April 21, 1953 J. S. ASKETH 2,635,696

APPARATUS FOR ABSTRACTING FLUIDS FROM AND DELIVERING FLUIDS TO AQUIFERS

Filed April 13, 1948 3 Sheets-Sheet 1

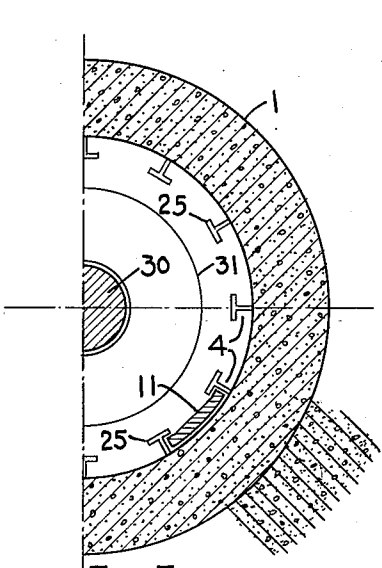


Fig. 3

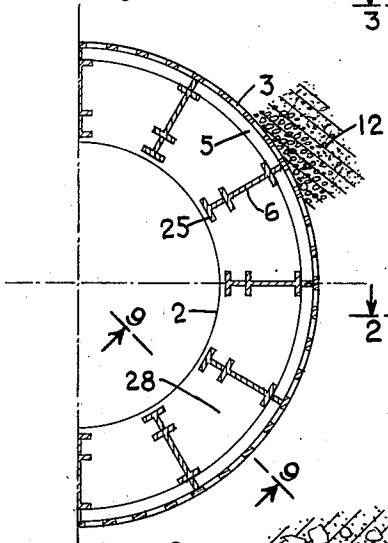


Fig. 2

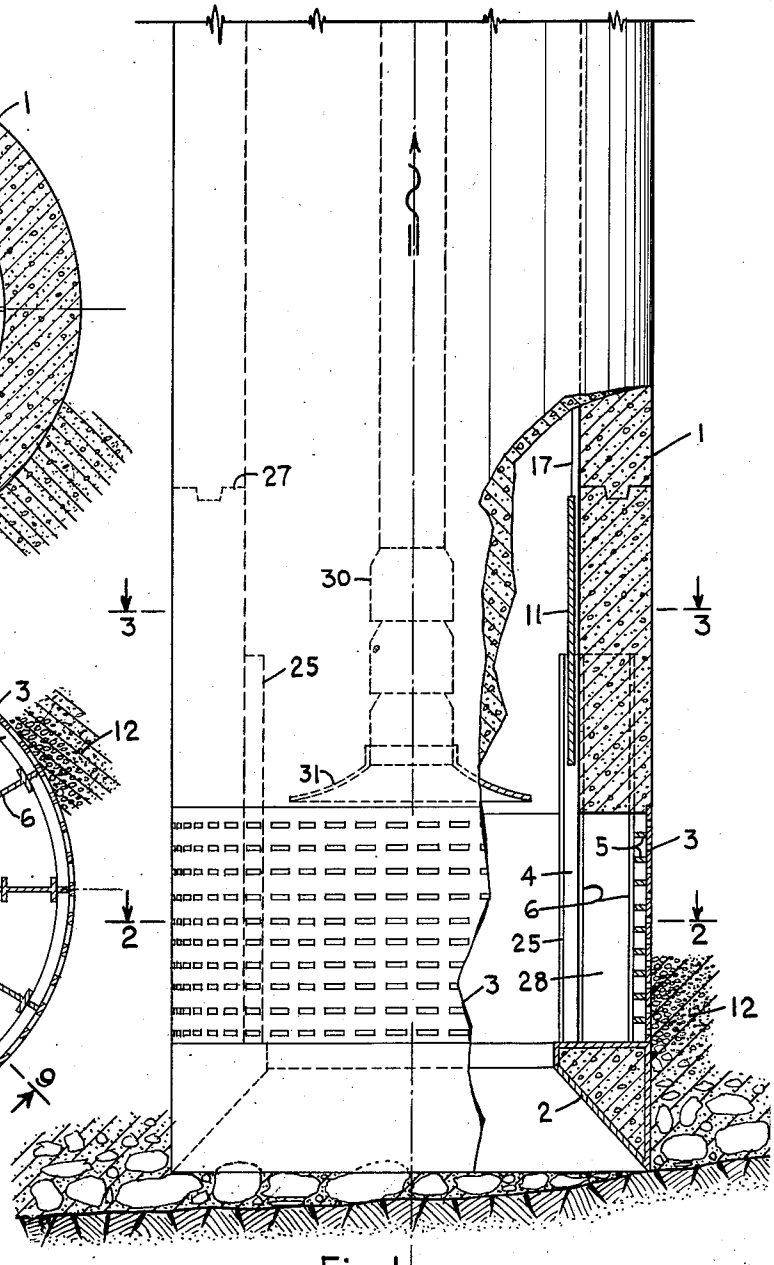


Fig. 1

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APPARATUS FOR ABSTRACTING FLUIDS FROM AND DELIVERING FLUIDS TO AQUIFERS

