

Dec. 31, 1935.

L. R. JORGENSEN

2,025,948

METHOD OF GROUTING BY CHEMICAL MEANS

Filed May 26, 1933

3 Sheets-Sheet 1

Fig. 1.

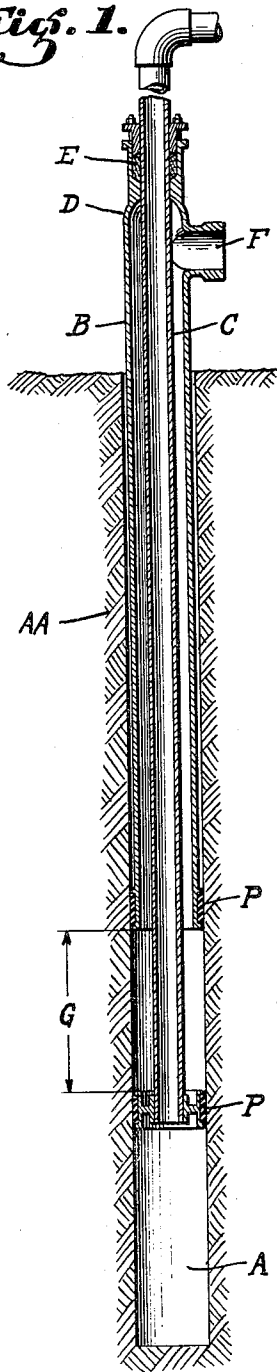


Fig. 2.

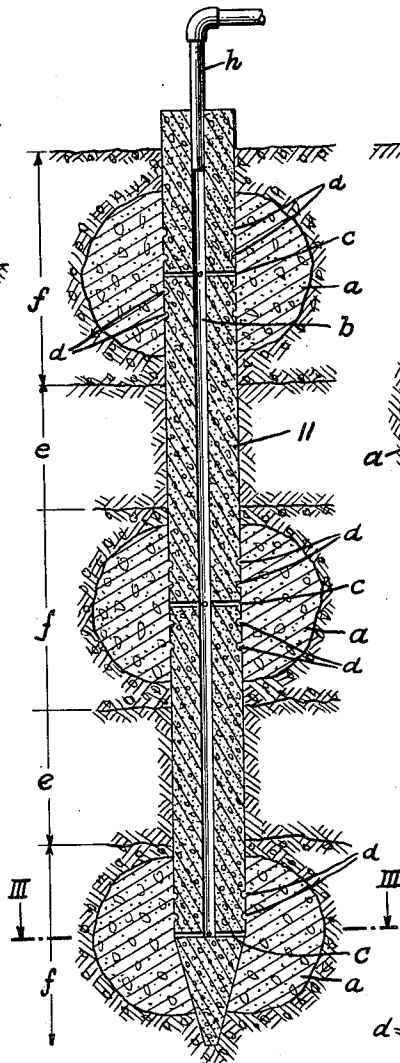


Fig. 2A

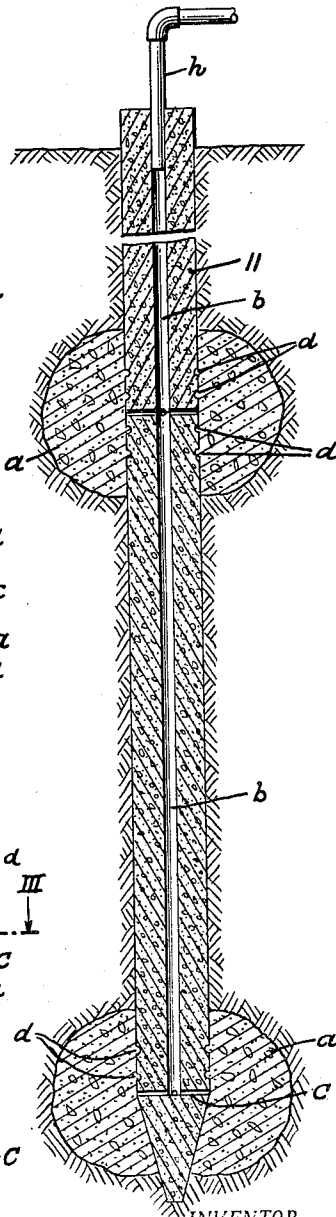
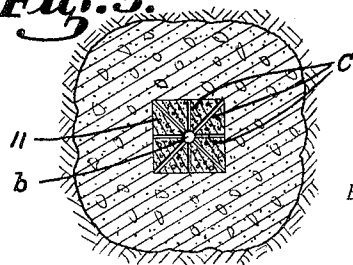


Fig. 3.



