Sept. 5, 1967 A. W. KAMMERER, JR 3,339,647

HYDRAULICALLY EXPANSIBLE DRILL BITS

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FIG. 1.

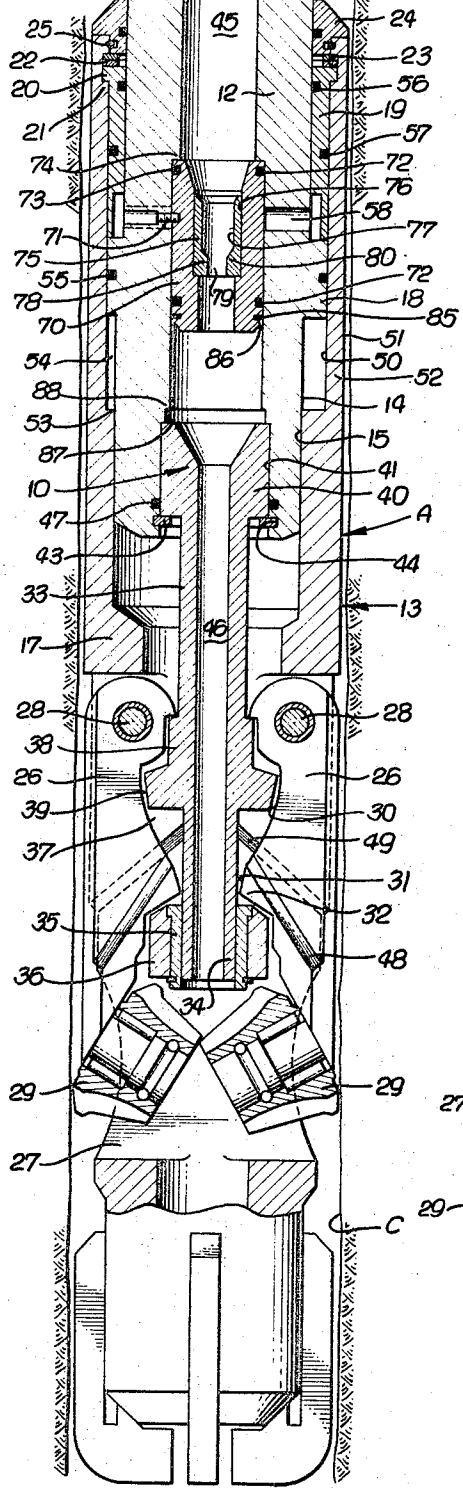

FIG. 2.

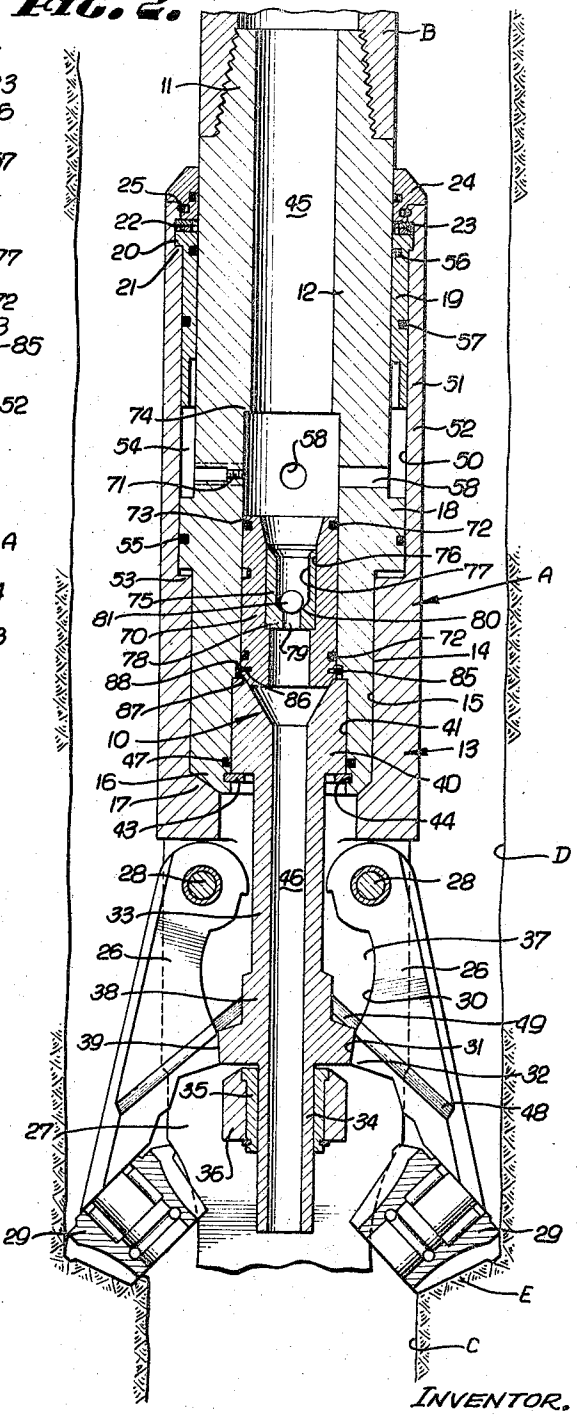

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FIG. 3.

