June 18, 1946. K. A. WRIGHT 2,402,223

ROTARY WELL BORE CLEANER

Filed June 26, 1944 2 Sheets-Sheet 1

Fig. 1.

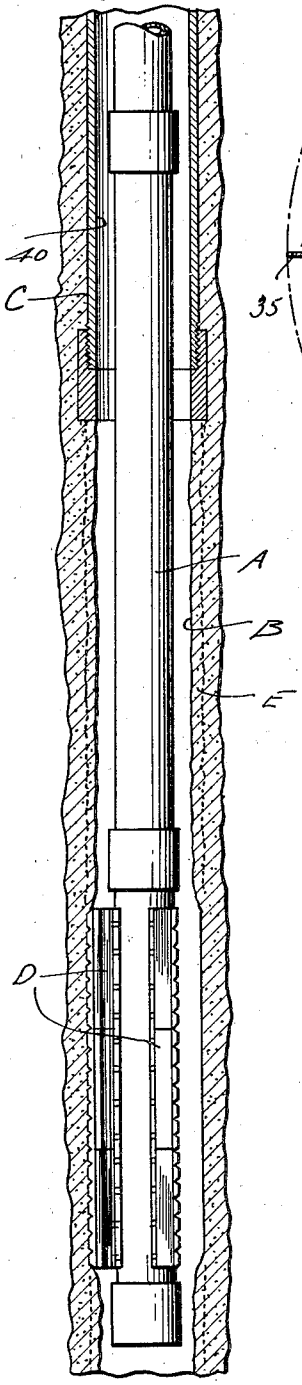


Fig. 2.

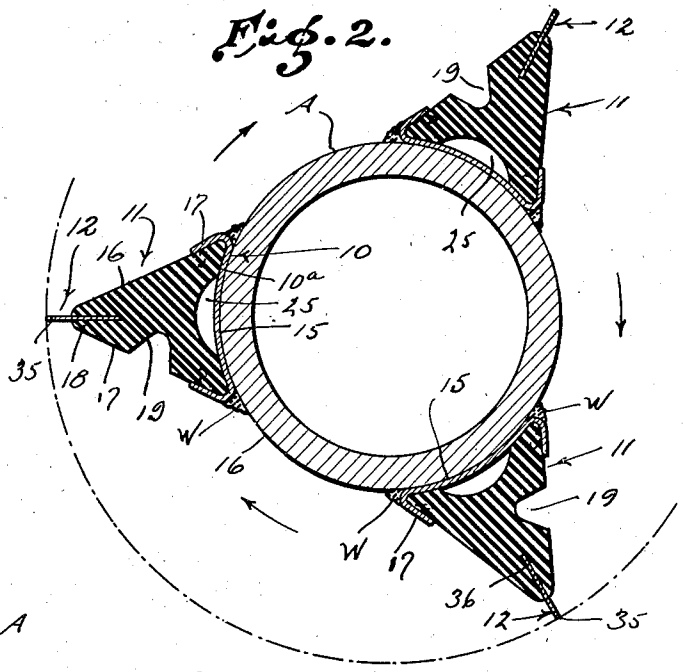


Fig. 3.

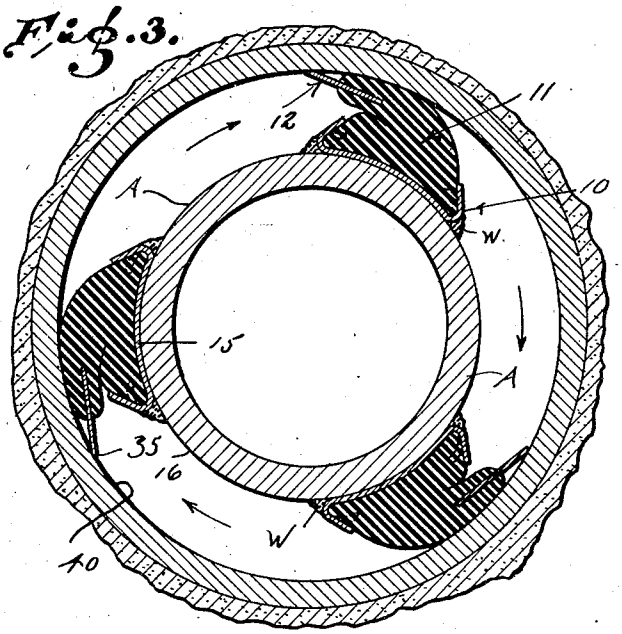


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Fig. 4.

