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MEANS AND METHOD FOR CONTROLLING THRUST OR WEIGHT ON DRILLING TOOL

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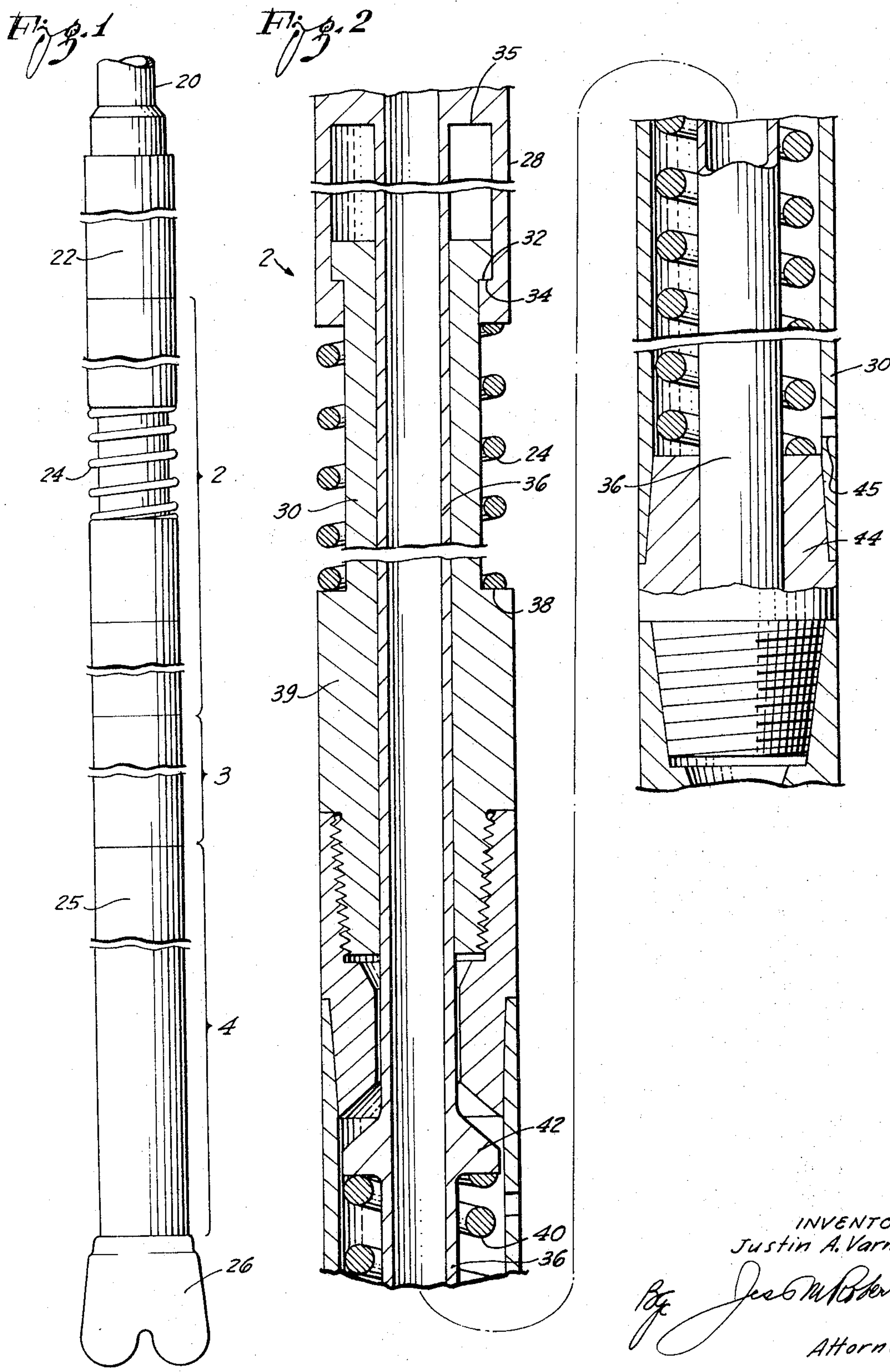


