This invention is directed to a novel refractory slurry mixer and applicator for use in the repair, maintenance and relining of high temperature furnaces, such as open hearth furnaces, Kaldor and Linz-Donowitz furnaces and the like. These furnaces are lined with refractory bricks, panels or slabs which are composed of silica, chrome ore, magnesia or combinations of chrome ore and magnesia etc. Notwithstanding the high refractoriness of these materials, they (unless protected) will deteriorate under the furnace heat and other conditions and necessitate the rebuilding of the furnace linings.

It has heretofore been proposed, as a means of protecting the furnace linings against such deterioration, to apply to the surfaces of the linings while the furnaces are in operation a coating composition composed of a highly refractory material in slurry form. One such coating composition, consisting primarily of chrome ore combined with a suspension agent, a binding agent and a wetting agent, is disclosed in the Murphy and Dermon Patent No. 2,809,126, dated October 8, 1957; another coating composition, consisting of chrome ore and magnesia, with chrome ore predominating, along with a suspension, binding and dispersion agent, is disclosed in the Demaison and Dreyfing Patent No. 3,093,496, dated June 11, 1963; and still another coating composition, consisting of chrome ore and magnesia with magnesia predominating, along with suitable suspension, binding and wetting agents, is disclosed in the Demaison Patent No. 3,093,497, dated June 11, 1963. These three coating compositions are eminently suited to be sprayed onto furnace roofs to form a protective coating thereon.

Another composition, which may be used for repairing the walls and forming the tap holes of open hearth furnaces, is one which consists almost entirely of magnesia with suitable binders and is known in the art as "Gunitite."

Still other refractory materials, which may be used for making repairs or replacements of linings, are well known to the art and may consist of different combinations of refractory materials such as the well known products marketed under the names of Insulag, Panelag, Insulcrete, Hearthcrete, etc.

The choice of these materials may vary according to the type of furnace requiring repair or rebuilding and the type of linings being used therein, and the nature of the refractory materials used, along with the other ingredients employed in making up the composition, likewise may vary in order to be compatible with the lining and stand up under service conditions to protect said lining.

The present invention is intended to provide a refractory slurry mixer and applicator which can be adapted to handle any one of these and other different compositions regardless of the refractory materials or the suspension, binding or wetting agents used therewith.

Specifically, the improved apparatus comprises a discharge nozzle, a mixing tank, means for supplying dry refractory material to the tank, a liquid supply line leading to the tank, means for agitating and thoroughly mixing the dry material and liquid to produce in the tank a sprayable slurry of a given viscosity, a hydraulic pump for transferring the slurry from the tank to the discharge nozzle, a connection between the discharge side of the pump and the mixing tank to create a circulating system for the slurry produced in the tank to maintain it in the desired sprayable mixed condition, a flow control valve located in said connection, a valve located on the inlet side of the pump to open or close communication between the pump and the tank, control means on the discharge side of the pump to vary the volume and pressure of the sprayable slurry transferred to the discharge nozzle, a connection leading from the liquid supply line to the discharge side of the pump to alter the viscosity of the sprayable slurry produced in the tank, volume control means in the connection from the liquid supply line to the pump, a meter located in the liquid supply line to measure the quantity of liquid passing therethrough to the tank and to the pump, a gas supply line connected to the discharge side of the pump beyond the volume and pressure control means in advance of the discharge nozzle, and control means in the gas supply line for varying the gas supply to produce variations in aeration and velocity and thereby vary the volume and pressure of the slurry transferred by the pump to the discharge nozzle.

The improved apparatus will also comprise a first valve located in advance of the volume control means on the discharge side of the pump to permit or prevent flow of the sprayable slurry, a second valve located in the liquid supply line in advance of the volume control means therein to permit or prevent the flow of liquid, a third valve located in the gas supply line in advance of the volume and pressure control means therein to permit or prevent the flow of gas. Preferably, there will be provided automatic means for operating the first, second and third valves recited above and for also operating the flow control valve located in the connection between the discharge side of the pump and the mixing tank as well as the valve located on the inlet side of the pump.

As a further feature of the invention, the refractory slurry mixer and applicator described above will be equipped with means for heating the discharge nozzle, mixing tank, the hydraulic pump and the connecting lines and connections between said parts in order to maintain the slurry in a fluid and sprayable condition.

