United States Patent

[11] 3,561,550

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[54] **EXPANSIBLE ROTARY DRILL BIT**
10 Claims, 5 Drawing Figs.

[52] **U.S. Cl.** **175/271,** 175/273, 175/292
[51] **Int. Cl.** **E21b 9/26**
[50] **Field of Search** 175/267, 269, 271, 273, 292

[56] **References Cited**

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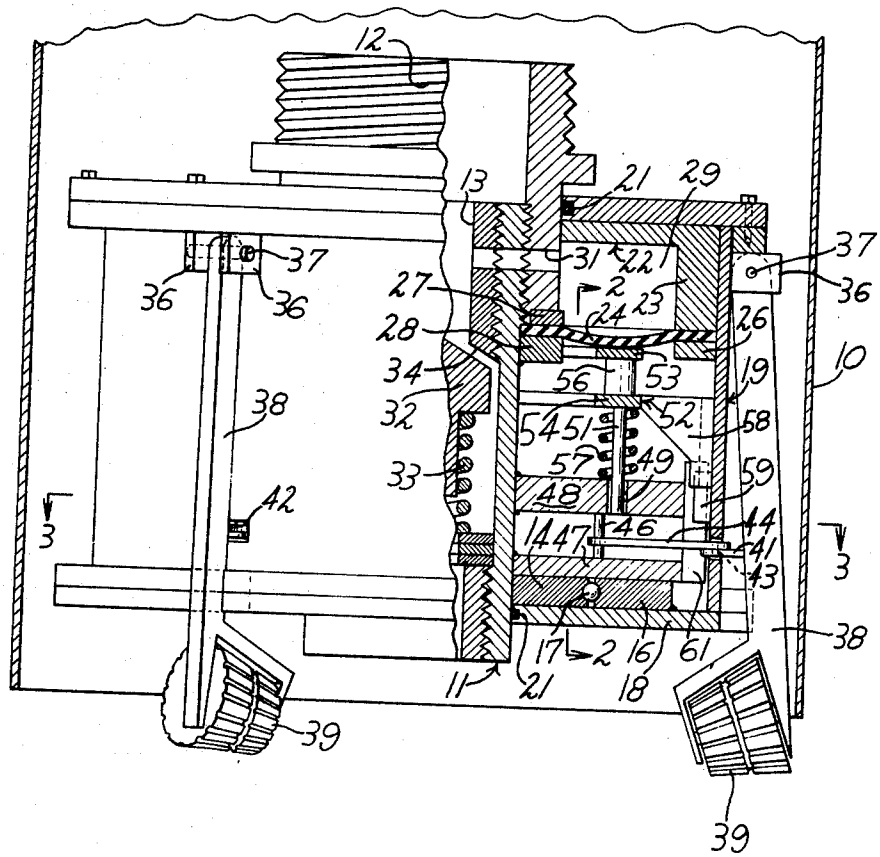
ABSTRACT: A bit body having passageway therethrough receiving fluid under pressure. Pressure responsive unit communicates with passageway and moves from one position to another upon receiving fluid under pressure. Cutter assembly carried by bit housing surrounding bit body and movable by actuating member to expanded position upon angular movement of bit body prior to introduction of fluid under pressure. Movable restraining member limits angular movement of bit body relative to bit housing upon introduction of fluid under pressure prior to angular movement of bit body.



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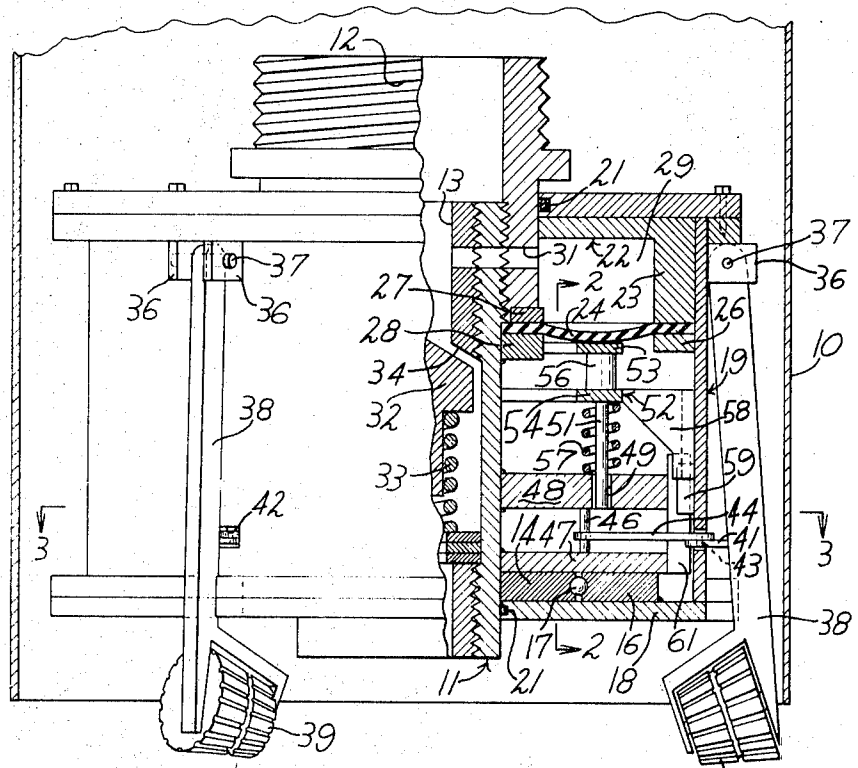

