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[54] **WELL CLEANING APPARATUS**

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[52] **U.S. Cl.** **166/223,** 166/312

[51] **Int. Cl.** **E21b 37/00**

[58] **Field of Search** 166/222, 223, 312, 177, 166/105; 175/67, 205, 213, 215

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[57] **ABSTRACT**

An apparatus for cleaning a well and removing particle incrustation from a well screen, and a method of using the apparatus, is disclosed. The apparatus and method utilize a source of high pressure gas to air lift well liquid and particles to the ground surface, and simultaneously apply a high pressure fluid to the well screen inner surface to dislodge particles, wherein the volume of well liquid removed is greater than the volume of high pressure fluid injected into the well.

7 Claims, 5 Drawing Figures

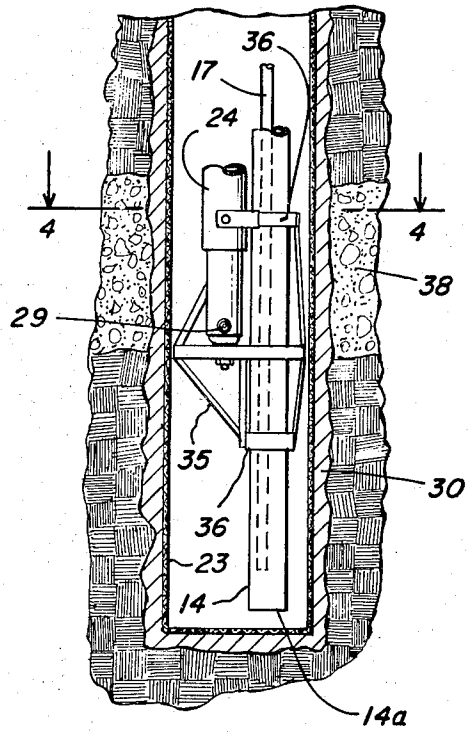


FIG. 1A.

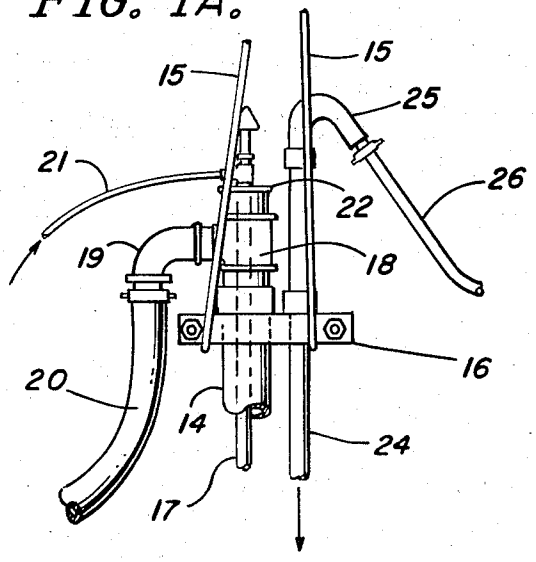


FIG. 1B.

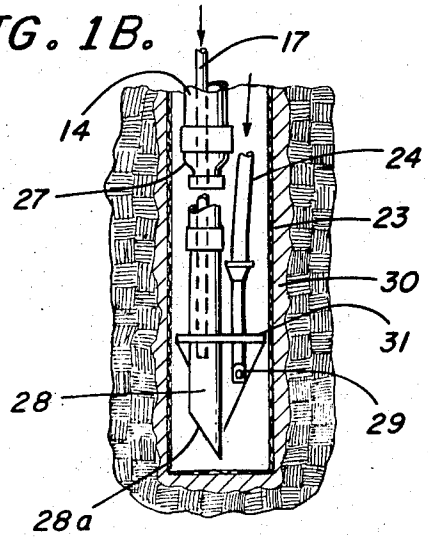


FIG. 2.