Filed April 13, 1948 3 Sheets-Sheet 2

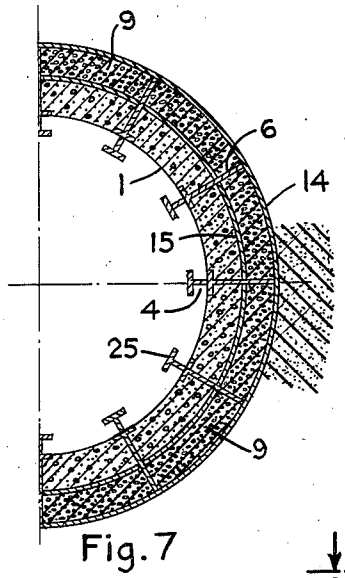


Fig. 7

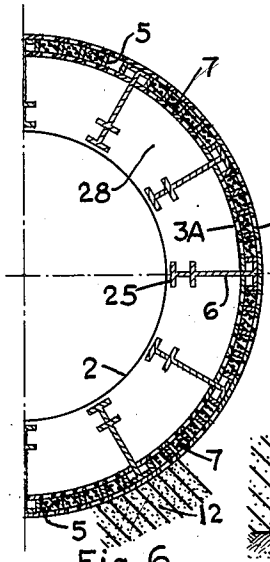


Fig. 6

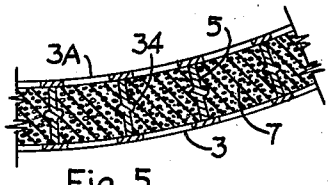


Fig. 5

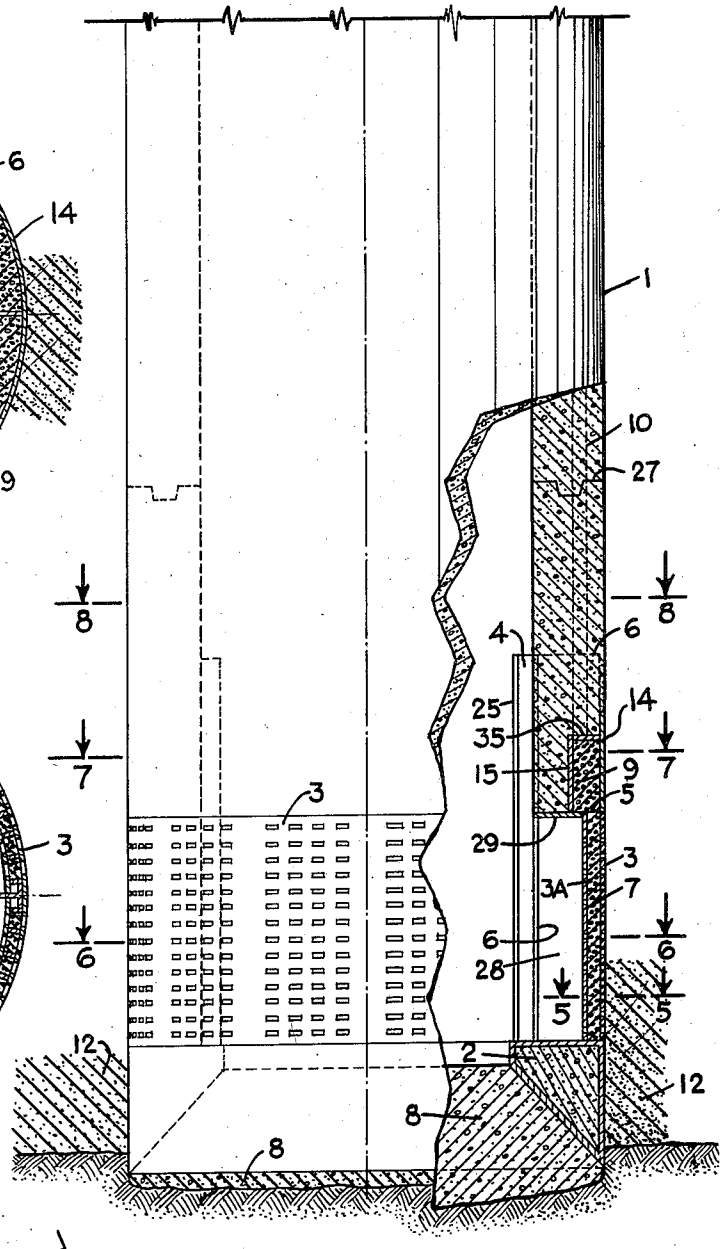


Fig. 4

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APPARATUS FOR ABSTRACTING FLUIDS FROM AND DELIVERING FLUIDS TO AQUIFERS

