Sept. 13, 1955 J. M. McGREGOR 2,717,762

WELL DRILLING APPARATUS

Filed Oct. 23, 1951

Fig. 1.

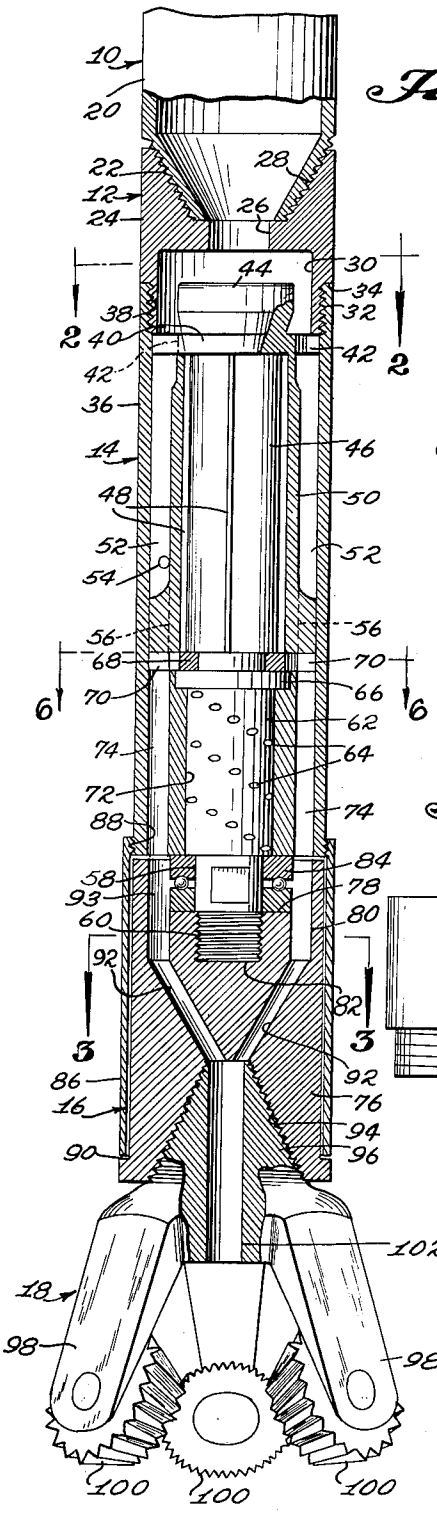


Fig. 2.

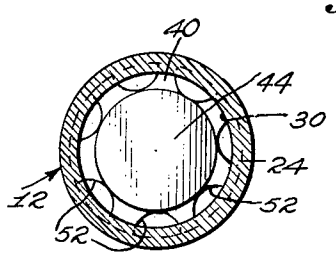


Fig. 3.

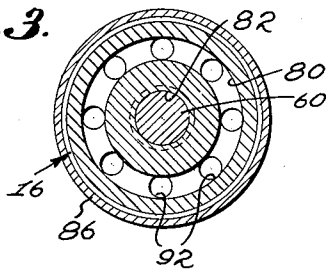


Fig. 4.

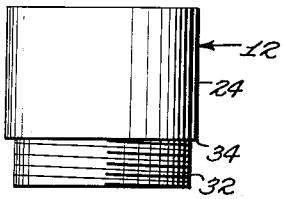


Fig. 5.

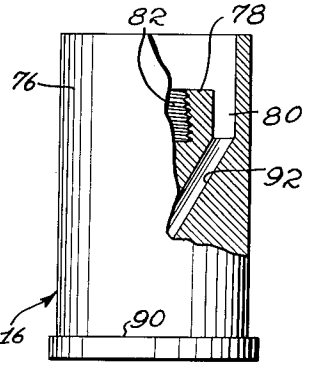
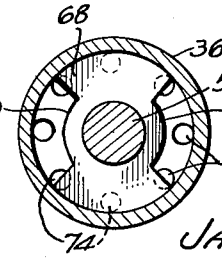


Fig. 6.



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WELL DRILLING APPARATUS

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Application October 23, 1951, Serial No. 252,627

3 Claims. (Cl. 255—4)

This invention relates to apparatus for drilling wells. More particularly, the invention has reference to a drilling tool adapted particularly for the drilling of oil wells.