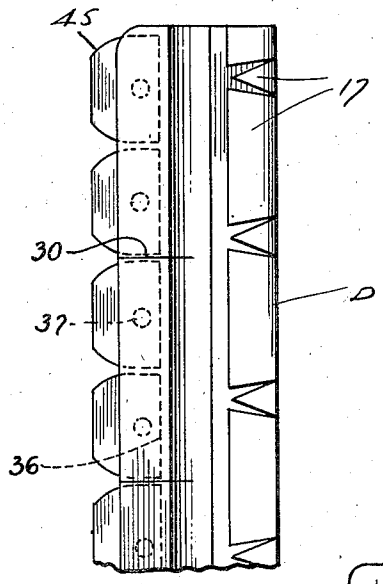



Fig. 5.

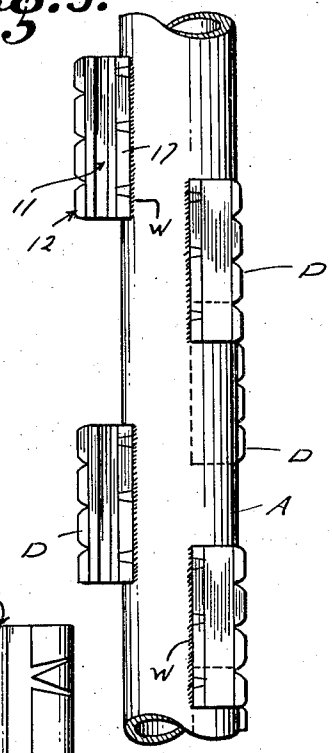



Fig. 8.

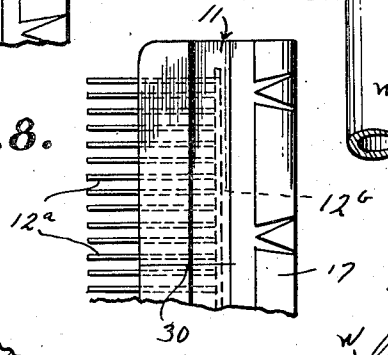



Fig. 6.

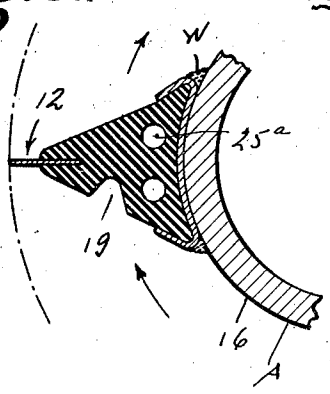
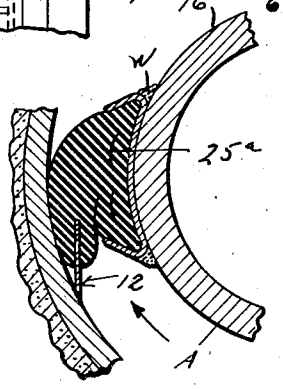



Fig. 7.

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Patented June 18, 1946 2,402,223

# UNITED STATES PATENT OFFICE

2,402,223

## ROTARY WELL BORE CLEANER

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Application June 26, 1944, Serial No. 542,033

8 Claims. (Cl. 166—18)

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This invention has to do with a cleaner for rotary drilled well bores and has particular reference to a device for removing a mud cake from the well wall during cementing or completion operations. A general object of the invention is to provide a simple, effective device or structure involving unique principles of construction and which is safe and dependable in operation.