INVENTOR.
Justin A. Varney
By [signature]
Attorney

Fig. 3

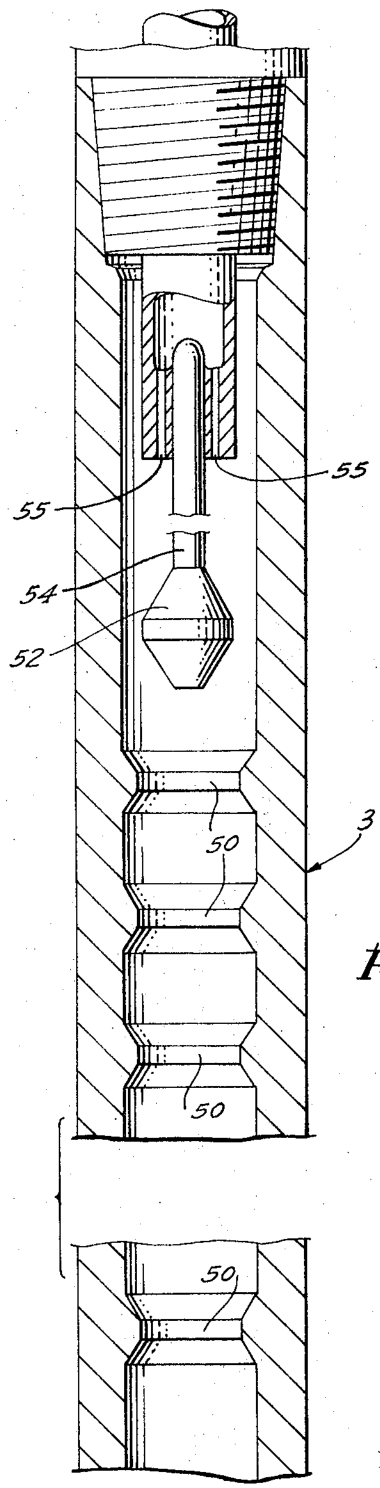
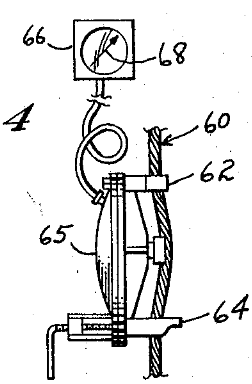


Fig. 4



INVENTOR:
Justin A. Varney
By Jesse M. Roberts
Attorney

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MEANS AND METHOD FOR CONTROLLING THRUST OR WEIGHT ON DRILLING TOOL

Justin A. Varney, 7326 Ogelsby Ave.,
Los Angeles, Calif. 90045

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This invention relates to the control of cutting or drilling operations in a well bore with special reference to measurement and control of the weight or thrust on the cutting tool. This application is a continuation-in-part of my copending application Serial Number 322,676 entitled, "Means for Ascertaining and Maintaining Optimum Weight on Turbodrill," filed November 12, 1963 and now abandoned.

It is well known that the amount of weight imposed on a drill bit at the bottom of a well bore is a factor of primary importance to both rate of penetration and directional control in drilling operations. Obviously, the optimum weight varies with such factors as the character of the formation that is being penetrated, the type of drill bit that is being used, and desired rate of rotation of the bit. The difficulty of accurately measuring and controlling the weight imposed on a drill bit or other tool on a drill string at the bottom of a well bore, and especially in a deep and/or slanted well bore, and the importance of such accurate measurement and control, may be understood by considering a number of typical situations experienced in drilling earth boreholes.

The optimum thrust on the drill bit under given conditions for drilling through a given formation occurs when some given portion of the total weight of the drill string is imposed on the drill bit. Under these circumstances the lower portion of the drill string below a neutral point is under compressive stress and the portion of the drill string above the neutral point is suspended under tension from the top of the well.

