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Larralde

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[54] **VARIABLE RATE HYDRAULIC-PNEUMATIC WEIGHT CONTROL AND COMPENSATING APPARATUS**

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[52] **U.S. Cl.** **60/413,** 60/907, 175/5, 175/27, 267/126, 254/172

[51] **Int. Cl.** **F15b 1/02**

[58] **Field of Search** .... 60/51, 52 PJ, 413, 414, 415, 60/464, 469, 907; 91/390; 175/5, 27; 267/125, 126; 254/172

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[57] **ABSTRACT**

Apparatus automatically compensating for relative vertical movement between a hoisting or supporting mechanism and a load carried thereby, which load, for example, may be a running string connected to a drill bit used in drilling a subaqueous well bore, the mechanism supporting the running string being mounted on a floating vessel positioned over the well bore. The compensating apparatus includes a cylinder and piston device containing a hydraulic fluid exerting a lifting or tensioning force on the running string, or other load, the pressure on the hydraulic fluid being maintained generally constant by a gaseous medium, despite relative axial movement between the cylinder and piston portions of the device, that might result from heaving of the vessel due to wind and wave action, or the lowering of the running or drilling string as the bit drills the hole. The volume of the gaseous medium for pressurizing the hydraulic fluid can be changed in order to vary the spring-like rate of the gaseous medium.

19 Claims, 3 Drawing Figures

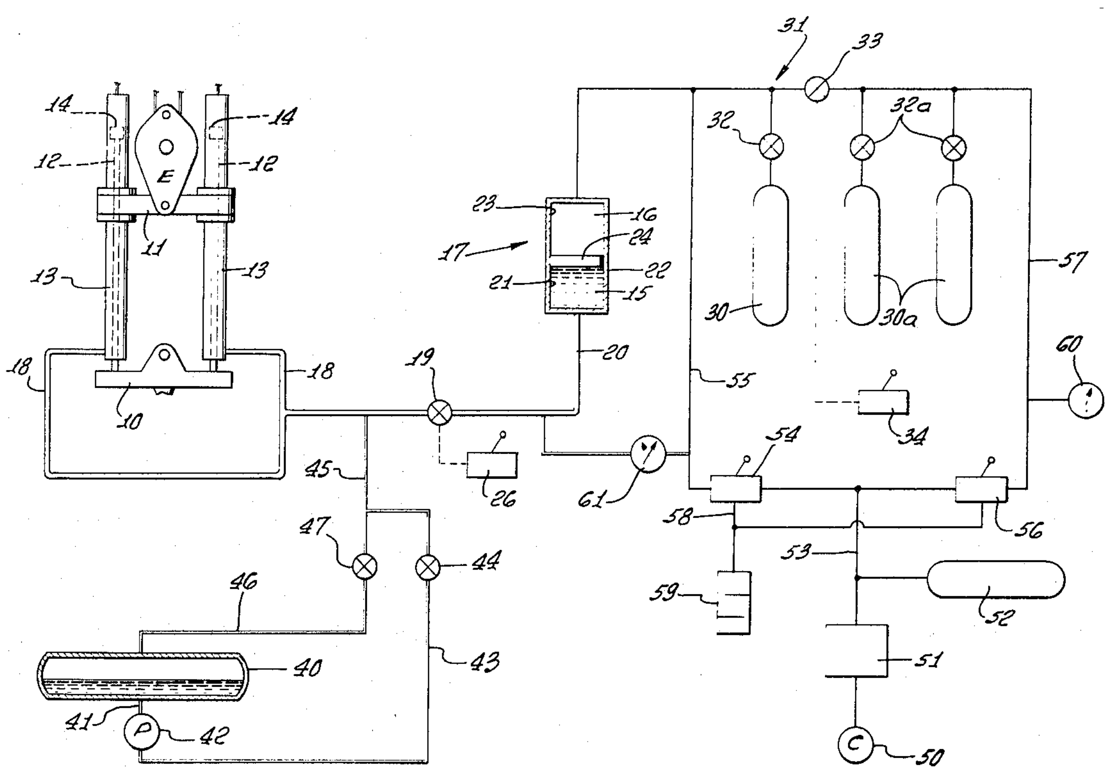


FIG. 1.

