April 17, 1945. J. B. WARREN, JR 2,373,795

SPECIFIC GRAVITY INDICATOR FOR DRILLING MUD

Filed May 6, 1938 4 Sheets-Sheet 1

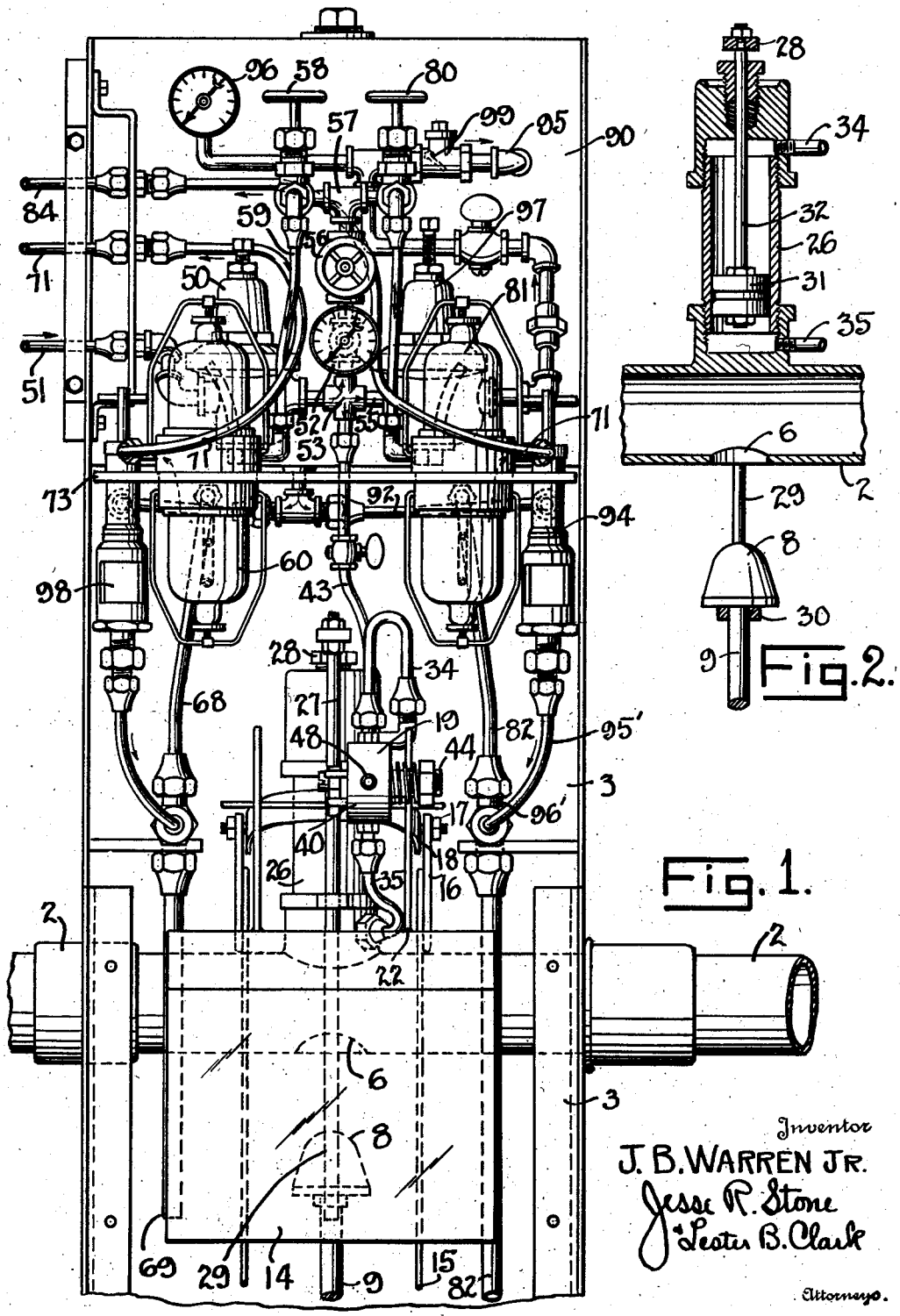


Fig. 1.

Fig. 2.

