July 4, 1967 R. W. WALKER 3,329,221

PRESSURE BALANCED BUMPER SUB

Original Filed April 22, 1963

3 Sheets-Sheet 1

FIG. 1.

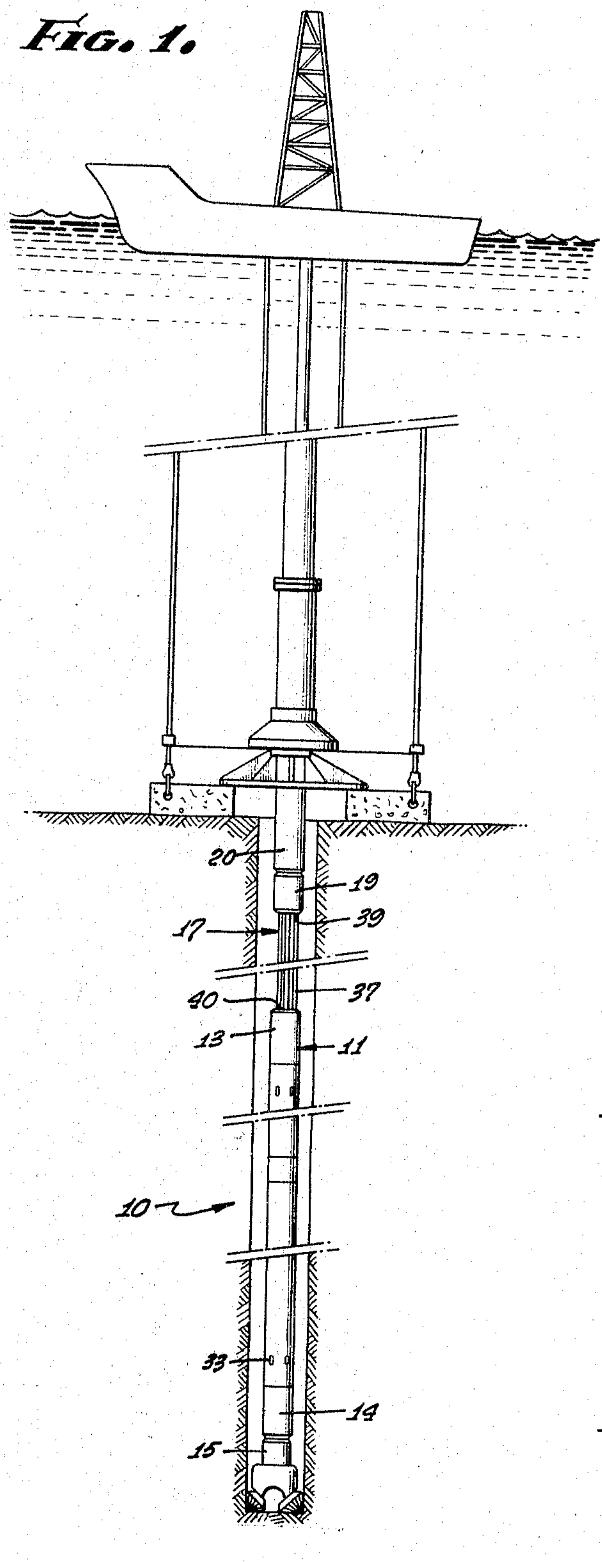


FIG. 5.

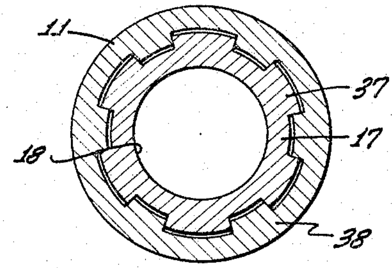


FIG. 6.

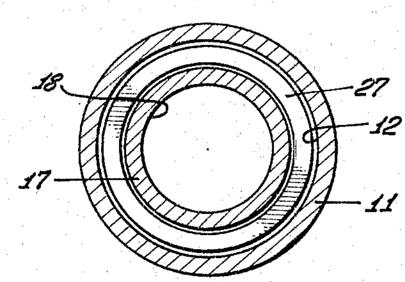
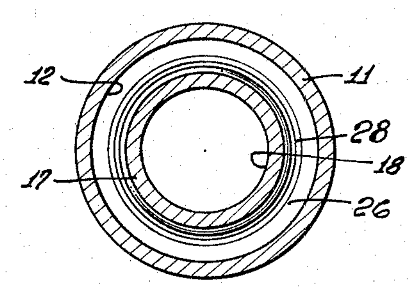


FIG. 7.