As previously stated, the unitary mixer and applicator of the instant invention was conceived to allow a wide variety of refractory materials to be used therein as well as a wide variety of liquids, so as thus to adapt the same mixer and applicator to open hearth furnaces, Linz-Donowitz, Kaldor and various other types of metal working furnaces. The normal custom in this field is to build up the worn, eroded or spalled surfaces of the refractory lining of any furnace or vessel as well as to build up a new lining, and a bottom in the same furnace or vessel if desired. The conception did not cease here, as the applicator is simple to operate and may be automated if desired and will always deliver completely and intimately mixed materials in slurry form of a given consistency.

The mixer of the apparatus is large enough to hold a sufficient quantity of refractory material for mixing therein which will be sufficient for an entire 8 hour shift when used for normal spraying on furnace surfaces for the repair and maintenance thereof. It can be made in any given size, especially when it is desired to use the applicator for putting in furnace bottoms or linings where thicker coatings are necessary. If necessary, where certain refractory materials and liquids are being used, the entire apparatus is arranged to be heated, the slurry conduit and the liquid lines by means of resistance or high frequency units contained around or in the walls of the conduits, and the mixer and slurry transfer means by the use of steam jackets to maintain the materials and liquids at a proper temperature and thus allow them to be completely and intimately mixed and transferred to the discharge nozzle for delivery therefrom.
The mixer is arranged to be filled by means of an opening contained in the top of the unit with suitable refractory materials contained in bags or boxes but may also be filled by means of an overhead hopper or conveyor and is equipped with suitable primary mixing equipment to insure complete and intimate mixing of the materials. The slurries used for the slurry transfer means include a hydraulic pump to circulate the completely mixed slurry contained in the mixer when not spraying to thus retain all of the ingredients of the slurry in contained suspension and to continue the mixing. The liquids used with the refractory materials will be stored in suitable conduits and tanks located in the vicinity and kept at suitable temperatures for transferring to the mixer. In the event that water is used as the liquid, it will only be necessary to hook up the supply line to a water line and the apparatus is ready to go.

The main theme of the invention is to provide a piece of apparatus to repair and replace furnace linings that has extremely wide latitude in handling different types of refractory materials and liquids suitable for a wide variety of refractory linings used in various furnaces. In open hearth furnaces using oxygen lances, the linings used are tending more and more to magnesium while in the Kaldo and Linz-Donowitz furnaces the linings are composed of magnesite with tars and asphalts as binders. In addition, recent linings in the Kaldo and Linz-Donowitz furnaces have had recourse to electrically fused magnesite or burned magnesite and chrome. Thus, it is evident that such a wide variety of refractory materials as well as such a wide variety of binders necessitate special apparatus to meet the many different conditions encountered in actual practice.

When tars and asphalts are used as binders in the linings for the Kaldo and Linz-Donowitz furnaces, they produce carbonaceous material distributed throughout the linings upon continual heating. As a result, the refractory compositions used for repairing will of necessity differ for hot repairs and for cold repairs, hot repairs requiring a slurry of a porous nature and cold repairs requiring a slurry having a bond similar to the parent lining.

In most of the steel mills today, they are still using the old open hearth furnaces and in some instances they have installed the new Kaldo and Linz-Donowitz units, so that it is necessary to effect repairs on both types of furnaces in the same shop and that would ordinarily require two or more different types of applicators, depending on whether linings used and under what conditions they must be repaired. The instant invention is the answer to this problem, since the improved apparatus is able to handle all types of refractory materials as well as all types of liquids used as binders and in addition can apply the slurry on the lining of a furnace while it is in full operation, or is cooling down, or is completely shut down.

The invention possesses other objects and features of advantage, some of which, with the foregoing statements, will be set forth specifically or be readily apparent in the following description of a typical embodiment of the invention which is illustrated in the accompanying drawings, in which:

FIG. 1 is a schematic view of the complete refractory slurry mixer and applicator arranged for operation thereof by means of hand operated valves;
FIG. 2 is a schematic view of the complete refractory slurry mixer and applicator arranged to be automatically operated by means of air and shows the control system in the mixing position; and
FIG. 3 is a schematic view of the complete refractory slurry mixer and applicator arranged to be automatically operated by means of air and shows the control system in the spraying position.

