United States Patent [19]

Crow

[11] **3,744,580**

[45] **July 10, 1973**

[54] **LUBRICANT RESERVOIR FOR ROCK BITS**

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[52] **U.S. Cl.** **175/228,** 308/8.2, 175/372

[51] **Int. Cl.** **F16c 19/00,** E21b 9/10

[58] **Field of Search** 175/227–229, 371, 372; 308/8.2

[56] **References Cited**

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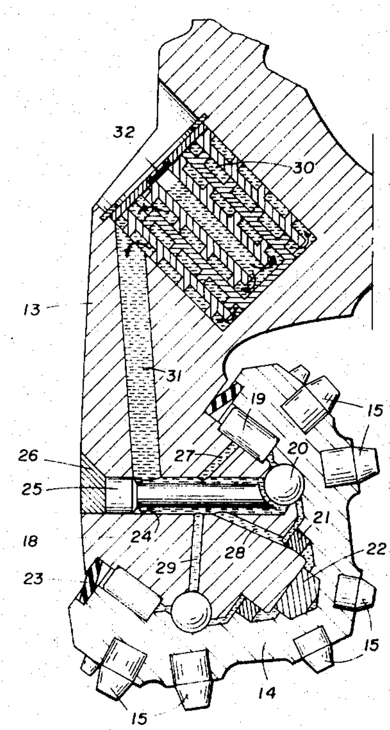
Primary Examiner—David H. Brown
Attorney—Robert W. Mayer, Eddie E. Scott et al.

[57] **ABSTRACT**

A cone cutter is rotatably mounted upon a bearing pin extending from the arm of a rotary rock bit. Lubricant is supplied to the bearings between the cone cutter and the bearing pin by a protracted passageway containing lubricant. The protracted passageway extends through the arm and bearing pin of the bit to the bearing area with the outer end of the protracted passageway connected to the exterior surface of the bit. The protracted passageway provides pressure equalization between the pressure of the lubricant and the pressure of fluid in the well bore and insures that lubricant reaching the bearing area is free of contaminants.

7 Claims, 3 Drawing Figures



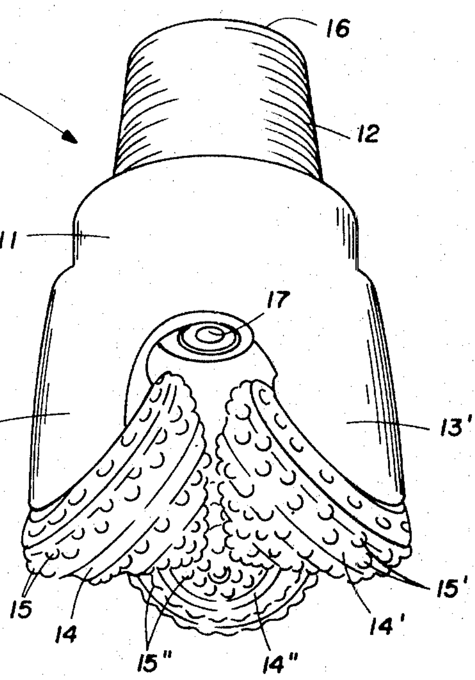

16
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FIG. 1

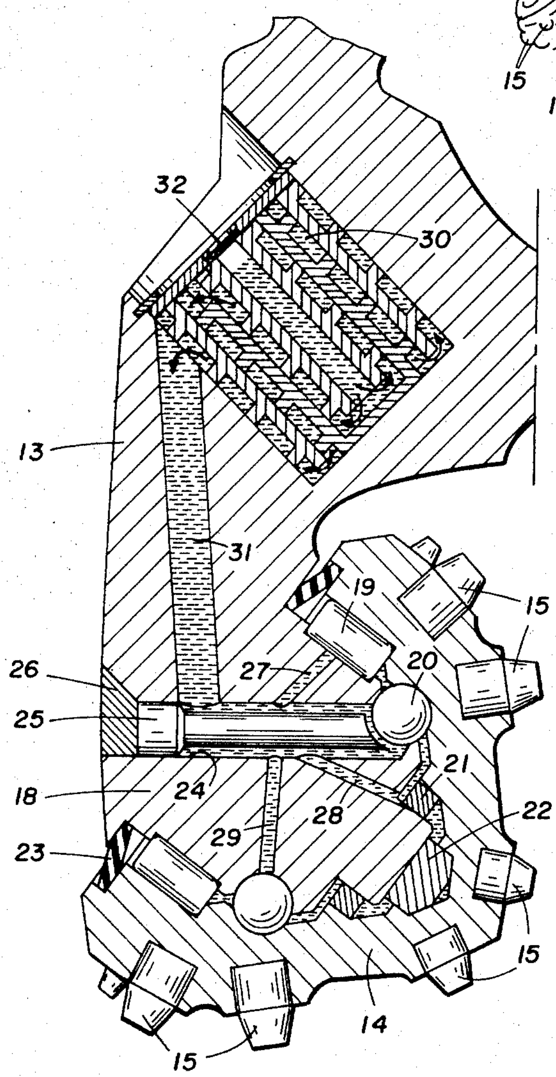
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FIG. 2