With the rotary method of drilling wells mud is circulated through the drill pipe to the bottom of the bore as the drill stem is rotated. The mud returns in the annulus between the drill pipe and the formation. Filtration of water from the mud fluid into the formation results in the formation of a mud cake on the face of the formation. When subsequent operations are to be performed it is desired to remove the mud cake as it is not a solid or stable body against which to operate or build.

In rotary drilling, the entire drill stem comprising the bit, drill collar, drill pipe, and kelly is rotated in order to advance the drilling bit into and through the producing formation. After the well has been drilled to its desired depth, casing is run to, or near bottom and cemented. While the rotation of drill pipe is considered necessary, the general practice in cementing casing has been to either leave it stationary during the cementing operation or at best to move it upwardly and downwardly through a very limited vertical range. In a very few instances casing has been rotated as the cement slurry was pumped into position, but such rotation of casing has never been combined with the mounting of abrading devices on the outside of the casing at selected critical points to remove mud cake from the irregular annulus and from the formation face at these points in order to effect complete filling of the annular volume between the casing and clean formation with cement slurry.

The rotation of casing has been demonstrated to be safe practice regardless of depth and very little extra preparation and equipment is required to afford rotation of the casing string during the cementing operation. The devices that have been heretofore developed as cementing accessories for the centering of the casing have been designed for up and down travel of the casing during the cementing operation and are such as to clean away a mud cake through reciprocation of the casing.

It is a general practice to land and cement surface or conductor casing in a shale or other consolidated formation below the surface or fresh water bearing sands. This is usually at depths ranging from 300 to 2000 feet. This casing varies

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in size in different cases but is generally in the range of 8⅝ inches to 13⅜ inches in outer diameter. The inside diameter of this surface casing then controls the diameter of the drilling bit that can be used to drill to the productive formations and also controls the diameter of the production casing which may be used. Further, this inside diameter of the surface casing controls the design of any device that can be mounted on the production casing or on the drill pipe to be used in removing mud cake from the well bore opposite any of the lower formations. The design of such devices is also controlled by the normal hazards of depth, limited clearances, circulation requirements, higher temperatures, etc.

Particular care must be taken in performing operations in a well to avoid the use of any sort of a device or structure that may interfere with the free movement of the operating string through the well casing or which might tend to hang up or to be destroyed or injured in the course of being run through the well casing. In this connection it must be remembered that there are numerous shoulders exposed within a well casing where the sections are joined together and there may even be restricted portions in the well.

A method for the removal of the mud cake is the subject of my patent, No. 2,338,372, issued January 4, 1944, entitled "Method for conditioning well bores," and a device for use in carrying out such method is the subject of my Patent No. 2,374,317, issued April 25, 1945, entitled "Well production equipment."

The primary object of the present invention is to provide a device mountable on selected portions of well casing or drill pipe to be run through casing already installed or cemented in place and operable to expand and remove mud cake from the well bore, which device is not only dependable and effective in operation but safe to run under the severe and limited conditions encountered in practice. The device of the present invention is free of projecting parts subject to being caught or injured while being passed through a well casing and it is of a nature which permits of its being forced through the casing if circumstances so require.

Another object of the present invention is to provide a device of the general character referred to which not only collapses to facilitate passage through a well casing, or the like, but presents smooth effective bearing surfaces to engage the walls of the well casing, allowing free passage through the casing. When the device of the

present invention is operated through a well casing it presents smooth continuous parts which are effectively lubricated by the fluid in the well so that the device offers a minimum of friction or resistance to movement.

Another object of the invention is to provide a device of the general character referred to having abrading members yieldingly mounted to normally project in a manner to effectively act on a mud cake. These members may be plates or blades or they may be wires mounted to have abrading, scratching or scraping action and are designed to effectively scrape or peel the mud cake from the formation wall.

Another object of this invention is to provide a device of the general character referred to having a semi-rigid mounting which will hold the casing away from the formation wall regardless of the inclination of the well bore.

