April 14, 1959 J. S. BECK 2,882,015

DIRECTIONAL WINDOW CUTTER FOR WHIPSTOCKS

Filed June 10, 1957 2 Sheets-Sheet 1

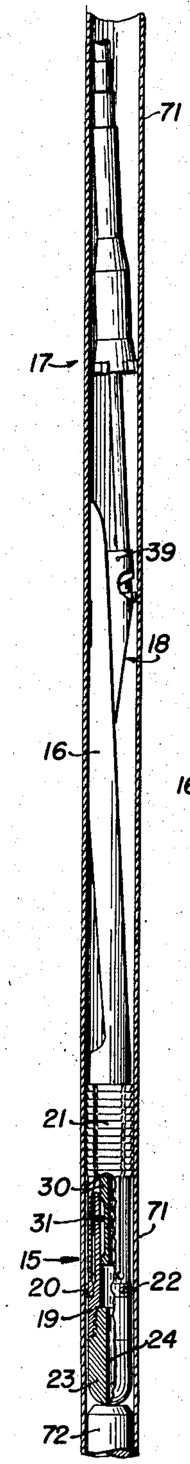


FIG. 1.

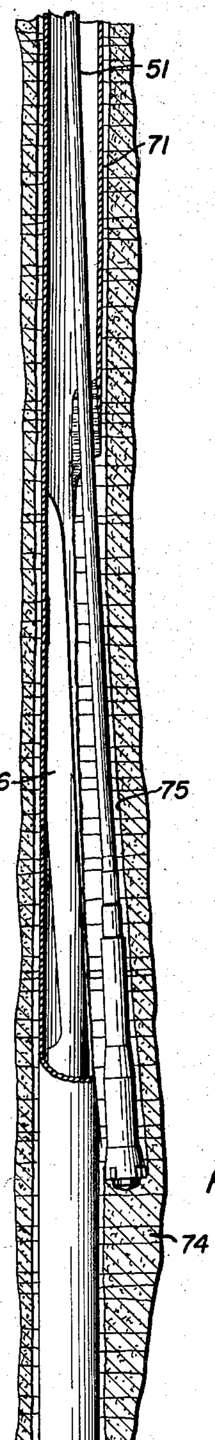


FIG. 2.

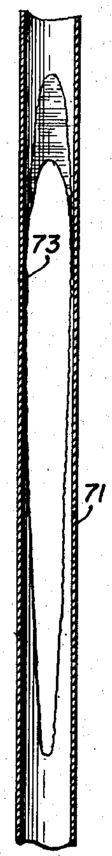
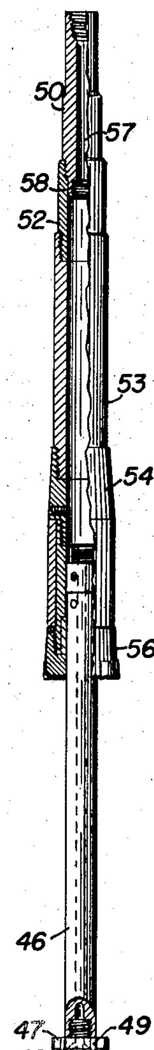


FIG. 3



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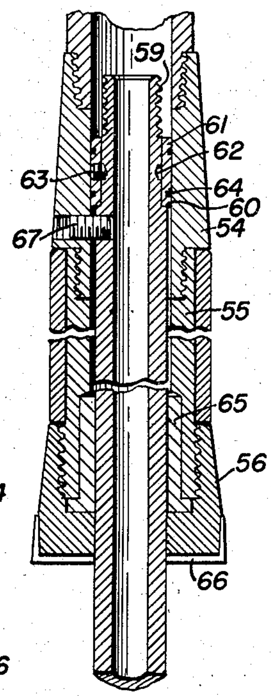

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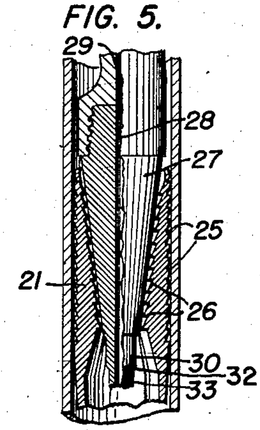

FIG. 13.