FIG 1.

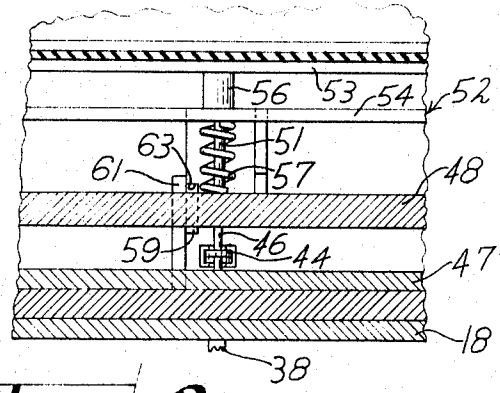

FIG 2.

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FIG 3

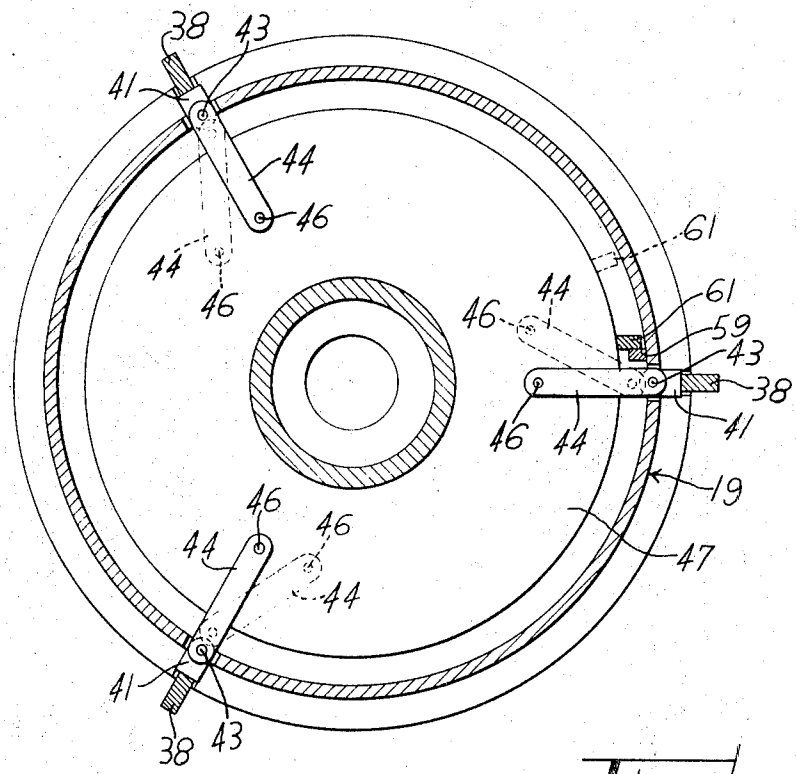
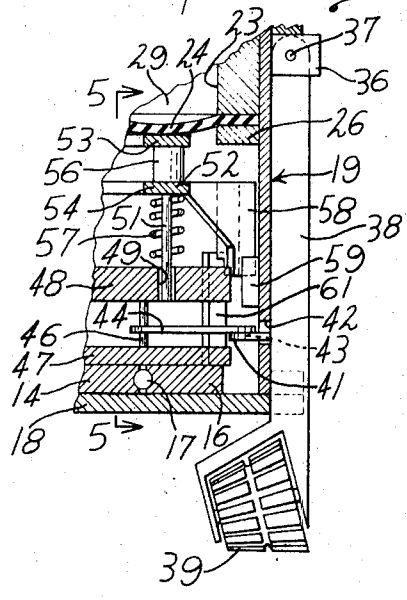


