

Oct. 5, 1943.

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2,330,933

DRILLING APPARATUS

Filed Nov. 20, 1940

2 Sheets-Sheet 1

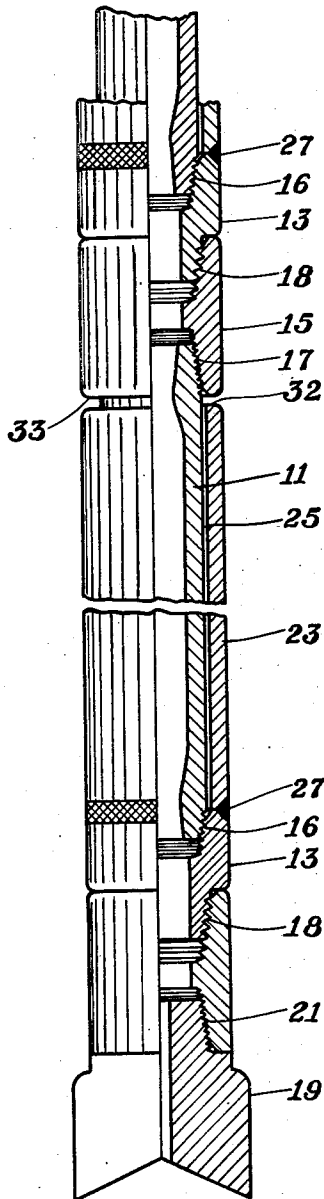


Fig. 1

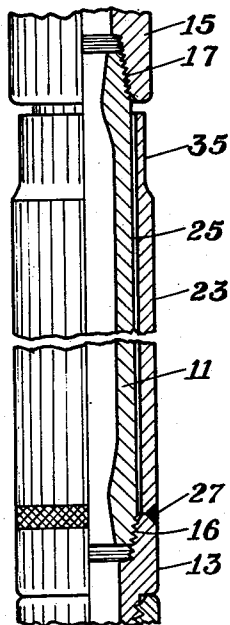


Fig. 2

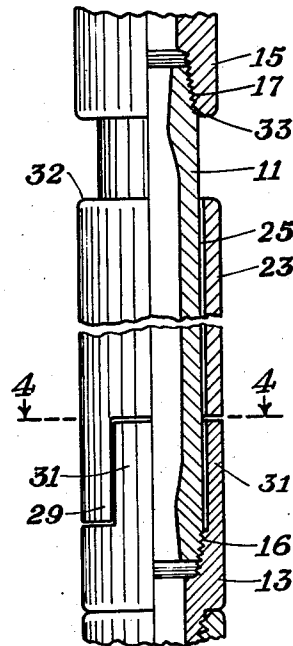


Fig. 3

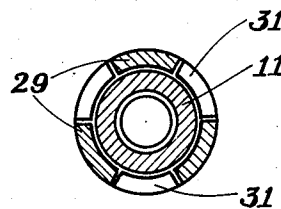


Fig. 4

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2 Sheets-Sheet 2

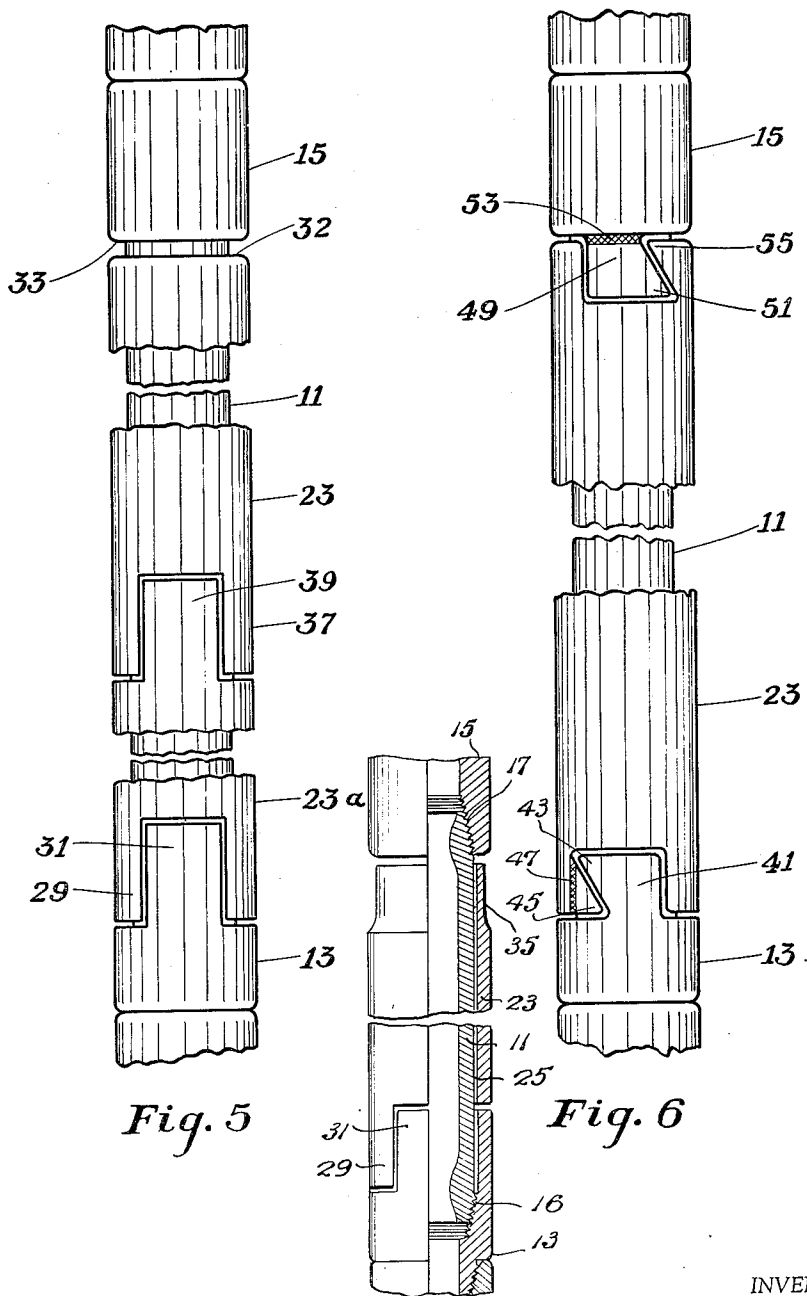


Fig. 5

Fig. 6

Fig. 7

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UNITED STATES PATENT OFFICE

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DRILLING APPARATUS

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4 Claims. (Cl. 255—28)

This invention relates to drilling strings employed in the rotary drilling of wells, and is more particularly directed to improved bottom hole assemblies.

In order to increase the rate of penetration of the drill bit into the formation, resort has generally been had to two methods, namely, increasing the speed of rotation of the bit and increasing the weight on the drill bit, so that the cutting edges of the bit bear against the formation with increased pressure. Greater rates of penetration can be obtained for a given speed of rotation when the weight on the drill bit is increased.

In well drilling operations, the drilling string bears on the drill bit with an amount of weight which is equal to the weight of the drilling string, less any amount of weight which is carried in suspension by the equipment at the surface of the bore hole. Due to the fact that the string is suspended from the derrick in such manner as to prevent the entire dead weight of the string from resting on the bottom of the hole, the upper portion of the string is under tension. The lower portion of the string is under compression between the bottom of the hole and that part of the string that is held in suspension due to the superimposed weight of the upper portion of that part of the string that is not held in suspension. The equilibrium point between compression and tension in a drilling string, that is the point in the string which is neither under suspension or compression, is variable depending upon the particular portions of the string in which weight is concentrated and upon that portion of the weight of the string suspended from the derrick at the ground surface.