The refractory slurry mixer and applicator shown in schematic form in FIG. 1 is completely hand operated and is particularly adapted to be used with all types of refractory materials and liquids. A mixing tank 10 is arranged to be filled with refractory material through a filling hopper 13 by means of bags, boxes, overhead hopper or conveyor. The tank 10 is equipped with a primary mixing mechanism 16 driven by either an electric or air motor 12 through a gear train 11 and will have suitable mixers for the slurry transfer means. The mixing mechanism 16 may be of any known type which will insure the complete and intimate mixing of the refractory materials and liquids into a slurry of given viscosity. A liquid supply line 19 is arranged to be fed from either tanks or conduits as deemed necessary, according to the nature of the liquids being used, and is connected to the mixing tank 10 by means of conduit 19a having a control valve 20 to control the amount of liquid that will be added to the material for initially mixing the slurry of a given consistency. When it is desired to measure the amount of liquid being used, a liquid meter 21 is located in the supply line 19 and it might be stated here that the placement of such a meter might also be used to control the amount of liquid to be made while spraying. The supply line 19 is also connected by means of a conduit 19b to a liquid injection nozzle 25 for adding liquid at a continuous rate to the slurry flowing from the mixing tank 10 through a slurry feed conduit 15 so as to allow additional liquid to be fed to the slurry to alter its viscosity. The flow of liquid into the liquid injection nozzle 25 is controlled by a control valve 23 while the actual volume of additional liquid fed to the slurry is controlled by a valve 24, which latter can be set to give any desired consistency to the slurry, one or, preferably, two is used along as the same consistency is desired. The setting of the valve 24 may also be varied to vary the consistency or viscosity of the slurry during spraying. The liquid meter 21 contained in the supply line 19 can therefore be used to measure the initial amount added to the refractory material in the mixing tank and in addition to measure the amount of liquid added during spraying to thus give an overall measure of the total amount of liquid added to any load contained in the tank. The slurry with the additional liquid added is then fed into a hydraulic pump 26, where it is further thoroughly and intimately mixed before being allowed to flow through the desired conduit and may be by-passed by means of a liquid conduit 38 having a control valve 39 to provide means for cleaning the passage of the nozzle 25 and in addition to furnish additional liquid for cleaning the hydraulic pump, slurry discharge line and discharge nozzle when necessary.

The hydraulic pump 28 is arranged to be driven by either an electric or air motor and may be either a positive displacement type of pump or a rotary type as shown. The rotary type is preferred as it is now possible to obtain pumps of this type with suitable wear resistant liners and impellers that are either covered, with abrasion resistant rubber or plastic material or made of special steels and are so designed and arranged as to allow a quick interchange of the impellers and liners. The hydraulic pump 28 may be operated at a given speed over a given range of speeds as desired to give the volume and velocity necessary to spray the slurry into the furnace walls. The slurry feed conduit 15 is arranged on the discharge from the hydraulic pump from the mixing tank and is equipped with a slurry feed control valve 26 which is used to control the flow of slurry to said hydraulic pump whether the pump is used for spraying or for the circulation of the mixed material through the tank.

In actual operation the refractory material will be added to the liquid in the mixing tank 10 and the mixing of the two materials will first be accomplished in the tank by the agitating mechanism 16. At this time, the valve
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26 will be closed but, after the desired mixing has been completed in the tank, the valve will be opened to feed the slurry to the hydraulic pump 28, from which it will be discharged into a slurry outfeed conduit 29 leading back to the tank 10. This conduit 29 is equipped with two valves 30 and 31, the former being located in the main portion of the conduit 29 and controlling the flow of slurry back into the tank 10 for circulation therethrough, and the valve being located in a branch portion 29a of the conduit 29 leading to a slurry discharge line 36 and controlling the flow of the slurry into said discharge line for spraying through a discharge nozzle 37. When the valve 25 is first opened, the valve 30 is opened and the valve 31 closed, thus forming a closed circulating system to effect a further thorough mixing of the refractory material and liquid and retaining all of the ingredients in continuous suspension. When the valve 30 is closed and the valve 31 opened, the slurry will be transferred from the hydraulic pump 28 into the discharge line 36 for spraying under pressure by the discharge nozzle 37.

The slurry feed conduit 15 is also equipped with a drain pipe having a clean out valve 27 which will be used for cleaning out the mixing tank 10 when the valve 26 is closed on shutting down the unit.