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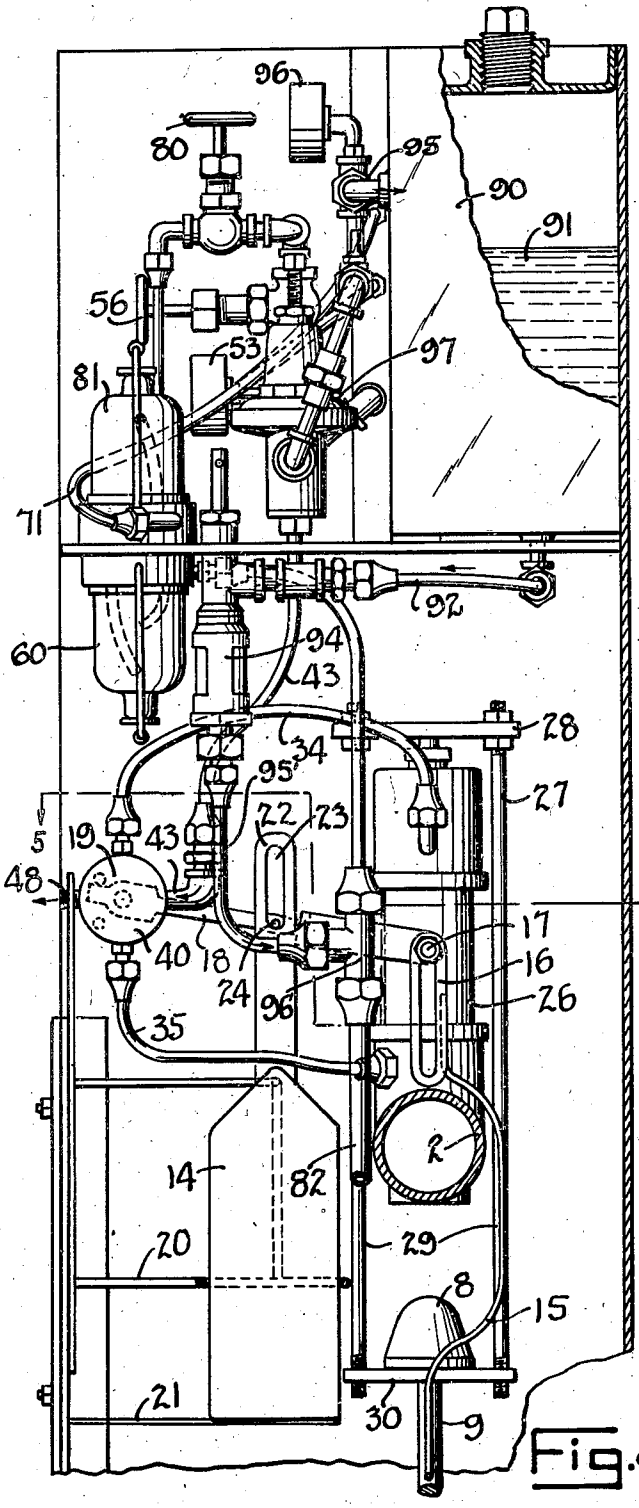


Fig. 3.

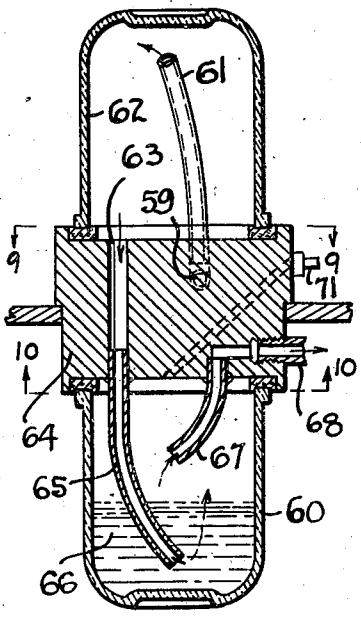


Fig. 8.

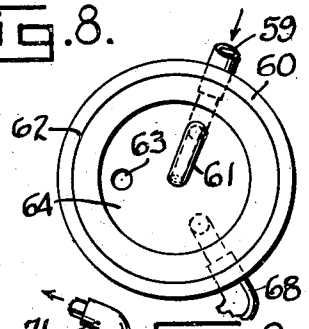


Fig. 9.

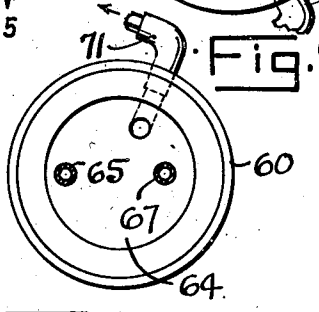


Fig. 10.

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SPECIFIC GRAVITY INDICATOR FOR DRILLING MUD

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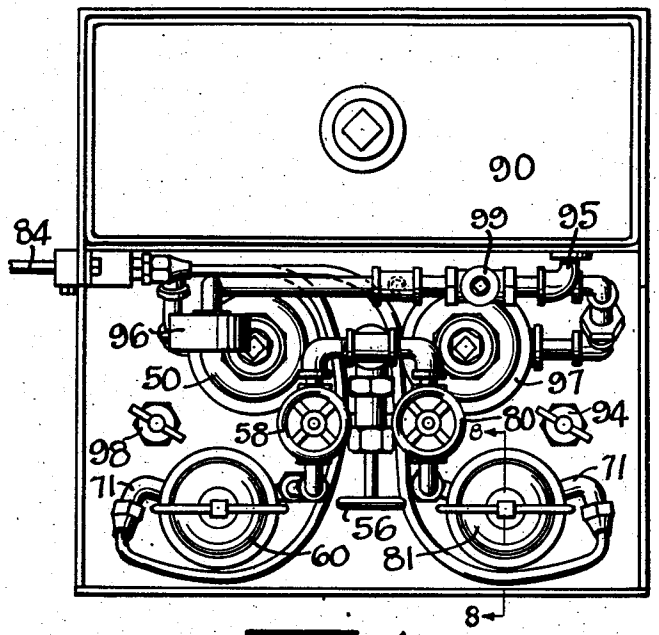


Fig. 4.