It would seem that the weight imposed on the drill bit would be simply the difference between the indicated weight of the drill string as determined by the conventional weight indicator at the rig floor with the bit just off the bottom of the borehole, and the indicated weight when the bit is on bottom and therefore carrying a certain portion of the total weight of the drill string. Under these circumstances, it would seem that the driller could maintain a given weight on the drill bit by simply manipulating the drill string draw works to hold a given indicated differential weight at the top of the well. This, in fact, is the standard procedure for attempting to control the amount of weight carried by the bit as drilling progresses. Unfortunately, however, such procedure can be quite inadequate and such indicated differential weight can be grossly different from the actual weight carried by the bit in given situations. A major contribution to this erroneous indication is friction due to contact of the drill string against the wall of the well bore, the magnitude of which friction is completely unknown. In a crooked well bore or in a well bore at a high slant angle, as found commonly in directional drilling, the combination of such frictional engagement of the drill string with the borehole and the partial support of the drill string afforded by the inclination of the hole from vertical may so obscure the true value of weight carried by the bit as to render drill string weight measurements meaningless. It may even be impossible to detect whether or not the bit is actually bearing on the bottom of the borehole under such circumstances, and such is not infrequent experience in slant drilling.

In cases where a turbodrill is used to rotate the bit, the fact that the drill string is not rotating permits very high static friction forces to develop between the drill string

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and the borehole, further compounding the problem relative to the conventional rotating drill string situation.

Moreover, it is well known that control of weight or thrust on the bit in turbodrill operations is particularly critical because of the relatively low torque developed by such motors and the consequent ease with which the turbodrill can be stalled by imposing excessive thrust on the bit. More sensitive weight-on-bit control than is possible with conventional weight indicators is an urgent need in connection with turbodrills.

A further problem area of importance in control of weight or thrust imposed on a cutting tool on a drill string is that in which the requirement for sensitivity and accuracy of weight detection and indication is greater than can be realized by conventional instruments due to their inherent principles of operation, irrespective of whether the problems of weight measurement and control cited above, relating to slant of a borehole or friction between the drill string and the borehole, are present in given situations. Attention is invited to the fact that surface weight indicators must be capable of registering weight values from very low weights, relatively speaking, as when the borehole is shallow and the drill string is short, to very large weights apparent when a borehole is deep and the drill string is enormously heavy. The scale of values which must be accommodated by a drill string weight indicator is, effectively, from one to over a hundred thousand pounds, values as high as two hundred fifty thousand pounds being experienced in some drilling situations. Within this large scale it is often important to know within very small differential values, such as a thousand pounds or even less, what precise weight is being carried by the cutting tool. Accuracy and sensitivity considerably greater than one percent is implied—a difficult achievement even in laboratory instruments, let alone oil field equipment. It is well known that conventional drill string weight indicators do not cannot achieve such refined measurements under the normal operating practice.

The importance of devising weight or thrust measurement and control of such threshold sensitivity and accuracy that values of a thousand pounds or less—even a few hundred pounds—can be detected and positively established by the driller is emphasized by the fact that many operations commonly performed in borehole drilling and completions are such that weights in this order of magnitude should, if possible, knowingly be imposed on the cutting tool for best efficiency of the operation. Greater weight or thrust can damage the tool, as by breaking down the cutting edges through overload, and undesirably low loads can impede the cutting actions of the tool and result in poor progress of the operation. Such problems are commonly experienced in such operations as milling and coring. Milling, especially, is considered largely an "art" to be performed by specialists who have developed such experience that largely subjective "feel" for the particular milling operation in question sufficies in lieu of actual knowledge of the critical weight which is optimum for that operation. Such specialists are in short supply and are highly paid, resulting in high operating costs and not infrequent costly delays in drilling programs.

It is therefore evident that basically improved weight and thrust measurement and control means would be of very great value to the drilling industry in multiple respects.

Broadly described, the method of controlling the weight on the drill bit that is taught by the present invention is to make the portion of the drill string near its bottom end longitudinally extensible and contractible and to provide means, preferably resilient yielding means, to progressively increase the downward thrust on the drill bit in response to progressive longitudinal contraction of the drill string. Since the thrust against the drill bit in such an arrangement varies directly with the longitudinal contraction of the drill string, the thrust may be measured indirectly by detecting and signaling the degree of longitudinal contraction.

As will be explained, the invention provides restricting means to choke the stream of drilling fluid to create pressure signals in the drill stream, the signals being created at selected points in the range of longitudinal contraction of the drill string. Thus the different pressure signals indicate different magnitudes of thrust on the drill bit.