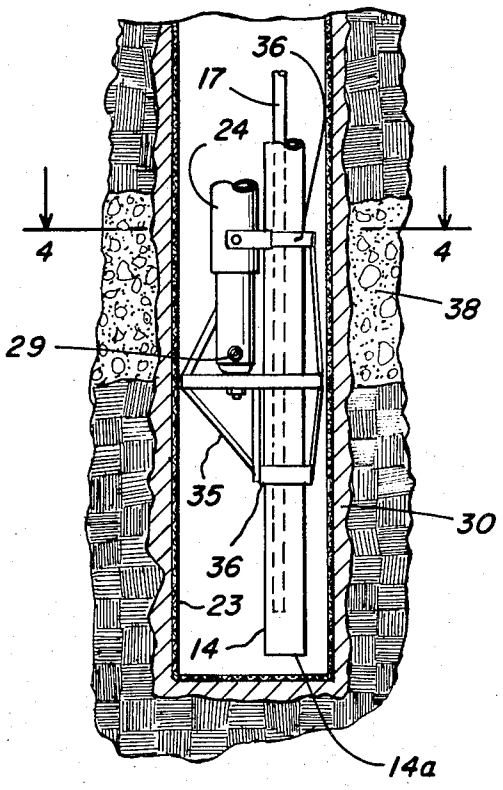


FIG. 3.

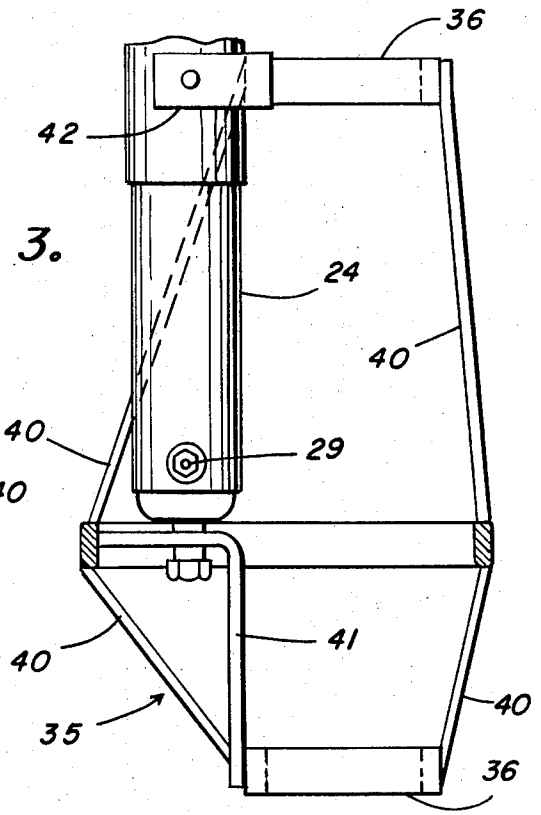
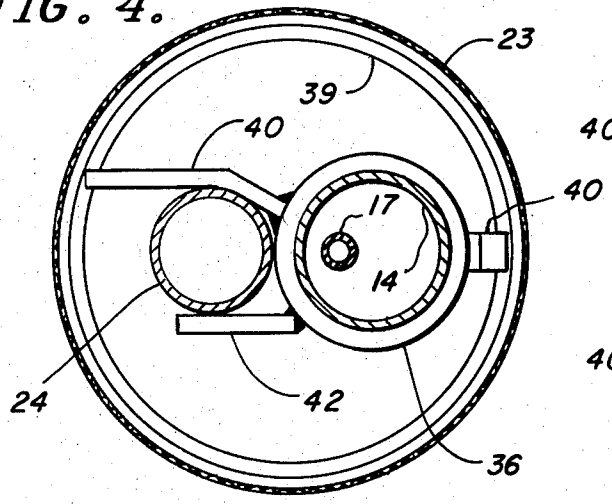


FIG. 4.