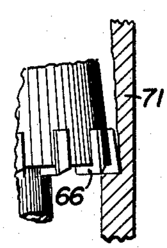

FIG. 14.

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DIRECTIONAL WINDOW CUTTER FOR WHIPSTOCKS

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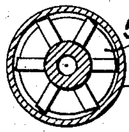
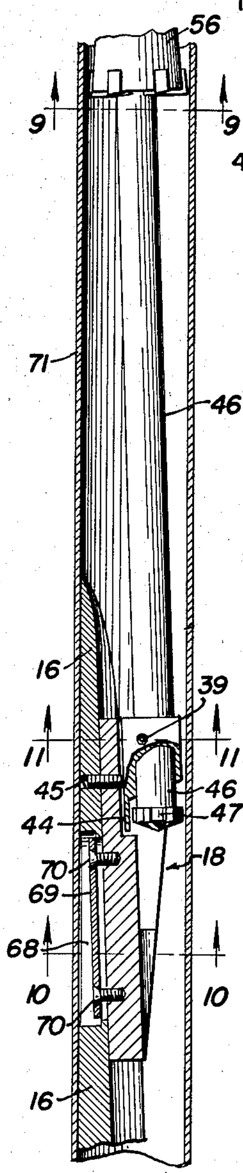


FIG. 9.



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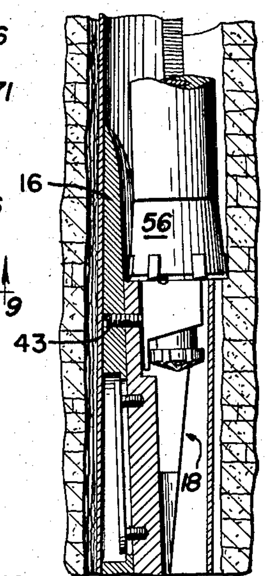
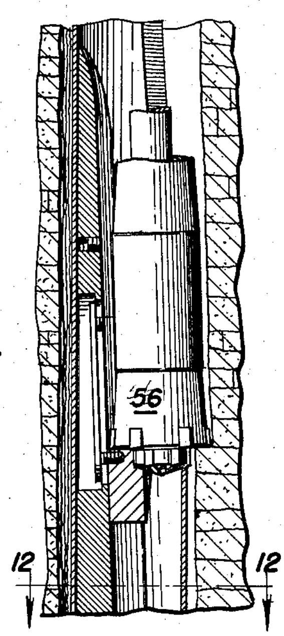


FIG. 7.



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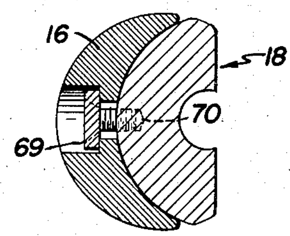

FIG. 10.

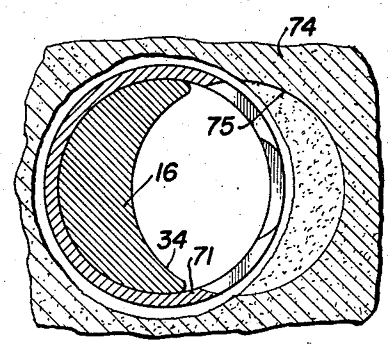

FIG. 12.

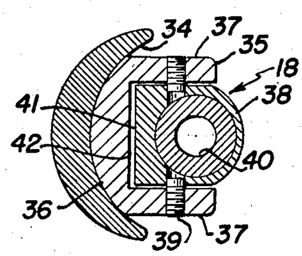

FIG. 11.

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DIRECTIONAL WINDOW CUTTER FOR WHIPSTOCKS

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Application June 10, 1957, Serial No. 664,602

7 Claims. (Cl. 255—1.6)

This invention relates to the rotary method of drilling wells and has reference to a whipstock and mill for cutting a side opening or "window" in casing in a well bore. This application is a continuation in part of my copending application, Serial No. 373,116, filed August 10, 1953, now Patent No. 2,807,440, issued Sept. 24, 1957. Generally, the invention is directed to improved apparatus for sidetracking an obstruction in a well, for diversional drilling, and for other whipstock operations.

