

Aug. 16, 1955

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2,715,552

DRILL STRING BUSHING TOOL

Filed March 1, 1954

3 Sheets-Sheet 1

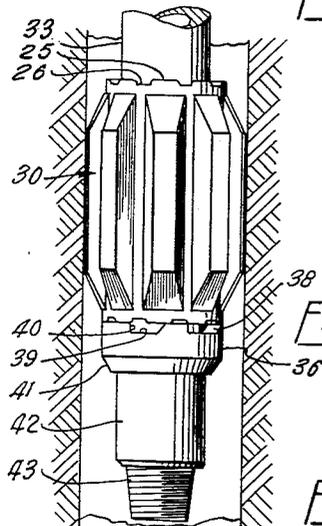
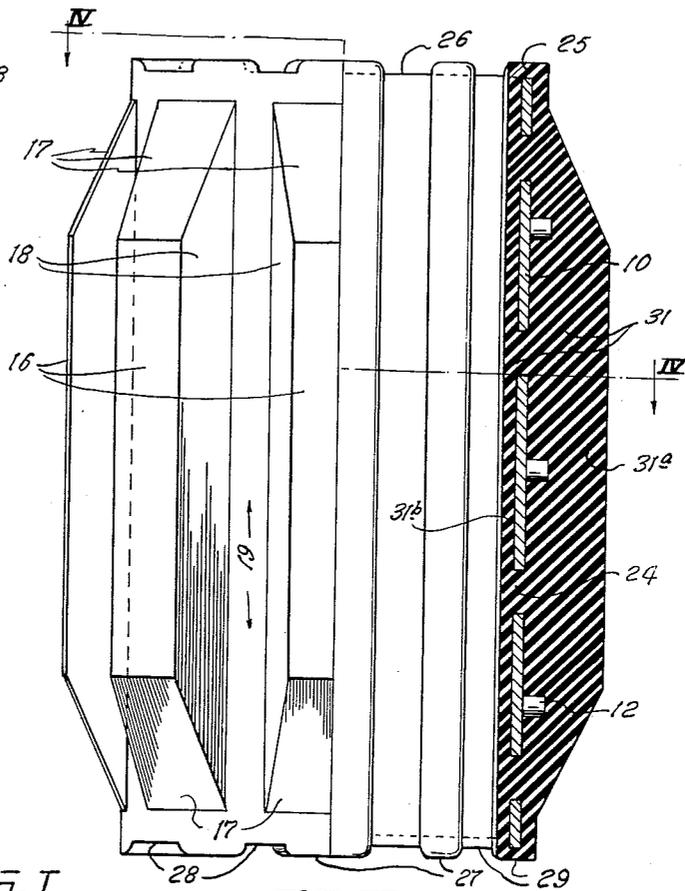
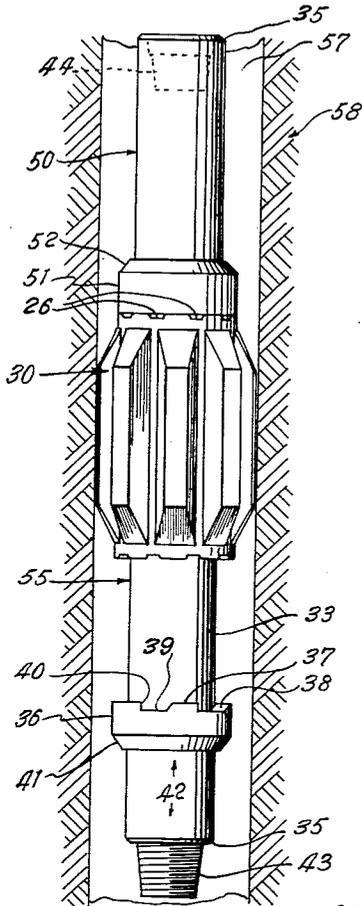