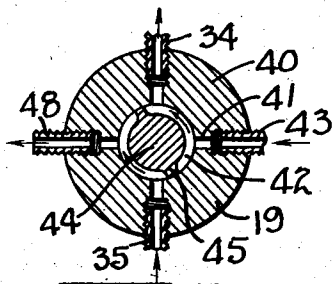


Fig. 7.

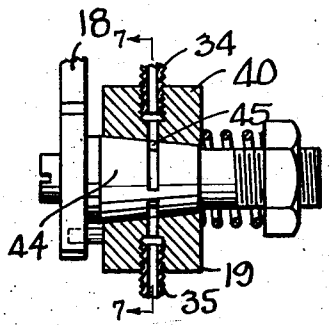


Fig. 6.

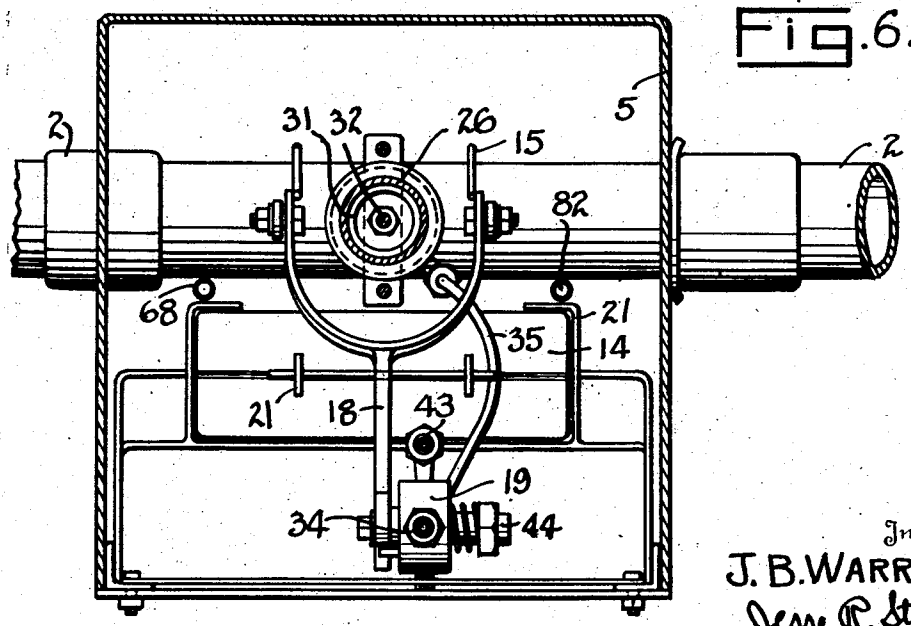


Fig. 5.

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SPECIFIC GRAVITY INDICATOR FOR DRILLING MUD

Filed May 6, 1938 4 Sheets-Sheet 4

Fig. 11.

