Nov. 16, 1943. S. STEUERMANN 2,334,228

PROCESS OF PRODUCING AN INTIMATE MIXTURE BETWEEN A MASS OF LOOSE MATERIAL AND FLUID OR FLUIDS

Filed July 1, 1939 2 Sheets-Sheet 1

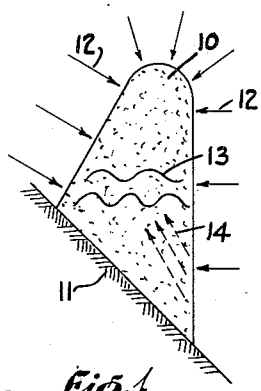


Fig. 1.

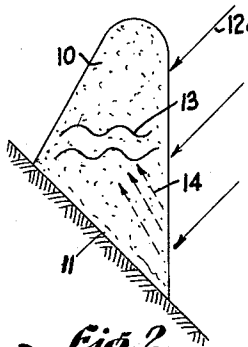


Fig. 2.

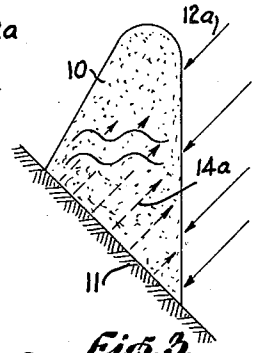


Fig. 3.

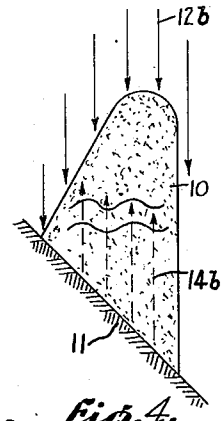


Fig. 4.

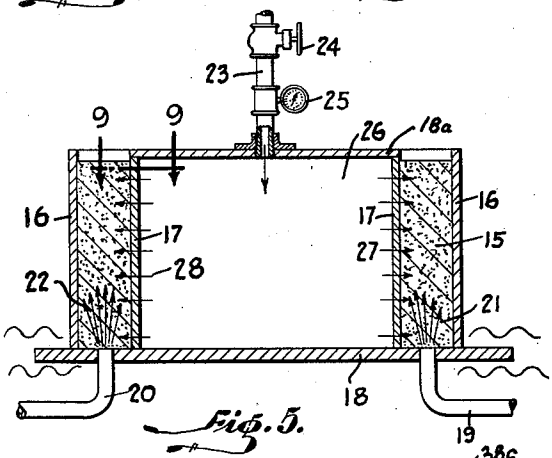


Fig. 5.

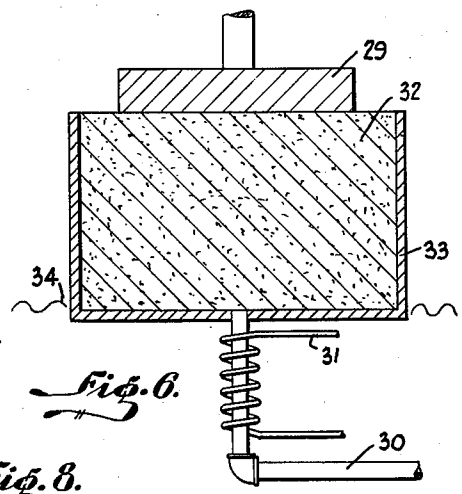


Fig. 6.

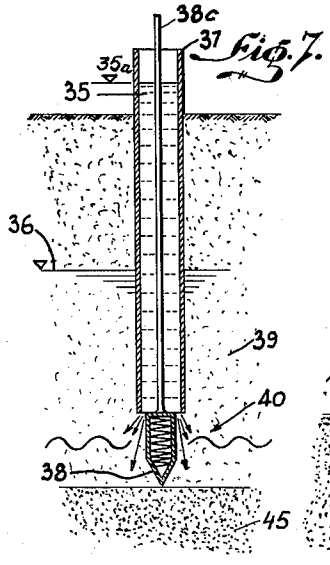


Fig. 7.