FIG 4



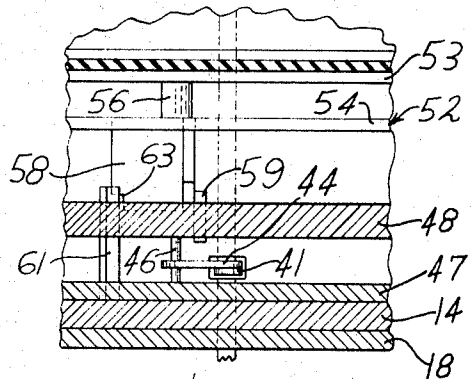


FIG 5

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EXPANSIBLE ROTARY DRILL BIT

BACKGROUND OF THE INVENTION

My present invention relates to rotary drill bits having roller or drag-type cutters designed for cutting rock or other hard earth formations of the type used in well drilling and related operations and more particularly to rotary drill bits having cutters that are expandable outwardly for cutting a larger diameter hole than the inside or even the outside of the well casing through which the bit may be lowered or removed.

An object of my invention is to provide a rotary drill bit of the character designated which shall be adapted for drilling a large diameter hole in formations which are neither uniform nor stable enough to be drilled without the use of some type of casing to retain the drill string in a straight line.

Another object of my invention is to provide an expandable drill bit which may be readily retracted or extended while the bit is still in the hole being bored, thus permitting the drill string to be removed from the hole through a well casing, allowing the casing to remain in the hole, and at the same time the bit mechanism and drill string may be moved relative to the well casing without any interference of opened cutters with casing joints or other rough obstructions within the well.

A further object is to provide an expandable drill bit of the character designated in which the cutter arms may be locked in retracted position or expanded position by employing the same mechanism which is employed to drill two different size holes by merely locking the bit in either extended position for the larger size hole or by locking the bit in the retracted position for a smaller size hole and at the same time no additional controls, lines, levers, pipes, rods or other related mechanisms are required other than those required for the normal functions of a rotary drilling rig.

A further object of my invention is to provide a drill bit of the character designated which permits the drilling operation to cease at any desired depth or location within the depth of the hole to be bored thereby providing a load bearing member or foundation and at the same time permitting the bit to advance further in the hole without withdrawing the bit from the hole for change or adjustment to provide an additional load bearing area at a greater depth.

A still further object of my invention is to provide an expandable rotary drill bit of the character designated which shall be extremely simple of construction, economical of manufacture and one which is simple to operated due to the fact that the operator need perform no additional movements of his drilling machine to actuate the locking mechanism, it being only necessary to deviate from the routine drilling procedure in the sequence of imparting rotation to the bit and the introduction of fluid under pressure.

Apparatus embodying features of my invention is illustrated in the accompanying drawings, forming a part of this application, in which:

FIG. 1 is a side elevational view, partly broken away and in section, showing the cutter arms in extended position;

FIG. 2 is a fragmental, sectional view taken generally along the line 2–2 of FIG. 1;

FIG. 3 is a sectional view taken generally along the line 3–3 of FIG. 1, the casing being omitted, for the sake of clarity;

FIG. 4 is a fragmental, sectional view showing the cutter arms in contracted position; and,

FIG. 5 is a fragmental, sectional view taken generally along the line 5–5 of FIG. 4.

Referring now to the drawings for a better understanding of my invention, I show a cylindrical casing 10 for receiving the expansible rotary drill bit. The drill bit comprises a bit body 11 which is connected for rotation with a threaded member 12 which in turn is adapted for connection to the lower end of a hollow drill string whereby air under pressure may be supplied to the bit body 11. An air passageway 13 in the bit body 11 communicates with the hollow passageway in the drill rod string for receiving air under pressure.

Secured rigidly to the bit body 11 is an inner race 14 of a bearing unit having an outer race 16 and ball bearings 17. Secured rigidly to the outer bearing race 16 is an annular plate 18 which defines the lower portion of a bit housing 19 which is adapted for angular movement relative to the bit body 11. Suitable annular seals 21 are interposed between the bit housing 19 and the bit body 11 to provide a fluid-tight fit therebetween.