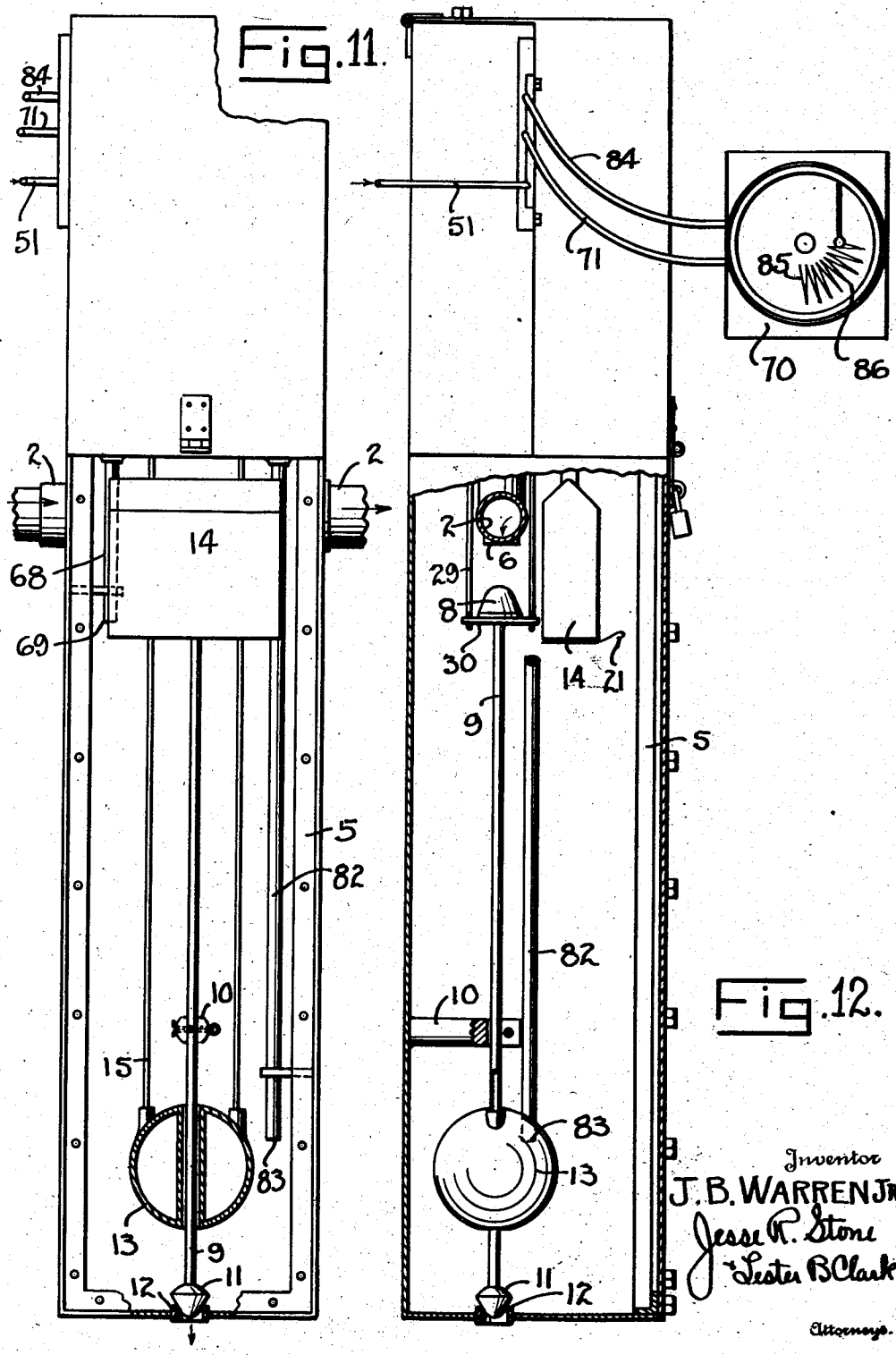


Fig. 12.

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UNITED STATES PATENT OFFICE

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SPECIFIC GRAVITY INDICATOR FOR DRILLING MUD

John B. Warren, Jr., Houston, Tex.

Application May 6, 1938, Serial No. 206,327

9 Claims. (Cl. 73—32)

The invention relates to a means for determining the specific gravity of a liquid and is particularly adapted for use in determining the specific gravity of drilling mud used in the rotary method of drilling wells.

In the rotary method of drilling wells a circulation of slush is pumped downwardly through the drill stem and discharged therefrom adjacent the cutting edges of the bit. This circulation of mud has many functions such as to carry the cuttings away from the bit and keep the bit cool and in some instances to wall up the formations which have been penetrated and to maintain such formations against caving. It is usual, therefore, to have this slush made up of clays suspended in water or other liquids and there are many ingredients which are used to obtain drilling muds having various specific characteristics. In some instances it is desirable to have the mud of greater specific gravity in order to prevent caving of the formation and to create a high unit area pressure on the formation to overcome the natural pressures encountered in the formation. In other instances it is desirable to have a mud with a greater viscosity so that it will carry cuttings from the well bore without permitting the cuttings to settle out of the mud. In other instances it is desirable that the mud have greater sliming qualities, so that it will not create an undue frictional resistance during its circulation into and out of the well bore and, in still other instances, it is desirable to have a mud from which the gas can be readily expelled so that there will be no gas cutting or reduction in specific gravity of the mud, due to the presence of gas therein, and while in still other instances the mud may become diluted by the inflow of water or other materials from the formation in the well bore.

During the drilling operation as the drill bit penetrates various formations the characteristics of drilling mud being introduced into the well bore must be changed in order to cope with the circumstances which arise and with this in mind it is desirable to determine the specific gravity of the mud which is being discharged from the well bore at quite frequent intervals because any change in the specific gravity may have disastrous results depending upon the conditions which are being encountered.

With the foregoing in mind it is one of the objects of the present invention to provide a means for periodically determining the specific gravity of the flow of mud as it emerges or enters the well bore.

Another object of the invention is to provide an arrangement whereby the specific gravity of a body of liquid may be determined as a function of the differential pressure required to inject two spaced streams of fluid into a body of the liquid.

Still another object of the invention is to provide a bubble glass for use with a device for introducing a flow of fluid into a body of liquid.

Still another object of the invention is to provide a device for lubricating the inflow of fluid into a body of liquid to offset evaporation at the point of inlet.

