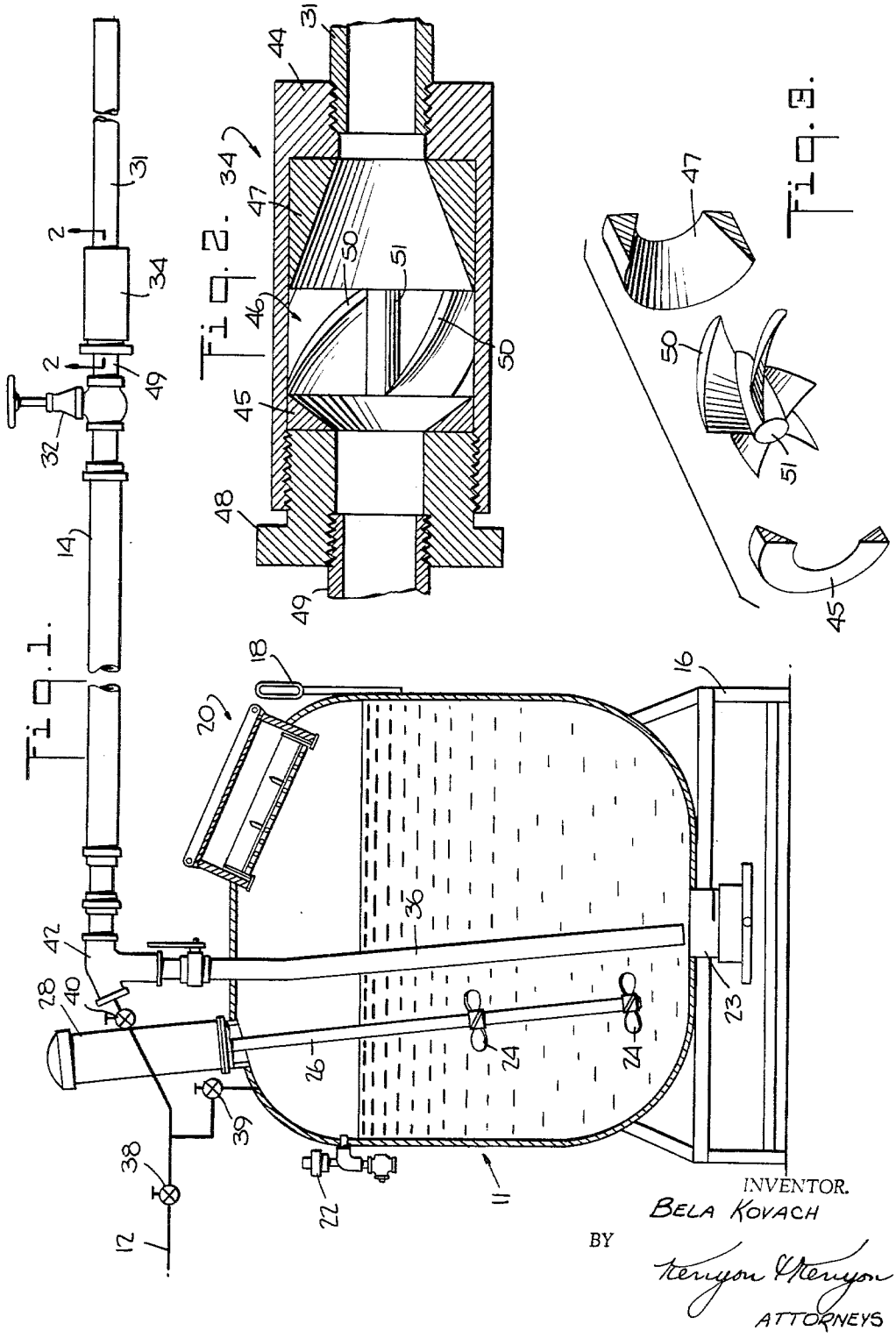
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APPARATUS FOR PROTECTING REFRACTORY LININGS

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APPARATUS FOR PROTECTING REFRACTORY LININGS

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In general, this invention is concerned with an improved method and associated apparatus for spraying a protective coating on the refractory lining of furnaces while the furnace is in operation.