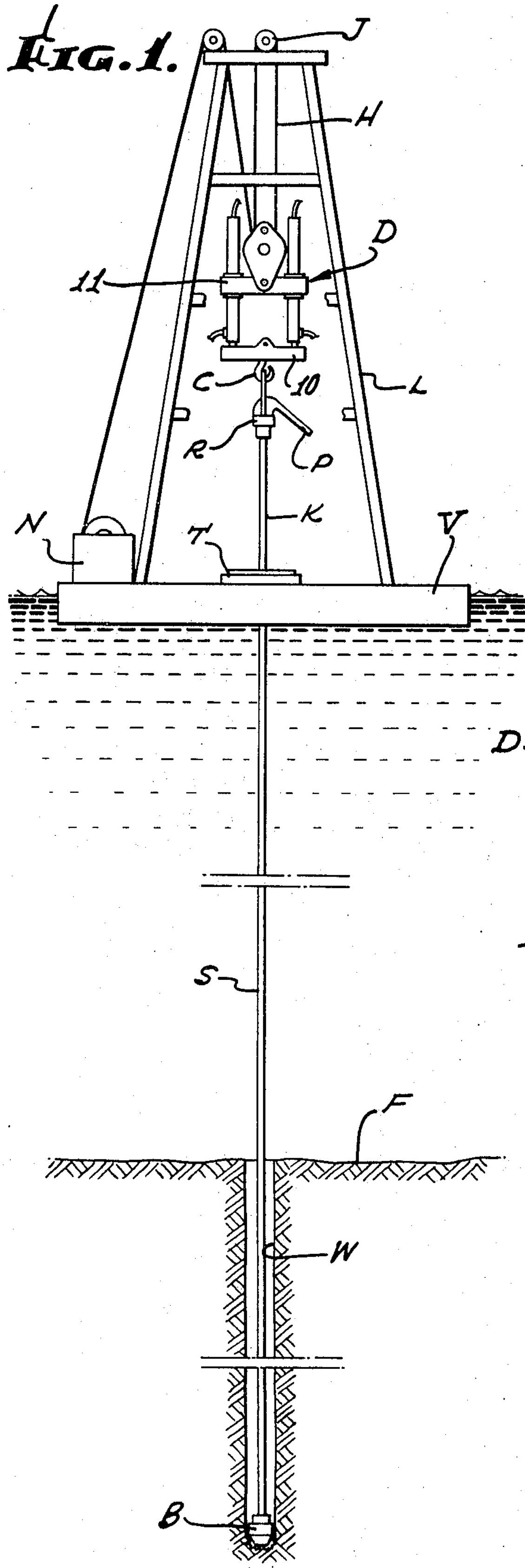


FIG. 2.

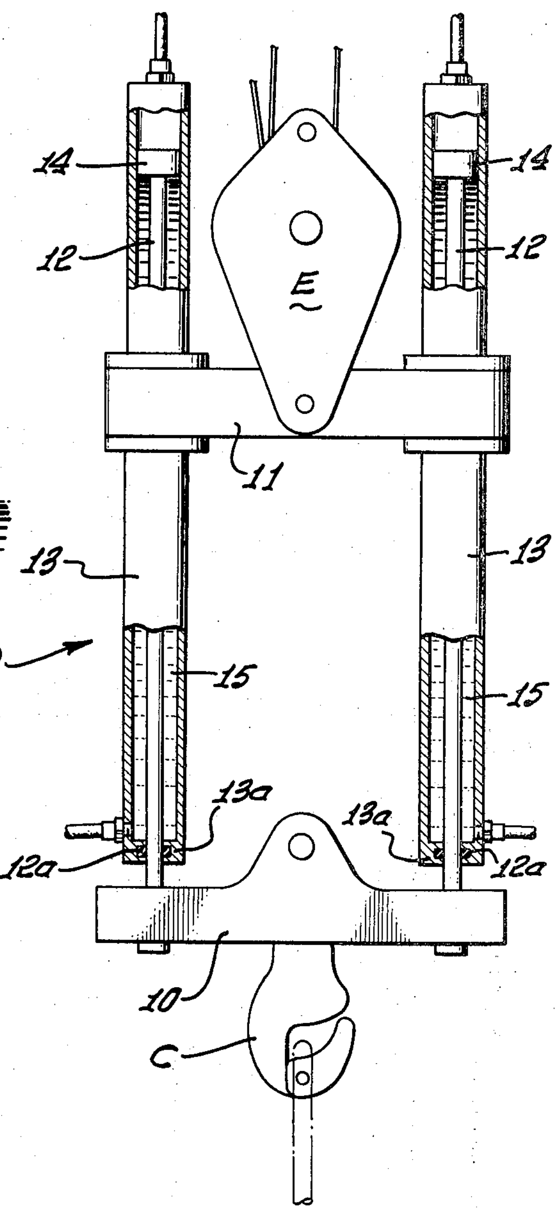
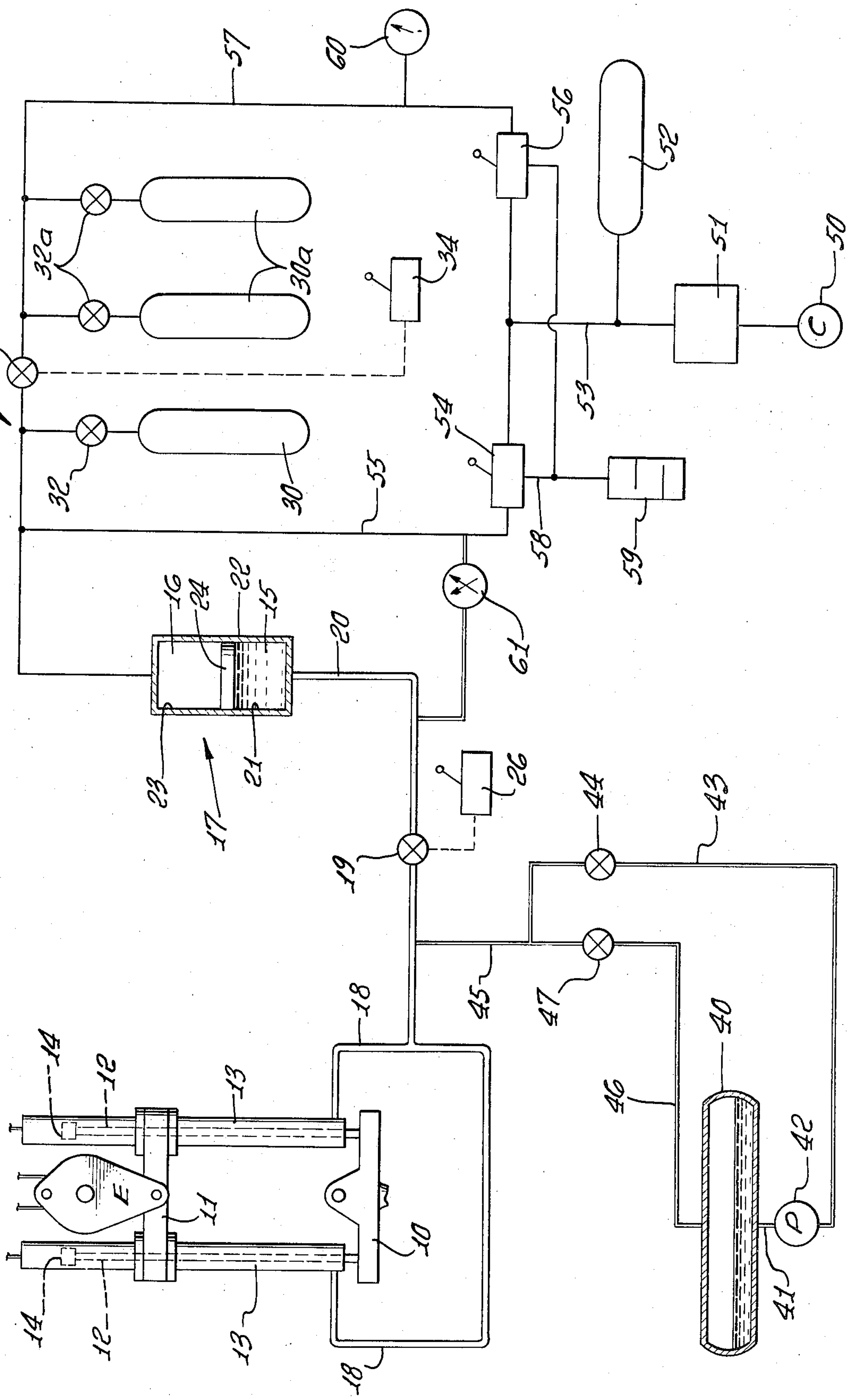


