Oct. 8, 1957 A. W. KAMMERER, JR 2,809,016

EXPANSIBLE ROTARY DRILL BITS

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Fig. 1.

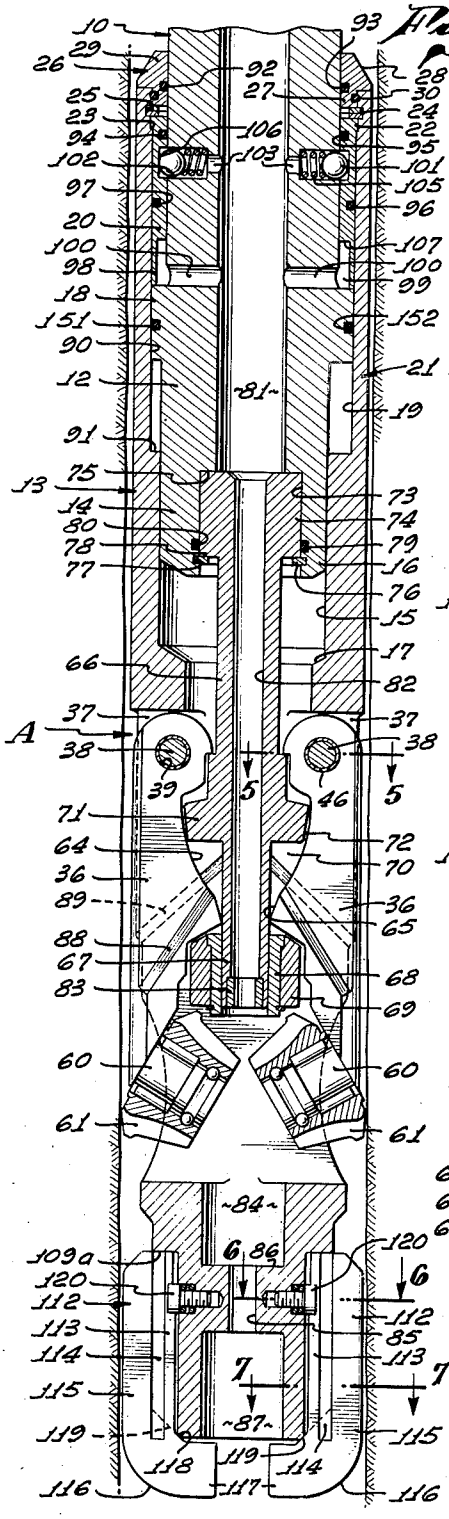
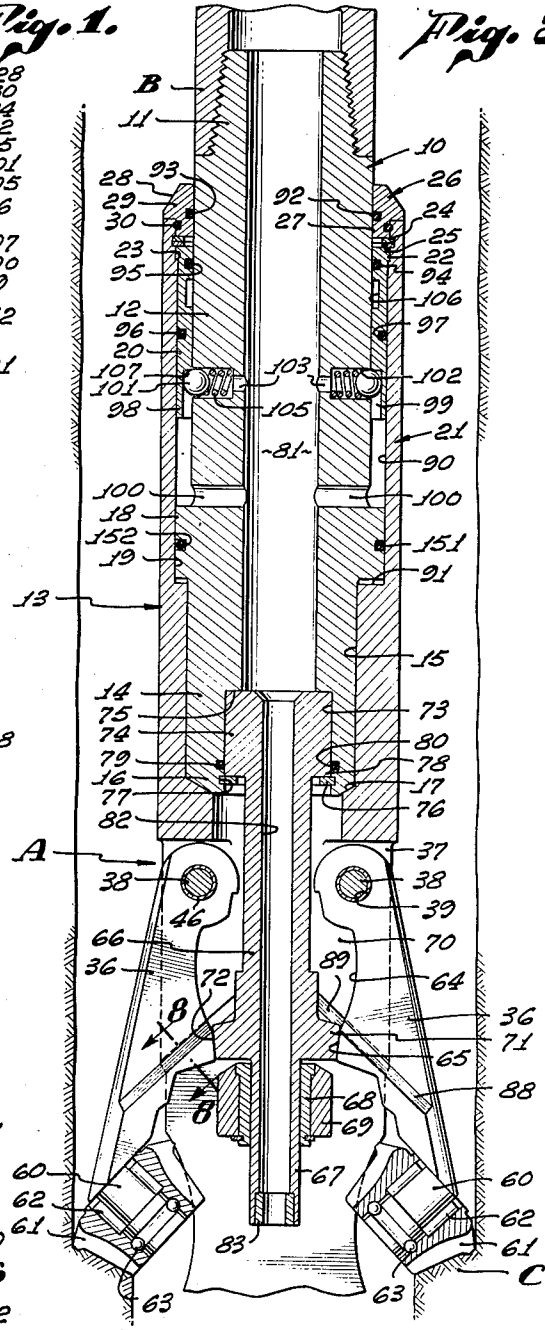


Fig. 2.



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Fig. 3.

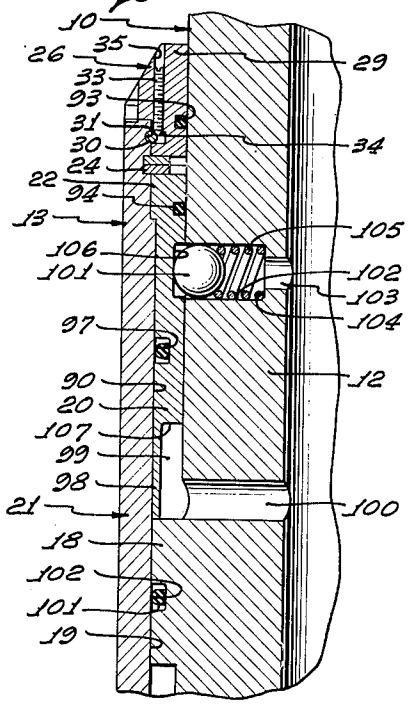


Fig. 4.