INVENTOR.
RAYMOND W. WALKER
BY
Miketta and Glenny
ATTORNEYS.

July 4, 1967

R. W. WALKER

3,329,221

PRESSURE BALANCED BUMPER SUB

Original Filed April 22, 1963

3 Sheets-Sheet 2

FIG. 2a.

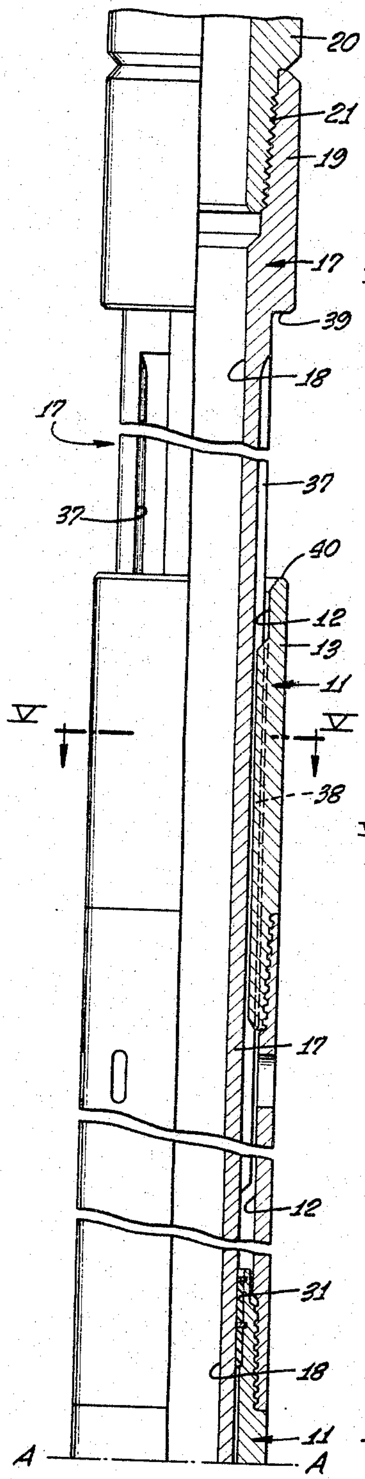


FIG. 2b.

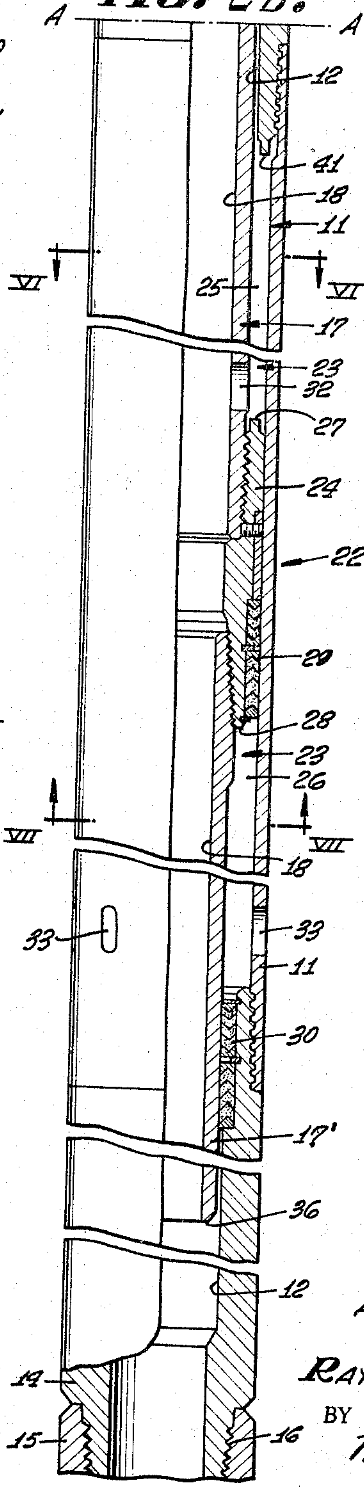
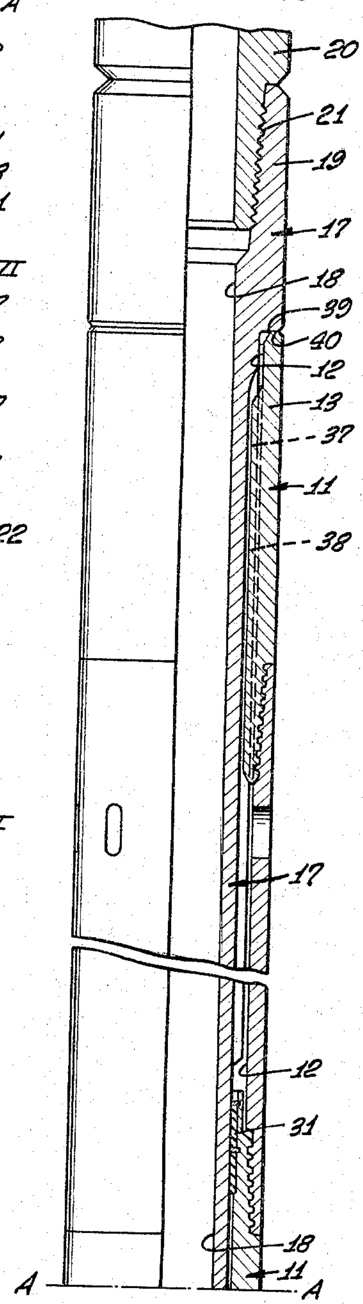