Heretofore, side openings were made in well casings by various methods, such as shooting explosives, the use of various types of successive graduated mills, grinding abrasives against the casing wall, and ripping the casing with special tools for that purpose; however, such methods were objectionable because they left ragged edges and irregular openings in the casing. Sometimes the resulting openings were too small for the intended purpose, and in some instances the openings extended more than one-half the diameter of the casing. In many instances the casing was weakened and parted causing difficulties in continuation of drilling. The ragged edges around the casing opening in prior methods severely scored the drill stem and sometimes cut through the same with the result that a difficult fishing job followed.

An object of the invention is to cut a maximum size window or opening in the side of a casing in a well bore; that is, to make the size of the opening in the casing equal to the inside diameter of the casing in a single operation.

Another object is to provide means for accurately controlling the angle of declination with respect to the axis of the well bore.

A particular object of the invention is to provide a multiple milling cutter assembly which will not leave an elliptical casing sliver such as formed when using a single rotary hollow mill.

Another object is to provide an inclination control mandrel which may be adjusted to prevent the first mill of a multiple mill assembly from contacting and marring the whipstock and thus prevent unnecessary wear on the mills.

A further object is to provide means whereby the milling cutter is prevented from penetrating the casing too abruptly; which abrupt penetration would result in a "dog leg" or opening which would be difficult to enter during subsequent drilling operations.

Other objects will become apparent from the following description which has reference to the accompanying drawings, wherein:

Figure 1 is a vertical section of a well casing and shows the present invention positioned to begin its cutting operation.

Figure 2 is a broken elevation of a well casing in an earth formation and showing the present invention after the same has cut a casing opening.

Figure 3 is a vertical sectional view of a casing and showing the casing opening formed by the present apparatus.

Figure 4 is a broken section and elevation of the present multiple milling cutter assembly.

Figure 5 is an enlarged vertical section of the large milling cutter and the mandrel on which it is mounted.

Figure 6 is a vertical sectional view of the casing and showing the upper portion of the whipstock in section and illustrating the hinged adjustment of the mandrel bearing.

Figure 7 is a vertical sectional view showing the relative positions of the two milling cutters after the casing has been partly cut.

Figure 8 is a sectional view similar to Figure 7, and showing a further step in the cutting operation.

Figure 9 is a transverse section taken on line **9—9** of Figure 6.

Figure 10 is an enlarged transverse section taken on line **10—10** of Figure 6.

Figure 11 is an enlarged transverse section taken on line **11—11** of Figure 6.

Figure 12 is an enlarged transverse section taken on line **12—12** of Figure 8.

Figure 13 is a vertical sectional view of the upper end of the anchor and showing the conical slip wedge secured to the lower end of the whipstock for securing the latter against rotation.

Figure 14 is a vertical fragmentary section showing the larger milling cutter partially through the casing and wherein part of the weight of the drill pipe is supported thereon.

As shown in the drawings, particularly Figure 1, the primary components of the invention are an anchor **15**, a whipstock **16** supported on and above the anchor, a dual milling cutter assembly **17**, and a bearing support generally indicated at **18**. The anchor is comprised of a hollow cylindrical body **19** having a shoulder **20** therearound for supporting split collet type slips **21**, the latter being secured to the body **19** by means of screws **22** through the circular lower portion of the body. A round nose plug **23** is threaded in the lower end of the slip body **19**, and which plug has an axial fluid circulating port **24** therethrough. In addition to the external teeth **25** on the slips **21**, the slips are provided with internal teeth **26** arranged to engage the conical surface of a wedge **27** threadedly engaged in the lower end of the whipstock **16**. Both the wedge **27** and whipstock **16** have axial passages **28** and **29**. There is a depending wedge extension **30** integral with the lower end of the wedge **27** for slidably engaging the anchor body **19** and supporting anchor **15** when the present apparatus is being placed in operating position. The last referred to engagement is accomplished by means of a screw **31** extending through the wall of the anchor body **19** where it engages the upper surface of a shoulder **32** on the lower end of the wedge extension **30**. The shoulder **32** is formed by reducing the outside diameter of the extension **30** between the ends thereof, and the length of which is of reduced diameter **33** to provide limited longitudinal movement between the anchor **15** and the whipstock **16**.

