Sept. 8, 1953 J. T. HAYWARD 2,651,198

WEIGHT ON BIT INDICATOR

Original Filed Jan. 31, 1946

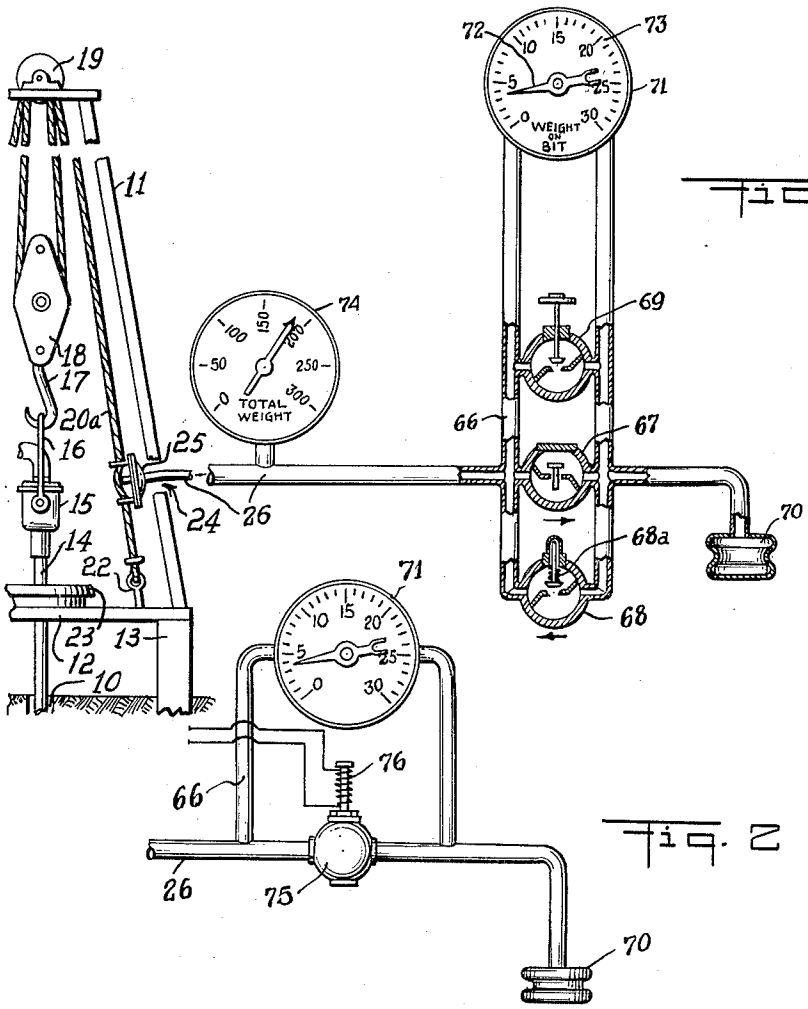

Fig. 1

Fig. 2

INVENTOR.
John T. Hayward
BY
ATTORNEY

Patented Sept. 8, 1953

2,651,198

UNITED STATES PATENT OFFICE

2,651,198

WEIGHT ON BIT INDICATOR

John T. Hayward, Tulsa, Okla.

Original application January 31, 1946, Serial No. 644,534. Divided and this application March 15, 1950, Serial No. 149,806

7 Claims. (Cl. 73—151)

1

This application is a division of co-pending application Serial No. 644,534, filed January 31, 1946, now Patent No. 2,528,883.

This invention relates to weight registering devices and particularly to such devices employed in connection with earth boring equipment such as a rotary drill for registering the weight applied to the drilling bit.

Conventional weight indicators, employed particularly in connection with rotary drilling, are normally designed to indicate the total weight on the drilling string. Such indicators are normally connected with the hoisting equipment for raising and lowering the drilling string in a well and indicate the load placed upon the hoisting equipment. They are usually of the hydraulic type and consist either of a piston and cylinder containing oil placed between the traveling block and lifting hook, or of an oil-containing diaphragm clamped to some part of the hoisting line such as the "dead line," the latter type being much the more common.