Still another object of the invention is to provide an apparatus for determining specific gravities, which apparatus will receive the body of the liquid, record the specific gravity thereof, and discharge the body of the liquid in an automatic sequence of periodic operations.

Still another object of the invention is to provide a mechanism for introducing fluid under pressure in order to determine the specific gravity of a body of liquid, which mechanism will operate continuously and automatically.

Still another object of the invention is to provide a particular type of bubble glass for determining the rate of flow of a fluid so that such glass may be tilted or turned without discharging the indicating liquid therefrom.

Still another object is to provide a self contained compact device which may be readily connected to determine the specific gravity of a well drilling fluid.

Other and further objects of the invention will be readily apparent when the following description is considered in connection with the accompanying drawings wherein:

Fig. 1 is a side elevation of the upper portion of the mechanism which may be used in practicing the invention.

Fig. 2 is a vertical sectional view through the plunger apparatus for controlling the inflow and outflow of the liquid the specific gravity of which is being measured.

Fig. 3 is a side elevation taken at right angles to the view of Fig. 1.

Fig. 4 is a top plan view looking down on the apparatus of Figs. 1 and 3.

Fig. 5 is a section taken on the line 5—5 of Fig. 3.

Fig. 6 is a sectional view of the control valve.

Fig. 7 is a section of the valve taken on the line 7—7 of Fig. 6.

Fig. 8 is a vertical sectional view through one of the bubble gauges taken on the line 8—8 of Fig. 4.

Figs. 9 and 10 are sectional views through the bubble gauge of Fig. 8 looking downward and upward, respectively, on the central portion of the gauge, to illustrate the arrangement of the inlets and outlets.

Fig. 11 is a side elevation of the device particularly illustrating the container for the liquid to be measured.

Fig. 12 is a view taken at right angles to Fig. 11 with certain of the portions broken away to illustrate the arrangement of the parts.

The device is particularly adapted for use at a drilling rig to measure the specific gravity of the drilling mud, oil or water.

The invention contemplates that a charge of the drilling fluid used in the rotary method of drilling wells will be trapped. A flow of the fluid under pressure will be introduced into this trapped body of liquid at predetermined spaced elevations and the pressure required to so introduce the flow of fluid under pressure will be different for the two different elevations. If the specific gravity of the liquid varies the differential pressure required to introduce the fluid under pressure at the spaced elevations will vary in direct proportion thereto so that the entire mechanism herein disclosed is for the purpose of automatically introducing and determining this differential pressure.

In the several figures a return or flow line 2 has been illustrated and this pipe may be either the usual return line from the well to the slush pit in which the mud is retained, or it may be a bypass therefrom, as circumstances may require. In either instance, however, it is intended that there will be a flow of drilling fluid from the well passing through this pipe 2.

The apparatus for determining specific gravity is indicated generally at 3 and is arranged about the pipe 2 so that a specimen of the liquid in the pipe may be deposited in the apparatus. The mechanism for obtaining such sample is best seen in Figs. 2 and 12. In Fig. 12 a container 5 of any desired size may be positioned about the pipe 2 in such a manner that a flow of liquid discharging from the opening 6 will flow into the container 5.

The container 5 is of sufficient height so that a predetermined volume of drilling mud will be trapped therein. In order to open the pipe 2 and admit a flow of drilling mud into the container a top valve 8 has been provided. This valve is arranged to move upwardly into the opening 6 to close the opening and to move downwardly out of the opening to admit a flow of mud into the container. This valve 8 is carried by a valve rod 9, which is guided through a support 10 extending from the side of the container 5. This valve rod carries a bottom valve 11, which is arranged to close the discharge outlet 12 in the base of the tank. As seen in Fig. 12, the bottom valve is closed and the top valve is open.

It seems obvious that with the valves in the position of Fig. 12 a flow of liquid will pass into the container 5 and be trapped therein, whereas when the valve rod 9 and the valves 8 and 11 move upwardly the inflow will be cut off by closing the inlet 6 and simultaneously therewith the discharge opening 12 will be uncovered and the liquid which has previously been trapped into the container 5 will discharge by gravity. In this manner a new charge of liquid can be received in the container by again lowering the valve rod 9.

It is desired that the inflow and outflow of the liquid to be measured shall be controlled automatically and that the determination of the specific gravity of the charge or specimen of liquid will also be automatically determined. With this in mind a float 13 has been provided near the base of the tank and another float 14 near the top of the tank. The bottom float 13 is connected by means of spaced rods 15, best seen in Figs. 11 and 3, to a link portion 16, which link is slidable relative to a bolt 17 carried by the valve arm 18, which arm serves to actuate the control valve 19. It seems obvious that as the float 13 moves upwardly there will be a tendency to lift the link 16 and slide it upwardly relative to the bolt 17 from the position shown in Fig. 3.