Another object of this invention is to provide a construction which permits free and undamaged travel of the device through restricted openings, and causes expansion of the abrading members into enlarged portions of the hole so the mud is effectively removed even though the contour of the wall is irregular.

Another object of this invention is to provide a device sufficiently flexible to adapt itself to the varying contour of the formation wall so that the protruding abrading members actuated by manipulation of the casing, either through rotation or reciprocation of the casing, effectively abrade, scrape, scratch or otherwise remove the undesirable mud cake from the formation wall.

Another object of this invention is to provide a device of the general character referred to which does not materially impede circulation of fluids in the well or within the casing as the device is being lowered therethrough. The structure of the present invention provides units that may be spaced circumferentially so that there are clear unobstructed channels for fluid circulation.

Another object of the present invention is to provide cleaner units of the general character above referred to which can be spaced longitudinally of the operating string and also circumferentially thereof as the operator desires, giving great latitude as to arrangement.

The various objects and features of my invention will be fully understood from the following detailed description of typical preferred forms and applications of the invention, throughout which description reference is made to the accompanying drawings, in which:

Fig. 1 is a view illustrating the lower end portion of a well that has been drilled by the rotary method and which has a casing set therein and showing the structure of the present invention on an operating string in the well and below the lower end of the casing to operate on the mud cake on the wall of the well. Fig. 2 is an enlarged detailed transverse sectional view of the operating string taken at the point where it is provided with the structure of the present invention showing several units of the present invention spaced around the operating string and showing the units fully expanded. Fig. 3 is a view similar to Fig. 2 showing the units of the present invention collapsed or contracted within a casing as is the case while the structure is being passed through a casing. Fig. 4 is a side elevation of one of the units of the present invention showing it detached from the operating string. Fig. 5 is a view of a portion of an operating string showing a manner in which units of



the present invention can be applied thereto. Fig. 6 is a transverse sectional view of a portion of an operating string showing a modified form of unit embodying the present invention applied thereto and in the expanded position, as is shown in Fig. 2. Fig. 7 is a view similar to Fig. 6 showing the structure illustrated in Fig. 6 collapsed as is shown in Fig. 3. Fig. 8 is a view similar to Fig. 4 showing a modified form of construction.

The device of the present invention, in accordance with certain broader aspects thereof, may be incorporated in various forms and may be applied to an operating string in various manners. A typical preferred form of the invention provides a plurality of individual units to be applied to the exterior of an operating string in a variety of arrangements. In the drawings I have shown two typical arrangements. In Figs. 1, 2 and 3 I have shown a plurality of units arranged in several rows disposed longitudinally of the operating string and circumferentially spaced around the operating string. In Fig. 5 of the drawings I have illustrated an arrangement in which the individual units are spaced apart longitudinally of the operating string and also circumferentially thereof to be in what may be termed a staggered arrangement.

The device of the present invention or the units provided thereby are such as to be applied to or handled on what I will term an operating string. This may be a string of pipe, or the like, such as drill pipe operated in the well specifically for the purpose of operating the cleaning units or it may be a pipe or casing intended to be left in the well as a part of the final well assembly. The operating string is essentially a string of pipe and may be either the surface or production casing or it may be the oil string which is left permanently in the well.

When the invention is used on drill pipe or tubing and the pipe is moved, either rotated or reciprocated or both, during the displacement of the cement slurry there is a proper placement of the cement against the cleaned formations. When the pipe is withdrawn the cement forms an impervious plug at the desired well depth Such placement of cement slurry opposite cleaned formation is a great improvement over present technique for installing plugs to exclude water or for directional drilling purposes.

For the purpose of example it may be considered that the operating string A shown in the drawings is a string of pipe lowered into the well for the specific purpose of handling and operating the units of the present invention.

In Fig. 1 of the drawings I have illustrated a well bore B with a casing C set therein, at a suitable point above the bottom, and I have shown the operating string A extending into the well bore below the casing C to there carry the units D of the present invention so that they are operable on the mud cake E occurring on the wall of the well bore.