WELL CLEANING APPARATUS

WELL CLEANING APPARATUS AND METHOD

This invention relates to apparatus for improving the productivity of wells, and more particularly to apparatus for maximizing the yield of liquid from wells by the method of unclogging particulate matter from well sceens and removing fine particulate from the region surrounding well screens. The invention comprises both a novel apparatus and a novel method for accomplishing this purpose. The inventive apparatus and method ard practiced within a well, and eliminate the necessity for removing the well screen and casing pipe to which it is attached from the interior of the well hole for cleaning and restoration. The invention conserves both time and expense, and achieves an improved result, in the cleaning of well screens and restoring of the well to its maximum operating capacity. The embodiment of the invention described herein is preferably applicable to water wells, although other types of liquid wells are also adaptable to the invention. Reference herein will be made to water when describing the normal content of a well, it being understood that other types of liquid wells are included within the scope of the invention.

There are at least two reasons why a well loses productivity and efficiency from a reduction of water flow into the well from the surrounding soil: the well screen can become clogged or incrusted, or the region of formation or soil outside of and adjacent the well screen can become densely packed with fine material and thereby prevent ground water from reaching the well screen. The process of bringing a well to its maximum efficient yield of water is referred to as "development" of the well. The process involves the removal of fine particulates, known as "fines," from the natural soil or formation outside of the well screen. On a newly constructed well, the well screen commonly has slot openings allowing from 25 to 60 percent of the natural surrounding formation to pass the screen. Removal of this fine material, and the simultaneous "grading" of the remaining material adjacent to the screen so that the coarser material lays closest to the screen, is the essential process of "development." The end result of adequate development is increased permeability and hence reduced friction loss to the water as it enters the well so that the well is at maximum productive efficiency.

In older wells, the water moving to and into the well from normal pumping causes, over a period of time, "fines" which initially were located in the surrounding formation beyond the reach of original well development to migrate to the zone immediately surrounding the well screen. This migration reduces permeability and productivity of the well. The process of removing these "fines" from an older well is referred to as "redevelopment." A further problem with older wells is incrustation on the surface of the well screen; this incrustation must also be removed if the well is to be returned to its original productivity.

Briefly, this invention includes apparatus for directing a high pressure fluid jet at the interior surface of the well screen, thereby removing incrustation and dislodging particulates from within the well screen and in the region immediately adjacent to and exterior of the well screen. The liquid jet is applied in combination with a high pressure gas which is injected into the well at a point near the bottom. The high pressure gas, typically air, generates rising gas bubbles which lift water within the well to the ground surface in considerable volume. The application of high pressure gas to the bottom portion of the well utilizes the principle of air lifting, known in the art, and in combination with the liquid jet application results in a significant improvement to the development process. The inventive apparatus comprises a first pipe for removing water from the well according to the principle of air lifting, a second pipe for injecting a high pressure gas, such as air, to the bottom of the well, and a third pipe for admitting a high pressure fluid via a jet nozzle and directing the fluid jet to the interior surface of the well screen. The inventive method comprises the novel steps practiced in the development process described herein.

A further problem related to the development and redevelopment of wells is the normal stratification of soil formations along the length of any well hole. Soil formations are typically not uniform in sieve analysis, even throughout the length of a well screen. There may be layers of variable thickness from as little as several inches of depth, and such layers may comprise fine or coarse material, or mixtures thereof. During the development process, each such layer requires a longer or shorter time time of "development" to optimally restore the well screen efficiency in that layer. Another novel aspect of the present invention is that the method of implementing the invention enables the operator to measure and observe the removed particulates, and therefore to gauge the relative efficiency at which a particular level or depth of well screen is operating. This enables the operator to concentrate the development process at well screen depths that are most in need of it.

Yet another advantage of the present invention is that the "fines" removed from the well are automatically pumped to the surface of the ground, and are not permitted to settle at the bottom of the well. This removal of "fines" eliminates any necessity for subsequent bailing of the well, which might be needed to remove sediment.

Further advantages and novel features of this invention will become apparent from a reading of the following specification and claims, together with the appended drawings, in which:

FIG. 1A illustrates the apparatus forming a part of the invention which is located on the surface of the ground over the well;

FIG. 1B illustrates an embodiment of the inventive apparatus which is submerged within the well;

FIG. 2 shows a preferred embodiment of the inventive apparatus which is submerged within the well;

FIG. 3 is a partial elevational view of the apparatus of FIG. 2;

FIG. 4 shows a top plan view of the apparatus of FIG. 2 and the surrounding well screen.

