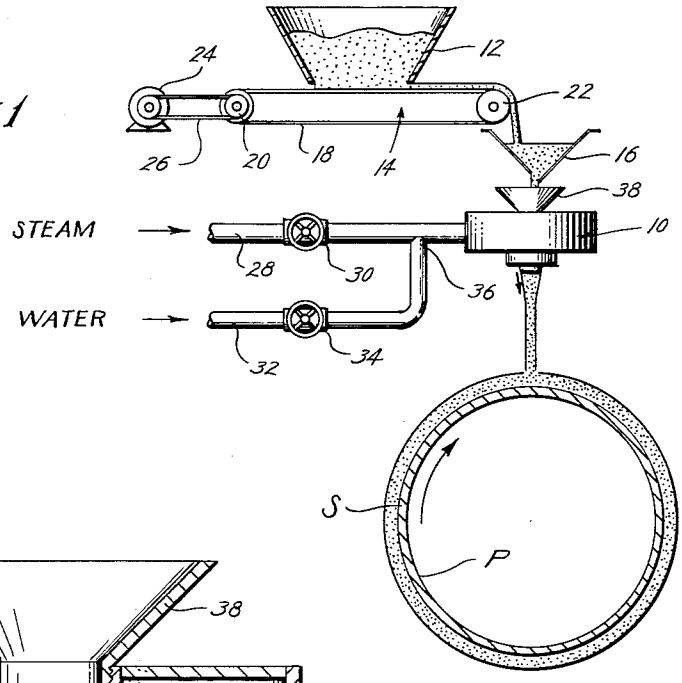
Oct. 18, 1955 R. E. SULLIVAN 2,721,147

METHOD AND APPARATUS FOR COATING

Filed May 5, 1952

Fig. 1



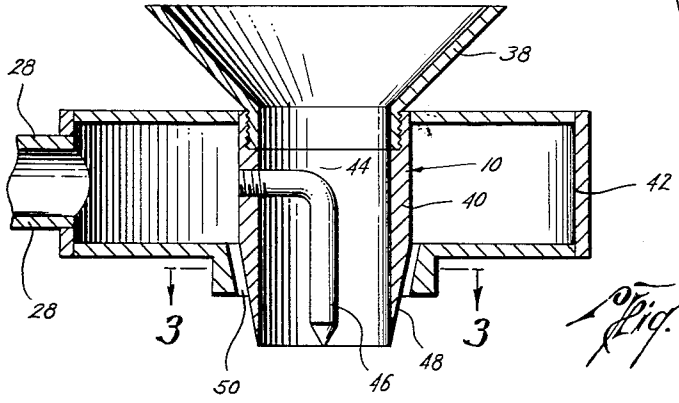


Fig. 2

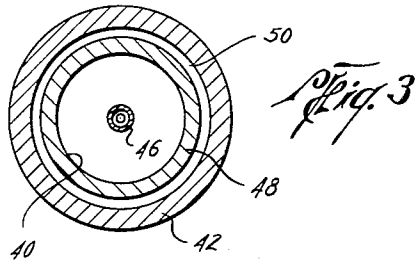


Fig. 3

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United States Patent Office 2,721,147 Patented Oct. 18, 1955

2,721,147

METHOD AND APPARATUS FOR COATING

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Application May 5, 1952, Serial No. 286,072

19 Claims. (Cl. 117—104)

This invention relates to a method of and an apparatus for applying a coat of cementitious material to a surface and, more particularly, relates to a method of and apparatus for forming a jet of cementitious material by which the coating may be applied to the surface.

In the industry generally coatings of cementitious materials have been applied to many and varied surfaces. A common example is the coating of pipe surfaces, both inner and outer, with cementitious materials, such as concrete, to provide a protective layer about the surface of the pipe to prevent corrosion or erosion of the pipe. Many times it is desirable to provide weight to a pipe line which is laid beneath the surface of the earth in riverbeds, swampy or marshy areas, when the pipe lines in transporting gas are buoyed thereby which makes it difficult to maintain them in place. In applying a coating of concrete to the pipe line to make it heavier and overcome this buoyancy, the concrete coating serves as a protecting coating to prevent corrosion, in the event metal pipe is used, by fluids present where the pipe is laid.