FIG. 3a.



INVENTOR.
RAYMOND W. WALKER

BY

Miketta and Glenny

ATTORNEYS.

PRESSURE BALANCED BUMPER SUB

Original Filed April 22, 1963

FIG. 3b.

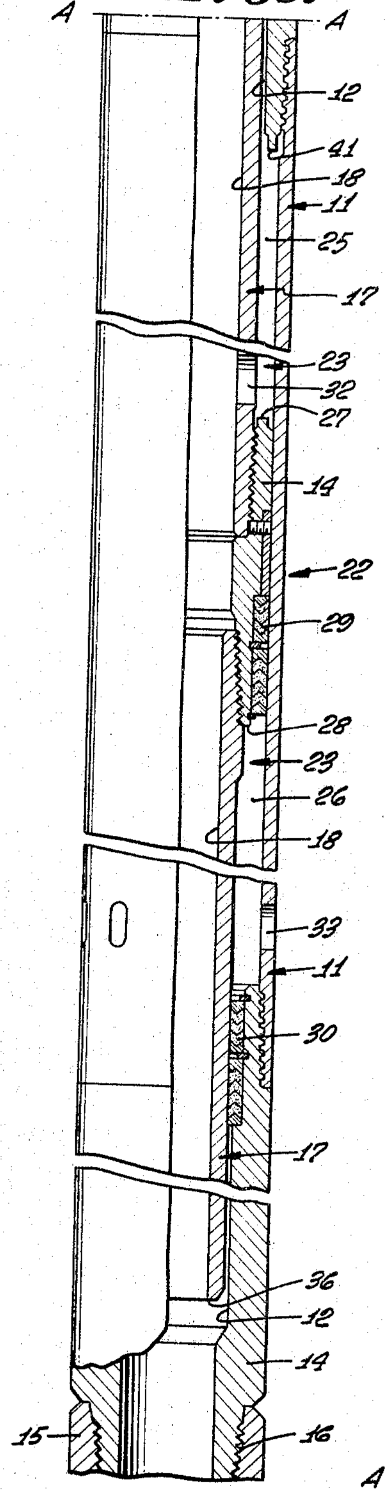


FIG. 4a.