Secured rigidly to the bit body 11 is an annular member 22 having a depending annular flange 23. An annular, flexible diaphragm 24 is secured to the lower edge of depending, annular flange 23 by a clamping ring 26. The inner or opposite edge of diaphragm 24 extends between clamping rings 27 and 28 whereby the diaphragm 24 is clamped therebetween and defines the lower portion of an annular chamber 29 which communicates with passageway 13 by a passageway 31 provided in the bit body 11, as shown in FIG. 1. The diaphragm 24 and the annular chamber 29 associated therewith thus define a pressure responsive unit which moves from an upper position to a lower position in response to introduction of fluid under pressure through passageways 13 and 31.

Mounted for axial movement within the opening 13 in bit body 11 is a pressure relief valve 32 which is urged toward closed position by a compression spring 33. While no fluid under pressure is being introduced through passageway 13, the relief valve 32 moves into engagement with an annular seat 34 whereby there is no flow through the lower discharge end of passageway 13. Upon introducing fluid under pressure through passageway 13, pressure within chamber 29 is increased to force diaphragm 24 downwardly toward a lower position. Also, upon a predetermined increase in pressure within the chamber 29, the relief valve 32 is moved downwardly whereby fluid under pressure passes around valve 32 and is discharged adjacent the lower end of bit body 11. In the drawings I show the bit as being of the type wherein air under pressure is discharged at the lower end of passageway 13 whereupon cuttings are blown from the hole by passing upwardly between the bit housing 19 and the inner surface of the casing 10.

As shown in FIGS. 1 and 4, outwardly projecting pairs of brackets 36 are secured to the outer upper portion of bit housing 19. Extending upwardly between each pair of brackets 36 and pivotally connected thereto by a pivot pin 37 is a cutter arm 38. The lower end of each cutter arm 38 carries a conventional-type cutter 39. In view of the fact that such cutter elements are well known in the art to which my invention relates, no further description thereof is deemed necessary.

Secured to each cutter arm 38 and extending inwardly thereof is a bracket 41. An opening 42 is provided through the bit housing 19 for receiving the bracket 41, as shown in FIGS. 1 and 4. Pivotally connected to the bracket 41 by a pivot pin 43 is the outer end of a link 44. The other end of each link 44 is pivotally connected by a pivot pin 46 to a pair of annular members 47 and 48 which in turn are rigidly secured to the bit body 11 by suitable means, such as by welding. Accordingly, upon rotating the members 47 and 48 relative to the bit housing 19 in a clockwise direction, as viewed in FIG. 3, the links 44 move from the dotted line position to the solid line position to thus move the link members 44, brackets 41 and the cutter arms 38 in an outward or expanded position. On the other hand, upon rotating the annular members 47 and 48 in the opposite direction, the links 44 and 41 move from the solid line position to the dotted line position shown in FIG. 3 whereupon the cutter arms 38 move inwardly adjacent the bit housing 19 to contracted position, as shown in FIG. 4. The annular members 47 and 48, together with the links 44 and bracket 41 define actuating members which are adapted to move the cutter arms 38 selectively to contracted position and expanded position, as shown in FIGS. 4 and 1, respectively.

Angularly spaced openings 49 are provided in the annular member 48 with each opening being disposed to receive the lower end of an upstanding rod 51 which is secured at its upper end to an annular assembly 52 comprising upper and

lower annular members 53 and 54, connected to each other by spacer elements 56. Surrounding each rod 51 between annular members 48 and 54 is a compression spring 57 which is adapted to urge the annular assembly 52 upwardly upon interruption of fluid under pressure to chamber 29 of the pressure responsive unit. Accordingly, upon release of pressure the diaphragm 24 would move upwardly from the position shown in FIGS. 1 and 4.

Secured rigidly to the annular member 54 of the annular assembly 52 is a depending restraining member 58 which is adapted to move with the annular assembly 52 from an upper position to a lower position in response to introduction of fluid under pressure into the chamber 29 of the pressure responsive unit.