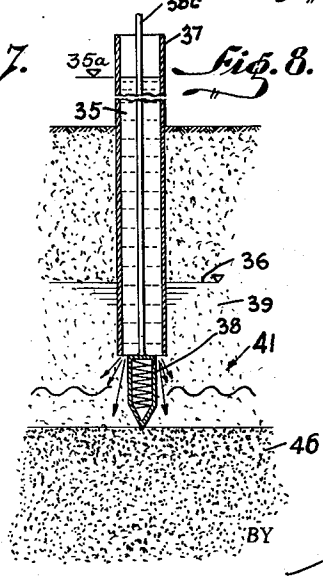


Fig. 8.

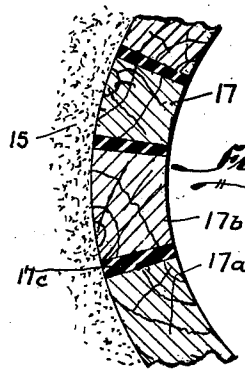


Fig. 9.

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PROCESS OF PRODUCING AN INTIMATE MIXTURE BETWEEN A MASS OF LOOSE MATERIAL AND FLUID OR FLUIDS

Filed July 1, 1939 2 Sheets-Sheet 2

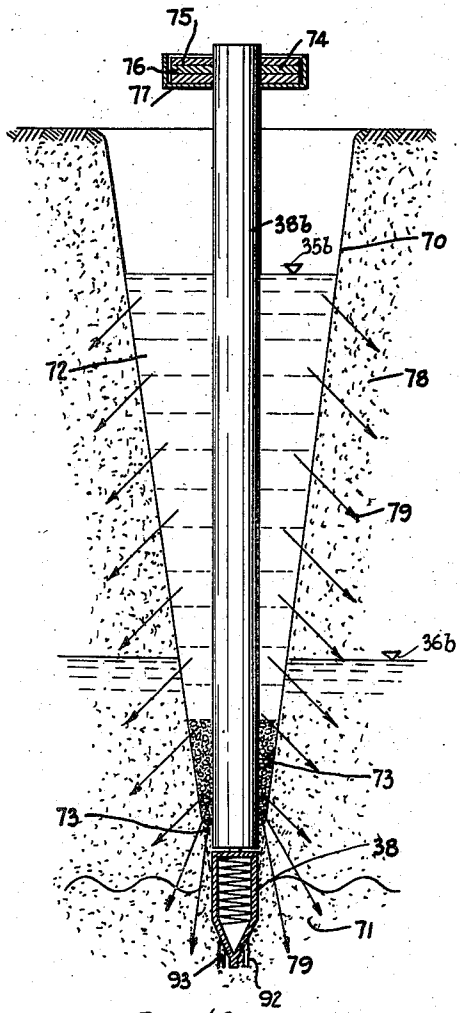
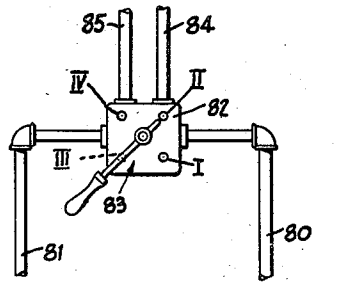


Fig. 10.



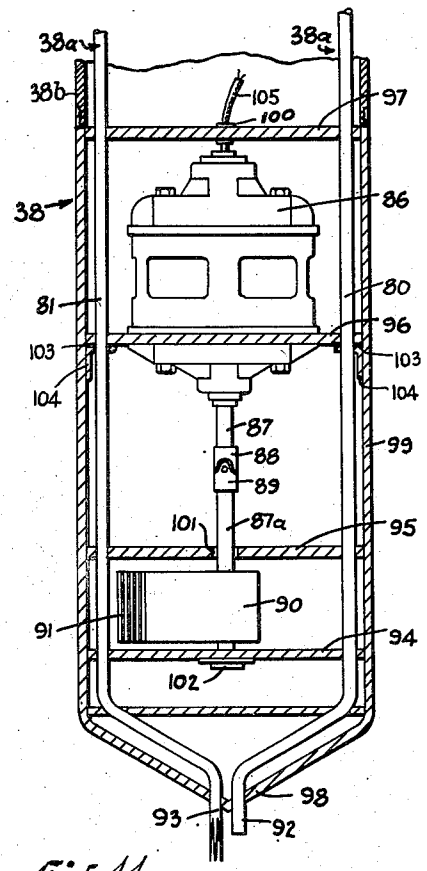


Fig. 11.