Filed April 13, 1948 3 Sheets-Sheet 3

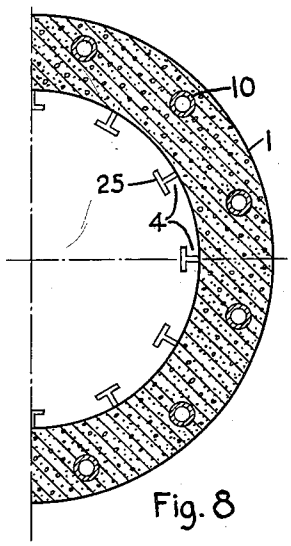


Fig. 8

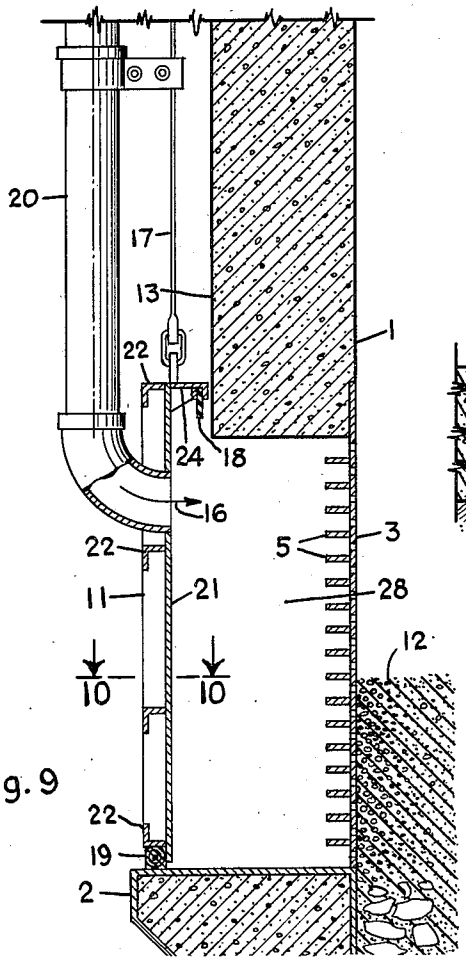


Fig. 9

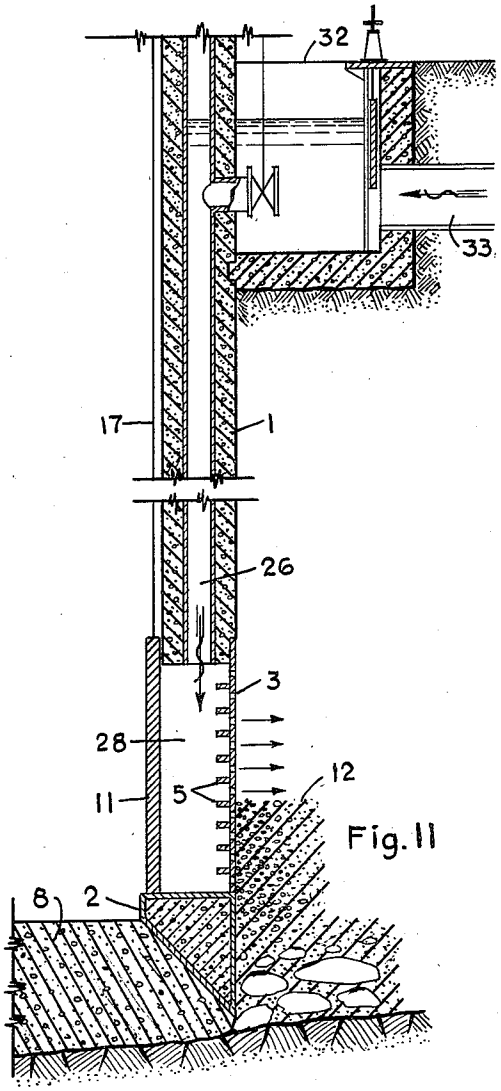


Fig. 11

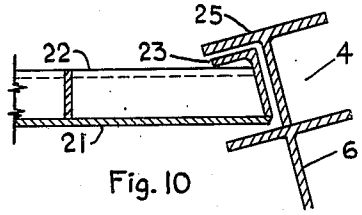


Fig. 10

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Patented Apr. 21, 1953

2,635,696

UNITED STATES PATENT OFFICE

2,635,696

APPARATUS FOR ABSTRACTING FLUIDS FROM AND DELIVERING FLUIDS TO AQUIFERS

Jordan Socrates Asketh, Jackson Heights, N. Y.

Application April 13, 1948, Serial No. 22,446

8 Claims. (Cl. 166—1)

1

This invention relates to apparatus for abstracting fluids from and delivering fluids to aquifers. One object of the invention is the abstraction of relatively large capacities of water from shallow aquifers by eliminating part of frictional losses therein and by utilizing practically all of the available water head in the ground. A further object of the invention is the reduction of screen clogging and incrustation to a minimum through the provision of a large screen area and the development of a gravel pack in situ from aquifer material around this screen, through which water may flow into the apparatus at a greatly reduced velocity. A still further object of the invention is to render feasible the abstraction of relatively large and undiminished water capacities from fine grain aquifers, with no sand entrainment, through the provision of a suitable gravel-packed screen restraining the flow of granules into the apparatus. A still further object of the invention is to make possible the recharge of underground formations with surface water of which the major load of suspended and colloidal matter has first been removed by mechanical settlement, coagulation and sedimentation.