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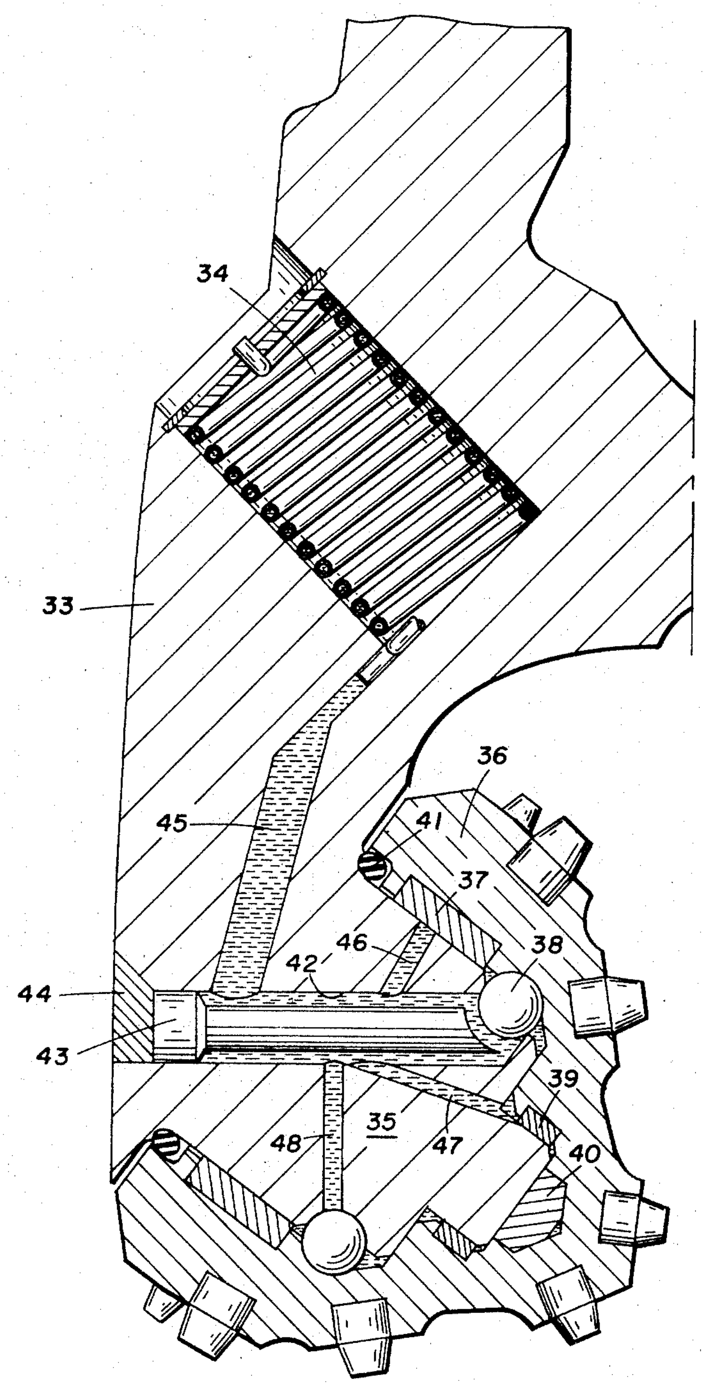

FIG. 3

LUBRICANT RESERVOIR FOR ROCK BITS

BACKGROUND OF THE INVENTION

The present invention relates to the art of earth boring and more particularly to a system for providing lubricant to the bearings between the cutter and the bearing pin of a rotary rock bit that will allow the bit to be operated for an extended period of time under changing pressure conditions.