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Patented Nov. 16, 1943 2,334,228

UNITED STATES PATENT OFFICE

2,334,228

PROCESS OF PRODUCING AN INTIMATE MIXTURE BETWEEN A MASS OF LOOSE MATERIAL AND FLUID OR FLUIDS

Sergey Steuermann, New York, N. Y.

Application July 1, 1939, Serial No. 282,386

11 Claims. (Cl. 61—35)

The invention relates to a process of producing an intimate mixture between a mass of loose material which mainly consists of solid granules, and liquid or liquid-like fluid or fluids, as, for instance, water, cement paste, etc., particularly for use in connection with building or structural purposes or the like.

It will be, however, apparent from this specification that the process according to the invention may also be applied in a very convenient manner to other classes of the industry, as for instance, to chemical, pharmaceutical, agricultural, mining or similar industries.

The process according to this invention generally consists in introducing a liquid or liquid-like fluid into a loose mass of granular particles in stacked or piled form while said mass is subjected simultaneously to vibration and applied pressure influences.

Not every liquid or liquid-like fluid is suitable for impregnation of a loose mass and vice versa, not every loose mass may be soaked or penetrated by the liquid. Primarily, the degree of fineness of the granules of the loose mass on the one hand and the viscosity of the liquid on the other hand is to be taken in consideration, and particularly in the event that the liquid or liquid-like fluid is a suspension. It can be said first of all, that the smallest granules of the loose mass should be at least ten times greater than the thickest constituent prevailing within said suspension.

The vibration can take place in a direction from above said mass (surface vibration), or laterally (external vibration), or in case of large quantities of said mass being subjected to the influence of vibration, the vibrations may take place within said mass (internal vibration).

The required intensity, the amplitude and the frequency of the vibrations may be readily determined by experience. The frequency of the vibrations is of less importance in connection with the new process than, for instance, where the mixed concrete is settled by vibration, the vibration in the new process being increased by virtue of the liquid motion within the loose mass. By the movement of the liquid within the loose mass the static friction prevailing between the granules is transformed into a hydrodynamic friction which is less than the static friction, whereby the effect of the vibration of the loose mass will be enhanced.

On the other hand, the vibrations increase considerably the hydraulic conductibility of the loose mass and decrease the filter resistance thereof. This will be apparent if the loose mass is considered as a plurality of sieves which are superposed upon each other whereby the oscillations of these sieves facilitate the penetration of the material to be sieved (in this instance: the liquid); each oscillation opening a path for the liquid between the granules of the loose mass. The vibrations facilitate and simultaneously direct the movement of the liquid within the loose mass, as the liquid moves in a direction of the lowest resistance, that is, to those points where the vibrations within the loose mass are the greatest.

The physical characteristics of the mixture produced by the process in accordance with this invention may be varied and consequently the various applications thereof are based on the fact that said applied pressure and the direction of the liquid flow within the loose mass may be varied.

The applied pressure may be varied in its direction with respect to the particles of the loose mass and with respect to its degree or amount and extent, always within the limit of the crushing strength of said particles. In this disclosure under "applied" pressure is understood any additional pressure or any applied external pressure exerted upon said mass, other than that which is inherently produced by the vibrator device or treated mass by virtue of their weights proper.

The liquid or liquid-like fluid which penetrates the loose mass and flows between the granules thereof is preferably directed from below in a substantially upward direction through the loose mass. This particular flow is of great necessity when a pseudo-liquid (suspension, emulsion, etc.) is used as the liquid for mixing with the loose mass, otherwise a complete permeation of the mass would not result.

A liquid which flows freely within the loose mass produces a pressure of flow on the individual granules of the loose mass, which pressure of flow depends upon the quality of the liquid and the speed of flow thereof. If the flow of liquid or the vertical component thereof is upwardly directed, the pressure of the liquid flow is directed against the action of gravity so that the granules of the loose mass will be transformed into a state similar to that of a suspension. When the intensity or rate of liquid speed is so great, that the pressure of the flow is equal to the action of gravity on the loose mass in a given section, the flow pressure and flow speed are called the "critical" pressure and speed. If the speed is increased the mass will be loosened.

If an applied pressure is exerted externally of the mass and in a downward direction upon the mass in addition to the force of gravity thereof, the speed of the liquid from below said mass, as explained above, can consequently be increased to such extent without attaining the critical speed, so that the mixture treatment of the loose mass will be quicker and more efficiently effected.