The units of the present invention, regardless of how they are arranged or disposed in the operating string and whether the string be drill pipe or a casing, may be alike or substantially alike and, therefore, I will proceed to describe the construction of a single unit, it being understood that such description applies equally well to the several units that may be assembled on the operating string.

Referring in particular to the form of unit illustrated in Figs. 1 to 5 of the drawings, inclusive,

the unit includes, generally, a base 10, a body 11 and a blade 12. The base is a metallic element which serves as the means for mounting the unit on the exterior of the operating string A and to carry or support the body 11. The body 11 is preferably a unitary or integral member formed of rubber, or the like, and is retained or held by the base 10. The body is capable of expansion to an expanded or full operating position, as is shown in Fig. 2, and is collapsible to a retracted or collapsed position such as is shown in Fig. 3. The blade 12 is a metal element supported on the outer or projecting part of the body to project therefrom so that it will engage the mud cake to remove it from the well bore.

The base 10 in the preferred form of construction is a sheet metal part preferably formed of a single body of sheet metal and has a plate portion 15 designed to fit or bear upon the outer surface 16 of the operating string A. It is preferred that the plate portion 15 of the body have a concave surface that corresponds in curvature to the exterior 16 of the operating string so that the body has a flat, continuous bearing support on the operating member.

The base 10 is provided with means for holding or retaining the body 11. In practice this means may vary widely in form and construction. In the case illustrated the base is provided with projecting flanges or ears 17 formed and related to grip and hold the body 11. It is preferred to locate the ears 17 at the longitudinal edges or margins of the plate portion 15 and to shape or form them so that the ears at the opposite edges of the plate portion bear inwardly toward each other and thus confine and grip the body 10. It will be apparent that the flanges may be varied widely in shape and number and that they can be readily operated into pressure engagement with the body 11 to firmly and securely hold it. The body 11 is preferably an integral unit formed of rubber or the like. For use in oil wells where hydrocarbons are present it is preferred to form the bodies 11 of synthetic rubber of a kind or grade that is not attacked by oils.

The body 11 is an elongate member overlying the base 10 and may, in practice, correspond generally in length and width to the base 10. The body is formed or designed so that it is normally maintained in the expanded position shown in Fig. 2, by reason of the shape or inherent form and characteristics of the body itself, and yet is subject to being deflected or collapsed from the extended position to a collapsed position such as is shown in Fig. 3.

In the preferred form the body is generally triangular in cross sectional configuration in which case it has a base 10a that bears on or against the plate portion 15 of the base 10, sides 16 and 17 which extend outwardly from the margins of the base 10 and converge to form an apex portion 18. To facilitate the desired operation of the body the side 16 which is the leading side of the structure is operated or rotated in the direction indicated by the arrows in the drawings may be a continuous or plain flat wall such as is best illustrated in Fig. 2 of the drawings. With a plain or flat formation of the leading side of the body the trailing side 17 is preferably relieved as by a recess 19 so that it can be readily folded over or collapsed to a position such as is shown in Fig. 3. In the particular case illustrated I have shown but a single recess 19 and have shown such recess merely in the form of a groove extending longitudinally of the body. It is to be understood



that in practice various details can be incorporated in the trailing portion or side of the body that will allow it to readily fold in the manner shown in Fig. 3.

In accordance with the preferred form of the invention means is provided to facilitate the collapse of the body in addition to the folding above described. In the form of the invention shown in Figs. 2 and 3 this additional means is provided by recesses 25 in the base 16 of the body. When the body is collapsed the recess 25 is flattened so that its wall conforms to the plate portion of the base and is not apparent, as will be seen in Fig. 3 of the drawings.

In Figs. 6 and 7 of the drawings I have illustrated another manner whereby collapse of the body can be facilitated. In this case longitudinal openings or cavities 25a are provided in the body and are such as to flatten out so that their opposite walls bear on one another as is shown in Fig. 7 when the body is moved to the collapsed position.