A rotary rock bit in general consists of a main bit body adapted to be connected to a rotary drill string. The bit includes at least one rotatable cutter mounted upon a bearing pin extending from the main bit body. Bearings are provided between the cutter and the bearing pin to promote rotation of the cutter and means are provided on the outer surface of the cutter for disintegrating the formations as the bit and cutter rotate. A sufficient supply of lubricant must be provided to the bearings throughout the lifetime of the bit.

Problems have been encountered with prior art systems of supplying lubricant to the bearings because of the relatively long lifetime of the bits and the wide variation of environmental conditions encountered during the drilling operation. When a rotary rock bit is lowered into a well bore, the environmental pressure surrounding the bit increases at the rate of approximately ½ pound per square inch for each foot of depth. This means that at a depth of 10,000 feet, the hydrostatic pressure on the outside of the bit could be 5,000 psi or more because of the weight of the drilling fluid in the well bore above the bit. In order for a lubrication system to function properly at the elevated downhole pressures, some means must be provided to equalize the internal pressure of the lubricant in the system with the hydrostatic pressure of the drilling fluid in the well bore.

When providing pressure equalization, a wide variety of environmental conditions must be considered. For example, the temperatures will rise as the well bore penetrates deeper into the earth and temperatures in the range of 250° to 350° F at 10,000 feet depth and still higher temperatures at greater depths may be expected. As the bit is rotated and the cutters engage the formations, a large amount of heat is generated causing the environmental temperature of the bit to rise. Friction in the bearings and seals generates a large amount of heat and a large amount of heat is generated by the action of the bit on the formations. The elevated temperature has an adverse effect on the lubricant and the elements of the lubrication and bearing systems. Changing pressure conditions are also detrimental to a lubrication system. Periodic pressure variations are produced during the drilling operation and these pressure variations can damage the structural elements of the lubrication system. During drilling, joints of pipe must be added to the drill string for progressively deeper penetration. This may mean that 50 or 60 joints of pipe are added to the drill string during the normal life of a rotary rock bit. In order to add a joint of pipe, which is usually 30 feet in length, rotation of the drill bit must be stopped and the entire string of pipe, including the bit, must be raised high enough to allow the kelly to clear the rotary table (35–50 feet). Since operating costs of an oil well drilling rig are quite high, the time that the bit is off bottom and not drilling must be kept to a minimum. Therefore, the addition of a joint pipe must be accomplished quickly and the drill string

must be raised and lowered as rapidly as possible. This raising and lowering of the drill stem creates pressure variations that affect the lubrication system.

When the bit is on bottom, the pressure of the lubricant is the same as, or nearly the same as, the hydrostatic pressure of the fluid in the well bore. However, as the drill stem is elevated in the well bore, the bit body acts in much the same manner as a piston in a cylinder. The enlarged diameter of the bit body exerts a force on the column of drilling fluid above it due to the velocity of the bit traveling up the well bore. The velocity of fluid moving past the large diameter portion of the bit may be fairly high causing a low pressure area in the zone between the cutters and the main bit body where the seal is located. The pressure differential between the pressure of fluid in the area of the seal and the pressure of lubricant inside of the bit may be in the order of 100 psi or more during periods of high acceleration of the drill stem.

In a substantial number of rotary rock bits, the seals are designed to hold pressure in one direction only. If the pressure on the inside of the bit reaches 50 to 75 psi greater than the pressure on the outside of the bit, the seals may leak. Thus, each time a joint of pipe is added to the drill string, the bit is elevated in the well bore causing a low pressure around the seal and forcing a portion of the lubricant out past the seal. The entire supply of lubricant may be pumped out in this manner resulting in a complete failure of the lubrication system and the inevitable failure of the bearings and the bit.

When seals are provided that resist flow in both directions, such as an O-ring seal, a substantial pressure buildup within the lubrication system may be encountered. Some of the potential sources of the pressure buildup are the pressure differential resulting from raising and lowering the bit, and thermal expansion of the lubricant due to the elevated temperatures encountered during the drilling operation. This pressure buildup has resulted in destruction of prior art pressure equalizing systems. The flexible reservoir diaphragms used in one of the prior art lubrication systems generally fails under the pressure buildup because the diaphragm is ruptured or pushed out of place and damaged.