If an outside pressure is exerted in a lateral direction relatively to the mass while said mass is being under treatment of vibration and liquid flow, this pressure will produce an additional decrease of the void space between the particles of

the loose mass without considerably changing the corresponding critical speed.

In general, the application of the new process produces the following characteristics and properties of the loose mass mixture: The hydraulic conductibility increases; the liquid raises the quickest within the section of said increased conductibility; the mix is complete within the zone of vibration; the static friction between the granules is changed into hydrodynamic friction; and the volume of voids of this loose mass, or the amount of liquid filling out this space volume is considerably reduced to a minimum while outside pressure is exerted. The obtained mixture becomes in the course of the process a viscous mass or paste-like liquid.

If the liquid or liquid-like fluid selected is water, the complete penetration of the mass may be obtained also if the liquid is made to flow from above downwardly through the mass.

In such case, which presents the simplest working condition, a suitable paste-like liquid or mass in a viscous state is, at least temporarily not obtained, but the water column above said mass will penetrate the mass from above, thus simultaneously applying an external pressure from above (in addition to the gravity of the mass) to said mass so that the void space between the particles of the loose mass may be reduced to a minimum during such procedure.

It is therefore an object of the present invention to provide means for producing an intimate mixture between a mass of loose material and liquid or liquids while said mass is simultaneously vibrated and subjected to external pressure or pressures other than that caused by the force of gravity of said mass.

It is another object of the present invention to provide means for introducing said liquid or liquids into said material from either above or below while said mass is being vibrated and subjected to external pressure.

It is another object of the present invention to provide means for simultaneously heating said mixture during said process.

It is still a further object of the present invention to provide means for heating said liquid before it is introduced into said mass.

Still another object of the present invention is to provide means for stirring said mass while it is subjected to the aforesaid treatment; and as a further object to provide means for introducing an electric current into the zone of the mass to be treated.

A still further object of the present invention is to provide means for simultaneously exerting a pressure against the said mass while it is vibrated and penetrated for mixture by the liquid, said pressure being directed either laterally or from above against said mass.

Still another object of the present invention is to provide means for chainging the direction of and varying said pressure.

Yet another object of the present invention is to provide the apparatus for producing vibrations with conduits for introducing said liquid at any desired point or zone within said mass where said vibrations are to be directed.

The foregoing primary features and objects of the invention and other corollary features are realized in the preferred embodiments of the process and apparatus herein disclosed, the same being set forth in the following detailed specification which is based upon the accompanying drawings in which:

Figs. 1 to 4 show diagrammatically various applications of the new process.

Fig. 5 shows a sectional view in diagrammatic form of a device for carrying out the process of the invention.

Fig. 6 is a sectional view of a modified form of a device by which the process may be realized.

Figs. 7 and 8 show different steps in effecting the process applied in a given section of the soil.

Fig. 9 is a partial sectional view along 9—9 of Fig. 5.

Fig. 10 shows diagrammatically the application of the new process for building purposes.

Fig. 11 shows an apparatus used in connection with the new process.

Referring now particularly to Figs. 1 to 4 there is shown a granular mass 10 forming a zone or section of the soil, the untreated or already treated section 11 thereof forming a bearing area of the soil section 10 to be treated which may be inclined relatively to said section 11. The pressure 12 upon mass 10, the vibrations 13, and a flow of liquid 14 are simultaneously impinged upon the mass 10 in a predetermined direction (Figs. 1 and 2).

Fig. 2 shows the applied pressure 12*a* being directed perpendicularly to the bearing area 11, while the influence of the flow of liquid 14 and of the vibrations 13 remain unchanged with respect to Fig. 1.

In Fig. 3 the pressure 12*a* is directed perpendicularly against the bearing area 11 whereas the flow of liquid 14*a* is directed opposite to said direction of said pressure 12*a*. As it is apparent from Fig. 4, the pressure 12*b* may be directed in vertical direction but at an angle other than the perpendicular with respect to the bearing area 11 (from above against said bearing area 11), whereas the flow of liquid 14*b* is directed from said area 11 and in upward direction opposite to that of said pressure 12*b*.