In applying coatings of cementitious materials to the surface of pipes it is highly desirable that the coating be tightly bonded to the surface to prevent seepage of fluid between the coating layer and the coated surface and to prevent cracking of the layer of cementitious material thereby avoiding separation of the coating from the surface. It is also highly desirable that the apparatus and method be economical and competitive with other types of coatings, and that the apparatus for applying the coating may be readily used in the field, transported from place to place and which is economical to manufacture, maintain and operate.

Providing a cementitious coating to a surface has been attempted by forming the coating material into a high velocity jet and then impinging this jet against the surface to be coated. For example, the cementitious material, in dry form and composed of a mixture of cement and sand, has been formed into a moving column of material and contacted in a hydrating zone with a water containing gas, such as steam, by which the cementitious material is hydrated. This hydrated jet is then directed against the surface to be coated. Considerable difficulty has been experienced with clogging of the means or nozzle by which the jet is formed in that moisture collects about the nozzle which causes dry particles to adhere to the nozzle thereby causing the nozzle to be bridged or plugged by the dry cement contacting the moisture. Also, complete or substantially uniform hydration has been difficult in applying cementitious materials to a surface by directing a jet of such material against the surface, the force of the jet causing dry particles to adhere temporarily to the surface, but subsequently such particles became loose thereby causing weak spots of flaking in the coating.

Various methods and means have been attempted to overcome this plugging or bridging of the nozzle and to provide complete or substantially uniform hydration of the cementitious particles. One of such methods is to provide a sheath or column of an inert gas about the

column of cementitious particles in an attempt to prevent the particles from being wetted while in the nozzle and, if so, to prevent plugging or bridging of the nozzle. This means has not proven satisfactory and, in addition, requires the provision of an inert gas or means to supply the inert gas and further complicates the nozzle by which the jetting and hydration of the cementitious particles is attempted.

Thus, it can readily be seen that it is highly desirable to provide a method of and a means for forming a particulate mass of cementitious material into a moving column and thoroughly or uniformly hydrating this mass with a water carrying gas without clogging the apparatus in which the hydration occurs and in which inert gas and attendant apparatus for supplying same are unnecessary. It is generally desirable to provide the hydrated cementitious material in the form of a high velocity stream or jet to impinge a surface to be coated and ordinarily only sufficient water to hydrate the cementitious material to a semi-plastic state is desirable in order to provide a high density, tenacious coating strongly adhering to the surface when applied thereto as a high velocity jet.

It is therefore among the objects of the present invention to provide a simplified method of and apparatus for applying a dense, strong and tenacious cementitious coating to a surface in the form of a high velocity jet impinging on the surface.

A further and important object of the present invention is the provision of such a method and apparatus in which it is not necessary to provide or use inert gas to prevent condensed moisture from collecting in the hydrating zone about its boundary thereby causing plugging or bridging of the nozzle.

Yet a further and important object of the present invention is the provision of a method of and apparatus for applying a coating of cementitious material to a surface, in which steam is used as the jetting agent and no auxiliary equipment or gases are necessary to prevent clogging of the jetting apparatus.

Still a further and important object of the present invention is the provision of a method of and a means for applying a coating of cementitious material to a surface, which method and means are flexible and in which the cementitious material may be substantially and completely hydrated or partially and uniformly hydrated, as desired.

A still further and important object of the present invention is the provision of a method of and apparatus for forming a jet of hydrated or partially hydrated cementitious material for impinging a surface to be coated therewith in which steam is used as a jetting agent and as a carrier of a hydrating agent in which it is unnecessary to provide auxiliary means or inert gases to prevent clogging of the jetting apparatus.

Other objects and features of the present invention will be apparent from the following description of an example of the invention, given for the purpose of disclosure, taken in connection with the accompanying drawing, in which like character references designate like or corresponding parts throughout the several views, and in which

Fig. 1 illustrates an example of an apparatus constructed in accordance with the invention by which the external surface of a pipe is coated,

Fig. 2 is a sectional elevation of an apparatus constructed in accordance with the invention and adapted for use to coat the outer surface of the pipe, and

Fig. 3 is a cross-sectional view taken along the lines 3—3 of Fig. 2.