INVENTOR.
Lars R. Jorgensen.
BY Townsend & Loftis.
ATTORNEYS.

Dec. 31, 1935.

L. R. JORGENSEN

2,025,948

METHOD OF GROUTING BY CHEMICAL MEANS

Filed May 26, 1933

3 Sheets-Sheet 2

Fig. 4.

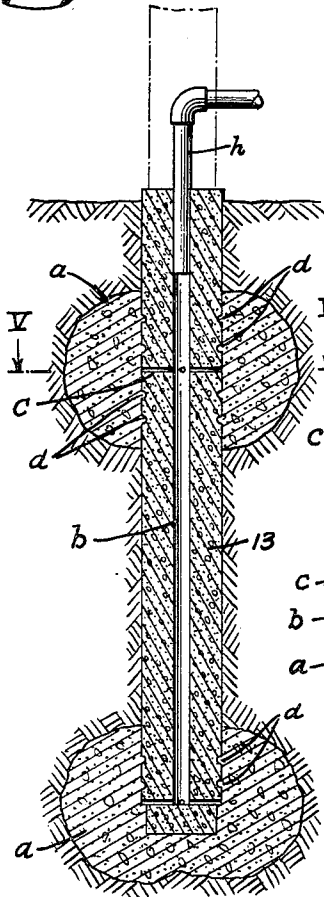


Fig. 5

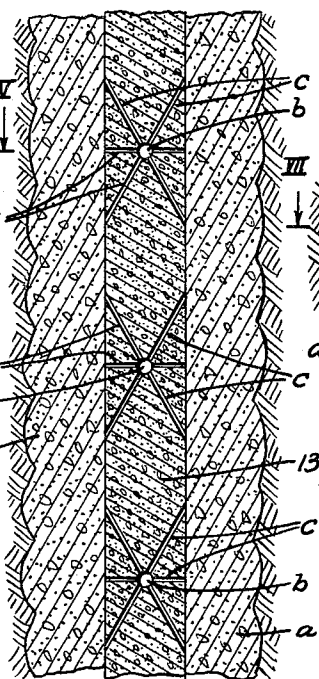


Fig. 6.

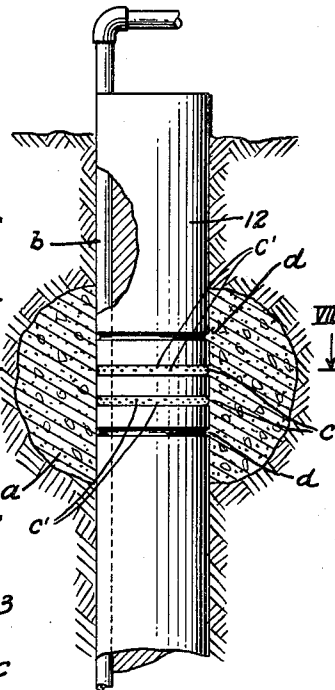
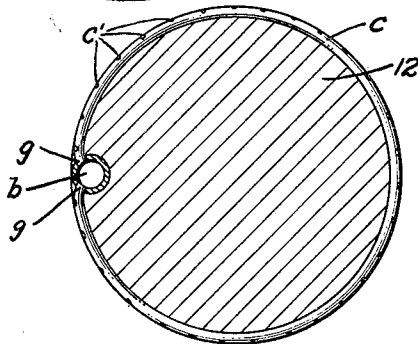


Fig. 7.



INVENTOR.
Lars R. Jorgensen.
BY Townsend & Loftus.
ATTORNEYS.

Dec. 31, 1935.