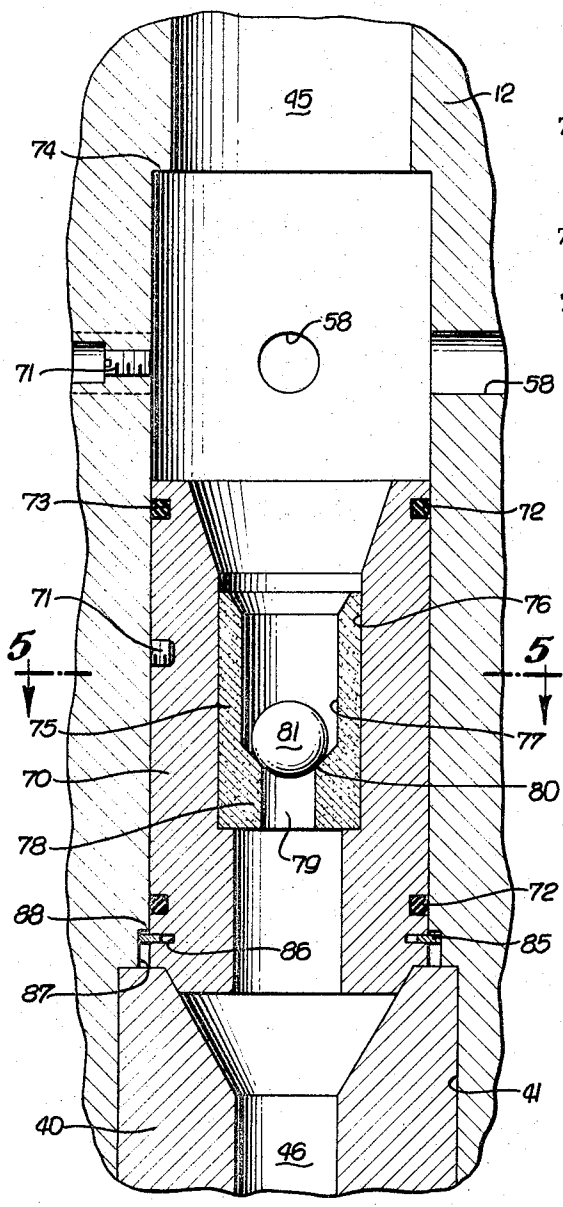

FIG. 4.

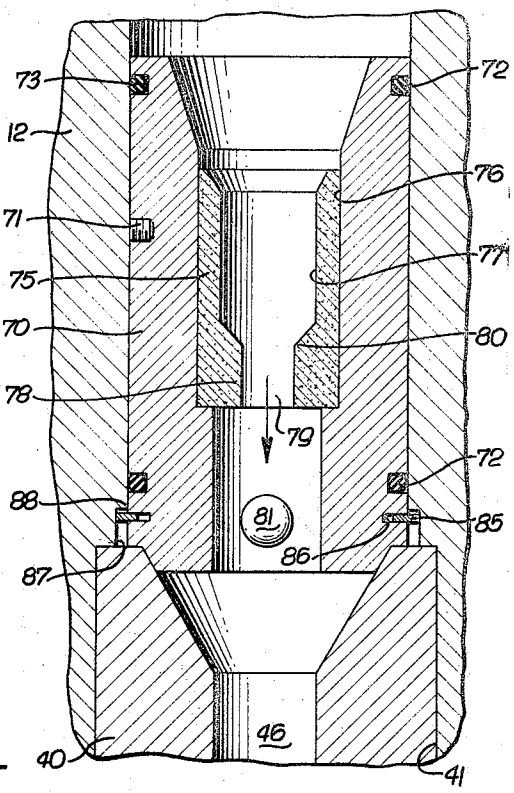

FIG. 5.

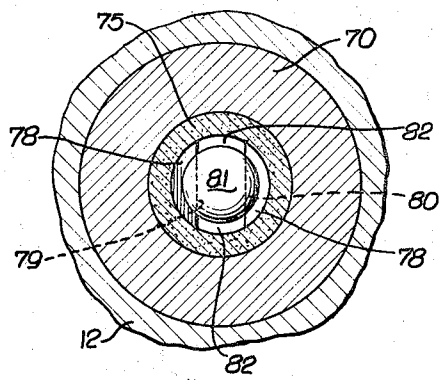

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FIG. 6.

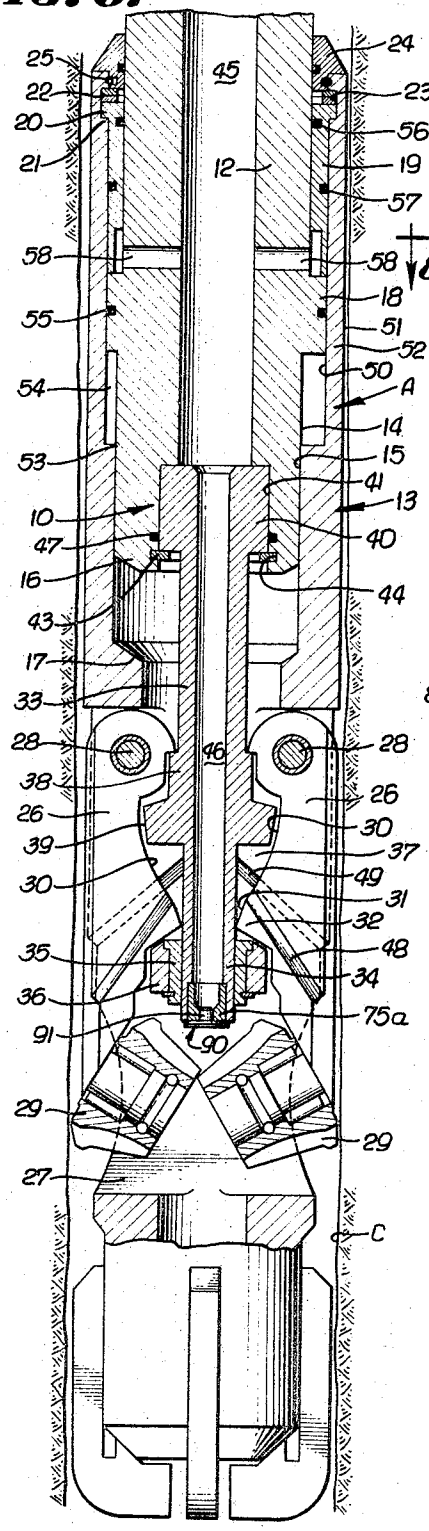


FIG. 7.

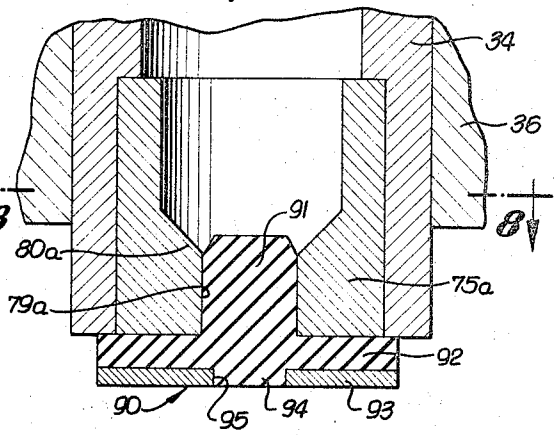


FIG. 8.