Fig. I

Fig. III

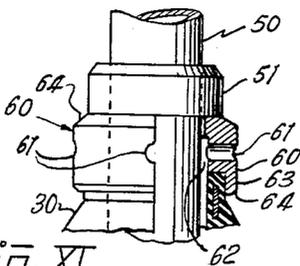


Fig. XI

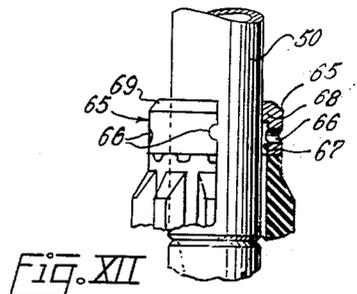


Fig. XII

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3 Sheets-Sheet 2

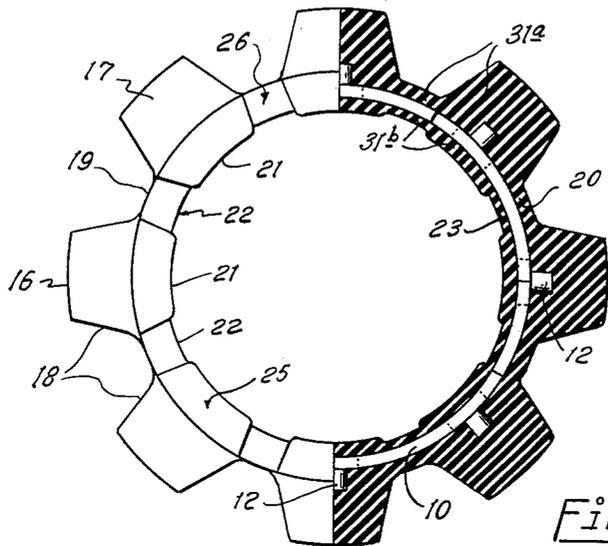


Fig. IV

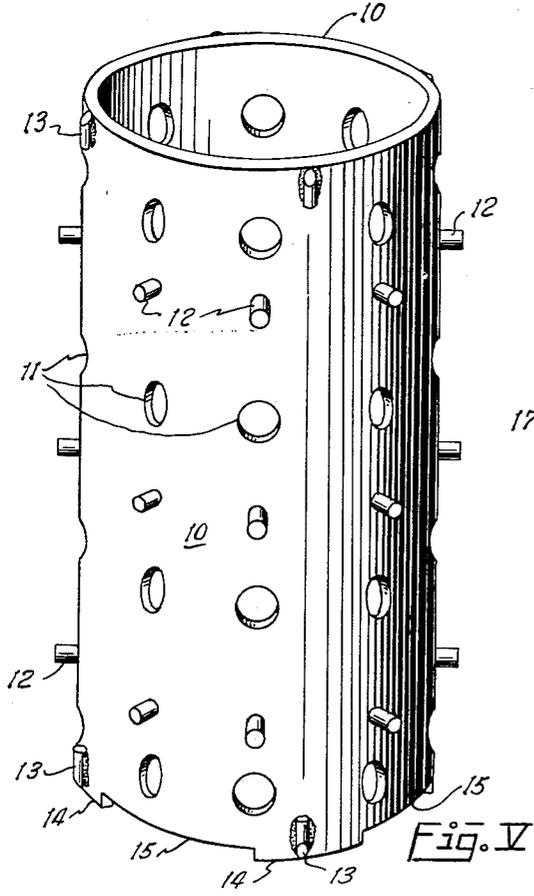


Fig. V

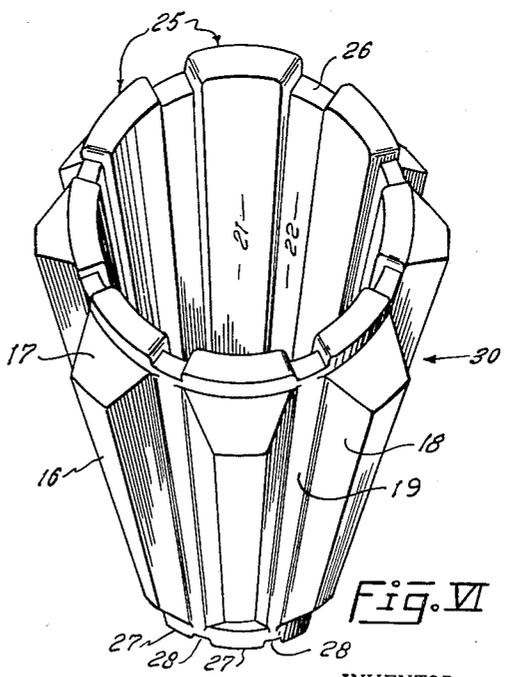


Fig. VI

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DRILL STRING BUSHING TOOL

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3 Sheets-Sheet 3

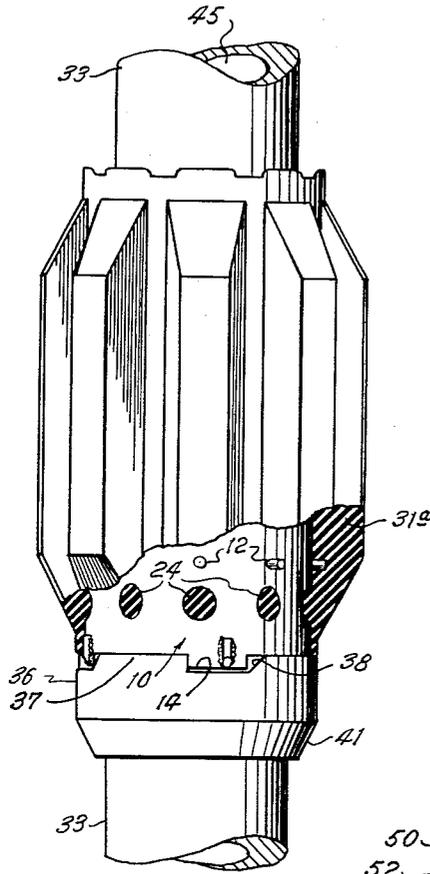


Fig. VII

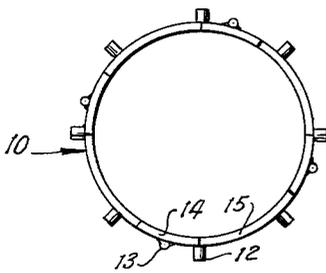


Fig. IX

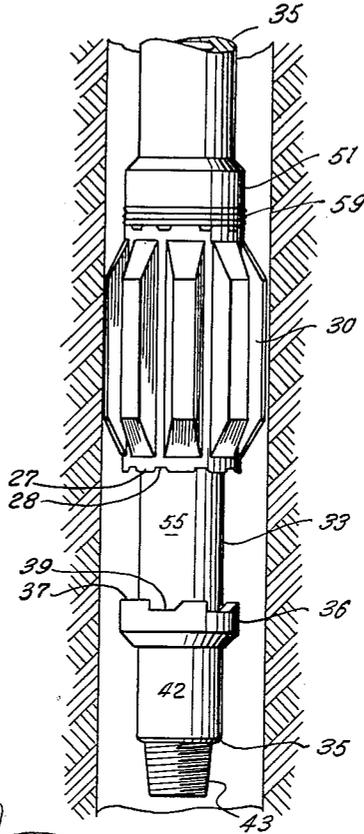


Fig. X

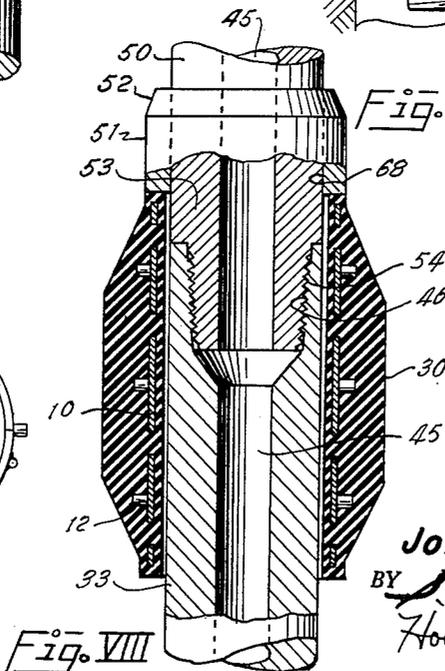


Fig. VIII

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2,715,552

DRILL STRING BUSHING TOOL

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Application March 1, 1954, Serial No. 413,246

8 Claims. (Cl. 308-4)

This invention is concerned with a drill string bushing tool, including a journal and bearing, used in the drilling of wells. It is particularly concerned with a rigid tubular reinforcing member having rubber-like ribs so as to provide a resilient bushing arranged to be slideably disposed on a journal forming part of a drill collar, or other section of drill string, and permitted relative rotation with respect to such section. A string of drill collars, carrying thereon any desired number of these special bushings, may be incorporated as part of the drill string used in the rotary drilling of a hole in the earth.

