2 to 4 includes a short rear section 11 of relatively thick black iron pipe having sufficient strength to be used in a steel furnace without bending greatly. The short rear section 11 is threaded on its rear end 12 adapting it to be attached to other sections of pipe (not shown). The lance 1 further includes a long front section of tubing 14 having a relatively thin wall which makes it light in weight. The tubing 14

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is press fitted into the front end 13 of the rear section 11 to attach the two pieces together. Preferably, the front end 13 of the rear section 11 is heated and the rear end of the tubing 14 is inserted into the heated rear section 11 which is then cooled. As the rear section 11 cools, it contracts sufficiently to tightly grip the tubing 14.

As an example, the tubing 14 may be a welded steel tubing having an outside diameter of $\frac{5}{8}$ inch and a wall thickness of about .031 inch. This example tubing will be used with a short length of black iron pipe having an inside diameter of slightly less than $\frac{5}{8}$ inch serving as the short rear section 11. The tubing 14 is so thin that it cannot be satisfactorily threaded. This is the reason for attaching it to the rear section 11 which can be threaded.

A heat-resistant refractory coating 15 is applied over the entire length of tubing 14 and over the front end portion 13 of the rear section 11 holding the tubing 14. Preferably, the coating 15 is molded onto the tubing 14 in intimate contact with the tubing 14 so that there are no spaces or openings between the tubing circumference and the coating 15. The coating 15 can be applied in the form of a mortar which sets or hardens to form the refractory coating 15.

Various materials are on the market today which can be used to form the coating 15. A material useful for this purpose may be one containing high percentages of alumina and silica. Generally, this type of material is referred to as an aluminosilicate base material. As an example, the coating 15 may have a thickness of about $\frac{1}{4}$ inch.

During use of the lance 1, the tubing 14 does not expand outward sufficiently to crack or break the refractory coating 15, such as would be the case if the tubing 14 were as thick as a conventional black iron pipe (having a thickness of about .1 inch). The reason for this appears to be because of the relatively thin wall of the tubing 14. The tubing 14 is sufficiently thin to flex inward as it expands under a temperature rise so that it does not exert a large enough force acting radially outward to crack or damage the coating 15. Longitudinal expansion of the tubing 14 does not seem to create problems. It is believed that the gas flowing through the lance 1 maintains most of the tubing 14 cool, except for its discharge end.

Although the tubing 14 is relatively weak in bending strength, the refractory coating 15 reinforces it sufficiently to resist bending when used within a steel furnace.

When the lance 1 is used in a steel furnace 2, as shown in FIG. 1, with its discharge end 16 immersed within a molten bath 4, its discharge end is subject to very high temperatures (substantially higher than 3000 degrees F.). These temperatures are caused by the combustion taking place around the discharge end 16 as a result of the oxygen being discharged therefrom. In addition, the discharge end 16 is in contact with various highly corrosive constituents in the molten bath 4. These high temperatures and corrosive constituents rapidly burn or corrode away the exposed end portion 17 of the tubing 14.

The remainder of the tubing 14 is cooled by the oxygen passing through it and is protected from the slag or molten bath by the refractory coating 15. Because of being cooled by the oxygen, the end 17 of the tubing 14 stops burning after it is sufficiently burned away for the coating 15 to project ahead of the tubing for a short distance, say one inch. This is illustrated in FIG. 10. Thereafter, the tubing 14 does not burn further until the projecting end of the coating 15 is burned or eroded away sufficiently for the heat and corrosive elements in the molten bath to attack the tubing further. The coating 15 is able to withstand the eroding action of the bath 4 much better than the tubing 14. As a result, the lance 1 lasts longer.

Another advantage provided by the lance 1 is that the coating 15 is intimately attached to the tubing 14 to prevent the molten bath from flowing between the tubing 14 and coating 15. In prior lances, the refractory coating is loosely mounted on the inner pipe so that the molten bath

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can run into the clearance or space between the coating and pipe and burn away the pipe very quickly.

The lance embodiment 19 shown in FIG. 5 differs from the embodiment of FIG. 2 by having a spirally wrapped refractory coating 20 mounted on flexible strips 21. The strips 21 can be paper, cloth, resin impregnated asbestos or other types of materials. An operative example uses strips of brown wrapping paper commonly known as "kraft" paper.

The strip 21 may be about 3 inches wide. A refractory coating material 20 is applied to one face of the strip in the form of a paste or mortar with a thickness of about $\frac{1}{4}$ of an inch. The coated strip 21 is spirally wrapped about the inner portions of the lance 19 in a spirally overlapping relationship with the coating 20 disposed on the inside face of the strip 21. The strip 21 is fastened in place as a result of the hardening of the coating 20.

FIGS. 6 and 7 illustrated one way of applying the spirally wrapped coating 20. The rear section 11 is mounted in a rotating member 22 and the strip 21 is coated with a layer 20 from the nozzle 24 as it is progressively and spirally wrapped about the tubing 14 and front end of the pipe 11. It will be noted that the coated strip 21 is wrapped in overlapping relationship.

The lance embodiment 26 shown in FIG. 8 differs from FIG. 5 by utilizing a core 27 formed entirely from a length of black iron pipe. Black iron pipe can be practically used because of the spiral wrapping technique and the strip 21 which prevents the coating 20 from cracking and falling from the pipe 27 as it thermally expands during use. Although the lance 26 of FIG. 8 operates satisfactorily, it has the disadvantage over the earlier embodiment of being much heavier. This added weight makes it more difficult to handle when being inserted into and removed from a furnace.

