United States Patent

[11] 3,572,450

[72] Inventor Derry R. Thompson
Box 1052, Kenai, Alaska

[21] Appl. No. 765,137
[22] Filed Oct. 4, 1968
[45] Patented Mar. 30, 1971

[54] WELL DRILLING APPARATUS
18 Claims, 8 Drawing Figs.

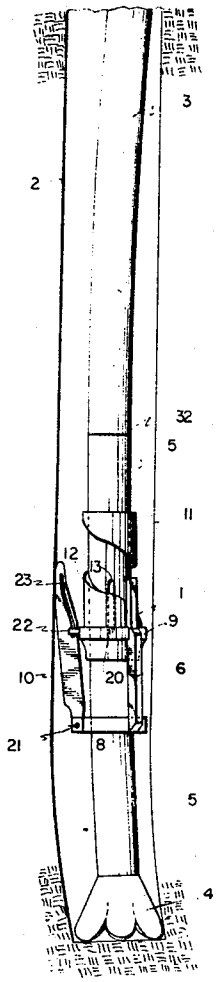
[52] U.S. Cl. 175/76, 175/81, 175/325
[51] Int. Cl. E21b 7/08, E21b 7/10
[50] Field of Search 175/73, 74, 76, 79, 81, 82, 61, 83; 166/117.6

[56] References Cited
UNITED STATES PATENTS

2,643,859	6/1953	Brown	175/73
2,796,234	6/1957	Mann	175/76
2,819,040	1/1958	James et al.	175/76
3,098,534	7/1963	Carr et al.	175/325X
3,196,959	7/1965	Kammerer	175/73
3,460,639	8/1969	Garrett	175/81X

Primary Examiner—David H. Brown
Attorney—William D. Stokes

ABSTRACT: Apparatus for drilling directional bore holes in the earth and for preventing or correcting lateral drift in bore holes comprising at least one undergauge stabilizer blade and at least one movable stabilizer blade connected to a drill string sub so that flow of drilling mud through an orifice valve in the drill string forces the movable stabilizer blade outward and into contact with the wall of the bore hole, thus urging the drill string toward the opposite wall of the bore hole. The apparatus may be used alone or in pairs to alter the direction of the bore hole.