In rotary drilling of an oil well, a string of drill pipe, having a drill bit secured to the lower end thereof, is progressively lowered into the earth by the rotation of the drill string, as the bit cuts away the various formations encountered.

A long drill string is relatively flexible, being subject to lateral deflection especially at its joints or couplings; and, upon the addition of weight thereto, the string is caused to bend and thereby produce an undesirable hole deviating from the vertical. It has been found practically impossible to drill a perfectly vertical hole.

At the lower end of the drill string (and as a part thereof), there is usually provided a plurality of very thick-walled sections of heavy pipe, referred to in the oil industry as "drill collars." The drill bit is usually secured to the lowermost drill collar.

Drill collars in a drill string have been multiplied in number in recent years in order to furnish increased weight immediately above the drill bit so as to thereby accelerate the rate of making hole, and to further provide more rigidity to the drill string (the collar walls being quite thick and made with heavy joints or couplings) in an attempt to reduce the bending of the string and the wobbling of the drill bit. By using many such elongated heavy collars it was hoped that the hole could be cut more nearly straight.

However, the addition of increased weight and the added lengths of heavy drill collars together have been found to cause further bending of the drill stem, thereby increasing the deviation of the hole from the vertical. The crooked hole continues to be a great problem.

When the hole is inclined or made crooked, the drill string contacts one side of the hole, thereby causing the bit to make uneven contact with the bottom of the hole. The individual cutters of the bit can not contact the bottom of the hole simultaneously. When the bit fails to contact the bottom of the hole evenly, then the individual cutters on the bit can only successively strike or contact the bottom of the hole, and usually at only one point. Such undesirable contact materially lessens the rate of drilling and causes further deviation of the hole. Very often, the hole becomes so irregular in shape and inclination as to cause the drill stem to be twisted in two. Serious trouble follows the breaking or twisting off of a drill stem.

The above problems are accentuated when drilling through hard formations wherein the drillstring often

buckles under very heavy weight, thus causing the drill string to spiral around the wall of the hole.

The heavy drill collar string, disposed at the lower end of the lighter weight drill pipe, in making up the string, is usually rotated in the open hole below the point to which the well has been cased with large well pipe or casing. Therefore, in its gyratory motion, as described above, the string of drill collars will forcibly strike and continue to contact the hard wall of the open hole. The hole wall is often of rock formation, very rough and irregular, and it causes undue wear and abrasion to the drill collars striking it, thus decreasing their life.

It is desirable that appropriate means be provided (a) to center and properly place the drill string in the hole, and (b) to keep it centered, and (c) to cause the bit to contact the bottom of the hole evenly and therefore cut a straighter hole, and (d) to cut the hole faster, and (e) to prevent the drill collars from unduly contacting the walls of the hole, and (f) to prevent damage to the drill string, especially through flexure thereof and fatigue therein.

Various types of so-called "stabilizers" have been provided in the past in an attempt to accomplish these purposes, but they have not been very successful.

In the past, the most generally used type of stabilizer has been a device made of cast iron, closely secured to the drill stem, and provided with fins or blades laterally spaced thereabout.

These cast iron stabilizers were easily broken and worn away by contact with the rocky walls of the hole. It was also found necessary to make such stabilizers somewhat smaller in diameter than the hole in which they were run. This was done in an attempt to prevent or minimize contact between the stabilizers and the wall of the hole. This always allowed the drill bit to wobble. Therefore, the stabilizers were broken by constant bumping against the rough and irregular wall of the hole. They often "froze" to the pipe.

The instant invention solves the serious problems and overcomes the expensive difficulties hereinabove indicated.

This invention provides a novel drill string bushing which has a rigid and continuous and unbroken metallic inner sleeve or core. This bushing has rubber or neoprene material firmly molded on both the inner and the outer sides of the core. It is provided with connected resilient ribs or ridges on both the inner and the outer sides thereof. It is so constructed as to provide fluid flow channels or troughs about the bushing and also between the bushing and the drill collar or mandrel on which it is carried. The bushing is slideably carried on a special mandrel capable of rotating therein.

This new bushing is arranged so that the outer rubber ribs thereof may contact the walls of the well hole and allow the bushing to remain stationary, and permit the drill string (collar or mandrel) to rotate within the bushing. The well fluid can flow freely through the channels on the inside of the bushing and flush out bit cuttings and continuously provide lubrication for the bushing. The well fluid can also flow around the bushing and keep it lubricated.

My special bushing provides maximum centering and continuous protection of the drill string while the latter is in the hole. It keeps the string in line. It causes the faster cutting of straighter hole.

The inherent resiliency of the rubber ribs on the outer side of the bushing allows such ribs to yieldably conform to the irregularities encountered in the wall of the hole, and to easily pass over rough projections without any rupturing or tearing of the rubber material. Such built-in capacity greatly increases the life of the bushing.

A novel mandrel and subassembly is provided for

attaching the bushing in the drill string as a part thereof. Such provision and its arrangement permits the bushing to be easily and quickly assembled as a working unit, and also permits it to be quickly disassembled.

Emergency locking means is provided between the mandrel and the lower end of the drill string bushing, whereby the bushing may be locked with relation to the mandrel and thereby prevent relative rotation between these members. Such locking means is a safety device to be used when the bit, or some tool or pipe below the bushing, breaks and/or gets stuck in the hole. The bushing can be locked in place so that the rubber ribs may be cut off from the outside of the bushing body or core, in an emergency, as when it becomes necessary to pass a "fishing tool" over and around the bushing, in order to "fish" out of the hole a lower section of the drill string or some other part or tool.