The apparatus covered by the invention consists of a vertical shaft of reinforced concrete, steel, or other suitable material, installed or sunk in the ground, the lower end of which is provided circumferentially with a perforated wall or screen, flush with the outside face of shaft, permitting the inflow or outflow of water therethrough but preventing aquifer material from running into the shaft. This perforated wall is provided at its lower extremity with a heavy shoe solidly connected to the shaft-body by a plurality of columnar members, which also serve to divide the perforated wall region into a plurality of individual compartments and to brace the perforated wall against the thrust of the unconsolidated deposits from outside. Means are provided for isolating each or all of the compartments and shutting off the flow, partly or wholly, from the aquifer to the shaft and vice-versa. Means are also provided for developing the well and for forming a graduated gravel pack around the perforated wall or screen, thus insuring a supply of water free from entrained grains and precluding clogging of the perforated wall. Means are also provided for backwashing the aquifer in the vicinity of the perforated wall; also, for delivering into the aquifer partly treated surface water which can be stored therein and recovered later by pumping, said water being

2

subjected to natural filtration in its flow radially outward from the shaft to and through the aquifer material.

The invention is applicable to water abstraction from almost any aquifer, ranging from an extremely pervious one, containing poorly graded coarse grains, to a relatively tight one, containing well graded fine grains. It is particularly useful in shallow aquifers where efficient utilization of the available head is of utmost importance. By the provision in the invention of a greatly enlarged shaft diameter, the hydraulic gradient of the ground water flow in the proximity of the shaft is reduced substantially and the extra head made thus available may be converted into useful work and not wasted in the form of frictional losses within the aquifer. Moreover, a greatly enlarged shaft diameter may accommodate an adequately large but low circumferential screen, resulting in an additional head saving, while low and safe water infiltration velocities are maintained. In vertical well practice, drawdowns are limited to approximately the top of the screen, it being considered unsafe to draw the water level below this point. It is obvious then that an amply large but low screen will permit a greater drawdown and a larger discharge capacity.

The invention may also be applied advantageously to aquifers located adjacent to surface water bodies where there is a possibility of surface erosion due to wave action or flood flow. Ordinarily, pump houses for vertical wells are installed on foundations supported directly on the ground around the well. Where there is danger of erosion, special deep foundations have to be provided to prevent the structure from being undermined, and the problem becomes more complicated where the pump house has to be installed above flood level, at a considerable height in the air, and when the thrust of flood flow becomes large. The apparatus under the invention is heavy and sufficiently large to support the pump house and is safe from undermining, since it is carried deep down to firm foundation. Furthermore, it may withstand the flood water thrust successfully by combined gravity and cantilever action.

I am fully aware that shafts provided with screen at the bottom have long been in existence and the invention makes no claim on such apparatus broadly. The novel features of this invention are, apparatus for developing a graduated gravel pack during installation, apparatus for backwashing the aquifer with air, water or

any other fluid, apparatus for abstracting ground water from fine-grain aquifers with no entrainment of fine granules, and apparatus for recharging the ground with partly treated surface water, by utilizing a natural sand-gravel formation as a filter bed. In the accompanying drawings, wherein certain embodiments of the invention are illustrated:

Figure 1 is an elevation of the lower part of the shaft with a cut-away section showing arrangement of cutting shoe, perforated wall and columnar members.

Figure 2 is a half sectional plan on line 2—2, Figure 1.

Figure 3 is a half sectional plan on line 3—3, Figure 1.

Figure 4 is an elevation of the lower part of the shaft with a cut-away section illustrating the installation of a special gravel packed perforated wall, applicable to fine-grain aquifers.

Figure 5 is a part sectional plan on line 5—5, Figure 4.

Figure 6 is a half sectional plan on line 6—6, Figure 4.

Figure 7 is a half sectional plan on line 7—7, Figure 4.

Figure 8 is a half sectional plan on line 8—8, Figure 4.

Figure 9 is a part vertical section on line 9—9, Figure 2, showing gates for developing a graduated gravel pack, and for delivering surface water to aquifers.

Figure 10 is a part sectional plan on line 10—10, Figure 9, showing part of the gate inside one of its grooves.

Figure 11 is a vertical section of the shaft wall as used in delivering water to aquifers. This section is taken at the center line of one of the compartments formed by columnar members, as explained hereinbelow.