Referring first to FIG. 1A, the apparatus is shown which normally is positioned over a well hole on the surface of the ground. This apparatus is connected to various devices common in the art, such as a high pressure air source, a high pressure fluid source, and supportive apparatus for suspending the assembly of FIG. 1A over the well hole. One skilled in the art will readily have the knowledge to select appropriate ones of these available devices for connection to the apparatus of FIG. 1A, especially in light of the specification herein.

The apparatus of FIG. 1A is suspended from a suitable well rigging by means of cables **15.** The rigging has the capability of raising and lowering the entire assembly under the control of an operator. Cables **15** are attached to support brackets **16,** which support and clamp the remaining apparatus together. An eduction pipe **14** is clamped thereto, and is attached to a drain hose **20** by means of tee connection **18** and other pipe fittings **19.** Drain hose **20** is coupled to a storage tank (not shown) or other suitable drainage means. An air hose **21** is connected to air pipe **17** through suitable valving, air pipe **17** being located within eduction pipe **14.** The top end of eduction pipe **14** is sealed by cover **22,** which has a hole at its center to provide for the passage of air pipe **17.** The other end of air hose **21** is connected to a source of high pressure air (not shown), such as a compressed air tank and delivery system of a type commonly known in the art.

Also clamped to support bracket **16** is high pressure fluid pipe **24.** The top end of fluid pipe **24** is connected by means of coupling **25** to a high pressure line **26.** This high pressure line **26** is connected to a source of high pressure fluid (not shown). Typically, the high pressure fluid source comprises a high pressure water tank and associated delivery system. The entire apparatus shown in FIG. 1A is suspended above a well hole, and eduction pipe **14,** air pipe **17,** and fluid pipe **24** extend downwardly into the well. The lower end of air pipe **17** is located well below the natural level of the water in the well; at least half, and preferably more than half, of the length of the air pipe **17** is submerged in the water of the well below the natural water level. Eduction pipe **14** is also submerged below the natural water level, and fluid pipe **24** extends downwardly to the vicinity of the well screen and is terminated in a high pressure nozzle to be hereinafter described. When air is forced under pressure down air pipe **17** into the water in the eduction pipe **14,** the rising air bubbles carry water and particles with them, and the water and particles are carried to the surface without mechanical pumping.

FIG. 1B illustrates the inventive apparatus which is submerged within the well in the vicinity of the well screen. Eduction pipe **14** is connected via a reducer coupling **27** to an open-ended section of eduction pipe **28.** Pipe **28** has an open **28***a* into which water and particles can be drawn and air-lifted to the surface as previously described. Air pipe **17** is shown extending downwardly near the vicinity of open end **28***a*. Fluid pipe **24** is also shown in FIG. 1B; it terminates in a high pressure nozzle **29** designed to direct a fluid jet at generally right angles to the direction of fluid pipe **24.** This fluid jet strikes the inner surface of well screen **23,** dislodging incrustation particles from the well screen and the surrounding region. FIG. 1B pictorially illustrates a zone **30** immediately surrounding well screen **23,** which zone includes the region where "fines" are accumulated to generally lower the efficiency of the well. Eduction pipe **28** and nozzle **29** are held in a fixed relationship by means of bracket **31,** which generally strengthens the apparatus located within the well.

The combination of air pipe **17** and eduction pipes **28** and **14** acts to remove a significant quantity of water and particles from the well. At the same time as this action occurs, fluid pipe **24** carries a volume of high pressure fluid to be ejected through nozzle **29.** It is necessary that the guantity of water lifted to the surface through eduction pipes **28** and **14** be greater than the quantity of water supplied through nozzle **29,** so that water is actually being removed from the formation around the well as the well is being cleaned. The entire assembly can be rotated within the well to allow nozzle **29** to direct its fluid jet around the entire inner circumference of the well. When the incrustation particles have been removed sufficiently from a first circumferential zone the entire assembly may be raised or lowered by means of cables **15** to enable cleaning of a second circumferential zone. This process eventually allows the entire well screen and surrounding formation to be cleaned.