The whipstock **16** includes the usual inclined guiding surface **34**, arcuate in cross section, and near the top of which is located a bearing support **35** shown in detail in Figures 6, 10 and 11, and which support is of readily drillable material, such as aluminum. By contrast, the whipstock **16** is of heat treated steel or other suitable hard material. The bearing support **35** has an arcuate side **36** to fit the inclined surface **34** of the whipstock **16**, whereas the adjacent sides **37** of the support project perpendicularly to provide a cradle for a mandrel bearing **38** received therebetween. The bearing **38** is hingedly supported by plain end set screws **39** in the support sides **37**, the axis of which is perpendicular to the axis of the bearing bore **40**. As shown in Figure 11, the surface **41** of the bearing **38** between the inner corners of the sides **37** is preferably flat and spaced from the opposing flat surface **42** of the support **35** to permit limited hinged movement of the bearing **38**. As shown in Figures 1 and 6, the hinge screws **39** are near the top of the support **35** and bearing **38**, and are inwardly positioned with respect to the axis of the bearing bore **40**. The angular position of the bearing **38** is determined and fixed by means of an angle control set screw **43** threaded in the upper portion of the support **35** and in engagement with the flat surface **41** of the bearing. The axis of the angle control set screw **43** is perpendicular to, but below the axis of the hinge screws **39**. A depending stop **44**, for contact with the surface of the support **35**, may be provided at the lower end of the flat bearing surface **41** for further limiting the hinged movement of the bearing **38**. A hole **45** is provided in the whipstock **16** for access to the outer end of the angle control set screw **43**.

The dual mill cutter assembly **17** includes a tubular mandrel **46** rotatably and slidably mounted in and extending through the bore **40** of the bearing **38**. A conical pilot milling cutter **47** is secured to the lower end of the mandrel **46**, which cutter has circulation ports **48** between the cutter blades **49** for communication with the axial opening through the mandrel. The upper portion of the dual milling cutter assembly **17** is comprised of an upper sub **50** for connection with the lower end of a drill pipe **51**, a connecting sub **52**, a tubular receiver **53**, an adapter sub **54**, a cylindrical mill support **55** and a primary cutting mill **56**. As will be apparent from Figure 6 of the drawing the diameter of the primary cutter **56** is substantially equal to the internal diameter of the casing **71**.

The passage **57** through the upper sub **50** is of somewhat reduced diameter so as to provide sufficient material for internal threads **58** in the lower end thereof, which threads are adapted to engage external threads **59** on the upper end of the mandrel **46**. As shown in Figure 5, the upper end of the mandrel **46** is of reduced diameter so as to provide a shoulder **60** for supporting a bearing sleeve **61** thereon. The bearing sleeve **61** is a sliding fit in the adapter sub **54**, the tubular receiver **53**, and the connecting sub **52**. The bearing sleeve **61** is rotatably mounted on the upper end of the mandrel **46** where the latter is provided with a circular groove **62** on its outer surface for receiving the round end of a retaining screw **63** threadedly engaged in the said sleeve. Ring seals **64** may be provided around the sleeve **61** to prevent entry of drilling fluids around the mandrel **46**.

The lower end of the cylindrical mill support **55** is counterbored to receive a flanged bearing **65** for slidably and rotatably receiving the mandrel **46**. Similarly, the axial center of the mill or primary cutter **56** is provided with an opening for the same purpose. It will be noted that the blades **66** of the mill **56** extend inwardly to the diameter of the mandrel **46**, and that the blades **49** on the lower mill extend outwardly beyond the mandrel diameter. Thus, the two mills, when in operation, act upon and cut an entire circular area as will become apparent from the description of operation to follow.

A threaded shear pin **67** is positioned through the side of the adapter sub **54** and into the mandrel **46** near the top thereof for initially maintaining the pilot and primary milling cutters **47** and **56** in extended spaced relation whereby downward and lateral sliding movement is imparted to the bearing support **18** mounted on the upper inclined surface of the whipstock **16**. The sliding movement last referred to is accomplished by means of the connection between the whipstock **16** and bearing support **18**, which connection is comprised of an inwardly shouldered vertical slot **68**, a holding plate **69** slidably mounted in the slot, and bolts **70** through the plate and threaded in the bearing support.