Heretofore, it has been the common practice to secure a drilling bit directly to the lower end of a drill pipe, with the drill pipe often extending many thousands of feet into the hole. The drill pipe is then rotated at its upper end, for the purpose of imparting rotation to the entire length of the pipe and to the drill bit secured to its lower end. It will be appreciated that the speed of rotation of the drill bit is relatively slow under the circumstances, since high speed rotation of a drill pipe which may be of great length would be quite difficult. As a result, the drill bit is conventionally rotated at speeds of approximately 100 to 150 revolutions per minute. Only by the imposition of great weight upon the drill bit, accordingly, is the effective drilling of a formation achieved. Further, drilling operations as conventionally practiced require in most instances the use of drilling mud, at heavy expense.

In this connection, it is well appreciated among those skilled in the art of oil well drilling that if, for example, an unconsolidated formation is encountered during the drilling—as for instance, a fractured shale stratum—the drilling mud will be dissipated laterally through said formation instead of being swept upwardly within the hole. It is then necessary to case the portion of the hole extending through the unconsolidated formation.

The main object of the present invention is, accordingly, to provide oil well drilling apparatus which will eliminate the necessity of using drilling mud, thus to reduced materially the expense involved in the drilling operation.

It is a further important object of the invention to provide apparatus as stated wherein the entire length of the drill stem will remain stationary, the drill stem carrying at its lower end an air motor to which a drill bit is operatively coupled, whereby the drill bit will be powered by said motor, the motor being operated by air fed under pressure through the drill stem. Heretofore, it has been considered that the use of air in rotating a drill bit could not be practical, in view of the problems arising from the necessity of cooling a drill bit rotated at high speed by air supplied under pressure. However, in accordance with the present invention a novel subassembly or connecting means is interposed between the air motor and the drill bit, whereby air expanded through the motor and used for the purpose of powering the same is caused to flow over the several cones of the drill bit, in a manner to effectively cool the same.

Still another important object of the present invention is to use air for cooling the cones of the drill bit at the precise moment when the air is expanded after being fed through the air motor, thus to make efficient use of the cooling qualities of expanding air.

Yet another important object is to provide apparatus as stated wherein the air used for powering the air motor and cooling the bit is adapted to float the cuttings to the surface.

Other objects will appear from the following description, the claims appended thereto, and from the annexed drawing, in which like reference characters designate like parts throughout the several views, and wherein:

Figure 1 is a longitudinal sectional view through oil well drilling apparatus formed in accordance with the present invention, portions remaining in elevation;

Figure 2 is a transverse sectional view taken substantially on line 2—2 of Figure 1;

Figure 3 is a transverse sectional view taken on line 3—3 of Figure 1;

Figure 4 is a side elevational view of a means employed for connecting the air motor to the drill stem;

Figure 5 is a view partly in side elevation and partly in longitudinal section of the subassembly or connector fitting interposed between the air motor and drill bit; and

Figure 6 is a transverse sectional view on line 6—6 of Figure 1.

The invention may be appropriately considered as embodying a plurality of units, each of which will be considered in order hereinafter. These units comprise the drill stem or drill pipe **10**, the connector **12** used to connect the drill stem to the air motor, the air motor **14**, the subassembly or rotor extension member **16**, and the drill bit **18** connected to said extension membr.

Referring first to the drill stem **10**, this is of conventional construction and as will be understood, comprises a plurality of axially aligned drill pipe sections **20** connected in end to end relation. Only one of these has been illustrated, but it will be understood that said pipe sections extend fully to the surface of the ground, with additional sections being added as the drilling progresses.

The lowermost pipe section **20** is provided with the usual tapered, externally threaded lower end **22**, for connection of the connector fitting **12** to said lowermost pipe section. The fitting **12** is of one piece formation, comprising a solid body **24** having in its upper end a tapered socket **28** formed with threads complementary to the threads of the tapered end **22** of the pipe section **20**. The tapered socket receives the tapered end **22**, for fixed connection of the body **24** to said pipe section.

Formed in the body **24** is an axial bore **26**, communicating at its upper end with the tapered socket **28**, and at its lower end with a counterbore **30** of substantial diameter.

At its lower end the body **24** is provided with external threads **32**, the threads **32** being formed upon an end portion of reduced diameter, so as to define an angular shoulder **34** intermediate opposite ends of the body **24**.

This completes the construction of the connector fitting **12**, and it will be readily seen that the connector fitting is adapted to be fixedly but removably connected to the lower end of the drill stem, and when connected, will constitute an adaptor whereby the air motor **14** can be attached to the drill stem.

