United States Patent [19]

Wolfe

[54] COMBINED DEPTH INDICATOR AND WATER SAMPLER

- [75] Inventor: Court L. Wolfe, Pittsburgh, Pa.
- [73] Assignee: Gulf Research & Development Company, Pittsburgh, Pa.
- Dec. 14, 1972 [22] Filed:
- [21] Appl. No.: 315,072
- [52] U.S. Cl...... 73/291, 73/300, 73/425.4 R
- Int. Cl...... G01f 23/16, G01n 1/10 [51]
- [58] Field of Search... 73/291, 300, 425.4 R, 170 A, 73/412; 137/540

[56] **References Cited**

UNITED STATES PATENTS 1 202 529 72/202

1,392,538	10/1921	1 ice / 3/303
1,631,909	6/1927	Badin
1,861,886	4/1925	Slough 73/303 X

[11] 3,841,156

[45] Oct. 15, 1974

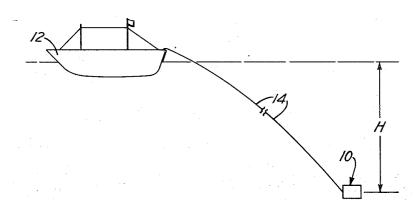
2,942,473	6/1960	Mayes 73/412 X
3,301,066	1/1967	Leonard et al 73/425.4 R
3,455,904	7/1967	Hopkin
3,651,697	3/1972	Januzzi 73/412

Primary Examiner-Richard C. Queisser Assistant Examiner-Daniel M. Yasich

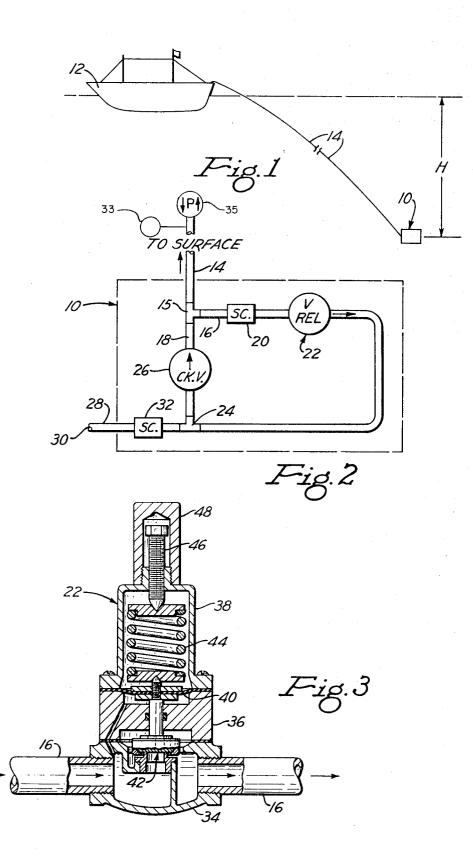
ABSTRACT [57]

A device for sampling a fluid such as water and for determining the pressure and therefore the depth of the water at the sampling location. A single hose is used for both upward flow for sample taking and downward flow to operate a back pressure valve having a sealed pre-set loading chamber to resist opening by pressure from the surface. The pressure exerted by the fluid in the hose automatically increases with increasing depth, and thus the surface measured pressure required to open the valve correlates to depth.