In the preferred practice of the invention, all weight that is variably imposed on the drill bit is located near the end of the drill string, whereby the drill string above such portion is at all times maintained and known to be in tension—a centrally important advantage of the present invention. It is well known that to allow the drill pipe—that portion of the drill string above the drill collars—to accept compressive loads can lead to buckling and consequent early failure of the drill pipe. Since the weight indicating and controlling mechanism taught by this invention is located at the lower end of the drill string, the cooperation of the various parts for varying the weight of the drill bit is not affected by any friction that develops along the major portion of the length of the drill string. Similarly, variation in density of drilling fluid, which may reach values as high as twice that of water, and consequent variation in effective mass of the drill string, is no longer of consequence to weight indication.

The presently preferred form of the invention taught herewith involves a pair of telescoping sections of drill pipe. Suitable energy-storing means is interposed to act between the two relatively movable sections, for example coil spring means, to create rising thrust force in response to progressive contraction of the pair. Preferably, a plurality of coil springs may be arranged for simultaneous compression, the overall spring rate being the sum of the spring rates of the individual coil springs. The two telescoping sections are adapted to create pressure signals in the drill stream at selected points in their range of relative movement thereby to indicate changes in the magnitude of thrust against the drill bit.

The features and advantages of the invention may be understood from the following detailed description together with the accompanying drawings.

In the drawings, which are to be regarded as merely illustrative:

FIG. 1 is a fragmentary elevational view of the lower end portion of a drill string illustrating the presently preferred embodiment of the invention;

FIG. 2 is a longitudinal sectional view of that portion of the structure in FIG. 1 that is generally designated by numeral 2, the structure including coil springs for varying the weight imposed on the drill bit;

FIG. 3 is a longitudinal sectional view of the signaling section in FIG. 1 that is indicated by the numeral 3, the view showing the structure for creating pressure signals at various degrees of compression of the springs shown in FIG. 2; and

FIG. 4 is an elevational view of a conventional indicator for the weight of a drill string.

FIG. 1 shows the lower end of a drill string **20** with the following components connected thereto: at least one drill collar **22** to provide adequate weight for imposition on the drill bit; a bumper sub, generally designated **2**, incorporating at least one coil spring **24** for creating variable force for application to the drill bit; a signaling section, generally designated **3**; and a cutting tool **26**. A lower drill collar **4**, or series of such collars, may be interposed between the signaling section **3** and the cutting tool **26** in order to provide any desired minimum and nonvariable weight to be carried by the cutting tool, as hereinafter described.

The bumper sub **2** which is shown in detail in FIG. 2 is of construction typical of bumper subs manufactured by several firms in the oil tool industry such as Baash-Ross Division of Joy Manufacturing Company, Bowen Tools, Inc., Shaffer Tool Works, and Reed Roller Bit Co. In the construction shown the bumper sub **2** provides a telescoping joint in the drill string which includes an upper bumper sub body **28** and a mandrel **30** telescopically connected to the body, the body and mandrel constituting two telescoping sections of the drill string. In the construction shown, the mandrel **30** is fixedly connected to the lower signaling section **3** which may be regarded as a part of the mandrel. The signaling section **3** is connected, as indicated above, to an additional drill collar or collars **4** to apply additional and non-variable weight to the drill bit. It is common practice in drilling a given borehole to apply weight to the bit always within a predetermined range; not less than some selected value, such as, for instance, 10,000 pounds, and not more than, say, 20,000 pounds. The practice of the present invention in this case would involve employment of lower drill collars **4** weighing 10,000 pounds and upper drill collars **22** providing available additional weight of 10,000 pounds, applicable incrementally through spring means **24**.

The upper end of the mandrel **30** is provided with an outer circumferential shoulder **32** which engages a cooperating inner circumferential shoulder **34** of the bumper sub body **28** to limit the downward longitudinal extension of the mandrel relative to the body. At this lower limit position the two telescoping sections are fully extended.