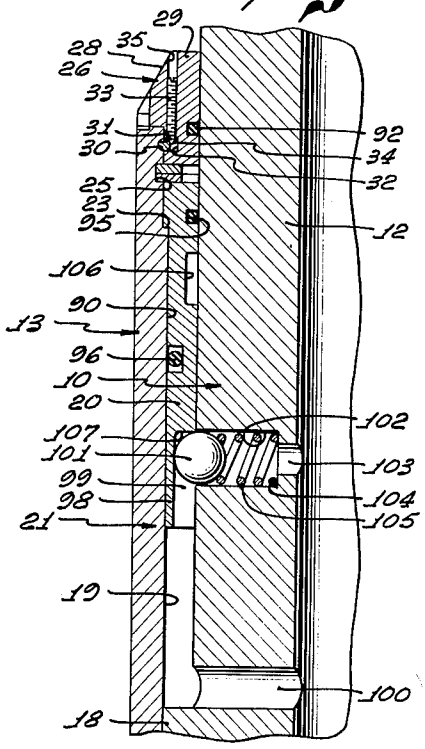


Fig. 5.

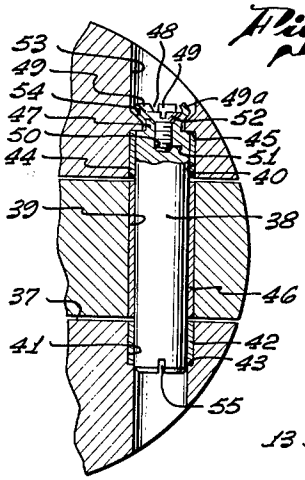


Fig. 7.

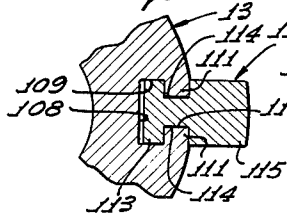


Fig. 8.

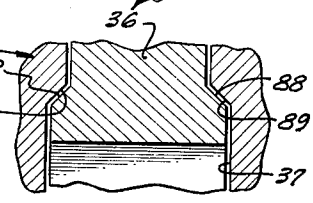
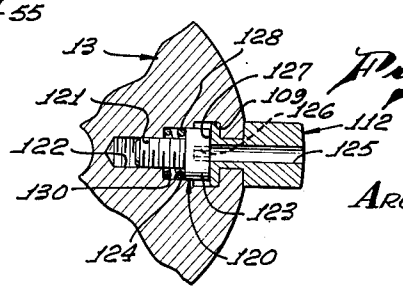


Fig. 6.



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2,809,016

EXPANSIBLE ROTARY DRILL BITS

Archer W. Kammerer, Jr., Fullerton, Calif., assignor of three-fifths to Archer W. Kammerer, and one-fifth to Jean K. Lamphere, Fullerton, Calif.

Application May 26, 1955, Serial No. 511,187

15 Claims. (Cl. 255—76)

The present invention relates to rotary drill bits, and more particularly to rotary drill bits of the expansible type adapted to be lowered through well casing, for the purpose of drilling or enlarging a well bore below the casing to a greater diameter than the inside diameter of the casing.

An object of the invention is to provide a rotary drill bit having cutters expandible laterally outward by hydraulic pressure, in which the cutters are releasably retained in their outwardly expanded position in the absence of hydraulic pressure in the drill bit, and despite the lack of drilling weight on the cutters.

Another object of the invention is to provide an expansible rotary drill bit having cutters expanded laterally outwardly by hydraulic pressure, and embodying a detent device for retaining the cutters in their expanded position, in which the detent device can be availed of for relieving the fluid pressure tending to hold the cutters in their expanded position, to insure retraction of the cutters when the bit is to be retrieved from the well bore. Liquids are permitted to pass to and from the hydraulic portions of the drill bit through the detent device, but the detent device is of such character as to prevent solid particles from passing therethrough to the hydraulic portion of the apparatus, thereby minimizing any tendency for such hydraulic portion to become plugged.

A further object of the invention is to provide an expansible rotary drill bit having cutters expanded laterally outward by hydraulic pressure, and embodying a detent device for retaining the cutters in their expanded position or for inadvertently allowing the cutters to be expanded when their retention in a retracted position is desired.

This invention possesses many other advantages, and has other objects which may be made more clearly apparent from a consideration of a form in which it may be embodied. This form is shown in the drawings accompanying and forming part of the present specification. It will now be described in detail, for the purpose of illustrating the general principles of the invention; but it is to be understood that such detailed description is not to be taken in a limiting sense, since the scope of the invention is best defined by the appended claims.

Referring to the drawings:

Figure 1 is a longitudinal section through an embodiment of the invention disposed in a well bore, with the cutters and other parts in their initial and retracted positions;

Fig. 2 is a longitudinal section similar to Fig. 1, disclosing the cutters locked in their fully expanded position;

Fig. 3 is an enlarged fragmentary longitudinal section disclosing the hydraulic and detent portion of the apparatus in the relative position they occupy when the cutters are in their retracted position;

Fig. 4 is a view similar to Fig. 3, disclosing the relative position of the parts when the cutters are in the expanded position disclosed in Fig. 2;

Fig. 5 is an enlarged cross-section taken along the line 5—5 on Fig. 1;

Fig. 6 is an enlarged cross-section taken along the line 6—6 on Fig. 1;

Fig. 7 is an enlarged cross-section taken along the line 7—7 on Fig. 1;

Fig. 8 is an enlarged cross-section taken along the line 8—8 on Fig. 2.