The float 13 is guided by the valve rod 9 and will be stopped in its upward movement by the guide arm 10 and this arm is so spaced relative to the float that the link 16 will not quite reach its upward limit of movement when the arm 18 is in the position shown in Fig. 3, so that while the float 13 may move upwardly on an accumulation of liquid in the container it will not move upward a sufficient distance to affect the arm 18 when it is in the position shown in Fig. 3.

The float 14 on the other hand is slidably mounted in a cage 20 and is arranged to rest upon a stop 21 when it is in the position shown in Fig. 3. This float 14 has a member 22 which has a slot 23 therein arranged to slide relative to the pin 24, which projects from the arm 18. In the position shown in Fig. 3 any upward movement of the float 14 will tend to carry the arm 18 upward with it by virtue of the pin 24 contacting the bottom of the slot 23. Thus, as the container 5 fills with liquid and it approaches the elevation of the float 14 the float will move upwardly and in this manner move the lever 18.

On the other hand when the valve rod 9 is reversed, as will be later described, the valve 8 closes and prevents any further inlet of liquid and simultaneously the valve 11 opens and allows the liquid from the chamber to discharge. As the liquid settles away from the float 14 it will move downwardly. As the elevation of the liquid in the container continues to fall it will pass the float 13 and allow the float and the rods 15 to move downwardly. In order to move the lever 18 down and reverse the movement of the piston 31 as hereinafter described, the link 16 will engage the bolt 17 and bring the lever 18 down when the container is substantially empty. It is of advantage to flow the sample into the container from the top as it has been found in practice that a more uniform sample is thus obtained. The container 5 will thus be either filling or emptying in a continuous but periodic manner.

The mechanism for operating the valve rod 9 and the valves 8 and 11 is best seen in Figs. 2 and 3 and comprises a cylinder 26 which may be mounted upon a suitable section of the pipe 2, or may be otherwise mounted so that it is in alignment with the frame 27 about the pipe 2.

This frame 27, as best seen in Fig. 3, constitutes a cross piece 28 and the spaced rod members 29. These rods straddle the pipe 2 and the cylinder 26 and extend down into the container 5 where the cross piece 30 surrounds the valve rod 9. When this framework is moved to its upper position it will raise the valve rod 9 and the valves 8 and 11, but when it is moved downwardly, as seen in the drawings, it allows the valve 11 to seat and close the container. A piston 31 is connected to the rod 32, which is slidable within the cylinder 26 and is connected to the cross bar 28.

A pipe 34 enters the cylinder 26 to introduce and allow the escape of fluid under pressure to move the piston 31 and a similar pipe 35 is connected to the base of the cylinder. It seems obvious that when pressure is introduced below the piston it will rise and carry with it the frame 27 to raise the valve rod and open the container by opening the valve 11, whereas when the piston moves downwardly the frame 27 will move downwardly and the valve 11 will close and the valve 8 will open.

In order to control the flow of fluid under pressure in the pipes 34 and 35, the control valve 19 is arranged for operation by means of the lever 18. The detailed construction of this valve is best seen in Figs. 6 and 7 wherein the valve body 40 has a plurality of passages 41 therein which lead to a central chamber 42. A pipe 43 furnishes a supply of fluid under pressure to the control valve 19 and this pressure is introduced into the chamber 42. A valve member 44 is movable in the chamber by means of the lever 18 previously described. This valve member is seen in section in Fig. 7 and has the outstanding wings 45 therein which form a seal with the periphery of the chamber 42. In the position shown in Fig. 7, fluid is entering the pipe 43 and flowing out of the valve from the pipe 34. Fluid is also entering through the pipe 35 on the opposite side of the valve and discharging from the pipe 48. The pipes 34 and 35, as previously pointed out, are connected to the top and bottom, respectively, of the cylinder 26 so that with the valve in the position shown in Fig. 7 pressure is being applied on top of the piston to force it downwardly and that fluid which was in the cylinder 26 below the piston is being allowed to discharge through the pipe 35 and through the valve to exhaust into the atmosphere, as seen in Fig. 2.

It seems obvious that as the lever 18 moves to its upper position the valve member 44 will turn a sufficient amount so that the wings will pass over the openings to which the pipes 34 and 35 are connected. If this valve member moves approximately 15° from the position shown in Fig. 7, then the pressure pipe 43 will be connected to the pipe 35 and pressure will be introduced under the piston 31 in the cylinder 26 and at the same time any pressure which was above the piston will escape through the pipe 34 and the pipe 48 into the atmosphere.

The flow of gas from the pipe 43 thus provides the power for actuating the valves to control the trapping and discharging of the body of liquid in the container 5 whose specific gravity is to be determined. This supply of gas is directed into the valve 19 from a pressure reducer 50, which receives its supply of gas from the inlet pipe line 51. While gas has been used as the term to describe the fluid under pressure which is used to actuate the device it is to be understood that compressed air or any other suitable fluid may be used for this purpose.

