

May 5, 1959

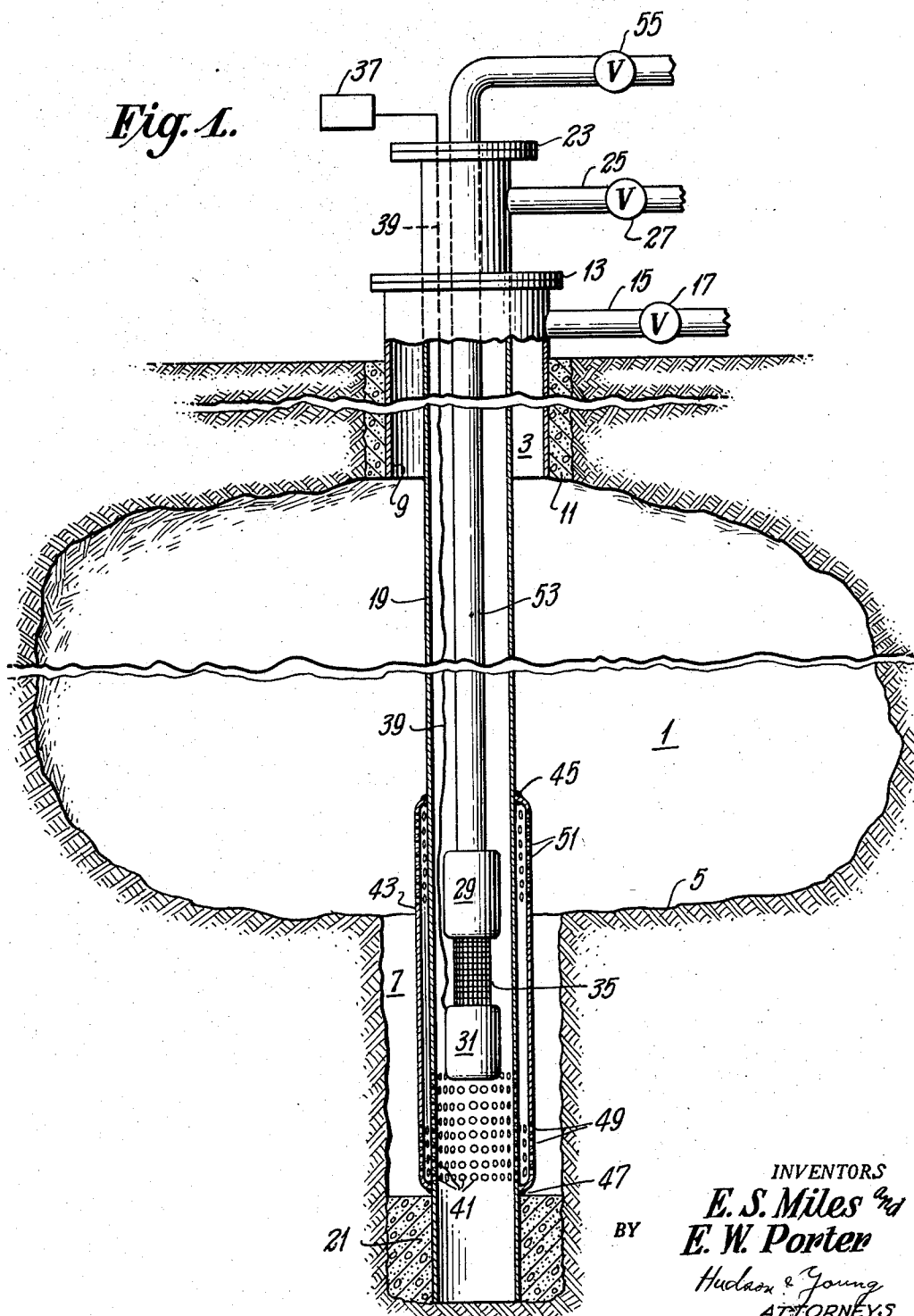
E. S. MILES ET AL
PUMP INTAKE APPARATUS

2,884,761

Filed July 6, 1954

3 Sheets-Sheet 1

Fig. 1.