Special and dependable means have been provided for permitting and insuring regular, continuous and unending circulation and lubrication in and about the bushing. Such means will give long life to this tool, and will not hinder the normal and necessary circulation of fluid throughout the well.

A primary object of this invention is to provide a drill string bushing which will afford and maintain maximum centering, proper spacing and continuous stabilization of the drill string, and thereby cause the drilling of a straighter hole and effect better protection of the drill collars of the string.

Another object is to provide a drill string bushing of great strength and unusual durability, toughness and resilience, and thereby insure its longer life and usefulness.

A still further object of this invention is to provide a drill string bushing which may be allowed to contact the wall of the drilled well hole and remain stationary, and yet allow the drill stem to rotate therein, without damage to the bushing.

A further object is to provide a drill stem bushing so constructed as to allow the outer peripheral faces thereof to contact the wall of the drilled hole and at the same time permit flow of well fluid exteriorly of the bushing, with provision for a minimum of actual contacting exterior surface.

Another object of this invention is to provide a drill stem bushing which is self-lubricating and self-flushing by reason of construction permitting the continuous flow of well fluid through the bushing and between it and the drill stem on which it is carried.

An object of this invention is to provide a drill string bushing having continuously open flow ports communicating with flow channels to insure constant lubrication and flow of well fluid through the bushing, which functions somewhat as a journal bearing.

Another object is to provide a drill string bushing having a continuous rigid tubular core, carrying resilient ribs, both on the outer side and on the inner side thereof, so constructed and arranged that the ribs are keyed and bonded to the core and also bonded together in cooperating pairs which are integrally united through spaced apertures arranged longitudinally of the core, thereby providing a safe, secure and tenacious unity between the resilient material and the core and also between the ribs themselves.

An additional object is to provide means for locking the bushing to the drill string when found necessary in an emergency, so that the rubber-like material may be milled off the outer side of the bushing, if such be required to reach equipment below the bushing.

A further object is achieved by providing means whereby accidental locking of the bushing to the drill string is made impossible.

A further object is to provide a drill string bushing which increases the penetration rate of the drill bit and at the same time prevents excessive abrasive wear and

damage to the drill string and to the drill collars thereof.

Among the objects realized by the special design and construction of this drill string bushing are these: It may safely contact the wall of the hole, and thereby bridge the clearance between the drill string and the wall of the hole, and thus minimizing the bending and wobbling of the drill string so as to insure the drilling of a straighter hole, and also the more rapid penetration of earth formations by the drill bit.

Other objects of this invention will become apparent on further reading of this specification and examination of the drawings.

Preferred forms of this invention, and some modifications thereof, are shown in typical views in the accompanying drawings, in which:

Fig. I is an elevational view of a typical drill string bushing assembly, including mandrel, arranged in a normal operating position within a well bore being drilled in the earth.

Fig. II is an elevational view of the bushing, of Fig. I, lowered on its mandrel to a position of proximity with the clutch ring.

Fig. III is a partially sectionalized elevational view of a typical bushing, disclosing a cross-section of its cylindrical metallic core.

Fig. IV is a partially sectionalized plan view of the bushing shown in Fig. III, the section being taken along line IV—IV of such figure.

Fig. V is a perspective view of a preferred form of the cylindrical core of a typical bushing.

Fig. VI is a perspective view of a typical bushing, showing some construction details, both interiorly and exteriorly, when looked into at the top.

Fig. VII is an elevational view of a clutch band, mounted on a fragment of the mandrel, and of a bushing in which a part of the rubber body has been cut away at its lower end to expose teeth on the metallic core of the bushing.

Fig. VIII is a partially sectionalized elevational view of an intermediate fragment of a typical mandrel, showing connection between the shank member thereof and the head member thereof, the latter carrying an enlarged head band, below which is disposed a sectionalized elevational view of a typical bushing and its core.

Fig. IX is a plan view of a typical metallic core, as seen from below.

Fig. X is an elevational view indicating the main parts of a modified bushing assembly wherein a plurality of loose anti-friction rings are disposed between the bushing and the head band on the mandrel.

Fig. XI is a fragmentary elevational view of the upper end of a bushing in contact with a modified form of free-riding and rotatable circulation cap ring disposed between the mandrel head band and the bushing, the ring and the bushing being partially sectionalized.

Fig. XII is a fragmentary elevational view of the head member of the mandrel carrying a modified form of the head band, above a fragment of the upper end of a bushing, the band and the bushing being partly sectionalized.

The principal parts and elements of this invention are indicated by numerals in the drawings, in which like parts have been given like numerals.

The resilient bodied drill string bushing, as an entire unit, is shown as at 30. The bushing is carried on a special mandrel, which becomes part of the general drill string and is rotated therewith. The complete mandrel unit is indicated as at 35.

The bushing's resilient rubber-like body 31 is composed of a resilient outer body 31a and a resilient inner body 31b; and these two elements are integrated into one single resilient member, among the functions of which is that of a cushioned "bumper" between open hole and drill string.

The numeral 10 indicates one suitable form of cylindrical metallic core, around which and to which and

through which rubber-like plastic material is molded, vulcanized and fixed, to constitute the resilient body of drill stem journal or bushing 30.

A plurality of spacedly related apertures or holes 11 are arranged through the circular wall of metallic core 10. In and through these holes the rubber-like exterior part 31a of the resilient body of the bushing is firmly joined and united and integrated with the rubber-like lining constituting the internal part 31b of the resilient body of the bushing.

Each outer rib 16 may be aligned vertically and paired with an internal ridge 21, and the two are integrated. Stabilizing and yieldably recoverable "bumper" resistance by the bushing is doubled and strengthened and made more safe and sure, with less actual lateral movement of the bushing as unit, by this parallel provision of ribs and ridges.

The exterior and interior parts of the resilient plastic body also may be merged and unified around each end of the core, if desired, as hereinafter explained.

Thus it will be seen that the resilient material surrounding and encasing the core 10 and the resilient material arranged within the core are made into one unitary body of monolithic character, capable of providing a guiding journal about the rotating drill string which will remain centered even when the bushing body yields to thrust.