The pressure reducer 50 may be of any desired type so as to reduce the pressure from the source in the pipe 51 to the pipe 43. In actual practice it has been found that a pressure of approximately twenty pounds per square inch in the pipe 43 is sufficient for operation of the mechanism, whereas if gas pressure to be found in the oil fields is utilized it is not uncommon to have a pressure in excess of one hundred pounds per square inch in the pipe 51. A gauge 52 in Fig. 1 indicates the pressure which is present beyond the pressure reducer 50 and which is flowing through the four-way cross 53. In this manner the pressure can be directed into the pipe 43, into the gauge 52, or into the extension 55, which is also connected to the cross 53.

Two streams of fluid are to be bubbled into the body of liquid in the container in order to determine the differential pressure required to force the fluid into the liquid and to accomplish this a stream of pressure fluid moves upwardly through the gauge 52, past the valve 56, and into the T 57. As seen in Fig. 1, a regulator or choke valve 58 controls the flow of fluid through the pipe 59 and into the bubble glass 60. This sight or bubble gauge is provided for the purpose of determining the rate of flow of the pressure fluid into the column of mud and the gauge is best seen in section in Fig. 8. The pipe 59 is connected to the inlet on the backside of the gauge and the pressure fluid thus entering the device will discharge from the open pipe 61 into the upper chamber 62 of the gauge. A passage 63 through the central body 64 of the gauge in turn discharges the fluid from the lower pipe 65 into a body 66 of suitable liquid so that any pressure fluid discharging through the device will bubble up through the liquid 66 and the rate of flow may be observed by the bubbles passing through this liquid.

The pressure fluid passing through the liquid 66 will enter the pipe 67 and discharge into the low pressure pipe 68, which extends from the bubble gauge 60 downwardly to the elevation of the lower end thereof at 69 in the tank 5. In this manner pressure fluid will be forced from the lower end 69 of the pipe and the pressure required to effect such a continuous discharge will be either indicated or recorded upon the gauge 70 shown generally in Fig. 12. This pressure is conveyed from the glass 60 by means of a conduit or coupling 71, which is connected to the body 64 of the gauge, as seen in Fig. 8.

Particular attention is directed to the fact that the pipes 61, 65 and 67 are all curved so that the ends thereof are approximately in a vertical plane which is midway between the sides of the gauge. In this manner if the gauge is laid on its side the liquid 66 will be retained therein and will not flow through any one of these pipes. The upper chamber 62 is provided so that if there is a back pressure on the pipe 68 sufficient to force the liquid upwardly through the pipe 65 it will not escape through the pipe 61 but will merely accumulate in the top chamber until such pressure is reduced. As seen in Fig. 1, the gauge 60 is suspended on a shelf 73, which is carried by the device. It seems obvious that by adjusting the valve 58 any desired rate of flow may be introduced into the low pressure pipe.

A valve 80 is similar to the valve 58 and controls the rate of flow of the fluid through a second sight gauge 81, which will be known as the high pressure gauge because it controls the rate of flow through the high pressure line 82 by which the flow of fluid is introduced into the lower portion of the container 5 where the fluid pressure discharges from the lower end 83 of the line 82. By manipulation or arrangement of the valve 80 any desired rate of flow may be provided through this pipe.

It seems obvious that, inasmuch as the distance between the lower end of the low pressure pipe at 69 and the lower end of the high pressure pipe at 83 is a fixed distance, there will be a differential pressure which is the difference between the pressure required to force the flow of fluid through

the high pressure pipe 82 and the pressure required to force the fluid through the low pressure pipe 68. This differential pressure can be measured and will, of course, vary with the specific gravity of the liquid which is in the container 5. If the liquid is heavier a greater differential pressure will be required. If the liquid is lighter a lesser differential pressure will be required. In Fig. 12 the gauge line 84 extends from the sight gauge 81 the same as explained in connection with the line 71. The recording meter 70 in Fig. 12 will record the differential pressure and as seen by the recording line 85 the pressure drops down materially when the container is emptied and builds up to a maximum point when the container is filled. Therefore, the maximum radial distance which the recording line reaches, as at 86, when the tank is filled will indicate the specific gravity of the liquid which fills the container. The gauge 70 may be so calibrated that this recording will be either in pounds per gallon or may be otherwise suitably calibrated.

In actual practice it has been found that the discharge of a fluid under pressure from the pipes 68 and 82 causes an evaporation at the point of discharge such as 69 and 83. This evaporation dries the drilling mud and forms a cake or nozzle about the ends of the pipe and it has therefore been found to be desirable to lubricate the fluid under pressure which is being introduced into the device and to this end a tank 90 carries a body of water or other liquid 91, which can be fed through the pipe 92 into a lubricator injector 94, which in turn discharges through the pipe 95' into a connection 96' so that there is a small flow of liquid downwardly through the pipe 82, as best seen in Fig. 3.