Referring now to the drawing and, particularly to Fig. 1, the reference numeral **10** designates suitable apparatus for forming the jet to which is supplied cementitious material in particulate form by means of the hopper

12 depositing such material on the conveyor 14, which in turn deposits such material in the hopper 16 from which it is deposited into the apparatus 10 and formed into a column and hydrated as later described. Obviously, the hopper 12, conveyor 14 and hopper 16 may be any convenient or desired form to supply cementitious material to the apparatus or nozzle 10.

As illustrated in Fig. 1, the conveyor 14 may include an endless belt 18 secured about the driving and driven rollers 20 and 24, respectively, the driving roller 20 being driven by the variable speed motor 24 by means of the linking belt 26. Thus, by varying the speed of the motor a predetermined amount of cementitious material may be supplied to the nozzle 10. Of course, other factors may be varied and other conventional arrangements may be used to provide the desired amount of this material to the nozzle.

In order to hydrate the cementitious material it is necessary to contact it with a water carrying gas and it is desirable to use such a gas which will increase the velocity of the column of cementitious material flowing through the nozzle 10 to form a high velocity jet. Steam is satisfactory and may controllably be supplied to the nozzle 10 by means of the conduit 28 having the valve 30. A hydrating fluid, such as water, is controllably supplied to the nozzle 10 by means of the conduit 32 having the valve 34. While the steam and water may separately be supplied, it is preferable to admix them before they are supplied to the nozzle. To accomplish this purpose the conduits 28 and 32 may be merged at 36. Thus, hydrating fluid or a water carrying gas is provided to the nozzle 10 to hydrate the cementitious material and form a jet which infringes the surface S of the pipe P desired to be coated.

Referring now to Figure 2 and to the nozzle 10, a funnel 38 is provided at the upper end of the hollow body 40, the latter being substantially tubular and having substantially straight inner walls. Particulate material supplied to the funnel 38 thus forms a flowing column as it moves through the tubular body 40.

Circumferentially and coaxially disposed about the tubular body 40 is a fluid receiving chamber 42 into which the admixed steam and water or fluid in conduit 28 is received. Communicating with the fluid receiving chamber 40 is the conduit 44 extending laterally into the center of the body 40, the conduit 44 having a turned down portion 46 which preferably extends axially of the body 40 in the direction of flow. Preferably, the lower end of the turned down portion 46 should be positioned substantially at the lower end of the body 40 or at such a point that the jet of fluid emanating therefrom spreads at a point below the lower boundary of the body 40, as will be apparent later. The jet of water containing gas is thus introduced centrally of and in the same direction of flow as the moving column of cementitious material, and increases its velocity as well as hydrates the central portion of the column.

In order to provide a confined jet and provide fluid or water containing gas about the moving column, and preferably inwardly of but in the same direction of flow as the flowing column of cementitious particles, the tubular body 40 is inwardly tapered about its outer lower portion at 48 and, substantially parallel thereto there is provided an annular opening 50 disposed at the lower portion of the annular chamber 42. Thus, the water containing gas is directed inwardly of the column of cementitious material, thereby accelerating the velocity of the column and providing a jet to impinge the surface S of the pipe P.

In order to prevent clogging it is critical that the particulate cementitious material be not hydrated until after it leaves the hydrating nozzle so that moisture will not collect, such as by capillary attraction, about the lower boundary of the lower extremity 48 of the body 40 of the jetting nozzle 10. This is accomplished by having the lower extremity of the annular port 50 above the lower end 48 of the body 40 and the lower end of the interior jet 46 disposed as indicated. With this arrangement the cementitious particles are hydrated at a point below the lower end of the nozzle or as they leave the nozzle. Thus, moisture does not collect at the lower boundary and clogging or bridging of the nozzle is prevented.

In practice, in order that a jet stream is provided, it is desirable that the jet of fluid from the jet nozzle 50 be of an order greater than that of the jet of fluid from the jet nozzle 46 at the interior of the column. This, of course, tends to accelerate the velocity and hold the hydrated material in the form of a jet rather than dispersing it outwardly, as would be the case in the event the inner jet were of a pressure higher than the outer jet. Merely as an example and for the purposes of illustration only and not by way of limitation, the pressure of the internal jet may be of the order of 50 to 60 p. s. i. and the pressure of the external jet may be of the order of 70 pounds p. s. i. These pressures have proved satisfactory.