Such indicators are widely used for various purposes connected with rotary drilling where an indication of the weight of the drilling string is employed to provide significant information with respect to drilling conditions. A particularly important use is the determination of the weight carried on the bit during drilling. Proper downward pressure on the bit determines the drilling rate, avoids corkscrewing of the lower joints of the drilling pipe and controls the straightness of the hole. If too much weight is carried, the hole tends to deviate from the vertical and it is common drilling procedure to run frequently a tool to determine how far the hole is off from the vertical and to govern the weight carried on the bit accordingly.

However, conventional weight indicators do not record directly the weight on the bit which is the information most frequently desired and of greatest significance in connection with the drilling operation. Such devices normally indicate only the total weight being supported by the hoisting equipment. Thus, in order to obtain the desired information, namely, the weight actually applied to the bit at the bottom of the well, it is necessary for the operator to first read the total weight which is indicated when the entire drill string is freely suspended in the well, then to lower the string until the bit is on bottom and some of the weight placed thereon and again read the indicator which will now show a reduced total weight corresponding to the original weight less the weight resting on the bit.

2

Therefore, a calculation must be made to determine the weight on the bit. However, this relatively simple procedure is greatly complicated by the fact that as the well is deepened and the drilling string lengthened accordingly, the total weight of the string changes correspondingly and since the weight to be carried on the bit may not be changed at all or only to a small degree, repeated calculation must be made in order that the weight applied to the bit may be correctly determined and properly controlled. Since the weight carried on the bit is normally only a relatively small percentage of the total weight, errors frequently result from such calculations and such errors may and do result in severe damage to the well and the drilling equipment. This difficulty is increased by the fact that the gauges normally employed with conventional weight indicators must be capable of recording extremely large weights, as, for example, in the case of a well 10,000 feet deep, where the weight of the drilling string will be of the order of 160,000 pounds. On the other hand, the weight to be carried on the bit in such a well may be, for example, 4,000 pounds, which means that only 2½ percent of the weight of the drilling string is to be carried on the bit. This small proportion of the weight, therefore, frequently produces an error due to scale effect. That is, since the gauge scale must cover such a very large range as, for example, from zero to 200,000 pounds, or more, it is obvious that a variation of, for example, 1,000 pounds in the weight carried on the bit will be difficult to observe on such conventional weight indicators, although such a difference of 1,000 pounds in the weight carried on the bit will most likely produce very significant ecects on the drilling operation. In addition, as noted above, as the drilling proceeds and the well gets deeper, the weight of the drilling string continuously increases. In order to determine, therefore, the weight that he is currently placing on the bit, the driller is compelled, while drilling, to continuously refigure the indication that should be shown on the weight indicator. It should be noted also that with the conventional weight indicators, the more weight carried on the bit, the lower the reading on the indicator and, therefore, if the driller is instructed to carry, for example, 1,000 pounds "more" on the bit, which is the usual form of instruction given to drillers, he must in reality carry 1,000 pounds less on the indicator. This procedure also leads to frequent errors. Furthermore, it is impossible for anyone,

such as the drilling superintendent or engineer visiting the drilling rig, to determine from the weight indicator what weight is carried on the bit, since he must first find out what the indicator reading was when the bit was clear of the bottom, a figure which, as previously mentioned, is constantly changing.

All these difficulties are magnified when it is desired to make a continuous record of the weight carried on the bit. This is due both to the scale effect previously mentioned and to the fact that it is difficult to determine from the record made by such conventional weight recorders when the bit was on and off bottom and, therefore, to arrive at the difference.

Accordingly, the principal object of the present invention is the provision of devices which will obviate the aforementioned difficulties and to provide weight registering devices which register directly the weight carried on the bit.

Another important object of this invention is to provide weight registering devices which will directly register the weight carried on the bit and which automatically compensates for the changes in total weight of the drilling string.

A further object is to provide devices which will provide a continuous record of the weight actually carried on the bit.

Other and more specific objects and advantages of this invention will be apparent from the following detailed description when read in conjunction with the accompanying drawings which illustrate several embodiments in accordance with this invention.