From the preceding description it is evident that the said external pressure, vibrations and liquid flow are the main features and considerations in establishing the process of the present invention and that all of them may be applied in various ways and directions relatively to each other and to the mass section to be treated. It is further understood that the mass substance to be treated according to the process of the invention may be composed of any suitable material or materials although in this instance, by way of example only, the application of the process according to the invention is contemplated more specifically in regard to the treatment of sandy soil.

Fig. 5 shows a device for producing concrete pipes, conduits or the like, the concrete aggregate 15 being filled within the tubular device consisting of a stationary wall 16 and a displaceable wall 17. Walls 16, 17 and the concrete aggregate 15 are positioned on a platform 18 to which vibrations are imparted and in which provision is made for the passage of pipes 19, 20 to conduct the liquid-like fluid, which in this instance may be cement glue or cement paste from below through the aggregate 15 in upward direction, as indicated by the arrows 21 and 22. A conduit 23 is mounted upon a cover plate 18*a* supported by wall 17. This conduit 23 is controlled by valve 24 and pressure meter 25 which permit the entrance of compressed liquid or air within the space 26 between the wall 17, so that when the compressed liquid or air is introduced into said space 26 the wall 17 will be pressed in the direc-

tion of the arrows 27 and 28 in lateral direction and guided along plate 18a and platform 18 and substantially perpendicularly to the flow of said cement paste indicated by arrows 21 and 22.

Fig. 9 shows in section a portion of the displaceable wall 17 comprising wall sections 17a, 17b, which are interconnected by strips 17c of yieldable, preferably rubber material, so that the whole wall 17 will give as compressed air or liquid is introduced within space 26 of the device. During formation of the concrete conduit between walls 16 and 17 and while air or liquid pressure and cement paste are applied in the aforesaid particular manner, vibration is imparted to the aggregate 15 through vibrating platform 18 and by any known and suitable device. Thus the cement paste will thoroughly commingle and become dispersed within the aggregate 15 between the granules thereof and pressure and vibrations will cause the space volume between the granules to be considerably reduced and thus produce a compact concrete.

The applied pressure indicated by the arrows 27 and 28 in Fig. 5 may also be exerted by mechanical means 29 as indicated in Fig. 6. The liquid-like fluid (which may be for instance bitumen) passing through conduit 30 is subjected to a change of temperature by the heating coil 31 positioned at the end of said conduit 30. The aggregate 32 is placed in receptacle 33 which is subjected to vibrations as indicated by the undulated line 34 while the process is being effected.

Figs. 7 and 8 shows applications of the process for densifying a section of the soil to be treated. To this end, a pipe or conduit 37 is driven into the soil or ground 39 to section 40. Within conduit 37 is passed vibrator 38 provided with extension 38c projecting through conduit 37. When vibrator 38 is brought to the proper zone 40 to be treated water or similar liquid-like fluid is poured into the conduit 37 until a level, say 35a, is reached and now during vibrations produced by vibrator 38 this water column is maintained, so that not only is there a supply of liquid present to flow to the treated zone 40 but also there is provided an outside pressure formed by said water column above ground water level 36. After the vibrator 38 has been agitated within section 40 under the above conditions and for a definite period of time, pipe 37 is retracted to section 41 (Fig. 8) and vibrator 38 is worked within said section to densify the same. The soil after treatment is indicated by numerals 45 (Fig. 7) and 46 (Fig. 8).

Of course, it is understood that the vibrator 38 which is preferably wedge-shaped may be used to direct into the soil conduits, piles, etc. by being first lowered to the ground and water caused to flow out of a nozzle toward the ground under the vibrator. For this purpose, a vibrator 38 according to Fig. 11 may be employed.

When water flows into the soil and rises rapidly enough to approach the critical velocity of the water and the vibrator 38 is agitated, the soil will be softened and will be transformed into a paste-like state. The conduit itself may be then the external pressure means or an additional external pressure may be applied to the conduit as by means of a weight as particularly shown in Fig. 10. Vibrator 38 will thus sink into the soil and conduit 37 will follow the vibrator into the paste-like soil up to the desired depth thereof. The vibrator 38 is then withdrawn, whereas the conduit remains in the soil.

A similar procedure may, of course, be followed to retract or withdraw piles, conduits, etc., from within the soil.