As disclosed in the drawings, a rotary expansible drill bit A is provided which can be secured to the lower end of a string of drill pipe B extending to the top of a well bore, by means of which the drill bit is lowered through a string of well casing (not shown) to a region below the casing shoe (not shown) where the hole enlarging operation is to commence. The general type of expansible drill bit shown in the drawings is both illustrated and described in Patent No. 2,545,036, to which attention is invited for certain structural details that are not disclosed nor described herein in detail.

The upper portion of the rotary drill bit consists of a tubular mandrel **10** having an upper pin **11** threadedly connected to the lower end of the string of drill pipe B. This mandrel includes an upper kelly or drill stem member **12** slidably splined to the main body **13** of the bit, as by having a lower, non-circular portion **14** of the kelly adapted to be telescopically received in a companion socket **15** formed in the main bit body.

The mandrel **10** has a limited range of longitudinal movement within the body **13**, its downward movement being determined by engagement of the lower end **16** of the kelly with an inwardly directed body shoulder **17**, its upward movement being limited by engagement of an external shoulder or piston portion **18** of the kelly, which fits within a counterbore **19** in the body of the tool above its socket portion **15**, with a cylinder head **20** secured to the body. This cylinder head **20** constitutes the upper portion of a hydraulic cylinder **21** in which the piston **18** operates, the cylinder head having an upper outwardly directed flange **22** adapted to engage an upwardly facing shoulder **23** in the body to prevent downward movement of the head relative to the body. Upward movement of the head **20** with respect to the body is prevented by one or more split snap retainer rings **24** received within an internal groove **25** in the body and extending across the upper end of the cylinder head.

The upper end of the body **13** is closed by an annular upper guide member **26** including a depending portion **27** received within the upper end of the body and adapted to rest upon or be disposed closely adjacent the retainer rings **24**. This upper guide member has an upwardly tapering guide surface **28** in its flange portion **29**, which rests on the upper end of the body **13**, the guide being removably secured to the body by a split wire snap ring **30**, which may be round in cross-section, received within an internal groove **31** in the body and also within an opposed external groove **32** in the guide itself. The ring **30** may completely fill the internal body groove **31**, but when disposed therein only extends partially into the guide groove **32**, such groove being of sufficient lateral depth as to permit the wire ring to be disposed completely therewithin when the guide **26** is inserted into and removed from the upper portion of the bit body **13**.

In assembling the upper guide **26** in the body **13**, a longitudinally extending screw **33** having a tapered lower end **34** is threaded downwardly in a companion bore **35** in the guide through use of a suitable screw driver or other tool (not shown), the tapered end **34** of the screw engaging the outer peripheral portion of the split wire ring **30**, to retain it completely within the peripheral guide groove **32**. The guide **26** can then be inserted into the body to its fullest extent, whereupon the screw **33** is ro-

tated, to elevate it within the threaded bore 35 and remove its tapered point 34 from engagement with the wire ring 30, the latter then expanding outwardly into the body groove 31 and thereby secure the upper guide 26 to the main body 13 of the bit. To insure that the wire connecting ring 30 will remain in this position, the screw 33 can then be threaded downwardly, so that its tapered lower end 34 engages the inner peripheral portion of the wire ring, to prevent the latter from retracting from the inner body groove 31. In the event it is again desired to withdraw the guide 26 from the body 13, the screw 33 is rotated and elevated in the threaded bore 35, whereupon a sufficient upward force exerted on the guide 26 will cause the curved wall of the internal groove 31 to cam or force the ring 30 inwardly completely into the guide groove 32, allowing the guide to be completely elevated out of the body 13 of the tool.

The tool body 13 has a plurality of expansible parts mounted on it, including cutter supporting members 36 pivotally mounted in body slots 37 on hinge pins 38 secured to the body. As specifically illustrated in the drawings, each hinge pin 38 extends through a bore 39 in a cutter supporting member and into body bores 40, 41 on opposite sides of each body slot. To minimize wear on the parts, each hinge pin 38 may operate within a bushing 42 received within the counterbore 41 in the body on one side of the slot 37, this bushing being prevented from moving laterally outward by engaging a body shoulder 43 which the counterbore provides. Similarly, a bushing 44 is provided around the other end portion of the pin within the other body bore 40, engaging a shoulder 45 which prevents the bushing from moving outwardly of the tool body. The central portion of the hinge pin 38 also has a wear bushing 46 mounted thereon which has a working fit within the hole or bore 39 through the cutter supporting member 36.

One end portion 47 of the hinge pin 38 is reduced in diameter and has a central portion removed to form a relatively short tubular section that has circumferentially spaced transverse slots 48 cut through its wall to provide a plurality of fingers 49. Opening into the tubular portion is a threaded hole 50 in the pin adapted to receive a screw 51 which has a tapered head 52, as well as a slot, for the reception of a suitable screw driver (not shown). The end of the pin 38 adjacent the tubular portion 47 engages the body shoulder 45, the tubular portion extending in an outward direction through the body bore adjacent such shoulder and projecting into an enlarged bore portion 53 opening to the exterior of the body, the base 54 of this enlarged bore portion being tapered or inclined in an inward direction toward the body shoulder 45.

The bushings 42, 44, 46 are inserted in place and the cutter supporting member 36 disposed in the body slot 37, with its bushing 46 in alignment with the other bushings 42, 44. The cylindrical pin 38 is then inserted through one of the transverse bores 41 in the body and through the bushings 42, 46, 44 until its other end portion engages the body shoulder 45, with the fingers 49 of the pin disposed in the enlarged counterbore 53. The fingers 49 can then be bent outwardly through use of a suitable tool, to lie against the tapered shoulder 54. Such engagement of the fingers with the tapered shoulder prevents axial movement of the pin 38 in one direction, whereas engagement of the pin with the other shoulder 45 prevents its axial movement in the opposite direction.