L. R. JORGENSEN

2,025,948

METHOD OF GROUTING BY CHEMICAL MEANS

Filed May 26, 1933

3 Sheets-Sheet 3

Fig. 8

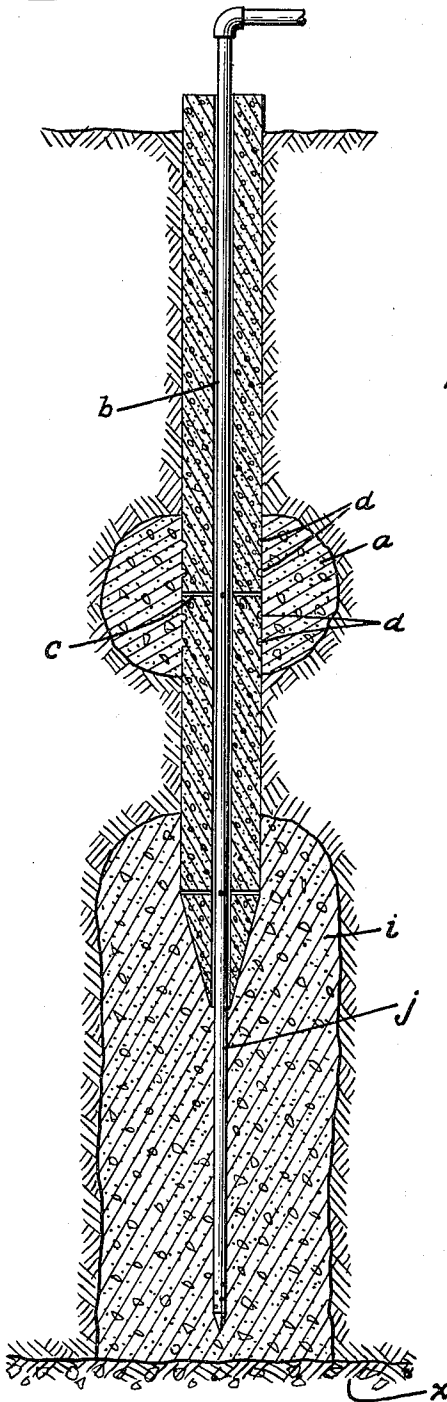
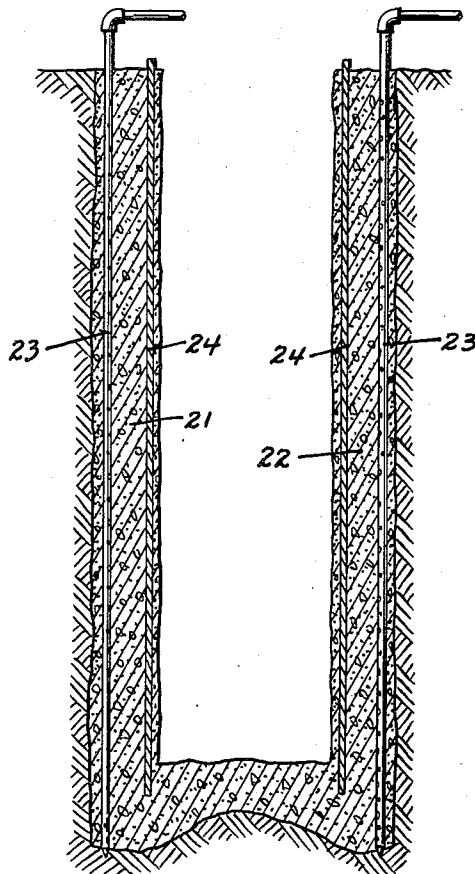


Fig. 9.



INVENTOR.
Lars R. Jorgensen.
BY
Townsend & Loftus.
ATTORNEYS.

UNITED STATES PATENT OFFICE

2,025,948

METHOD OF GROUTING BY CHEMICAL MEANS

Lars R. Jorgensen, Berkeley, Calif.

Application May 26, 1933, Serial No. 672,940

8 Claims. (Cl. 61—36)

This invention relates to an improved method of increasing the bearing area of piles, walls, foundations, etc., the solidification of poor rock and concrete, the shutting off of water in oil wells, dams, foundations, etc., making water-tight cut off walls and the like.

Certain chemicals are injected in a certain way, through conduits conveniently placed, into the granular or porous material to be solidified. These chemicals react upon one another and precipitate a gelatinous substance or mortar which fills out the voids present in the granular material and glues the particles together consolidating them into a solid mass.

In general it is known that sodium silicate will react with several salts and form a precipitate of a gelatinous nature.

In my invention I use sodium silicate for impregnating the mass to be solidified, as is common practice. Whenever necessary I first subject the mass to be solidified to compressed air in order to drive out any surplus water, as for instance may be present in an oil well, and to expand the pores and voids to facilitate the penetration of the sodium silicate into the fine voids.