It is to be noted that in all these examples applied pressure, vibrations and liquid-like fluid flow are the chief characteristics of the process to be executed.

Fig. 10 shows the application of the process according to the present invention for introducing the vibrator 38 to the desired depth as well as for the densification of sandy soil thereafter. To this end the vibrator 38 may be coupled with conduit 38b which is of substantially the same diameter as that of the vibrator 38. The vibrator will first be lowered to the soil while water is supplied through nozzles 92, 93 into ground 78. Vibrator 38 is then agitated while external pressure is exerted toward the ground by weight 77 consisting of exchangeable elements 74, 75, 76 so that the ground becomes thereby a paste-like mass particularly that portion of the ground surrounding and in the vicinity of the vibrator 38 and the entire arrangement 38, 38b can readily be sunk into the ground even if thin layers of clay material etc. are contained in said ground or if mixtures of such material are present therein. By virtue of the ground being densified by application of the process thereto, a funnel-shaped hole 70 will first be formed. In Fig. 10 the condition is shown after the vibrator 38 has reached the desired depth within ground 78 at the zone 71 which is the first section to be densified from below in upward direction.

When said ground is to be densified section by section in accordance with the process shown and described with respect to Figs. 7 and 8, the supply of water may be shut off first at both nozzles 92, 93 but a column of water 72 within the funnel-shaped hole 70 is maintained at the water level 35b and water is pumped from any outside source to obtain said level, since water will penetrate and seep through the surrounding ground 78 and 71 (see arrows 79). Another possibility is to supply water from below through the nozzle 92, 93 to cause the water to rise from below upwardly but with a speed inferior to the critical speed (whereas the supply of water from above is not contemplated at all). In both instances, the funnel-shaped hole 70 is to be supplied with material (earth) 73 during the application of the process from section to section so that the supplied material may simultaneously be densified while the vibrator and the conduit 38b are retracted upwardly section by section.

Experiments have taught that the loose material 73 supplied to the funnel 70 will have at least the same density and bearing power as the densified soil surrounding said funnel.

If within the funnel 70 a concrete body is to be built up it will suffice to choose as material 73 an aggregate (concrete forming material) and to impinge thereupon from below through nozzle 93 (instead of water) cement paste or any other binding agent, in upward direction and water nozzle 92 is shut off. It is immaterial if the concrete mass is built up below the ground water level 36b since the slowly rising cement paste causes the water to move upwardly within the aggregate mass without becoming liquified. Simultaneously the mass is jarred or vibrated by vibrator 38 and the latter is then retracted together with conduit 38b during such procedure.

In case that one works in very deep depths it might be preferable to arrange within conduit

38b one or more additional vibrators with respect to the main vibrator 38.

It is further to be observed that in Figs. 7 and 8 the water column 35 is confined within conduit 37, thereby directing the flow of said water directly to the zone 40 being treated, whereas according to Fig. 10 the liquid or liquid-like fluid 72 penetrates soil 78 above vibrator 38 as well as directly to the zone 71 mainly due to vibration and pressure applied thereto.

When the vibrating apparatus is introduced into the ground it will exert either by virtue of force of gravity or/and under an additional weight connected to the vibrator a pressure from above upon the loose mass 71. In order that the ground, which may be a piled dam or part thereof, is transformed into a paste or liquid state to permit the introduction of the vibrating apparatus without flushing out any sand or removing the same from the surrounding soil, the flow of liquid in this instance, water, is introduced from below in an upward direction as heretofore stated. On account of an applied pressure from above due to weights 74 and conduit 38b the flow of water can be effected relatively rapidly in an upward direction without exceeding the "critical" speed thereof.

When the vibrating apparatus is introduced into the ground the water flows from below in an upward direction (with a speed close to the critical one) and the external pressure is exerted from above in downward direction, whereas vibrations are simultaneously produced in the zone or section where the liquification of the soil is desired.

Examples of practical uses of the new process which may be designated as "pressure-vibroflotation" have been described herein.

Referring again to the example, shown in Fig. 5, a wall of the mold is made expansible and may exert a lateral pressure of up to about 25 atmospheres in the direction of the arrows 27, 28. The mold is filled with loose aggregate (broken stones and ballast, gravel, coarse sand, etc.) and the cement glue is pressed into said material, the ratio between the amount of water and that of the cement in said cement glue being equal or greater than 2 to 1. The introduction thereof into the aggregate is effected from below through particular nozzles under a pressure of .1 to .2 atmosphere above atmospheric pressure, the mold being simultaneously vibrated at the rate of about 3000 vibrations per minute.