The refractory lining of furnaces, such as the open hearth electric and basic oxygen furnaces used in melting steel, are exposed to severe operating conditions. With the extensive use of oxygen, higher temperatures are now employed in the process of melting steel and there are also sudden changes of temperature which require that the refractory linings withstand severe thermal shocks. In addition, the linings are attacked by iron oxide fumes as well as the iron and lime deposits which are thrown up on the lining. As a result of these more severe operating conditions, the lining deteriorates faster, such deterioration taking the form of fluxing, peeling, spalling and burning.

To preserve the lining, it is standard to spray it with a refractory-cement coat. This cement coat is sprayed directly onto the hot face of the walls and roof of the furnace while the furnace is in operation. Because of the high operating temperatures, the cement, when it hits the furnace walls, sinters and bonds to the lining, thereby building up the lining.

A wide variety of refractory cements are used for this purpose, however most cements contain chrome ore or chrome and magnesite ores (chrome oxides and magnesium oxides). These ores are ground to a powder consistency and are mixed with certain additives to assure proper adhesion and bonding to the furnace lining. Sodium silicate is the additive normally employed for bonding. These oxides plus the sodium silicate are mixed with water to form a slurry which slurry is then sprayed upon the hot face of the furnace wall to build up the protective coat.

In this prior art technique, the ingredients are mixed in a special mixing unit with water and hot steam for about an hour. The mixing takes as long as one hour in order to insure that the bonding agent, the sodium silicate, is properly dissolved in the water.

In emergency cases, when the molten steel threatens to break through the eroded areas of the lining, very often there was no spray material immediately available (due to the required one hour mixing time) and the furnace had to be taken off for rebuilding or repair. This constituted heavy loss in production and expensive repair cost.

In practice, the ingredients (the sodium silicate as well as the ores) are premixed in dry form and shipped to the steel mill in paper bags. In the steel mill, this dry mix is in turn mixed with water to form a slurry. Heavy and expensive mixing equipment is required and such equipment is generally installed in the open-hearth floor far away from the furnaces.

After the cement has been mixed with the water in the mixer, the resulting slurry is dumped into a spray gun. The gun is then transported by crane or forklift truck to the furnaces. Air under pressure is fed into the spray gun to force the slurry out of the gun, through a material hose and into the operating furnace where it is sprayed on the walls of the furnace to form the desired protective coating.

There are a number of problems which arise in connection with this prior art procedure. The major, but certainly not the only, consequence of these problems is that a large amount of the slurry fails to adhere to the furnace wall resulting in what is called "rebound loss." This rebound loss increases the cost of the spray operating and causes some contamination of the molten metal being processed in the furnace. Any decrease in, or elimination of rebound loss will result in an improved protective coating and efficiency of spraying.

After the mixed slurry has been dumped into the spray gun, if there is any delay in the actual spraying, the refractory cements will start to harden, to settle and to separate. The critical time period is less than ½ hour. As a consequence, there is lack of uniformity in the mix and uneven flow of the material. At times, the gun will be jammed. Where the hardening has not gone so far as to jam the gun, what occurs is that at the beginning of the spraying the flow is of dense heavy mix from the bottom of the gun. Near the end of the spraying there is mostly water from the top of the batch. This very weak mix and liquid which is sprayed, near the end of such an operation, can do more damage to the hot wall of the furnace than good.

A further separation of refractory cement from liquid occurs in the long hose that leads from the spray gun to the furnace opening. The heavy material tends to run at the bottom of the hose while the lighter fraction (liquid and air) tends to run faster on top of the heavier material. The slower running heavier slurry at the bottom of the hose is thus insufficiently atomized at the hose outlet and consequently does not properly sinter and bond to the furnace wall.

