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Jackson

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[54] **SLAG DEPTH INDICATOR**

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[52] **U.S. Cl.** ..... **266/1 R,** 33/126.7 R

[51] **Int. Cl.** **F27d 21/04**

[58] **Field of Search** ... 266/1 R, 34 L, 34 LM, 34 R; 73/DIG. 9, 421; 33/126.7 R, 126.7 A

[56] **References Cited**

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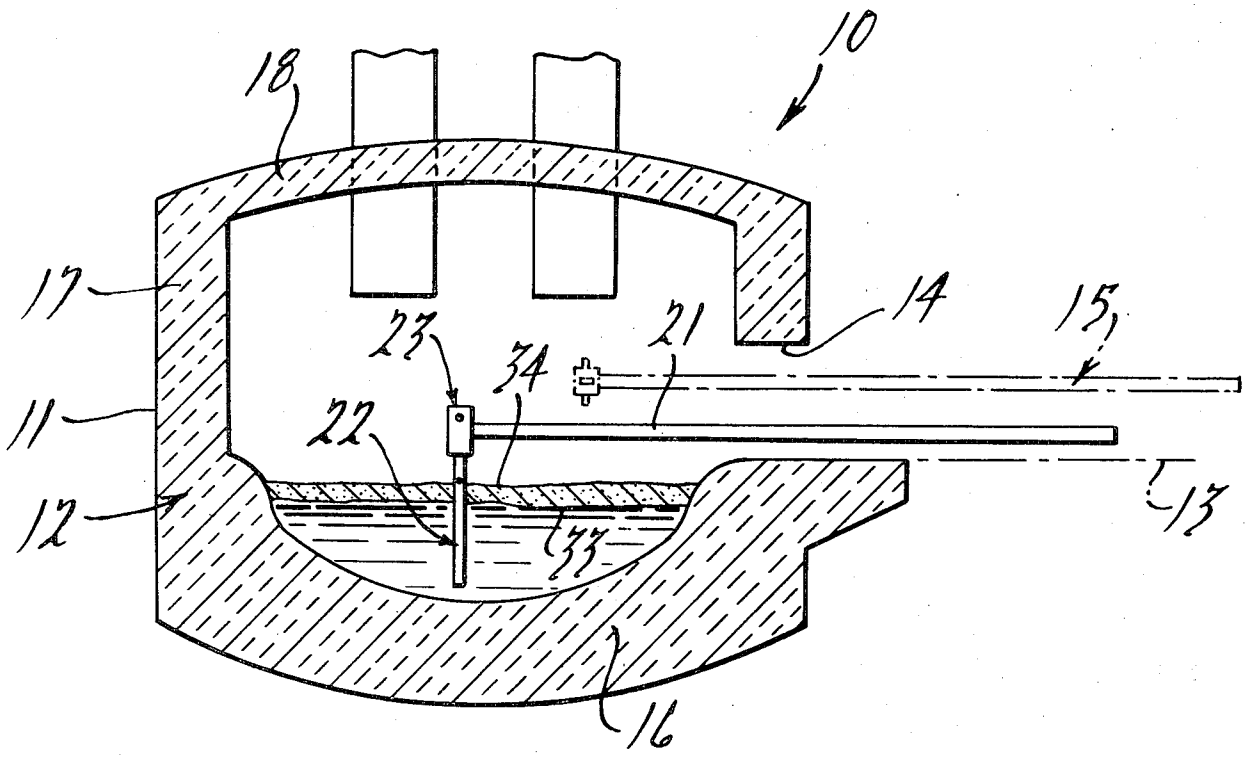
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[57] **ABSTRACT**

An apparatus and method for quickly determining the depth of slag in a furnace or ladle is disclosed. A pyrolytic coating is applied to a metallic lance so that upon immersion through said slag, the lance will be cleanly etched by the metal without hinderance from the slag. Determination of the depth is obtained by measuring between the top of the etched marking and an indicator which is aligned with the top of the slag layer.