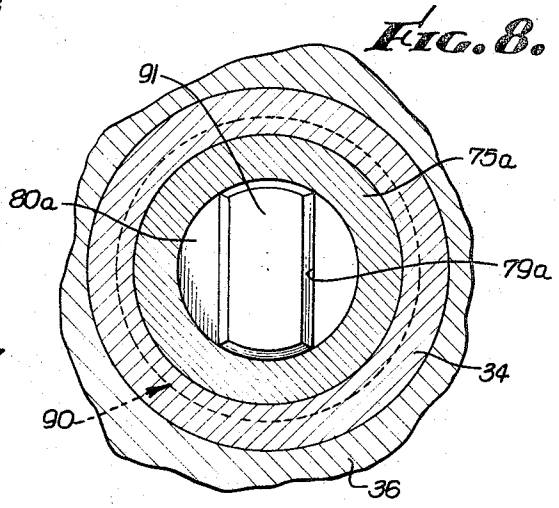
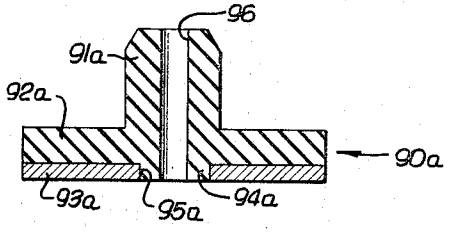


FIG. 9.



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United States Patent Office 3,339,647
Patented Sept. 5, 1967

3,339,647

HYDRAULICALLY EXPANSIBLE DRILL BITS

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Filed Aug. 20, 1965, Ser. No. 481,308
17 Claims. (Cl. 175—268)

The present invention relates to rotary drilling tools, and more particularly to drill bits of the expansible type capable of drilling or enlarging the diameters of well bores, severing casing and similar conduit strings disposed in well bores, and milling away sections of casing, and the like, disposed in well bores.

In certain rotary well drilling bits embodying expandable cutters, such as drill bits of the type disclosed in United States Patent No. 2,758,819, cutter expansion is effected hydraulically after the bit has been lowered in the well bore to its desired operating location. At times, the lowering of the drill bit on a tubular string through the fluid in the well bore causes inadvertent and undesirable premature outward expansion of the cutters, which can retard downward movement of the bit in the well bore, cause the bit to hang up in the well bore, and which might produce some damage to the cutters and other parts of the bit.

It is an object of the present invention to provide an expansible rotary drill bit, in which the fluid in the well bore cannot effect inadvertent expansion of the bit cutters during lowering of the drill bit in the well bore.

Another object of the invention is to provide an expansible rotary drill bit having cutters expanded outwardly in response to the application of fluid pressure to the bit, in which the fluid in the well bore cannot inadvertently expand the cutters of the bit during lowering of the latter in the well bore.

A further object of the invention is to provide an expansible rotary drill bit of the type disclosed in United States Patent No. 2,758,819, in which cutter expansion is effected by the relative upward movement of a cutter carrying body along a mandrel, and in which the fluid in the well bore is prevented from inadvertently elevating the body along the mandrel during lowering of the drill bit in the well bore. In fact, the fluid in the well bore is utilized to urge and hold the body in its position downwardly of the mandrel during lowering of the bit in the well bore.

This invention possesses many other advantages, and has other objects which may be made more clearly apparent from a consideration of several forms in which it may be embodied. Such forms are shown in the drawings accompanying and forming part of the present specification. These forms 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, with parts shown in elevation, through a drill bit embodying the invention, with its cutters in retracted position;

FIG. 2 is a view similar to FIG. 1 illustrating the drill bit with its cutters in their expanded position;

FIG. 3 is an enlarged section through a portion of the drill bit, with the parts in the position illustrated in FIG. 2;

FIG. 4 is a view similar to FIG. 3 illustrating ejection of an erodible tripping ball through the apparatus;

FIG. 5 is a cross-section taken along the line 5—5 on FIG. 3;

FIG. 6 is a longitudinal section through a drill bit, with the cutters in their initial retracted position, and illustrating another embodiment of the invention;

FIG. 7 is an enlarged section of a portion of the drill bit illustrated in FIG. 6;

FIG. 8 is a cross-section taken along the line 8—8 on FIG. 7;

FIG. 9 is a vertical section through another form of a portion of the apparatus illustrated in FIGS. 6 to 8, inclusive.

The invention is illustrated in the drawings as being applicable to a rotary expansible drill bit A, secured to the lower end of a string of drill pipe B extending to the top of a well bore C, and by means of which the drill bit is lowered in the well bore to a desired location therein, where a hole enlarging, or other, operation is to commence. The invention is also applicable to other specific expansible rotary drill bits, such as those used for severing casing, and for milling away a section or length of casing disposed in a well bore.

The upper portion of the drill bit includes a 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 drill bit. The exterior **14** of the lower portion of the kelly **12** is non-circular in shape, being telescopically received in a companion non-circular bore **15** formed in the main bit body. As an example, the kelly exterior **14** and the socket **15** may be of hexagonal shape to enable the kelly to be moved longitudinally with respect to the body while still being capable of transmitting rotary movement to the body.

The mandrel **10** has a limited range of longitudinal movement within the body, its downward movement being determined by engagement of the lower end **16** of the kelly with an inwardly directed body shoulder **17**, and its relative upward movement being limited by engagement of an external shoulder or piston portion **18** of the kelly with a cylinder head **19** secured to the body **13**. The upper end of the head has a flange **20** engaging a body shoulder **21**, the flange being prevented from moving upwardly of the body by split snap retainer rings **22** fitting in the body groove **23** and overlying the flange. An annular guide **24** is releasably secured to the body by a split snap ring **25** above the retainer ring.

The body **13** has a plurality of expansible parts mounted on it. These include cutter supporting members **26** pivotally mounted in body slots **27** on hinge pins **28** suitably secured to the body to prevent their loss therefrom. Each cutter supporting member **26** depends from its hinge pin **28** and carries a cutter **29** at its lower end, specifically disclosed as being of the toothed roller type, but which, if desired, may be of other form, such as a drag, milling, or casing severing cutter.