The upper end of the mandrel **30** is free to slide telescopically in the bumper sub body **28** to a second upper limit position (not shown) at which the upper end of the mandrel abuts an inner circumferential shoulder **35** of the bumper sub body. At this second upper limit position, the two telescoping sections are fully contracted and the whole weight of the drill string may be imposed on the drill bit **26**.

In a well known manner, the bumper sub body **28** is provided with what is termed a wash pipe **36** which telescopes into the mandrel **30** throughout the range of extension and contraction of the mandrel to provide a suitable channel for the drilling fluid between the two telescoping sections. The range of extension and contraction of the mandrel relative to the bumper sub is preferably relatively extension and may have a dimension of 5 feet or more.

The previously mentioned coil spring **24** surrounds the mandrel **30** under compression between the lower end of the bumper sub body **28** and a lower outer circumferential shoulder **38** that is formed by a collar **39** of the mandrel. A second coil spring **40** surrounds the wash pipe **36** inside the mandrel **30** below the collar **39** and acts in compression between a radial flange **42** of the wash pipe and a lower collar or end fitting **44** of the mandrel. Thus the two coil springs **24** and **40** are arranged for simultaneous compression when the bumper sub **2** is contracted, the spring rates of the two springs being additive.

It is apparent that either of the two springs **24** and **40** may be omitted if a single spring suffices to provide the required force. It is also apparent that the mandrel **30** may be lengthened downward to accommodate a third spring between the mandrel and the wash pipe if a third spring is desirable to increase the effective spring rate. The mandrel **30** is provided with at least one radial port **45** for pressure equalization and drainage.

As shown in FIG. 3, the signaling section **3**, which is connected to the lower end of the mandrel **30** and may be considered as an extension of the mandrel, is formed with a series of spaced choke rings **50** for cooperation with a choke head **52** that is fixedly connected to the bumper sub body **28**. In the construction shown, the choke head or enlargement **52** is mounted on a downwardly extending axial rod **54** that is connected to the lower end of the wash pipe **35** by a suitable apertured fitting or spider **55** permitting substantially unrestricted flow of drilling fluid therethrough.

When the drill string equipped with the described components is lowered initially into a well bore, the bumper sub is fully extended as indicated in FIG. 2 with the circumferential shoulder **32** of the mandrel **30** resting on the inner circumferential shoulder **34** of the bumper sub body **28** to support all of the components that are below the telescoping joint. At this time the choke head **52** is above the uppermost choke ring **50** as shown in FIG. 3.

When the drill string is bottomed in the well bore and the upper end of the drill string is lowered, the signaling section **3** along with the mandrel **30** and, of course, any members below signaling section **3**, become stationary in respect of vertical movement and the bumper sub body **28** continues to descend to move the choke head **52** downward through the signaling section **3**. The choke head **52** passes first through the uppermost choke ring **50** to restrict the downwardly flowing stream of drilling fluid with the consequence that the back pressure of the drilling fluid rises to create a pressure front or wave which travels at sonic velocity up the fluid column to the top of the well, the period of elevated pressure terminating as the choke head passes beyond the choke ring and normal flow through the signaling section **3** is resumed. The pressure wave may be detected at the top of the well by means of standard drilling fluid pressure gauge or recording instrument in communication with the interior of the drill string.

As the two telescoping sections continue to collapse, the choke head **52** passes successively through the remaining choke rings **50** to produce a corresponding succession of pressure signals each of which indicates a stage in the contraction of the two telescoping sections. Since the total force exerted by the two springs **24** and **40** to thrust the drill bit **26** against the bottom of the well bore increases progressively with the progressive contraction of the two telescoping sections, it is apparent that the successive pressure signals created by the choke head **52** in cooperation with the choke rings **50** indicate different degrees of magnitude of the weight imposed on the drill bit.