8 Claims, 4 Drawing Figures



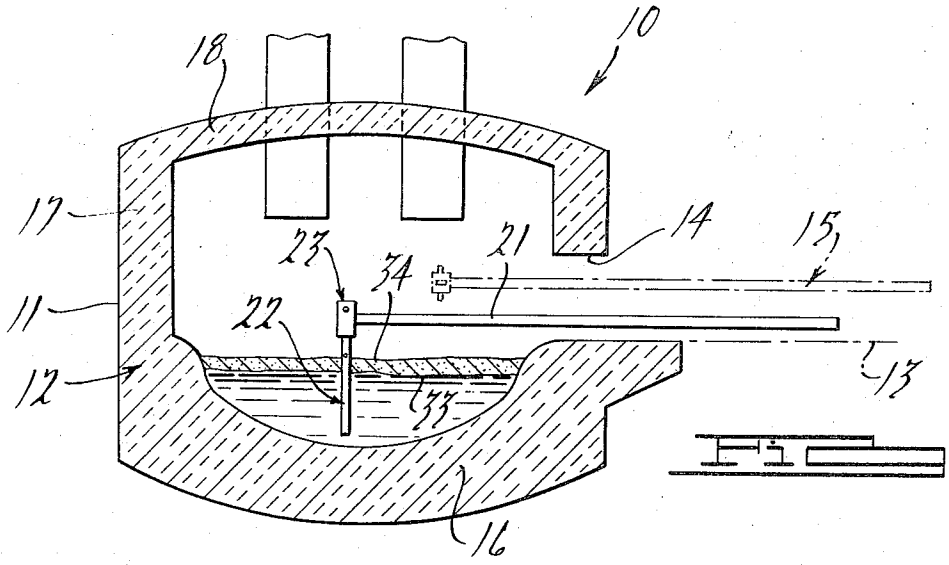


Fig. 1.

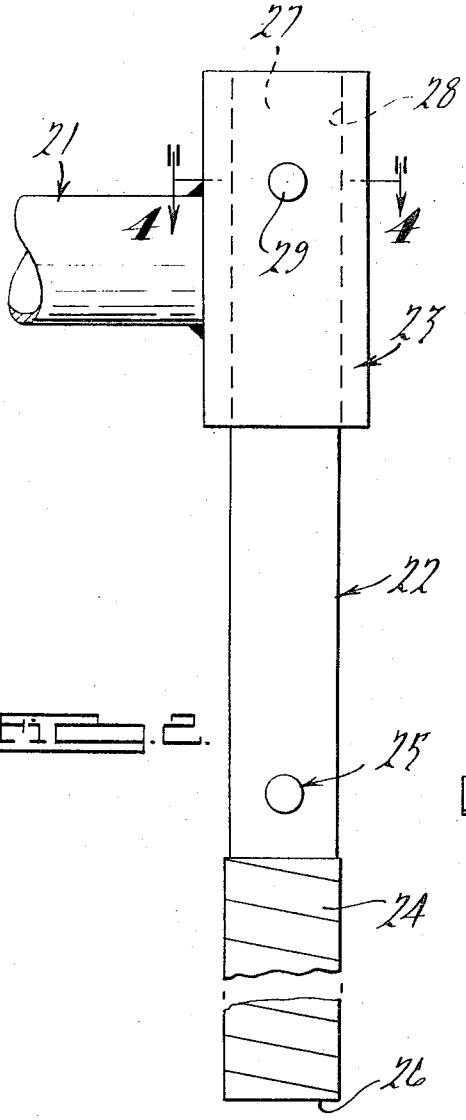


Fig. 2.

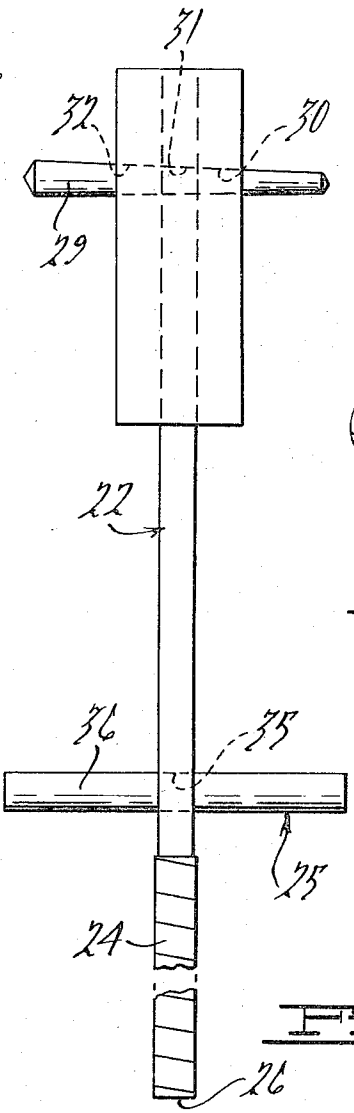


Fig. 3.