8 Claims, 4 Drawing Figures



SHEET 1 OF 2



PATENTED OCT 1 5 1974

3,841,156

SHEET 2 OF 2

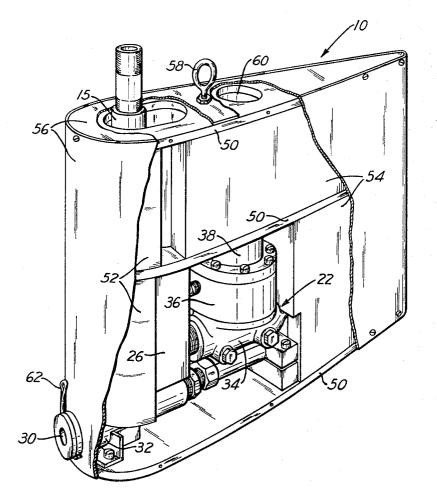


Fig.4

1 **COMBINED DEPTH INDICATOR AND WATER** SAMPLER

This invention relates to geophysical exploration, and more particularly it relates to method and apparatus for sampling water, such as in the ocean, using a single 5 hose or conduit running from the surface vessel to an underwater location to both take samples and determine the depth at which they are taken. Thus, the invention method and apparatus combines two previous individual pieces of apparatus into a single combined 10 device which performs both functions in a scientifically elegant manner and eliminates many prior problems.

The prior art uses the so-called well-known pressure method of determining depth. In this system, air pressure is pumped down the submerged hose, and the 15 pressure at which the air pressure overcomes the water pressure at the bottom end of the hose is noted. At this point, the water and air pressures are equal, and thus the pressure at the open end of the hose can be determined. Knowing the density of the sea water or other 20 which fluid medium, the depth in the medium of the exposed hose end can be determined.

The present invention uses a similar system, but most frequently, utilizes a liquid in the hose. When operating in water, such as oceans or lakes, the invention would 25 not operate well with a gas in the base because a relatively large conduit is utilized and such a correspondingly large quantity of a gas could have a buoyant effect on the sampler thereby changing the depth at which readings are made. Another reason that gases are 30 thought to be less desirable than liquids when the invention is used in a liquid outside environment such as water, is that the gas in the conduit would cause an unpriming effect on the system when the flow is reversed to take the water sample. For this reason, when operat- 35 ing in water, a liquid should be used in the system and not a gas.

More generally, however, since the invention can be used in a gaseous outside environment, such as in the atmosphere, the fluid in the conduit could be and in 40such case would be a gas. If the invention were used in the atmosphere then a liquid filled conduit would be much too heavy. Thus, in general, the fluid in the conduit will be gaseous or liquid to match the fluid of the 45 environment. That is, use a liquid in the hose when sampling liquids, and use a gas in the hose when sampling gases.

The apparatus of the invention includes an array of standard components, with a slight modification to one 50 of them, to alternately permit fluid samples to be drawn through the same hose used for depth determination.

Heretofore, when prospecting in water covered terrain and looking for seeps or the like evidences of hydrocarbon deposits, complicated equipment functionally equivalent to two separate pieces of equipment 55 were required, one for each function. The geophysical explorationist needs to accurately map the taking of samples in the water in order to accurately locate the places on the surface of the underwater terrain from which the seeps originate. Small inaccuracies in this mapping can result in a well being drilled in the wrong place. The invention overcomes these disadvantages by providing a single simple sampler which accurately takes water samples and determines the depth at which 65 the samples are taken. The longitude and latitude information portion of the sample taking is done by conventional means on the surface vessel.

The invention uses, as its measuring element, a diaphragm operated valve with top spring loading sealed in a reference chamber. Thus, the loading force is independent of depth or hydrostatic head. The unloading force operating under the diaphragm and tending to open the valve is a direct function of hydrostatic head within the supply/intake hose. Since the vertical component of the supply hose and depth to the sampler are directly related, the back pressure in the supply hose is a measure of the depth of the sampler. During the depth interrogating process, the intake screen is automatically back flushed. Reversing the flow in the connecting hose from pressure to suction automatically converts the invention apparatus from depth sensing to sample intake.

The above and other advantages of the invention will be pointed out or will become evident in the following detailed description and claims, and in the accompanying drawing also forming a part of the disclosure, in

FIG. 1 is a general view showing a surface vessel towing a sampler embodying the invention;

FIG. 2 is a schematic diagram of the sampler of the invention:

FIG. 3 is a cross-sectional view through the diaphragm controlled pressure sensor;

and FIG. 4 is a perspective view of the successfully constructed embodiment of the invention with some parts broken away and in cross-section.