Since the pressure is exerted in lateral direction, the speed of the cement glue or paste in upward direction should not be too great; therefore only a relatively small pressure of .1 to .2 atmosphere above atmospheric pressure is to be selected. Simultaneous pressure and vibrations cause a high densification of the aggregate to a minimum of space volume prevailing between the constituents thereof, so that an economical consumption of a cement will be reached, while the concrete body, obtained thereby will possess a very high density and strength.

In the second practical example shown in Figs. 7 and 8, the densification of soil for building purposes or of dams is explained. In the event that pure water is employed as fluid and not water with admixtures of trass, puzzolane, loam or clay or other sealing agents, the water may flow from above in downward direction to the soil to be densified.

Naturally the ground has to consist of granular material as for example, coarse sand, sand or gravel having relatively small intermediate layers or admixtures of clay or the like of non-granular character.

If the flow of water is desired from above in downward direction, this may be easily obtained by a water column above the section to be densified, either by increasing of the present ground water level or by creating an artificial water level. To this end, it is sufficient to pump into the opening above the vibrator a sufficient amount of water, thus further supplying water, so that the water level is maintained at the desired height. The water column produces during the flow of water from above in downward direction an additional pressure on the mass to be densified, so that a minimum of void volumn between the particles of the mass is obtained, whereby the granular particles settle readily into a compact form without being crushed. The vibrator may not itself be equipped with nozzles. In this instance, the introduction of the vibrator to the desired depth may be effected by boring holes into the soil, but then the change of the mass to be treated, temporarily at least, into a liquid state has to be disregarded.

The densification is effected sectionwise from below in upward direction by supplying material (earth), as each section is densified and the vibrator is retracted from one section to another. Therefore, each section is simultaneously vibrated, pressed and impinged upon by water. A suitable vibrating device for use in connection with this process is illustrated in Fig. 11. The device consists of a housing 99 which is watertight and is adapted for centrally placing therein driving means, as for example, an electric motor 86. Motor shaft 87 is connected through a universal joint or coupling 88—89 with the shaft 87a of the eccentric weight 90—91. Within the housing 99 there is provided the partition 97, forming the upper closure of said housing, whereas the electric motor 86 is supported on plate 96 which rests upon angle pieces or brackets 104. Between the angle pieces 104 and plate 96 there is positioned an insulating washer 103 in order to further keep the motor watertight. The current supply to motor 86 is effected by cables 105 which may pass through a watertight bushing 100 provided in the closure 97. The shaft 87a of the eccentric 90—91 is journalled on bearing 102 of the lower closure plate 94 and passes with play through an opening 101 of the partition 95. When motor 86 is set in motion the eccentric arrangement 90—91 will rotate and reciprocate within the space formed by the partitions 94, 95 and impart lateral thrust to the partition 95 since coupling 88—89 will give. Bearing 102 and guide opening 101 transfer the vibrations of the eccentric weight 90—91 through partitions 94, 95 to housing 99. Housing 99 is somewhat tapered or wedge-shaped at its end 98. Through housing 99 and outside of the range of the eccentric weight there pass conduits or pipes 80, 81 which terminate at one end thereof into nozzles 92, 93, respectively. 93 is a nozzle which is preferably designed for supplying cement paste therethrough to the mass to be treated whereas nozzle 92 permits water or similar fluid to be conducted to the desired place below the vibrator during the operation.

Pipes or conduits 80, 81 extend over the other end of the housing 99 (as indicated for instance in Figs. 7 and 8) to a fourway cock or valve 83 which permits the connection of pipes 80, 81, with respective hoses or flexible pipes 84, 85. In

the particular position II—III shown in Fig. 11 cock or valve 83 permits the cement paste to flow from hose 84 to pipe 81 whereas in the position I—IV hose 85 is connected to pipe 80 for supplying water therethrough.

Of course it is understood that regulation of pressure and speed of the different liquid or liquid-like fluids through the supply pipes may be effected in any convenient manner, for instance, by a regulating valve (not shown) connected with said cock 83.

The selected liquid or liquids may have any affinity with or may chemically react with the soil.