As the slurry is forced through the discharge line 36, it may be necessary to completely aerate and break up the continuous stream in order to allow it to be more readily directed, applied and retained on the furnace areas, and this is accomplished by means of a gas injector nozzle 35 fed with gas pressure under a supply line 33 containing a gas injector flow-and-volume control valve 34. The line 33 is connected to a suitable gas supply source under pressure, and the gas used may be air, steam, CO, CO₂, or N₃ as desired and deemed necessary in accordance with the refractories and liquid being used, the object being to continuously aerate and if necessary form a protective atmosphere about the slurry particles for their protection en route to the furnace areas. The amount of aeration will be controlled by the pressures and volumes being used and, in addition, the variation in pressures and volumes being used to aerate can also be utilized to throttle the output of the hydraulic pump and also control the volume of the slurry being discharged. When the applicator is shut down, valve 34 can be opened to blow gas through the discharge line and nozzle to clean out the residue that has remained therein.

The normal means used to control the output of the hydraulic pump will be the slurry volume control valve 32 which will be set at a predetermined value to insure a constant given volume being discharged through the discharge nozzle 37. The valve 32 should be of a design which will insure its operation without continual disassembling and cleaning and there are several valves on the market today which fit into this category.

The discharge nozzle 36 is a length of pipe of suitable diameter to handle the volume desired and should be of such length as to make it possible to spray any and all areas. It may be readily replaced by ones of different lengths and shapes. In addition it is also possible to use bends or radii on the nozzles which will allow hard-to-reach spots to be sprayed. As a matter of fact, this is another one of the redeeming features of the applicator as the nozzles may be readily changed or replaced and this is of particular importance where it is necessary to use nozzles of different lengths and contours to reach different portions of the furnaces, such as in reaching the back walls, roofs, and hearth areas of the furnaces. It is also possible to use a spray nozzle such as shown in Patent No. 2,997,244 which will redirect the slurry at right angles to the pipe to which it is applied. When it is desired to use liquids of high viscosity, such as tar and asphalt as binders, the mixing tank 10 may be heated by means of steam in a jacket 14 by means of inlet pipe 14a and outlet or drain pipe 14b to thus keep the slurry at a temperature sufficiently high to maintain the liquid or liquids flowable and mixable. This same heating means forms a safeguard against winter operation of the applicator when water is being used as the liquid, and in addition, where certain types of refractory materials and binders are used, it forms the means to insure dissolving of the binders and complete mixing and flowability. Moreover, the heating means will be in such a manner that the slurry to be heated when it is to be sprayed on furnace areas while the furnaces are in full operation or during cooling down periods. When the furnaces are completely down and cold, the heating means may be dispensed with unless the type of refractory material and liquid being used requires heating.

The liquid inlet conduit 19 and the liquid distribution conduits 19a and 19b as well as the slurry conduits 15, 29 and 36 may be likewise heated when necessary by means of electrical resistance or high frequency heating to insure proper viscosity for mixing and spraying.

From the foregoing description, it can readily be seen that the refractory slurry mixer and applicator of the instant invention is designed to be used with all types of refractory materials as well as all conceivable types of binders either in dry or liquid form. This mixer and applicator can therefore be used to service any or all of furnaces in the same shop, thereby eliminating the necessity of having various types of units to handle various types of refractory materials in combination with various types of binders either in dry or liquid form. In addition it may be stated that the arrangement of and makeup of the component parts of the instant mixer and applicator are so selected, assembled and controlled as to result in extremely wide versatility regardless of the refractory materials, liquids, conditions of operation, methods of application, or types of furnaces.

The refractory slurry mixer and applicator shown in schematic form in FIGS. 2 and 3 is completely automated and operable from a pair of control valves for mixing and spraying. The same reference numerals are used as in FIG. 1 for similar parts performing the same functions under pneumatic control, and in the interest of brevity the nomenclature attached to the valves will be omitted.