In the preferred form of the invention the body 11 has cuts 30 formed transversely of its axis at points spaced along its length and extending inward from the apex portion 18a. These cuts 30 divide the body into a plurality of sections capable of individual operation or deflection and serve to add flexibility to the body structure generally.

The blade 12 is carried by the apex portion 18 of the body 11 so that it has an active edge portion 35 projecting beyond the apex portion of the body to engage and act on the mud cake as the tool operates. The blade has an inner mounting portion 36 which is embedded in the body to be retained thereby. This portion of the blade may have openings 37 occupied by the material of the body so that the body securely retains the blade.

In accordance with the preferred form of the invention the blade projects from the apex portion 18 of the body so that it is substantially radial of the operating string A when the body is fully expanded, as is shown in Fig. 2, and barely clears the inner wall 40 of the well casing C when the body is collapsed to facilitate passage through the well casing. In this way the blade is made fully active against the mud cake when the body is expanded and it is prevented from being injured or worn by the casing as it is being passed therethrough.

The blade 12 may be divided along its length so that it is in sections corresponding generally to the sections into which the body is divided by the cuts 30. In fact, as shown in Fig. 4 of the drawings, the blade may be divided within each section of the body so that instead of being one continuous blade as it may be in some cases, it is in the form of a plurality of individual blade parts each capable of independent or individual movement. This construction gives the device flexibility that may be highly desired in some cases. In the form of the invention shown in Fig. 8 the blades instead of being flat are in the form of wires 12a. The wires are shown held or anchored to a tie 12b embedded in the body 11.

The blade 12 is preferably formed of steel or like metal and its end or the ends 45 of its several sections are preferably rounded off as shown in Fig. 4 to minimize any danger of it being caught on obstructions that may occur in the well casing.

In using units provided by the present invention they may be arranged in several rows length-

wise of the operating string A which rows are spaced circumferentially of the operating string as is shown in Figs. 1, 2 and 3 of the drawings, or they may be arranged in any manner that the operator desires to obtain the best results. In Fig. 5 the staggered arrangement is typical of an alternative arrangement that can be used.

In accordance with the broader aspects of the present invention the units constructed as above described can be applied to the operating string in any suitable manner. It is preferred to apply the units to the outer surface or wall 16 of the operating string and, in practice, this can be done most advantageously by welding W applied along the edges of the base 10 joining the edge portions of the base 10 with the operating string A. Throughout the drawings I have shown this welded form of mounting but do not wish to be understood as limiting the invention to this or any other specific form or mounting that may be employed.

The units of the present invention applied to the operating string A can be readily passed through the well casing C to a point below the lower end of the well casing. The bodies of the units collapse as they are passed through the well casing and are in the position shown in Fig. 3 while they are within the casing. It is to be noted that the leading sides 16 of the units have portions facing or bearing outwardly against the casing wall 40 forming bearings that are smooth and which allow free movement of the units through the casing. With fluid present in the well, as it normally is, and the bodies 11 being formed of rubber or the like, the faces or sides 16 which bear on the wall of the casing do so with a minimum of friction and without wearing or destroying the units.

During the passage of the unit through the casing its operating blade or blades are deflected from active position so that they do not catch on obstructions and are not in any way injured or worn by the movement through the casing.

When the units on the operating string are below the lower end of the well casing C and the operating string is rotated as indicated by the arrows, the bodies 11, which normally tend to move to the fully extended position shown in Fig. 2, operate the blades outwardly into engagement with the mud cake and as the mud cake is cut away the blades continue to expand until they have reached their maximum or fully expanded position, as shown in Fig. 2.

Because of the construction above described if an obstruction is encountered at any particular point the entire structure is not rendered inoperative. By rotating the operating string and advancing it longitudinally in the well bore either upwardly or downwardly the bore can be effectively cleaned of the mud cake E. The operating string can be rotated, or reciprocated, or both rotated and reciprocated. It is preferred in practice, of course, to employ the structure of the present invention in carrying out the method taught in my above mentioned patent. However, the nature of the present invention is such that it is not necessarily limited to any particular method of operation. It can be used to advantage on drill pipe intended to be removed from the well or on casing which is to be left or cemented in the well.

