Aug. 23, 1960 J. N. GREGORY 2,950,087

COMBINED ROTARY AND PERCUSSION DRILLING

Filed Oct. 24, 1955 2 Sheets-Sheet 1

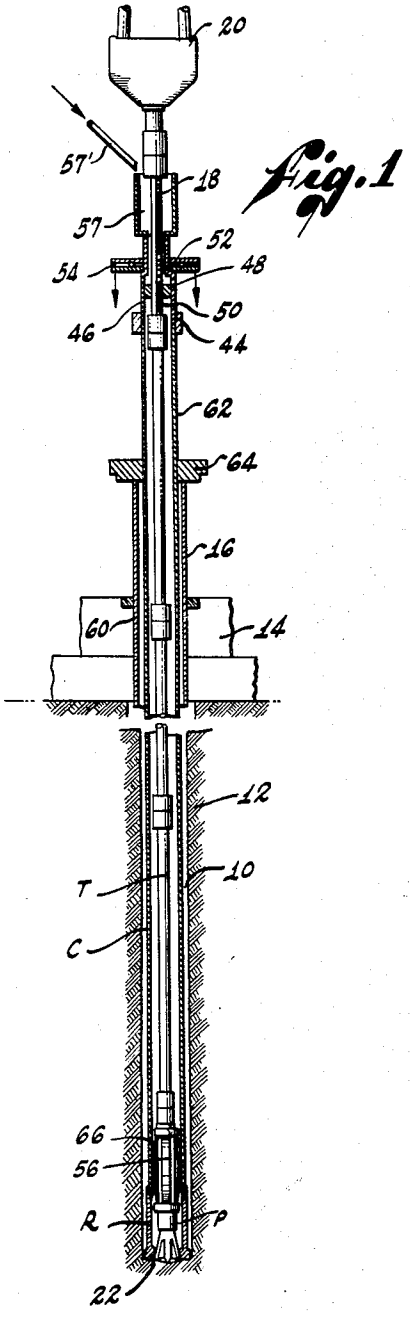


Fig. 1

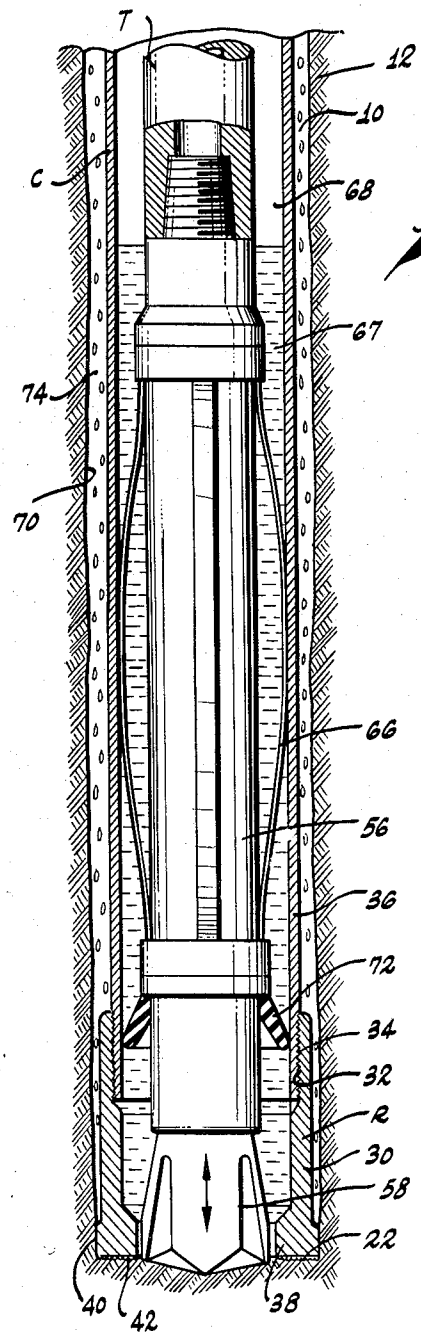


Fig. 2

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Fig. 3

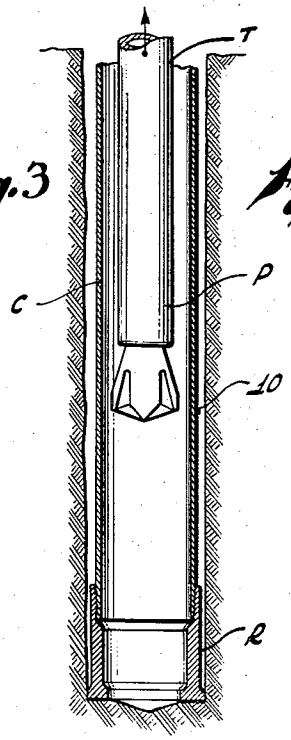



Fig. 4

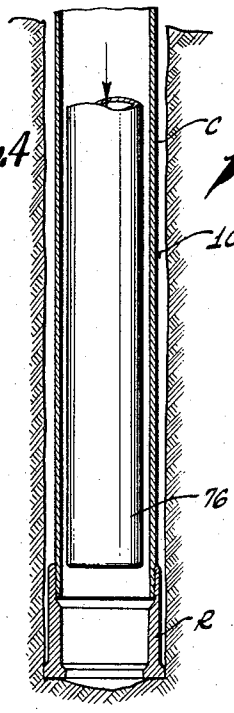



Fig. 5

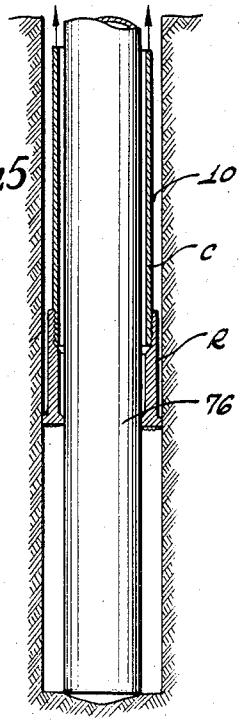



Fig. 6

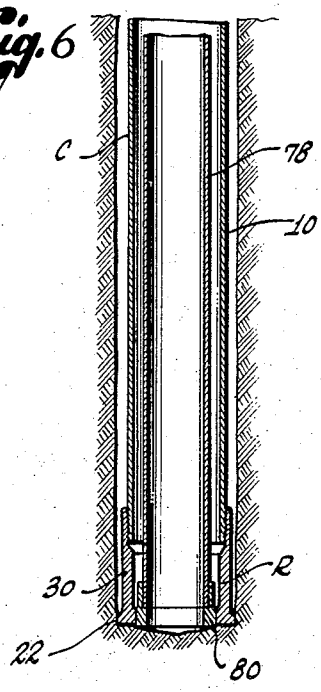
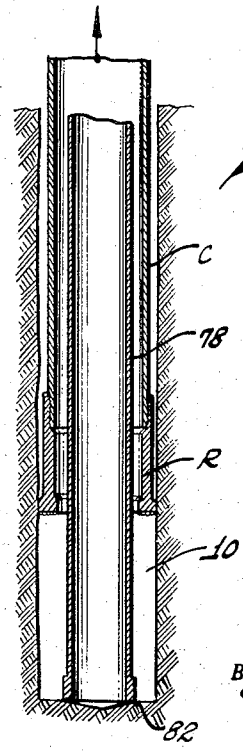



Fig. 7

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# COMBINED ROTARY AND PERCUSSION DRILLING

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6 Claims. (Cl. 255—4.4)

The present invention relates generally to the well drilling art and more particularly to combination percussion and rotary drilling.

A major object of the present invention is to provide novel and improved combined percussion and rotary drilling apparatus which effects the concurrent percussion and rotary drilling of a well.

Another object is to provide drilling apparatus which permits a well to be drilled in a minimum amount of time.

A further object is to provide combined percussion and rotary drilling apparatus which permits a well to be drilled through an unconsolidated formation by means of a percussion bit while eliminating the danger that said bit will be lost in event the bore hole caves in.