In operation, cementitious material in particulate form is fed from the hopper 12 onto the conveyor belt 18 and a predetermined amount thereof is supplied to the hopper 16, from where it is passed, by gravity, into the funnel 36 at the upper end of the jet nozzle 10. As the cementitious material passes into the tubular body 40 it is formed into a flowing column, and a water containing gas such as steam and water, is supplied to the annular chamber 42 in controlled amounts through the conduits 28 and 32. A jet of water containing gas, such as steam and water, is provided centrally of and to the column of cementitious material from the nozzle 46, in the same direction of flow of the column and substantially parallel to the longitudinal axis of the column of cementitious material. The water containing gas is applied to the column of cementitious material by means of the annular passageway 50 which directs a jet or sheath of the water containing gas at an angle inwardly of a line parallel with the longitudinal axis of, but in the same direction as, the column of moving cementitious material. As explained heretofore by extending the lower portion of the body 40 of the nozzle 10 below the lower boundary of the annular passageway 50 and positioning the jet 46 so that it spreads after it leaves the nozzle, accumulation of moisture about the lower boundary 48 of the body 40 is prevented, which thereby prevents clogging of the nozzle. As indicated, it is preferable to provide the outer jet of water containing gas at pressures of an order greater than the inner jet to prevent spreading of the column of cementitious material. Inasmuch as an internal jet of water carrying gas is provided centrally of the cementitious material, the latter is substantially uniformly hydrated to the desired extent and this column impinges the surface S of the pipe P, which may be rotated in any desired manner, if desired.

While various cementitious materials may be employed, preferably a mixture of commercial cement and plasterer's sand may be used. Preferably the sand has a particle size to pass through a number 8 U. S. mesh screen but can be larger. A ratio of about 4 to 1 to 6 to 1 by weight of sand to cement is satisfactory although mixes outside this range can be used.

The cementitious material is not hydrated to a point of plastic consistency, such as the conventionally fixed concrete, but has sufficient water admixed therewith to hydrate it to a state less than plastic consistency and has a substantially dry appearance. While the amount of water to be admixed with the jetting agent depends upon the nature of the latter, when steam is employed as such agent, and it is saturated, and an operating pressure within the range of 50 to 100 pounds p. s. i., at room temperature, and an amount of water from about 1 to about 5, and preferably about 3 gallons per bag (94

pounds) of cement which provides substantially complete hydration of the cement, is satisfactory.

When applying the coating of cementitious material to a surface and where a strong, dense and tenacious coating is desired, satisfactory results have been obtained by spacing the nozzle from about 10 to about 12 inches from the surface, although other distances outside this range may be used depending upon the jet velocity, the amount of hydration and the like. Also, the nozzle may be used to form a precoat upon the surface, which may be formed by reducing the amount of hydration and, after the precoat or thin layer of cement has been deposited, the usual coating may be applied. However, it is not necessary to provide such a precoat for satisfactory results.

In applying the coating to a surface, it is preferable that the longitudinal axis of the nozzle is substantially vertical or at right angles to the surface to be coated, although such may be held at certain angles from the vertical. The jet nozzle **10**, of course, can be used in other positions than vertical, but is preferable to apply the jet of hydrated cementitious material at substantially right angles to the surface to be coated.

It seems apparent that the present invention is one which fulfills the objects hereinabove set forth, and attains other advantages and features which are obvious and which are inherent in the method and apparatus.

The invention may be embodied in other forms and it is understood that the specific details and arrangement of parts are illustrative only for the purpose of disclosure and that the invention is to be limited only by its spirit and the scope of the appended claims.

What is claimed is:

1. An apparatus for jetting cementitious material on a surface to be coated comprising, in combination, a hollow body provided with inlet and discharge ends adapted to receive and discharge a column of solid particles, first means at the discharge end for introducing hydrating fluid into and centrally of the column of solid particles as the column of solid particles leaves the discharge end of the body, and second means disposed about the discharge end of the body for introducing hydrating fluid around the column of solid particles as the column of solid particles leaves the discharge end of the body in such a manner to substantially surround the column of solid particles whereby said column of solid particles is hydrated in free atmosphere as it leaves the discharge end of the body.

2. The apparatus of claim 1 where such first means introduces hydrating fluid in the direction of flow of such column, and such second means introduces hydrating fluid slightly inwardly of the direction of flow of such column.