Secured rigidly to the inner surface of bit housing 19 is a stop member 59. Secured to and adapted for angular movement with the annular members 47 and 48 is a stop member 61 which is spaced angularly from stop member 59 while the annular members 47 and 48 are in the positions shown in FIGS. 4 and 5. Accordingly, with the restraining member 58 in the down position, as shown in FIGS. 4 and 5, the restraining member prevents angular movement of the annular members 47 and 48 relative to the stop member 59 carried by bit housing 19. In this position, the cutter arms 38 are locked in contracted position so long as pressure is exerted downwardly on the diaphragm 24 by the fluid under pressure introduced into chamber 29. On the other hand, upon release of pressure within chamber 29, the springs 57 urge annular assembly 52 and the diaphragm 24 upwardly whereby the restraining member 58 moves upwardly to a position to permit stop member 61 to move relative to stop member 59 from the position shown in FIG. 5 to the position shown in FIG. 2 whereupon the link 44 moves from the dotted line position to the solid line position shown in FIG. 3. Accordingly, upon imparting angular movement between the stops 61 and 59 prior to the introduction of fluid under pressure into chamber 29, the annular members 47 and 48 and the stop member 61 carried thereby moves angularly relative to bit housing 19 to the position shown in FIG. 2 whereby stop 61 moves into engagement with stop 59. On the other hand, upon introducing fluid under pressure to chamber 29 prior to rotation of the bit body 11, the restraining member 58 moves downwardly between stops 61 and 59, as shown in FIG. 5, whereby there is no relative angular movement between the stops 59 and 61 thus locking the cutter arms 38 in their inner, contracted position, as shown in FIG. 4.

From the foregoing description, the operation of my improved expandable bit will be readily understood. To move the rotary bit down into the casing 10, the cutter arms 38 are moved inwardly to contracted position, as shown in FIG. 4. This is accomplished by rotating the drill rod string and the bit body 11 in a counterclockwise direction whereby the links 44 move to the dotted line position shown in FIG. 3. When it is desired to expand the cutter arm 38, the flow of fluid under pressure, such as air, to the passageway 13 is interrupted whereupon the pressure in chamber 29 drops permitting diaphragm 24 to move to an upper position. That is, upon release of pressure on diaphragm 24, the springs 57 urge the annular assembly 52 carrying the restraining member 58 in an upward direction thus moving the restraining member 58 out of the path of movement of stop 61. Accordingly, the annular members 47 and 48 which carry stop 61 are free to rotate relative to the bit housing 19 and its stop 59 whereby stop 61 moves to the position shown in FIG. 2 adjacent stop 59. In this position, the link 44 assumes the solid line position shown in FIG. 3 whereby the cutter arm 38 moves to extended position, as shown in FIG. 1. A larger diameter hole may then be drilled without removing the bit assembly from the hole. The cutter arms 38 are locked in the extended position upon introduction of fluid under pressure into the chamber 29 since an increase in pressure within chamber 29 forces diaphragm 24 downwardly to thus move the annular assembly 52 and its restraining member 58 to the down position, as shown in FIG. 2. A suitable recess 63 is provided in the lower portion of the restraining member 58 in position to engage the top of stop 59 while restraining member 58 is in the lower position to thus further lock the restraining member 58 and its annular assembly 52 to the stop 59 carried by the bit housing 19.

Where it is desired to move the cutter arms 38 from an expanded cutting position to a contracted position for cutting a smaller hole or for withdrawing the bit assembly from the hole, fluid under pressure to the chamber 29 of the pressure responsive unit is interrupted whereupon the springs 57 return the diaphragm 24 to its original position whereupon the restraining member 58 is elevated above the stop member 59. Upon rotation of the drill rod string and the bit body 11 in a counterclockwise direction, as viewed in FIG. 3, the annular members 47 and 48 move from the solid line position to the dotted line position to thus contract the cutter arms 38. After the cutter arms 38 have been contracted, fluid under pressure is then introduced through passageway 13 and 31 to chamber 29 whereupon diaphragm 24 moves downwardly to thus force restraining member 58 downwardly to the position shown in FIGS. 4 and 5 whereupon the cutter arms 38 are locked in contracted position.

Each time fluid under pressure is introduced into passageway 13, the pressure first builds up in chamber 29 of the pressure responsive unit until the diaphragm 24 is moved downwardly to force restraining member 58 downwardly. Upon reaching a predetermined pressure, the relief valve 32 is then moved downwardly whereupon fluid under pressure moves past valve 32 and is discharged through the lower end of passageway 13 to thus clear the hole being bored of cuttings. The air then travels upwardly between the bit housing 19 and the inner surface of the hole or the casing 10, as the case may be.

While I have described the fluid under pressure as being in the form of air, it will be apparent that other fluids under pressure, such as drilling mud or the like may be employed. Also, while I have shown the cutter arm 38 as being moved selectively to contracted and expanded position by a linkage and pin arrangement, it will be apparent that other mechanism may be employed for moving the arm 38 selectively to contracted and expanded position, such as by employing ball joints or the like, which will suggest themselves to one skilled in the art to which my invention relates.