Moist ground is not detrimental to the working of this process, but total water-soaking may dilute the sodium silicate to an undesired degree.

Should the ground contain chemicals which are detrimental to the success of the solidification process, these chemicals should be dissolved or reduced by introducing water or the proper solution of chemicals or gases, which will dissolve or reduce these undesirable chemicals. Compressed air may be used to again drive these solutions out of the zone to be solidified previous to injecting the solidification chemicals.

The exact proportion to use depends upon the nature and condition of the soil or material to be solidified. Various combinations can be used for the second injection. Cheapest and best results will be obtained by the use of such mixtures as calcium chlorides and magnesium sulphate or a mixture of calcium chloride and sulphate of aluminum, or a combination of calcium chloride and most any inexpensive sulphate.

Any of these combinations are to be injected into the sodium silicate impregnated material in order to produce the necessary chemical reaction and subsequent solidification during a predetermined time interval. In many cases it is desirable to lengthen the time interval of setting. This may be done by introducing certain substances into the sodium silicate solution before injecting it into the material to be solidified.

Where a high mechanical strength is not essential, somewhat less than concentrated solutions can be used.

Prolonging the setting time reduces the necessary pump pressure and pump capacity and widens the possible area, which can be solidified from one injection conduit.

Generally the sodium silicate is injected into the mass to be solidified first, but cases may well be found where it is desirable to inject the other chemicals first, or to alternate this procedure for adjacent injection conduits in order to more fully utilize all chemicals present.

Should the ground contain chemicals or gases, which will combine with other chemicals, such fact will be taken into consideration when injecting these other chemicals to complete the process of solidification.

In certain material solidification may be made more complete by cutting out some portion of the calcium chloride solution or combination solution and substituting therefor an equivalent amount, chemically, of gel-forming gas such as carbon dioxide or the like. The flow of gas meets less resistance in the voids and will drive the solutions further away from the injection conduits, besides helping the forming of an intimate mix of the various gel-forming substances.

In the drawings—

Fig. 1 is a vertical sectional view, illustrating a double piping system for injection purposes;

Fig. 2 is a vertical sectional view, illustrating the use of my invention with a concrete (or wooden) pile having a central, longitudinal hole therethrough;

Fig. 2A is a view similar to Fig. 2 but illustrating the uniting of unconnected, superimposed piles;

Fig. 3 is a sectional view taken on the line III—III of Fig. 2, looking in the direction of the arrows;

Fig. 4 is a vertical sectional view, illustrating the use of my invention with a concrete wall;

Fig. 5 is a sectional view taken on the line V—V of Fig. 4 looking in the direction of the arrows;

Fig. 6 is a vertical elevation, illustrating a modified application of the invention in connection with a wooden (or concrete) pile;

Fig. 7 is a sectional view on the line VII—VII of Fig. 6 looking in the direction of the arrows;

Fig. 8 is a vertical sectional view, showing the formation of a foundation under a driven pile; and

Fig. 9 is a vertical sectional view, illustrating

the formation of trenches and other excavations.

Referring to Fig. 1, a hole A is first made at any desired angle into the rock or material AA to be solidified, of a diameter somewhat larger than the diameter of the outside groutpipe B. Groutpipe C is of a diameter small enough to be inserted into pipe B and leave sufficient area for the solidification chemicals to flow in the annular space between the two pipes.

The two pipes B and C are provided with packing rings P at the lower end. The inside pipe goes through an end casting D provided with a stuffing box E and inlet opening F for the chemicals. The length G between the packing rings P can be varied from zero to several feet, by moving the two pipes relatively to one another, and it is of course through this space that the chemicals can penetrate into the rock or other kind of material to be treated. It is not desirable to just pump the chemicals into a long hole at one time as a very irregular solidification would result.

The inside pipe C is reserved for the cement grout or the like. The procedure of solidification using the device illustrated in Fig. 1 would be thus: The two pipes B and C are inserted into the top of the hole, or into the outer end of the hole, if the hole is horizontal, and the packing rings P set, say, five feet apart. The proper amount of sodium silicate is then injected through the annular space between the two pipes. Then the pipes are moved downward or forward as the case may be, say, five feet, and the performance is repeated until the lower or inner end of the hole has been reached.