As a result of long experience it has been found that less wear and fatigue failures in the drilling string, such as twist-offs and fractures, occur when a substantial portion of the string is maintained under tension by being suspended from the surface, thereby preventing the entire dead weight of the string from being allowed to rest on the drill bit. Operation of the drilling string with a large proportion of the string under compression causes a considerable amount of bending in the drill pipe and high frictional losses due to rubbing of the tool joints, which ordinarily are of greater diameter than the drill pipe, against the walls of the bore hole. This results in excessive wear and frequent replacement of the tool joints. Further disadvantages of this type of operation are the increased tendency to drill crooked holes and a tendency to

concentrate stresses in the threaded portions and points of diametral reduction of the drilling string. However, when larger proportions of the weight of drillings strings are maintained in tension during drilling operations in order to avoid the foregoing disadvantages, slower rates of penetration of the drill bit result due to the reduction of effective cutting force with which the bit bears against the formation.

In order to effect faster rates of drill bit penetration, resort has been had in the past to the use of "drill collars" at the lower end of the drilling string instead of ordinary drill pipe. These drill collars are extra heavy sections of pipe constructed similarly to drill pipe and may range from about 6 to 40 feet in length and may weigh as much as 40 pounds per foot for 4-inch to about 260 pounds per foot for 10-inch outside diameter collars. By using these heavy sections in the lower end of the drilling string, increased weight can be carried on a drill bit without increasing the portion of the length of the string under compression. For example, with a given equilibrium point of compression and tension forces in a drilling string, the weight carried on the drill bit may be 10,000 pounds. By the use of a number of collars in the lower end of the string instead of ordinary drill pipe and tool joints, the weight carried on the bit may be increased to 12,000 or 13,000 pounds and by simultaneously increasing the amount of weight suspended from the derrick, the equilibrium point may be lowered. Thus, the amount of the string under compression is reduced, although the weight on the bit is increased. It has been found, however, that the amount of weight which can be satisfactorily added to the drilling string in this manner is limited to relatively small increments due presumably to a concentration of bending and torsional stresses in the threaded sections of the drill collars. The drill collars being formed of very thick-walled pipe, are so stiff and inflexible that all of the bending and torsional stresses concentrate at the aforementioned points and frequent fractures through the threaded sections result.

It is an object of this invention to provide a drilling string of increased weight at the lower end thereof, and more particularly, to provide a bottom-hole assembly of increased weight.

It is another object of this invention to provide a bottom-hole assembly having increased weight distributed in such manner as to reduce failures in the drilling string.

It is a further object of this invention to pro-

vide weighted bottom-hole assemblies in which the concentration of stresses in the joints is avoided.

It is still another object of this invention to provide a bottom-hole assembly having weighting sleeves mounted thereon.

It is still another object of the invention to provide means for increasing the rate of penetration of the drill in rotary drilling operations.

Other objects will make themselves apparent from the following description and drawings of which

Figure 1 is a vertical view partly in section of the lower end of a weighted drilling string in accordance with one form of this invention.

Figure 2 is a vertical view, partly in section, of a portion of the lower end of a drilling string showing an alternative method of attaching a weighting element.

Figure 3 is a vertical view partly in section of a portion of the lower end of a drilling string showing another alternative method of attaching a weighting element.

Figure 4 is a horizontal cross section through 4-4 of Figure 3.

Figure 5 is a vertical view of a portion of the lower end of a drilling string showing a plurality of interlocking weighting sleeves positioned between tool joints.

Figure 6 is a vertical view of a portion of the lower end of a drilling string showing a weighting sleeve which is rotatably and vertically interlocked at each end with adjacent tool joints.

Figure 7 is a vertical view, partly diagrammatical and partly cross sectional of the portion of the lower end of a drilling string showing a weighting sleeve which is rotatably and vertically interlocked at its lower end with adjacent tool joints and has an upper end of reduced outside diameter.

Referring to the drawings, standard drill pipe sections 11 are connected by tool joints composed of pin elements 13 and box elements 15 of larger outside diameter than the drill pipe. The pin portion 13 is threaded to the lower end of a section of drill pipe at 16 in a conventional manner and the box portions are likewise threaded in a conventional manner to the upper end of the sections of drill pipe at 17. The pin and box portions of the tool joints are joined by a coarse threaded connection 18. A drilling bit 19 is threaded to the assembly at 21 in a conventional manner.