As a consequence of the separation within the gun and of the separation in the long hose, as much as 30% to 50% of the cement will be lost in rebound loss. This is not only uneconomic in terms of refractory cement material but also creates a contamination problem for the steel, and particularly for alloys, being manufactured.

For the sintering and bonding process to operate properly so that there will be a minimum of rebound loss, it is necessary that the cement ores be finely mixed throughout the slurry so that each particle is thoroughly exposed to the high heat of the furnace, which exposure is required for proper sintering and bonding.

In brief, this invention involves a new approach towards the preparation and application of protective coatings to the refractory lining of furnaces. This new method calls for a preliminary mixing of the bonding material with sufficient water so as to dissolve the bonding material. This premixed bonding agent can then be readily mixed with the protective coating powders. Because the mixing may be more readily done (5–10 minutes as contrasted with 1 hour) it becomes possible to have the mixing occur in the gun which is used to spray the protective coating on the furnace walls. Accordingly, this invention also provides an improved gun which includes an agitator so that the final material may be mixed in the gun before spraying. The agitator has the further advantage that it prevents the protective powders from settling out of the mixed material during the time it takes to use up a single charge for the gun. In this fashion, the combination of a partial premixing of binder with water and the use of an agitator within the pressure gun provides a more uniform, better mixed spray which flows more evenly and which makes it possible to greatly increase the efficiency of use of the spray materials.

This invention further provides a small nozzle pipe mixer attached to the steel pipe nozzle near the end of the spraying hose so that the advantages gained by the partial premixing of bonding material and the use of an agitator are not partially lost through the settling out of the protective material during travel from the gun through

the spraying hose to the exit nozzle from the spraying hose.

Other objects and purposes of this invention will become apparent from a consideration of the following drawings and detailed description, in which:

FIG. 1 is a partially broken away mechanical schematic of the apparatus involved in this invention;

FIG. 2 is a longitudinal cross section of the novel nozzle pipe mixer employed in this invention; and

FIG. 3 is an isometric view of the mixer of FIG. 2.

FIG. 1 illustrates the container or vessel of a spray gun **11** which in many respects is similar to the prior art spray gun but which has been modified in certain respects for use in this invention. To this gun **11** there is connected a main air supply line **12** and a long hose **14** for spraying the inside of the furnace walls with the slurry from which the refractory cement coat is formed.

The gun **11** itself is mounted on a frame **16**, which frame **16** is designed so that the gun may be carried by or maintained on a forklift truck. Alternatively, the gun may be transported by means of a crane and chain which lifts the spray gun **11** by the eyes **18**. The opening **20** that is shown is used to feed a charge of powdered ores and additives together with the specially prepared concentrated sodium silicate liquid. The opening **20** is simply adapted from the prior art guns where such an opening is a manhole provided for the purpose of cleaning out the spray gun. A standard water feed and overflow **22** is shown, which water feed includes a water meter, for the purpose of adding a measured amount of water to the charge that is added through the opening **20**. A plug **23** which is shown at the base of the gun **11** is also used for cleaning purposes.

More important to the particular operation of this invention is the inclusion of a means for mixing the material, the agent and water while in the spray gun **11**. The mixing means illustrated involves two propellers **24** which are mounted on a shaft **26** in such a fashion that they can be adjusted longitudinally along that shaft **26**. A motor **28** drives the shaft **26** through a speed reducer **29**. To obtain maximum efficiency of mixing, it has been found preferable to maintain the propeller shaft **26** at an angle somewhere between 30 and 35° to the vertical. Two propellers **24** are shown as it has been found that two propellers provide adequate mixing in the standard size spray gun **11**. In one preferred embodiment each propeller has a tip to tip span of approximately eight inches.