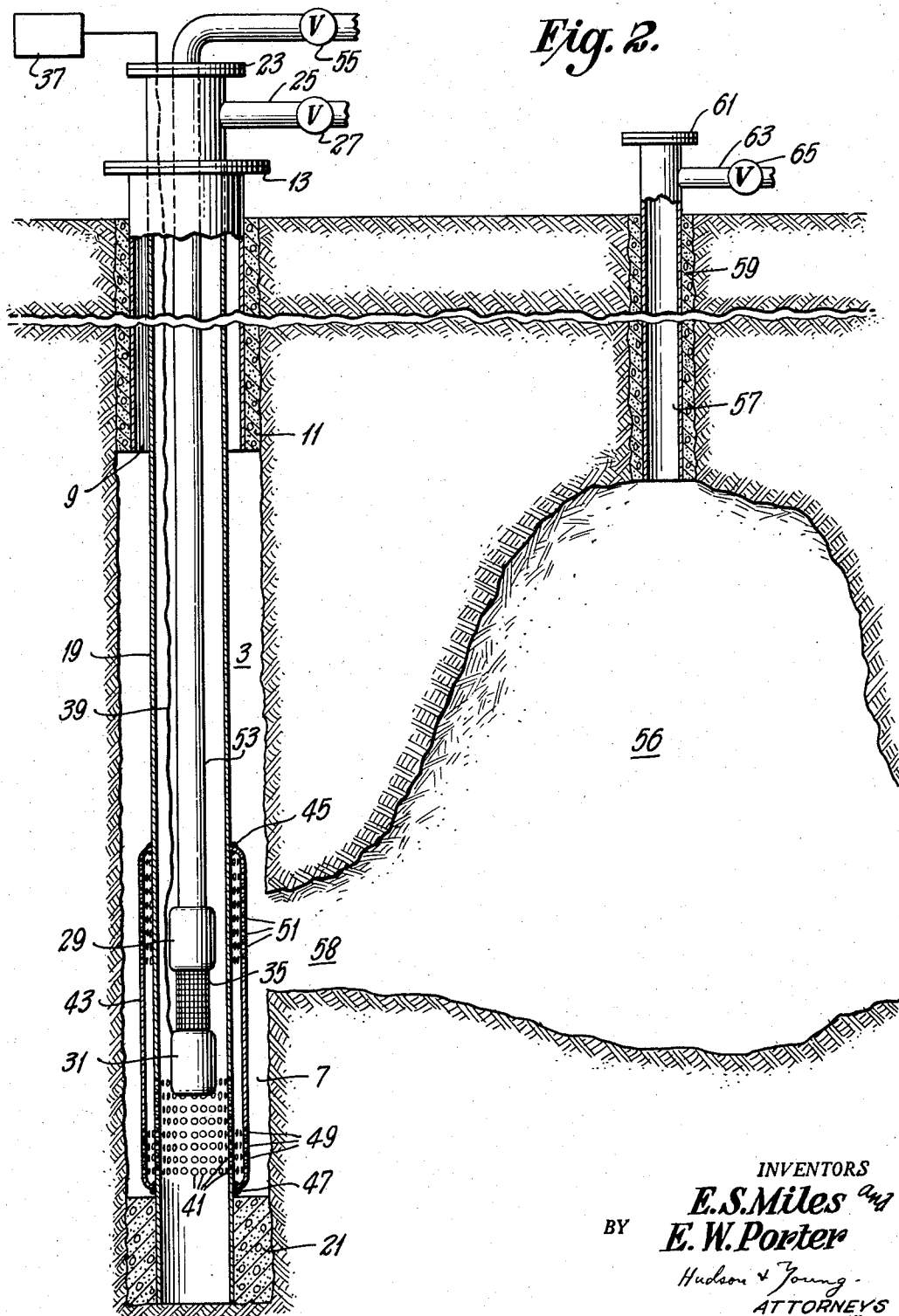
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