Referring now to the air motor **14**, this includes a relatively elongated, hollow casing **36** of cylindrical formation. At its upper end, the casing **36** is provided with internal threads **38** engageable with the threads **32** of the connector fitting **12**. The upper end of the casing **36** is thus adapted to be fixedly but separable connected to the connector fitting **12** and to the drill stem **10**, with the end of the casing abutting against the stop shoulder **34** of the connector fitting.

The air motor **14** is of substantially conventional construction, so far as its rotor is concerned. However, it is believed advisable to provide a full understanding of the

operation of the air motor, so as to show clearly how the air motor operates in combination with the drill stem and with the drill bit, to produce the desired results in drilling operations. Accordingly, the air motor used is provided with a bearing plate **40** of circular outer configuration, that bears against the inner surface of the casing **36**, the plate **40** being provided with diametrically opposite recesses **42** through which air fed through the connector fitting **12** may pass, in the supplying of said air to the rotor.

A bearing **44** is integral with the plate **40**, and receives one end of a rotor **46** that extends longitudinally and centrally of the casing **36**. The rotor **46** is provided with longitudinal blades **48**, spaced circumferentially thereabout, and is rotatably mounted in a stationary rotor housing **50**. The rotor housing **50** is exteriorly formed with a plurality of longitudinal passages **52**, with which ports **54** communicate, said ports extending into communication with the space surrounding the rotor, so as to supply air under pressure to the blades **48** and thus impart rotative movement at high speed to the rotor.

Conventionally, air is supplied under pressure of approximately 200 pounds, to the rotor **46**, and is effective to rotate the shaft of the rotor at speeds up to 3,000 revolutions per minute. The air, after being expanded through the air motor, is directed through exhaust passages **56**, for discharge from the lower end of the motor.

Integral with the rotor **46**, and disposed in coaxial relation therewith, is a rotor shaft **58**, the lower end of which is formed with a threaded portion **60**. The shaft **58** is partially encased within a bearing sleeve **62**, formed with circumferentially spaced apertures **64** used for lubrication purposes.

At one end, the sleeve **62** is formed with a collar **66**, which abuts against a plate **68**, that is interposed between the sleeve **62** and the main body of the rotor **46**. The plate **68** is provided with diametrically opposite recesses **70**, that are in communication with the exhaust passages **56** of the rotor housing **50**.

The rotor casing **36** is closed at its lower end by a solid cylindrical part formed integrally therewith, such part forming a bearing support for the rotor **46**. The solid part closing the lower end of the rotor casing is provided with an axial bore **72** in which is received the bearing sleeve **62** which surrounds the shaft **58** projecting from the rotor **46**. In said solid part there is also a plurality of longitudinal passages **74** communicating at one end with the recesses **70** of the plate **68**. Thus, the air expanded through the motor will be directed through the circumferential series of passages **74**, after passing beyond the rotor **46**.

Referring now to the construction of the rotor extension **16**, this includes a one-piece body **76** formed at one end with a recess **78** (Figure 5) with which communicates an annular extension **80** of said recess.

Also in communication with the recess **78**, and arranged concentrically with the annular extension **80**, is a threaded socket **82**, engaging the threaded end portion **60** of the rotor shaft. Thus, the rotor extension **16** is fixedly but separably secured to the rotor of the air motor, so as to be rotated jointly with the rotor shaft.

Seated in the recess **78** is a ball bearing **84** of conventional construction, that surrounds the rotor shaft, one race of the bearing engaging against the lower end of the stationary air motor casing **36**, and the other engaging against the rotor extension **16**. The purpose of the bearing **84** is to reduce friction between the stationary and rotatable portions of the device, and to further prevent said friction from occurring, the body **76** of the rotor extension is spaced slightly from the contiguous end of the rotor casing, as may be readily noted from Figure 1.

It will be observed from Figure 1 that positioning of the bearing **84** within the center portion of the recess **78** defines, in the rotor extension, an annular passage communicating with the extension recess **80**, said passage opening from the outlet end of the circumferential series of passages **74** of the rotor casing. Thus, expanded air fed through the passages **74** is discharged into the annular passage of the rotor extension.

Surrounding the rotor extension, and extending substantially from end to end thereof, is a thin walled, cylindrical shell **86** formed open at its opposite ends. At one end, the shell **86** is provided with internal threads **88** engaging external threads formed upon the lower end of the rotor casing **36**. Thus, the shell **86** is a stationary portion of the device, said shell being utilized for the purpose of protectively enclosing the rotor extension.