Referring now in detail to the drawing, in FIG. 1 there is shown a surface vessel 12 which tows a sampler 10 embodying the invention via any conventional geophysical hose or conduit 14. The object is to both take samples at the depth H and determine depth H. In the successfully constructed embodiment, hose 14 was a Synflex 3300-8 (one-half inch dia.) with a stainless steel braid covering.

Referring to FIG. 2, there is shown a schematic diagram of the successfully constructed embodiment of the sampler 10. Hose 14 from the surface vessel 12 terminates at a "Tee" junction generally designated by reference numeral 15. Reference numeral 15 also indicates suitable means to make a secure and flexible connection between the hose 14 and sampler 10, and will to this end include a swivel and other hardware such as a pipe nipple or the like. A pair of conduits 16 and 18 branch off of the other two legs of junction 15. Conduit 16 contains, in series, a screen 20 (indicated by the legend "SC." in the drawing) and a diaphragm operated valve 22 shown in more detail in FIG. 3. Conduit 16 terminates at one leg of another "Tee" joint 24. Conduit 18 runs between the Tee joints 15 and 24 and contains a check valve 26 (indicated in the drawing by the legend "CK. V."). Check valve 26 permits the flow of fluid in the conduit 18 only in the direction indicated by the arrow. A conduit 28 is connected to the third and final leg of joint 24, and it contains the inlet end 30 for sea water to be sampled and the screen 32 in series therewith.

Referring now to FIG. 3, the valve 22 is shown in cross-sectional elevational view. This component is a spring loaded diaphragm valve, a standard item of commerce, the one used in the successfully constructed embodiment having been made by Cla-Val Co. of Newport Beach, California, their model number Clayton CRL5, and it is a ^{1/2} inch size valve. This valve has a feature which is desirable in the invention, namely, a rela-

60

tively flat flow versus back pressure curve characteristic

Referring now to FIG. 3, valve 22 is made up of three portions; a flow portion 34, a main body 36, and a sealed loading chamber defining portion 38. A dia- 5 phragm 40 is held between the portions 36 and 38 in the conventional manner. This diaphragm carries a valve assembly 42 which controls the flow through the flow portion 34. Note that when valve assembly 42 is closed, a negative or suction force on the underside of 10 the valve assembly will close the valve and will not permit flow in the direction opposite to that indicated by the arrows. Loading chamber portion 38 includes spring 44 which bears against the upper side of diaphragm 40 and valve assembly 42, and renders valve 22 15 spring loaded nromally closed. A screw 46 threadedly mounted in a boss in the upper end of the housing or portion 38 adjusts the force with which spring 44 bears against the diaphragm. This adjustment is important to the operation of the invention as will appear below. A 20 removable seal 48 is provided over the top end of the screw 46, and a suitable sealing gasket, not shown is also provided in the usual manner.

testing the invention. The purpose of this FIG. 4 is to enrich this disclosure by illustrating said successfully constructed embodiment, the conceptual teachings being provided in the previous drawings and corresponding description. Other specific configurations and 30 arrangements of parts will present themselves to those skilled in the art. In this regard, it should be noted that the invention is not limited to use in sea water, but could be used to detect the pressure of and take samples of any fluid, for example, it could be used in air for ³⁵ pollution work, or surveying altitude as of a mountain or other rugged terrain, or determining vertical distance in a fluid from some higher reference point, such as depth in a borehole, or generally for sampling a fluid 40 and determining its pressure at a sampling location from a remote location vertically spaced from the sampling location.

Referring now to FIG. 4 in detail, the embodiment is of generally faired or airfoil configuration to facilitate 45 its movement through sea water or other fluid medium. Sampler 10 is made up of three horizontal plates 50 held together in any suitable manner not shown in detail. At the front end, there are provided weights 52, and these cooperate with blocks or layers of buoyant 50 material 54, such as styrofoam. By adjustment of the amounts of weights 52 and buoyant or float members 54, with due regard to the other apparatus mounted in sampler 10, the attitude or natural angle which the sampler will assume in water, or other fluid, can be pre-55 determined.