In the drawings:

Fig. 1 illustrates the general arrangement of apparatus in accordance with this invention mounted on a drilling rig;

Fig. 2 illustrates a modification of the embodiment illustrated in Fig. 1.

As used herein, the term "register" is intended generally to include both "indicate" and "record."

Referring now to Fig. 1, the upper portion of a well 10 is shown which is being drilled by the rotary method. The rotary drilling apparatus is conventional and is shown in very simplified form. This apparatus includes a derrick structure 11 having a floor 12 mounted on foundation members 13. A string of drill pipe having a drill bit (not shown) at its lower end and Kelly joint 14 and mud swivel 15 at its upper end is supported from the upper portion of derrick 11 by means of bail 16, hook 17, traveling block 18, crown block 19 and cable 20. One end of cable 20 is wound upon the usual draw works drum (not shown) and the other end, commonly known as the "dead line" and designated by the numeral 21*a*, is connected to an anchor bolt 22 which is fastened to the derrick structure. Mounted upon derrick floor 12 is a rotary table 23 for the purpose of rotating Kelly joint 14 and hence the entire drill string.

A weight indicator, indicated generally at 24, including a generally conventional pressure element 25, a gauge line 26 and a gauge 71, is shown mounted on dead line 20*a* in a manner conventional in this art. The details and mode of operation of pressure element 25 is described in my aforementioned U. S. Patent No. 2,528,883. While the weight indicator 24 is shown mounted on the dead line, it will be understood, of course, that this arrangement is shown only by way of example since, as is well known in the drilling art, such weight indicators may also be mounted at other points along the hoisting system which will reflect the load carried by the hoisting system. Another conventional arrangement is to mount a hydraulic type weight indicator between the traveling block 18 and hook 17. An electrical recorder, of conventional construction, may be connected to gauge 71 in any suitable manner, as shown in my aforementioned U. S. Patent No. 2,528,883, for recording the quantities registered by the gauge.

In the conventional forms of weight indicators, such as that described, the gauge employed is normally calibrated to indicate the total weight carried by cable 20. Such a conventional form of gauge is shown at 74 in Fig. 1. In order to overcome the disadvantages, such as described above, in the use of this conventional type of weight indicator and gauge, it is contemplated in accordance with this invention that gauge 71 be of a novel form which is constructed and arranged to read directly the weight actually carried on the bit.

Fig. 1 illustrates an embodiment in accordance with this invention in which gauge line 26 leading from pressure element 25 is connected to a manifold 66, containing valves 67, 68 and 69 in parallel arrangement, a bellows 70, and a differential gauge 71. Valve 67 is a conventional check valve, arranged, as indicated by the arrow in the drawing to pass fluid only in the direction away from the diaphragm casing of pressure element 25. Valve 68 is a spring loaded check valve, also of conventional construction, which is arranged to pass fluid only in the direction toward the diaphragm casing of pressure element 25. The loading on spring 68*a* will preferably be such as to keep this valve closed up to differential pressures exceeding the maximum weight-on-bit to be registered on gauge 71, for example, 30,000 or 40,000 pounds. Valve 69 is a conventional hand-operated valve which is employed for purposes of rendering the weight indicating system inoperative when desired. Gauge 71 is a differential pressure gauge of any suitable standard or conventional form or construction for registering the differential pressure on opposite sides of check valve 67. Bellows 70 is also of conventional construction and is designed to receive and store pressure fluid, expressed from pressure element 25, under the pressure of the system and to provide the necessary back pressure required for operation of the differential pressure gauge 71. Differential pressure gauge 71 is provided with the usual indicator hand 72 and a scale 73, calibrated in a suitable manner to cover the range of weights expected to be applied to the bit, as for example, from zero to 30,000 pounds. An ordinary type pressure gauge 74 is connected into gauge line 26 and is calibrated to display the total weight supported by cable 20 in the usual manner. This gauge is of no moment for the purposes of this invention but may be employed; if desired, to obtain information as to the total weight of the drilling string.