The mixer tank 10 with its air or electric motor driven mixer mechanism as well as the air or electric motor for operating the hydraulic pump 28 will be directly controlled by a main air valve 49 located in a main air supply conduit 51 to thus provide the air to the complete apparatus and also on an air operated switch 50 which will energize the mixing mechanism and hydraulic pump and allow them to be started when necessary. The control valve 20 contained in the liquid line 19a is still hand operated, as it is felt this must be closely controlled and there fore necessary to measure the amount of liquid by the liquid meter 21 for the initial mixing to a suitable viscosity. A main control valve 41, with two positions, "mix" and "spray," is arranged to be hand operated by means of lever 42 to control the air actuating cylinders 23a, 30a, 34a and 48a by means of air conduits 45 and 46 for the remote actuation of the control valves 23, 30, 31 and 40, thus resulting in a completely automated system of controls for the apparatus. A second air control valve 43, with two positions "open" and "closed," is similarly arranged to be hand operated by means of lever 44 to control air actuating cylinder 26a by means of air conduits 47 and 48 for the actuation of the slurry control valve 26 to first keep the slurry in the mixing tank 10 until it is completely mixed and then allow the use of the hydraulic pump for circulating the slurry through the tank to insure that the refractory material will remain in suspension and further to insure the complete and intimate mixture of the materials and liquids into the slurry or the use of the hydraulic pump for spraying.

The air actuating cylinder 23a is arranged to open and close the liquid control valve 25 to control the feeding
of additional liquid into the slurry when deemed necessary for spraying, while the liquid metering valve 24 when set at any one position meters said liquid at a continuous rate for mixture with the slurry being fed into the hydraulic pump 28 for mixture therein during spraying.

The air actuating cylinders 30a and 31a are arranged to position the slurry flow control valve 30 for mixing and the slurry control valve 31 for spraying to thus, in cooperation with the control valve 41 in “mix” position, cause the slurry being discharged from the slurry conduit 29 and hydraulic pump 28 to be directed back into the mixing tank 10 to form in effect a secondary mixing system operating in conjunction and simultaneously with the primary mixing means 16 in the tank 10 to insure the complete and intimate mixing of the refractory materials and liquids. With the control valve 41 in “spray” position, it will actuate valve 30 into closed position and valve 31 into open position and so redirect the slurry being discharged from the slurry conduit 29 and hydraulic pump 28 into the discharge line 36.

The air actuating cylinder 31a is arranged to position the slurry flow control valve 31 for spraying and thus form in conjunction with the valve 30 for mixing, with its air actuating cylinder 30a, a means of controlling the output of slurry from the slurry conduit 29 and hydraulic pump 28. These two valves 30 and 31, with their air actuating cylinders 30a and 31a controlled by main control valve 41 are therefore opened and closed alternately, depending upon whether the slurry is being kept in a mixed condition or whether it is being discharged into the nozzle 37 for spraying. Beyond the slurry flow control valve 31 for spraying is positioned the slurry volume control valve 32 for controlling the amount of slurry being discharged through the slurry discharge line 36 and discharge nozzle 37. In addition, the valve 32 is used to build up a suitable pressure head on the transfer means and furnish an additional means for controlling the amount of slurry being discharged from said discharge nozzle 37. The slurry feed control valve 26 may also be used under certain conditions of slurry viscosity to control the flow of slurry into the hydraulic pump to be discharged through the discharge nozzle. This can be accomplished by using a partial stroke on the actuating cylinder.

The control valve 26 is normally kept in a closed position on starting the applicator until such time as the refractory materials and liquids contained in the mixing tank have been premixed into a slurry of suitable consistency; then the valve 43 is actuated to open control valve 26 and thus allow the hydraulic pump 28 to circulate the completely mixed slurry through the tank until the spraying operation is started. The primary feature of control valve 26, therefore, is to prevent the liquid and refractory material from entering the hydraulic pump 28 until it has been mixed with a suitable amount of liquid to produce a slurry of desired consistency and then maintain it in a completely mixed condition until needed for spraying.

The air actuating cylinder 40a is arranged to move the gas injector flow control valve 40 to a closed position when the main control valve 41 is in a “mix” position and to an open position when the tube valve 41 is in a “spray” position so as to inject a controlled amount of gas under pressure into the slurry line 36 to eradicate the continuous stream of slurry flowing therethrough when deemed necessary to allow it to be more readily directed and applied to and retained on the furnace area. The actual metering of the gas is accomplished by setting the gas injector pressure-and-volume control valve 34 and then using the valve 40 to do the actual controlling. In this manner, it is simple to duplicate the amounts of gas passing through adjacent batches as the valve 34 will remain at a set position until such time as the aeration of the slurry is to be changed. It is also possible when desired to use the gas that is injected into the slurry under pressure to serve as a volume control medium by building up said pressure to a point where it will create a back pressure on the hydraulic pump 28 and thus throttle the output thereof.