Having described only typical preferred forms and applications of my invention, I do not wish to be limited or restricted to the specific details herein set forth, but wish to reserve to myself



any variations or modifications that may appear to those skilled in the art and fall within the scope of the following claims.

Having described my invention, I claim:

1. A device of the character described for use on an elongate operating member and for passage through a casing, or the like, including, a body of rubber for attachment to the operating member, and a straight elongate blade carried by and projecting substantially radially outward from the body to extend parallel with the operating member, said body and blade normally projecting a substantial distance from the operating member to which the body is applied, the body being so arranged as to be subject to being circumferentially folded inward by a surrounding medium when in a well to position the blade inwardly of its normal position.

2. A device of the character described for use on an elongate operating member and for passage through a casing, or the like, including, a body of rubber for attachment to the operating member, and a straight elongate blade carried by the body to extend parallel with said member and projecting outwardly from the body, said body and blade normally projecting a substantial distance from the operating member to which the body is applied, the body being so arranged as to be subject to being circumferentially folded inward by a surrounding medium when in a well to position the blade inwardly of its normal position, the body being an elongate member divided transversely into a plurality of sections free to fold individually, the blade being sectional and having a section carried by each section of the body.

3. A device of the character described for use on an elongate operating member and for passage through a casing, or the like, including, a body of rubber for attachment to the operating member, and a straight elongate blade carried by and projecting substantially radially outward from the body to extend parallel with the operating member, said body and blade normally projecting a substantial distance from the operating member to which the body is applied, the body being so arranged as to be subject to being circumferentially folded inward by a surrounding medium when in a well to position the blade inwardly of its normal position, the blade being divided transversely into a plurality of independently movable sections.

4. A device of the character described for use on an elongate operating member and for passage through a casing, or the like, including, an elongate body of rubber for attachment to the operating member to extend parallel therewith, and a straight, elongate, rigid working element carried by the body to extend parallel therewith and projecting outward from the body, the body and element normally projecting a substantial distance from the operating member, the body being so arranged as to be subject to being circumferentially folded inward by a surrounding medium when in a well to position the working element inwardly of its normal position, there being an opening in the body lengthwise thereof to facilitate folding thereof.

5. A device of the character described for use on an operating member and for passage through a casing, or the like, including, an elongate body of rubber having a recessed base portion to be supported on the operating member, and side walls that project from the base portion and converge to an apex portion, and a working ele-

ment carried by and projecting outward from the apex portion of the body, one of the side walls being recessed so the body will fold circumferentially inward to position the working element inwardly of its normal position.

6. A device of the character described for use on an operating member and for passage through a casing, or the like, including, an elongate body of rubber having a longitudinally recessed base portion to be supported on the operating member, and side walls that project from the base portion and converge to an apex portion, and a working element carried by and projecting outward from the apex portion of the body, one side of the body having a longitudinal recess therein arranged to facilitate folding of the outer portion of the body circumferentially inward for passage through a casing.

7. A device of the character described for use on an operating member and for passage through a casing, or the like, including, an elongate body of rubber having a base portion to be supported



on the operating member, and side walls that project from the base portion and converge to an apex portion, and a working element carried by and projecting outwardly from the apex portion of the body, one side of the body being smooth and continuous to slide on the casing when the body is folded circumferentially for passage through a casing, the other side of the body being longitudinally recessed to facilitate such folding of the body.

8. In combination, an operating string and a plurality of elongate units arranged longitudinally of the string and spaced apart circumferentially thereof, each unit including a body of rubber longitudinally recessed so it is free to fold circumferentially of the string to facilitate passage of the string through a casing and a work element carried by the foldable portion of the body to normally project radially outward from the string and to project substantially circumferentially of the string when the body is folded.

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