Although I have described in considerable detail some specific examples of devices and processes according to my invention to more clearly define the invention, the latter is not to be regarded as limited in any way either by the foregoing particular description of the theories which I entertain and to which I attribute the benefits of the process or by the specific examples given except in so far as such limitations are included within the terms of the accompanying claims, in which it is my intention to claim novelty inherent in my invention as broadly as is permissible in view of the prior art.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent, is:

1. The process of converting a loose mass comprised of solid granular particles and located within the soil to an intimate mixture with a liquid, which consists in simultaneously, subjecting said particles to vibrations, compressing said mass thereby reducing the void space between the particles by applying an external pressure upon said mass, and directing into said mass a flow of said liquid; and adjusting the intensity of said liquid flow with respect to said externally applied pressure as to incorporate said liquid within the compressed mass.

2. The process of converting a stacked loose mass comprised of solid granular particles and located within the soil to an intimate mixture with a liquid, which consists in simultaneously, subjecting said particles to vibrations, compressing said mass by applying to said mass an external pressure whereby to reduce the void space between said particles, and directing into said mass a flow of said liquid in the direction opposite to that of said external pressure; and adjusting the intensity of said liquid flow in such manner that the pressure of said liquid flow within the compressed mass prevails over said external pressure, whereby said mixture is permeated by said liquid as to assume the quality of a pasty liquid.

3. The process of converting a loose mass comprised of solid granular particles and located within the soil to an intimate mixture with a liquid, which consists in simultaneously, subjecting said particles to vibrations, compressing said mass by external pressure thereby reducing the void space between the particles to a minimum, and directing a flow of liquid into said mass in the direction opposite to that of said external pressure; and adjusting the intensity of said liquid flow in such manner that said external pressure prevails over said pressure of said liquid flow within said mass.

4. The process of converting a stacked loose mass comprised of solid granular particles and located within the soil to an intimate mixture with a liquid, which consists in simultaneously, subjecting said particles to vibrations, compressing said mass by a water column producing an external pressure on said mass thereby reducing the void space between the particles to a minimum, and directing a flow of said liquid into said mass; and adjusting the intensity of said liquid flow in such manner that the component of the pressure of said liquid flow within the compressed mass is directed in the direction of said external pressure of said water column applied to said mass.

5. The process according to claim 1 wherein said liquid consists of a liquid binding agent.

6. The process according to claim 1 wherein the vibrations are effected at a predetermined level and within the loose mass.

7. The process according to claim 1 wherein within the mass under treatment a pile is moved relatively thereto.

8. The process of converting earth material comprised of solid granular particles and located within the soil, to an intimate mixture with water, which consists in simultaneously, subjecting such particles to vibrations, compressing said earth material by applying an external pressure in form of variable mechanical weight upon said earth material thereby reducing the void space between the particles, directing into said earth material a flow of water; and adjusting the intensity of said flow of water with respect to said external pressure so as to incorporate said water within the compressed earth material.

9. The process of converting earth material comprised of solid granular particles and located within the soil, to an intimate mixture with water, which consists in simultaneously subjecting such particles to vibrations, compressing said earth material by applying an external pressure in form of a water column upon said earth material thereby reducing the void space between the particles, and adjusting the height of said water column so as to direct some of the water of said column into said earth material and to incorporate said directed water within the compressed earth material.

10. The process of converting an aggregate mass to an intimate mixture with cement paste, said mass being comprised of solid granules and located within the soil; said process consisting in simultaneously, subjecting said granules to vibrations, compressing said aggregate mass by applying an external pressure in the form of a water column upon said mass thereby reducing the void space between its granules, and directing into said mass a flow of said cement paste; and adjusting the intensity of said cement paste flow with respect to said external pressure of said water column so as to incorporate said cement paste within the compressed aggregate mass.

11. The process of converting an aggregate mass to an intimate mixture with cement paste, said mass being comprised of solid granules and located within the soil; said process consisting in simultaneously, subjecting said granules to vibrations, compressing said aggregate mass by applying an external pressure in the form of a variable mechanical weight upon said mass thereby reducing the void space between its granules, and directing into said mass a flow of said cement paste; and adjusting the intensity of said cement paste flow with respect to said external pressure so as to incorporate said cement paste within the compressed aggregate mass.

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