Such body construction permits stress suffered by the resilient material arranged exteriorly of the core to be yieldably received, distributed and absorbed by the resilient material arranged within the core. Likewise, stress and shock to the resilient material arranged within the core may be transferred in part to such material arranged exteriorly thereof, and become partially absorbed by the latter.

It is usually desirable that the ends of the core 10, both top and bottom, be completely covered, enclosed and encased by a continuous body of the resilient material. However, the upper edge of the metallic core need not always be so covered. For instance, no such covering is needed when there is used a modified form of construction employing a special flow cap ring 60, or special head band 65, both described elsewhere herein.

When desired, the cap-ring 60, and/or the head band 65, can be employed with the preferred form of the bushing which has its upper end covered with rubber. Such arrangement will provide multiple rows of flow ports above the bushing body, these ports being 26, 61 and 66.

The bottom edge of the core 10 (and its clutch teeth 14) should be encased and covered with rubber-like material, for reasons set out elsewhere herein.

Therefore, shocks and thrusts accepted by either end of the bushing, whether coming vertically, obliquely or laterally, may be distributed to and partially absorbed by yieldable material adjacent thereto, both within and without the bushing.

Integration of the resilient material, in some suitable fashion, at spaced intervals throughout the entire mass thereof, allows the rubber body of the bushing to sustain, without any damage, the many and severe forces exerted thereagainst from whatever quarter.

The novel bushing construction herein disclosed permits of wide distribution, throughout the resilient body, of all manner of stress, shock and strain, thereby preventing the disruption, tearing, breaking or shearing of any parts of the rubber-like element, even under conditions of roughest usage. It is to be noted that rough use is usually met with, even in ordinary drilling operations.

On the outside of a typical core 10, there should be disposed some rigid projections or deformities by way of reinforcing, such as a number of laterally extending stubs 12, arranged in spaced relation and firmly fixed to the wall of the core. They may be attached thereto in any suitable manner which will insure their rigid con-

nection. The core and the stubs (or other projections) may be welded together by fusion, which is one satisfactory form of union.

A row of stubs 12, or their equivalents, consisting of a plurality thereof, should be arranged in substantially or approximately vertical alignment. Such arrangement will greatly strengthen and better unite and hold together the vertical rubber ribs 16 and the core 10. The construction will allow each rib to yield laterally, without being severed or ruptured; and it will also hasten the recovery to normal position of any rib which has been deflected or forced into temporary deformation.

Drill string bushing 30 is slideably mounted on special mandrel 35, the latter being made up of two principal parts, the mandrel head 50 and the mandrel shank 33. Head and shank must be disconnected to install the bushing, then re-assembled into a working unit, which is made up into the drill string.

Mandrel shank member 33 carries clutch band 36, which encircles the lower part of the shank and is firmly attached thereto.

Intermediate the ends of mandrel head 50 there is arranged an enlarged head band, encircling such part of the mandrel and rigidly attached thereto. A typical head band is shown as at 51. Another form of head band is indicated by the numeral 65.

An attachment face is provided on the inside of each form of head band, so arranged as to effect close contact with mandrel head 50. It is at or along attachment face 68 that means is provided for fixedly connecting band and head together.

Face 68, in the head band, marks the upper limit of travel of fluid flowing between the bushing and the mandrel. Flowing fluid must move laterally through flow ports arranged below such face of such band.

Clutch band 36 and head band 51 (or 65) may be pinned to the hollow mandrel, or otherwise attached thereto, as by welding. They may be "sweated on." This is done by heating the bands and placing them on a cool or cold mandrel, in properly spaced relation to one another, and then allowing the hot bands to cool and shrink into a tight fit against the mandrel along an attachment face provided in each band, such as face 68 or the equivalent.

Free travel space 55 is provided on mandrel 35 between the head band and the clutch band. Such space is considerably longer than the overall height of bushing unit 30. The bushing is allowed to freely slide up and down on the mandrel in this travel space between the bands. The direction of flow of well fluid outside of the drill string determines the position of the bushing in space 55.

Bushing 30 and mandrel 35 are so constructed, arranged and assembled as to allow relative rotation therebetween. In ordinary operational use, mandrel 35, which is a part of the drill string carrying the drill bit, is rotated through the bushing, while the well is being drilled. During such time the bushing 30 usually does not rotate at all, or it may occasionally rotate for short periods of time or only intermittently, depending on physical conditions, such as the viscosity and pressure of well mud and the debris carried in the mud.

Actual rotation on the part of the bushing itself sometimes results from the accumulation of foreign materials therein, such as well cuttings, which may become temporarily lodged between the bushing and the mandrel. Raising the drill string a short distance and then dropping it will usually free the bushing from accumulated debris.

Constant circulation of well fluid (well mud, water or oil) is arranged for and intended to be maintained so as to flow through the bushing at all times. This will not only continuously lubricate the bushing but it will usually wash out all foreign materials from within the bushing, i. e., from between the mandrel and the body of the bushing.

The drill string is a heavy walled tubular conduit of great strength and weight, running from several hundred to several thousands of feet in length; and it usually has incorporated therein, as a component part thereof, a number of heavy drill collars, which are made up into the string beginning just above the drill bit.

The term "drill collar" does not imply a "collar" in the ordinary sense of the term. It connotes an extremely heavy and very thick walled pipe of elongated character, which is heavier and stouter than the other parts of the drill stem or string.

The entire drill string, from ground level to drill bit at the bottom of the hole, is rotated as a unit, so that the bit can cut into the earth. Standard rotation for drilling a well is clockwise, when seen from above.

A normal installation of that part of the drill string which makes up the bushing assembly of this invention is shown in Figure I of the drawings. It is shown therein as disposed within well bore 57, which has been cut into the earth by the rotating drill bit as it descends there-through.

In the drilling of the well there is constant circulation of well fluid, which is normally forced downward through the hollow drill string and out into the bottom of the well bore at or through the well bit. Reverse circulation can be had by pumping the well fluid downward in the well bore and upward through the drill string; and this is done occasionally for brief periods.

Well fluid for drilling operations usually consists of heavy and specially prepared "well mud." During drilling operations such viscous mud is usually circulated downward through the drill string conduit, under pressure from large pumps located above ground.