BRIEF DESCRIPTION OF THE ART

In U. S. Pat. No. 3,370,895 to G. A. Cason, Jr. patented Feb. 27, 1968, a sealed bearing rock bit with a lubricant reservoir is shown. A movable piston is positioned in the lubricant reservoir and the area above the piston is vented to the exterior of the bit to expose the upper side of the piston to the environmental pressure of the well bore. A seal is provided between each of the cutters and the arm upon which they are mounted. The seal retains lubricant in the bearing area and prevents ambient fluid and any entrained materials from entering the bearing area.

In U. S. Pat. No. 3,476,195 to E. M. Galle patented Nov. 4, 1969, a sealed bearing rock bit is shown that includes a lubricant reservoir and a flexible diaphragm for equalizing the internal pressure of lubricant in the lubricant reservoir with the hydrostatic pressure of drilling fluid in the well bore. A check valve is provided which operates at low pressures to permit flow out of the lubricant reservoir to the outside of the bit but blocks any flow in the reverse direction.

SUMMARY OF THE INVENTION

The present invention provides a lubrication system containing a sufficient volume of lubricant to provide lubricant to the bearings of a sealed bearing rock bit for an extended period of time and the lubrication system will operate effectively under widely varying environmental conditions. A rotatable cutter is mounted upon the bearing pin portion of an arm extending from the main bit body. A seal is positioned between the cutter and the arm to retain lubricant in the area of the bearings and to prevent the bearings from being contaminated by fluid and materials in the well bore. A protracted passageway containing lubricant extends from the bearing area to an area on the external surface of the bit.

It is therefore an object of the present invention to provide a lubrication system for a rotary rock bit that contains a sufficient supply of lubricant for the bit to operate over an extended period of time.

It is a further object of the present invention to provide a lubrication system for a rotary rock bit that will operate effectively under changing pressure conditions.

It is a further object of the present invention to provide a lubrication system for a rotary rock bit that will operate under adverse environmental conditions including high temperature.

It is a still further object of the present invention to provide a lubrication system that will extend the useful lieftime of a sealed bearing rotary rock bit.

It is a still further object of the present invention to provide a lubrication system for a sealed bearing rotary rock bit that will operate effectively with a seal that permits a limited amount of lubricant flow out of the bit.

It is a still further object of the present invention to provide a lubrication system for a sealed bearing rotary rock bit that will operate effectively with a seal that prevents flow in either direction.

It is a still further object of the present invention to provide a sealed bearing rotary rock bit that includes a protracted lubricant passageway for supplying lubricant to the bearings.

The above and other objects and advantages will become apparent from a consideration of the following detailed description of the invention when taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows a three cone rotary rock bit constructed in accordance with the present invention.

FIG. 2 is a sectional view of one arm of the rock bit of FIG. 1 showing the lubrication system.

FIG. 3 is a sectional view of one arm of a rotary rock bit illustrating another embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Referring now to the drawings and to FIG. 1 in particular, shown therein and generally designated by the reference character **10** is a three cone rotary rock bit. As illustrated, the bit **10** includes a bit body **11** including an upper threaded portion **12.** The threaded portion **12** allows bit **10** to be connected to the lower end of a rotary drill string (not shown). Depending from the bit body **11** are three substantially identical arms. The arms **13** and **13'** are shown in FIG. **1.** The lower end of each of the arms is provided with an extended journal portion or bearing pin and the details of this journal portion will be discussed subsequently. Three rotary cone cutters **14, 14', 14''** are rotatably positioned upon the three journal portions of the arms. Each of the cone cutters includes cutting structure **15, 15', 15''** on its outer surface adapted to disintegrate the formations as the bit is rotated and moved downward. The cutting structure **15, 15', 15''** is shown in the form of tungsten carbide inserts; however, it is to be understood that other cutting structure such as steel teeth may be used as a cutting structure on the cone cutters.