It is now readily apparent that the main control valve 41, with its hand operating lever 42, is the sole control means necessary to operate the gun once the slurry is in mixed form with any desired viscosity. The steps necessary to put the applicator in operation are as follows:

1. The valve 49 contained in the air inlet conduit 51 is opened to allow the air to pressurize the mixer and applicator and operate the air controlled switch 50 to energize the electric motor drive for the mixing mechanism and hydraulic pump.

2. The air pressure will be directed through the main control valve 41 in “mix” position and secondary control valve 43 in “closed” position to cause: (a) slurry control valve 26 to close and prevent the liquid and refractory material from entering the hydraulic pump 28, (b) liquid control valve 23 to close and prevent liquid from being fed into the liquid injection nozzle 25, (c) open slurry flow control valve 30 to allow the slurry to be circulated back into the mixing tank 10 when valve 26 is operated through the solids in suspension until ready for spraying, (d) close slurry control valve 31 to prevent the slurry from being discharged into the slurry discharge line 36 and nozzle 37, and (e) close gas injector flow control valve 40 to prevent the injection of a gas (in this instance air, although other gases may be used and the control system remains the same) into the continuous stream of slurry.

3. The hand operated liquid control valve 41 for mixing is now operated and a suitable amount of liquid allowed to pass through the liquid meter 21 to produce a slurry of a given consistency with a given amount of refractory material when mixed in tank 10.

4. A given amount of refractory material is loaded into the tank 10 through the filling hopper 13. The amount added is such as to produce a slurry of a given consistency with the amount of liquid already in said tank 10.

5. The starter on the electric motor drive 12 is now operated to cause the mixing mechanism 16 to mix the refractory material and liquid contained in the tank 10 into a slurry of given consistency.

6. The starter on the electric motor driving the hydraulic pump 28 is now operated to cause the hydraulic pump 28 to come up to speed and be ready to accept the slurry.

7. The secondary control valve 43 will be moved to “open” position to cause the slurry contained in tank 10 to be fed into the hydraulic pump 28 and be recirculated back into the tank through the slurry discharge conduit 29 and valve 30 in open position. In this manner, the solids contained in the slurry are kept in suspension and the slurry in an intimately and thoroughly mixed condition. The main control valve 41 is kept in “mix” position until such time as it is desired to spray.

8. The main control valve 41 is then moved to “spray” position when it is desired to spray and with the air pressure directed through valve 41 (and valve 43 in open position) to: (a) close slurry flow control valve 30 for mixing and thus prevent the slurry from being recirculated back into the mixer, (b) open slurry flow control valve 31 for spraying and cause the slurry to be discharged in a continuous stream into the slurry discharge line 36 and slurry discharge nozzle 37 for projection onto a furnace refractory surface, (c) open gas injector flow control valve 40 for spraying and inject gas under pressure into the continuous stream of intimately mixed slurry to aerate said slurry, (d) open liquid control valve 23 to adjust hand operated valve 24 to allow additional liquid to be fed at a controlled rate into the mixed slurry to change the viscosity of the mixed slurry for spraying, the
pump effecting a further mixing of the slurry before it is discharged in a continuous stream into the discharge line and nozzle. When no change in viscosity is desired, valve 24 is left in a closed position and valve 23 still open but no fluid will be added.

In closing down the mixer and applicator regardless of whether the pump stops or the tank has some slurry remaining therein, the operation is as follows: The actuation of the main control valve 41 to "mix" position will position the valves associated and controlled thereby to cause the slurry to be redirected into the mixing tank for recirculation and where there is no slurry remaining the mixing mechanism and the hydraulic pump will be shut down to make the whole apparatus inoperative and ready for the next load. If it is desired to blow out the discharge line 36 and discharge nozzle 37 after use, it is possible to arrange valve 40 to be closed slowly and thus supply air. On a complete shutdown, when it is desired to wash out the unit, liquid may be supplied to the mixing tank and the mixing mechanism put in motion, after which the liquid may be shipped by means of drain valve 27. When the hydraulic pump needs to be cleaned, the liquid by-pass valve 39 may be opened to supply liquid to the pump.