The cutter supporting members **26** and the cutters **29** tend to occupy a retracted position substantially entirely within the confines of the main body **13** of the bit. These cutter supporting members and cutters are expandable outwardly to enlarge the well bore to a diameter D and operate upon a formation shoulder E between the enlarged well bore and the smaller diameter well bore C therebelow. To accomplish the expansion, each cutter supporting member has an inclined expander surface **30** on its inner portion below the hinge pin which tapers in a downward and inward direction. Each expander surface terminates in a lock surface **31** formed on a lock portion **32** of the cutter supporting member **26**. The outward expansion is accomplished by producing relative longitudinal movement between the mandrel **10** and the bit body **13**, which will produce relative longitudinal movement between the cutter supporting members **26** and a tubular member **33** that forms part of the main mandrel

10. This tubular member includes a lower portion 34 slidable within a guide bushing 35 mounted in a bridge 36 secured to the body and extending across the body slots 27. This guide bushing is disposed below the lock portions 32 of the cutter supporting members.

Located initially substantially above the guide bushing 35, and below the hinge pins 28 and in cutter member recesses 37, is a mandrel lock and expander 38 adapted to engage the expander surfaces 30, and which has outer surfaces 39 adapted to engage the lock surfaces 31. The lock and expander 38 may be formed integral with the tubular member 33, the upper end portion 40 of the latter being piloted within a socket 41 formed in the lower portion of the kelly 12. The upper portion 40 is an enlarged boss on the tubular member, engaging a downwardly facing shoulder 42 of the kelly, the tubular member being held against this shoulder by a suitable split retainer or lock ring 43 snapped into an internal groove 44 encompassing the kelly socket and engaging the lower end of the tubular member boss 40.

Drilling mud, or other fluid, can pass down through a central passage 45 in the kelly or drill stem and into a central passage 46 extending completely through the tubular member 33. Leakage of fluid around the exterior of the tubular member is prevented by a suitable side seal ring 47 mounted in the kelly and engaging the exterior surface of the boss 40.

Assuming that the body 13 of the tool is elevated relatively along the tubular mandrel 10, the inclined expander surfaces 30 of the cutter supporting members 26 are shifted upwardly along the lock and expander portion 38 of the tubular member 33. During such upward shifting, the cutter supporting members 26 and the cutters 29 carried thereby will be pivoted about the hinge pins 28 and urged in an outward direction. The upward movement of the body 13 with respect to the tubular mandrel 10 can continue until the cutters 29 have been shifted outwardly to their fullest extent, as determined by engagement of stop shoulders 48 on the cutter supporting members with companion shoulders 49 formed in the body on opposite sides of the body slots 27. When such engagement occurs, the lower end 16 of the kelly portion 12 of the tubular mandrel engages the body shoulder 17, and the lock and expander 38 on the tubular member will be disposed behind and in engagement with the lock portions 32 of the cutter supporting members, as disclosed in FIG. 2.

The relative longitudinal movement between the tubular mandral 10 and the body 13 of the tool is accomplished hydraulically. Thus, the piston or enlarged portion 18 on the drill stem 12 is received within a counterbore 50 formed in the upper portion of the tool body. This upper portion actually constitutes a cylinder 51 having a cylindrical wall 52 extending from a lower shoulder 53, defining the bottom of the counterbore, to and around the cylinder head 19.

A confined cylinder space 54 is formed between the piston portion 18 of the kelly, the periphery of the kelly above the piston 18, and the cylinder 51. A suitable packing or side seal ring 55 is mounted on the piston for slidable sealing against the cylindrical wall 52 of the cylinder. Fluid is thereby prevented from passing in a downward direction between the piston 18 and cylinder 51. Similarly, fluid is prevented from passing in an upward direction out of the annular cylinder space 54 by an inner side seal ring 56 in the cylinder head 19 slidably and sealingly engaging the periphery of the kelly 12 above the piston and also by an outer side seal ring 57 in the cylinder head sealingly engaging the cylinder wall 52.

When permitted to do so, fluid under pressure in the string of drill pipe B and in the tubular mandrel passage 45 is fed into the cylinder space 54 through one or more side ports 58 establishing communication between the central passage 45 through the kelly and the cylinder space. As described hereinbelow, such fluid under pressure is developed by restricting the flow of fluid through the passage 45 and through the tubular member passage 46 of the mandrel, creating a back pressure in the passage 45 which will be imposed on the fluid in the cylinder space 54, and which will act upon the cylinder head 19 to urge the body 13 of the tool in an upward direction with respect to the tubular mandrel 10, for the purpose of moving the cutter supporting members 26 along the expander 38 and effecting outward expansion of the latter and of the cutters 29 carried thereby, in the manner described above.

In rotary expansible drill bits of the general type described above and in the above-identified patent, the lowering of the bit by means of the string of drill pipe B through the drilling mud or other liquid in the well bore C sometimes caused such liquid to shift or tend to shift the body 13 of the tool relatively upwardly along the mandrel 10, causing the cutter supporting members 26 to move upwardly along the mandrel lock and expander 38 and be urged in an outward direction. Such action is prevented in the embodiments of the invention illustrated in the drawings. In fact, the fluid in the well bore externally of the drill bit A is caused to actually act in a downward direction on the body 13 and retain it in its downward position relative to the mandrel 10, in which the cutter supporting members 26 and cutters 29 are in their fully retracted positions, until cutter expansion is desired.

As disclosed in the form of invention illustrated in FIGS. 1 to 5, inclusive, the ports 58 through which fluid can flow between the central mandrel passage 45 into the cylinder space 54 are closed initially by a valve sleeve 70 extending across them and releasably retained in such position by one or more shear screws 71 securing the valve sleeve to the mandrel kelly 12. Leakage of fluid around the exterior of the valve sleeve 70 is prevented by upper and lower side seal rings 72 thereon on opposite sides of the ports 58 sealingly engaging the inner wall of the mandrel passage 45. Upward movement of the valve sleeve in the mandrel is prevented by engagement of its upper end 73 with a downwardly facing mandrel or kelly shoulder 74.