FIG. **2** illustrates another, and preferred, embodiment of the apparatus located within the well. In this embodiment eduction pipe **14** and air pipe **17** remain stationary in a location near the bottom of the well during the entire well screen cleaning operation. Fluid pipe **24** is slidably attached to the outside of eduction pipe **14** by means of housing **35,** which has an upper and lower collar **36** designed to loosely fit around eduction pipe **14.** The assembly consisting of fluid pipe **24,** housing **35,** and collars **36** can be raised or lowered independently of eduction pipe **14** and air pipe **17.** With this construction nozzle **29** can direct a fluid jet at aparticular well screen circumferential depth while the open end **14***a* of the eduction pipe remains close to the bottom of the well. This enables encrustation particles to be drawn into open end **14***a* and air lifted to the surface, said encrustation particles originating at any and all well screen depths. Because this embodiment allows all the encrustation particles to be collected and carried out of the well as the cleaning job progresses it enables the operator to make a determination of the degree of cleaning, by merely examining the outflow from the eduction pipe. For example, if the operator observed a reduction in particles in the eduction pipe outflow he can assume that the well has been cleaned at the particular nozzle depth he is operating. He can therefore adjust the nozzle depth by raising or lowering housing **35** to select another depth within the well for cleaning. This method of operation is particularly useful in wells having strata of soil formations which contain varying degrees of "fines;" FIG. **2** pictorially illustrates an example of a soil level **38** which differs in degree of coarseness from neighboring soil strata. Such a soil strata may require a greater or lesser degree of cleaning and therefore require a greater or lesser application of high pressure fluid through nozzle **29.** The apparatus of FIG. **2** enables the operator to deal with situations of this type, and a trained operator can detect changes in the soil strata by merely observing the outflow from eduction pipe **14.**

FIG. **3** illustrates in enlarged view the apparatus connected to housing **35.** Collars **36** are attached at the upper and lower ends of housing **35** and encompass the eduction pipe. A rigid annular bar **39** is connected to collar **36** by struts **40;** an L-bracket is welded between annular bar **39** and one of the collars **36.** L-bracket **41** provides a mounting base to which the closed bottom end of fluid pipe **24** can be bolted so as to hold nozzle **29** in a fixed relationship with housing **35.** Fluid pipe **24** is also rigidly attached to the second collar **36** by means of bracket **42.** With these connections the entire assembly consisting of housing **35,** fluid pipe **24,** and nozzle **29** can be rotated around eduction pipe **14** and guided along eduction pipe **14.** This arrangement permits the nozzle **29** to be operated at various elevations and with-

out requiring major disassembly of the eduction pipe **14** and air pipe **17** at the top of the well.

FIG. **4** illustrates a top sectional view taken at lines **4—4** in FIG. **2.** This figure shows the relationship of the various components within the well screen. In particular, it illustrates annular bar **39** concentrically positioned within well screen, and collar **36** encompassing eduction pipe **14.** Fluid pipe **24** is rigidly attached to collar **36** by means of bracket **42**; struts **40** rigidly connect collar **36** to annular bar **39.** This construction provides an adequate and economical interconnection of the various elements of the invention, but other similar constructions would also be useful to accomplish the intended purpose of the invention. water from the nozzle will cause some damage to the screen. The bracket plate **31** which is substantially circular in shape, will maintain the nozzle **29** in spaced relation from the screen at all times. The off center position of the nozzle **29,** and the orientation of the nozzle causes the stream of high pressure water to be directed oblique to a radius from the center of rotation so that the jet reaction at the nozzle tends to contribute to the rotating of the assembly in the well.