3. An apparatus for jetting cementitious material on a surface to be coated comprising, in combination, a tubular body provided with inlet and outlet ends and adapted to receive and discharge a column of solid particles, first means disposed at the outlet end for introducing hydrating fluid into and centrally of and in the same direction of flow as the column of solid particles as it leaves the outlet end of the body, and second means disposed about the outlet end for introducing hydrating fluid around and slightly inwardly of the direction of flow of the column of solid particles as it leaves the outlet end of the body whereby the column of solid particles is hydrated in unconfined atmosphere beyond the outlet end of the body.

4. An apparatus for jetting cementitious material on a surface to be coated comprising, in combination, vertical conduit means having substantially vertical inner walls and having upper inlet and lower discharge ends adapted to receive and discharge a column of solid particles flowing in a vertical direction, first downwardly-directed and centrally-disposed hydrating fluid introducing means at the discharge end for introducing hydrating fluid in the direction of flow and centrally of the flowing column as the column leaves the discharge end, and second downwardly and inwardly-directed hydrating fluid introducing means disposed adjacent and exteriorly of the discharge end for introducing hydrating fluid substantially around, downwardly and inwardly of the flowing column of solid particles as it leaves the discharge end whereby the column of solid particles is hydrated in unconfined atmosphere below the discharge end of the vertical conduit means.

5. An apparatus comprising, in combination, a nozzle provided with inlet and discharge ends adapted to receive and discharge a column of flowing solid particles, the outer wall of the discharge end of the nozzle being inwardly-sloped, a first hydrating fluid distributing means disposed centrally of the nozzle at the discharge end and being outwardly-directed for introducing hydrating fluid centrally of and substantially parallel to the direction of flow of the column as it leaves the nozzle, and second hydrating fluid distributing means disposed about the nozzle adjacent the discharge end and having a fluid passage parallel to the inwardly-sloped outer wall so that hydrating fluid flows along the inwardly-sloped outer wall into engagement with the column as it leaves the discharge end thereby hydrating the column of solid particles in unconfined atmosphere beyond the discharge end of the nozzle.

6. An apparatus comprising, in combination, a tubular nozzle having inlet and discharge ends adapted to receive and discharge a flowing column of particulate cementitious material, such nozzle having substantially straight inner walls and having its outer wall at the discharge end inwardly-sloped, first means centrally-disposed of the nozzle at the discharge end and outwardly-directed for supplying hydrating fluid centrally of and in a direction parallel to the direction of flow of the column at a point beyond the discharge end of the nozzle, and second means for supplying hydrating fluid disposed exteriorly of the nozzle at the discharge end and having a fluid passage parallel to the inwardly-sloped outer wall of the discharge end so that hydrating fluid flows along the inwardly-sloped outer wall and is introduced about and substantially surrounds the column at a point beyond the discharge end of the nozzle whereby the column is hydrated in unconfined atmosphere beyond the discharge end of the nozzle.

7. The apparatus of claim 6 where the first means is so constructed and arranged to introduce hydrating fluid into such column at a lesser pressure than the second means introduces such hydrating fluid to such column.

8. An apparatus comprising, in combination, a tubular body provided with an upper inlet and a lower discharge end and adapted to receive and discharge a flowing column of particulate cementitious material, such nozzle having substantially straight inner walls and having its outer wall inwardly-sloped at its lower discharge end, first fluid introducing means disposed centrally of the nozzle at the discharge end and downwardly-directed for supplying fluid centrally of and in a direction parallel to the direction of flow of the column at a point below the discharge end of the nozzle, second fluid introducing means disposed exteriorly of the nozzle and above the discharge end and having a fluid passage parallel to the inwardly-sloped outer wall for supplying fluid above and exteriorly of the discharge end of the nozzle and parallel to the inwardly-sloped outer wall so that fluid flows along the inwardly-sloped outer wall and is introduced into the column at a point below the lower discharge end of the nozzle, and gravity means for passing the column of particulate cementitious material by gravity into the upper inlet of the nozzle.

9. An apparatus comprising, in combination, a tubular nozzle having an upper inlet end and a lower discharge end adapted to receive and discharge a flowing column of particulate cementitious material, said nozzle having substantially straight inner walls and having its outer wall inwardly-sloped at the lower discharge end, first means

for supplying hydrating fluid disposed centrally of and adjacent the discharge end and having its fluid discharge opening in a downward direction parallel to that of the flow of the column, and an annular hydrating fluid passageway disposed about the nozzle above and parallel to the inwardly-sloped end of the nozzle for flowing hydrating fluid downwardly along the inwardly-sloped outer wall thereby introducing the hydrating fluid into the column as it leaves the discharge end whereby the column is hydrated in free atmosphere below the discharge end of the nozzle.