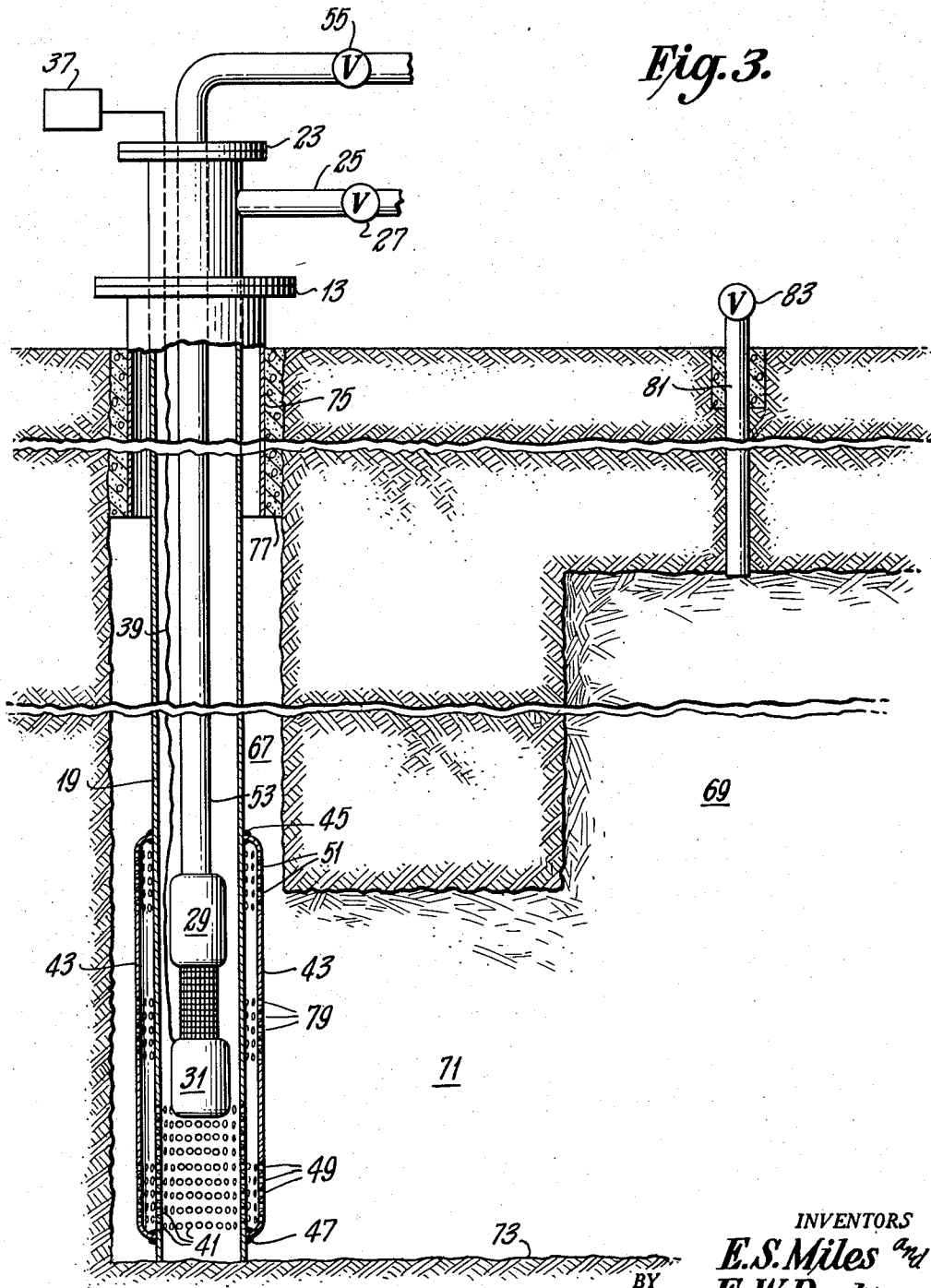
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PUMP INTAKE APPARATUS