FIG. 3.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VARIABLE RATE HYDRAULIC-PNEUMATIC WEIGHT CONTROL AND COMPENSATING APPARATUS

The present invention relates to apparatus for controlling the stress in a running string, and more particularly to apparatus used on or in connection with a floating vessel for maintaining the strain in a running string, such as a pipe string, substantially constant while being used in the performance of diverse functions in a subaqueous well bore, such as drilling and completion operations therein, despite vertical movement of the vessel while such operations are performed. One specific form of such apparatus is disclosed in U.S. Pat. application Ser. No. 69,758, filed Sept. 4, 1970 for "Hydraulic-Pneumatic Weight Control and Compensating Apparatus", now U.S. Pat. No. 3,718,316.

In the normal operation of drilling a well bore on land, or from a drilling platform supported in a fixed position from the ocean floor, the weight imposed on the drill bit is equal to the total weight of the drilling string less the weight of the drill pipe carried by the drawworks. Usually, the weight imposed on the bit is equal to the weight of the drill collar sections connected to the lower end of the drill pipe. In drilling a sub-aqueous well bore from a floating vessel, problems of compensating for the weight on the bit arise due to the heaving of the vessel under conditions of tide, wind and waves. In the above-identified U.S. patent, an apparatus is illustrated in which the drilling string is supported hydraulically by interposing a compensating apparatus between the travelling block and hook of the usual drilling apparatus employed in drilling the well bore. The apparatus relies upon the maintenance of a required pressure in the hydraulic fluid disposed within a cylinder and piston device of the apparatus by subjecting the hydraulic fluid to the pressure of a gaseous medium, such pressure being maintained in the absence or presence of longitudinal movement of the cylinder and piston portions of the device with respect to each other, the hydraulic fluid exerting a continuous and substantially constant stress on a running string, such as a drilling string. When the apparatus is used in the drilling of a sub-aqueous well bore from a floating vessel, the stress exerted is a substantially constant lifting force on the drilling string despite heaving of the drilling vessel in the water, thereby insuring the maintenance of the desired drilling weight on the drill bit secured to the lower end of the drilling string. The pressure of the gaseous medium can be varied to vary the lifting force on the drilling string, and thereby determine the drilling weight on the drill bit.

In the apparatus or system illustrated in U.S. Pat. application Ser. No. 69,758, filed Sept. 4, 1970, now U.S. Pat. No. 3,718,316 the desired pressure on the hydraulic fluid is maintained through use of an accumulator hydraulically connected to the compensator cylinder and containing gas at a desired pressure acting on the hydraulic fluid, the gas expanding and contracting as the compensator piston moves relatively longitudinally in the compensator cylinders to maintain a generally constant pressure on the hydraulic fluid. The effective gas volume of the accumulator portion of the apparatus remains substantially constant, thereby providing a "gas spring" having a substantially constant spring rate for a particular gas pressure, regardless of the range of relative movement of the compensating piston in the compensator cylinder.

By virtue of the present invention, the rate of the gas spring for a given pressure can be changed at any time. More particularly, such change is effected by changing the effective gas volume of the accumulator, an increase or decrease of the volume correspondingly decreasing or increasing the spring rate. If the relative longitudinal movement of the compensator piston in its cylinder is large, due to a large vertical reciprocation of the drilling ship in the water, it would be desirable to provide a large effective accumulator gas volume to hold variations in the gas pressure to a low value. On the other hand, if the relative movement of the compensator piston in its cylinder is small, due to a small vertical reciprocation of the ship in the water, a lesser effective accumulator gas volume can be provided, variations in gas pressure still being held to a low value.

The present invention also contemplates apparatus capable of readily reducing the effective gas volume of the accumulator to provide a relatively rapid change in the gas pressure in the system, either its increase or decrease. Moreover, while the compensator is in operation with a reduced effective accumulator gas volume, due to a portion of the available gas value being held ineffective, the pressure in said ineffective portion can be changed so as to be available to change the accumulator gas pressure promptly when rendered effective. Such pressure in the ineffective portion of the system can be changed to the same pressure as exists in the effective portion to permit prompt reduction of the gas spring rate of the system to a relatively low value.

