Jan. 16, 1968 R. J. FARRIS ET AL 3,363,704

DIRECTIONAL DRILLING TOOL

Filed March 24, 1966

2 Sheets-Sheet 1

Fig. 1

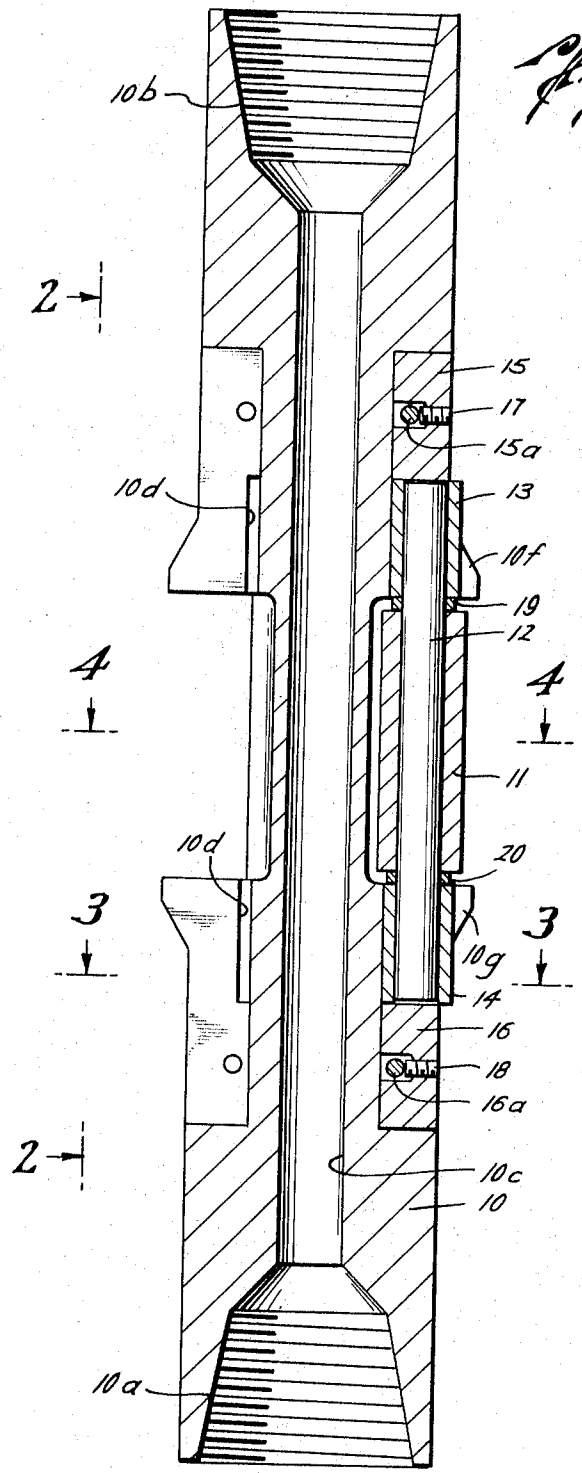
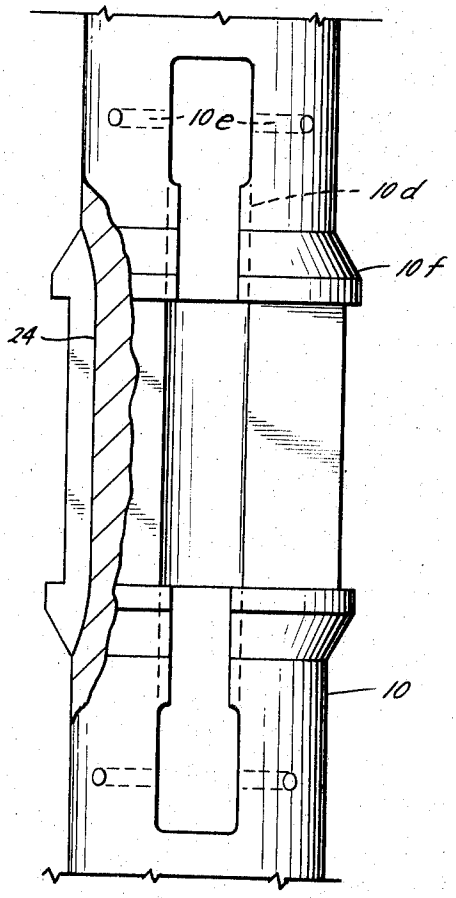