The method by which the driller may establish and maintain a known weight or thrust on the cutting tool, within very close limits, using the present invention may be described as follows. Let it be assumed for a given operation, such as drilling with a diamond core drill, that the desired range of thrust on the bit in the given formation being penetrated is in the range of five thousand pounds plus or minus twenty-five hundred pounds, for instance. An embodiment of the invention herein described having a lower mandrel portion weighing approximately two thousand pounds would be selected. Drill collars weighing something over six thousand pounds would be incorporated in the drilling assembly just above the bumper sub means which is an integral part of the present invention. Spring means with a total, fully-compressed reactive force of six thousand pounds would be incorporated with the bumper sub, as heretofore depicted and described, thereby providing a range of thrust values, depending on the extent to which the spring means is compressed at any given moment, from two thousand pounds minimum (no compression of the spring means) to eight thousand pounds maximum (spring means fully compressed). Signaling section **3** would be provided with choke ring means spaced, for instance, at four-inch intervals over a range of four feet, thereby providing a series of signals numbering twelve over the four-foot scope of travel of the telescoping joint. Each four-inch increment of compression of the spring would require five hundred pounds, from the fully extended (unloaded) position of the spring means to the fully compressed state of the spring means (6000 lbs. divided into 12 equal parts).

Since the above noted characteristics of the weight control device to be used in the given drilling situation would,

of course, be known to the driller, his manipulation of the tool would follow the steps indicated below, in order to establish and maintain a given weight-on-bit value: Initially, the driller lowers the drill string until the bit touches the bottom of the borehole and the telescoping joint commences to retract. This fact is signaled to the driller by virtue of the entry of the choke head **52** into the uppermost choke ring **50**, giving rise to a pressure surge readily observed on the drilling fluid pressure gauge. At this point, the driller knows positively and precisely that he has twenty-five hundred pounds of weight on the bit—the bit is carrying the weight of mandrel **30** and all members below mandrel **30**, or two thousand pounds, plus the first five hundred pound increment of thrust required to deflect the spring means the initial four inches from its fully extended and free (unloaded) state. As the driller continues to lower the drill string, each successive pressure signal will indicate an additional five hundred pound increment of weight or thrust on the bit. If, for instance, he desires to carry a thrust on the bit in the range of 3500 to 4000 pounds, the driller will count signals up to the fourth in the series as he progressively lowers the drill string after the bit touches bottom, indicating, successively, 2500 pounds, 3000 pounds, 3500 pounds, and then 4000 pounds. At this point, he sets his drawworks brake, to check further lowering of the drill string, and permits the bit to drill ahead. As the borehole advances, the telescoping joint of the bumper sub extends accordingly and the spring means likewise expands, thereby progressively unloading the spring means. At the point where the borehole has advanced approximately four inches, another pressure signal is generated by approach of the "3500 lbs." choke ring downward into close proximity to the choke head, which has remained at a fixed vertical position since the brake was locked, as noted above. (Actually, slightly less than four inches of borehole advance is required since the previous signal pressure rise was generated as the choke head moved down into a choke ring, and the signal pressure next generated is caused by a *choke ring* moving down into proximity to the choke head. The choke ring as well as the choke head must, obviously, be of finite vertical dimensioning, whence derives the apparent loss of travel between successive signals while a given incremental range of weights is maintained.)

Upon noting the signal indicating a four-inch advance of the borehole, the driller lowers the drill string until he observes another signal pressure rise. At this point, he will have again added five hundred pounds of thrust to the bit, to bring the total thrust on the bit back up to 4000 pounds. This cycle of drilling and lowering the drill string by stages can, of course, be continued indefinitely with constant positive knowledge of the weight-on-bit condition. If at any time the driller wishes to vary the weight on the bit, he may do so by five hundred pound increments by manipulating the drill string as indicated above to increase or lessen the amount of compression of the spring means, thereafter, having arrived at the new desired thrust value, maintaining that value by cycling between the appropriate adjacent choke rings as drilling progresses.

It will be immediately apparent that the examples of weight or thrust values described above represent operation with but a single specific embodiment of the inventive combination herein described and set forth. Other ranges of weight or thrust can be readily obtained simply by employing various combinations of drill collars above and below the spring-loaded bumper sub and, of course, by varying the spring rate of the spring means and the distance between successive choke rings in the signaling section. In all cases, the invention achieves the advantages and objects noted above with simplicity and with structures which are rugged and reliable.