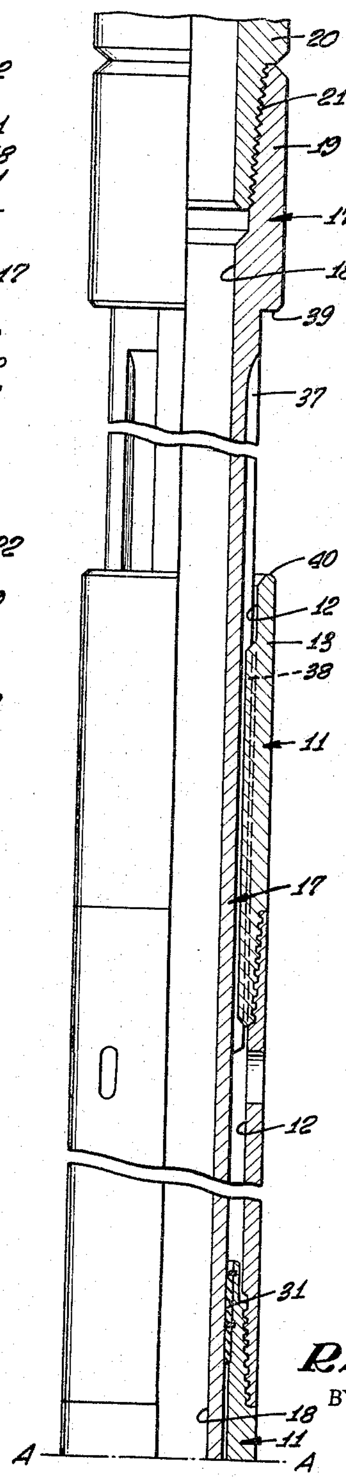
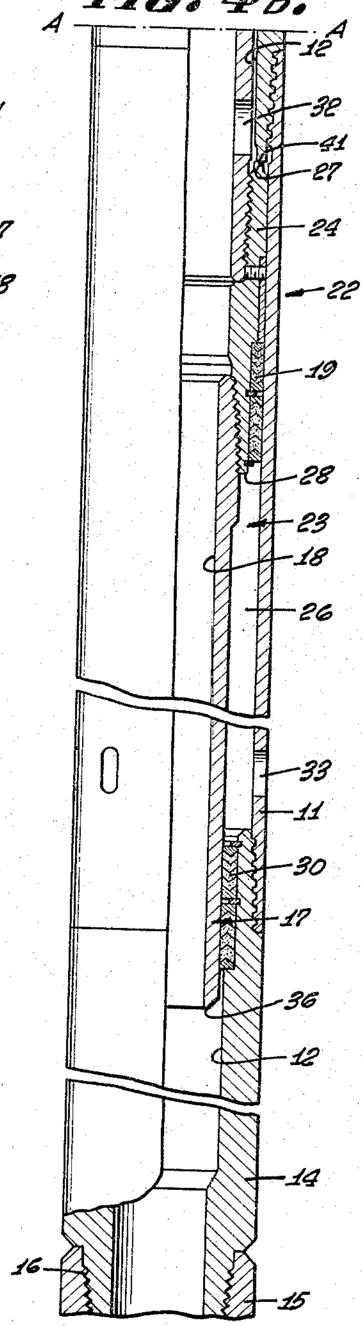


FIG. 4b.



INVENTOR.
RAYMOND W. WALKER
BY
Miketta and Glenny
ATTORNEYS

United States Patent Office

3,329,221

Patented July 4, 1967

1

3,329,221

PRESSURE BALANCED BUMPER SUB

Raymond W. Walker, Huntington Beach, Calif., assignor to Shaffer Tool Works, Brea, Calif., a corporation of California

Continuation of abandoned application Ser. No. 274,485, Apr. 22, 1963. This application Mar. 21, 1966, Ser. No. 559,698

4 Claims. (Cl. 175—296)

This invention relates to a pressure balanced bumper sub particularly adapted for use in subsea drilling operations and is particularly designed to maintain contact and control of drilling and other tools in a subsea well hole without deleterious effect of the rise and fall of a floating drilling platform upon the operation of the tools or drilling pressure applied thereto. This is a continuation of copending application Ser. No. 274,485, filed by me Apr. 22, 1963, and now abandoned (35 U.S.C. 120).

Drilling operations conducted from a floating platform, barge or other vessel anchored on the surface of a large body of water gives rise to numerous problems, most of which are due to the rise and fall of the platform by reason of swells, tides or storms. It has long been recognized that it is desirable to maintain a substantially uniform and controlled drilling weight upon the drilling tools operating through a casing. Weighted drilling collars are often used immediately above the drilling tool in order to provide a predetermined weight and minimize the transmission of bit bounce and drilling vibrations through the drill stem to the surface. Prior bumper subs were capable to transmitting rotation and also lengthening or shortening (within limits), but the pressure of the drilling mud or fluid being pumped down through the drill string produced an inherent "pump-open" effect which tended to impose additional penetrating force on the bit and maintain the sub in its fully lengthened position, thereby increasing the compressive load in the drill pipe and nullifying the possible longitudinal motion of the sub for which it was designed. It is to be remembered that a drill tool may become jammed or frozen, damaged or broken, and the bumper sub should be available to release the tool by upward blows; such upward blows cannot be imparted when the sub has been operating in a fully open position. Similarly, a bumper sub should be in operating condition when it is being used on a drill string with a fishing tool.