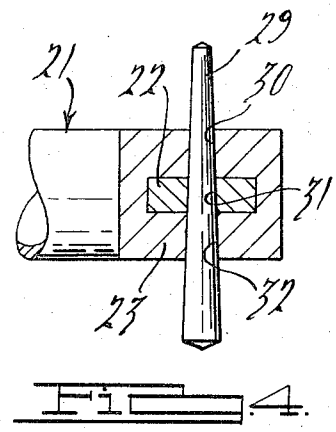


Fig. 4.

SLAG DEPTH INDICATOR

BACKGROUND OF THE INVENTION

One of the continuing problems of operating a melting facility is the need to preserve refractory life over longer periods of use. This is particularly true in connection with furnaces which must maintain high temperature conditions for continuing availability of molten material over extended periods. Some operators typically keep the slag cover in such furnaces relatively thick and heavy according to prior art techniques to preserve the heat content of the molten metal. Other operators may unintentionally maintain a slag depth which is also too great. This has several drawbacks; slag typically contains many chemical components which not only will attack various types of refractory linings used in such furnaces over extended use, but the impurites trapped by the slag may revert to the melt causing an off-target metallurgical make-up. This reversion problem is also common to a slag cover carried in a transfer ladle, the latter being used when charging furnaces with molten metal. It has been found that the insulating qualities of slag do not improve significantly for slag depths beyond about 3 inches in thickness for a typical furnace of vessel. Accordingly, if the slag thickness is highly in excess of three inches, approaching 12 inches or more, the insulating qualities are not improved, and the larger volume of impurities in the slag is available for reversion and the slag can also more readily attack the refractory lining.

Earlier attempts to measure slag depths have been with simple objects passed through the slag layer to permit the slag to freeze thereon offering some hope of demarking its depth. However, upon withdrawal of such objects, it has been noted that the slag material will consistantly chill and freeze about the object while being passed therethrough as well as when held steady, much in the fashion of molten molasses; there will be no discrete line of demarcation between the molten steel level and that of the slag. Accordingly, such approach is incapable of providing a measurement of the slag depth.

SUMMARY OF THE INVENTION

A primary object of this invention is to provide a simple and economical apparatus for accurately indicating the depth of a molten slag layer covering molten metal within a furnace or resting upon a molten charge within a ladle.

Another object of this invention is to provide an apparatus in conformity with the above object which will avoid the problems which will attend the uniform solidification or adherency of the molten slag thereon, while permitting molten metal to etch the apparatus.

Still another object of this invention is to provide a unique method which will permit furnace operators to quickly and manually insert a lance through restrictive openings in present day furnaces and which will allow accurate determination of the slag depth within a period of time no greater than 15 seconds.

SUMMARY OF THE DRAWINGS

FIG. 1 is a schematic view of a typical electric furnace showing the apparatus of this invention in two stages of use;

FIG. 2 is an enlarged elevational view of the apparatus of this invention;

FIG. 3 is an end view of the device shown in FIG. 2; and

FIG. 4 is a top plan view of the device as shown in FIG. 2.

DETAILED DESCRIPTION

Slag is the fused product formed by the action of a flux upon the gangue of an ore or a fuel, or upon the oxidized impurities in a metal. Most importantly, the fuseability, chemical activity, dissolving power and low density of slags, furnishes the means by which they can separate impurities from the metal. In addition, the slags perform other important functions, most importantly serving as a blanket to protect the metal from the action of gases and, since they are a poor conductor of heat, to conserve the heat of the metal.