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4 Claims. (Cl. 61—5)

This invention relates to a pump intake apparatus. In a more specific aspect, this invention relates to an improved pump intake apparatus in an underground storage system for liquefied gases.

New developments have occurred recently in the underground storage of liquefied gases, due in a large measure to the demand for such materials on a seasonal basis. Surface storage of liquefied gases is exceedingly expensive and therefore storage of these materials in caverns underground has been found to be useful and economically attractive. In general, there are two types of such underground storage systems. One type which has found wide usage comprises a well or cavern dissolved out of a salt bed. The salt well is usually dissolved out by the introduction of fresh water until a well of sufficient capacity has been formed. The walls of such a salt well are impervious and do not adversely affect the quality of many liquefied gases such as liquefied petroleum gas. The other general type of underground storage system which is finding general acceptance is a system of caverns which are mined out of an impervious rock such as a shale rock. In this type of underground storage system a vertical shaft is mined down to the level of the shale rock bed in which the cavern is to be located and caverns are mined out of this bed and connected to the central shaft by tunnels.

Underground storage systems such as those described above may or may not have a lining material to prevent caving or sloughing of the cavern walls. Whether or not such a lining is present, caving and sloughing of the cavern walls is an ever-present problem. This problem is even more important where the stored fluids are removed from the underground storage systems by a downhole pump, rather than a fluid pressuring arrangement, since caving of the cavern walls can seal or bury the intake to the pump causing expensive repairs or even permanent loss of storage capacity. Where such a downhole pump is used for removal of the stored fluid, the pump is usually placed as near to the floor of the underground storage system as is possible so that the maximum amount of the stored fluids can be removed from the system. However, this placement of the pump near the floor of the system increases the danger that the pump intake will be sealed off by caving or sloughing of the cavern walls. In extreme cases such caving can cause a major portion of the underground storage system to become unavailable for further use since a new pump intake pipe cannot be lowered into place through the debris.

It is, therefore, an object of this invention to provide an improved pump intake apparatus.

It is a further object to provide an improved pump intake apparatus for use in underground storage systems for fluids.

It is a still further object to provide a pump intake apparatus which permits withdrawal of the stored fluids from the lowest point in the storage system during normal operations, but which permits withdrawal from a higher point in the underground storage system in the event that

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the lower intake is sealed off due to caving of the cavern walls.

We have discovered a pump intake apparatus which fulfills the foregoing objects of this invention and which comprises a downhole pump and a pair of concentric pipes surrounding said pump, the inner pipe being perforated in a region adjacent to the intake of said pump. The outer pipe is closed at its ends, attached at its ends to the walls of said inner pipe, and is perforated in a region adjacent to but below said inner pipe perforations and is perforated in at least one region above the intake to the pump. In the event caving of the cavern walls should occur to seal the lower perforations in the outer pipe, the outer pipe prevents the perforations in the inner pipe from being sealed and permits stored fluid to be withdrawn through the upper perforations in the outer pipe.

The foregoing and other objects and advantages of this invention will become more apparent and more readily understood when read in conjunction with the drawings wherein:

Figure 1 is a diagrammatic sketch, partially in section, of a salt well for the storage of fluids having a central vertical shaft and a downhole pump disposed in the pump intake apparatus of the present invention;

Figure 2 is a diagrammatic sketch, partially in section, of a salt well for the storage of fluids having a pair of vertical shafts and a downhole pump disposed in the pump intake apparatus of this invention; and,

Figure 3 is a diagrammatic, vertical section of the lower portion of a mined cavern for the storage of fluids, showing a vertical shaft, a lower tunnel connecting said shaft to said cavern, and a down hole pump disposed in the pump intake apparatus of the present invention.

Referring to Figure 1, we have shown a salt well or cavern 1 connected by a vertical shaft 3, to the surface of the ground. The shaft 3 extends below the floor 5 of the cavern to form a sump 7 below the floor of the cavern. A metal liner 9 lines the shaft from the surface of the ground to the roof of the cavern 1 and is held firmly in place by cement 11. A well head 13 closes liner 9 and seals the contents of the well from the atmosphere. Pipe 15 provides communication through the side of the liner 9 below well head 13. A valve 17 controls pipe 15 and fluids to be stored in the well can be introduced through valve 17 and pipe 15 into shaft 3.

A casing 19 extends through well head 13 into shaft 3 to the bottom of sump 7 where it is secured in place by cement 21. A casing head 23 seals the contents of the casing and a pipe 25 in the wall of the casing 19 below the casing head 23 and above well head 13 provides an additional entry point for the introduction of fluids to be stored in the well. A valve 27 controls pipe 25.

A downhole pump 29 is disposed within the casing 19 in the region of the floor 5 of the cavern 1. Pump 29 can be any of the well known types of downhole deep well pumps. The pump illustrated includes an electric motor 31 attached to the lower end of the pump 29 by an intake 35. Electric motor 31 is energized by a power source 37 at the surface of the ground which is connected to motor 31 by cable 39.

Pump 29 is suspended within casing 19 by discharge tubing 53 which extends upwardly through casing 19, well head 13 and casing head 23 to suitable discharge piping at the surface, not shown. The discharge tubing 53 is controlled by valve 55.