As may be seen in FIG. 1, the agitation provided by the propellers **24** and shaft **26** avoids one of the major problems in the prior art. That problem arose out of the settling and separation of the solids in the slurry which settling becomes significant as a problem in about ten minutes after the gun is loaded. Because of the settling, the initial flow from the gun is of a dense heavy mix from the bottom of the gun and the final flow of slurry is excessively liquid. The excessively liquid slurry frequently does more damage to the hot wall of a furnace than good. Since the settling and separation of the material starts to take place in about ten minutes after the mixing is completed, any delay in the use of the gun results in some undesirable separation unless the agitation provided by this invention is present.

The hose **14** is made of a flexible material and generally runs 40 to 50 feet long. At the end of the hose **14** a rigid metal pipe nozzle **31** is attached. This nozzle **31** generally runs between 12 and 16 feet in length and is the portion of the equipment that projects into the furnace which is to be sprayed. Between the nozzle **31** and the hose **14** there is a standard valve **32**. There is added by this invention a mixer pipe assembly **34** between the valve **32** and the pipe nozzle **31**. The purpose of this mixer assembly **34** is to mix the slurry after it is passed through the rather long hose **14** and thus after the solids have had a chance to partially separate out. The mixer assembly **34** is illustrated in greater detail in FIGS. 2 and 3 and

described below in connection with those two figures. The major point to be made here is that such a mixer assembly **34** is one of the improvements added by this invention to assure that the slurry which is sprayed from the pipe nozzle has an appropriate uniform atomized consistency in which the particles of ore or cement are carried in fine suspension so that they will properly bond to the furnace wall on which they are sprayed.

The spray gun **11** end of the flexible hose **14** is connected to a discharge pipe **36** which extends to near the bottom of the gun **11**. When the slurry has been properly mixed in the gun **11** and the air valves **38** and **39** are opened, compressed air with a pressure of approximately 80 to 100 p.s.i. is fed into the top of the gun **11** and forces the mixed slurry up through the discharge pipe **36** and into the material hose **14**. An additional opening at the T-shaped elbow **42** permits a portion of the compressed "jet" air to be directly fed into the hose **14**, when the jet air valve **40** is turned on, so as to enhance the flow of slurry down the hose **14** and pipe nozzle **31**.

As the slurry passes down the long hose **14** there is a tendency for the solids to settle out to the bottom of the hose and for the air and water to run ahead faster on top of the denser material that is settled down. As a consequence of this settling, the material that is sprayed from the pipe nozzle is inadequately atomized. This invention adds a nozzle pipe mixer assembly **34**. As may be seen in FIG. 2, the nozzle mixer assembly **34** constitutes a sleeve **44** in which there is contained a diverging cone **45**, a mixer unit **46** and a converging cone **47**. The sleeve **44** is screwed onto a connector **48** so that the interior units **45**, **46** and **47** are held tightly within the sleeve **44**.

The connector **48**, in turn, is screwed onto a pipe nipple **49** on which the valve **32** operates and which leads to the flexible hose **14**. The outlet portion of the sleeve **44** is screwed onto the pipe nozzle **31** as shown in FIG. 2. Thus slurry under high pressure is fed through the diverging cone **45** into the mixer **46** where the stationary blades **50** cause the slurry to swirl around sufficiently to provide an even mix. The slurry then proceeds through the converging cone **47** into the pipe nozzle **31** and then into the furnace where it is sprayed onto the furnace walls in a properly atomized and properly distributed form.

The mixer unit **46** has a number of curved blades **50** which are mounted on a hub **51** (see also FIG. 3). The hub **51** and blades **50** cause the effective cross sectional area of the mixer unit **46** to be less than the required cross sectional area of the spray pipe and thus the inner diameter of the mixer unit **46** is made sufficiently larger than the diameter of the hose **14** or pipe nozzle **31** so that the effective open cross sectional area of the mixer **46** is equal to the cross sectional area of the hose **14** (and of the pipe nozzle **31**). Accordingly, the diverging cone **45** and converging cone **47** are provided so that there will be a controlled and relatively even flow of slurry through the mixer assembly **34** in spite of the restrictions.