In Figures 1, 2, and 3, shaft 1 is shown, by way of example, as having a circular cross section and as being built of reinforced concrete. A conventional type of cutting shoe 2, is provided at the shaft's lower extremity which is rigidly connected to the shaft body by means of annularly spaced columnar members 6, dividing the annular space between the shaft body and cutting shoe into equal compartments 28, and transferring the superimposed load to the cutting shoe and thence to the ground. Flush with the outside face of the shaft, a perforated wall 3 is provided between cutting shoe 2 and shaft superstructure 1, Figures 1 and 2. This wall, continuous all around the shaft, is provided with a plurality of perforations, and the ratio of open to total area of perforated wall is made as large as practicable so that it will admit a less obstructed water flow into the shaft. Perforated wall 3 may be formed from suitable metal plates punched flat, rolled to proper curvature, and then secured in position surrounding columnar members 6 by welding or otherwise. As is well known, in commercial punching operations, the plate thickness cannot be greater than the least width of perforation, and since the latter must be sufficiently narrow to cause arching of the material outside the shaft, the perforated wall thickness is necessarily limited by the size of aquifer grains which is generally small. For this reason, the resisting strength of perforated wall 3 to earth pressures and secondary loads, prevalent during installation, is inappreciable, and uniformly spaced bars 5, rigidly mounted in position, are provided to stiffen the perforated wall and to transfer the outside load to the shaft structure. Said bars may be disposed either horizontally, as in Figures 1 and 2, or vertically as in Figures 4, 5, and 6.

In Figures 1 and 2, members 5 may be individual metal bars bent to the shaft's curvature, and properly spaced so as not to obstruct the water flow through the perforated wall apertures; or they may be formed of welded subway grating bent likewise to the shaft's curvature and secured in position by welding or other convenient method.

The bottom of the shaft may or may not be sealed, depending on local conditions. If, for instance, the shaft bottom rests on a clay formation, it may be desirable to place a seal or plug at the bottom, to prevent possible heaving of loose clay and to distribute the shaft-load to a larger area through the intermediary of said seal which may be of reinforced concrete placed under water. Such seal may be required if the shaft is to be used for delivering water to underground formations, as described later in this specification.

The shaft is normally constructed on the ground surface in sections and after installation of the perforated wall and completion of the lower section below construction joint 27, it is caused to sink through its own weight, by excavating and removing earth material from within the shaft. A second section is placed on top of the first, when construction joint 27 reaches at or near the ground surface, and the shaft is allowed to sink further. The process is repeated until the shaft bottom reaches a prescribed elevation, such that the perforated wall is at the lower part of the water bearing formation to be developed.

At this stage, the piezometric conditions inside the shaft and out in the aquifer are the same; namely, for a free-water aquifer, the water surfaces inside and outside the shaft are at the same elevation and for a confined-water aquifer, the water head inside the shaft is in equilibrium with the piezometric head in the aquifer. Lowering of the water level inside the shaft induces an inward flow, while raising of same induces an outward flow into the aquifer. In both cases, provided the shaft is sealed at the bottom, the flow takes place through perforated wall 3, which at this stage is surrounded by pervious material 12 naturally graded from coarse to fine and which is in intimate contact with the perforations. When the flow is from the aquifer to the shaft, fine grains may be entrained by the flow and if the structure of the aquifer around the perforated wall remains undisturbed and as naturally graded, these loose particles may be entrapped in the interstices and may gradually block the flow.

It is therefore essential that all loose fine grains be removed from the vicinity of wall 3, in order to form a graduated gravel pack with coarse material at this wall and progressively finer material radially outward, development of which is accomplished by means of gates 11, suspended from the shaft's top with cable 17 (Figure 9) and properly manipulated inside grooves 4 to create a surging or pulsating flow, as explained hereinbelow.

Gates 11 are rectangular in shape and are made substantially water-tight at their four sides, being slidably mounted in grooves 4, Figures 3 and 10. They may be of any suitable material or design, and the various parts are put together by

welding or otherwise. According to one construction, a skin plate 21, Figures 9 and 10, extending from one groove 4 to the one next opposite, may be provided. Secured to this plate are horizontal beams 22 and vertical edge beams 23 transferring the water load to spaced vertically extending guide or bearing members 25 attached tightly or welded solidly to columnar members 6 and forming the grooves 4. A hardwood seal 19 may be provided at the bottom and, if necessary, the bearing faces of beams 23 and members 25 may be machined. To prevent outflow from the top, each gate is provided with part 24, solidly secured to the gate, the outside edge of which conforms to the shaft wall profile and is bent downward to form a continuous lip, as shown in Figure 9. A longitudinal seal 18 is securely bolted on this lip and end faces of beams 23, extending all along the narrow opening between the gate, wall face 13 and web faces of members 25. Seal 18 is so mounted as to be close to and uniformly spaced from wall face 13 and web faces of members 25. When the gate is in lowered position and pressure in compartment 28 is greater than that within the shaft, the gate will be forced to bear tightly on members 25 while seal 19 will prevent water loss from the bottom. Water, however, will be forced upward through the narrow opening between seal 18, wall face 13 and web faces of members 25, but due to partial conversion within said opening of pressure head into velocity head, an unbalanced pressure condition will be created and the larger pressure in the space behind seal 18 will force same against the wall face and webs of members 25, thus stopping leakage.