The operation of this embodiment is as follows: With the drilling string hanging in the derrick, gauge 74 will show the total weight in the usual manner and some of the fluid forced from the diaphragm casing of pressure element 25 will flow through pipe 26 and through check valve 67 into bellows 70, which will be, of course, expanded thereby. When the bit touches bottom and some of the weight of the drilling string is applied thereto, the pressure in the diaphragm casing will be thereby reduced, check valve 67 will close, preventing the return of pressure fluid to the dia-

phragm casing, and differential pressure gauge 71 will register, the differential pressure in the gauge line on opposite sides to check valve 67, the back pressure being supplied by bellows 70. This differential pressure will correspond to the difference between the total weight of the drilling string and this weight less that applied to the bit, thereby producing a measurement of the weight applied to the bit. When a new joint of pipe is to be added to the drilling string, the drilling string will be set in the slips in the rotary table in the usual manner, causing the pressure in the diaphragm casing to fall to zero. The resulting increased differential pressure across the manifold causes pressure fluid to flow back from bellows 70 through the spring loaded check valve 68 until the pressure in the system is equalized. Therefore, when the full weight of the drilling string again comes on cable 20 and the pressure rises in diaphragm casing 29, the differential pressure gauge 71 will again be returned to zero and will thus be automatically reset and in position to again measure the differential pressure when weight is again applied to the bit. Globe valve 69 may be opened when it is desired to render this form of weight indicating system inoperative.

Fig. 2 illustrates a modification of the embodiment illustrated in Fig. 1 in that vales 67, 68 and 69 are replaced by a single valve 75, which is operated by means of a solenoid 76. The leads of solenoid 76 are connected to an "on-bottom" switch employed with a well-depth recorder which is operative to de-energize solenoid 76 and allow valve 75 to close whenever the drilling bit touches bottom, valve 75 being held normally open by solenoid 76 at all other times. Such a switch and its circuit connected to a well-depth recorder are described in detail in the aforesaid Hayward U. S. Patent No. 2,326,219.

The operation of this modification is as follows: Valve 75 is normally open and remains open during all movements of the drilling string prior to the instant the drilling bit touches the bottom of the well, since, under these conditions, the circuit arrangement referred to in U. S. Patent No. 2,326,219 will be such as to cause current to flow through solenoid 76 and energize the same. With valve 75 open, differential gauge 71 will, of course, register zero weight on the bit. As soon as the bit reaches the bottom of the well, the on-bottom switch will open the circuit to solenoid 76 de-energizing the same and closing valve 75, and differential gauge 71 will thereafter register the differential pressure across valve 75 which will be proportional to the weight on the bit. As soon as the drilling string including the drilling bit is lifted above the bottom of the well for any reason, the solenoid will again be energized, opening valve 75 and differential gauge 71 will again return to zero. With this arrangement, it will be evident that differential gauge 71 will always register the weight on the bit irrespective of any changes in the total weight of the drilling string.

Various alterations and changes may be made in the embodiments herein described without departing from the scope of the appended claims but within the spirit of this invention.

What I claim and desire to secure by Letters Patent is:

1. In earth boring apparatus including a drilling string carrying a drilling bit, means to support said drilling string and load-responsive means of the pressure fluid-actuated type operatively connected with such support means, a weight-on-bit registering device comprising, a conduit connected to said load responsive means for the reversible flow of pressure fluid therethrough in response to increases and decreases in load on said support means, an expandible fluid reservoir connected to close the outer end of said conduit, flow control means positioned in said conduit and including valve means interposed between the load-responsive means and the reservoir operative to prevent return flow of fluid from said reservoir whereby to establish differential pressures in said conduit corresponding to the differences between the maximum pressures and lower pressures in said load-responsive means, and means connected across said valve means for measuring said differential pressures.