This invention possesses many other advantages, and has other purposes which may be made more clearly apparent from a consideration of a form in which it may be embodied. This form is shown in the drawings accompanying and forming part of the present specification. It will now be described in detail, for the purpose of illustrating the general principles of the invention; but it is to be understood that such detailed description is not to be taken in a limiting sense.

Referring to the drawings:

FIG. 1 is a diagrammatic view of a drilling rig mounted on a floating vessel for drilling a sub-aqueous bore hole;

FIG. 2 is a front elevational view, with parts in longitudinal section, of the compensator portion of the apparatus disclosed in FIG. 1; and

FIG. 3 is a diagrammatic view of the compensator system.

Apparatus is disclosed in FIGS. 1 to 3 in connection with the drilling of a vertical well bore W from a subaqueous floor F above which a floating vessel V, such as a drilling barge, is located, the barge being suitably anchored against lateral displacement for the purpose of holding a tubular drilling string S in centered relation with respect to the well bore. A drill bit B is secured to the lower end of the drill string, such as a string of drill pipe or drill casing, the upper kelly portion K of the drill string passing through the usual rotary table T rotated by a suitable drive mechanism (not shown). The upper end of the kelly is secured to a swivel R suspended from a hook C pivotally connected to the lower end of a compensating apparatus D, the upper end of which is pivotally connected to the travelling block E associated with the usual lines H passing over the crown block J at the upper end of the derrick L secured in place on the floating drilling vessel, the cables or lines being connected to a suitable drawworks N mounted on the floating barge.

A suitable mud line P is connected to the swivel for the purpose of delivering drilling mud to the drill string for discharge from the drill bit B, to remove the cuttings produced by the latter while appropriate drilling weight is imposed thereon, with the drilling string being rotated by the table T at the desired speed. Usually, the drilling weight is provided by a suitable length of drill collars disposed in the lower portion of the drill string immediately above the drill bit, the drill string above the drill collars being maintained in tension by the drawworks N and lines H, the drawworks permitting the drill string to lower as the hole W is being produced.

The compensating apparatus D permits the floating vessel V, and the mechanism carried thereby, to shift vertically relative to the well bore W and drilling string S without appreciably modifying the drilling weight imposed on the drill bit B. This compensating apparatus includes a lower supporting structure **10** connected to the hook C, and an upper supporting structure **11** connected to the lower end of the travelling block E. In the specific form of compensating apparatus illustrated, the lower supporting structure **10** is secured to the lower ends of a pair of piston rods **12** extending upwardly into a pair of cylinders **13** affixed to the upper supporting structure **11.** The upper ends of the piston rods are secured to pistons **14** having appropriate seal rings (not shown) thereon for slidably sealing against the cylinder walls, the rod ends of the cylinders carrying appropriate packings **12a** for slidably sealing against the periphery of the piston rods **12.** The cylinders **13** are disposed on opposite sides of the travelling block E and extend thereabove, to reduce the overall length of the compensating unit D while permitting the pistons **14** and rods **12** to shift longitudinally within the cylinders to a substantial extent, the pistons, when disposed at the upper, head ends of the cylinders, still permitting the drawworks to elevate the travelling block and compensating unit to an extent at which the usual length of drill pipe can be connected to, or removed from, the drilling string. The arrangement of the compensating apparatus D with respect to the travelling block E and hook C forms the subject matter of the application of Edward Larralde and James W. E. Hanes, for "Motion Compensating Apparatus," U.S. Pat. Ser. No. 69,759, Filed Sept. 4, 1970 now U.S. Pat. No. 3,714,995.

It is evident that the travelling block E is secured to the cylinders **13** so that the latter move vertically therewith, while the pistons **14** and piston rods **12** are secured to the hook C, and through the swivel R to the upper end of the drill string S. The weight of the drill string is transmitted through the hook C to the piston rods **12** and pistons **14,** and then to liquid **15** filling the cylinder spaces below the pistons **14,** from where it is transmitted to the lower cylinder heads **13***a* and to the cylinders **13** themselves, from where the load is transferred to the travelling block E and the lines H to the crown block J. As noted above, elevation and descent of the travelling block, and, therefore, of the compensating unit D, and the entire load S suspended therefrom, is determined by the operation of the drawworks N.

A substantially constant predetermined pressure is maintained on the liquid medium **15** disposed in the cylinders. Such liquid under pressure acts in an upward direction on the pistons **14** and, therefore, on the hook C, swivel R and drill string S connected thereto. Since the weight of the entire drill string is known, the unit pressure of the liquid medium is selected such that all of such weight, with the exception of the drilling weight to be imposed on the drill bit B, which is usually the weight of the drill collars, is supported by the liquid pressure acting in an upward direction over the areas of the pistons. This pressure is derived from a gaseous medium **16,** such as dry compressed air, or any other suitable gas, disposed in one or a bank of accumulators **17** supported on the vessel V. The rod ends of the cylinders **13** are connected to liquid lines **18** extending to a control valve **19,** from where fluid lines **20** run to the liquid ends **21** of the cylindrical accumulator member or members **22.** The lower portions of the accumulators are filled with the liquid **15,** and the upper ends **23** are filled with the gas **16** under pressure, the gas and liquid in each cylindrical accumulator being separated by a floating piston **24** that makes a suitable slidable seal against the cylindrical wall of the accumulator housing **22.** Accordingly, the gas pressure of the gas **16** is transmitted through the floating piston **24** to the liquid **15,** the same liquid pressure being present in the compensator cylinders **13.** Movement of the pistons **14** in the cylinders **13** is permitted, the floating pistons **24** correspondingly shifting while transmitting the pressure of the gaseous medium **16** to the liquid **15** in the accumulators, and thence through the lines **20, 18** to the liquid **15** in the compensator cylinders **13.**