The valve sleeve 70 carries a flow restricting member 75, such as a choke, secured within the valve sleeve passage 76 and preferably made of an erosion resisting material, such as tungsten carbide. The upper portion of this choke or sleeve 75 has a cylindrical wall 77, the lower portion 78 of the sleeve extending inwardly from opposite sides to provide a non-circular fluid passage portion 79 of restricted area, which area is to be further restricted by the subsequent engagement with the upwardly facing seat 80 that the inwardly directed portion 78 of the sleeve provides by an erodible valve element 81 to be pumped down through the drill string B and into the drill bit A. This erodible valve element 81, which may be in the form of a ball made of mild steel, or other suitable material, subject to a relatively slow erosion under the action of fluid acting thereon and flowing therearound, engages the seat 80 at diametrically opposite points, as disclosed in FIGS. 2, 3 and 5, there being a space or an orifice passage 82 around the ball between the ball and the sleeve seat 80 of relatively restricted area, through which the fluid can pass.

The drill bit A is lowered through the fluid in the well bore C by means of the string of drill pipe B, the valve sleeve 70 being retained in its port closing position, as illustrated in FIG. 1, which prevents fluid in the well bore, and also from within the drill pipe and drill bit, from passing through the ports 58 into the cylinder space 54, which will retain air at substantially atmospheric pressure. During lowering of the drill bit through the drilling mud, or other fluid, in the well bore, such fluid acts on the bit body 13 and tends to elevate it relatively along the mandrel 10, tending to effect outward expansion of the cutter supporting members 26 and cutters 29. In the

present case, however, such upward movement tendency is prevented by the fact that the hydrostatic head of fluid is acting in a downward direction on the cylinder head **19**, the force of such hydrostatic head of fluid increasing as the drill bit is lowered to greater depths in the well bore and holding the body in the downward position along the mandrel illustrated in FIG. 1. The force can be quite substantial since the hydrostatic head of fluid externally of the apparatus is acting in a downward direction over the full cross-sectional area of the cylinder head **19**, and the only resisting force acting in an upward direction on the cylinder head is air at atmospheric pressure trapped within the cylinder space **54**.

During lowering of the drill bit in the well bore, fluid can pass upwardly through the passage **46** through the tubular member **33** into the lower portion of the kelly **12**, flowing upwardly through the valve sleeve **70** and the choke **75** into the kelly passage **45** thereabove, continuing on into the drill pipe B to automatically fill the latter with fluid.

When the location in the well bore is reached at which the cutters **29** are to be expanded outwardly, the erodible trip ball **81** is allowed to gravitate down through the fluid in the drill pipe B, or is pumped downwardly therethrough, coming to rest upon the valve seat **80** formed by the restricted portion of the choke. The fluid under pressure in the drill pipe B and in the kelly passage **45** above the valve sleeve is then increased, some of the fluid still being capable of passing around the ball **81** for continued movement downwardly through the mandrel **10** and into the well bore below the lower end of the tubular member **33**. A back pressure is built up in the kelly passage **45** above the sleeve **70** of sufficient value as to overcome the shear strength of the screw or screws **71** and disrupt the latter, the sleeve **70** then being shifted downwardly to a position below the ports **58**, the sleeve coming to rest upon the upper end of the tubular member **33** of the mandrel (FIGS. 2 to 4). It is prevented from moving back upwardly in the passage **45** to a position across the ports **58** by a retaining device in the form of an expandable split snap ring **85** disposed in a groove **86** in the lower portion of the sleeve **70**, and which expands outwardly into a groove **87** formed between the kelly **12** and the upper end of the tubular member **33**, the ring being adapted to engage the upper side **88** of the groove and thereby preventing the valve sleeve from returning to its upper position.

After the valve sleeve **70** has been shifted downwardly to its port opening position, as illustrated in FIG. 2, fluid under pressure, resulting from pumping drilling mud, or the like, downwardly through the drill pipe B and through the mandrel **10**, will build up a back pressure in the ported region of the kelly, due to the restriction to downward flow of fluid around the ball **81** and through the choke **75**, the fluid under pressure passing through the ports **58** into the cylinder space **54** and acting in an upward direction to urge the body **13** upwardly of the mandrel **10** and the cutter supporting members **26** upwardly along the expander **38**. During such downward pumping of fluid through the drill pipe and mandrel, the drill pipe and the drill bit are rotated to cause the cutters **29** to commence enlarging the well bore C. When the cutters have been expanded outwardly to their fullest extent, the body **13** of the tool moves upwardly to bring its shoulder **17** into engagement with the lower end **16** of the kelly, at which time the expander and lock portion **38** of the mandrel is disposed behind the lock surfaces **31** on the cutter supporting members, as disclosed in FIG. 2.

After the cutters **29** have been expanded outwardly to their fullest extent, drilling fluid continues to be pumped down through the drill pipe B and out of the tool A for upward passage around the cutters in the drilling region and through the annulus around the drill pipe B to the top of the hole. The ball valve element **81**, being erodible, will gradually be worn away as fluid is pumped therearound. Under conditions usually encountered in the well bore, substantial erosion of the ball valve element will take place by the time the cutters have been hydraulically expanded outwardly to their maximum outward position. As such erosion occurs, the orifice area between the valve element **81** and the sleeve **75** increases, permitting greater quantities of fluid to be pumped from the mandrel **10** into the well bore. Eventually, erosion of the valve element **81** will occur to such an extent that it is forced completely through the lower fluid passage portion **79** of the sleeve **75** and into the tubular member passage **46**, being ejected through the lower end of the latter into the well bore.

The hole enlarging operation can continue with the appropriate amount of drilling weight being imposed upon the cutters **29**. Such downward drilling weight will retain the mandrel lock **38** behind the cutter supporting members **26** to prevent inadvertent inward shifting of the cutters from their full outward expanded position.

When the drill bit is to be removed from the well bore, the pumping of fluid downwardly through the drill pipe and through the tool is discontinued and the drill pipe B elevated, which will raise the mandrel **10** within the body **13** of the tool back to the position illustrated in FIG. 1. This will allow the cutters **29** to shift inwardly to their initial retracted position and allow the tool to be elevated in the well bore and removed completely therefrom.