4 Sheets-Sheet 1

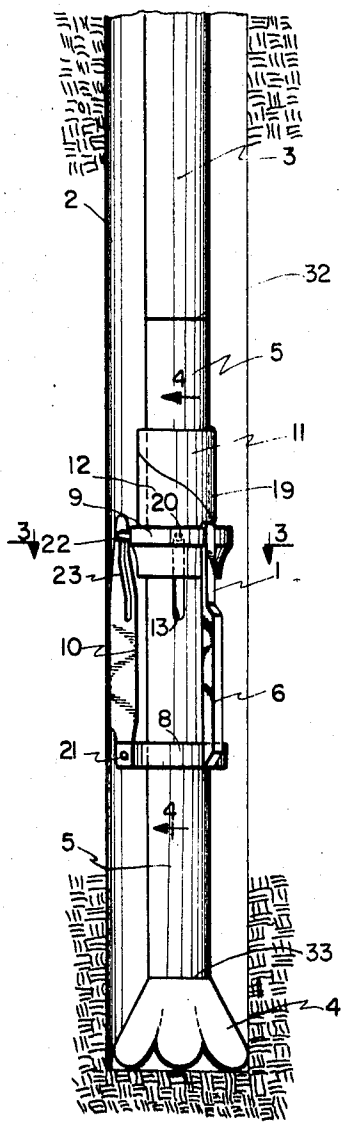


FIG. 1

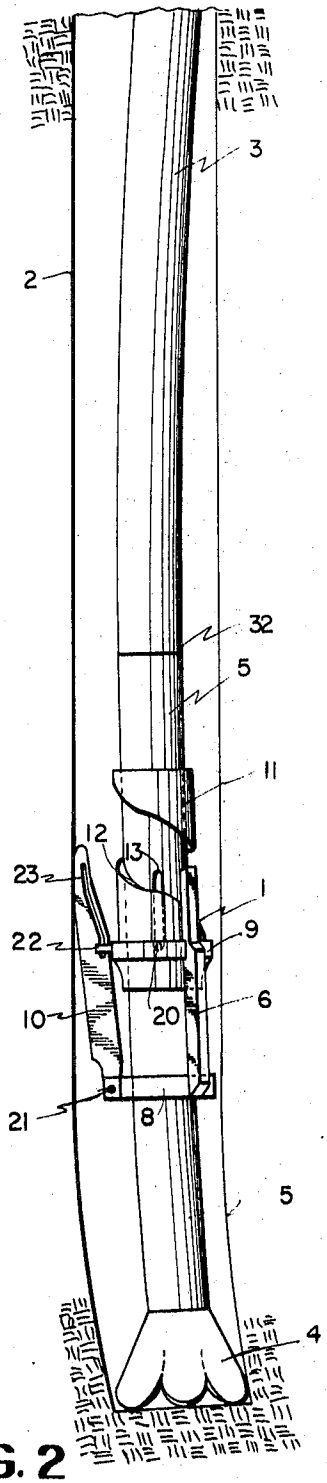


FIG. 2

INVENTOR
DERRY R. THOMPSON
BY William A. Stoker
ATTORNEY

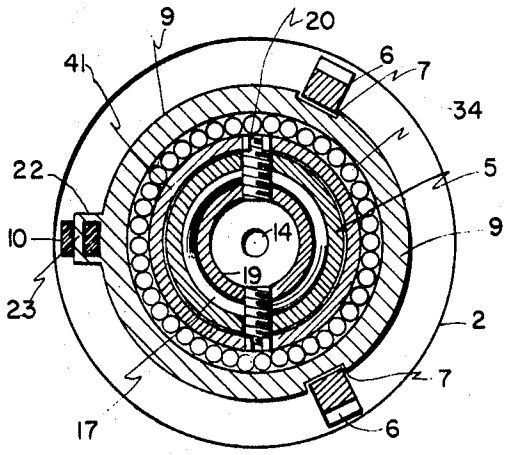


FIG. 3

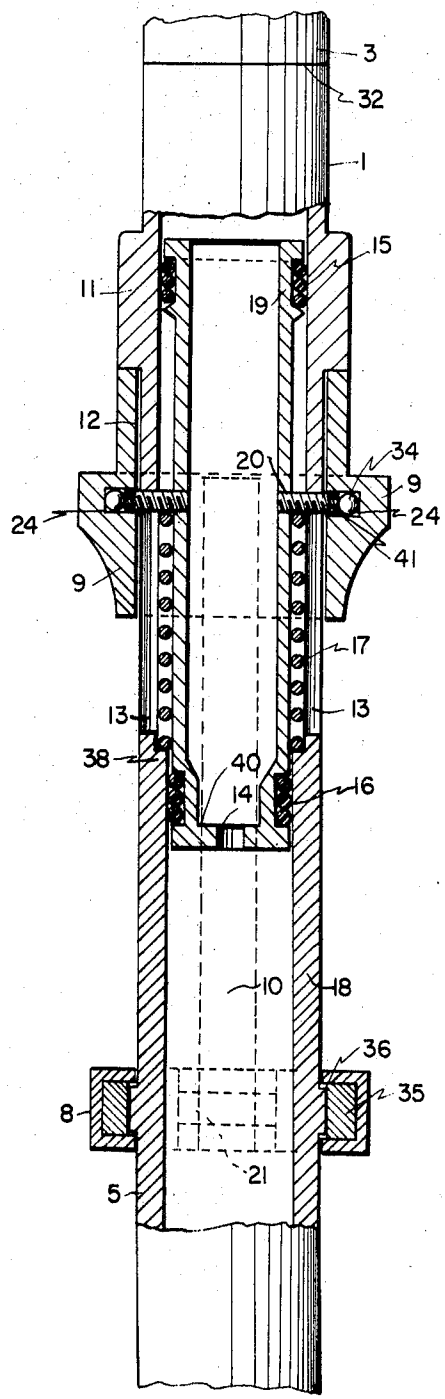


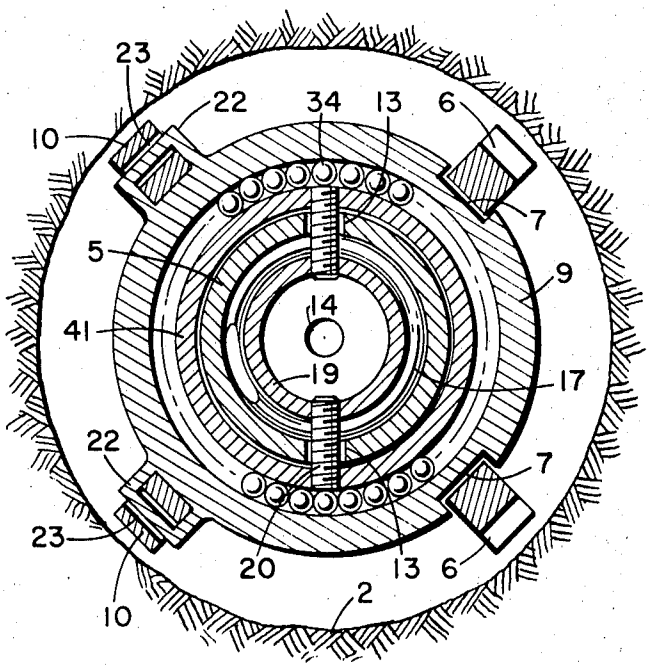
FIG. 4

INVENTOR
DERRY R. THOMPSON

BY William A. Stokes

ATTORNEY

FIG. 3A



INVENTOR
DERRY R. THOMPSON

BY William D. Stokes
ATTORNEY

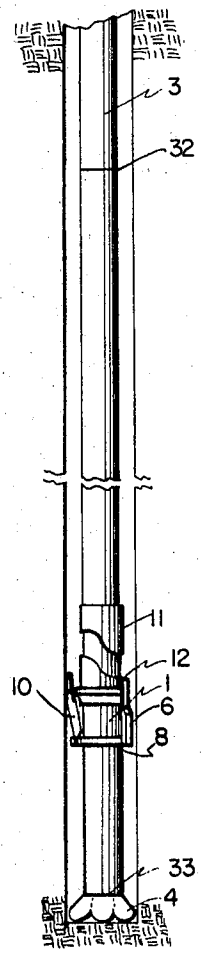


FIG. 5

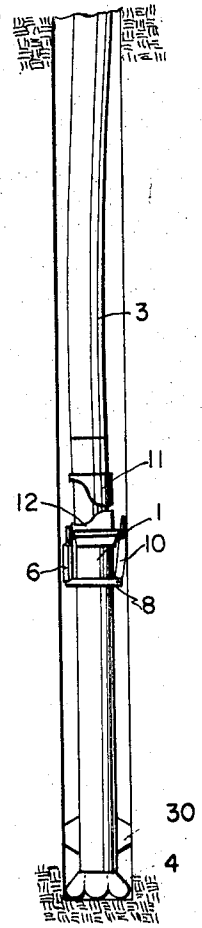


FIG. 6

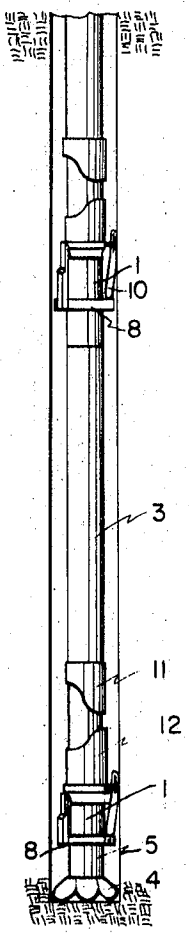


FIG. 7

INVENTOR

DERRY R THOMPSON

BY William H. Stokes

ATTORNEY

WELL DRILLING APPARATUS

This invention relates to apparatus for drilling oil wells, gas wells and similar holes in the earth and relates more particularly to a device useful in drilling directional holes and preventing or correcting deviations or lateral drift during the drilling of such holes. This invention is particularly concerned with an apparatus for carrying out accurate directional drilling, and for bypassing or "sidetracking" any obstacles that might be in the drill path, e.g., portions of a drill string or other material previously lost in a drill hole.