It is obvious that when a pair of telescoping sections incorporating a spring means is inserted into a drill string for the purpose of the present invention, the weight of the drill string below the telescoping pair must equal the desired minimum weight to be imposed on the drill bit and the weight of the drill string above the telescoping pair must be sufficient to collapse the spring means to the degree required for the desired maximum weight on the drill bit. Thus, if necessary, one or more drill collars will be added below the telescoping pair to place the desired minimum weight on the drill bit and one or more drill collars will be added above the telescoping pair to provide the desired available maximum weight on the drill bit.

The invention includes the further concept of controlling the weight on the drill bit as desired without creating signals in the stream of drilling fluid. To carry this concept requires using a pair of telescoping sections as heretofore described with spring means having a known spring rate so that collapsing the pair of telescoping sections to any known degree adds a corresponding known amount of weight to the minimum weight that is provided in the drill string below the telescoping pair.

The new concept also requires a well known type of device at the top of the well to indicate the weight of the drill string that is imposed on the cable. FIG. 4 illustrates such a device that is known to the trade as a Martin-Decker weight indicator. The cable **60** that carries the weight of the drill string is offset by a pair of shackles **62** and **64** with the offset portion exerting side thrust against a hydraulic sensing means **65**. The hydraulic sensing means **65** is connected by a hydraulic hose with an indicator **66** having a pointer **68** that indicates the weight carried by the cable.

Assuming that the choke head **52** and the choke rings **50** are omitted so that no signals are created in the stream of drilling fluid, the driller lowers the drill string into the well until a sudden drop of the weight registered by the pointer **68** indicates that the drill string has bottomed in the borehole. The driller knows that any further lowering of the drill string will correspondly collapse the pair of telescoping sections and he knows how much weight will be transferred to the drill bit by each inch of the collapse. Accordingly, when the drill string bottoms the driller then lowers the drill string further by a selected measured amount to add a known increment of weight to the weight below the telescoping pair that is imposed on the drill bit.

At this time, the driller may note that the weight indicated by the pointer has dropped to some given magnitude below the magnitude that indicated bottoming of the drill string. Thus the driller correlates the desired weight on the drill bit with a given weight indication at the top of the well and then as drilling continues the driller may maintain the desired weight on the drill bit by watching the pointer **68** and controlling the lowering of the drill string to maintain the position of the pointer as drilling continues.

My description in specific detail of the selected embodiments of the invention will suggest various changes, substitutions and other departures from my disclosure within the spirit and scope of the appended claims.

I claim:

1. In an apparatus for operation in a well bore, the combination of:

- a drill string having a drill bit on its lower end, the drill string having longitudinal telescoping sections whereby with the drill string bottomed in the well bore, the upper end of the drill string may be raised and lowered for axial extension and contraction of the drill string;
- resilient yielding energy-storing means interposed between telescoping sections, said means being compressible in response to progressive contraction of the drill string to progressively increase the thrust of the drill bit against the bottom of the well bore;
- means to force a stream of drilling fluid down the drill string;
- and means to create momentary pressure signals in the stream in response to retraction of the drill string to indicate changes in the degree to which the compressible means is compressed thereby to indicate changes in the magnitude of the thrust of the drill bit against the bottom of the well bore.

2. In an apparatus for operation in a well bore, the combination of:

- a drill string having telescoping sections for longitudinal extension and contraction of the drill string;
- spring means interposed between telescoping sections to be stressed to exert force to extend the drill string with progressive rise of the force in response to progressive contraction of the drill string whereby progressively contracting the drill string by lowering the drill string against the bottom of the well bore progressively increases the downward thrust of the drill bit against the bottom of the well bore;
- and means responsive to extension and contraction of the drill string to create hydraulic signals to indicate changes in the degree to which the spring means is stressed thereby to indicate changes in the thrust of the drill bit against the bottom of the well bore.

3. In an apparatus for operation in a well bore, the combination of:

- a drill string having a drill bit on its lower end;
- at least one pair of telescoping sections in the drill string comprising an outer section and an inner section being relatively movable for longitudinal extension and contraction of the drill string;
- resilient yielding means acting between the two sections to urge the two sections apart whereby, with the drill bit at the bottom of the well bore, progressively lowering the upper end of the drill string to progressively contract the drill string progressively stresses the yielding means to progressively increase the thrust of the drill bit against the bottom of the well bore;
- means to force a stream of drilling fluid down the drill string;
- and cooperative choke means on the inner section and the outer section, respectively, to restrict the stream at spaced points in the range of relative movement of the two sections to indicate different degrees of thrust of the drill bit against the bottom of the well bore.