The present invention is directed to a virtually balanced bumper sub wherein the sub normally operates in a balanced position or condition, neither fully extended nor fully closed. In this position, the drilling weight or force on the drill tool is maintained substantially constant and the rise and fall of the floating drilling platform is isolated by the bumper sub. The device of the present invention is adapted to maintain a uniform and continuous drilling weight on the drilling tool within the well hole so as to allow constant contact between bit and formation and control over the tool even when the drilling rig or platform is rising or falling in rough seas. The device of the present invention is relatively simple to assemble, may be introduced into a drill string at any desired point (preferably above the drill collars and tools and below the major length of drill pipe extending to the platform) and utilizes the balance between the pressure of drilling mud being pumped down through the drill string and the pressure of the drilling mud, cutting, etc. flowing upwardly exteriorly of the drill string, to maintain a balanced position and overcome the heretofore usual pump-open effect.

Generally stated, the device of the present invention includes an external barrel of smooth uniform external diameter virtually equal to the outer diameter of drill collars of the drill string in which it is to be used, thereby

2

permitting ready introduction through usual well head equipment, blow-out preventers and other devices into the casing and not interfering with free insertion or withdrawal from the well hole. The main section of this barrel is provided with a smooth uniform internal surface. Within this barrel there is provided a hollow mandrel; means are provided whereby the mandrel and barrel may rotate jointly and thereby transmit torque while, at the same time, the mandrel and barrel may move longitudinally with respect to each other. Two annular chambers are provided around the mandrel and between the mandrel and the main section of the barrel; it has been found desirable to make the hollow mandrel with a non-uniform external diameter so as to produce two chambers differing in effective cross-sectional area. As hereinafter described in greater detail, packing and sealing means are provided so as to isolate the two chambers from each other, the chamber of smaller effective cross-sectional area being in communication with the interior of the mandrel and the drilling mud or fluid being pumped to the tool whereas the larger chamber is in communication with the fluid pressure existing externally of the barrel. By such construction, the "pump-open" effect is nullified and the sub is virtually balanced irrespective of depth at which the device is positioned within a well hole. In addition, the device includes suitable hammers and anvils so that tools may be driven down or bumped up as circumstances warrant.

The present device reacts in response to existing internal circulating drilling fluid pressure and the fluid pressure outside the tool to maintain a virtually constant and uniform drilling weight or force on the drill tool in the well hole. The present device prevents vertical movement of the drill string (caused by any means) from being transmitted to a drilling tool or that portion of the drill string below the device. By means of the device of the present invention, any sudden up or down movement of the drill string (or of the drilling platform or vessel) is isolated by the pressure balanced bumper sub and is not transmitted to the drill tool in the well hole. The device of this invention is self-stabilizing and will remain in substantially the position in which it is initially placed. The construction is simple and the device does not utilize springs or other actuating devices.

Accordingly, it is the general object of the present invention to disclose and provide a pressure balanced bumper sub which is particularly adapted for use in subsea drilling operations and eliminates the dangers and changes which take place due to the rise and fall of a vessel or platform from which the hole is being drilled.

An object of the present invention is to disclose and provide a pressure balanced bumper sub that allows a well operator to maintain constant contact with, and control of, tools in a well hole.

A further object of the invention is to provide a pressure balanced bumper sub which absorbs bounce, does not transmit these vibrations upwardly through the drill stem as shock loads, does not exhibit the "pump-open" effect and thereby reduces the increase in drilling weight and the compressive load in the drill pipe which was inherently obtained by prior art subs.

Other objects and advantages of the invention will be readily appreciated by those skilled in this art from the following detailed description of an exemplary form of the device, wherein:

FIG. 1 is a diagrammatic view of a subsea drilling apparatus and arrangement in which the device of the present invention may be used;

FIGS. 2*a* and 2*b* constitute a side elevation partly in section of an exemplary form of device in the completely balanced position (midway between open and closed position), the complete device being broken along transverse plane A—A;

FIGS. 3*a* and 3*b* illustrate the device of the present invention in the down or closed position whereby a down bump is effected;

FIGS. 4*a* and 4*b* illustrate the device in the up or open position whereby an up bump is obtained;

FIG. 5 is a transverse section taken along the plane V—V of FIG. 2*a*;

FIG. 6 is a transverse section taken along the plane VI—VI of FIG. 2*b*; and

FIG. 7 is a transverse section taken along the plane VII—VII of FIG. 2*b*.