Fig. 2



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2 Sheets-Sheet 2

Fig. 3

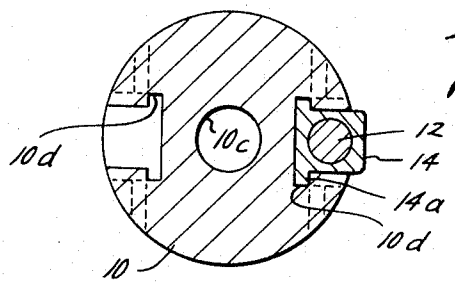


Fig. 4

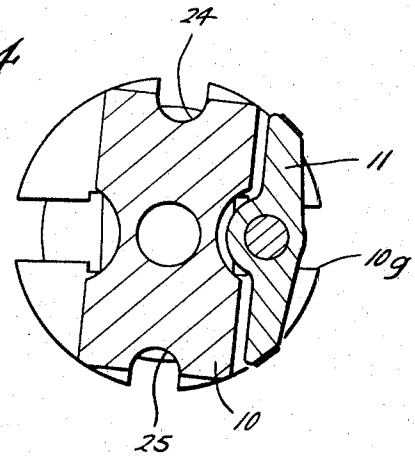
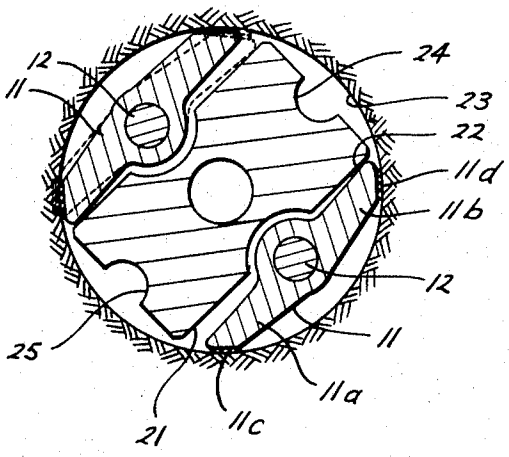


Fig. 5



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3,363,704

DIRECTIONAL DRILLING TOOL

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8 Claims. (Cl. 175—76)

This invention relates to improvements in directional drilling tools and refers more particularly to that type of tool which is made up in the drill string for rotation therewith and adapted to impart a series of forces tending to move the bit in one direction as the drill string is rotated.

This invention is an improvement upon the invention shown in United States Letters Patent 3,092,188 issued June 4, 1963.

The invention of said Patent 3,092,188 has proven to be of great utility in directional drilling of wells. The tool is expensive, however, both to build and maintain and an object of the present invention is to provide an effective directional drilling tool which is much cheaper to manufacture and, due to its ruggedness and simplicity, to maintain.

Another object is to provide an effective directional drilling tool which can impart more than a single force tending to move the bit upon each rotation of the tool.

Another object is to provide an effective directional drilling tool which is relatively short and which may place all of the effective working parts at a single level along the longitudinal axis of the tool body.

Another object is to provide a directional drilling tool in which the force is imparted to the drill string tending to move the bit in one direction very close to the bit itself.

Another object is to provide a directional drilling tool which may serve as a bottom stabilizer of the drill string.

Other and further objects will appear from the specification, drawings and claims.