The fingers 49 are prevented from being inadvertently retracted by threading the screw 51 into the threaded bore 50 in the pin, the tapered head 52 on the screw engaging the outwardly bent fingers 49 to hold them in such outwardly bent fashion. To facilitate insertion of the screw 51, the other end of the cylindrical pin may be provided with a screw driver slot 55 to receive a screw driver and prevent the pin 38 from rotating during the threading of the screw into the threaded bore. Once the screw 51 has been assembled in this manner, it can be prevented from inadvertent loosening by bending one of the fingers 49*a* back over against the head portion 52 of the screw.

In the event it is desired to withdraw the pin 38 from its assembled position, the finger 49*a* bent against the head of the screw is forced laterally outward, the screw 51 is removed, and the fingers 49 bent inwardly sufficiently to pass through the small diameter bore portion surrounded by the shoulders 45, 54, then allowing the pin 38 to be withdrawn from the body through the opposite bore portion 41 of the latter.

Each cutter supporting member 36 depends from a hinge pin 38 and terminates in a bearing supporting pin 60 inclined inwardly and downwardly. A side roller cutter 61 is rotatably mounted on each bearing supporting pin, being mounted on anti-friction roller and ball bearing elements 62, 63 rollable on the bearing supporting pin 60. The ball bearing elements 63 lock the cutters against endwise movement on the bearing supporting pin 60, as well as transmitting axial and radial thrusts between the cutter and supporting pin. The roller bearing elements 62 transmit primarily radial thrusts between these parts. The manner of mounting the ball and roller bearing elements 62, 63 between the cutters and bearing supporting pins, and of retaining them in place is specifically described in the above-mentioned Patent No. 2,545,036.

The cutter supporting members 36 and cutters 61 mounted thereon tend to occupy a retracted position substantially and entirely within the confines of the main body 13 of the bit. These cutter supporting members and cutters are expandible outwardly, to enlarge the sides of the well bore and to operate upon a formation shoulder C that the cutters produce in the latter. To accomplish the expansion, each cutter supporting member 36 has an inclined expander surface 64 on its inner portion below the hinge pin 38, which tapers in a downward and inward direction. Each expander surface terminates in a lock surface 65 formed on the cutter supporting member. The outward expansion is accomplished by producing relative longitudinal movement between the mandrel 10 and the bit body 13, which will produce correspondingly relative longitudinal movement between the cutter supporting members 36 and a tubular member 66 of the mandrel. This tubular mandrel includes a lower portion 67 slidable within a guide bushing 68 secured in a guide support 69 attached to the body and extending across the slotted region of the latter below the lock surfaces 65.

Located initially above the guide 69 and below the hinge pins 38, and in cutter supporting member recesses 70, is a mandrel lock and expander 71 having its outer surface 72 adapted to engage the expander surfaces 64 and the lock surfaces 65. The lock and expander 71 may be formed integrally with the tubular member 66, the upper end of the latter being piloted within a socket 73 in the lower portion of the kelly 12. An enlarged boss 74 on the tubular member engages a downwardly facing shoulder 75 on the kelly, the tubular member being held against this shoulder by a suitable split retainer ring 76 snapped into an internal groove 77 encompassing the Kelly socket 73 and engaging a downwardly directed shoulder 78 formed on the tubular member boss. Leakage between the boss 74 and the wall of the Kelly socket 73 is prevented by a suitable side seal, in the form of a rubber O ring 79 disposed within a groove 80 in the boss and engaging the wall of the socket.

The kelly 12 has a central fluid passage 81 therethrough communicating with the string of drill pipe B. Fluid pumped through this passage can pass into an aligned central passage 82 in the tubular member 66, whereby drilling mud, or similar drilling fluid, can be pumped down through the tool for the purpose of removing the cuttings from the well bore and flushing them up around the drill pipe to the top of the hole.

As disclosed, a central nozzle **83** is located in the lower end portion of the tubular member passage **82**. When the mandrel **10** is in its lower position with respect to the body **13**, this central nozzle will be located above a central enlarged cavity or body space **84** immediately below the body slots **37**. This relatively large diameter space or passage **84** has a relatively small diameter central passage **85** leading downwardly from it to form an upwardly facing shoulder **86**. The small diameter passage, in turn, opens into another relatively large diameter central passage **87** in the body terminating at the lower end of the body **13**.

After the cutters **61** have been expanded outwardly, fluid discharged in a downward direction from the nozzle **83** will strike fluid in the upper enlarged passage **84**, which is relatively dead fluid since it cannot readily pass downwardly through the restricted passage **85**, the fluid discharged from the nozzle being deflected by this relatively dead fluid in lateral outward directions toward the cutters **61** to clean the cuttings from the region of the shoulder C and flush them upwardly around the tool A and the drill pipe B to the top of the well bore.

Assuming that the body **13** of the tool is elevated relatively along the tubular mandrel **10**, the inclined expander surfaces **64** of the cutter supporting members will be shifted upwardly along the lock and expander portion **71** of the tubular member **66**. During such upward shifting, the cutter supporting members **36** and the cutters **61** carried thereby will be pivoted about the hinge pins **38** and urged in an outward direction. Movement of the body **13** with respect to the tubular mandrel **10** can continue until the cutters **61** have been shifted outwardly to their fullest extent, as determined by engagement of stop shoulders **88** on the cutter supporting members **36** with companion shoulders **89** formed in the body on opposite sides of the body slots **37**. When such engagement occurs, the lower end **16** of the kelly portion of the tubular mandrel **10** will engage the body shoulder **17** and the lock and expander **71** on the tubular member **66** will be disposed behind and in engagement with the lock surfaces **65** on the cutter supporting members **36**.

It is to be noted that the lock surfaces **65** on the cutter supporting members **36** and the companion surfaces **72** on the lock and expander portion **71** of the tubular member **66** are substantially parallel to the axis of the drill bit, to prevent the reactive forces of the formation on the cutters **61** from moving the latter inwardly. As a practical matter, it is preferred that the coengaging lock surfaces **65**, **72** be inclined slightly in a downward direction toward the axis of the tool to insure release of the lock and expander portion **71** from the cutter supporting members **36** when the latter and the cutters **61** are to be shifted back to their retracted positions.