In the form of invention illustrated in FIGS. 6, 7 and 8, the body **13** of the drill bit is prevented from shifting inadvertently upwardly along the mandrel **10** by preventing fluid under pressure from entering the cylinder space **54** during lowering of the tool through the drilling mud, or other fluid, in the well bore C. As disclosed, a choke orifice **75*a*** is welded, or otherwise suitably mounted, within the lower end of the tubular member **33**. This choke orifice may have the same shape as the one **75** illustrated in the other embodiment of the invention, and the same non-circular passage **79*a*** through its lower portion. It is closed initially by a plug **90** having an upper portion **91** shaped to conform to the shape of the non-circular opening **79*a*** through the choke, and which has an outwardly extending flange **92** adapted to engage the lower end of the choke or tubular sleeve **75*a***. The portions **91**, **92** of the plug are made of a suitable elastomer material, such as rubber, so that its flange **92** seals against the lower end of the sleeve **75*a***. A metal disc **93** is molded to the lower end of the elastomer plug, which has a lower extension **94** projecting through a central hole **95** in the metal disc.

The plug is mounted within the carbide sleeve **75*a***, as disclosed in FIGS. 6, 7 and 8, to close the passages **46**, **45** through the mandrel **10** against upward flow of fluid thereinto. During lowering of the drill pipe B and drill bit A through the drilling mud, or other fluid, in the well bore, such fluid cannot pass upwardly into the mandrel passage for the purpose of filling the latter and the drill pipe B. Accordingly, the cylinder space **54** will contain air at atmospheric pressure only. As the drill bit moves downwardly through the fluid in the well bore, the latter cannot shift the body **13** upwardly with respect to the mandrel **10**, since the hydrostatic head of fluid is acting downwardly on the body over the area of its cylinder head **19** and will hold the body **13** in its full downward position along the mandrel, in the same manner as described above in connection with the form of invention disclosed in FIGS. 1 to 5, inclusive.

When the location in the well bore is reached at which the cutters **29** are to be expanded, the drill pipe B and mandrel passage **45**, **46** are filled with drilling mud, or the like, from the top of the well bore, whereupon the erodible ball **81** is placed in the drill pipe and is pumped downwardly therethrough. The initial pumping action will blow the plug **90** out of the choke orifice **79**, whereupon the fluid can pass out of the lower end of the mandrel **10** into the well bore. When the ball **81** reaches its

seat **80***a* in the choke orifice, fluid pressure can be built up in the mandrel and in the cylinder space **54** for the purpose of elevating the body **13** along the mandrel **10** while the drill pipe B and drill bit A are being rotated to effect cutter expansion and enlargement of the well bore, in the manner described above in connection with the other form of the invention. During the cutting action on the formation, some fluid can pass around the ball **81** and into the well bore so as to carry the cuttings upwardly around the bit and drill pipe to the top of the hole. The erosion of the ball **81** will reduce its size to the extent at which it will be pumped out through the choke orifice **75***a* into the well bore, after which a larger volume of drilling mud can be pumped through the apparatus during operation of the drill bit in enlarging the well bore.

In lieu of the solid elastomer plug, illustrated in FIGS. 6, 7 and 8, a similarly shaped plug **90***a*, but one having a small diameter passage **96** therethrough, can be used and inserted in the choke orifice **75***a* in the same manner as illustrated in FIGS. 6 and 7. The small diameter passage **96** will allow the fluid in the well bore to flow into the mandrel passage **46**, **45** at a restricted rate during lowering of the drill bit A in the well bore. However, during such lowering, the hydrostatic head of fluid in the drill pipe will be substantially less than that surrounding the drill pipe B, which will still provide a hydrostatic head differential externally of the drill pipe acting in a downward direction on the body **13** over the area of the annular cylinder head **19**, holding the body in its downward direction. Each time downward movement of the drill pipe B and bit A is arrested, the fluid in the well bore can continue to pass upwardly through the hole or passage **96** in the plug to continue filling the drill pipe with fluid.

When the location in the well bore is reached at which the cutters **29** are to be expanded, the drill pipe is allowed to fill with fluid in the well bore flowing through the plug hole **96**, or filling of the drill pipe can be completed from the top of the well bore by pumping fluid thereinto. In any event, the trip ball **81** can be placed within the drill pipe B and pumped downwardly therethrough, the plug **90***a* being blown out of the choke and the ball coming to rest upon its seat **80***a*, whereupon fluid pressure can be built up in the drill pipe, mandrel passage and cylinder space for the purpose of hydraulically elevating the body **13** along the mandrel **10**, while the drill pipe and bit are rotated, to effect cutter expansion. The erodible ball **81**, as before, will reduce in diameter and will be ejected from the choke passage **79**.

The plug **90***a* illustrated in FIG. 9 may be used when the drill bit is to be lowered to relatively deep locations in the well bore, which will introduce comparatively high external hydrostatic pressures acting in a downward direction on the body **13** of the tool and tending to keep it downwardly along the mandrel **10**. The fluid in the well bore flowing through the plug passage **96** will cause the drill pipe to fill partially with fluid and decrease the hydrostatic head differential acting downwardly on the body of the drill bit. For that matter, when the solid plug illustrated in FIGS. 6 to 8 is used, the drill pipe could be partially filled with drilling mud, or the like, from the top of the well bore to prevent the hydrostatic head differential acting downwardly on the bit body from becoming too great.

I claim:

1. In a rotary drill bit to be lowered through fluid in a well bore on a drill string: a body structure having a passage through which drilling fluid is adapted to flow; cutter means mounted on said body structure for expansion laterally outwardly thereof; fluid actuated means responsive to the pressure of fluid in said passage for expanding said cutter means, said fluid actuated means being responsive to the hydrostatic head of fluid in the well bore externally of the drill bit which tends to resist expansion of said cutter means by said fluid actuated means; means for maintaining fluid pressure within the drill bit, and acting on said fluid actuated means, at a substantial lower value than the external hydrostatic head of fluid acting on said fluid actuated means during lowering of the drill bit in the well bore to prevent expansion of said cutter means; and means for rendering said maintaining means ineffective to permit said cutter means to be expanded by said fluid actuated means.

2. In a rotary drill bit to be lowered through fluid in a well bore on a drill string: a body structure having a passage through which drilling fluid is adapted to flow; cutter means mounted on said body structure for expansion laterally outwardly thereof; fluid actuated means responsive to the pressure of fluid in said passage for expanding said cutter means, said fluid actuated means being responsive to the hydrostatic head of fluid in the well bore externally of the drill bit which tends to resist expansion of said cutter means by said fluid actuated means; means for restricting upward flow of fluid in said passage to said fluid actuated means during lowering of the drill bit in the well bore to prevent expansion of said cutter means; and means for rendering said restricting means ineffective to permit said cutter means to be expanded by said fluid actuated means.