4. A combination as set forth in claim **3** in which the cooperative means comprises a first form of choke means on one of the two sections and a plurality of a second form of choke means on the other of the two sections, one of said forms being a choke head, the other of said forms being a choke ring.

5. A combination as set forth in claim **3** in which the yielding means comprises a plurality of individual springs arranged for simultaneous compression with an overall spring rate equal to the sum of the spring rates of the individual springs.

6. A combination as set forth in claim **3** which includes a wash pipe on the inner section extending downward through the outer section, the wash pipe having an outer circumferential shoulder;

- and which further includes spring means in the annular space between the wash pipe and the outer section under compression between the outer circumferential shoulder of the wash pipe and the outer section.

7. A combination as set forth in claim **3** which includes spring means surrounding the inner section under compression between the two sections.

8. In an apparatus for operating a drill bit in a borehole at selected magnitudes of weight imposed on the drill bit over a range of magnitudes upward from a given minimum magnitude to a given maximum magnitude, the combination of:

- a drill string having a pair of telescoping sections dividing the drill string into an upper length and a lower length, the weight of the lower length being substantially the given minimum magnitude, the weight of the upper length being at least equal to the difference between the given maximum and minimum magnitudes;

spring means interposed between the two telescoping sections for stressing in compression by selected increments by corresponding increments of contraction of the telescoping sections to create reaction force with the reaction force of the resilient means at the various increments of contraction corresponding to the selected magnitudes of weight minus the given minimum magnitude;

and means to generate signals perceptible at the top of the borehole in response to the increments of contraction of the telescoping pair of sections.

9. A combination as set forth in claim **8** in which the means to generate the signals comprises a series of choke elements carried by one of the two telescoping sections and choke means carried by the other of the two telescoping sections to cooperate with the choke elements to restrict flow through the drill string at each of said increments of contraction of the pair of telescoping sections.

10. A method of controlling the thrust on a drill bit in a well bore characterized by the use of a drill string weight indicator and a drill string incorporating a pair of telescoping sections with resilient yielding means interposed between the two sections for compression progressively by progressive contraction of the pair of telescoping sections, said method including the steps of:

with the drill bit off bottom and the indicator indicating maximum weight, lowering the drill string until a drop in the indicated weight indicates bottoming of the drill string and the imposition on the drill bit of the weight of the drill string below the pair of telescoping sections,

and then lowering the drill string by a given amount within the range of contraction of the two telescoping sections to cause the weight of the drill string above the pair of sections to compress the yielding means to a given degree to impose a given magnitude of additional weight on the drill bit.

11. A method as set forth in claim **10** which includes the further steps of:

noting the indicated weight when the drill string is lowered by the given amount,

and thereafter as drilling proceeds manipulating the drill string to maintain the noted indicated weight thereby to maintain the given magnitude of additional weight on the drill bit.

12. A method of drilling a well bore by means of a drill string carrying a drill bit, characterized by the steps of:

incorporating a pair of telescoping sections in the drill string with a substantial mass of the drill string above the pair of telescoping sections and with a given mass below the pair to impose a given minimum weight on the drill bit;

interposing resilient yielding means between the two telescoping sections to be compressed by given increments by given increments of contraction of the telescoping pair of sections;

with the drill string of sufficient length to bottom the drill bit, adjusting the elevation of the drill string while continually weighing the drill string until a maximum weight indication indicates that the drill bit is off bottom;

then lowering the drill string while continually weighing the drill string until a drop in the indicated weight indicates bottoming of the drill bit with consequent imposition of the given minimum weight on the drill bit;

and then lowering the drill string by a given amount to cause the pair of sections to be contracted by a corresponding known increment to transfer to the drill bit a corresponding known amount of the weight of the drill string above the pair of telescoping sections.

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ERNEST R. PURSER, *Primary Examiner.*