With reference to the spray gun **11** and associated items described above, the spraying method of this invention can be described as follows. All the solids, except the sodium silicate, that are required for the appropriate slurry are mixed together in powder form. The important operative solids are chrome oxides and magnesium oxides which are generally referred to as chrome ore and magnesite ore and are broadly referred to as the cement ores. In this fashion a dry powder is obtained which can be packaged as such for direct loading into the gun **11**.

In addition there is separately packaged a mixture of sodium silicate with just enough water so as to dissolve the sodium silicate. The amount of water used to dissolve the desired quantity of sodium silicate is to some extent a matter of choice but economy in shipment costs dictates that as little water as possible be used and the purpose of this invention which is to provide a ready mix in the spray gun **11** dictates that as much water as is necessary to dissolve the sodium silicate is used.

The sodium silicate that is thoroughly pre-mixed with

a minimum amount of water necessary to dissolve it forms a sodium silicate liquid concentrate which can be shipped in plastic containers to the furnace site, along with the dry cement in separate paper bags, from whatever plant or source manufactured the furnace coating material.

This dissolved sodium silicate is then also loaded into the gun **11** through the opening **20**. The rest of the water needed to make the appropriate slurry is then added through the water feed **22** or charge opening **20**, while the motor **28** is turned on to assure a proper mixing of the water, dissolved sodium silicate and dry powder cement mix.

In preparing the slurry in the spray gun **11**, the sodium silicate liquid concentrate is added to the total amount of additional water required for the spray mix. The additional amount of water required is approximately three to four times as much as is present in the concentrate. After the sodium silicate concentrate has been properly diluted, the dry cement mix is added to the solution and agitated for approximately five to ten minutes, after which time the slurry is ready for spraying.

There is accordingly a considerable time saving over the one hour mixing time required by the prior art method, which prior art method involved having to mix and dissolve the sodium silicate and the refractory cements in dry form, on the job site. In addition, since it becomes possible to mix the materials inside the gun **11**, it becomes possible to eliminate the need for the heavy and expensive mixing machinery that was hitherto required and the necessity of using hot steam for the dissolving of sodium silicate. Economy of time and in the use of equipment thus become major advantages of the method taught by this invention.

One advantage obtained by the teachings of this invention is that the spray gun **11** does not have to be transported between the mixing equipment and the furnace for loading and for use. Thus the cranes which are frequently used for transporting the spray gun need not be diverted from their normal use in loading the furnace. In this fashion, there is an additional facet to the speeding up of the operation of the steel mill.

What is claimed is:

A spray gun assembly for spraying a slurry of refractory cement on the inner walls of an operating refractory furnace, said assembly comprising in combination with:

a spray gun container, having an opening for receiving a charge,

a main air supply line connected with said container,

a water and overflow feed connected with said container,

a plug closing an opening at the base of said container,

a shaft extending through another opening at the top of said container substantially close to the bottom thereof, said shaft extending at an angle of substantially 30° to 35° to the vertical,

two propellers mounted upon said shaft and rotatable therewith, said propellers being longitudinally adjustable upon said shaft,

a valve member located outside of said container,

means opening and closing said valve member,

a pipe connecting said air supply line with said valve member,

a valve carried by said pipe,

a discharge pipe connected to said valve member and extending through a further opening at the top of said container substantially close to the bottom thereof,

a hose having one end connected to said valve member, and

an elongated pipe nozzle,

a mixer assembly comprising a sleeve,

means connecting one end of said sleeve with said hose, said pipe nozzle being connected with the other end of said sleeve,

a diverging cone located within said sleeve adjacent the last-mentioned means,

a converging cone located within said sleeve adjacent said pipe nozzle,

and a mixer unit located within said sleeve between said cones and consisting of

a plurality of curved blades, and

a hub carrying said blades.

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