Although the open end **28***a* of the eduction pipe **28** moves upwardly and downwardly along the wall screen during the cleaning operation, some of the particles of incrustation and other materials loosened by the jet stream will move with the water into the end of the eduction pipe so that the discharge of these particles can be monitored to permit the operator to observe the particles and obtain information as to the nature of the formation and incrustation at the various levels of the well.

I claim:

1. Apparatus for cleaning a well and well screen, comprising:

a. an eduction pipe disposed within said well and having an open end positioned along said well screen length;

b. a gas pipe disposed within said eduction pipe and having at least one-half its length immersed beneath the normal liquid surface of said well, and having an open submerged end within the eduction pipe and above the open lower end of the latter;

c. a high pressure fluid pipe disposed within said well and adjacent but outside said eduction pipe, said fluid pipe having a jet nozzle positioned along said well screen length and at an angle to direct a jet stream of fluid against said well screen to dislodge fine particles;

d. drain means connected to said eduction pipe for conveying fluid away from said well;

e. means for conveying a high pressure gas into said gas pipe to cause air-lifting of water and entrained fine particles through the eduction pipe; and

f. means for delivering a high pressure fluid into said fluid pipe.

2. Apparatus as claimed in claim **1,** further comprising a housing rigidly mounted to the high pressure fluid pipe and rotatably mounted to the eduction pipe, and enabling the housing and fluid pipe to be rotated about the eduction pipe to cause said jet nozzle to direct a jet stream of fluid at all circumferential positions within said well.

3. Apparatus as claimed in claim **2,** further comprising means for raising and lowering said jet nozzle to selected elevations within said well connected to said third pipe.

4. Apparatus as claimed in claim **3** wherein said housing includes a first and second collar slidably encompassing said first pipe and having bracket means for rigidly attaching said third pipe to said collars.

5. Apparatus for unclogging a submerged well screen and surrounding region in a well, comprising:

a. an eduction pipe having an open end positioned near the bottom of said well and having its other end in communication with the surface of said well;

b. a high pressure air pipe disposed within said eduction pipe and having an open positioned adjacent but above the open end of said eduction pipe, and means for connecting the air pipe to a source of compressed air;

c. a housing slidably attached to said eduction pipe;

d. a jet nozzle attached to said housing and directed toward said well screen, and means for connecting the jet nozzle to a source of high pressure fluid; and

e. positioning means, connected to said housing and extending to the surface of said well, for varying the elevation and rotational position of said housing.

6. Appartus as claimed in claim **5,** wherein said housing further comprises a first collar encompassing said eduction pipe and rigidly attached to the jet nozzle an annular bar of diameter less than said well screen, attached to said first collar; and a second collar encompassing said eduction pipe, and attached to said annular bar, wherein said annular bar is approximately intermediate said first and second collar.

7. Apparatus for cleaning a well and unclogging a submerged well screen and surrounding region in a well, comprising:

a. an air pipe submerged in the well, wherein more than one-half the length of said air pipe is immersed in well liquid and the bottom end of said pipe is open, and means for connecting the air pipe to a source of high pressure air;

b. an open-ended eduction pipe of diameter at least several times that of said air pipe and of length at least several feet longer than said air pipe and extending below the bottom end of the air pipe, said eduction pipe fitted concentrically around said air pipe and having a drain connection at the ground surface of the well to convey well liquid away from said well;

c. a high pressure water pipe extending into said well to a region including said well screen, said high pressure water pipe being positioned adjacent but outside said eduction pipe in said well and including means for connecting the high pressure water pipe to source of water under high pressure;

d. a high pressure jet nozzle connected to the bottom end of said high pressure pipe, and directed toward the inner surface of said well screen;

e. a housing rigidly attached to said high pressure water pipe, and having a pair of collars encompassing said eduction pipe but of inner diameter larger than the outer diameter of said eduction pipe, and having an annular bar of diameter less than said well screen diameter; and

f. a supporting means allowing changing of the elevational and rotational position of said high pressure water pipe, said supporting means located at the ground surface of said well and attached to said high pressure pipe and being capable of both elevational and rotational movement.

* * * * *