If any particular zone took the sodium silicate freely and took a large amount, indicating a wide crack, its location is noted. The second solution is now injected as the first and the piping system pulled out of the hole in stages in the same manner as it was previously inserted.

When the zone which took a large amount of sodium silicate has been reached on the way out, cement grout, or the like, may be injected through the inside pipe C. As previously stated, the calcium chloride solution may be mixed with the cement grout, especially towards the end of the grout operation and the calcium chloride will then enter into combination with the sodium silicate previously injected, making the total combination one of great strength and tightness.

For making building stones, pipes, statuary, or the like, the metal forms, wooden forms, plaster of Paris forms, or the like, used for this purpose are first to be filled with the granular material to be used such as sand, gravel, stones, colored rocks, marble, or the like. The injection of the chemicals may then proceed through conduits and projections in the forms distributed at convenient points.

For increasing the bearing capacity of piles, transmission tower legs, 11, Figs. 2 and 2A, and 12, Fig. 6, and walls, 13, Fig. 4, it is intended to form projections, collars, flanges, or the like, *a* as in Figs. 2-7, around piles and along walls, etc., at various elevations or/and at the bottom of the piles, transmission tower legs or walls by means of chemically solidifying the surrounding soil after the piles, tower legs and walls have been placed in final position. Such collars will also be useful around pipes buried in fills for preventing leaks in joints or flow along the pipes. The piles and walls are to be provided with suitable conduits *b* for conducting the solidifying chemicals and with small pipes *c* leading to the exterior for

the chemicals to escape at predetermined elevations into the surrounding soil and solidify a certain volume of soil or material surrounding the piles or walls near the exit openings and make it an integral part of the pile or wall. For the purpose of solidifying a certain volume of material around the bottom of a transmission tower leg or the like, the injection pipe, perforated towards the bottom, is inserted alongside this leg in the hole made for the tower leg. This hole is then back filled and the solidification chemicals injected.

By this procedure the bearing capacity of the piles, tower legs, walls or foundations has been largely increased. The exit openings can be regarded as the middle plane of the solidified projection. The piles, walls, or foundations are to be provided with recesses, corrugations, sawtooth-like dents, or similar kind of roughness *d*, Figs. 2-7, at the intended location of the solidified zone in order to mechanically increase the bond strength and shearing strength between pile and collar or projection. Wooden piles can also be used, but the injection conduit may then most conveniently have to be fastened lengthwise to the outside of the wooden pile in a recess therein, as shown on Figs. 6 and 7, although a hole can be drilled lengthwise through the wooden pile, in which case the arrangement will be similar to that shown in Fig. 2.

In Figs. 6 and 7, *b* indicates the main conduit; *c* indicates smaller distributing pipes fastened around the pile in grooves *d* and connected with the main conduit *b* at *g*. The distributing pipes are provided with a series of small holes *c'* for the escape of the chemicals. The pipes *c* may entirely, or only partly, surround the pile. These pipes are securely fastened in grooves at predetermined levels, wherever it is desired to solidify a collar around the pile. Additional transverse grooves *d* are cut into the wood to increase the frictional resistance and shearing strength of the joint between collar and pile.

The chemicals are preferably introduced through a movable pipe *h*, see Fig. 2, inserted into conduit *b*, having its lower end provided with a packing ring, as shown on Fig. 1, and the upper end connected to pumps or other pressure sources. Some cement grout, or the like, may be used towards the very last of the operation in order to increase the bonding strength between the solidified projections and the piles or walls.

The soil into which piles are driven may consist of alternate layers of clay *e* and granular material *f*, Fig. 2. After driving the piles it may be desirable to solidify all the layers of granular material around the piles in order to obtain greater bearing capacity and solidarity. This can be done very efficiently by locating the injection conduit and exit openings in or on the piles themselves, Figs. 2 and 6, the exit openings being placed at the levels of the granular material, thus avoiding the driving of separate injection pipes.

In places where it is not practical or economical to drive ordinary bearing piles or sheet piles to solid ground such as rock or tight clay, hardpan, or the like, the material in the space between the bottom of the pile or wall and the hard ground *x* can most conveniently be solidified by means of forcing the chemicals through an injection pipe *j*, Fig. 8, inserted through a suitable conduit or hole *b* in or on the pile or wall and provided with openings at the bottom. This movable pipe *j* can be pressed or jetted down into the material below the pile or wall already in position. A column *t*, 75

Fig. 8, can thus be solidified between the bottom of the pile or wall and the hard ground. If desired, collars *a* can also be solidified around the pile at any predetermined elevation, especially at joints of two piles.