In the drilling of boreholes, as for oil wells, gas wells, and the like, it is customary practice to utilize rotary drilling techniques wherein the drill string, comprising pipe sections connected together, drill collars, a bit and any other necessary tools such as directional devices, is caused to rotate usually by a power unit located above ground. There are also well-known well-drilling systems in which the rotary driving power is generated at the bottom of the hole utilizing hydraulic or electrical power sources. In either case, the heavyweight of the drill collars located adjacent the bit end of the drill string impresses the bit with sufficient pressure to cause the bit, so to speak, to bite into the formation to the end that a substantially circular downwardly extending borehole is drilled. While the hardness or type of stratum to be drilled, depth of the well and other factors, e.g., wobble, dull drill bits, singly or in combination, can and often do cause a drill bit to deviate from the desired path; the torque developed in the direction opposite to the rotation of the bit is one of the principal causes of throwing off the entire direction of the hole being drilled. This torque which develops in the direction counter to the direction of rotation of the bit is commonly referred to as the "reactive" torque.

It may well be appreciated that even the most minute of deviations from a predetermined drilling path, particularly in deep wells, can bring about great errors in, and/or prevent, reaching a well. Among the more common difficulties caused as a result of directional deviations is the great difficulties in removal and reinsertion of the drill string in the bore, referred to as "tripping." It is often desirable and necessary to drill at an angle effecting controlled deviation, for example, when drilling from and into formations submerged below water or simply when necessary to bypass surface obstacles. Angular drilling, utilizing known devices has been difficult and often impossible to accomplish with any degree of precision. Utilizing the apparatus of this invention, a simple and practical device is provided for use in connection with drill equipment which permits drilling of a well with excellent precision, particularly useful in accurately drilling deep wells, bypassing obstacles and preventing the development of reactive torque.

In accordance with the invention, an apparatus is provided for drilling directional holes, which has an effective diameter less than that of the borehole when being raised or lowered in the borehole, and when positioned in the desired location, directionally expandable to apply force against the wall of the borehole in such manner that the drill bit will be caused to move in a desired lateral direction to change the angle or direction of drilling.

The inventive device is an apparatus for altering the direction of boreholes during drilling comprising a specially equipped and constructed sub inserted into the drill string. The sub has a passage through its length for the flow of drilling fluids. Positioned within the passageway is a fluid volume flow responsive device movable in response to the volume rate of flow of drilling fluid. The movement of the fluid volume flow responsive device is transmitted to at least one movable stabilizer blade attached to the outside of the sub to force the movable stabilizer blade into contact with the wall of the borehole. Further motion of the movable stabilizer blade results in sidewise movement of the sub, influencing the direction in which the drilling proceeds.

It is therefore an object of this invention to provide a device usable with conventional drilling apparatus for controlling the angle or direction of drilling.

It is another object of this invention to provide a device which enables the bypassing of any portion of drill string or any other material "lost" in the drill hole.

It is a further object of the invention to provide a device for controlling or eliminating deviations from the perpendicular in drilling wells.

Still another object is to provide means for correcting directional deviations in boreholes which is inserted in the drill string at a location near the drill bit and which will not interfere with tripping the drill string.

One of the principal objects of the invention is the provision of a directional control device which when located in the desired location in the borehole is operatively controlled by the volume of flow or drilling fluid through the system.

Still another principal object of the invention is the provision of a well-drilling tool which prevents reactive torque, particularly in deep hole drilling and drilling in harder formations.

Not the least of important objects of the invention is the provision of a well-drilling device which would permit efficient running of the drill at lower speeds than normally used to the end that more footage may be obtained on a bit, hence decreasing the number of times the drill string must be removed to replace the bit.

Another object is the provision of a drilling device which permits gradual turns in the deflection of the hole being drilled.

These and other objects of this invention will be more clearly described and enumerated in the attached drawings in which:

FIG. 1 is a side view of the directional device of this invention in a well bore;

FIG. 2 is a view of the directional device of FIG. 1 in operation;

FIG. 3 is a cross section of the directional device taken on line 3–3 of FIG. 1;

FIG. 3A is a cross section essentially similar to that of FIG. 3 but showing another embodiment having two movable stabilizer blades;

FIG. 4 is a longitudinal section of the directional device taken on line 4–4 of FIG. 1;

FIG. 5 is a schematic illustration of one method of utilizing the directional tool of the invention;

FIG. 6 is a schematic illustration of another method of utilizing the device of this invention;

FIG. 7 is a schematic illustration of the utilization of two devices of this invention in well drilling.