The well mud returns upwardly through the annular space between the drill string and the wall of the well bore 57, washing away and carrying with it the bit cuttings. This upward flow is under considerable pressure. Therefore it must be allowed to freely pass the drill string bushing 30, and its assembly.

Part of the upwardly moving stream of well fluid passes outwardly of bushing 30. Also part of this stream of well fluid flows upwardly through such bushing, passing between it and the mandrel 35 (or drill string) which carries it.

The rubber-like resilient ribs 16, which comprises the bulk of the outer wall 31a of the drill stem bushing, are beveled, as at 17 on each end. This enables them to pass more easily any obstructions encountered during vertical movements of the bushing and the drill string, especially when going in and out of the well hole.

Ribs 16 are also beveled along their sides, as at 18. This construction lessens the outer and contacting surface of the ribs which may be subjected to abrasion; and it provides a broader and stronger base for the ribs.

Ribs 16 are spaced apart so as to form therebetween the flow troughs 19, through which the well fluid rises around the bushing. The rib construction indicated provides generous space for the flow of well fluid there-through.

Within the bushing, rubber-like ridges 21 are formed at spaced intervals, so as to leave therebetween the many flow channels 22, through which the well fluid also rises in its return to the surface of the earth.

The liberal streams of well fluid, and especially of well mud, moving within and without the bushing 30, themselves provide a multiplicity of viscous fluid cushions which must be displaced, in part at least, before the rubber material of the bushing body can suffer abrasion from well pipe or bored hole.

A relatively thin layer of rubber 20 forms the bottom of the troughs 19 exteriorly of the bushing; and a relatively thin layer of rubber 23 forms the bottom of interior channels 22. These layers are integrated with their respectively adjacent ribs 16 and ridges 21, so as to offer continuous resiliency and binding resistance to all forces

tending to widen the space between the ribs or between the ridges. The continuity of the rubber jacket and casing prevents the breaking away or peeling off of the ribs and of the ridges.

Most of the returning well mud passes exteriorly of the bushing through the troughs 19. Some quantity thereof passes exteriorly of the bushing about the periphery of the ribs 16. Such mud fills every space lying without and around the bushing.

Returning well fluid also passes upwardly through the interior channels 22, and some of it passes upwardly across the arcuate faces of the internal ridges 21, thereby lubricating the latter and lessening the possibilities of friction between the interior of the bushing and the mandrel on which it is carried.

Lubrication of the entire outer peripheral surface of the bushing is also accomplished by the upward flowing well fluid thereabout, and abrasion of the outer walls of the bushing, particularly of the rib faces, is drastically reduced and minimized.

The structure which permits generous exterior and interior lubrication of the bushing 30, while in use in the drilling of a well, greatly prolongs its life. Nevertheless, this same structure permits the use of a multi-ribbed bushing which so nearly contacts the bore of the well as to severely limit lateral movement of the drill string.

It is to be noted that bushing 30 ordinarily rides at the upper end of the free travel space 55, which is arranged on mandrel 35 between head band 51 and clutch band 36. Therefore, in normal operation, there is more prolonged frictional contact between the upper end of the bushing and the head band than there is between the lower end of the bushing and the clutch band. Means preventing any serious consequences by reason of friction between head band and bushing have been provided for in several forms.

So that the well fluid flowing upwardly within and through the bushing may be allowed to escape at all times from the top of the bushing, there may be provided around its top edge, the flow ports or notches 26, which are arranged between projections 25 extended from the rubber body of the bushing. Such notches are open ended, and they thereby permit a continuous flow of viscous lubricating fluid, under pressure, across the entire upper edge of the bushing. This liquid lubricant passes through and over notches 26, and, to some extent, across the faces of projections 25, depending on volume and pressure of the fluid.

In the terminology of the oil field a "drill string" and a "drill stem" are synonymous terms. Either term comprehends the entire length of heavy drill pipe, whether drill collars are incorporated therein or not, and whether or not the special mandrel 35, which is a part of this invention, is incorporated in the string of drill pipe. All such members have a communicating or continuous bore (shown as at 45 in the drawings) providing a conduit from the ground level to the drill bit at the bottom of the hole or well being drilled. It is therefore proper to say that resilient bushing 30 is carried by and slidably mounted on the drill string.

In best practice, a plurality of bushings 30 are mounted on sections of the drill string in spaced relation therealong. The lowermost bushing is usually mounted close to the drill bit. At intervals thereabove other such bushings are carried on the drill string, so that a considerable number of spaced bushings 30 may be carried within a relatively long distance above the bit. Such distance may extend over scores of feet or even over hundreds of feet. The character of the earth formations encountered by the drill bit has much to do with the number of bushings used and the distances at which they are spaced apart. Periodicity in waves of vibration along the rotating drill string is to be taken into account in properly spacing bushings on the drill string.

Some earth formations have a greater tendency than

others to cause deflection of the bit. Such changes in deflection have resulted in irregularly occurring and marked deviations of the drilled hole from the desired vertical. The degrees of hardness of such formations, the fissures encountered therein, and other varying conditions, all affect the drilling of the hole with regard to its degree of straightness. A marked or sudden declination of the hole, or any pronounced lateral deflection thereof, will usually produce serious consequences, some of which are indicated herein elsewhere.

Crooked holes, "dog legs" and other deviations from the vertical, frequently result in severe damage to the drill string, especially at its threaded couplings, the latter being occasionally broken off by reason of such undesired deviations.

One of the most expensive results of hole deviation is found in the slowness of making hole, with consequent loss of time and manpower. Such are among the serious consequences of the crooked hole.

Furthermore, once a well has been drilled to a productive formation from which oil and/or gas may be recovered in commercial quantities, it must be cased with large pipe. Casing a crooked hole is a difficult job.

When a crooked well is being pumped, with a working barrel placed below the oil level and reciprocating pump rods (sucker rods) actuating it, the sucker rods and the tubing are both worn down by abrasion until they become dangerous or break or are otherwise rendered useless.

A number of properly spaced and located bushing assemblies (each including mandrel 35 and bushing 30) will protect the drill string itself, keep it substantially straight and prevent "dog legs," lateral deflections and other undesirable deviations in the drilled hole.