The ability of the liquid to pass between the compensator cylinders and the accumulators is controlled by the valve **19** of any suitable type, which may be remotely opened or closed by the operator manipulating a manually operated control valve **26.** Normally, during the operation of the compensator apparatus, the valve **19** is in its open position to permit the free transfer of liquid between the compensator cylinders **13** and the accumulator cylinders **22.**

An accumulator gas supply at a desired pressure is contained in a bank of accumulator back-up containers **30, 30***a* of a suitable number, which are connected to the gas side of the accumulator cylinder **22** through a suitable manifold **31,** there being a shut-off valve **32, 32***a* between each back-up container and the manifold. One of the containers **30** can be isolated from the other containers **30***a* by an isolation valve **33** in the manifold, and this isolation valve can be opened or closed from a remote point by a suitable isolator valve **34** appropriately connected thereto. The number of back-up gas containers **30, 30***a* placed in communication with the accumulator cylinder or cylinders **22** can be varied to thereby vary the effective volume of the gas operating upon the liquid **15** in the accumulator, thereby effecting a change in the spring rate of such gas, as described more in detail hereinbelow.

The liquid medium **15** is derived from a reservoir **40,** a suction line **41** from the reservoir running to one or more pumps **42,** which can force the liquid through a discharge line **43** through a valve **44** into a branch line **45** communicating with the line **20** and the compensator and accumulator cylinders **13, 22.** An exhaust or return line **46** extends between the liquid reservoir **40** and the branch line **45,** permitting a reduction in the volume of liquid in the system through opening of a suitable valve **47** in the return line.

As specifically illustrated in the drawings, the gas used in the system is air. Air compressors **50** are the primary source of the energy for the system, the compressed air passing through one or more air dryers **51** to one or more high-pressure air storage containers **52** which supply air at a pressure substantially higher than the maximum pressure of the air in the accumulator cylinders **22** and back-up containers **30, 30*a***. Such higher pressure is desired to reduce the time required to increase the operating pressure of the gas in the accumulator cylinders **22** and back-up containers **30, 30*a***.

The compressed air in the storage container **52** can flow through a suitable line **53** to a valve **54** connected through a line **55** to the manifold **31**. The connection of such line **55** to the manifold is located between the back-up container **30** and the isolation valve **33**. The high pressure air can also pass through the line **53** and another valve **56** connected through a line **57** to the manifold **31** on the other side of the isolation valve **33**. The valves **54, 56** are manually operable and are of a known type, each of them being capable of occupying a closed position and open position, to permit air to pass from the high pressure storage container **52** to the manifold **31**, or to an exhaust condition, to allow air to bleed from the manifold **31**, and the back-up containers **30, 30*a*** and cylinders **22** connected thereto through an exhaust line **58** and through a muffler **59** to the atmosphere, whenever a reduction in the gas or air pressure in the system is desired. Suitable pressure gauges **60, 61** indicate the pressures of the compressed air in the back-up containers **30*a*** connected to the manifold **31** on one side of the isolation valve **33** and accumulators **17** and back-up container **30** on the other side of the isolation valve.

In the operation of the apparatus illustrated in the drawings, the accumulators **17** and back-up containers **30, 30a** are charged with dry compressed air at a desired pressure through suitable manipulation of the valves **54, 56**, there being sufficient liquid **15** in the system such that the same pressure is imposed on the liquid in the compensator cylinders **13** which exerts an upper force on the pistons **14** and on the drill string S, the supported load being carried from the cylinders **13** to the travelling block E and from the lines H to the crown block J. Drilling proceeds through appropriate rotation of the rotary table T, with drilling mud being pumped down the drilling string, returning in a normal manner to the floating vessel V through a marine conductor pipe (not shown in the interest of clarity of the illustration) extending from the drilling vessel V to the well bore W. In the event the floating vessel were to shift vertically, for example, rise, the cylinders **13** would move upwardly along the piston rods **12** and pistons **14**, the liquid **15** therein remaining at substantially the same pressure and being forced through the lines **18, 19** into the lower portions **21** of the accumulators **17**, forcing the floating pistons **24** upwardly to further compress the air to a small extent, which will reflect some increase in the pressure of the liquid **15**, but, as a practical matter, to too small an extent as to have any material effect on the drilling weight imposed on the drill bit B. Similarly, should the vessel V move downwardly, the cylinder **13** will move downwardly therewith, the cylinder volume below the pistons **14** increasing, the compressed air **16** under pressure forcing the liquid **15** from the accumulators **17** back into the compensator cylinders **13** while maintaining the required pressure on the liquid **15**.

Thus, within the operative scope of the compensator apparatus, the drilling vessel V can heave upwardly and downwardly relative to the drill string S without materially altering the drilling weight on the drill bit B. The number of accumulators **17** and their effective gas or compressed air volume, which is made variable by the number of back-up containers **30, 30*a*** connected thereto, is preferably many times the annular areas of the pistons **14**, so that a large liquid volume change in the cylinders **13** produces a much smaller combined volume change in each accumulator or expansion space **21** and **23** and the back-up containers **30, 30*a*** operatively connected thereto, thereby effecting only a relatively small change in the pressure of the compressed air in the upper portion **23** of the accumulators.