In the FIGS. wherein like parts are designated by the same numerals, reference is now made specifically to FIGS. 1—4. The directional device of this invention, designated as numeral 1, is shown in operative engagement with drill collar 3 and drill bit 4 at joints 32 and 33 respectively, in well bore 2. The directional device 1 comprises a conduit, or more commonly referred to as a "sub" 5, providing a passageway for drilling mud or other drilling fluids, flowing through the drill string from the surface to the drill bit 4. Vertically disposed in conduit member 5 are slots 13. As shown in the illustrated embodiment, two slots 13 are provided, but as will become apparent hereinafter, one or more than two slots can satisfactorily be used. Slidably mounted within conduit 5 is valve body 19. The outer surface of valve body 19 is held in sealing engagement with the inner wall of conduit 5 by upper and lower O-ring seals 15 and 16 respectively. Extending outwardly from and integrally connected with valve body 19 are threaded projection members 20 extending through slots 13 and connected on their outer ends to a bearing ring 41. Threaded projection members 20 are of such size and shape as to be capable of moving upwardly and downwardly within slots 13. Bearing ring 41 is in operative engagement with bearing slot 24 in the inner surface of rotatable collar 9 which abuts roller bearings 34 disposed within bearing slot 24. From the foregoing it may be seen that as valve body 19 moved upwardly or downwardly, collar member 9, connected with valve body 19 through bearing ring 41 and threaded projections 20 through slots 13 in

conduit 5 will also move upwardly and downwardly with the valve body. It will also be appreciated that the construction allows collar member 9 and valve body 19 to be rotated independently of each other.

Extending around the inner surface of conduit 5 below slots 13 is a shelf 38. Shelf 38 is preferably constructed as an integral part of conduit 5. Mounted on shelf 38 and surrounding valve body 19 is a spring means 17 biasing valve body 19 upwardly through threaded projections 20 and in turn capable of being depressed by pressure applied through threaded projections 20.

The inner portion of valve body 19 is cylindrical in form, open at its upper end to the flow of drilling fluids from the surface. The lower end of valve body 19 is closed by a bottom member 40 in which an orifice 14 is disposed. It will be appreciated from the descriptions hereinafter, in the light of the foregoing description, that the diameter of orifice 14 may be varied dependent upon, for example, such factors as tension of spring 17 and the degree of pressure created on the bottom 40 of valve body 19 by drilling fluids pumped therethrough. Mounted on collar 9, and in the preferred embodiment integral therewith, is a dovetailed skirt member 12. Fixedly mounted on sub 5 above skirt member 12 is an upper dovetailed skirt member 11 designed to mesh with skirt 12 to hold the inventive device in strict angular alignment when the deflection tool of the invention is not in operation. The top skirt member may be aligned, for example, with a "muleshoe" orientation landing assembly (not shown) positioned within the upper part of sub 5.

A laterally movable stabilizer blade member 10, hereinafter referred to as the overgauge stabilizer blade is laterally movably connected by means of a pin key member 22 extending through eccentric key slot 23 and permanently affixed to vertically movable and rotatable collar 9. The lower end of overgauge stabilizer blade 10 is pivotally mounted on bearing means by a pivot member 21. In the illustrated embodiment, the bearing means comprises a ring member 36 fixedly mounted on sub 5, a bearing 35 and a bearing collar 8. It is essential that bearing collar 8 be vertically fixed, but rotatable around sub 5. It may be seen in the illustrated embodiments of FIGS. 1 and 2 that as collar 9 is lowered, the mesh of dovetailed skirts 11 and 12 is broken and at the same time overgauge stabilizer blade 10 is forced in a lateral direction to forcefully engage the adjacent wall of well bore 2 whereby forcefully causing deflection of sub 5 and in turn drill bit 4. Two undergauge stabilizer blades 6 are fixedly mounted on bearing collar 8 on their lower ends and slidably mounted in slots 7 in collar 9. In the preferred embodiment where two undergauge stabilizer blades are utilized, the overgauge and undergauge stabilizer blades are preferably mounted at 120° angles with respect to the other. Another embodiment having two movable stabilizer blades is shown in FIG. 3A.