On the basis of the above, when gates 11 are in lowered position and the water inside the shaft withdrawn by pumping, there will be no flow into the shaft, except an imperceptible amount of leakage from the gates and a small upflow from the shaft bottom, if no seal is provided therein. In any event, the water pressure in the aquifer will be much higher than that within the shaft, and as soon as any one of the gates is partly or wholly raised, the water will gush into the shaft at a greatly increased velocity. A constant difference in water head between the outside and inside of the shaft is maintained by withdrawing the inflowing water as fast as it pours in.

Lowering of the raised gate within a relatively short period will interrupt the flow of water and at the same time it will create a surge in the aquifer close to perforated wall 3 due to the propagation of a pressure wave backwards originated by the hammer effect of the water on the gate.

Alternately raising and lowering one gate at a time while all the others are in lowered position, will create a strong pulsating flow which will loosen the structure of the aquifer material and which will force all loose grains into the shaft whence they can be removed mechanically. The process may be applied on all gates a sufficient number of times until no loose fine material is entrained into the shaft.

Under certain conditions, when the grains of the aquifer material 12 are cemented together with clay, carbonates, or other similar substance or when the perforations become temporarily clogged with clay or other impervious material, one or more of the gates may be provided with a hose connection 20 through which a strong jet 16 of water, dilute acid or air may be forced into the aquifer in order to break, loosen and wash out any cementing minerals that may cause clogging. Moving one of the gates up and down while such jetting is in progress will cause a pulsating effect much more pronounced than that developed by the gate, and movement of a few inches may be sufficient to accomplish the desired effect.

Since almost always the shaft after its sinking will have a certain inclination, members 25 may be extended up to or above the water level to facilitate lowering of the gates in grooves 4. Or, they may extend only a short distance above the top of the perforated wall, as shown in Figures 1 and 4. In the latter case, placing the gates inside the grooves 4 will be a blind operation, but their installation on the low side (half of shaft periphery that moved away from the vertical passing through the cutting shoe center) will be a relatively simple matter. Since, however, on the high side, a vertical line from the top of the wall will be at a progressively greater distance from the wall face, the gate may be suspended at a certain eccentricity from its longitudinal centroidal axis to cause it to assume a tilted position, with its bottom away from the vertical and closer to the wall, the requirement being that the suspension point and gate centroid must be on the same vertical line. Any reasonable amount of departure from the vertical may thus be secured such that will place the gate bottom on top of grooves 4. In case of extreme inclination conditions, an added weight (not shown) may be securely mounted on the back of the gate to increase the eccentricity between the point of suspension and the centroidal axis of the combined weight, and thus to cause a further tilting of the gate bottom toward the shaft wall. This weight may also be required to overcome the frictional resistance at the gate bearings during lowering operations, if this is greater than the weight of the gate alone.

As stated in the preamble, the invention is also applicable to fine-grain aquifers. Since in punching operations, the thickness of metal may not be greater than the width of perforations, fine sand passing Number 100 sieve, for instance, will require an extremely thin metal sheet which may not be satisfactory as a structural member both during sinking or normal operation periods. Moreover, the life of such fine perforated wall may be short due to possible clogging, incrustation or corrosion. On the other hand, it has been proved that a gravel pack, ½" to 1" in thickness, containing pea-size gravel, may effectively arrest the entrainment of very fine sand without blocking the flow of water. In applying the invention to fine-grain aquifers, Figures 4, 5, 6, 7 and 8, an outside perforated wall 3 is provided, with perforations slightly smaller than pea gravel diameter, in which the ratio of open to total area is made as large as practicable. Vertically disposed and uniformly spaced bars 5 are rigidly mounted in position, as shown, to transfer the outside load to the shaft, and a second continuous perforated wall 3A, with perforations also slightly smaller than pea gravel diameter, is firmly secured onto said bars from the inside. A series of prismoidal individual sheaths 7 is thus developed all along the shaft's circumference which filled with pea gravel form a gravel-packed wall. The ratio of open to total area in perforated wall 3A must obviously be much smaller than that in wall 3. The pea gravel is placed in the sheaths in layers, to insure maximum compaction, mechanical means such as vibration or water flow being used, if necessary. Bars 5 are provided on their sides with continuous longitudinal ridges 34, as shown in Figure 5, or grooves, not shown, to discourage

any tendency of fine grains to flow along the bar sides and into the shaft. A seal or plug 8 may or may not be provided at the shaft bottom depending on local conditions, as already explained.

An annular segmental gravel storage box 9, Figures 4 and 7, is provided on top of the gravel-packed wall to feed the individual sheaths with gravel, if and when a void is created at the top of said wall due, possibly, to further compaction, or deterioration of the gravel grains through solution, chemical action or mechanical abrasion with sand grains. This gravel box is formed by an outside imperforate wall 14, continuous all along the circumference of the shaft, inner wall 15, top plates 35 and bottom plates 29, while it is partly open at the bottom to allow the free settlement of gravel into the sheaths. Walls 14 and 15 and plates 35 and 29 are rigidly connected or welded to columnar members 6, which extend a certain distance upward into the shaft body, to insure a rigid connection therewith and to form separate gravel boxes, one per gravel-packed section between members 6. All gravel boxes are individually provided with pipes 10 to replenish the gravel storage, if necessary. These pipes are extended up to a desired level, such as above the water level, and are sealed airtightly at the top with a removable plug (not shown) accessible from the shaft's inside. They may also be provided at their top with a check valve through which air or water may be forced downward into any one of the gravel boxes.