The drawings illustrate one preferred embodiment of the invention. It is contemplated that other embodiments and modifications may be made within the scope of the appended claims and the drawings and specification describing same should therefore be interpreted in an illustrative rather than a limiting sense. In the drawings:

FIG. 1 is a longitudinal sectional view, with parts removed for clarity, illustrating the preferred embodiment of the invention;

FIG. 2 is a longitudinal elevational view taken at about 90° to FIG. 1 and shown partially in section;

FIG. 3 is a cross-sectional view taken along the line 3—3 in FIG. 1 in the direction of the arrows;

FIG. 4 is a view taken along the line 4—4 in FIG. 1 in the direction of the arrows; and

FIG. 5 is a view similar to FIG. 4, but looking down, and showing the bore engaging rockers in place and illustrating the tool in a bore hole.

In the drawings, the tool body **10** has fastening means **10***a* and **10***b* at its ends for securing the body in a drill string to become a part thereof. Usually and preferably the tool is mounted immediately adjacent the bit, and may replace the bottom stabilizer which often is run. It is contemplated that the tool body may be the body of the bit itself, but this is not usually preferred because of the relatively short life of the bit.

The body may be a relatively short sub for example, somewhat less than four feet long. The body is circular throughout most of its length and the major diameter may be that of the drill collar to which it is secured. The body is tubular providing the flow passage **10***c* for circulating the drilling fluid to the bit.

The body or sub **10** provides a support for the active

elements which provide the directional drilling forces for pushing the bit one way or another. For this purpose the body is provided with one or a plurality of recesses in its periphery for mounting the rockers **11**, the number of recesses depending on the number of rockers used. The rockers are pivotally mounted on pivot pin **12** whose ends are retained in bearings **13** and **14**. These bearings are blocks for receiving the ends of pivot pin **12**. The blocks have flanges as shown at **14***a* for fitting in the grooves **10***d* formed in the body. The retainer blocks **15** and **16** are secured in the upper end of the recesses to retain the bearings and pivot pin **12** in place. Openings **10***e* provide means for securing the retainer blocks in the body by means of retainer pins **15***a* and **16***a*. When retainer blocks **15** and **16** are removed, the bearing blocks **13** and **14** may be slid into or out of place. Set screws **17** and **18** may be provided to secure the key pins **15***a* and **16***a* respectively, in place. The mounting assembly may include bushings and washers **19** and **20**. In the embodiment shown, two such rocker arm mounting assemblies are provided. Each are identical and it is contemplated that more of such units may be employed.

Semi-circular guard shields **10***f* and **10***g* may be provided above and below the rockers **11**. They have tapered upper and lower surfaces, respectively to provide protection against impact for the rockers as the tools are lowered into and pulled from a well bore. The greatest radius of the periphery of the shields should be greater than that of the drill string but less than that of a drill bit with which the tool is to be used.

The rockers are best shown in FIG. 5. Each rocker **11** is provided with arms **11***a* and **11***b* which are adapted to swing around the pivot pin **12**. The free end of each arm provides a part that is adapted to move substantially radially toward and away from the longitudinal axis of the body as the rockers are pivotally moved. Each part contains a hardened wear-resisting surface **11***c* and **11***d* which are adapted to engage and rub against the wall of the bore hole. Tungsten carbide or other suitable hard material may be used to resist wear of this wall-engaging portion.

Means are provided for limiting the movement of the parts or arms **11***a* and **11***b*. This includes the abutment surfaces **21** and **22** adapted to be engaged by arms **11***a* and **11***b*, respectively, to limit pivotal movement of the arms. Preferably the arrangement is such that the wall engaging surface of one arm will extend further outwardly from the longitudinal axis of the body than will the wall-engaging surface of the other arm at the two limits of rotation of the rocker. This may be accomplished by providing the surfaces **21** and **22** as included in a cord and making one arm slightly longer than the other. As seen in FIG. 5 rocker **11** is shown in full line and dotted line positions. In the full line position, the arm **11***a* is extended outwardly and the arm **11***b* is retracted. Because of the means for limiting the extent to which the arm **11***a* may extend outwardly relative to the extent arm **11***b* may extend outwardly, means is provided for exerting a force or push against the wall of the well bore, the reaction of which tends to move the sub and therefore the bit attached to it, in one direction or the other relative to the low side of the hole. The dotted line position of rocker **11** illustrates the degree that contact surface **11***b* may be pushed relative to the possible extension of arm **11***a*. It is seen that arm **11***b* may extend from the axis of the body a greater distance than the radius of the drill bit which forms the well bore **23**. On the other hand, surface **11***c* of arm **11***a* cannot extend as far outwardly from the longitudinal axis of the body as does **11***d* of arm **11***b*. Thus when surface **11***c* is moved past the low side of the hole it is pushed inwardly into its receiving recess in the body until the force exerted by **11***d* engaging the bore hole wall overcomes this force. The net result is to push