In operation, the deflector tool of the invention would be mounted in the drill string between drill collar 3 and drill bit 4. The inventive tool would be in the undergauge condition at all times during tripping, i.e., raising and lowering the drill string into the well bore. When the drill bit reaches the desired location in the bore, a mule shoe orientation survey would be run on a wireline. The desired location is, of course, dependent upon the job to be efficiently accomplished by the invention, e.g., bypassing obstacles lost in the hole, slant drilling, correction of deviation in direction of the hole, etc. The drill string is then rotated so that the movable stabilizer blade is properly oriented. A "check shot," i.e., another mule shoe orientation survey would then be run to insure proper orientation. This is to make sure no torque was in the drill pipe and that the tool had turned the proper number of degrees. Drilling mud would then be passed through the drill string and valve body of the device. When the flow of mud through the orifice 14 reaches the volume necessary to move the orifice valve body 19 against the bias of spring 17 the movable roller bearing 9 would move downwardly with consequent movement of overgauge stabilizer 10 laterally and into forcing engagement with the well bore which movement causes the drill string to move away from the side of the well bore engaged by the movable stabilizer blade 10 toward the opposite wall of the well bore. This lateral force causes deflection of the drill bit in the desired direction. With the mud flow on, and the deflector tool in its operative position, the drill string would be rotated in the conventional manner to move the bit down through the strata being drilled on its new course. When sufficient footage has been completed to assure that the desired direction and drift angle have been established, the tool may be removed or the mud flow volume may be decreased to an amount at which spring 17 overcomes the downward force of the drilling mud flowing through orifice 14 permitting overgauge stabilizer blade 10 to return to its closed undergauge position in which case normal drilling procedures are reestablished. Utilizing the device of this invention makes it unnecessary to remove the entire drill string to remove the deflector tool as is required with other presently known deflector tools. It will be appreciated that the deflector tool of this invention is operated by controlling the volume of flow of drilling fluid. It is only necessary to provide an adequate flow of drilling fluid without regard to its pressure and/or other parameters and properties of the drill string and drilling fluid.

The inventive device may be used in several different locations in the drill string to accomplish the desired results. FIGS. 5—7 show three of the many possible applications of the inventive device. FIG. 5 shows a "near bit" location for the deflector tool in which the inventive device is located immediately above the drill bit in the drill string. The sidewise force developed acts directly upon the drill bit to alter the direction of drilling away from the wall of the borehole against which the movable stabilizer blade 10 abuts.

FIG. 6 shows the inventive device set up to cooperate with a standard stabilizer 30. The inventive device in this arrangement bows the drill string as shown and angles the drill bit slightly to cause the drilling to proceed in a line angled toward the side of the borehole upon which the movable stabilizer blade 10 abuts.

FIG. 7 shows the use of two of the inventive devices to maintain the direction of drilling in, for example, a formation which has washed out or otherwise will not drill in a vertical manner.

Alternately, the two devices could be oriented with the movable stabilizer blade 10 on opposite sides of the drill string to combine the beneficial effects shown in FIGS. 5 and 6. Such an arrangement would cause a much more severe deviation in the direction of drilling and could be used, for instance, in bypassing a section of the borehole plugged by lost equipment.

When it is necessary to bypass any portion of the drill string or any other material lost in the hole, a cement plug is placed on top of the lost material, commonly referred to as the "fish" and thereafter deflecting the bit off of the cement plug and bypassing the "fish."

The difference in size between the undergauge stabilizer blades 6 and 7 and the movable stabilizer blade 10 determines the amount of deflection which would result from the use of this deflector tool. The deflector tool can, of course, be manufactured with interchangeable blades for different amounts of deflection and also for use in boreholes of various sizes. The undergauge blades may be mounted on long springs forcing them outward from the sub into the wall. Thus, if the hole was "washing" overgauge, the blades would still maintain force on the wall of the hole and not let the tool rotate out of orientation.

The roller bearings 8 and 9 can be either sealed bearings with pressure differential pistons incorporated in the bearings to compensate for hydrostatic pressure or mud lubricated bearings.

The deflector tool can be adapted for use with the presently used "Dyna drill" or turbo drill units which utilize a hydraulic or similar power developing unit at the bottom of the boreholes. The deflector tool adaptation for this purpose would have no roller bearings and would be utilized to counter

the reactive torque developed by such drill units. The deflector tool would be attached directly to the sub to counteract reactive torque.

It is obvious that many changes, modifications and alterations in addition to those listed above can be made by those skilled in the art without departing from the spirit and scope of this invention.