The lance embodiment 30 shown in FIG. 9 is the same as that shown in FIG. 5 except that it has an additional spirally wrapped refractory coating 31 applied to a strip 32 similar to the first coating 20. The coating 31 is applied on top of the inner spirally wrapped refractory coating 20. This embodiment is useful where the lance needs a thicker refractory coating than can be applied as a single spirally wrapped coating (a single coating can have a thickness of about $\frac{1}{4}$ of an inch).

The lance embodiment 34 shown in FIG. 11 is similar to that shown in FIG. 9 except that it includes an additional spirally wrapped layer 35 of resin impregnated asbestos tape placed on the tubing 14 prior to the application of the refractory coatings 20 and 31 previously described in connection with the embodiment of FIG. 9. The added use of the resin impregnated asbestos tape layer 35 has been found to be very effective in extending the life of the lance 34 when the lance is used in certain types of steel-making slags having high oxidizing properties. As an example, such slags are usually present when making low alloy steels having a high carbon content.

In an example of the lance 34, the resin impregnated asbestos tape layer 35 was made of a tape manufactured by Raybestos-Manhattan, Inc., Reinforced Plastics Department, Manheim, Pennsylvania. This type is designated R/M Style 41-RPD, type 9600, and is formed of an asbestos felt base impregnated with a phenolic resin. The tape has a thickness of .010 inch and a width of three inches. The tape is wound on the tubing 14 in a manner so that each turn overlaps the previous turn by about one half or 50%. Specifications for this specific tape are found in the Raybestos-Manhattan specification RPD-1041C, dated Apr. 15, 1964. Copies of this specification can be obtained from Raybestos-Manhattan, Inc., Reinforced Plastics Department, Manheim, Pa., and from the Asbestos Textile Institute, P.O. Box 239, Pompton Lakes, N.J. 07442.

A temperature measuring tube 37 is shown in FIGS. 12 and 13. The tube 37 is used by immersing its front

end portion 38 in a molten metal bath to measure the temperature of the molten bath.

The temperature measuring the tube 37 includes an elongate tubular sleeve core 39 which should be composed of a material which is a non-conductor of electricity. As an example, the core 39 may be formed of a strong cardboard. The exterior of the core 39 is covered with a single spirally wrapped refractory coating 20 which is substantially identical to the coating 20 of the lance embodiment 19 shown in FIG. 5. The coating 20 includes the strip 21 explained in connection with FIG. 5.

The contents of the core 39 are conventional and include a temperature measuring thermocouple unit 40 firmly fixed in the front end portion of the core 39 and an elongated connector rod 41 slidably mounted in the core 39. The rod 41 contains conductors running to terminals at the front end of the rod 41 which are detachably connected to the thermocouple unit 40 for transmitting the electrical current of the unit 40 to a temperature indicating device (not shown). Details of the rear end of the rod 41 are not shown as it is conventional. It should be noted that the rod 41 is not a disposable element; hence, the tube 37 should give sufficient protection to the tube 41 to prevent it from being damaged while measuring the temperature of a bath of molten metal.

A second embodiment of temperature measuring device 43 is shown in FIG. 14. The embodiment 43 is identical to the embodiment 37 shown in FIGS. 12 and 13 except that the second embodiment contains a core 44 formed of two layers 45 and 46 of spirally wrapped tape composed of a resin impregnated asbestos material. The layers 45 and 46 may be formed of the same material which is used to form the spirally wrapped layer 35 in FIG. 11. This material is previously described in connection with FIG. 11.

FIG. 15 illustrates how the core 44 may be formed from the resin impregnated asbestos tape. The tape may be spirally wrapped on a rotating mandrel 48 until sufficient layers are wrapped on the mandrel. Thereafter, the wrapped tape is cured while in place on the mandrel using heat and pressure until the core 44 is rigid and self supporting. The steps for curing the resin impregnated tape are well known and therefore are not explained. Thereafter, the refractory coating 20 is applied to the core 44, either while the core 44 remains on the mandrel 48 or after it has been removed from the mandrel. In addition, the refractory coating 20 may be applied over the core 44 before it is cured. If this is done, it is necessary for the core 44 to remain on the mandrel 48 while the refractory coating 20 is applied to it.

Although several embodiments of the invention are illustrated and described, it should be understood that the

invention is not limited to these embodiments, but is measured and limited by the scope of the claims.

Having described my invention, I claim:

1. An oxygen lance having an outlet end adapted to be immersed in a bath of molten steel for injecting oxygen or other gas into the bath, said lance comprising:

a short length of metal pipe having a relatively thick wall having sufficient bending strength to support itself within a steel furnace without bending, said pipe being adapted to be coupled to a gas line for feeding gas to said lance;

an elongated length of metal tubing having a relatively thin wall, relative to said pipe, fixed end-to-end to said pipe and in axial alignment with said pipe, said tubing serving as the outlet end of said lance; and

a heat-resisting insulating refractory coating covering said length of tubing and the end portion of said pipe adjacent to said tubing, said refractory coating being several times as thick as said tubing to reinforce said tubing sufficiently to prevent its bending when the lance is used in a steel furnace and to substantially protect said tubing from the heat of the steel furnace, the other end portion of said pipe being free of said refractory coating for coupling said lance to a gas line;

said tubing being sufficiently thin when expanded by the heat of a steel furnace to yield without breaking said refractory coating and being of an insufficient thickness to be threaded.

2. The lance of claim 1 wherein:

said refractory coating is deposited on a flexible strip which is wrapped in spiral overlapping relationship about said tubing.

3. The lance of claim 1 wherein said tubing is covered by a layer of resin impregnated asbestos underlying said refractory coating.

4. The lance of claim 1 wherein:

said refractory coating is molded around said tubing in intimate contact with said tubing.

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J. SPENCER OVERHOLSER, *Primary Examiner*.

E. MAR, *Assistant Examiner*.