10. The apparatus of claim 9 where the first means for supplying hydrating fluid is so constructed and arranged to supply hydrating fluid at a lesser pressure than hydrating fluid supplied by such annular fluid passageway.

11. The apparatus of claim 10 including means for passing a column of particulate cementitious material into the upper end of such nozzle.

12. A nozzle for jetting hydrated particulate cementitious material onto a surface comprising, in combination, a tubular body adapted to receive a flowing column of solid particles, such nozzle having substantially straight inner walls and having its outer wall inwardly sloped at its lower end, and means for introducing jetting and hydrating fluid into such column comprising, a fluid receiving chamber disposed about such body, a conduit in communication with such chamber and extending into such body, the fluid discharged end of which is disposed axially of and in a downward direction at a point substantially at the lower end of such body, and an annular discharge passageway in said chamber disposed above the lower end and parallel to the inwardly sloped end of such nozzle for flowing fluid downwardly along such inwardly sloped outer walls for introducing such fluid about such column as it leaves the nozzle.

13. The apparatus of claim 12 including means for introducing such solid particles into the upper end of such nozzle.

14. A nozzle for hydrating particulate cementitious material and jetting such hydrate material onto a surface comprising, in combination, a tubular body adapted to receive a flowing column of solid particles, such nozzle having substantially straight inner walls and having its outer wall inwardly sloped at its lower end, a fluid chamber disposed coaxially of such body, means for introducing jetting and hydrating fluid onto such fluid chamber, and a conduit in communication with such fluid receiving chamber and extending into such body, the fluid discharged end of which is disposed axially of and in a downward direction at a point substantially at the lower end of such body, and an annular discharge passageway in said chamber disposed above the lower end and parallel to the inwardly sloped end of such nozzle for flowing fluid downwardly along such inwardly sloped outer walls for introducing such fluid about such column as it leaves the nozzle.

15. A method of applying a dense tenacious coating of cementitious material to a surface which comprises, confining a flowing column of hydratable cementitious particles to a tubular conduit, introducing a water containing gas centrally of and in the direction of flow of, and around and in the direction of flow of such column, said introduction being substantially at the point of exit of said column from said conduit while said column is in unconfined atmosphere, said water containing gas hydrating said cementitious particles and increasing the velocity thereof, and directing the flowing column against the surface to be coated.

16. A method of applying a dense tenacious coating of cementitious material to a surface which comprises, confining a flowing column of hydratable cementitious particles to a tubular conduit, introducing a water containing gas centrally of and in the direction of flow of, and around and in the direction of flow of such column, said introduction being at substantially the same point and at the point of exit of said column from said conduit while said column is in unconfined atmosphere, said water containing gas hydrating said cementitious particles and increasing the velocity thereof, and directing the flowing column against the surface to be coated.

17. A method of applying a dense tenacious coating of cementitious material to a surface which comprises, confining a flowing column of hydratable cementitious particles to a tubular conduit, introducing a water containing gas centrally of and in the direction of flow of, and around and slightly inwardly of and in the direction of flow of such column, said introduction being substantially at the point of exit of said column from said conduit while said column is in unconfined atmosphere, said water containing gas hydrating said cementitious particles and increasing the velocity thereof, and directing the flowing column against the surface to be coated.

18. The method of claim 17 where the water containing gas introduced around such column is introduced at a pressure greater than that of the water containing gas introduced centrally of such column.

19. A method of applying a dense tenacious coating of cementitious material to a surface which comprises, confining a flowing column of a hydratable cementitious mixture comprised of dry cement and sand particles, introducing steam containing liquid water centrally of and in the direction of flow of, and around and converging slightly inwardly of the direction of flow of such column, said introduction being substantially at the point of exit of said column from said conduit while said column is in unconfined atmosphere, the introduction of said steam around said column being at a pressure greater than that of the introduction of said steam centrally of said column, said steam containing liquid water hydrating the sand and cement particles and increasing the velocity thereof, and impinging the resulting jet of hydrated material onto said surface.

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