The relative longitudinal movement between the tubular mandrel **10** and the body **13** of the tool, for effecting outward expansion of the cutters **61**, is accomplished hydraulically. The counterbore **19** receiving the piston **18** of the drill stem member **12** is formed in the upper portion of the body **13**, to provide the cylinder **21** having a cylinder wall **90** extending from a lower shoulder **91** defining the bottom of the counterbore to the location of the upper guide member **26**. As was previously described, this upper guide member **26** closes the upper end of the body **13**, and can also prevent foreign substances from moving down into the body through the use of a suitable wiper ring **92**, which may be in the form of a rubber, or rubber-like O ring, disposed in an internal groove **93** in the upper guide and slidably and sealingly engaging the periphery of the mandrel **10**.

The cylinder head **20** retained in the upper portion of the body or cylinder **21** has an inner seal ring **94**, in the form of a rubber, or rubber-like, O ring, received within an internal groove **95** in the cylinder head and slidably and sealingly engaging the periphery of the mandrel **10**. This head **20** also has an external sealing

structure in the form of a rubber, or rubber-like, O ring **96** disposed in an external groove **97** in the head and sealingly engaging the wall **90** of the counterbore or cylinder **21**. The head **20** itself has a depending skirt **98** that is engaged by the upper end of the piston portion **18** of the mandrel, for the purpose of limiting the extent of relative upward movement of the mandrel **10** with respect to the body **13** of the tool. This skirt **98** is disposed at the outer portion of the cylinder head **20**, to provide an annular space **99** between the periphery of the mandrel or kelly **12** above the piston portion **18** and the skirt **98** itself, into which fluid under pressure from the central passage **81** of the mandrel can enter, such fluid flowing through intercommunicating lateral ports **100** in the mandrel immediately above the piston portion **18**.

Fluid from the cylinder space **99** is prevented from passing downwardly around the periphery of the piston **18** by a suitable side seal ring **101**, such as a rubber, or rubber-like, O ring, disposed in a piston groove **102** and sealingly engaging the cylinder wall **90**.

Fluid under pressure in the string of drill pipe B and within the tubular mandrel **10** is fed into the cylinder space **99** through the side ports **100**, such fluid under pressure being developed by the back pressure built up through the necessity of the fluid to pass through the relatively restricted passage **82** through the tubular member **66** and the nozzle **83** at its lower portion. This back pressure imposed on the fluid in the cylinder space **99** acts in an upward direction on the cylinder head **20**, urging the body **13** of the tool upwardly with respect to the tubular mandrel **10**, and correspondingly elevating the cutter supporting members **36** and cutters **61** with respect to the lock and expander portion **71** of the tubular member **66**, until the cutters **61** are expanded to their fullest extent. With the fluid pressure elevating the body relative to the mandrel, the tool can be rotated, the cutters **61** operating upon the formation and gradually being expanded outwardly as the body continues to be elevated along the mandrel until the cutters have been expanded outwardly to their fullest extent, as determined by engagement of the cutter supporting arm shoulders **88** with the companion body shoulders **89**. When this occurs, the mandrel lock portion **71** is disposed behind the companion lock surfaces **65** of the cutter supporting members **36** to retain the cutters **61** in their outwardly expanded position, the downward drilling weight being transmitted from the lower end **16** of the kelly **12** to the body shoulder **17**, and from the stop shoulders **89** on the latter on opposite sides of the slots **37** to the cutter supporting members **36**, being transmitted from the latter through the cutters **61** to the formation shoulder C. The cutters **61** will remain locked in their outwardly expanded position, so long as drilling weight is being imposed upon the drill pipe B and the drill bit A, the cutters **61** operating upon the formation shoulder C to progressively enlarge the bore in a downward direction.

In the event the drill pipe B and drill bit A are elevated in the well bore, and in the absence of hydraulic pressure within the tool, the body **13** would tend to drop down along the mandrel **10**, allowing the cutters **61** to return to their retracted position. If this were to occur, it would be necessary to first apply pressure to the tool to reexpand the cutters **61** before lowering the apparatus back to the position in which the cutters engage the shoulder C.

The apparatus disclosed in the drawings prevents the cutters **61** from inadvertently retracting from their maximum outwardly expanded position in the absence of fluid pressure within the drill pipe B and the mandrel passages **81**, **82**, and upon elevation of the tool to raise the cutters above the shoulder. To accomplish this purpose, a detent device is provided between the body **13** and the mandrel **10** to retain the body in its elevated position relative to the mandrel in which the cutters are ex-

panded outwardly. However, the mandrel and body can be released from one another, to allow the body to be lowered relative to the mandrel, enabling the cutters to return to their retracted position. When in this lower position, the body and mandrel are again releasably locked to each other to prevent inadvertent outward expansion of the cutters.

As specifically shown, one or more detents are provided between the mandrel **10** and the body **13** of the tool. Each detent includes a ball movable radially in a radial passage **102** formed through the mandrel at a particular distance above the mandrel ports **100**. The inner portion **103** of the ball detent passage is smaller in diameter than its outer portion to form a shoulder **104** against which a helical compression spring **105** can seat, the outer end of this spring engaging the ball **101** and urging it in a direction radially outwardly of the mandrel **10**. When the body **13** is in its lowermost position relative to the mandrel, such as shown in Fig. 1, the balls **101** are disposed opposite an internal circumferential groove **106** formed in the cylinder head **20** immediately below its upper internal seal ring **94**. This groove **106** is of such depth that the detent ball **101** can partially enter it, and is of such a length that the mandrel **10** and body **13** can move only a relatively short distance with respect to each other before further movement is precluded by engagement of the ball **101** with the upper or lower ends of the groove **106**.