An additional object is to provide apparatus of the aforedescribed nature which permits the drilling of a bore hole having a larger diameter than that of the percussion bit.

Another object of the invention is to provide combined percussion and rotary drilling apparatus which is simple in design and rugged of construction.

A further object is to provide combined percussion and rotary drilling apparatus which employs compressed air both to operate the percussion bit and to lift the cuttings out of the bore hole.

Yet an additional object of the invention is to provide combined percussion and rotary drilling apparatus wherein the percussion bit may be removed from the bore hole independently of the rotary bit.

Yet another object is to provide combined percusion and rotary drilling apparatus wherein the rotary bit may be removed from the well bore without danger that the bore hole will be lost due to a cave-in.

It is yet a further object of the invention to provide apparatus of the aforedescribed nature which permits a final casing string to be run into the bore hole with minimum danger that the bore hole will cave-in.

These and other objects and advantages of the present invention will become apparent from the following detailed description of a first and second embodiment thereof, when taken in conjunction with the appended drawings, wherein:

Figure 1 is a vertical sectional view of a first form of apparatus embodying the present invention;

Figure 2 is an enlarged vertical sectional view of the bit portion of said apparatus;

Figure 3 is a vertical sectional view showing the manner whereby the percussion bit of said apparatus is changed;

Figures 4 and 5 are vertical sectional views showing the manner whereby the rotary bit portion of said apparatus is changed; and

Figures 6 and 7 are vertical sectional views showing the manner of setting a final string of casing when said apparatus is employed to drill a bore hole.

Referring to the drawings and particularly Figures 1 and 2 thereof, the first form of apparatus embodying the present invention is employed to drill a vertically extending bore hole **10** through an earth formation **12** in conjunction with derrick equipment located at the earth's surface. This derrick equipment includes a rotary table **14**, a rotary drive member **16**, a kelly **18** and a rotary swivel **20**. The apparatus itself includes a tubular rotary shoe R formed at its lower end with bit means **22** and at its upper portion with means for attaching it to the lower end of a casing string C. This apparatus also includes a percussion bit P concentrically disposed within the rotary shoe R and secured at its upper end to the lower end of a tubing string T which extends through the interior of the casing string C. With this arrangement, the percussion bit P may be recovered from the bottom of the bore hole **10** while the casing string C remains within the well bore. The percussion bit P may be of a type exemplified by the air operated percussion bit manufactured by Ingersoll Rand, 11 Broadway, New York city, New York, and referred to as the Depth-Master.



More particularly, referring to Figure 2, the rotary shoe R of the first form of apparatus of the invention includes a tubular main body **30** having its upper portion formed with internal threads **32** engageable with complementary external threads **34** formed on the lower end of the lowermost section **36** of the casing string C. The lower portion of the rotary shoe R is formed with a radially inwardly extending lip **38** and a radially outwardly extending lip **40**. The underside of the rotary shoe R is coated with abrasive hard facing material **42** that is adapted to drill through the formation **12** when the shoe is rotated.

Referring again to Figure 1, the upper end of the casing string C is secured at **44** to the lower end of a driving sub **46**. This driving sub **46** is formed with a horizontal plate **48** having a central opening **50** for vertically slidably receiving the kelly **18** while keying it to the driving sub for concurrent rotation therewith. The driving sub **46** also includes a horizontally extending shoulder **52** upon which is seated a pull-down bearing **54**. Extending upwardly from the driving sub **46** is an open-topped drum **57**. This drum **57** is adapted to receive drilling mud and/or water from a spout **57'**. The plate **48** is formed with vertically extending passages (not shown) to permit liquid from spout **57'** to flow downwardly therethrough. The round rotary drive member **16** is formed with vertical splines (not shown) so as to key it to the rotary table **14**. This arrangement permits the kelly drive to move vertically relative to the rotary table while being positively locked thereto for concurrent rotation therewith. The upper end of the rotary drive member **16** is releasably affixed to the upper section **62** of the casing string C by a conventional clamp **64**. Referring again to Figure 2, the percussion bit or drill P is of the conventional pneumatic type and includes a main body **56** housing a suitable motor (not shown) and a bit element **58** which is vertically reciprocated relative to the lower end of this main body by the motor. The percussion bit P is maintained concentrically within the lowermost section **36** of the casing string C by means of a conventional bow-spring type centralizer **66**. A suitable percussion bit or drill P is marketed by Ingersoll-Rand, 11 Broadway, New York city, New York, under the trademark "Depth-Master".