Development operations in a shaft installed in a fine-grain aquifer are similar to those already described. The pulsating flow of water through the gravel-packed wall will cause loose fine grains to be entrained into the shaft, whence they can be removed mechanically, and to cause the arching of coarser aquifer grains on the gravel pack. The pulsating flow will further cause compaction of the gravel pack, additional gravel being fed from storage, if necessary, by gravity assisted by up-and-down flow of water in gravel boxes 9. Air trapped in gravel boxes 9 and feed pipes 10 during sinking of the shaft, will alternately be compressed and expanded by the action of water surge developed by the up-and-down motion of the gates. During lowering of the gates, water will be forced upward into the gravel box, compressing the air therein, while during the raising of the gates, the pressure will be released and the water will flow downward and into the top part of the gravel pack (where a void may likely have developed).

In recharging underground pervious formations with surface water, it is essential that the water be partly freed of its suspended load, if it contains any, through mechanical settlement, coagulation and sedimentation, as in rapid sand filters. Settlement of the heavier solids may be accomplished mechanically in a settling basin and the colloidal matter may be removed by flocculation and subsequent sedimentation through the introduction of a suitable coagulant in a separate basin on the ground surface. After the major load is thus removed, the water is led into shaft 1, Figure 1, and is allowed to build up a head greater than the hydrostatic head in the aquifer, thus inducing a flow, radially outward into the aquifer. Backwashing of the natural filter bed close to and around the shaft, when the head inside the shaft reaches a predetermined maximum level, may be effected by suspending temporarily recharge operations and reversing the flow, causing the water to travel from the aquifer to the shaft. Such flow reversal may be established by an electrically driven heavy-duty deep well pump 30, Figure 1, and the entire process of backwashing may be made automatic through the introduction of a relay, operated by a float mechanism inside the shaft which may start operation of pump 30, and shut off the supply of surface water. The pump is allowed to operate for a certain length of time, which from experience will suffice to remove the solids collected in the aquifer around the shaft, and a clock-operated relay may be used to stop operation of the pump and to restore feeding of surface water. The float mechanism may be so located as to energize the relay when the water level inside the shaft reaches a certain desirable level, determined by experience, and is arranged to set in operation the clock of the clock-operated relay. The pump intake may be located near the top of perforated wall 3, as shown, and may be provided with a bell-shaped member 31 facilitating the streamline flow of waste water to the pump intake, thus preventing, as much as possible, mixture of waste water with water in the shaft.

Each time during flow reversal, the water level inside the shaft must be drawn down to a certain depth to create the necessary velocity conditions in the natural filter bed for a satisfactory removal of solids, although complete withdrawal of said solids is not indicated. This arrangement would, therefore, be rather slow for recharge conditions requiring frequent backwashing, and in such cases the layout shown in Figure 11 may be employed, where a plug 8 is provided for sealing the shaft bottom. Surface water is led into the aquifer through feed pipes 26 extending from the ground surface down to compartments 28 formed by members 6, as described. One pipe is provided for each compartment and the shaft interior is maintained substantially dry by the provision of watertight gates 11, described previously, and by pumping. An annular chamber 32 is provided all around the shaft at or near the ground surface from which all pipes 26 are supplied with surface water, led to said chamber by a valved main 33.

Backwashing of the natural filter bed is accomplished by raising one gate at a time and letting a stream of water discharge into the empty space within the shaft, while pumping it out of the shaft by a deep well pump installed therein (not shown).

The system may become automatic, if desired, by the installation of a float mechanism (not shown) in feed pipes 26 energizing a relay which will start operation of the shaft pump, cause the lifting of preferably all gates 11, simultaneously, while shutting off supply main 33. Recharge conditions may be reinstated by the provision of a clock-operated relay which will stop operation of the pump, cause all gates to be lowered in seating position, while opening supply main 33. The float mechanism is arranged to set in operation the clock of the clock-operated relay when actuated by the rise in water level.

One and the same shaft can be used both for abstracting water from and for delivering water to an aquifer, depending on seasonal requirements. For instance, in winter, the shaft may be used to store water in the ground and, in summer, to withdraw water therefrom and make it available for human consumption.