Thus, the balls **101** will be disposed partly within the radial passages **102** and partly within the circumferential grooves **106**, to releasably lock the body **13** and mandrel **10** in their initial position, wherein the cutters **61** are retracted. However, the center of each ball **101** is still disposed inwardly of the periphery of the mandrel **10**, wherein an upward force imposed on the body will cause the lower side of the groove **106** to engage each ball and shift it inwardly in the passage **102** against the compressive force of the spring **105**, until all of the balls are disposed completely within the confines of the radial passages **102**, whereupon the body **13** can move upwardly with respect to the mandrel **10**, the balls merely sliding along the inner surface of the cylinder head **20** below the internal groove **106**.

When the cutters **61** have been expanded outwardly to their fullest extent, and the lock portion **71** of the tubular member **66** is disposed behind the companion lock surfaces **65** on the cutter supporting members **36**, the detent passages **102** are then disposed immediately below a downwardly facing shoulder **107** of the cylinder head **20** at the upper end of the head skirt **98**. The springs **105** can urge the balls **101** outwardly, so that they engage such shoulder **107**. The tool is rotated and the hole enlarging operation proceeds, with the fluid being pumped down through the apparatus. The fluid pressure is constantly tending to elevate and retain the body **13** in an elevated position relative to the mandrel **10**, but the upward movement is obviously limited by engagement of the body shoulder **17** with the lower end **16** of the kelly **12**. In the event the tool is elevated in the enlarged well bore to raise the cutters **61** above the shoulder C, and if the pumping of fluid through the tool is discontinued, the absence of hydraulic pressure in the cylinder **21** will not cause the weight of the body and the cutter members mounted thereon to drop the body and cutters with respect to the mandrel **10**, which would allow the cutters to retract. The springs **105** exert sufficient force on the ball detents **101** to retain them under the cylinder head shoulder **107** and prevent such action from occurring. As a matter of fact, it is only when the tool A has been elevated in the well bore to the point at which the cutter supporting members **36** enter a smaller diameter portion of the well bore, or engage the shoe of the well casing, that sufficient restraint to upward movement of the body **13** occurs, permitting an upward force to be imposed on the mandrel to cause the shoulder **107** to push the balls **101** back into their confining bores **102**. The mandrel **10** can now be moved upwardly of the body **13**, with the balls **101** sliding along the inner wall of the head **20** until the balls again snap out into the internal groove **106**, to releasably retain the body **13** and mandrel **10** in a relative cutter releasing position. The apparatus can now be elevated through the well casing to the top of the hole.

It is preferred that the radial passages **102** containing the balls **101** establish communication between the central Kelly passage **81** and the exterior of the mandrel kelly **12**. Despite such communication, the pumping of fluid through the apparatus will not provide any leakage of fluid from the cylinder space **99** since the same pressure is being imparted to the fluid in the upper passages or ports **102** as in the lower passages or ports **100**, the disposition of the upper head seal ring **94** above the detent passages or ports **102** preventing fluid from leaking out of the cylinder space in such direction. However, the upper ports **102** facilitate the removal of fluid from the cylinder space **99** when the mandrel **10** is to be elevated with respect to the body **13** to secure retraction of the cutters **61** from their outwardly expanded position. Thus, upward movement of the mandrel might ordinarily be accompanied by fluid being forced out of the cylinder space **99** back through the lower ports **100** into the central passage **81** in the mandrel. However, in the event that such return flow of fluid is prevented or retarded, as through the existence of some sand in the lower portion of the cylinder space resting upon the piston **18**, then the fluid can be forced around the periphery of the balls **101** and radially inwardly through the upper ports **102** into the mandrel passage **81**.

It is preferred that the balls **101** make a sliding fit with the walls of the lateral passages **102**. This will permit fluid to pass around the balls **101**, but solid particles, such as sand and the like, are prevented from passing thereby. During the use of the tool, the relatively close fit of the balls **101** in the passages **102** will prevent any sand in the drilling fluid from passing through the upper ports **102** and around the balls into the cylinder space **99**, which might tend to clog the latter. The chance of sand entering through the lower ports **100** and rising upwardly in the cylinder space **99** is relatively small. However, any sand that might enter the cylinder space through the lower ports and tending to plug the latter will not prevent retraction of the apparatus, since the elevation of the mandrel **10** relative to the body **13**, as explained above, will force some of the liquid in the cylinder space back around the balls **101**, through the upper set of ports **102**, and into the central passage **81**.

The lower portion of the apparatus disclosed in the drawings is formed as a pilot cutter device or guide, to assist in retaining the apparatus in a central position within a previously drilled hole. The lower portion of the body **13** is provided with longitudinal, circumferentially spaced grooves **108**, each of which terminates at a downwardly facing transverse body shoulder **109***a*, and which opens downwardly through the lower end of the body. Each groove **108** includes a relatively wide inner portion **109** communicating with the periphery of the body through a substantially narrower central portion **110** to form opposed longitudinal body ribs **111**. A cutter and pilot blade **112** is insertable upwardly into each groove **108**, each blade including longitudinally extending transverse flanges **113** adapted to slide upwardly within the inner groove portion **109** and having longitudinal grooves **114** in its medial portion to receive the body ribs **111**, the outer portion of each cutter blade **112** projecting laterally from the body **13** to the hole in which the tool is to operate.

The upper outer end **115** of each blade **112** is inclined in an upward and inward direction, to prevent the blades from hanging up on projections or casing coupling spaces. The lower portion **116** of each blade is curved in a downward and inward direction to form a guide, such curved

portions merging into a bottom hole engaging portion **117**, which extends inwardly across the bottom of the body. As stated above, the blade **112** is inserted in the body **13** until its upper end engages the body shoulder **109***a*, at which time a tapered inner surface **118** on each blade will engage a companion tapered surface **119** at the lower end of the body.