From the foregoing, it will be seen that I have devised an improved expandable drill bit which is movable by an actuating member to expanded position upon angular movement of the bit body prior to introduction of fluid under pressure and is retained in a contracted position by a restraining member upon introduction of fluid under pressure prior to angular movement of the bit body. Also, by permitting the bit to be moved selectively to contracted and expanded positions by merely varying the sequence of the driller's normal operations, the cutter arms are expanded and contracted without the necessity of complicated actuating members. Furthermore, by providing an expandable bit wherein the cutter arms are movable selectively to contracted and expanded position at any time regardless of the position of the drill assembly within the hole, the size of the hole may be readily varied without having to withdraw the bit assembly from the hole.

While I have shown my invention in but one form, it will be obvious to those skilled in the art that it is not so limited, but is susceptible of various other changes and modifications without departing from the spirit thereof.

I claim:

1. In an expansible rotary drill bit:

a. a bit body adapted to be attached to and rotate with a rotary drill stem and having a passageway therethrough for receiving fluid under pressure;

b. a bit housing surrounding said bit body and adapted for angular movement relative thereto;

c. at least one cutter arm carried by said bit housing and movable relative thereto selectively to a contracted position and an extended position;

d. a cutter carried by said cutter arm;

e. an actuating member carried by said bit body and operatively connected to said cutter arm and movable selectively to a first position placing said cutter arm in said contracted position and to a second position placing said cutter arm in said expanded position;

f. a pressure responsive unit communicating with said passageway and movable from one position to another position upon introducing fluid under pressure to said passageway;

g. means returning said pressure responsive unit to said one position upon interruption of said fluid under pressure to said passageway;

h. a first stop member operatively connected to said bit housing;

i. a second stop member operatively connected to said actuating member; and

j. a restraining member operatively connected to said pressure responsive unit movable to a position to restrain movement of said actuating member to said second position in response to movement of said pressure responsive unit to said another position and movable to a position permitting movement of said actuating member to said second position in response to movement of said pressure responsive unit to said one position.

2. An expansible rotary drill bit as defined in claim 1 in which said bit body is a cylindricallike member having a lateral passageway therethrough communicating said bit body with said pressure responsive unit and a pressure relief valve is mounted within said cylindricallike member beyond said lateral passageway relative to the direction of fluid flow restraining flow of fluid under pressure through said cylindricallike member until a predetermined pressure is reached within said pressure responsive unit.

3. An expansible rotary drill bit as defined in claim 1 in which said bit housing comprises a cylindrical member surrounding said bit body and adapted for angular movement relative thereto.

4. An expansible rotary drill bit as defined in claim claim 3 in which said pressure responsive unit comprises an annular, hollow member carried by said bit body and movable angularly within said cylindrical member with one side of said annular, hollow member being flexible and movable selectively

to said one position and said another position.

5. An expansible rotary drill bit as defined in claim 3 in which said cutter is carried by one end of said cutter arm and the other end of said cutter arm is pivotally connected to said cylindrical member with said one end being movable selectively to contracted position and expanded position.

6. An expansible rotary drill bit as defined in claim 1 in which said actuating member comprises a laterally extending member mounted for rotation with said bit body and at least one link member pivotally connecting said laterally extending member to said cutter arm, there being an opening through said bit housing for receiving said link member whereby upon relative movement of said laterally extending member and said bit housing in opposite directions said cutter arm moves selectively to said contracted position and said expanded position.

7. An expansible rotary drill bit as defined in claim 6 in which said laterally extending member comprises at least one annular disclike member secured to said bit body.

8. An expansible rotary drill bit as defined in claim 6 in which said restraining member is carried by an annular member mounted between said laterally extending member and said pressure responsive unit with said annular member being movable toward and away from said laterally extending member in response to movement of said pressure responsive unit to said one position and said another position.

9. An expansible rotary drill bit as defined in claim 8 in which spring means is interposed between said annular member and said laterally extending member urging said annular member and said restraining member away from said laterally extending member upon interruption of fluid flow to said pressure responsive unit so that said actuating member and said second stop member carried thereby are movable to said second position upon angular movement of said bit body prior to the introduction of fluid under pressure to said pressure responsive unit.

10. An expansible rotary drill bit as defined in claim 9 in which said restraining member is provided with a recess therein engageable with said first stop member retaining said actuating member in said second position with said cutter arm in expanded position until the flow of fluid under pressure to said pressure responsive unit is interrupted.