Sometimes it may be desirable to force out all the sodium silicate in the injection pipe before introducing the second chemical in order to minimize the tendency to plug up the injection pipe or the fine cracks. This can most conveniently be done by means of letting compressed air in behind the sodium silicate liquid at the time the proper amount has been introduced.

When making deep excavations, trenches or the like, as shown in Fig. 9, it is desirable to have the sides of the excavation stand up as nearly vertical as possible. This can be accomplished by solidifying a wall 21, 22 on each side of the proposed trench, excavation, or the like. In order that these walls will stand up better and act more efficiently as retaining walls or beams after the material between them has been removed, an adequate number of steel rods or pipes, acting as reinforcing members 23, are to be driven into the material before solidification, so located that they will take up the tension due to bending. The inside walls may be of sheet piling 24.

Having described my invention, what I claim is:—

1. A process of solidifying loose sand, gravel and other granular material surrounding piles, pile clusters, tower legs, fills or walls, which comprises injecting into a system of conduits embedded in or attached to the piles, tower legs, fills or walls or other building details a solution of sodium silicate, followed by calcium chloride in combination with a gel forming gas, the injection conduits being provided with exit openings at various elevations a considerable distance apart, whereby separate collars and projections of solidified material are formed around the piles and tower legs and on the face of the walls or other building details and below the bottom of the piles and walls at said exit openings.

2. A process of solidifying layers of loose sand, gravel and other granular material penetrated by piles or the like, by means of injecting through a system of conduits embedded in or attached to the piles sodium silicate and calcium chloride solution and a gel-forming gas in the proper chemical proportion.

3. A process of solidifying loose sand, gravel, and other granular material, loose rock, deteriorated concrete, or the like, by injecting a sodium silicate solution, followed by the injection of a calcium chloride solution and of a gel-forming gas in the proper chemical proportion.

4. A process of solidifying fissured rock, loose rock, deteriorated concrete, sand, gravel and other granular materials, which comprises the steps of

separately injecting a solution of a soluble silicate and a solution of calcium chloride in combination with a gel-forming gas.

5. A process of solidifying loose sand, gravel and other granular material surrounding piles, well casings, pipes, pile clusters, tower legs, fills or walls which comprises injecting into a system of conduits embedded in or attached to the piles, tower legs, pipes, fills or walls or other building details a solution of sodium silicate, followed by calcium chloride in combination with a gel-forming gas, the injection conduits being provided with exit openings at one or more elevations, whereby separate collars and projections or shells of solidified material are formed around the piles, well casings, pipes and tower legs and on the face of the walls or other building details and below the bottom of the piles and walls at said exit openings.

6. A process of solidifying loose sand, gravel and other porous material surrounding piles, well casings, pipes, tower legs, fills or walls, which comprises injecting into a system of conduits embedded in or attached to the piles, well casings, pipes, tower legs fills or walls or other building details a solution of sodium silicate, followed by a solution of calcium chloride in combination with a gel-forming gas, the combination being pre-cooled, the injection conduits being provided with exit openings at one or more elevations, whereby separate collars, projections or shells of chemically solidified material are formed around the piles, well casings, pipes, tower legs and on the face of the walls, fills or other building details and below the bottom of piles, walls and fills at said exit openings.

7. A process of solidifying loose sand, gravel and other porous material surrounding piles, well casings, pipes, tower legs, fills or walls, which comprises injecting into a system of conduits embedded in or attached to the piles, well casings, pipes, tower legs, fills or walls or other building details a solution of sodium silicate, followed by a solution of calcium chloride in combination with carbon dioxide, the combination being pre-cooled, the injection conduits being provided with exit openings at one or more elevations, whereby separate collars, projections or shells of chemically solidified material are formed around the piles, well casings, pipes, tower legs and on the face of the walls, fills or other building details and below the bottom of piles, walls and fills at said exit openings.

8. A process of solidifying layers of loose sand, gravel and other porous material penetrated by piles or the like, by means of injecting through a system of conduits embedded in or attached to the piles sodium silicate, calcium chloride solution and a gel-forming gas in the proper chemical proportion.

LARS R. JORGENSEN. 60