In order to withdraw the maximum amount of the stored fluids from the salt well, it is advantageous to place the pump so that the pump intake 35 is within the sump 7 and, in any event, is not higher than the floor of the cavern. It can be readily seen that if the pump were not enclosed in the casing 19, as is shown in

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Figure 1, the intake to the pump could be sealed off very easily by caving or sloughing of the cavern walls.

In accordance with this invention, the casing 19 has a series of perforations 41 in a region adjacent to the intake of the pump. In the case where a pump is used which includes an electric motor attached to the lower end of the pump intake, as is shown in Figure 1, it is desirable that the upper level of the perforations 41 in the casing be below the motor 31 so that fluids withdrawn from the cavern flow past motor 31 and cool motor 31. Further, in accordance with this invention, an outer pipe 43 is attached to casing 19. Outer pipe 43 is closed at its ends and is attached by welds 45 and 47 to the outer surface of casing 19. Pipe 43 is of sufficient length to extend from above the region of the top of the pump 29 to below the region of perforations 41 in the wall of casing 19. Outer pipe 43 has a lower series of perforations 49, the upper level of which is below the upper level of perforations 41 in casing 19. Outer pipe 43 also has at least one upper series of perforations 51 in the region of the top of outer pipe 43.

It will be readily apparent that during normal operations the stored fluid is withdrawn from the cavern 1 into sump 7 through perforations 49 and perforations 41 into pump intake 35, from whence it is passed via tubing 53 to suitable discharge piping at the surface.

Referring now to Figure 2, the present invention is illustrated in combination with an underground storage system which has been actually reduced to practice by the applicants. In Figure 2 as in Figure 3, elements of the drawings which are the same in Figure 1 are given the same reference numbers. A salt cavern 56 is connected to the surface of the ground by a pair of vertical shafts 3 and 57. Shaft 57 provides communication between the surface of the ground and the top of the cavern 56 and has a metal liner 59 cemented from the top of the well to the surface of the ground. Liner 59 is sealed by a well head 61 and has a pipe 63, controlled by valve 65, in its side for introducing fluids to be stored to the cavern. Shaft 57 is used solely for introducing fluids to be stored into the well. The second shaft 3 extends from the surface of the ground to a region adjacent to and below the floor of the cavern 56 to form sump 7. The lower region of the cavern 56 tapers out on one side to form a tunnel 58 which intersects shaft 3. The arrangement of shafts and the cavern illustrated in Figure 2 has been found in actual practice to be highly useful and the intake apparatus of the present invention has prevented any caving or sloughing of the cavern walls from sealing off the intake 35 to the downhole pump 29.

Referring now to Figure 3, the pump intake apparatus of the present invention is shown in a cavern mined out of an impervious rock, such as shale rock. A vertical shaft 67 extends from the surface of the ground to the floor of a cavern 69. The cavern 69 is connected to the shaft 67 by a tunnel 71. It will be noticed that in the embodiment shown in Figure 3 shaft 67 terminates at the floor 73 of the cavern. The shaft 67 usually has a metal liner 75 which can extend to the region of the top of cavern 69, as shown, or can extend all the way to the bottom of shaft 67. The metal liner 75 is usually cemented throughout its length by cement 77. Also, an additional pipe 81, controlled by valve 83, extends from the surface of the ground into the top of cavern 69 and provides a separate means for admitting fluids to be stored to the cavern.

It will be noticed that in the embodiment shown in Figure 3 the outer pipe 43 contains an additional series of perforations 79 and it is within the scope of the invention to provide a plurality of such series of perforations. Thus, an apparatus is provided which permits withdrawal of stored fluids from succeeding higher levels in the underground storage system as caving or sloughing occurs to seal off lower series of perforations in the outer pipe.

In the operation of underground storage systems utilizing the pump intake apparatus of the present invention, the stored fluids can be withdrawn down to the lowest perforations in the outer pipe which are available. Before any caving has occurred this means that the stored fluids can be withdrawn down to the lowest level of perforations 49. In the event caving does occur, the outer pipe prevents perforations 41 in casing 19 from being clogged. To this end, it is desirable that the upper level of perforations 49 be substantially below the upper level of perforations 41. By this arrangement, should caving occur, only the lower level of perforations 41 could be clogged due to entrance of the caved material through perforations 49. Thereafter, the stored material can be withdrawn through perforations 79 into the upper level of perforations 41 to the pump intake. If caving should occur of such proportions as to clog perforations 79, the stored material can be withdrawn through perforations 51 and perforations 41 to the pump intake.