The use of a plural number of bushing assemblies, installed along the drill string as required by physical conditions indicated, will result in faster and less expensive hole making, leaving a hole more quickly and easily cased, with pumping difficulties reduced to a minimum.

Sometimes it comes about that an oil well tool, appliance, drill bit, drill stem, or other piece of equipment, may get stuck or become broken in the hole below a drill bushing 30. Such happening may necessitate an emergency operation, often requiring that all of the external rubber body 31a be cut away from each bushing 30 which is located above the trouble spot where the break or hang-up occurs.

A special cutting tool (not shown) is then lowered into contact with the rubber body which it is desired be sheared or cut away from the bushing. Such a tool is usually rotated around the core 10 of bushing 30 until the outer rubber body is removed therefrom.

The rotating cutting tool can not easily remove the outer rubber covering of the bushing unless and until the bushing itself is secured against rotation.

Under such conditions, the weighted cutting tool is lowered into contact with the external ribs of the bushing, and the bushing is forced downwardly against base band 36 on mandrel 35.

Band 36 is provided with upward looking clutch teeth 37. Each such tooth is provided with a beveled side or edge 38, and with a square or vertical side 40, leaving tooth slot 39 between each of the indicated sides of the adjoining teeth on band 36.

Base band 36 has two functions. Normally it fixes the lowest limit of vertical travel of bushing 30. It is also a clutch band, having its clutch teeth always open and extending upwardly.

When the drill string is rotated clockwise, during normal drilling operations, the open clutch teeth on band 36 will not enmesh with anything. Even when bushing 30 falls against base band 36, such as would be the case if well fluid were not being circulated, or if there were reverse circulation in the well, there would be no clutch engagement between band 36 and bushing 30.

The square edged teeth 14, depending from the lower part of core 10, are normally completely encased in a protective resilient rubber covering, so that teeth 14 are not exposed.

The rubber-like material covering bushing teeth 14 should be so formed as to provide depending extensions or projections of rubber 27, with lateral flow ports or notches 27 arranged between such projections.

This construction will insure the release and outward flow from the bushing of any well fluid entering it, as when the drill string is being lifted to the surface of the earth, through well mud, or the like, or when the well is temporarily in reverse circulation.

However, upon any emergency which requires the fixing of bushing 30 to the drill string, so as to prevent relative rotation therebetween, the bushing is forced downwardly with such thrust and weight that teeth 37 on clutch band 36 will penetrate the normally protective rubber covering encasing the lower end of core 10, so that core teeth 14 will be forced into clutch band recesses 39, and the band teeth 37 will come into locking engagement in the core recesses or gaps 15 between core teeth 14 in bushing 30.

In any event, it will be seen that whenever it is found necessary so to do, the bushing can be locked into engagement with the drill string, so that relative rotation therebetween is no longer possible. When this is done it becomes relatively easy to shear and cut away the exterior rubber body of the then firmly held bushing 30, through the use of a proper tool for such purpose.

If it be desired, the projecting stubs 12 can be dispensed with. To compensate for loss of bonding surface when stubs are not used, the number of holes 11, arranged through the core 10, should be greatly increased. Such holes may be placed closer together, either in vertical or staggered pattern. If two parallel lines of holes are provided for each external rib 16, then the internal ridges 21 may be staggered with respect to the ribs, so that one rib overlaps the proximate edges of two ridges, yet each rib will be bonded to each ridge through a double row of holes.

In normal drilling operations, in which the drill string has been stabilized and is being centrally maintained, through the use of a plurality of bushing assemblies stationed at proper intervals along the drill string, the upward circulation of well fluid through the interior of bushing 30 may be insured in several ways, through the use of structure hereinabove indicated, and/or other structure hereinafter described.

Fig. XI discloses a modified form of free-riding, rotatable anti-friction cap-ring 60, which may be loosely carried around mandrel 35, below head band 51 and above bushing 30.

Cap-ring 60 is provided with a plurality of lateral flow ports 61, arranged through the wall of the ring, below the area in which ring 60 makes contact with the outer wall of mandrel 35.

Flow ports 61 are in constant and free communication with an open passageway 62, which is an annular space arranged within cap-ring 60 and lying about the outer face of mandrel 35.

The free passageway 62 is in open communication with internal flow channels 22, which are vertically arranged within bushing 30.

Special cap-ring 60 may be provided with an overhanging lip 63, which is a protective member lying immediately about the upper extremity of bushing 30. Such lip will prevent any spreading or splitting of the top of bushing 30, and especially of the core 10 therein.

Cap-ring 60 should be beveled on its upper edge, as at 64, and a like bevel may be arranged around its lower edge. Such beveling will make vertical movement of the well string more safe and easy by lessening the chance of the ring being caught or hung under or against any projection in the well.

Should modified cap-ring 60 be added to a bushing assembly which includes the preferred form of bushing 30, which is made with flow notches or ports 26 around its upper edge, then such arrangement will provide a double row of flow ports, being those indicated as at 26 and at 61. Port 61 can never be worn away and will always remain open.

Where bushing 30 is made with a straight and smooth upper edge, and without the usual provision of projections 25 having flow ports or notches 26 therebetween, or whenever such projections may become worn off in use, it is considered necessary to use some suitable means to insure the lateral flow of fluid from the interior of the bushing, such as the cap-ring 60, or the modified form of head band shown as at 65. Head band 65 may be used in place of head band 51.

Modified head band 65 is detailed in Fig. XII, wherein it is shown provided with attachment face 68 for securing it to head member 50 of mandrel 35. Head band 65 is therefore not rotatable with respect to the mandrel. However anti-friction rings 59 may be carried immediately below head band 65 to protect the upper edge of bushing 30, if desired. Of course, the freely rotatable cap-ring 60 could be used for this purpose also.

Modified head band 65 is provided with a plurality of flow ports 66 which communicate with annular passage 67 arranged within the head, and such passage also communicates with vertical flow channels 22 arranged within bushing 30. Band 65 should be beveled as at 69.

Regardless of the form of head band employed as a part of the mandrel assembly, the head section 50 of the mandrel should be made to extend a short distance below the head band. A suitable lower extension of mandrel head 50 is shown at 53. A reduced portion thereof should be provided with external threads 54 to receive and engage the internal threads 36 arranged within the upper end of mandrel shank 33.