The two separate valves 30 and 31 may be dispensed with and a Y-valve substituted therefor, and the single flapper in this type of valve will be operated and actuated by means of a single air actuating cylinder to thus dispense with one air actuating cylinder and further simplify the control system. It is also within the concept of the invention to use electric or hydraulic actuating means for the control system, it only being a matter of choice as to which type will fit into the services available at each location.

If deemed necessary, the body of the hydraulic pump 28 may also be arranged to be heated in order to keep the liquids and slurries at a higher and more even temperature, whether circulating through the tank 10 or discharging into the discharge line 36 and nozzle 37. It will now be evident that the instant invention represents an entirely new concept in mixer and applicator design. The use of individual units unique in their design and function, coupled with the individual or collective control thereof, result in a mixer and applicator combination which is extremely versatile in respect to the materials and liquids capable of being handled and still simple to control and operate, whether this be accomplished manually or automatically. In addition, the design of the individual units and their controls allow the use of a variety of refractory materials and liquids, even though in some instances it may be necessary to heat the units in order to keep the liquids at a viscosity which will allow them to flow freely. The mixer and applicator of the instant invention is therefore made available at an opportune time due to the wide diversification of the types of furnaces used in the metal arts today. All of this new technique fits especially well into this new design since it is now possible, for instance, by the use of sprayed coatings placed on furnace bottoms, walls and roofs while the furnaces are in operation, to keep furnaces on duty for over 1000 heats during any one campaign, which is quite a departure from the 350 to 400 heats normally obtained by old methods. In addition, it may be pointed out that this extension in the life of the refractory linings in open hearth furnaces in particular has decreased the refractory costs per ton of steel produced quite extensively.

While the invention has been described and illustrated in its preferred embodiment, it is to be understood that the invention is susceptible to variations and modifications without departing from the spirit or essential attributes thereof, and I accordingly wish to avail myself of all the variations and modifications falling within the purview of the appended claims.

What is claimed is:

1. A refractory slurry applicator comprising, in combination, a discharge nozzle, a supply tank for containing a sprayable slurry of refractory material mixed with liquid, a hydraulic pump, a connection between the discharge side of the pump and the discharge nozzle, a slurry supply line leading from the tank to the inlet side of the pump, and a liquid injection nozzle located in the slurry supply line at a point in advance of the pump and arranged to discharge the liquid in the direction of flow of the slurry to the pump.

2. A refractory slurry applicator according to claim 1, including a liquid supply line leading to the injection nozzle, volume control means in the liquid supply line to maintain a predetermined volume of additives liquid fed to the slurry by the injection nozzle and thus alter the viscosity of the refractory slurry drawn from the supply tank, and a flow control valve located in the liquid supply line in advance of the volume control means to permit or prevent the flow of liquid through the supply line.

3. A refractory slurry applicator comprising, in combination, a discharge nozzle, a supply tank for containing a sprayable slurry of refractory material mixed with liquid, a hydraulic pump, a connection between the discharge side of the pump and the discharge nozzle, a slurry supply line connecting the tank with the inlet side of the pump, a liquid injection nozzle located in the slurry supply line at a point in advance of the pump and arranged to discharge the liquid in the direction of flow of the slurry to the pump, a liquid supply line having a branch connection to the liquid injection nozzle and a branch connection to the supply tank, two flow control valves, one located in the branch connection of the liquid supply line to the liquid injection nozzle, and one located in the branch connection of the liquid supply line to the supply tank, to permit or prevent the flow of liquid to either of the branch connections, and a meter located in the liquid supply line in advance of the branch connections to measure the quantity of liquid passing through either of said connections when the flow control valve therein is open.

4. A refractory slurry applicator comprising, in combination, a discharge nozzle, a supply tank for containing a sprayable slurry of refractory material mixed with a liquid, a hydraulic pump for transferring the slurry from the tank to the discharge nozzle, a liquid supply line connected to the inlet side of the pump to alter the viscosity of the sprayable slurry, and by-pass means in the liquid supply line for cleaning out the pump and discharge nozzle after use of the applicator.