Turning now to the Figures and first to FIG. 1, there is illustrated a typical or conventional electric arc furnace showing two different stages of operation of using the slag depth indicator of this invention. The furnace **10** comprises a shell structure **11** which is lined with refractory material **12** to a considerable thickness; the shell is a welded steel structure effective to support the refractory material. A sill line **13** represents the bottom portion of the working opening **14**, through which the slag depth indicator **15** may be introduced to the interior of the furnace. Furnace **10** may have other smaller openings, such as for slag removal, metal pouring and measuring purposes. Any one of these openings could feasibly be utilized for introducing the slag depth indicator provided the opening has sufficient width to accommodate the indicator. It will be understood that the electric furnace is chosen only as an example. The dished bottom portion **16** is lined typically with burned magnesite brick covered by a magnesium oxide ramming mix. The side wall lining **17** is typically metal encased direct bonded magnesite-chrome brick and the roof lining **18** is typically high alumina brick. The entire furnace is tiltable so that the furnace portion (above the plane of the drawing) defining a pouring spout may be used to discharge the molten metal. Because the furnace can also be tilted to pour off slag, the electric arc furnace can be operated with slag volumes controlled to a minimum (1–20 percent of the bath weight or may be much less) and the slag composition can be adjusted and controlled quickly by relatively small additions of oxidizing or de-oxidizing materials. Therefore, the steel may be treated by a succession of different slags. Electrodes **19** depend through the furnace roof and are mechanically lowered for operating.

The slag depth indicator **15** consists of a support means **21**, a dependent lance **22** removably carried on the support means by a journal **23**. A pyrolytic material **24** is applied as a thin wrapping or coating about the lance extending from a location determined by indicator means **25** to the bottom or outer extremity **26** of the lance.

The support means **21** may comprise a suitable beam or tubular bar in sufficient length to permit the dependent lance to be supported over and thence lowered through the slag layer while the operator or operating mechanism is comfortably located adjacent the exterior of the electric furnace. This may required a support mean length of at least 10 feet or more.

When working with molten steel or cast iron, the lance should consist of a flat-faced bar or member which is particularly constituted of ferrous material, such as **1010** or **1008** plain carbon steel. The lance must be adapted to be discarded after a single use; therefore, one end **27** is arranged to be quickly fitted and snugly journalled within the opening **28** of journal **23.** A mechanically tapered pin **29** is adapted to be quickly inserted and wedged against the walls defining aligned openings **30, 31** and **32** in the lance end and journal, or in some cases a bolt and wing nut may be used for this assembly. The lance should have sufficient length to penetrate through the anticipated maximum depth of slag, which in some cases may be as much as **18** inches thick. A suitable length for use in furnaces would be about 24 inches; for use in ladles, considerably longer lengths may be required. The cross sectional configuration may be approximately one-fourth inch by three-fourths inch and constituted of typical **1008** plain carbon steel.

An important element of the apparatus is the use of the pyrolytic material **24** or equivalent material that will volatize upon contact with the heated slag; an electric arc furnace slag may have a temperature in excess of 3,000°F, it will be low in specific gravity and be poor in thermal conductivity. A convenient stock material that can be utilized for the pyrolytic material is conventional masking tape which typically is comprised of impregnated paper coated with adhesive. The masking tape may be wrapped about the lance from the indicator means **25** to the extremity **26.** A single wrapping may be feasible, but two layers would be desirable. Other equivalent materials may comprise varnish, bituminous paint or tar, each applied as paintable material.

The purpose of the pyrolytic material is to provide an anti-adherent with respect to the slag as the lance penetrates therethrough to reach the metal. Molten metal will have little difficulty in penetrating the material **24** to etch the metal and thereby provide a clean demarcation of the bottom level **33** of the slag **34.** The material **24** need only operate as an anti-adherent during a period of a few second in which the lance is immersed through the slag. Should longer periods of immersion be required, then a material must be selected which will maintain anti-adherency of the slag over such longer period. Without the use of the material **24,** the slag will have a definite tendency to wet whatever object is passed therethrough and coat indiscriminately during all movements in and out; a clean line of demarcation is not obtainable as to either the top or bottom level of the slag.

Ordinarily, slag will attach to the coated lance after pyrolysis of the material **24.** This slag can be easily and conveniently knocked off after withdrawal of the indicator from the furnace leaving a clean indication of the upper surface of the metal.