Having described my invention, presenting a durable and resilient drill string bushing, centralizer, stabilizer and journal bearing, for the making of faster drilled and straighter holes in the earth, together with preferred forms of certain safety flow mechanism and emergency clutch means, I claim:

1. In a drill string bushing tool, a hollow mandrel arranged to be incorporated as a part of a drilling string; a bushing loosely disposed on the mandrel; said bushing being comprised of a rigid tubular member having longitudinal ribs of resilient material bonded to the outer side thereof, longitudinal flow channels between the ribs, longitudinal ridges of resilient material bonded to the inner side of the tubular member, longitudinal flow grooves between said ridges, and lateral flow apertures provided about the upper end of the bushing; a head member arranged on the mandrel adapted to limit the upward movement of the bushing on the mandrel; a base member on the mandrel adapted to limit the downward movement of the bushing on the mandrel; and the lateral flow apertures being arranged to communicate with the grooves on the inner side of the bushing.

2. In a drill string bushing tool, a hollow mandrel arranged to be incorporated as a part of a drill string; a bushing loosely disposed on the mandrel, said bushing being comprised of a rigid tubular member having longitudinal ribs of resilient material bonded to the outer side thereof, longitudinal flow channels between the ribs, longitudinal ridges of resilient material bonded to the inner side of the tubular member, and longitudinal flow grooves between said ridges; a head member arranged on the mandrel adapted to limit the upward movement of the bushing on the mandrel; a base member on the mandrel adapted to limit the downward movement of the bushing on the mandrel; a ring loosely disposed about the mandrel between the end of the bushing and the head member, the said ring having lateral flow ports therein arranged to communicate with the flow grooves on the

inner side of the bushing while the ring is engaged by the bushing and the head member.

3. In a drill string bushing tool, a hollow mandrel arranged to be incorporated as a part of a drill string; a bushing loosely disposed on the mandrel, said bushing being comprised of a rigid tubular member having longitudinal ribs of resilient material bonded to the outer side thereof, longitudinal ridges of resilient material bonded to the inner side thereof, and longitudinal grooves between the ridges; a head member on the mandrel arranged to limit the upward movement of the bushing; a base member on the mandrel arranged to limit downward movement of the bushing; flow passages arranged at the upper end of the bushing communicating with the grooves on the inner side of the bushing; and an elongated travel area provided on the mandrel between the head member and the base member to permit longitudinal movement of the bushing relative to the mandrel.

4. In a drill string bushing tool, a hollow mandrel arranged to be incorporated as a part of a drill string; a bushing loosely disposed on the mandrel, said bushing being comprised of a rigid tubular member having longitudinal ribs of resilient material bonded to the outer side thereof, longitudinal ridges of resilient material bonded to the inner side thereof, and longitudinal flow grooves between the ridges; a head member on the mandrel arranged to limit the upward movement of the bushing; a base member on the mandrel arranged to limit downward movement of the bushing; lateral flow passages arranged at the upper end of the bushing communicating with the grooves on the inner side of the bushing; an elongated travel area provided on the mandrel between the head member and the base member; clutch teeth provided on the upper face of the base member; clutch teeth provided on the lower end of the tubular member, engageable with the clutch teeth on the base member.

5. In a drill string bushing tool, a hollow mandrel arranged to be incorporated as a part of a drill string; a bushing loosely disposed on the mandrel, said bushing being comprised of a rigid tubular member having longitudinal ribs of resilient material bonded to the outer side thereof; longitudinal ridges of resilient material bonded to the inner side of the tubular member, and flow grooves between the ridges; a head member on the mandrel arranged to limit the upward movement of the bushing; a base member on the mandrel arranged to limit downward movement of the bushing; lateral flow apertures arranged at the upper end of the bushing communicating with the grooves on the inner side of the bushing; and means for disengageably joining the mandrel intermediate the head and base members.

6. In a device of the character described, a hollow mandrel; an elastically coated rigid tubular member loosely disposed about the mandrel, the tubular member having longitudinal ribs of resilient material bonded to the inner and outer sides thereof, thereby forming longitudinal flow channels between the ribs; the said tubular member being slidably and rotatably carried on the mandrel; an enlarged head ring secured to the upper part of the mandrel and arranged to limit upward movement of the tubular member on the mandrel; an enlarged base ring secured to the mandrel in spaced relation to the head ring and arranged to limit the downward movement of the tubular member on the mandrel; and lateral flow passages provided intermediate the upper end of the mandrel and the upper end of the tubular member and arranged to allow fluid to flow through the tubular member and outwardly of the mandrel.

7. In a drill string bushing tool, a hollow mandrel arranged to be incorporated as a part of a drilling string; a bushing loosely disposed on the mandrel; said bushing being comprised of a rigid tubular member having longitudinal ribs of resilient material bonded to the outer side thereof, longitudinal flow channels between the ribs, longitudinal ridges of resilient material bonded to the

13

inner side of the tubular member, longitudinal flow grooves between said ridges, and flow apertures provided about the upper end of the bushing; a head member arranged on the mandrel adapted to limit the upward movement of the bushing on the mandrel; a base member on the mandrel adapted to limit the downward movement of the bushing on the mandrel; the flow apertures being arranged to communicate with the grooves on the inner side of the bushing; and at least one loose ring arranged about the mandrel intermediate the head and the end of the bushing.

8. In a drill string journal bearing tool, an elongated hollow mandrel; a circular head band arranged about the mandrel and having an inner face attached thereto; a circular base band arranged about the mandrel and attached thereto in such spaced relation to the head band as to provide therebetween an extended free travel space; a rigid tubular core slidably carried by the mandrel in said

14

space, the axial length of the core being substantially less than the axial length of the travel space, the core having attached thereto internally protruding resilient ribs arranged lengthwise of the core and so spaced apart as to provide flow channels therebetween; and flow apertures provided about the mandrel in spaced relation thereto between the upper end of the core and the attachment face of the head band and arranged to communicate with said channels; and spaced resilient ribs vertically arranged externally of the core and secured thereto.

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