5. A refractory slurry applicator according to claim 1, including a gas injection nozzle located in the connection between the pump and the discharge nozzle in the vicinity of the discharge nozzle to produce aeration of the refractory slurry fed from the pump to the discharge nozzle.

6. A refractory slurry applicator according to claim 5, including control means for varying the volume of gas supplied to the gas injection nozzle.

7. A refractory slurry applicator comprising, in combination, a discharge nozzle, a mixing tank, means for supplying dry refractory material and a liquid to the tank, means for agitating and thoroughly mixing the dry material and liquid to produce in the tank a sprayable slurry of a given viscosity, a hydraulic pump for transferring the slurry from the mixing tank to the discharge nozzle, and means for heating the mixing tank, the hydraulic pump, the liquid supply line connected to the tank, the connection between the mixing tank and the inlet side of the pump and the connection between the discharge side of the pump and the discharge nozzle.

8. A refractory slurry applicator according to claim 7 including a liquid supply line connected to the inlet side of the pump, and means for heating said supply line.

9. A refractory slurry mixer and applicator comprising, in combination, a discharge nozzle, a mixing tank, means for supplying dry refractory material to the tank, a liquid supply line connecting the tank with the inlet side of the pump, a liquid injection nozzle located in the slurry supply line at a point in advance of the pump and arranged to discharge the liquid in the direction of flow of the slurry to the pump.
supply line leading to the tank, means for agitating and thoroughly mixing the dry material and liquid to produce in the tank a sprayable slurry of a given viscosity, a hydraulic pump for transferring the slurry from the tank to the discharge nozzle, a connection between the discharge side of the pump and the mixing tank to create a circulating system for the slurry produced in the tank to maintain it in the desired sprayable mixed condition, a flow control valve located in said connection, a valve located on the inlet side of the pump to open or close communication between the pump and the tank, control means on the discharge side of the pump to vary the volume and pressure of the sprayable slurry transferred to the discharge nozzle, a connection leading from the liquid supply line to the inlet side of the pump to alter the viscosity of the sprayable slurry produced in the tank, volume control means in the connection from the liquid supply line to the pump, a gas supply line connected to the discharge side of the pump beyond the volume and pressure control means in advance of the sprayable slurry, and control means in the gas supply line for varying the gas supply to produce variations in aeration and velocity and thereby vary the volume and pressure of the slurry transferred by the pump to the discharge nozzle.

10. A refractory slurry mixer and applicator comprising, in combination, a discharge nozzle, a mixing tank, a liquid supply line leading to the tank, means for agitating and thoroughly mixing the dry material and liquid to produce in the tank a sprayable slurry of a given viscosity, a hydraulic pump for transferring the slurry from the tank to the discharge nozzle, a connection between the discharge side of the pump and the mixing tank to create a circulating system for the slurry produced in the tank to maintain it in the desired sprayable mixed condition, a flow control valve located in said connection, a valve located on the inlet side of the pump to open or close communication between the pump and the tank, control means on the discharge side of the pump to vary the volume and pressure of the sprayable slurry transferred to the discharge nozzle, a connection leading from the liquid supply line to the inlet side of the pump to alter the viscosity of the sprayable slurry produced in the tank, volume control means in the connection from the liquid supply line to the pump, a gas supply line connected to the discharge side of the pump beyond the volume and pressure control means in advance of the discharge nozzle, and control means in the gas supply line for varying the gas supply to produce variations in aeration and velocity and thereby vary the volume and pressure of the slurry transferred by the pump to the discharge nozzle.

11. A refractory slurry mixer and applicator according to claim 10, including a first valve located in advance of the volume control means on the discharge side of the pump to permit or prevent flow of the sprayable slurry, a second valve located in the liquid supply line in advance of the volume control means therein to permit or prevent the flow of liquid, and a third valve located in the gas supply line in advance of the volume and pressure control means therein to permit or prevent the flow of gas.

12. A refractory slurry mixer and applicator according to claim 11, including automatic means for operating the first, second and third valves recited in said claim.

13. A refractory slurry mixer and applicator according to claim 12, wherein said automatic means also operates the flow control valve located in the connection between the discharge side of the pump and the mixing tank, as well as the valve located on the inlet side of the pump.

14. A refractory slurry mixer and applicator according to claim 10, including means for heating the discharge nozzle, the mixing tank, the hydraulic pump and the various recited connections between said parts.

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