Referring now to the drawings, wherein like reference characters designate like or corresponding parts throughout the several view, there is shown in FIG. 1 a pressure balanced bumper sub **10** in its normal balanced position (see FIGS. 2*a* and 2*b*) within a drill string as adapted to be used in a subsea drilling apparatus.

As best seen in FIGS. 2, 3 and 4, the pressure balanced bumper sub **10** may include an elongated hollow barrel or outer tubular portion **11**, which may have an upper end **13** (FIG. 2*a*), a lower end **14** (FIG. 2*b*) and an axially extending through bore **12**. Lower end **14** of the outer tubular portion **11** may be adapted to be connected to a drill string section or tool **15** (FIG. 2*b*) by means such as the threadable connection or pin **16**. Drill string section **15** may be a drill bit, drill tool, fishing tool or some other section such as a drill collar of the drill string.

Concentrically disposed within the outer tubular portion **11** and adapted to be telescopically received therein, is an inner elongated hollow mandrel **17**. The hollow mandrel **17** may be axially and slidingly received within the barrel bore **12**, and may also have an internal bore **18** throughout the length of the mandrel **17**. The upper end **19** (FIG. 2*a*) of the mandrel **17** is adapted to be connected to a successive portion **20** of the drill string as by a threadable connection or screw box **21**. The bore of the mandrel cooperates with the bore extending through the various pieces of drill pipe to permit free passage of circulating drilling fluid.

The pressure balanced bumper sub **10** may have means **22** adapted to respond to pressure to maintain a predetermined longitudinal relationship between the barrel **11** and mandrel **17**. The means **22** may be positioned within the barrel bore **12** and may act in a cooperating manner to longitudinally balance the bumper sub **10**. The drawings (particularly FIG. 2*b*) show that the main or central section of the barrel is of uniform internal diameter and carries an inwardly extending annular seal ring **30** adjacent the lower end and an annular inwardly extending seal ring **31** adjacent the upper end (FIG. 2*a*). The internal diameters of these seal rings are smaller than the internal diameter of the main barrel section therebetween. These seal rings slidably engage the outer surfaces of lower and upper sections **17′** and **17** of the mandrel. As shown in FIG. 2*b*, the outer diameter of mandrel section **17′** is smaller than that of section **17**, and these two sections are connected together by a member **24** which carries a seal **29** and slidingly contacts the smooth inner surface of barrel **11**.

Annular chevron-type sealing rings made of rubber or some other resilient material which would produce an effective dynamic seal may be used for sealing means **29**. Such sealing means **29** function to create two pressure sealed or pressure tight chambers **25** and **26**. The additional sealing means **30** and **31** are similar to **29**. The lower sealing means **30** (FIG. 2*b*) prevents the high circulation fluid in the barrel bore **12** from seeping or leaking into the low pressure chamber **26** thereby preserving the pressure differential. Therefore, by the coaction of sealing means **29** and **30** a pressure sealed, low pressure chamber **26** is provided. The upper sealing means **31** (FIG. 2*a*) prevents the high circulation fluid pressure

in the high pressure chamber **25** from escaping out to the environment thereby creating a similar pressure tight high pressure chamber **25**.

The mandrel sections, seals **29**, **30** and **31**, and the inner surface of the barrel cooperate to form fluid pressure balancing chamber **23** into a varying volume high pressure chamber or region **25** and a varying volume lower pressure chamber or region **26**.

Immediately adjacent the connector **24** may be provided means for introducing the high pressure circulation fluid circulating in the mandrel bore **18** into the high pressure chamber **25**. Such means may be a plurality of circumferentially spaced fluid ports **32** communicating the mandrel bore **18** with the high pressure chamber **25**.

Additional means may be provided for introducing the exterior environmental fluid into the low pressure chamber **26**. Such means may be a plurality of circumferentially spaced fluid inlets **33** near the lower end of the lower pressure chamber **26** and extending laterally through the barrel **11** to communicate the low pressure chamber **26** with the ambient environment.