Once the blades **112** are moved upwardly into the body grooves **108** into engagement with the body shoulder **109***a*, they are each retained in such position by a holding screw **120**. This holding screw has a threaded shank **121** received within a lateral threaded bore **122** in the body, the head **123** of the screw being slidable within an enlarged diameter bore portion **124** disposed inwardly of the longitudinal body groove **108**. Before a cutter blade **112** is moved upwardly into the body **13**, the screw **120** is threaded inwardly of the lateral bore **122** to its fullest extent, in which the outer end of the head **123** is disposed laterally inward of the longitudinal groove **108**, so as not to interfere with upward sliding of the blade **112** within the body groove. When the blade is disposed in engagement with the body shoulder **109***a*, a suitable tool, such as a screw driver (not shown), is inserted through a lateral hole **125** in the body in alignment with a non-circular opening **126** in the screw head, the screw **120** being rotated in an unthreading direction, so that it is fed laterally outward to locate its head **123** in a transverse groove **127** formed in the inner portion of the cutter blade **112**. The longitudinal extent of the groove **127** is only slightly greater than the diameter of the head, to prevent the blade from having any substantial motion lengthwise of the body. If desired, to prevent inadvertent return threading of the screw **120** into the lateral bore **122**, a helical spring **128** may be located in the enlarged bore portion **124**, bearing against the shoulder **130** at the inner end of the enlarged bore and against the head **123** of the screw. However, the spring **128** need not be used if desired.

In the use of the pilot arrangement, downward forces on the pilot blades **112** are transmitted directly from the body shoulders **109***a* to the blades, whereas rotary motion is transmitted from the body **13** directly to the blades **112**, such rotary motion not being transferred at all through the retaining screws **120**. The blades **112** are preferably hardfaced, to increase their life.

The inventor claims:

1. In a rotary well drilling bit connectible to a tubular drill string: a main body having a fluid passage therein adapted to communicate with the tubular drill string; cutter means mounted on said body for expansion laterally of said body; hydraulically operable means operatively connected to said cutter means for expanding said cutter means laterally outward; an inlet for conducting fluid under pressure from said passage to said hydraulically operable means to actuate said hydraulically operable means and cause said hydraulically operable means to expand said cutter means laterally outward; an outlet for conducting fluid from said hydraulically operable means to said passage; and releasable holding means in said outlet engageable with said hydraulically operable means to releasably hold said cutter means expanded laterally outward.

2. In a rotary well drilling bit connectible to a tubular drill string: a main body having a fluid passage therein adapted to communicate with the tubular drill string; cutter means mounted on said body for expansion laterally of said body; hydraulically operable means operatively connected to said cutter means for expanding said cutter means laterally outward; passage means for conducting fluid between said passage and hydraulically operable means, whereby said fluid acts on said hydraulically operable means to cause said hydraulically operable means to expand said cutter means laterally outward; and releasable holding means in said passage means engageable with said hydraulically operable means to releasably hold said cutter means expanded laterally outward.

3. In a rotary well drilling bit connectible to a tubular drill string: a main body having a fluid passage therein adapted to communicate with the tubular drill string; cutter means mounted on said body for expansion laterally of said body; hydraulically operable means operatively connected to said cutter means for expanding said cutter means laterally outward; passage means for conducting fluid between said passage and hydraulically operable means, whereby said fluid acts on said hydraulically operable means to cause said hydraulically operable means to expand said cutter means laterally outward; and releasable holding means in said passage means engageable with one portion of said hydraulically operable means to releasably hold said cutter means expanded laterally outward, said holding means being releasably engageable with another portion of said hydraulically operable means when said cutter means is in retracted position on said body to releasably hold said cutter means in such retracted position.

4. In a rotary well drilling bit connectible to a tubular drill string: a main body having a fluid passage therein adapted to communicate with the tubular drill string; cutter means mounted on said body for expansion laterally of said body; hydraulically operable means operatively connected to said cutter means; an inlet for conducting fluid under pressure from said passage to said hydraulically operable means to actuate said hydraulically operable means and expand said cutter means laterally outward; an outlet for conducting fluid from said hydraulically operable means to said passage; a detent element in said outlet engageable with said hydraulically operable means to releasably hold said cutter means expanded laterally outward; and a spring in said outlet engaging said element to urge it into engagement with said hydraulically operable means.

5. In a rotary well drilling bit connectible to a tubular drill string: a main body having a fluid passage therein adapted to communicate with the tubular drill string; cutter means mounted on said body for expansion laterally of said body; hydraulically operable means operatively connected to said cutter means; passage means for conducting fluid between said passage and hydraulically operable means; a detent element in said passage means engageable with said hydraulically operable means to releasably hold said cutter means expanded laterally outward; and a spring in said passage means engaging said element to urge it into engagement with said hydraulically operable means.

6. In a rotary well drilling bit connectible to a tubular drill string: a main body having a fluid passage therein adapted to communicate with the tubular drill string; cutter means mounted on said body for expansion laterally of said body; hydraulically operable means operatively connected to said cutter means; passage means for conducting fluid between said passage and hydraulically operable means; a detent element in said passage means engageable with one portion of said hydraulically operable means to releasably hold said cutter means expanded laterally outward; said detent element being releasably engageable with another portion of said hydraulically operable means when said cutter means is in retracted position on said body.

7. In a rotary well drilling bit connectible to a tubular drill string: a main body having a fluid passage therein adapted to communicate with the tubular drill string; cutter means mounted on said body for expansion laterally of said body; hydraulically operable means operatively connected to said cutter means; an inlet for conducting fluid under pressure from said passage to said hydraulically operable means to actuate said hydraulically operable means and expand said cutter means laterally outward; an outlet for conducting fluid from said hydraulically operable means to said passage; a detent element in said outlet engageable with said hydraulically operable means to releasably hold said cutter means expanded laterally outward; and a spring in said outlet

engaging said element to urge it into engagement with said hydraulically operable means; the diameters of said detent element and outlet being substantially equal.