Where the downhole pump being used has an electric motor attached to the lower end of the pump, it is desirable that the upper level of perforations 41 be below the electric motor. This assures that the withdrawn fluid must pass and flow around the electric motor to reach the pump intake thereby providing desirable cooling for the electric motor by direct heat exchange. Obviously, where other types of downhole pumps are used, such as one driven by a rotating shaft from a source of power at the surface, the latter requirement does not hold true and perforations 41 can be placed immediately adjacent to the pump intake. In all cases, however, the relationship of the perforations in outer pipe 43 to the perforations in casing 19 must be maintained as described herein before. The pump intake apparatus of this invention is useful in other installations as well as those specifically described. In general, the pump intake apparatus is useful wherever caving can occur to clog or bury a pump.

It should be apparent that the objects of this invention have been accomplished. The several embodiments of the invention shown and described herein are illustrative only and should not limit the invention unduly.

We claim:

1. In an underground storage system for fluids under pressure comprising an underground cavern, a shaft connecting said cavern to the surface of the ground, a downhole pump, having an intake positioned below said pump, suspended by discharge tubing within said shaft and disposed in the region of the floor of said cavern, a casing within said shaft containing said pump, pump intake and discharge tubing and extending from the surface of the ground to below said pump, said casing being perforated in the region below the intake of said pump, and an outer pipe disposed about said casing closed at its ends and attached to said casing adjacent to the upper end of said pump and below the perforations in said casing, said outer pipe being perforated in a region adjacent to its upper end above the intake to the pump and being perforated in a region adjacent to its lower end, the upper level of said lower outer pipe perforations being below the upper level of the perforations in said casing.

2. In an underground storage system for fluids under pressure comprising an underground cavern and a downhole pump, having an intake positioned below said pump, carried by discharge tubing and positioned in the region of the floor of said cavern, a casing containing said pump, pump intake and discharge tubing, said casing being perforated in a region below the intake to said pump, and an outer pipe disposed about said casing and closed and attached at both of its ends to said casing, said outer pipe extending from the region of the upper end of said pump to below the perforations in said casing, and said outer pipe being perforated in a region adjacent to its upper end above the intake to the pump and being perforated in a region adjacent to its lower end, the upper level of

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said latter perforations being below the upper level of the perforations in said casing.

3. An underground storage system for liquefied petroleum gases which comprises, in combination, an underground cavern, a shaft connecting said cavern to ground level, said shaft extending to below the floor of said cavern to form a sump therein, a pump, having an intake positioned below said pump, positioned in said sump and carried by discharge tubing in said shaft, a casing in said shaft extending from ground level to the bottom of said sump and containing said pump, pump intake and discharge tubing, said casing being perforated in a region below the intake to said pump, and an outer pipe disposed about said casing and closed at both ends, one of said outer pipe ends being attached to said casing in the region adjacent to the upper end of said pump and the other of said outer pipe ends being attached to said casing in the region below and adjacent to the perforations in said casing, said outer pipe being perforated in at least one upper level adjacent to its upper end above the intake to the pump and being perforated in a region adjacent to its lower end, the upper level of said lower outer pipe perforations being below the upper level of the perforations in said casing.

4. An apparatus which comprises, in combination, a casing permanently fixed in the earth, a deep well pump suspended by a discharge tubing within and adjacent the lower end of said casing, said pump comprising an electric motor attached thereto and an intake, said pump

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intake being positioned below said pump and said motor being positioned below said intake, said casing being perforated in a region adjacent to said electric motor, the upper level of said casing perforations being below said electric motor, an outer pipe concentrically disposed about said casing, said outer pipe being closed at its ends and attached at its ends to the wall of said casing, the lower end of said outer pipe being attached to said casing below the lower end of the region of the perforations in said casing and the upper end of said outer pipe being attached to said casing at a position above said pump, said outer pipe being perforated adjacent to its lower end, said latter perforations being below the upper level of the perforations in said casing and said outer pipe being perforated in at least one region above the intake to the pump.

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