As evident from FIG. 2*b* and FIGS. 6 and 7, the connector **24** and its seal present an upward annular face **27** to chamber **25** and an oppositely directed annular face **28** to chamber **26**. From the drawings, it can be seen that the annular area **27** (between the internal diameter of the barrel and the outer diameter of the mandrel section **17**) in chamber **25** is smaller than the effective annular pressure area **28** in chamber **26** (between internal diameter of the barrel and the outer diameter of mandrel section **17′**). When scaled, the appended drawings show that the area **27** is virtually equal to an area having the diameter equal to the outer diameter of the lower mandrel section **17′**, whose end is indicated at **36**.

As best seen in FIG. 2*b*, mandrel **17** may have a lower end **36** which extends beyond the lower end of the low pressure chamber **26** and sealing means **30**. The high pressure circulation fluid circulating in the barrel bore **12** is adapted to exert an upward force on the mandrel end **36** that may tend to push the mandrel **17** in an upward direction. On bumper subs not using the construction here disclosed, the upward force generated by the drilling fluid produces the undesirable "pump-open" effect.

As best seen in FIG. 2*a*, the mandrel **17** may be provided with means for transmitting torque or rotational forces to the barrel **11**; such means may be circumferentially spaced longitudinally extending splines **37** (FIG. 5) carried by the outer surface of the mandrel **17** which are adapted to cooperate with mating longitudinally extending grooves **38** formed in the inner surface of the barrel bore **12** of barrel **11**. Splines **37** and grooves **38** slidingly and interlockingly cooperate to transmit any torque or rotational force imparted to the mandrel **17** to the barrel **11** which in turn transmits to the successive sub or section **15** of the drill string. It is understood that these interlocking splines **37** and **38** permit a free relative longitudinal motion of the mandrel **17** within the barrel **11** within predetermined limits.

Means may be provided on the mandrel **17** and barrel **11** to effect an up or down bump of the tool as the situation may demand in order to dislodge, engage or free jammed, stuck or frozen drill strings or tools. Such bumping means may include an annular downwardly directed shoulder or hammer **39** provided near the upper end screw box **21** of the mandrel **17** which is adapted to cooperate with the upwardly directed annular anvil surface **40** at the end **13** of the barrel **11** to produce an instantaneous down bump when the drill string is handled at the surface as known in the art. As best seen in FIG. 3*a*, the mandrel **17** may be driven or inserted completely into the barrel **11** bringing the shoulder **39** into forceful contact with anvil surface **40**. Therefore, downward longitudinal motion of the mandrel **17** will be forcefully imparted to the barrel **11**.

In addition, an annular downwardly directed anvil surface 41 may be provided in the barrel bore 12 of barrel 11 to cooperate with a hammer face provided on 27 of the connector-seal 24 to create an up bump. Anvil surface 41 also forms the upper end of the high pressure chamber 25. Should a drill tool get stuck, jammed or frozen in the well hole, the mandrel 17 can be manipulated to bring hammer surface 27 into forceful contact with anvil surface 41 (see FIGS. 4*a* and 4*b*), to provide an up bump to the device 10 and jar the struck tool loose.

The operation and use of the device 10 is simple, positive and effective. The device 10 is preferably located in a drill string immediately above the drilling tool which may be indicated as section 15 in the exemplary drawings. The drill string may then be lowered into the well hole to its operative position. When the drilling fluid or mud is pumped into the drill string it may circulate freely through mandrel bore 18 and barrel bore 12 down into the drill tool which will discharge it under pressure into the well hole. Since the drilling fluid is pumped into the drill string and the discharge orifices in the drilling tool are relatively small, the pressure of this fluid can build up to several thousand pounds per square inch depending upon depth, weight of drilling mud, formation, character of well hole, and other factors known in the art. Fluid ports 32 permit the high pressure circulating fluid to flow into the high pressure chamber 25 from the mandrel bore 18. This high pressure circulating fluid is retained within the high pressure chamber 25 by means of sealing means 29 and 31. The pressure in the high pressure chamber 25 may exert an axial force on the first annular effective pressure area 27 which tends to axially move the flange 24 and mandrel 17 downwardly. The magnitude of this force will be the pressure in the high pressure chamber 25 times the cross sectional area 27.