The entire sampler 10 is covered with suitable smooth surfaced streamlined fairing 56 having suitable openings to pass the inlet end 30 and screen 32, the Tee junction and connection means 15, a safety and carry-60 ing hook 58, and means to allow access to a hole 60 which hole provides access to cover 48 and screw 46 for adjusting the force of spring 38 on the diaphragm in valve 22. Hook 58 is for general utility purposes, it can be used to carry the sampler, or to attach a safety 65 line to it during use under exceptionally adverse conditions, or the like. It is preferred to mount the sampler on only the hose 14 because the faired body tows neat

when the tow point coincides with the center of gravity. which is the case in this successfully constructed embodiment.

The parts of fairing 56 are held onto the plates 50 by suitable screws (not numbered) as partially indicated in FIG. 4. A cotter pin 62, external to the fairing 56, is provided to hold the inlet end 30 and the screen 32 together and to permit their disassembly easily from the outside for purposes of cleaning the screen as required.

A slight modification to the valve 22 was required, and this change entailed sealing of the spring chamber above the diaphragm from the chamber below the diaphragm.

The terms "pressure method" and the like expressions as used in the specification and claims herein shall be understood to mean that method of determining depth, or more broadly vertical distance between two locations in a fluid, which comprises overcoming the pressure at the sampling location with the same fluid or with another fluid pressurized from a remote location whose pressure is measurable, and then determining vertical distance between the two locations using this Referring now to FIG. 4, there is shown a view of the pressure data and the density of the fluid. A modified actually constructed embodiment used in successfully ²⁵ "pressure method" is used in the invention, as will appear below.

> In this regard, it would be a simple matter to scale a gauge onboard the vessel or at any other remote location to read directly in depth or vertical distance knowing the density of the water (whether salt or fresh), or the density of other fluid. The loss term is additive, and the other relationships are linear. Of course, the invention is equally applicable to fresh water use as in lakes and salt water in use as in the ocean, and can be used in any body of water, whether navigable or not. The remote location could be on the shore. Further, as mentioned above, the invention is also operable for use in air for various purposes, and thus the terms "sampling location" and "remote location" and the like terms as used in the specification and claims herein shall be understood to mean, respectively, the place where the sampler is located in the fluid, and the place where the operator and other equipment is located. For example, it might be desirable to send the sampler aloft on a kite or the like for doing air pollution studies or surveying, and thus, in such case, the remote location would be a ground station and the sampling location would be the position of the kite borne sampler in the air above the ground.

> Since fluid can flow in a conduit in only one direction at any one time, the invention must alternate sample takings with its flow away from the sampler and pressure and depth determination which requires a flow towards the sampler. The change time is relatively short for typical depths, on the order of 30 seconds, and does not introduce any harmful errors into the final data. Automatic cycling between sampling and depth determination can be added to the invention.

> Use of the invention is extremely simple. The user first places the apparatus at a reference level to determine a reference pressure from which the measurements will be taken. The reference pressure will be set at some predetermined amount greater than the maximum pressure it is anticipated the sampler 10 will encounter in use. The principle of operation of the invention is to balance the independent loading force on the valve produced by the spring 44 against the changing

described above.