I claim:

1. A drill bit deflecting tool comprising a sub having housed therein fluid volume flow responsive means longitudinally movable, at least one movable deflecting blade means and at least one undergauge stabilizer blade means attached to said sub, said movable blade means and said stabilizer blade means being connected with means for allowing independent rotation of said blade means about said sub and maintaining and returning said blades in and into respectively strict angular alignment with said sub when the tool is not in operation, means for transmitting motion of said fluid volume flow responsive means to said movable deflecting blade means, and slidably engaging said undergauge stabilizer blade means attached to said sub, said deflecting blade means constructed and arranged to be undergauge when said tool is not operative and progressively overgauge in response to the longitudinal movement of said fluid volume flow responsive means.

2. The apparatus of claim 1 wherein said fluid volume flow responsive device comprises a movable venturi section.

3. The apparatus of claim 1 wherein said fluid volume flow responsive device comprises a movable orifice valve assembly.

4. The device of claim 1 having two undergauge stabilizer blades and two movable stabilizer blades.

5. The apparatus of claim 1 having two undergauge stabilizer blades and one movable stabilizer blade.

6. The apparatus of claim 5 wherein said undergauge stabilizer blades and said movable stabilizer blade are located 120° apart.

7. The apparatus of claim 1 having two full gauge stabilizer blades, one undergauge stabilizer blade and one movable stabilizer blade.

8. The apparatus of claim 7 wherein said two full gauge stabilizer blades and said undergauge stabilizer blade and said movable stabilizer blade are located 90° apart.

9. Drill bit drive means comprising:

a drill string;

a tubular sub provided with means for connection to a drill bit at one end and to a drill string at the other to provide fluid communication from said drill string to said drill bit;

an orifice valve disposed within said sub responsive to the volume of fluid flow through said sub, movable bearing means outside said sub and operatively connected to said orifice valve for longitudinal movement along the axis of said sub;

stationary bearing means attached to said sub below said movable bearing means;

at least one undergauge stabilizer blade attached to said stationary bearing means and slidably engaging said movable bearing means; and

at least one movable stabilizer blade pivotally attached to said stationary bearing means and engaging said movable bearing means cam-fashion, so that movable stabilizer blade is undergauge when not in use and progressively overgauge responsive to the longitudinal movement of said movable bearing means.

10. A drill bit deflecting tool comprising a sub having a plurality of lengthwise slots, said sub enclosing a spring biased volume flow responsive valve in a drilling fluid conduit, said volume flow responsive valve positioned at said slots and provided with sealing means to prevent flow of drilling fluid through slots, a movable bearing means disposed outside of and around said sub and operatively attached to the body of said volume flow responsive valve through said slots for longitudinal movement a stationary bearing means attached around the outside of said sub below said slots, said stationary bearing means carrying at least one undergauge stabilizer blade, said undergauge stabilizer blade slidably engaging said movable bearing means, at least one movable stabilizer blade pivotally attached to said stationary bearing means, said stabilizer blade engaging said movable bearing means on a cam surface such that said movable stabilizer blade is undergauge when not in use and progressively overgauge responsive to the longitudinal movement of said movable bearing means.

11. A drill bit deflecting tool comprising a tubular sub with means for connection to a drill bit at one end and to a drill string at the other to provide fluid communication from said drill string to said drill bit, a fluid volume flow responsive device disposed within said sub responsive to fluid volume flow in said sub for movement, a movable ring disposed around the outside of said sub and operatively connected to said fluid volume flow responsive device for movement in response to movement of said fluid volume flow responsive device, at least one undergauge stabilizer blade attached to the exterior of said sub, and at least one movable stabilizer blade pivotally attached at one end to said sub and slidably engaging said movable ring at the other end cam-fashion such that said movable stabilizer blade is undergauge when not in use and progressively overgauge responsive to the longitudinal movement of said fluid volume flow responsive device.

12. The apparatus of claim 11 wherein said fluid volume flow responsive device comprises a movable venturi section.

13. The apparatus of claim 11 wherein said fluid volume flow responsive device comprises an orifice valve.

14. The device of claim 11 having two movable stabilizer blades and one undergauge stabilizer blade.

15. The device of claim 11 having two full gauge stabilizer blades, one undergauge stabilizer blade and one movable stabilizer blade.

16. The device of claim 11 having two undergauge stabilizer blades and two movable stabilizer blades.

17. The device of claim 11 having two undergauge stabilizer blades and one movable stabilizer blade.

18. The device of claim 17 wherein said undergauge stabilizer blades and said movable stabilizer blade are spaced at 120° intervals around said sub.