the body to the left of the low side of the bore hole. However, upon further rotation of the device arm **11***d*, as it passes the lower side of the hole, will be forced against surface **22** and surface **11***c* will not be forced into contact with the bore hole wall to the right of the low side of the hole. This is because the arrangement is such that it does not extend far enough outwardly from the longitudinal axis of the body in its fully extended position to engage the wall of the bore hole.

While mechanical means are shown to provide the parts which move substantially radially of the body relative to its axis, it is contemplated that hydraulic means may be included for providing these parts. In any event, the arrangement is such that the movement of one part outwardly is accompanied by inward movement of the other part, and one part is capable of moving a somewhat greater distance from the body axis than the other part.

Due to the radial extent of guard shields **10***f* and **10***g* substantially filling the bore hole, thus restricting the fluid flow past the working elements of the sub, grooves **24** and **25**, extending longitudinally of the device and parallel to its axis, are provided. They by-pass drilling fluid past the sub. These grooves extend through the shields **10***f* and **10***g* to provide adequate fluid passage.

It is believed that the operation of the apparatus is apparent from the foregoing description. The body is made up into the drill string and either end may be attached to the bit. In the arrangement shown the device will have a tendency to cause the tool to move or "walk" to the left relative to the low side of the hole. The rotation of drill tools is usually in a clockwise direction looking down so that visualizing clockwise rotation of the body in FIG. 5, wall engaging surface **11***c* will be caused to engage the low side of the hole ahead of surface **11***d*. Inasmuch as the weight of the drill collars above the body tends to push the tool against the low side of the hole, this force will cause rocker **11** to move part **11***c* inwardly toward the longitudinal axis of the body. At the same time wall engaging surface **11***d* will be moved outwardly to engage the wall of the hole. Thus a force is imparted on the body tending to move the body to the left relative to the low point or side of the bore hole. As the next rocker arm moves its leading edge toward the low side of the hole another force will be exerted on the body tending to move it to the left. These repeated forces occur each time a part **11***c* moves past the low side of the hole. There is no counteracting force however, tending to move the body to the right as part **11***d* passes the low side of the hole because part **11***c* is not moved out far enough to engage the wall of the hole.

In order to cause the tool to walk to the right, the tool may merely be reversed end for end so that the lower end **10***a* is secured to the lower end of the drill collar string and the upper end **10***b* is secured to the bit. This will reverse the arrangement of rockers so that as surface **11***c* passes the low side of the hole, it is trailing, in a rotational sense, end **11***d*. Then as arm **11***a* is rotated inwardly, surface **11***d* is moved into contact or engagement with the left side of the bore hole wall thus tending to provide a force urging the body to the right. Successive rotations of rocker past the low side of the hole apply successive forces to the tool tending to urge it to the right. The ends of arms **11***a* and *b* are tapered whereby they tend to slide over the formation rather than to dig into it.

While it is contemplated that usually only a single level of rockers or pusher parts will need to be provided it is possible, where further forces are required, to utilize more than one level of such means. If this is done, it is contemplated that if desired the successive levels of wall engaging parts may be staggered circumferentially with respect to each other so as to provide a more or less continuous tendency to urge the tool in one direction or they may be aligned circumferentially so as to provide the same number of impulses as a single layer, but of greater bearing area. This may be of particular help in drilling relatively soft shales where the pusher means will tend to push in to the relatively soft shale of the bore hole. By providing a greater bearing area the net effective push is greater.