unloading force on this valve produced by the column of liquid or other fluid in the hose 14. As mentioned above, the loading force, the force of the spring in valve 22, is pre-set slightly greater than the greatest unloading force (pressure or depth) it is expected the sampler 5 will experience in any particular application. The unloading force automatically increases with increasing depth as more hose is played out from the reference level since the column of fluid in the hose increases correspondingly during the taking of a depth determi- 10 nation. Thus, the pressure produced by the pump at the reference level will be equal to only the additional force necessary to "pop" valve 22 at any particular depth. It is this additional force which is measured and it is this additional force which will be correlated to 15 depth. To make a depth determination then, this additional force is subtracted from the reference pressure stored in the spring in the valve, and the resultant number, which corresponds to depth, is correlated to depth of the sampler below the reference level. As an exam- 20 ple, when operating in sea water, assume the maximum depth anticipated is 250 feet which corresponds to a pressure of about 111 pounds. The spring in valve 22 will be set for a pressure of 121 pounds, the additional being 10 pounds. Ten pounds is preferred because it is 25 a minimum practical value for proper valve operation. Now the sampler is lowered into the water. At some unknown depth, assume the pressure read on the boat needed to "pop" the valve is equal to 50 pounds. To determine depth, subtract 50 from 121, and correlate 30 the resulting 71 pounds to depth via a reverse correlation, 71 divided by 0.444 (0.444 is a number proportional to the weight of the fluid, specifically the pressure per foot of depth in sea water), yielding about 160 feet. Now assume the sampler is located deeper in the ³⁵ water. The pressure at the surface required for operation of the valve is now 30 pounds, (the additional force grows snaller at greater depths) 30 from 121 equals 91, and 91 over 0.444 correlated to depth the 40 same way as above, equals about 205 feet. Finally, as a check, if the sampler is at 250 feet, 10 pounds will be needed to open the valve, 121 less 10 equals 111, and 111 pounds correlates to 250 feet as above.

The invention can also be used for single point depth determination. For example, one sets the reference ⁴⁵ pressure to correspond to some predetermined depth such as a depth at which it is desired to take samples. The sampler will automatically operate when it reaches this depth, the indicator at the surface being a flow towards the sampler. ⁵⁰

As an incidental matter, the reference level may or may not correspond to the surface of the water or other fluid in which the invention is operating, but in any case, this is a simple fixed correction. Typically, in water, the reference level will be the deck of the surface ⁵⁵ vessel.

On board vessel 12, the user will have suitable conventional pressure measuring means 33 and pump means 35 to both draw water up the hose 14 and to pump water down the hose 14. Such means are well known in the art and need not be described in any further detail herein. When there is suction on hose 14 to take a sample, sea water flows through inlet 30, screen 32 to protect the apparatus, check valve 26, and thence to the surface. The suction force aids the force of spring 44 in holding valve 22 securely normally closed during the taking of samples, and therefore there is no

flow in conduit 16. When a depth measurement is taken, check valve 26 operates, and the flow goes through conduit 16 to bear against the underside of the valve assembly 42. The user slowly increases the pressure in the hose 14 until, finally, the pressure reaches a value which equals and just slightly exceeds the loading force of spring 44. At this point, the valve opens, the user notes the pressure at which the valve opened, and this pressure is easily and very accurately transformed into the depth of inlet 30 below the surface, as

Another feature of the invention is the fact that conduit 16 loops back to Tee 24 to thereby reverse the flow through screen 32 when a depth measurement is made. Conceptually, the invention would work just as well were the right hand side of valve 22 exposed to the ambient sea water or other fluid. The looping gives the invention apparatus the advantage of automatic flushing of screen 32 during normal operation.

As mentioned above, it is desired that the spring 44 and the valve 22 have a relatively flat flow versus back pressure characteristic. As a practical matter, this results in the selection of a relatively long, relatively "soft" spring 44, whereby the valve opens easily and permits a relatively constant flow once it is open. Looked at another way, this sort of spring results in a constant back pressure. The desideratum is that the back pressure of the spring on the valve be as constant as possible over a large range of flow rates. This is accomplished by the soft spring. If the spring were relatively short and/or relatively stiff, the back pressure on the valve would increase greatly at increasing flows, which illustrates the need for a relatively long, relatively soft spring at 44. While the invention has been described in detail above, it is to be understood that this detailed description is by way of example only, and the protection granted is to be limited only within the spirit of the invention and the scope of the following claims.