The compressed air in the accumulators **17** and back-up containers **30, 30*a*** functions as a gas spring. By virtue of the system illustrated and described, the rate of this gas spring can be varied, depending upon the operating conditions of the compensator system. Such change or variation in spring rate is effected for each air pressure desired in the system, such air pressure depending upon the drilling weight to be supported by the liquid **15** in the compensator cylinders **13**. Thus, the greater the weight to be supported, the higher must be the liquid pressure, and, conversely, the less the weight to be supported the lower must be the liquid pressure. The change of the liquid pressure to the desired value is secured by changing the pressure of the air **16** in the accumulators **17** and in the back-up containers **30, 30a** connected therewith. Increasing air pressure is effected, as noted above, by manipulating the valve **54** to permit flow of air from the high pressure storage container **52** to the accumulators **17** and back-up containers **30, 30*a*** communicating therewith. If some of the back-up containers, such as **30*a***, are isolated from the accumulators through closing of the isolation valve **33**, the air pressure in such ineffective back-up containers **30*a*** can still be increased by appropriate manipulation of the other valve **56** to permit high pressure air to flow through the line **57** and into the ineffective back-up containers.

On the other hand, should it be desired to decrease the air pressure in the accumulators **17** and back-up containers **30, 30*a*** normally communicating therewith, the manual valve **54** is appropriately manipulated to permit some of the compressed air to exhaust through the line **58** and muffler **59** to the atmosphere. Similarly, the air pressure in the back-up containers **30*a***, if isolated from the container **30**, can also be reduced by suitably manipulating the other valve **56** to an exhaust condition, permitting air to exhaust through the line **58** and muffler **59** to atmosphere. If the isolation valve **33** is open and the shut-off valves **32, 32*a*** are open, then the air pressure in the accumulators **17** and the back-up containers **30, 30a** will be the same, manipulation of the single valve **54** or **56** effecting an increase or decrease in the air pressure in all accumulators **17** and back-up containers.

The back-up containers **30, 30*a*** are actually extensions of the accumulators **17** when operatively connected thereto. By changing the number of back-up containers **30, 30*a*** operatively connected to the accumulators, the effective gas volume is changed, as well as the spring rate of the compressed air **16** operating in the system. If, for example, the relative longitudinal movement of the compensator pistons **14** and their associated cylinders **13** is relatively large, because of relatively large vertical reciprocation of the drilling ship V in the water, a low spring rate is desirable to hold variations in the gas pressure to a low value. This condition can be provided by having the isolation valve **33** open, so that all of the back-up containers **30, 30***a* communicate with the accumulators **17,** such containers and accumulators having air at the same pressure. If the vertical reciprocation of the drilling ship V in the water is relatively small, then the isolation valve **33** can be closed, and only the single back-up container **30** illustrated in the drawings will be in communication with the accumulators **17,** the spring rate for a given pressure of the compressed air then being relatively high. Intermediate spring rates can be provided by a determination of the number of back-up containers **30, 30***a* operatively connectable to the accumulators, by closing one or more of the shut-off valves **32***a* between the back-up containers **30***a* and the manifold **31.** The number of such back-up containers **30***a* can be greater than specifically illustrated, thereby giving a wider potential variation that can be secured in the spring rate of the compressed air operating in the system.

Assuming the system is operating at a relatively high air spring rate, that is, with the isolation valve **33** closed, the air pressure can be rapidly increased in the system by charging the ineffective back-up containers **30***a* with compressed air at a higher desired pressure through manipulation of the valve **56,** to allow compressed air to flow from the high pressure storage container **52** to the ineffective back-up containers, until the desired pressure is achieved in such containers, as noted on the pressure gauge **60.** At any time the pressure in the accumulators **17** is to be increased, the isolation valve **33** is opened through suitable manipulation of the remotely located valve **34,** a very rapid increase in the air pressure in the system being achieved, since the higher air pressure flows from the initially ineffective containers **30***a* into the other back-up container **30** and the accumulator cylinders **22.**

Conversely, a reduction in air pressure can be achieved. The isolation valve **33** is closed, and the valve **56** then manipulated to bleed air from the ineffective back-up containers **30***a* into the atmosphere, until the pressure in the containers **30***a* is at a desired value, as noted on the gauge **60.** Thereafter, upon opening of the isolation valve **33,** a fairly rapid decrease in air pressure in the accumulator system will be achieved.

If the system is operating at a relatively high spring rate, the effective air pressure in the accumulators **17** can be changed rapidly. If it is to be increased, the valve **54** is suitably manipulated to permit high pressure air from the storage container **52** to flow to the accumulators **17** and the single back-up container **30** (the isolation valve **33** being closed), increase in pressure being achieved rapidly in view of the relatively small gas volume of the system. Similarly, if the air pressure in the system is to be decreased, within the system operating at a high spring rate, the valve **54** is suitably manipulated to exhaust some of the air to atmosphere, there being a relatively rapid decrease in the air pressure in the system.

I claim:

1. In apparatus for maintaining a predetermined stress in a running string: cylinder means; piston means slidable in said cylinder means; one of said means being adapted for operative connection to the running string; the other of said means being adapted for operative connection to a support; means for maintaining a liquid medium under pressure in said cylinder means on one side of said piston means as said piston means and cylinder means move longitudinally relative to one another in both longitudinal directions; said pressure maintaining means comprising container means containing a gaseous medium, said container means being separate from said cylinder means; and means for changing the effective volume of said container means and of the gaseous medium therein effective for operation upon said liquid medium at a given unit pressure to vary the spring rate of said gaseous medium.