Having now particularly described and defined the nature of my said invention and in what manner same is to be performed, what I claim is:

1. An apparatus for abstracting fluid from and delivering fluid to an aquifer comprising a hollow substantially vertical shaft structure having an annular cutting shoe at its lowermost extremity, plurality of vertically extending columnar members connected to the cutting shoe and extending upwardly therefrom and an annular shaft body vertically spaced from the cutting shoe and connected to the columnar members, said columnar members being circumferentially spaced from one another and providing closable compartments between them, an annular perforated vertically extending wall structure disposed between said cutting shoe and the shaft body and laterally supported by and against the outer edges of the columnar members, said perforated wall permitting the passage of fluid therethrough but preventing the entrainment of aquifer material from the aquifer into the shaft, gates removably connected to the columnar members to close the inner ends of the compartments provided between them and the perforated wall structure and means for supplying fluid under pressure from the ground surface to the respective compartments to remove the finer grains of the aquifer material about the exterior of the perforated wall structure, said gates being adjustable upon the columnar members between open and closed positions to assist in the said removal of finer grains of the said aquifer material about the perforated wall structure.

2. An apparatus for abstracting from and delivering fluid to an aquifer comprising a hollow substantially vertical shaft structure having an annular cutting shoe at its lowermost extremity, a plurality of circumferentially spaced vertically extending columnar members connected to said cutting shoe and extending upwardly therefrom and an annular shaft body vertically spaced from the cutting shoe and connected to the upper ends of the columnar members, whereby to provide closable compartments between the columnar members, said columnar members having their inner edges extending inwardly of the interior surface of the shaft body and having vertically extending guide flanges thereupon, a perforated wall structure surrounding the columnar members and extending vertically between the cutting shoe and the lower end of the shaft body, said perforated wall structure adapted to permit the passage of fluid therethrough but prevent the entrainment of aquifer material from the aquifer to the shaft, gates vertically adjustable on the inner portions of the columnar members and between the guide flanges thereof and adapted to be moved between open and closed positions and to be removed from the upper ends of the columnar members, means for supplying fluid under pressure from the ground surface to the respective compartments to cause the removal of all loose aquifer grains surrounding the perforated wall, said gates being alternately openable and closable to assist in said removal, means for maintaining the water surface within the shaft at a level lower than static level, and means for removing the collected aquifer grains outside the shaft.

3. An apparatus for abstracting fluid from and delivering fluid to an aquifer as defined in claim 2, and the lower end of the shaft body extending below the upper ends of the columnar members, flexible sealing means depending from the upper ends of the gates and adapted when fluid pressure is applied to the compartments to be flexed against the interior face of the shaft body whereby to seal off the compartment between the upper end of the gate and the shaft body.

4. An apparatus for abstracting fluid from and delivering fluid to an aquifer as defined in claim 2, and the cutting shoe extending radially inwardly of the vertical shaft structure beyond the interior face of the shaft body, said gates having a sealing element on the lower ends thereof and adapted to engage with the extended portion of the cutting shoe.

5. An apparatus for abstracting fluid from and delivering fluid to an aquifer as defined in claim 2 for delivering surface water through the shaft into the aquifer for recharging said aquifer and a pump in the shaft for periodically backwashing the colloidal solids absorbed by the aquifer material surrounding the perforated wall structure.

6. An apparatus for abstracting fluid from and delivering fluid to an aquifer as defined in claim 1, and said perforated wall structure including a perforated plate surrounding the shaft and lying flush with the exterior surface thereof and a plurality of vertically spaced backing bars lying on the inner face of the wall plate and abutting the vertically extending outer edges of the columnar members whereby to stiffen the perforated wall plate and to transfer the outside load to the shaft structure.

7. An apparatus for abstracting fluid from and delivering fluid to an aquifer as defined in claim 1 and said perforated wall structure comprising perforated concentric plates with spacing bars therebetween and connected to the columnar members, gravel packing material disposed between the concentric plates, a gravel storage space provided in the shaft above the lower end of the shaft body and communicating with the space between the concentric perforated plates whereby to automatically replenish the supply of gravel packing material thereto, and passage means extending through the shaft body for filling the gravel storage space.

8. An apparatus for abstracting fluid from and delivering fluid to an aquifer comprising a hollow substantially vertical shaft structure having an annular cutting shoe at its lowermost extremity, a plurality of vertically extending columnar members connected to the cutting shoe and extending upwardly therefrom and an annular shaft body vertically spaced from the cutting shoe and connected to the columnar members, said columnar members being circumferentially spaced from one another and providing closable compartments between them, an annular perforated vertically extending wall structure disposed between said cutting shoe and the shaft body and laterally supported by and against the outer edges of the columnar members, said perforated wall permitting the passage of fluid therethrough but preventing the entrainment of aquifer material from the aquifer into the shaft, gates removably connected to the columnar members to close the inner ends of the compartments provided between them and the perforated wall structure and means for supplying fluid under pressure from the ground surface to the respective compartments to remove the finer grains of the aquifer material about the exterior of the perforated wall structure, said gates being adjustable upon the columnar members between open and closed positions to assist in the said removal of finer grains of the said aquifer material about the perforated wall structure, and means for supplying fluid under pressure from the ground sur-

face to the respective compartments to cause the removal of all loose aquifer grains surrounding the perforated wall, said gates being alternately openable and closable to assist in said removal, means for maintaining the water surface within the shaft at a level lower than static level, and means for removing the collected aquifer grains outside the shaft.

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