I claim:

1. Apparatus for sampling a fluid at a sampling location, delivering the sample to a remote location vertically spaced an unknown distance from the sampling location and determining at the remote location the pressure at the sampling location comprising a flexible conduit having a first end adapted to be located at the remote location and a second end connected to sampling apparatus adapted to be located at the sampling location; said sampling apparatus comprising a sampling conduit having one end connected to said second end of the flexible conduit, a check valve in the sampling conduit and adjacent the second end, said check valve being adapted to allow flow only in one direction from the sampling conduit through the second end and through the flexible conduit to the first end, a pressure relief valve positioned adjacent the second end having an inlet communicating with the sampling conduit between the check valve and the first end and an outlet for communicating with the other end of the sampling conduit at the sampling location, said pressure relief valve being set to be opened at a predetermined pressure and constructed and arranged to permit flow only from the first end of the conduit through the pressure relief valve upon application of a pressure at the first end of the conduit exceeding the predetermined pressure for opening the valve; suction means connected to the conduit at the first end for drawing a sample

6

through the sampling conduit from the sampling location, pressure means connected to the conduit at the first end for delivering a fluid of the same phase as the sampled fluid through the flexible conduit at a pressure to overcome the predetermined pressure setting of the 5 pressure relief valve, and means at the remote location for measuring the pressure in the flexible conduit at the remote location.

2. Apparatus as set forth in claim 1 in which the pressure relief valve comprises a valve body having an inlet 10 communicating through the flexible conduit with the pressure means, a diaphragm in said valve body, an adjustable spring engaging one surface of the diaphragm constructed and arranged to keep the valve closed with a predetermined pressure, a valve seat in the valve 15 body, a valve plug actuated by the diaphragm adapted to move from a closed position in engagement with the valve seat to an open position, and a port providing communication between the inlet of the valve and the side of the diaphragm opposite the spring whereby 20 pressure applied to the fluid by the pressure means is exerted against the diaphragm in opposition to the force exerted by the spring.

3. Apparatus as set forth in claim 2 including means for operating the suction means and pressure means al- 25 ternately.

4. Apparatus as set forth in claim 1 including a bypass line around the check valve, and the pressure relief valve is in the bypass line.

5. Apparatus as set forth in claim 4 in which the 30 check valve, pressure relief valve and bypass line are enclosed within a sampler housing, and float means and weight means are positioned in the sampler housing to control the attitude of the sampler as it moves through the fluid to be sampled. 35

6. Apparatus as set forth in claim 5 in which a screen is in the conduit line between the sampling location and the bypass.

7. Apparatus as set forth in claim 1 in which the fluid

8

is a liquid and the remote location is above the sampling location.

8. A method of delivering samples of a fluid taken at a sampling location to a remote location vertically spaced from the sampling location and determining at the remote location the difference in elevation of the sampling location and the remote location comprising extending a flexible conduit from the remote location to the sampling location, said flexible conduit connected to a sampling conduit having a check valve therein permitting flow from the sampling location to the remote location, setting a pressure relief valve to open at a predetermined pressure higher than the static head of a column of the fluid having a height equal to the difference in elevation of the sampling location and the remote location, connecting the pressure relief valve into the sampling conduit between the check valve and the remote location arranged whereby the pressure relief valve is at substantially the elevation of the sampling location and permits flow from the remote location through said pressure relief valve to the sampling location, drawing a sample through the sampling conduit to the remote location, thereafter pumping a second fluid of the same phases as the fluid sampled and of known density from the remote location through the conduit and into the pressure relief valve, increasing the pressure on the second fluid to exceed the predetermined pressure of the pressure relief valve and cause flow therethrough, measuring at the remote location the pressure on the second fluid required to overcome the predetermined pressure of the pressure relief valve, subtracting the pressure measured at the remote location from the predetermined pressure at which the pressure relief valve is set to give the static head of the fluid being sampled at the pressure relief valve, and converting the static head to the depth of the fluid being sampled.

* * * * *

45

40

.

55

50

60

65