It is seen that the ends and objects of the invention have been accomplished. A directional drilling tool has been provided that may be manufactured at relatively low cost and which is especially rugged, and requires little maintenance which may be inexpensively performed. The construction is such that the same device may be used to cause walking to the right or to the left. The arrangement is such that a moment arm advantage is provided because arm **11***a* is longer than arm **11***b* thus magnifying the effect of the force urging the tool against the low side of the hole.

From the foregoing, it will be seen that this invention is one well adapted to attain all of the ends and objects hereinabove set forth, together with other advantages which are obvious and which are inherent to the device.

It will be understood that certain features and subcombinations are of utility and may be employed without reference to other features and subcombinations. This is contemplated by and is within the scope of the claims.

As many possible embodiments may be made of the invention without departing from the scope thereof, it is to be understood that all matter herein set forth or shown in the accompanying drawings is to be interpreted as illustrative and not in a limiting sense.

The invention having been described, what is claimed is:

1. A directional drilling tool for use in rotary drilling of wells comprising a tubular body with means for connecting it in a drilling string; means including two parts mounted on the body at substantially the same level along its longitudinal axis for substantially radial movement relative thereto and spaced circumferentially about the body so that the paths of movement of the parts are angularly disposed relative to the body, said means relating the movements of the parts to each other so that inward movement of one part imparts outward movement of the other part relative to the longitudinal axis of the body; each of the parts having a surface for engaging the wall of a bore hole; means limiting the movement of one of said parts outwardly from the longitudinal axis of the body relative to the maximum outward movement of the other of said parts to provide for the wall engaging surface of one of said parts to move somewhat outwardly from the periphery of the body when the second of said parts is in its innermost position and the second of said parts to move a greater distance outwardly from said axis of the body when the first of said parts is in its innermost position relative to said body axis.

2. The directional drilling tool of claim **1** wherein the maximum outermost position of the wall engaging surface of the first of said parts from the body axis is no greater than the radius of a bit with which the drilling tool is adapted for use and the outermost position of the wall engaging portion of the second part relative to said body axis is at least as great as the radius of a bit with which the drilling tool is adapted for use.

3. The directional drilling tool of claim **1** wherein the ends of an arm pivotally mounted on the body provide the two parts and the wall engaging surfaces thereof.

4. A directional drilling tool for use in rotary drilling of wells comprising a tubular body with means for connecting it in a drill string; a rocker, means mounting the rocker on the body for pivotal movement transversely of the longitudinal axis of the body with the arms of the rocker extending on two sides of the pivot at substantially the same level along the longitudinal axis of the body; means limiting pivotal movement of the rocker in one rotational sense to permit a first one of the arms, that will swing away from the body, from swinging outwardly from said axis of the body a distance greater than the radius of a bit with which the drilling tool is adapted for use; and means limiting pivotal movement of the

rocker in the opposite rotational sense to permit the second of said arms, that will swing away from the body, to swing outwardly from said axis of the body to an extent at least as great as the radius of a bit with which the drilling tool is adapted for use; whereby upon rotation of the body within a drill hole when the first arm passes over the low side of the hole the second of said arms is forced outwardly to engage the wall of the bore hole to tend to force the tool away from the side of the bore hole wall from the location of engagement of the second arm with the wall of the bore hole.

5. The directional drilling tool of claim 4 wherein the means for limiting movement of the rocker are surfaces on the body which in cross-section would lie on a cord and the first arm is longer than the second arm whereby upon rocking of the rocker the first arm can not move as far outwardly from the axis of the body as does the second arm.

6. The directional drilling tool of claim 4 wherein a plurality of rockers are mounted on said body and arranged symmetrically about the circumference of the body when viewed in cross-section along a plane intersecting said rockers, said rockers being located substantially at the same level along the longitudinal axis of said body.

7. A directional drilling tool as defined in claim 4 wherein the periphery of the body is recessed to provide by-pass passages for drilling fluid, the recesses spanning the longitudinal extent of said rocker.

8. The directional drilling tool of claim 4 wherein said body is provided with circular guard shields above and below said rocker, the radius of said guard shields being greater than the main portion of the body but less than the radius of a bit with which the drilling tool is adapted for use.

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