After being discharged from the drill bit orifices the drilling fluid then passes up around the drill string carrying sludge and grindings back to the surface. This fluid circulating around the outside of the drill string is under the normal hydrostatic pressure while rising to the surface. Fluid inlets 33 permit the exterior fluid to enter the low pressure chamber 26. This fluid will be retained within the low pressure chamber by sealing means 29 and 30. The pressure of the environmental fluid exerts an axial force on the area 28 which tends to move the flange 24 and mandrel 17 upwardly. The magnitude of this force will be the pressure in the low pressure chamber 26 times the cross sectional area of the second effective pressure area 28.

In addition, as previously stated, there is also another force tending to move the mandrel upwardly. This force is produced by the high pressure circulation fluid acting against the mandrel end 36. The magnitude of this force will be the pressure of the circulation fluid times the cross sectional area of the mandrel end 36.

From FIGS. 6 and 7 it can be seen that the area 27 (FIG. 6) may be appreciably smaller than the area 28 (FIG. 7). Therefore, the downward force in the high pressure chamber 25 substantially equals the lower upward force in the low pressure chamber 26. Any difference that may occur would favor the force tending to move the mandrel 17 downwardly. This motion would be resisted by the force acting at the mandrel end 36. It can readily be seen that the downward force will virtually equal the upward forces putting the pressure balanced bumper sub in static equilibrium.

Any vertical movement of the drill string will shift the connecting member 24 of the mandrel into a new longitudinal position within the chamber 23. However, the forces on the mandrel 17 and member 24 will allow this longitudinal motion, then operate to maintain the mandrel 17 in the new position. Throughout this entire operation, the drilling weight (resulting from the predetermined selection of the drill collar weighting elements) will be maintained on the drill tool due to the statical balancing of the mandrel 17 in different relative positions with respect to the barrel 11.

It should be noted at this point that the entire device may be inverted end for end without affecting the overall operation of the device.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

I claim:

1. A compact virtually balanced drilling sub for use in subsea drilling operations within a well bore and installation in a string of drill pipe above a drilling collar and tools and below a floating drilling platform, whereby rise and fall of such platform does not affect the effective drilling load on the tools, comprising:

an external, cylindrical hollow barrel provided with a smooth outer surface having an outer diameter virtually equal to the outer diameter of drill collars of the drill string in which it is to be used, and means at one end thereof for connection to a drill string;

said barrel having a main section presenting an internal surface of uniform internal diameter and carrying a pair of longitudinally spaced inwardly extending annular sealing means of smaller internal diameter;

a hollow mandrel in rotational engagement with said barrel, said mandrel being retained in said barrel for limited relative axial movement, means at one end of the mandrel for connecting the same to a drill string, said mandrel having an axial bore for drilling fluid and including a section in sealing contact with one of said inwardly extending sealing means of said barrel, another section of smaller outer diameter in sealing contact with the other inwardly extending sealing means, and means connecting the mandrel sections and including a seal means, said seal means being in sliding sealing contact with the internal surface of uniform diameter of the barrel;

said seal means, sealing means and mandrel sections cooperating with the barrel to form two annular chambers of different effective cross-sectional areas;

port means in one mandrell section communicating one of said annular chambers with the drilling fluid bore of said mandrel; and

port means in the main barrel section communicating the other chamber of larger effective cross-sectional area with the exterior of the barrel.

2. A balanced sub as stated in claim 1 wherein the means for connecting the mandrel to a drill string include a hammer shoulder in opposition to the adjacent end of the barrel.

3. A balanced sub as stated in claim 1 wherein the means connecting the mandrel sections includes a hammer, and the barrel carries an anvil in opposing relation to said hammer.

4. A balanced bumper sub as stated in claim 1 wherein the cross-sectional area of the annular chamber in communication with the bore of the mandrel is virtually equal to the area of a circle having a diameter equal to the outer diameter of the mandrel section cooperating to form the chamber in communication with fluid exterior of the barrel.

References Cited

UNITED STATES PATENTS

Re. 24,084	11/1955	McNeill	175—7
2,373,280	4/1945	Weber	285—302
2,568,256	9/1951	Shaffer	175—293
2,937,007	5/1960	Whittle	175—321
2,991,635	7/1961	Warren	54—23

ERNEST R. PURSER, *Primary Examiner.*

JAMES A. LEPPINK, *Examiner.*