Between the tool joints there is mounted a loose fitting hollow cylindrical weighting sleeve 23, the internal diameter of which is larger than that of the drill pipe and is sufficiently large to allow a free space 25 between the sleeve and drill pipe. This annular space may conveniently be about $\frac{1}{8}$ to $\frac{3}{4}$ inches, the minimum being that which permits the sleeve to fit loosely and still not reinforce the wall of the drill pipe and the maximum being that which permits the sleeve to have substantial weight per unit of length with an outside diameter not substantially in excess of the adjacent tool joints. By leaving a space between the drill pipe 11 and sleeve 23, the drill pipe is free to be laterally deflected and thus absorb over a relatively extended area, a large portion of the torsional and bending stresses and thereby avoid a concentration of stresses at the threaded portions 16, 17 and 18. This result is possible only so long as the wall of the drill pipe 11 is more flexible than the threaded portions of the pipe and tool joint con-

necting elements. The outer diameter of the sleeve 23 may be of any convenient diameter depending on the weight per foot which it is desired to add, but is preferably not substantially in excess of the outer diameter of the tool joints and may advantageously be of approximately the same diameter as the tool joints.

The sleeve 23 may consist of a single section of pipe or tubing which extends substantially the entire distance between tool joints or may consist of several short sections of pipe which may or may not be interlocked or fastened together since the assembly does not depend upon the sleeve for any reinforcing of the structural strength of the drill pipe 11. The principal function of the sleeve is to add weight without adding strength to the portion of the drill pipe between tool joints and it is therefore apparent that it is neither necessary nor desirable to rigidly attach the sleeve at both ends to the drill pipe or tool joints. The sleeve may simply rest on the shoulder of a tool joint. However, frictional losses may be reduced and other advantages secured by mounting the sleeve around the drill pipe in such a manner that the sleeve will necessarily rotate with the drill pipe. This may be accomplished by attaching the sleeve to the tool joint by welding one end of the sleeve as shown at 27 or by providing interlocking members on an end of the sleeve as at 29 in Figures 3 and 7, which interlock with suitable projecting elements 31 shown as formed on the pin element 13 of a tool joint. Alternatively, these interlocking elements may be formed by rigidly attaching a ring or collar having suitable interlocking elements thereon, to the tool joint and/or drill pipe. When the sleeve is welded to the tool joint, it is necessary to weld only one end as shown in Figures 1 and 2 in order that the portions of the drill pipe between tool joints will not be reinforced and made stronger than the tool joint portions. If the latter condition were allowed to prevail, the stresses would concentrate in the threaded portions of the drill pipe and tool joints and fractures through the threads would result. This is the condition which prevails when conventional methods of increasing the weight on the drill bit are used. To further avoid reinforcing the drill stem at portions between the tool joints, a space is left between the free end of the sleeve 32 and the adjacent shoulder 33 of a tool joint. The space may be at either the top or bottom of the sleeve. This space may be large enough, as shown in Figure 3, to provide for attachment of elevators or may be relatively narrow as in Figure 1, in which case the drilling string may be elevated by attachment of an elevator sub which screws into the tool joint threads 18 or by the use of slips. Another construction which may be employed to provide for an elevator grip utilizes a short section of sleeve of reduced outer diameter 35 as shown in Figures 2 and 7.

When the sleeve is interlocked with elements which rotate with the drill pipe as, for example, in the manner shown in Figure 3, the clearance between the free end of the sleeve and the adjacent tool joints is preferably such that the sleeve cannot be vertically moved a sufficient distance to disengage the interlocking members. The interlocking elements are preferably so constructed that there is no overlapping of the elements with the threaded portions of the tool joints since this would result in an undesirable structural weakness.

In Figures 5 and 6, alternative forms of weight-

ing sleeves are shown. In Figure 5 there is illustrated a plurality of weighting sleeves sections 23 and 23a positioned between tool joints. The lower section 23a is rotatably interlocked at its lower end with the pin element 13 of a tool joint and is also rotatably interlocked with an upper section of tool joint 23 by interlocking elements 37 and 39. Any convenient number of sleeve sections may be thus employed.