At its lower end, the body **76** is provided with an annular shoulder **90**, spaced closely from the lower end of the shell **86**, as may be readily seen from Figure 1.

Formed in the body **76** is a circular series of downwardly converging passageways **92**, which are in communication at their upper ends with the annular chamber defined within the rotor extension by the extension recess **80** and the recess **78** in which the bearing **84** is disposed, said annular chamber being designated **93** in Figure 1.

At their lower, convergent ends, the passageways **92** are in communication with a tapered, threaded, seat **94** formed in the body **76**, and adapted to engage the correspondingly tapered, exteriorly threaded shank **96** of the drill bit **18**. The drill bit **18**, in this connection, is of conventional construction, and in the illustrated example is of the 3-cone type, having a plurality of downwardly diverging, equidistantly spaced arms **98** on which are mounted drilling cones **100**. The drill bit **18** is formed with an axial bore **102** communicating at its upper end with the convergent ends of the passageway **92**, and opening at its lower end upon the space between the several cones **100**.

I believe it will be apparent that after the air has been expanded through the air motor, it will be directed through the chamber **93** of the rotor extension, and will then move through the passageways **92** of said extension. After moving out of the passageways **92**, the air will be forced through the bore **102** of the drill bit, and will be directed against the several cones **100** of said bit.

It is important, in this connection, to note that the air directed against the drilling cones is expanded air, and thus will have a cooling effect upon the cones. In practical applications of the invention, it has been found that it is possible to rotate the drill bit **18** at speeds much higher than any which have heretofore been possible, the drill bit remaining cool in every instance. I believe this to be due directly to the fact that the air blown across the faces of the drilling cones passes across said faces while being expanded, thus to be given a much greater cooling characteristic than would otherwise be the case.

The invention, it has been found, permits the use of a diamond bit, which can be rotated at a speed of 3,000 revolutions per minute with the air motor illustrated in Figure 1. At the same time, the bit need carry only 200 to 300 pounds of weight, the cutting action obtaining entirely by reason of the high speed at which the bit is rotated. In actual well drilling operations conducted with the apparatus illustrated, both shallow and deep holes have been drilled, through both soft and hard formations, and these holes have been drilled at a speed increased substantially above that possible when conventional methods are employed.

At the same time, the use of drilling mud is dispensed with entirely, since the air blown past the cones **100** moves upwardly through the hole to the surface of the ground, carrying with it the drill cuttings. Air ordinarily would not be able to carry cuttings, where said cuttings constitute large chips. However, by rotating the drill bit at high speed, and by imposing only a relatively small amount of weight thereupon, exceedingly fine cuttings are obtained, which are floated away upon the air. Further, should unconsolidated formations such as fractured shale be encountered, it is not necessary to case the hole where

it passes through said formations, since there is no objection to the air being dissipated through said formations while carrying with it the fine cuttings referred to above.

It is believed clear that the invention is not necessarily confined to the specific use or uses thereof described above, since it may be utilized for any purpose to which it may be suited. Nor is the invention to be necessarily limited to the specific construction illustrated and described, since such construction is only intended to be illustrative of the principles of operation and the means presently devised to carry out said principles, it being considered that the invention comprehends any minor changes in construction that may be permitted within the scope of the appended claims.

What is claimed is:

1. Well drilling apparatus comprising a stationary, hollow drill stem extendable into a drill hole and adapted to serve as a passage for air under pressure forced into the upper end of the stem for movement to the lower end thereof; an air motor depending from the lower end of the stem, the motor having a stationary casing fixedly connected to said lower end of the stem and a rotor rotatably mounted in the casing and arranged for rotation by said air under pressure, said casing having a solid part provided with an axial bore integrally formed therewith and closing its lower end and the rotor having a shaft extending within the bore of said solid part and formed with a threaded lower end, the air expanding upon passage thereof beyond the rotor, the solid part of said casing having a plurality of longitudinal exhaust passages and spaced about the bore thereof, said exhaust passages opening at their upper ends upon the lower end of the rotor to provide an exit for the expanded air; a bearing sleeve fitted in said bore of the solid part and having said shaft journaled therein; a rotor extension depending from and rotating with the rotor and disposed below the lower end of the air motor, said extension embodying a solid body having a recess formed in its upper end and a threaded socket concentric with and communicating with the recess, the threaded end of the rotor shaft being threadedly engaged within said socket, said threaded socket being spaced from the wall of said recess to define an annular chamber in the rotor extension communicating with the lower ends of the exhaust passages, the extension being formed with a series of passageways communicating at one end with said chamber and opening at their other ends upon the lower end of the extension; and a drill bit fixedly connected to said extension for rotation therewith and having at least one passage communicating with said passageways, said passage of the drill bit being arranged for directing air against the cutting faces of the drill bit to cool the same, said air passing upwardly after movement over the cutting faces of the drill bit to float cuttings upwardly within the drill hole.