The bit **10** includes a central passageway **16** extending along the central axis of body **11** to allow drilling fluid to enter from the upper section of the drill string immediately above and pass downward through three jet nozzles. One of the jet nozzles **17** is shown in FIG. **1.** In use, the drill bit **10** is connected as the lower member of a rotary drill string (not shown) and lowered into a well bore until the rotatable cone cutters **14, 14', 14''** engage the bottom of the well bore. Upon engagement with the bottom of the well bore, the drill string is rotated rotating bit **10** therewith. Drilling fluid is forced down through the interior passage of the rotary drill string and continues through the central passageway **16** of bit **10** passing through the three nozzles past the cutting structure of the cutters to the bottom of the well bore, thence upward in the annulus between the rotary drill string and the wall of the well bore carrying with it the cuttings and debris from the drilling operation.

In order to add additional sections of the drill string, the bit **10** must be lifted a short distance in the well bore, the new section of drill string added and the bit **10** lowered until it again reaches the bottom of the well bore wherein drilling continues. As each section of the drill string is added, the bit is elevated in the hole causing a pressure change in certain areas along the bit. In prior art sealed bearing rock bits, the lubricant would be pumped out past the seal. The loss of lubricant, of course, has a deleterious effect on the bearing systems and the bit would be subject to early failure. In addition, the periodic pressure differentials result in failure of structural elements of the lubrication system of the bit. The present invention overcomes the pressure differential problem and provides a sufficient volume of lubricant to supply lubricant to the bearings for an extended period of time.

Referring now to FIG. **2,** a sectional view of one arm **13** of the earth boring bit **10** is shown. The cutter **14** is rotatably positioned on the journal portion of the arm **13** and adapted to disintegrate earth formations as the bit is rotated. The cutting structure **15** on the outer surface of cutter **14** contacts and disintegrates the formations. The journal portion of arm **13** consists of a bearing pin **18** upon which the cutter **14** is mounted. A plurality of bearing systems are located in the bearing area between the cutter **14** and the bearing pin **18.** The bearing systems in the bearing area include a series of roller bearings **19,** a series of ball bearings **20,** a friction bearing **21** and a thrust button **22.** A seal **23** is positioned between the cutter **14** and the bearing pin **18.** This seal **23** retains lubricant in the bearing area around the bearing systems and prevents any materials in the well bore from entering the bearings. A passage **24** extends from the area around the bearings to allow lubricant to be transmitted to the bearings. The passage **24,** as shown, allows the balls that make up the ball bearing system **20** to be inserted into position after the cone cutter **14** is placed on the bearing pin **18.** The series of ball bearings **20** serves to lock the cone cutter **14** on bearing pin **18.** After the balls are in place, a plug **25** is inserted into the passage **24** and welded therein by weld **26.** Plug **25** has a reduced diameter throughout the major portion of its length to allow lubricant to be transmitted to the bearing systems. Additional passages **27, 28** and **29** extend from passage **24** to the bearing area to insure a sufficient supply of lubricant to bearings **19, 20, 21** and **22.**

The seal **23** is a positive seal in one direction only, that being from the fluid in the well bore to the bearing area. If the pressure of the lubricant in the bearing area reaches 50 to 75 psi greater than the pressure outside of the bit, lubricant will be forced out past seal **23** into the well bore. In prior art rotary rock bits, the lubricant pressure inside of the bit would build up periodically resulting in pressure pulses forcing lubricant out past the seal. In addition, difficulties were experienced because the pressure pulses would form an emulsion within the lubricant and bearing damage would result. Temperature changes were also encountered that lead to pressure buildup with an associated lubricant loss resulting in bearing failure.

A protracted lubricant passageway **30** positioned in arm **13** provides a sufficient volume of lubricant to provide lubrication for the bit even though the bit may run for an extended period of time. The protracted lubricant passageway **30** provides a long, small cross sectional area flow passage for lubricant. The passageway **30** extends through a series of helical grooves from an area on the outside of the bit to a passage **31.** The passage **31** in turn is connected to passage **24** to allow lubricant to be transmitted to the bearings. Drilling fluid pressure may enter the open end of passageway **30** through a screen or filter **32** and equalize the pressure of lubricant inside of the bit **10** with the pressure of fluid outside of the bit **10.** Expansion of lubricant due to heating or other causes will simply displace lubricant away from the bearings through the chain of passages **27, 28, 29, 24, 31** and **30.** Lubricant compression due to hydrostatic pressure and thermal contraction upon cooling will be equalized in pressure by flow of the drilling fluid toward the bearings. The protracted passageway **30** will keep an interface between the drilling fluid and the lubricant and keep the drilling fluid and any materials in the drilling fluid away from the bearings. Sufficient lubricant volume is provided in the chain of passages **27, 28, 29, 24, 31** and **30** to allow some lubricant loss due to thermal expansion and yet provide a sufficient volume of lubricant to maintain a supply of lubricant to the bearings for an extended period of time. A screen of filter **32** may be provided at the mouth of passageway **30** to prevent large particles from entering the small diameter passageway **30.** The passageway **30** extends through a series of baffles and the lubricant cannot emulsify with the drilling fluid throughout the entire length of the chain of passageways. Therefore, lubricant reaching the bearings will be free of any contaminants.