Figure 6 illustrates a weighting sleeve that is both rotatably and vertically interlocked at each end with pin element 13 and box element 15 of tool joints adjacent the ends of the sleeve. While the interlocking elements may take various forms, it is convenient to employ elements at the lower end of the sleeve formed by a projection 41 extending from the tool joint the outer end of which is wider than the portion adjoining the main body of the tool joint, thus forming a shoulder 43 which is in rotational and vertical interlocking engagement with a shoulder 45 of the weighting sleeve. By making the sleeve and tool joints vertically interlocking, fishing jobs made necessary by failures in the drill pipe, are greatly expedited. In assembling sleeves interlocked as shown in Figure 6 it is necessary to attach portions of the interlocking elements subsequent to assembling the sleeve around the drill pipe. This may be conveniently accomplished at the lower end of the sleeve by welding the triangular shaped shoulder portion 45 to the sleeve along the line 47 after the sleeve is in place. At the upper end, since the tool joint is usually threaded to the drill pipe, thus requiring rotation in order to effect assembly, it is more convenient to attach the projecting element 49 and shoulder portion 51 to the tool joint 15 by welding along the line 53 after the tool joint has been threaded into place on the drill pipe. The shoulder element 51 affixed to the tool joint 15 thus is in vertical engagement with shoulder element 55 of the sleeve. The same result may also be effected by mounting the sleeve around the drill pipe in two pieces which are not rotatably engaged with each other. This will permit rotating the box element 15 to thread it in place and the two sections of sleeve may then be welded together to form a single continuous sleeve which interlocks both rotatably and vertically with tool joints at each end of the sleeve.

Any suitable number of weighting sleeves may be added, depending upon the pressure with which it is desired that the bit bear upon the formation being drilled and upon the point in the drilling string at which it is desired to maintain the equilibrium between compression and tension forces. For example, if it is desired to maintain a given equilibrium point and at the same time increase the load carried on the bit from 10,000 pounds to 20,000 pounds, a sufficient number of sleeves are added to the lower end of the string to amount to 10,000 pounds additional weight. If

3½" O. D. drill pipe and 5" O. D. tool joints are being used in the lower portion of the string, the weight will be about 16 pounds per foot. Sleeves having 3⅝" I. D. and 5" O. D. are mounted between the tool joints. These sleeves weigh about 32 pounds per foot and in order to add the desired 10,000 pounds weight, it is necessary to add 312.5 feet of sleeve (10,000 pounds divided by 32 pounds per foot).

Weighting sleeves which are attached to drilling strings at the lower ends thereof in the aforementioned manner, preferably as close as possible to the drill bit, have the effect of increasing the rate of penetration of the drill bit into the formation by increasing the weight on the drill bit and this is effected without causing a concentration of stresses in the threaded portions of the drilling string with resultant drill pipe and tool joint failures, high friction losses and crooked holes. The sleeves may be used in conjunction with or instead of conventional drill collars, although because of both structural and economic advantages, the latter alternative is preferred. If drill collars are employed, the sleeves are usually positioned above and adjacent to the drill collars.

While a particular form of the invention has been described, it will be apparent to those skilled in the art that numerous modifications thereof may be devised without departing from the spirit of the invention.

It is claimed:

1. In a drilling string having offset tool joints, the combination of a weighting sleeve positioned on a lower portion of the string, said sleeve having an inner diameter less than the outer diameter of adjacent tool joints, the sleeve fitting loosely around the drill pipe and having an end thereof in non-rigid rotational interlocking relationship with vertically projecting lugs affixed to an adjacent tool joint, the vertical projection of the lugs being greater than the clearance between the ends of the sleeve and adjoining tool joints.

2. Apparatus in accordance with claim 1 in which each end of the sleeve is in rotational interlocking relationship with lugs affixed to adjacent tool joints.

3. Apparatus in accordance with claim 1 in which the vertically projecting lugs are shaped to provide both vertical and rotational interlocking relationship between the sleeve and lugs.

4. Apparatus in accordance with claim 1 in which the upper end of the sleeve is of sufficient smaller outer diameter than the adjacent tool joint to form a shoulder between the sleeve and tool joint, said shoulder being of sufficient thickness to permit elevators to be attached thereto in lifting engagement.

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