Operation

In operation, the angle control screw **43** is first adjusted to determine the angle of declination, after which the described apparatus is lowered in the well casing **71** by means of the drill pipe **51** until the nose **23** of the anchor **15** contacts the obstruction **72** in the casing. In some operations, it is a pinched casing to be sidetracked, and in which case the nose **23** contacts the pinched casing portion. In other operations, as in directional drilling, a plug (not shown) may be set in the casing for seating the anchor **15**.

When the apparatus is suspended, as during the lowering operation, the bearing support **18** is in a raised position on the upper end of the whipstock **16**, and the slips **21** are retracted by reason of the suspended position of the anchor **15**. When the anchor nose **23** makes contact, as above referred to, continued downward movement of the drill pipe causes the cylindrical wedge **27** on the lower end of the whipstock **16** to expand the slips **21** and grip the inner surface of the casing **71**. The last referred to operation is carried out by means of the external teeth **25** on the slips **21** and at the same time the internal teeth **26** grip the wedge **27**. Thus, the whipstock **16** is secured against rotation in the casing **71**. Continued downward movement of the drill pipe **51** brings the lower cutter **47** in contact with the inner surface of the casing **71**, and after which the shear pin **67**, connecting the adapter sub **54** with the mandrel **46**, is sheared. The lower cutter **47** in contact with the casing **71** secures the mandrel **46** against rotation during the immediately following stage of the operation. Rotation of the drill pipe **51**, and downward movement thereof, causes the upper mill **56** to begin the window cutting operation in the casing. As the upper mill **56** moves downwardly, the upper end of the mandrel **46** is slidably received through the upper or primary cutter **56**, the cutter bearing **65**, adapter sub **54**, tubular receiver **53**, and ultimately the threads **59** in the upper end of the mandrel engage the threads **58** in the lower end of the upper sub **50**. After the threaded engagement takes place, the lower mill or pilot cutter **47** begins its cutting operation. Continued downward cutting causes the upper mill or primary cutter **56** to cut away the bearing support **35** and bearing **38**; however, by this time the angle of the cut has been started and additional guiding of the cut is by reason of the contact of the primary mill **56** on the inclined surface **34** of the whipstock **16**. The resulting cut is an elliptical opening **73** or "window" as shown in Figure 3, and after which the drilling operation is continued into the earth formation **74**, as shown in Figure 2. Smaller casing (not shown) for the sidetrack bore **75** is then lowered through the previously described casing **71** and set in the usual manner.

The invention is not limited to the exemplary construction herein shown, but may be varied within the scope of the accompanying claims.

What is claimed is:

1. Apparatus for cutting a side opening in a casing in a well bore, comprising an anchor including means for securing the same to the inner surface of the casing, a bearing supported and secured by said anchor at the upper end thereof, the axis of said bearing being angularly positioned with respect to the axis of the well bore, a mandrel rotatably and slidably mounted in and extending through said bearing, a primary mill cutter, means for securing the primary mill cutter to the lower end of a rotary drill pipe above said bearing, a pilot milling cutter secured to the lower end of said mandrel below said bearing, said primary cutter including an axial open-

ing therethrough slidably and rotatably receiving said mandrel, and means engaging the pilot cutter with said primary cutter to rotate therewith when said mandrel is substantially fully received in the primary cutter.

2. Apparatus as set forth in claim 1, wherein a whipstock is mounted on said anchor and said bearing is mounted on the upper inclined surface of said whipstock.

3. Apparatus as set forth in claim 2, wherein the bearing is mounted for slidable movement along the inclined surface of said whipstock.

4. Apparatus for cutting a side opening in a casing in a well bore as defined in claim 1, the construction wherein said bearing is hingedly supported above said anchor, the hinged axis being perpendicular to the axial bore of the bearing.

5. Apparatus for cutting a side opening in a casing in a well bore as defined in claim 4, and including a screw carried by said anchor, one end of said set screw being in contact with said bearing, the axis of said screw

being offset with respect to the hinged axis of the bearing.

6. A cutting apparatus as set forth in claim 1, wherein the diameter of the primary mill cutter is of substantially the same diameter as the diameter of the casing, and the diameter of the pilot cutter is of less diameter than the diameter of the primary cutter but of greater diameter than the axial opening in the primary cutter, and the combined cutting surfaces of the primary and pilot cutters being such that a complete side opening is cut in the casing by the two cutters combined.

7. A cutting apparatus as set forth in claim 1, wherein the said bearing is formed of readily drillable material.

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