To obtain a reference as to the top level of the slag **34,** indicator means **25** is employed. It consists of a steel pin **36** rigidly fitted in an opening **35** of the lance to extend transversely thereof. The lance is lowered by the operator to align the pin **36** in contact with the upper surface of the slag and thereby provide a reference for making depth measurements. In cases where measurements are being made in ladles having the top surface of the slag well down from the rim of the ladles, pin **36** may be located at a considerable distance from journal **23.**

Method Of Determining Slag Depth

A useful and preferred method of determining slag depth in any furnace or ladle having significant slag volumes, the following should be undertaken:

a. Prepare an apparatus having a support means with a lance depending from one end thereof, the lance being releasably secured within the end of the support means for being discarded and replaced after one use. The dependent lance should have a generally flat-faced cross-section so that an easily observable line of demarcation of the metal surface may be determined; the other dimension of the lance may be relatively thin to facilitate reduction in weight as well as ease the penetration of the slag. The lance must have an indicator for visual alignment in contact with the slag top surface and have a pyrolytic coating on the lance from the indicator to the extremity.

b. The support means and lance is introduced through a furnace or ladle opening above the slag and metal with the dependent lance and support means generally aligned in a common plane parallel to the surface of the slag (see position A of FIG. **1**). After the dependent lance is in an appropriate position over the slag for making a depth measurement, the support means is twisted so that the dependent lance is aligned generally vertically for penetrating through the slag (see position B of FIG. **1**). The support means is lowered to align the indicator with the slag top. Even if the dependent lance is slightly askew with respect to a vertical line, an appropriately accurate reading will be obtained since the flat face of the lance will have an etched line angled with respect to the lance still allowing for measurement. The dependent lance is held immersed in the slag and hot metal for a period of between five and ten seconds and then raised, twisted to the horizontal plane again and withdrawn from the furnace.

c. Slag is knocked from the dependent lance and a determination is made by measuring between the etched marking on the lance and the indicator means.

I claim as my invention:

1. Apparatus for determining slag depth in a vessel, comprising:

a. a lance having sufficient length to extend above, through and below the most extreme slag condition anticipated for said vessel,

b. support means for controllably positioning said lance over said slag and for permitting said lance to be inserted through said slag while said support means remains above said slag,

c. indicator means of said lance for permitting alignment of a predetermined location on said lance in contact with the exposed surface of said slag, and

d. coating means on and along substantially the entire length of said lance, said coating being effective to pyrolyze upon contact with said molten slag.

2. The instrument as in claim **1,** in which said lance is substantially constituted of plain carbon steel.

3. The instrument as in claim **1,** in which said pyrolyzible coating for said lance is comprised substantially of impregnated paper having a layer of adhesive for joining said paper to said lance.

4. The instrument as in claim 1, in which the support means has a joint for replaceably holding said lance in a direction transverse to said support means.

5. The instrument as in claim 4, in which said replaceable journal comprises a sleeve having an opening for snugly receiving said lance therethrough, said journal also having aligned openings with similar openings in said lance whereby a tapered pin may be inserted therethrough for releaseably holding said lance locked in said sleeve.

6. A method for determining the depth of molten slag in a vessel, comprising:

a. providing a lance of sufficient length to penetrate the intended slag layer in the furnace, said lance being provided with a pyrolytic coating substantially throughout the length of said lance and an indicator at one end of the lance,

b. while releaseably supporting said lance at the end of a beam, insert said lance and beam through the furnace door with the lance and beam in a common horizontal plane, upon reaching a centralized position over said slag the beam is rotated to bring the lance into a perpendicular position so that it may be lowered to penetrate through said slag, thence lowering the lance through the slag while aligning said indicator in contact with the upper surface of the slag,

c. holding said lance in said lowered position for a period of time between 5–10 seconds,

d. raising said lance and rotating said lance to return to the horizontal place and thence withdrawing said lance from the furnace, and

e. releasing said lance from the beam and analyzing the displaced lance to note where molten metal has etched the lance, and measuring the distance from the top of said etching point to said indicator for rendering a measurement of the slag depth.

7. The method as in claim 6, in which the pyrolytic material is comprised of an adherent paper tape impregnated with said tape being applied to the exterior of said lance throughout substantially its entire length.

8. The method as in claim 6, in which the pyrolytic material is an organic coating selected from the group consisting of varnish, tar bituminous paint.

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