8. In a rotary well drilling bit connectible to a tubular drill string: a main body having a fluid passage therein adapted to communicate with the tubular drill string; cutter means mounted on said body for expansion laterally of said body; hydraulically operable means operatively connected to said cutter means; passage means for conducting fluid between said passage and hydraulically operable means; a detent element in said passage means engageable with said hydraulically operable means to releasably hold said cutter means expanded laterally outward; and a spring in said passage means engaging said element to urge it into engagement with said hydraulically operable means, the diameters of said detent element and passage means being substantially equal.

9. In a rotary well drilling bit connectible to a tubular drill string: a main body; cutter means mounted on said body for expansion laterally of said body; a mandrel connectible to a drill string and slidably splined to said body; said mandrel having a fluid passage communicating with the drill string; coengageable expander means on said mandrel and cutter means; hydraulically operable means on and operatively connected to said body; means for feeding fluid under pressure from said passage into said hydraulically operable means to cause said hydraulically operable means to elevate said body and cutter means with respect to said mandrel to cause said expander means to expand said cutter means laterally outward; and releasable holding means on said mandrel and hydraulically operable means to releasably hold said cutter means expanded laterally outward.

10. In a rotary well drilling bit connectible to a tubular drill string: a main body; cutter means mounted on said body for expansion laterally of said body; a mandrel connectible to a drill string and slidably splined to said body; said mandrel having a fluid passage communicating with the drill string; coengageable expander means on said mandrel and cutter means; hydraulically operable means on said body; means for feeding fluid under pressure from said passage into said hydraulically operable means to elevate said body and cutter means with respect to said mandrel to cause said expander means to expand said cutter means laterally outward; an outlet in said mandrel for conducting fluid from said hydraulically operable means to said passage; and releasable holding means in said outlet releasably engaging said hydraulically operable means to releasably hold said cutter means expanded laterally outward.

11. In a rotary well drilling bit connectible to a tubular drill string: a main body; cutter means mounted on said body for expansion laterally of said body; a mandrel connectible to a drill string and slidably splined to said body; said mandrel having a fluid passage communicating with the drill string; coengageable expander means on said mandrel and cutter means; hydraulically operable means on and operatively connected to said body; means for feeding fluid under pressure from said passage into said hydraulically operable means to cause said hydraulically operable means to elevate said body and cutter means with respect to said mandrel to cause said expander means to expand said cutter means laterally outward; and releasable holding means in said feeding means releasably engaging said hydraulically operable means to releasably hold said cutter means expanded laterally outward.

12. In a rotary well drilling bit connectible to a tubular drill string: a main body; cutter means mounted on said body for expansion laterally of said body; a mandrel connectible to a drill string and slidably splined to said body; said mandrel having a fluid passage communicating with the drill string; coengageable expander means on said mandrel and cutter means; hydraulically operable means on said body; means for feeding fluid under pressure from said passage into said hydraulically operable means to elevate said body and cutter means with respect to said mandrel to cause said expander means to expand said cutter means laterally outward; a detent element in said feeding means engageable with said hydraulically operable means to releasably hold said cutter means expanded laterally outward; and a spring in said feeding means engaging said element to urge it into engagement with said hydraulically operable means.

13. In a rotary well drilling bit connectible to a tubular drill string: a main body; cutter means mounted on said body for expansion laterally of said body; a mandrel connectible to a drill string and slidably splined to said body; said mandrel having a fluid passage communicating with the drill string; coengageable expander means on said mandrel and cutter means; hydraulically operable means on said body; means for feeding fluid under pressure from said passage into said hydraulically operable means to elevate said body and cutter means with respect to said mandrel to cause said expander means to expand said cutter means laterally outward; an outlet in said mandrel for conducting fluid from said hydraulically operable means to said passage; a detent element in said outlet engageable with said hydraulically operable means to releasably hold said cutter means expanded laterally outward; and a spring in said outlet engaging said element to urge it into engagement with said hydraulically operable means.

14. In a rotary well drilling bit connectible to a tubular drill string: a main body; cutter means mounted on said body for expansion laterally of said body; a mandrel connectible to a drill string and slidably splined to said body; said mandrel having a fluid passage communicating with the drill string; coengageable expander means on said mandrel and cutter means; hydraulically operable means on said body; means for feeding fluid under pressure from said passage into said hydraulically operable means to elevate said body and cutter means with respect to said mandrel to cause said expander means to expand said cutter means laterally outward; an outlet in said mandrel for conducting fluid from said hydraulically operable means to said passage; a detent element in said outlet engageable with one portion of said hydraulically operable means to releasably hold said cutter means expanded laterally outward; said detent element being releasably engageable with another portion of said hydraulically operable means when said cutter means is in retracted position on said body; and a spring in said outlet engaging said element to urge it into engagement with said hydraulically operable means.

15. In a rotary well drilling bit connectible to a tubular drill string: a main body; cutter means mounted on said body for expansion laterally of said body; a mandrel connectible to a drill string and slidably splined to said body; said mandrel having a fluid passage communicating with the drill string; coengageable expander means on said mandrel and cutter means; hydraulically operable means on and operatively connected to said body; means for feeding fluid under pressure from said passage into said hydraulically operable means to cause said hydraulically operable means to elevate said body and cutter means with respect to said mandrel to cause said expander means to expand said cutter means laterally outward; and releasable holding means in said feeding means releasably engaging said hydraulically operable means to releasably hold said cutter means in retracted position on said body.

References Cited in the file of this patent

UNITED STATES PATENTS

1,478,306	Sweetman	Dec. 18, 1923
2,545,035	Kammerer	Mar. 13, 1951
2,755,070	Kammerer	July 17, 1956