3. In a rotary drill bit to be lowered through fluid in a well bore on a drill string: a body structure having a passage through which drilling fluid is adapted to flow; cutter means mounted on said body structure for expansion laterally outwardly thereof; fluid actuated means responsive to the pressure of fluid in said passage for expanding said cutter means, said fluid actuated means being responsive to the hydrostatic head of fluid in the well bore externally of the drill bit which tends to resist expansion of said cutter means by said fluid actuated means; means for restricting flow of fluid in said passage to said fluid actuated means during lowering of the drill bit in the well bore to prevent expansion of said cutter means; and means for rendering said restricting means ineffective to permit said cutter means to be expanded by said fluid actuated means.

4. In a rotary drill bit to be lowered through fluid in a well bore on a drill string: a body structure having a passage through which drilling fluid is adapted to flow; cutter means mounted on said body structure for expansion laterally outwardly thereof; fluid actuated means responsive to the pressure of fluid in said passage for expanding said cutter means, said fluid actuated means being responsive to the hydrostatic head of fluid in the well bore externally of the drill bit which tends to resist expansion of said cutter means by said fluid actuated means; means for restricting flow of fluid in the well bore upwardly into said passage during lowering of the drill bit in the well bore to prevent expansion of said cutter means; and means for rendering said restricting means ineffective to permit said cutter means to be expanded by said fluid actuated means.

5. In a rotary drill bit to be lowered through fluid in a well bore on a drill string: a body structure having a passage through which drilling fluid is adapted to flow; cutter means mounted on said body structure for expansion laterally outwardly thereof; fluid actuated means responsive to the pressure of fluid in said passage for expanding said cutter means, said fluid actuated means being responsive to the hydrostatic head of fluid in the well bore externally of the drill bit which tends to resist expansion of said cutter means by said fluid actuated means; and passage closure means restricting the flow of well bore fluid upwardly in said passage during lowering of the drill bit in the well bore to prevent expansion of said cutter means, said closure means being removable from closed relation to said passage by fluid pressure in said passage thereabove.

6. In a rotary drill bit to be lowered through fluid in a well bore on a drill string: a body structure having a passage through which drilling fluid is adapted to flow;

cutter means mounted on said body structure for expansion laterally outwardly thereof; fluid actuated means responsive to the pressure of fluid in said passage for expanding said cutter means, said fluid actuated means being responsive to the hydrostatic head of fluid in the well bore externally of the drill bit which tends to resist expansion of said cutter means by said fluid actuated means; and passage closure means restricting the flow of well bore fluid upwardly in said passage during lowering of the drill bit in the well bore to prevent expansion of said cutter means, said closure means being removable from closed relation to said passage by fluid pressure in said passage thereabove, said closure means having a choke orifice therethrough to permit well bore fluid to flow upwardly therethrough at a restricted rate into said passage.

7. In a rotary drill bit to be lowered through fluid in a well bore on a drill string: a body structure having a passage through which drilling fluid is adapted to flow; cutter means mounted on said body structure for expansion laterally outwardly thereof; fluid actuated means responsive to the pressure of fluid in said passage for expanding said cutter means, said fluid actuated means being responsive to the hydrostatic head of fluid in the well bore externally of the drill bit which tends to resist expansion of said cutter means by said fluid actuated means; valve means in said body structure initially preventing flow of fluid from said passage to said fluid actuated means; and means for shifting said valve means to a position permitting flow of fluid from said passage to said fluid actuated means.

8. In a rotary drill bit to be lowered through fluid in a well bore on a drill string: a body structure having a passage through which drilling fluid is adapted to flow; cutter means mounted on said body structure for expansion laterally outwardly thereof; fluid actuated means on said body structure for expanding said cutter means; said body structure having port means communicating said passage with said fluid actuated means; said fluid actuated means being responsive to the hydrostatic head of fluid in the well bore externally of the drill bit which tends to resist expansion of said cutter means by said fluid actuated means; a valve sleeve in said passage initially closing said port means; and means for shifting said valve sleeve to port opening position.

9. In a rotary well drilling bit to be lowered through fluid in a well bore on a drill string: a body; cutter means mounted on said body for expansion laterally outwardly thereof; a mandrel connectible to a drill string and slidably splined to said body, whereby drilling torque is transmitted from said mandrel to said body, said mandrel having a passage through which the drilling fluid is adapted to flow; coengageable expander means on said mandrel and cutter means; hydraulically movable means on said body subject to the pressure of fluid in said passage for elevating said body and cutter means with respect to said mandrel to cause said expander means to expand said cutter means laterally outward; said hydraulically movable means being responsive to the hydrostatic head of fluid in the well bore externally of the drill bit which tends to resist elevation of said body and cutter means with respect to said mandrel; means for maintaining fluid pressure within said passage and acting on said hydraulically movable means at a substantially lower value than the external hydrostatic head of fluid acting on said hydraulically movable means during lowering of the drill bit in the well bore to prevent elevation of said body and cutter means with respect to said mandrel; and means for rendering said maintaining means ineffective to permit fluid pressure in said passage to elevate said body and cutter means with respect to said mandrel.

10. In a rotary drill bit to be lowered through fluid in a well bore on a drill string: a body structure having a passage through which drilling fluid is adapted to flow; cutter means mounted on said body structure for expansion laterally outwardly thereof; actuating means on said body structure for expanding said cutter means, said actuating means being responsive to the hydrostatic head of fluid in the well bore externally of the drill bit which tends to resist expansion of said cutter means by said actuating means; means for maintaining fluid pressure within the drill bit and acting on said actuating means at a substantially lower value than the external hydrostatic head of fluid acting on said actuating means during lowering of the drill bit in the well bore to prevent expansion of said cutter means; and means for rendering said maintaining means ineffective to permit said cutter means to be expanded by said actuating means.