2. In apparatus for maintaining a predetermined stress in a running string: cylinder means; piston means slidable in said cylinder means; one of said means being adapted for operative connection to the running string; the other of said means being adapted for operative connection to a support; means for maintaining a liquid medium under pressure in said cylinder means on one side of said piston means as said piston means and cylinder means move longitudinally relative to one another in both longitudinal directions; said pressure maintaining means comprising a gaseous medium under pressure exerting its pressure force on said liquid medium; and means for varying the volume of said gaseous medium at the same unit pressure effective for exerting its pressure force on said liquid medium; said pressure maintaining means further including an accumulator cylinder containing part of said liquid medium in one portion thereof and said gaseous medium in another portion thereof for transmitting its pressure to said liquid medium; said volume varying means comprising a plurality of gaseous medium containers connected to the gaseous medium portion of said accumulator cylinder, and means for communicating said accumulator cylinder with different numbers of said containers to selectively determine the spring rate of said gaseous medium by permitting gas to flow simultaneously and in both directions between the selected number of containers and said accumulator cylinder.

3. In apparatus as defined in claim **2**; said communicating means including valve means for selectively permitting or preventing flow of said gaseous medium between some of said containers and said accumulator cylinder.

4. In apparatus as defined in claim **2**; a source of said gaseous medium under pressure; conduit means for conducting said gaseous medium from said source to said accumulator cylinder and said containers; and valve means in said conduit means for controlling flow of said gaseous medium through said conduit means.

5. In apparatus as defined in claim **2**; a source of said gaseous medium under pressure; conduit means for conducting said gaseous medium from said source to said accumulator cylinder and said containers; and valve means in said conduit means for controlling flow of said gaseous medium through said conduit means, said valve means being operable to selectively effect increase or decrease in pressure of said gaseous medium in said accumulator cylinder and containers.

6. In apparatus as defined in claim **2**; a source of said gaseous medium under pressure; conduit means for conducting said gaseous medium from said source to said accumulator cylinder and said containers; and valve means in said conduit means for controlling flow of said gaseous medium through said conduit means, said conduit means including a first tubular line for conducting said gaseous medium between said source and some of said containers and a second tubular line for conducting said gaseous medium between said source and other of said containers and said accumulator cylinder; said valve means including valves in said first and second tubular lines for individually controlling flow of said gaseous medium in said tubular lines.

7. In apparatus as defined in claim **2**; a source of said gaseous medium under pressure; conduit means for conducting said gaseous medium from said source to said accumulator cylinder and said containers; and valve means in said conduit means for controlling flow of said gaseous medium through said conduit means, said valve means being operable to selectively effect increase or decrease in pressure of said gaseous medium in said accumulator cylinder and containers, said conduit means including a first tubular line for conducting said gaseous medium between said source and some of said containers and a second tubular line for conducting said gaseous medium between said source and other of said containers and said accumulator cylinder; said valve means including valves in said first and second tubular lines for selectively effecting increase or decrease in the pressure of the gaseous medium in said some of said containers and said other of said containers and accumulator cylinder.

8. In apparatus as defined in claim **2**; a source of said gaseous medium under pressure; conduit means for conducting said gaseous medium from said source to said accumulator cylinder and said containers; and valve means in said conduit means for controlling flow of said gaseous medium through said conduit means, said conduit means including a first tubular line for conducting said gaseous medium between said source and some of said containers and a second tubular line for conducting said gaseous medium between said source and other of said containers and said accumulator cylinder; said valve means including valves in said first and second tubular lines for individually controlling flow of said gaseous medium in said tubular lines; and means including an isolation valve selectively preventing or permitting communication between said some of said containers and said other of said containers.

9. In apparatus as defined in claim **2**; a source of said gaseous medium under pressure; conduit means for conducting said gaseous medium from said source to said accumulator cylinder and said containers; and valve means in said conduit means for controlling flow of said gaseous medium through said conduit means, said valve means being operable to selectively effect increase or decrease in pressure of said gaseous medium in said accumulator cylinder and containers, said conduit means including a first tubular line for conducting said gaseous medium between said source and some of said containers and a second tubular line for conducting said gaseous medium between said source and other of said containers and said accumulator cylinder; said valve means including valves in said first and second tubular lines for selectively effecting increase or decrease in the pressure of the gaseous medium in said some of said containers and said other of said containers and accumulator cylinder; and means including an isolation valve selectively preventing or permitting communication between said some of said containers and said other of said containers.

10. In apparatus for maintaining a predetermined stress in a running string disposed in a well bore and which is supported by a rig: elongate cylinder means; piston means slidable in said cylinder means; one of said means being adapted for operative connection to the running string; the other of said means being adapted for operative connection to the rig; means for maintaining a liquid medium under pressure in said cylinder means on one side of said piston means as said piston means and cylinder means move longitudinally relative to one another in both longitudinal directions; said pressure maintaining means comprising container means containing a gaseous medium under pressure exerting its pressure force on said liquid medium, said container means being separate from said cylinder means; and means for changing the effective volume of said container means and of the gaseous medium therein effective for operation upon said liquid medium at a given unit pressure to vary the spring rate of said gaseous medium.

11. In apparatus for maintaining a predetermined stress in a running string disposed in a well bore and which is supported by a rig: elongate cylinder means; piston means slidable in said cylinder means; one of said means being adapted for operative connection to the running string; the other of said means being adapted for operative connection to the rig; means for maintaining a liquid medium under pressure in said cylinder means on one side of said piston means as said piston means and cylinder means move longitudinally relative to one another in both longitudinal directions; said pressure maintaining means comprising a gaseous medium under pressure exerting its pressure force on said liquid medium; and means for varying the volume of said gaseous medium at the same unit pressure effective for exerting its pressure force on said liquid medium; said pressure maintaining means further including an accumulator cylinder containing part of said liquid medium in one portion thereof and said gaseous medium in another portion thereof for transmitting its pressure to said liquid medium; said volume varying means comprising a plurality of gaseous medium containers connected to the gaseous medium portion of said accumulator cylinder, and means for connumicating said accumulator cylinder with different numbers of said containers to selectively determine the spring rate of said gaseous medium.