The passageway **30** should have a length-to-area ratio great enough to insure that the fluid in the well bore outside of the bit **10** will not migrate through the lubricant to the bearings. For example, the passageway **30,** shown in FIG. **2,** may have a cross sectional area of 0.2 square inches and be 10 inches in length. This will provide a length-to-area ratio of 50 to 1 and insure that the bearings will not be contaminated by material in the well bore. The cross sectional shape of the passageway **30** may take any form. For example, the cross sectional shape of passageway **30** may be circular, square, rectangular or irregular as long as the length-to-area ratio is great enough to prevent fluid in the well bore from migrating to the bearings.

Referring now to FIG. **3,** another embodiment of the present invention is shown. One arm **33** of a rotary rock bit is shown in section illustrating another embodiment of a lubrication system constructed in accordance with the present invention. The arm **33** contains a spiral tube **34** that forms a portion of the lubricant passageway. The spiral tube **34** is connected to the bearing area between the bearing pin **35** extending from the arm **33** and the rotatable cone cutter **36** by series of interconnecting passages. The bearing systems positioned in the bearing area include an outer friction bearing **37,** a series of ball bearings **38,** an inner friction bearing **39** and a thrust button **40.** An O-ring seal **41** is located between the bearing pin **35** and the cutter **36.** The seal **41** is positioned in a groove located near the upper end of the bearing pin **35.** The seal **41** prevents fluid flow in either direction and maintains lubricant in the bearing area as well as preventing materials in the well bore from entering the bearing area.

The passages that extend from the spiral tube to the bearing area allow lubricant to be transmitted to the bearings. One of the intermediate passageways, passageway **42,** serves a dual purpose in that it provides a portion of the passage for transmitting lubricant to the bearings and also serves as a passage to allow the balls that make up the ball bearing system **38** to be inserted into position after the cone cutter **36** is placed on the bearing pin **35.** The series of ball bearings **38** serves to lock the cone cutter **36** on the bearing pin **35.** After the balls are in place, a plug **43** is inserted into the passageway **42** and welded therein by a weld **44.** The plug **43** has a reduced diameter throughout the major portion of its length to allow the lubricant to be transmitted to the bearing area.

The seal **41** resists flow in both directions. When this type of seal was used in rock bits of the prior art, a substantial pressure buildup in the lubrication system would result. For example, during the drilling operation, the lubricant would become heated due to friction in the bearings and friction between the cutting structure and the bottom of the well bore. Thermal expansion would produce an internal pressure buildup, and the pressure buildup would soon lead to the destruction of one or more elements of the bit if some means of equalizing the internal lubricant pressure with the hydrostatic pressure of the fluid in the well bore were not provided.

The spiral tube **34** provides a long, small cross-sectional area flow passageway for the lubricant. The spiral tube **34** is connected between the bearing area and the exterior surface of the bit, thereby allowing drilling fluid to enter the open outer end of the spiral tube **34** and equalize the pressure of the lubricant with the pressure of the fluid outside of the bit. Expansion of lubricant due to heating will simply displace lubricant away from the bearings through the spiral tube **34.** Lubricant compression due to hydrostatic pressure and thermal contraction upon cooling will be equalized in pressure by flow of the drilling fluid into the outer end of the spiral tube **34**. The long passageway made up of the spiral tube **34** and the chain of passages **45, 42, 46, 47** and **48** will keep an interface between the drilling fluid and the lubricant, and the drilling fluid will be kept away from the bearings. Sufficient lubricant volume is provided in the spiral tube **34** and the passages **45, 42, 46, 47** and **48** to allow some lubricant loss due to thermal expansion and yet provide a sufficient volume of lubricant to prevent drilling fluid from traveling back through the passages to the bearings. A screen or filter may be used to prevent large particles from entering the small diameter spiral tube **34.** In this way, any difference in specific gravity between the drilling fluid and the lubricant cannot cause the drilling fluid to emulsify or displace the entire length of lubricant so that the lubricant reaching the bearings is contaminate free.