2. Well drilling apparatus comprising a stationary, hollow drill stem extendable into a drill hole and adapted to serve as a passage for air under pressure forced into the upper end of the stem for movement to the lower end thereof; an air motor depending from the lower end of the stem, the motor having a stationary casing fixedly connected to said lower end of the stem and a rotor rotatably mounted in the casing and arranged for rotation by said air under pressure, said casing having a solid part provided with an axial bore integrally formed therewith and closing its lower end and the rotor having a shaft extending within the bore of said solid part and formed with a threaded lower end, the air expanding upon passage thereof beyond the rotor, the solid part of said casing having a plurality of longitudinal exhaust passages and spaced about the bore thereof, said exhaust passages opening at their upper ends upon the lower end of the rotor to provide an exit for the expanded air; a bearing sleeve fitted in said bore of the solid part and having said shaft journaled therein; a rotor extension depending from and rotating with the rotor and disposed below the lower end of the air motor, said extension embodying a solid body having a recess formed in its upper end and a threaded socket concentric with and communicating with the recess, the threaded end of the rotor shaft being threadedly engaged within said socket, the threaded socket being spaced from the wall of said recess to define an annular chamber in the rotor extension communicating with the lower ends of the exhaust passages; bearings surrounding said end of the rotor and abutting against the rotor extension and a lower end portion of the casing respectively to reduce friction therebetween; said extension being formed with a series of passageways communicating at one end with said chamber and opening at their other ends upon the lower end of the extension; and a drill bit secured to the lower end of the extension for rotation therewith, said drill bit having at least one passage communicating with said passageways and arranged for directing air passing through the passageways and the passage of the drill bit against the cutting faces of the drill bit to cool the same, said air after movement over the cutting faces of the drill bit passing upwardly within the drill hole to float cuttings away from the bottom of the hole.

3. Well drilling apparatus comprising a hollow drill stem extendable into a drill hole and having a tapered lower end, said drill stem being adapted to serve as a passage for air under pressure forced into the upper end of the stem for movement to the lower end thereof; a connector fitting having a tapered socket at its upper end threadably engaged with the lower end of the drill stem, said connector fitting being of substantially sleeve-like formation and having an axial bore communicating with the interior of the drill stem, the lower end of the connector fitting being externally threaded; an air motor depending from and fixed to said lower end of the connector fitting and having a stationary casing internally threaded at its upper end for engagement with the threads of the lower end of the connector fitting, said motor having a rotor rotatably mounted in said casing and arranged for rotation by air forced under pressure through the drill stem and connector fitting, said casing having a solid part provided with an axial bore integrally formed therewith and closing its lower end and the rotor having a shaft extending within the bore of said solid part and formed with a threaded lower end, the air expanding upon passage thereof beyond the rotor, the solid part of said casing having a plurality of longitudinal exhaust passages and spaced about the bore thereof, said exhaust passages opening at their upper ends upon the lower end of the rotor to provide an exit for the expanded air; a bearing sleeve fitted in said bore of the solid part and having said shaft journaled therein; a rotor extension depending from and rotating with the rotor and disposed below the lower end of the air motor, said rotor extension embodying a solid body having a recess formed in its upper end and a threaded socket concentric with and communicating with the recess, the threaded end of the rotor shaft being threadedly engaged within said socket, the threaded socket being spaced from the wall of said recess to define an annular chamber in the rotor extension communicating with the lower ends of the exhaust passages; bearings surrounding said end of the rotor and abutting against the rotor extension and the lower end portion of the casing respectively to reduce friction therebetween; the extension being formed with a series of passageways communicating at one end with said chamber and opening at their other ends upon the lower end of the extension; and a drill bit secured to the lower end of the extension for rotation therewith, the drill bit having at least one passage communicating with said passageways, for movement of expanded air through the passageways and through the passage of the drill bit to pass over the cutting faces of the drill bit and thereby cool the same, said air after movement over the cutting faces of

the drill bit passing upwardly within the drill hole to float cuttings away from the bottom of the drill hole.

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