2. In earth boring apparatus including a drilling string carrying a drilling bit, means to support said drilling string in a well and load-responsive means of the pressure fluid-actuated type operatively connected with such support means, a weight-on-bit registering device comprising, a conduit connected to said load-responsive means for the reversible flow of pressure fluid therethrough in response to increases and decreases in load on said support means, and expandible fluid reservoir connected to close the outer end of said conduit, flow control means in said conduit including valve means interposed between the load-responsive means and the reservoir actuated by a decrease in fluid pressure in the conduit upon contact of said drilling bit with the bottom of said well to prevent return flow of fluid from said reservoir whereby to establish differential pressures in said conduit corresponding to the differences between the maximum pressures and lower pressures in said load-responsive means, and means connected across said valve means for measuring said differential pressures.

3. In earth boring apparatus including a drilling string carrying a drilling bit, means to support said drilling string and load-responsive means of the pressure fluid-actuated type operatively connected with said support means, a weight-on-bit registering device comprising, a conduit connected to said load-responsive means for the reversible flow of pressure fluid therethrough in response to increases and decreases in load on said support means, flow control means positioned in said conduit and operative to establish differential pressures therein corresponding to the differences between the maximum pressures and lower pressures in said load-responsive means, said flow control means comprising, an expandible fluid reservoir connected to close the outer end of said conduit and valve means interposed in said conduit between said load-responsive means and said reservoir automatically closable to prevent return flow of fluid from said reservoir when the pressure in said reservoir exceeds the pressure in said load-responsive means, and means connected across said valve means for measuring said differential pressure.

4. In earth boring apparatus including a drilling string carrying a drilling bit, means to support said drilling string and load-responsive means of the pressure fluid-actuated type operatively connected with said support means, a weight-on-bit registering device comprising, a conduit connected to said load-responsive means for the reversible flow of pressure fluid therethrough in response to increases and decreases in load on said support means, an expandible fluid reservoir connected to said conduit, check valve means in said conduit between said load-responsive means and said reservoir to normally prevent

return flow of liquid from said reservoir, and means connected to said conduit for registering the differential pressures therein across said valve means.

5. In earth boring apparatus including a drilling string carrying a drilling bit and means to support said drilling string in a well, a weight-on-bit registering device, comprising, load-responsive means of the pressure fluid-actuated type operatively connected to said support means, an expandible fluid reservoir, a conduit connecting said load-responsive means with said reservoir for the reversible flow of pressure fluid therebetween in response to increases and decreases in load on said support means, said reservoir closing the outer end of said conduit, valve means interposed in said conduit between the load-responsive means and the reservoir and operative to normally prevent return flow of fluid from said reservoir whereby to establish differential pressures in said conduit between said load-responsive means and said reservoir, and means for measuring the differential pressure connected across said valve means.

6. In earth boring apparatus including a drilling string carrying a drilling bit and means to support said drilling string in a well, a weight-on-bit registering device, comprising, load-responsive means of the pressure-fluid actuated type operatively connected to said support means, an expandible fluid reservoir, a conduit connecting said load-responsive means with said reservoir for the reversible flow of pressure fluid therebetween in response to increases and decreases in load in said support means, said reservoir closing the outer end of said conduit, valve means interposed in said conduit between the load-responsive means and the reservoir and operative to normally prevent return flow of fluid from said reservoir whereby to establish differential pressures in said conduit between said load-responsive means and said reservoir, means for measuring the differential pressure connected across said valve means, and pressure equalizing means connected to said conduit actuable by pressure differentials of predetermined magnitude to equalize the fluid pressure in said conduit across said valve means.

7. In earth boring apparatus including a drilling string carrying a drilling bit and means to support said drilling string in a well, a weight-on-bit registering device comprising a load-responsive means of the pressure-fluid actuated type operatively connected with said support means, a conduit connected to said load-responsive means for the reversible flow of fluid therethrough in response to increases and decreases in load on said support means, a variable volume fluid reservoir connected to close the outer end of said conduit, valve means interposed in said conduit between the load-responsive means and the reservoir and actuated by changes in fluid pressure in said conduit resulting from contact of the bit with the well bottom and retraction therefrom to respectively close and open, and differential pressure measuring means connected across said valve means.

JOHN T. HAYWARD.

References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
2,298,222	McShane	Oct. 6, 1942
2,309,211	Raphael	Jan. 26, 1943