The length of the long passageway that extends from the exterior surface of the bit to the bearing area and consists of the spiral tube **34** and passages **45, 42, 46, 47** and **48** is substantially greater than the linear distance between the outer end of tube **34** at the exterior surface of the bit and the bearing area of the bit. In the embodiment of the invention shown in FIG. **3,** the length of the long passageway is greater than one and one-half times the linear distance between the outer end of tube **34** and the bearings **37, 38, 39** and **40.** The spiral tube **34** has a length-to-area ratio of 50 to 1 thereby insuring that fluid in the well bore will not reach the bearing area.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A drill bit comprising:
a bit body;
at least one arm extending from said bit body;
a cutter rotatably mounted upon said arm;
bearing means between said cutter and said arm for promoting rotation of said cutter;
a seal positioned between said cutter and said arm; and
a passageway extending from an area on the exterior surface of said bit through said arm to said bearing means, wherein said passageway includes a series of helical grooves, said passageway containing lubricant.

2. A drill bit comprising:
a bit body;
at least one arm extending from said bit body;
a cutter rotatably mounted upon said arm;
bearing means between said cutter and said arm for promoting rotation of said cutter;
a seal positioned between said cutter and said arm; and
a passageway extending from an area on the exterior surface of said bit through said arm to said bearing means, wherein said passageway includes a coiled tube, said passageway containing lubricant.

3. A rotary rock bit comprising:
a bit body;
at least one arm extending from said bit body;
a cone cutter positioned upon said arm;
bearing means between said cone cutter and said arm for promoting rotation of said cone cutter;
a seal positioned between the open end of said cone cutter and said arm; and
passage means extending from the exterior surface of said bit to said bearing means for storing a supply of lubricant that will be transmitted to said bearing means, said passage means including a series of helical grooves.

4. A rotary rock bit comprising:
a bit body;
at least one arm extending from said bit body;
a cone cutter positioned upon said arm;
bearing means between said cone cutter and said arm for promoting rotation of said cone cutter;
a seal positioned between the open end of said cone cutter and said arm; and
passage means extending from the exterior surface of said bit to said bearing means for storing a supply of lubricant that will be transmitted to said bearing means, said passage means including a coiled tube.

5. A rotary rock bit comprising:
a bit body;
at least one arm extending from said bit body;
a cone cutter positioned upon said arm;
bearing means between said cone cutter and said arm for promoting rotation of said cone cutter;
a seal positioned between the open end of said cone cutter and said arm; and
passage means extending from the exterior surface of said bit to said bearing means for storing a supply of lubricant that will be transmitted to said bearing means, the length to area ratio of said passage means being at least 50 to 1.

6. A sealed bearing rotary bit comprising;
a main bit body;
at least one arm extending from said main bit body, said arm terminating in a bearing pin;
a cone cutter rotatably mounted upon said bearing pin;
cutting means on the surface of said cone cutter for disintegrating earth formations;
bearing means between said cone cutter and said bearing pin for promoting rotation of said cone cutter;
a seal positioned between the open end of said cone cutter and said bearing pin; and
a protracted passageway having a small diameter, said passageway extending from an area on the exterior surface of said arm to said bearing means for storing a supply of lubricant that will be supplied to said bearing means, the length to area ratio of said protracted passageway being greater than 50 to 1.

7. A drill bit comprising:
a bit body;
at least one arm extending from said bit body;
a cutter rotatably mounted on said arm;
bearing means between said cutter and said arm for promoting rotation of said cutter;
a seal sealingly engaging said cutter and said arm;
a lubricant reservoir communicating with the exterior of the bit and containing lubricant for said bearing means, said reservoir having a length to area ratio of at least 50 to 1; and
a passageway communicating said lubricant reservoir with said bearing means.

* * * * *