12. In apparatus as defined in claim **11**; said communicating means including valve means for selectively permitting or preventing flow of said gaseous medium between some of said containers and said accumulator cylinder.

13. In apparatus as defined in claim **11**; a source of said gaseous medium under pressure; conduit means for conducting said gaseous medium from said source to said accumulator cylinder and said containers; and valve means in said conduit means for controlling flow of said gaseous medium through said conduit means.

14. In apparatus as defined in claim **11**; a source of said gaseous medium under pressure; conduit means for conducting said gaseous medium from said source to said accumulator cylinder and said containers; and valve means in said conduit means for controlling flow of said gaseous medium through said conduit means, said conduit means including a first tubular line for conducting said gaseous medium between said source and some of said containers and a second tubular line for conducting said gaseous medium between said source and other of said containers and said accumulator cylinder; said valve means including valves in said first and second tubular lines for individually controlling flow of said gaseous medium in said tubular lines.

15. In apparatus as defined in claim **11**; a source of said gaseous medium under pressure; conduit means for conducting said gaseous medium from said source to said accumulator cylinder and said containers; and valve means in said conduit means for controlling flow of said gaseous medium through said conduit means, said conduit means including a first tubular line for conducting said gaseous medium between said source and some of said containers and a second tubular line for conducting said gaseous medium between said source and other of said containers and said accumulator cylinder; said valve means including valves in said first and second tubular lines for individually controlling flow of said gaseous medium in said tubular lines; and means including an isolation valve selectively preventing or permitting communication between said some of said containers and said other of said containers.

16. In apparatus for maintaining a predetermined stress in a running string disposed in a well bore and which is supported by a rig including a suspension mechanism: elongate cylinder means; piston means slidable in said cylinder means; one of said means having a device thereon for operative connection to the running string; the other of said means having a device thereon for operative connection to the suspension mechanism, whereby said cylinder means and piston means are disposed between the suspension mechanism and running string; means for maintaining a liquid medium under pressure in said cylinder means on one side of said piston means as said piston means and cylinder means move longitudinally relative to one another in both longitudinal directions, whereby the stress of the running string and of said one means is transmitted through the liquid to said other means and suspension mechanism; said pressure maintaining means comprising container means containing a gaseous medium under pressure exerting its pressure force on said liquid medium; said pressure maintaining means further including an accumulator cylinder communicating with said container means and containing part of said liquid medium in one portion thereof and said gaseous medium in another portion thereof for transmitting its pressure to said liquid medium; said container means being separate from said accumulator cylinder; and means for changing the effective volume of said container means and of the gaseous medium therein effective for operation upon said liquid medium at a given unit pressure to vary the spring rate of said gaseous medium.

17. In apparatus for maintaining a predetermined stress in a running string disposed in a well bore and which is supported by a rig including a suspension mechanism: elongate cylinder means; piston means slidable in said cylinder menas; one of said means having a device thereon for operative connection to the running string; the other of said means having a device thereon for operative connection to the suspension mechanism, whereby said cylinder means and piston means are disposed between the suspension mechanism and running string: means for maintaining a liquid medium under pressure in said cylinder means on one side of said piston means as said piston means and cylinder means move longitudinally relative to one another in both longitudinal directions, whereby the stress of the running string and of said one means is transmitted through the liquid to said other means and suspension mechanism; said pressure maintaining means comprising a gaseous medium under pressure exerting its pressure force on said liquid medium; said pressure maintaining means further including an accumulator cylinder containing part of said liquid medium in one portion thereof and said gaseous medium in another portion thereof for transmitting its pressure to said liquid means; and means for varying the volume of said gaseous medium at the same unit pressure effective for exerting its pressure force on said liquid medium; said volume varying means comprising a plurality of gaseous medium containers connected to the gaseous medium portion of said accumulator cylinder, and means for communicating said accumulator cylinder with different numbers of said containers to selectively determine the spring rate of said gaseous medium by permitting gas to flow simultaneously and in both directions between the selected number of containers and said accumulator cylinder.

18. In apparatus as defined in claim **17**; a source of said gaseous medium under pressure; conduit means for conducting said gaseous medium from said source to said accumulator cylinder and said containers; valve means in said conduit means for controlling flow of said gaseous medium through said conduit means; said conduit means including a first tubular line for conducting said gaseous medium between said source and some of said containers and a second tubular line for conducting said gaseous medium between said source and other of said containers and said accumulator cylinder; said valve means including valves in said first and second tubular lines for individually controlling flow of said gaseous medium in said tubular lines.

19. In apparatus as defined in claim **17**; a source of said gaseous medium under pressure; conduit means for conducting said gaseous medium from said source to said accumulator cylinder and said containers; valve means in said conduit means for controlling flow of said gaseous medium through said conduit means; said conduit means including a first tubular line for conducting said gaseous medium between said source and some of said containers and a second tubular line for conducting said gaseous medium between said source and other of said containers and said accumulator cylinder; said valve means including valves in said first and second tubular lines for individually controlling flow of said gaseous medium in said tubular lines; and means including an isolation valve selectively preventing or permitting communication between said some of said containers and said other of said containers.

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