The regulator or injector 94 may be so adjusted as to permit a predetermined flow. In order that the liquid 91 will be forced into the pipe 82 with sufficient pressure to overcome the back pressure due to the head of liquid in the container 5 a supply of pressure fluid is introduced into the tank 90 by means of the connection 95. This connection has a gauge 96 thereon and receives a flow of gas from the regulator 97, which in turn receives its flow of pressure fluid from the connection 55 through the cross 53. This regulator 97 may be set for a very low pressure, say five pounds per square inch, if the regulator 50 is set at twenty pounds per square inch. A similar lubricating injector 98 is provided for the low pressure line 68. A suitable check valve 99 is provided on the pipe 95 so that no backward flow of liquid from the tank 90 can occur.

In operation a charge of liquid will be introduced into the container 5 and the mere presence of this body of liquid wil actuate the floats 13 and 14 so that thereafter the device will operate automatically. By suitable adjustment of the valves and the levers the device will periodically determine and record the specific gravity of the drilling fluid which is flowing through the pipe 2 and the operator need only observe the gauge 70 in order to determine that the specific gravity of his drilling mud as it returns from the well bore is within predetermined limits. In event the mud becomes gas cut the specific gravity will be reduced and the operator will observe this change. The same applies to other factors which influence the specific gravity of the mud.

Broadly the invention contemplates a device which will operate automatically to periodically determine the specific gravity of a drilling mud, and which will be a compact self-contained unit adapted to be readily connected for use at a drilling rig.

What is claimed is:

1. A specific gravity measuring device for drilling muds including means to determine the differential pressure required to pass a flow of fluid into a body of mud, as an indication of the specific gravity of such mud, and additional means operable by the mud to effect the discharge and admission of the mud.

2. A device of the character described comprising a container, means to admit and discharge rotary drilling mud adjacent the top of and adjacent the bottom respectively of said container, means operable by the admission and discharge of mud to actuate said first means so that said device operates automatically to admit and discharge drilling mud, means to continuously effect a flow of fluid into said container at spaced elevations, and additional means to indicate the differential pressure required to maintain such flow of fluid as an indication of the specific gravity of the drilling mud which is in the container.

3. A device of the character described comprising a container, means to admit and discharge rotary drilling mud adjacent the top of and adjacent the bottom respectively of said container, means operable by the admission and discharge of mud to actuate said first means so that said device operates automatically to admit and discharge drilling mud, means to continuously effect a flow of fluid into said container at spaced elevations, and additional means to indicate the differential pressure required to maintain such flow of fluid as an indication of the specific gravity of the drilling mud which is in the container, said flow means including a bubble glass.

4. A device of the character described comprising a container, means to admit and discharge rotary drilling mud adjacent the top and adjacent the bottom respectively of said container, means operable by the admission and discharge of mud to actuate said first means so that said device operates automatically to admit and discharge drilling mud, means to continuously effect a flow of fluid into said container at spaced elevations, and additional means to indicate the differential pressure required to maintain such flow of fluid as an indication of the specific gravity of the drilling mud which is in the container, said additional means including a recording differential pressure gauge.

5. In a device for measuring specific gravity of a drilling mud, a means to introduce fluid into the body of drilling mud so that the pressure required for such introduction may be determined as an indication of the specific gravity, said means including a bubble glass including a top and a bottom, and curved inlet and outlet pipes for the flow of fluid, the ends of said pipes being substantially along the axis of said glass so that tilting thereof will not discharge the liquid therefrom.

6. A device for determining the specific gravity of a drilling mud, means to connect the device to periodically receive adjacent the top and discharge adjacent the bottom a quantity of drilling mud so that the mud may flow by gravity, and means to periodically indicate the specific gravity of the mud when the device contains a predetermined volume of mud by measuring the

differential pressure between two vertically spaced points in the drilling mud.

7. A device for determining the specific gravity of a drilling mud, means to connect the device to periodically receive adjacent the top and discharge adjacent the bottom a quantity of drilling mud so that the mud may flow by gravity, and means to periodically indicate the specific gravity of the mud when the device contains a predetermined volume of mud, both of said means being operable from a source of fluid under pressure.

8. In a specific gravity measuring device, a container, means to admit and discharge liquid whose specific gravity is being determined to the top and from the bottom respectively of said container, float means in said container and operable by the filling and emptying of such container, and fluid pressure power operated means connected to said float means to operate said first means, and additional means to continuously inject two streams of fluid under pressure into the varying head of liquid in the container at spaced elevations, and means to determine the pressure differential to effect such injection as an indication of the specific gravity of the liquid.

9. A device for measuring the specific gravity of a drilling mud used in the rotary method of drilling wells including a container, a pair of gaseous discharge members extending into the container, the ends of said members being spaced a predetermined distance, means to trap mud flowing into the container to cause the level to rise above the end of the shorter member, means to force fluid thru said members so that the differential pressure required to effect discharge is a function of the specific gravity of the mud in the container while the mud between the ends of the members is dormant, and means to discharge the mud when the level in the container reaches a predetermined position.

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