11. In a rotary well drilling bit to be lowered through fluid in a well bore on a drill string: a body; cutter means mounted on said body for expansion laterally outwardly thereof; a mandrel connectible to a drill string and slidably splined to said body, whereby drilling torque is transmitted from said mandrel to said body, said mandrel having a passage through which the drilling fluid is adapted to flow; coengageable expander means on said mandrel and cutter means; hydraulically movable means on said body subject to the pressure of fluid in said passage for elevating said body and cutter means with respect to said mandrel to cause said expander means to expand said cutter means laterally outward; said hydraulically movable means being responsive to the hydrostatic head of fluid in the well bore externally of the drill bit which tends to resist elevation of said body and cutter means with respect to said mandrel; means for restricting upward flow of fluid in said passage to said hydraulically movable means during lowering of the drill bit in the well bore to prevent elevation of said body and cutter means with respect to said mandrel; and means for rendering said restricting means ineffective to permit upward movement of said body and cutter means with respect to said mandrel in response to fluid pressure in said passage.

12. In a rotary well drilling bit to be lowered through fluid in a well bore on a drill string: a body; cutter means mounted on said body for expansion laterally outwardly thereof; a mandrel connectible to a drill string and slidably splined to said body, whereby drilling torque is transmitted from said mandrel to said body, said mandrel having a passage through which the drilling fluid is adapted to flow; coengageable expander means on said mandrel and cutter means; hydraulically movable means on said body subject to the pressure of fluid in said passage for elevating said body and cutter means with respect to said mandrel to cause said expander means to expand said cutter means laterally outward; said hydraulically movable means being responsive to the hydrostatic head of fluid in the well bore externally of the drill bit which tends to resist elevation of said body and cutter means with respect to said mandrel; means for restricting flow of fluid in the well bore upwardly into said passage during lowering of the drill bit in the well bore to prevent elevation of said body and cutter means with respect to said mandrel; and means for rendering said restricting means ineffective to permit elevation of said body and cutter means with respect to said mandrel in response to fluid pressure in said passage.

13. In a rotary well drilling bit to be lowered through fluid in a well bore on a drill string: a body; cutter means mounted on said body for expansion laterally outwardly thereof; a mandrel connectible to a drill string and slidably splined to said body, whereby drilling torque is transmitted from said mandrel to said body, said mandrel having a passage through which the drilling fluid is adapted to flow; coengageable expander means on said mandrel and cutter means; hydraulically movable means on said body subject to the pressure of fluid in said passage for elevating said body and cutter means with respect to said mandrel to cause said expander means to expand said cutter means laterally outward; said hydraulically movable means being responsive to the hydrostatic head of fluid in the well bore externally of the drill bit which

tends to resist elevation of said body and cutter means with respect to said mandrel; and closure means for said passage restricting the flow of well bore fluid upwardly in said passage during lowering of the drill bit in the well bore to prevent elevation of said body and cutter means with respect to said mandrel, said closure means being removable from closed relation to said passage by fluid pressure in said passage thereabove.

14. In a rotary well drilling bit to be lowered through fluid in a well bore on a drill string: a body; cutter means mounted on said body for expansion laterally outwardly thereof; a mandrel connectible to a drill string and slidably splined to said body, whereby drilling torque is transmitted from said mandrel to said body, said mandrel having a passage through which the drilling fluid is adapted to flow; coengageable expander means on said mandrel and cutter means; hydraulically movable means on said body subject to the pressure of fluid in said passage for elevating said body and cutter means with respect to said mandrel to cause said expander means to expand said cutter means laterally outward; said hydraulically movable means being responsive to the hydrostatic head of fluid in the well bore externally of the drill bit which tends to resist elevation of said body and cutter means with respect to said mandrel; and plug means in said passage restricting the flow of well bore fluid upwardly in said passage during lowering of the drill bit in the well bore to prevent elevation of said body and cutter means with respect to said mandrel, said plug means being ejectable from said passage by fluid pressure in said passage thereabove, said plug means having a choke orifice to permit well bore fluid to flow upwardly therethrough at a restricted rate into said passage.

15. In a rotary well drilling bit to be lowered through fluid in a well bore on a drill string: a body; cutter means mounted on said body for expansion laterally outwardly thereof; a mandrel connectible to a drill string and slidably splined to said body, whereby drilling torque is transmitted from said mandrel to said body, said mandrel having a passage through which the drilling fluid is adapted to flow; coengageable expander means on said mandrel and cutter means; hydraulically movable means on said body subject to the pressure of fluid in said passage for elevating said body and cutter means with respect to said mandrel to cause said expander means to expand said cutter means laterally outward; said hydraulically movable means being responsive to the hydrostatic head of fluid in the well bore externally of the drill bit which tends to resist elevation of said body and cutter means with respect to said mandrel; valve means in said passage initially preventing flow of fluid from said passage to said hydraulically movable means; and means for shifting said valve means to a position permitting flow of fluid from said passage to said hydraulically movable means.

16. In a rotary drill bit to be lowered through fluid in a well bore on a drill string: a 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, whereby drilling torque is transmitted from said mandrel to said body; coengageable expander means on said mandrel and cutter means; said mandrel having a passage through which drilling fluid is adapted to flow; hydraulically movable means on said body; port means in said mandrel establishing communication between said passage and hydraulically movable means, whereby fluid pressure in said passage can flow through said port to said hydraulically movable 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; said hydraulically movable means being responsive to the hydrostatic head of fluid in the well bore externally of the drill bit which tends to resist elevation of said body and cutter means with respect to said mandrel; a valve sleeve in said passage initially closing said port means; and means for shifting said valve sleeve to port opening position.

17. In a rotary drill bit to be lowered through fluid in a well bore on a drill string: a 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, whereby drilling torque is transmitted from said mandrel to said body; coengageable expander means on said mandrel and cutter means; said mandrel having a passage through which drilling fluid is adapted to flow; hydraulically movable means on said body; port means in said mandrel establishing communications between said passage and hydraulically movable means, whereby fluid pressure in said passage can flow through said port to said hydraulically movable 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; said hydraulically movable means being responsive to the hydrostatic head of fluid in the well bore externally of the drill bit which tends to resist elevation of said body and cutter means with respect to said mandrel; a valve sleeve in said passage initially closing said port means, said valve sleeve having a seat therein; and an erodible member movable downwardly in said passage into engagement with said seat to provide an orifice to choke the flow of fluid in said passage and cause a back pressure to be built up in said passage for shifting said valve sleeve to port opening position, said erodible member wearing away as fluid is pumped through said passage to substantially enlarge said orifice.

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