In the operation of the aforedescribed apparatus, the casing string C is first run to the bottom of a bore hole **10** with the rotary shoe R secured to the lower end thereof. Preferably, the casing string C will be of the flush joint type and in practice a size of 8⅝ inches has proved satisfactory. Next, the tubing string T is run

into the bore hole **10**, the percussion bit P being secured to the lower end thereof. Thereafter, the driving sub **46** may be made up on the upper sections of the casing string. Compressed air is then forced through the interior of the tubing string T by means of suitable connections (not shown) with the rotary swivel **20** and the kelly **18**. As soon as the bit element **58** of the percussion bit P commences reciprocation relative to the main body **56**, a small stream of drilling mud or water may be run through the annulus **68** between the casing and tubing strings by means of the spout **57'** and the drum **57**.

Referring now to Figure 2, sufficient liquid **67** should be added to prevent the air issuing from the exhaust ports (not shown) of the percussion bit from rising upwardly within the annulus **68**. Instead such exhausted air will be forced to rise upwardly between the exterior of the casing string C and the side walls **70** of the bore hole **10**. Preferably, a downwardly-facing cup type packer **72** will be secured to the percussion bit P, as indicated in Figure 2, so as to more positively restrain exhausted air from rising upwardly through the annulus **68**. As the percussion bit P is operating the rotary table **14** is rotated whereby concurrent rotation of the casing and tubing strings at the same speed will be effected.

During the concurrent rotation of the casing and tubing strings the bit element **58** of the percussion bit will simultaneously undergo reciprocation and rotation. In this manner, the percussion bit will chip and fracture the formation surrounding it. The abrasive hard facing **42** at the lower portion of the rotary shoe serves to cut away the formation which has not been chipped off by the percussion bit. The two drilling bits R and P are advanced simultaneously as the formation at the lower end of the bore hole **10** is removed. In this regard, the weight of the casing string C will ordinarily be sufficient to effect its downward advancement. Under certain circumstances, however, it may be necessary to utilize the pull-down bearing **54**. The percussion bit P is advanced into the formation **12** by lowering the rotary swivel **20**. The percussion bit P may be extended as far below the rotary shoe R as may be desired by adjusting the elevation of the rotary swivel **20** relative to the casing string C.

The cuttings resulting from the above-described drilling operation will be forced upwardly through the annular space **74** between the exterior surface of the casing string C and the side walls **70** of the bore hole **10** by the exhausted air issuing from the percussion bit P. It will also be observed that this exhausted air will serve to cool and lubricate both the bit element **58** of the percussion bit P and also the bit portion **22** of the rotary shoe R.

Referring now to Figure 3, when it becomes necessary to service the percussion bit P the tubing string T is pulled, the casing string C remaining in place within the bore hole. If desirable, the casing string C may be rotated during this pulling operation in order to prevent freezing thereof within the bore hole. During this operation the horizontal plate **48** can be removed and, drilling mud, air or water may be circulated through the casing string so as to maintain the bore hole clean and assist in preventing the casing string from sticking. Inasmuch as the casing string C remains in the bore hole during the time the percussion bit is withdrawn therefrom and reinserted therein, the danger that the bore hole may cave-in is substantially prevented.

Referring now to Figure 4, should it be necessary to change the rotary shoe R, the tubing string T is pulled and a string of flush joint casing **76** of smaller diameter than the rotary shoe S is run to the bottom of the bore hole **10**. Next, the casing string C is pulled and a new rotary shoe R secured to the lowermost section thereof. It will be apparent that the presence of the smaller casing string **76** within the bore hole **10** will substantially eliminate the danger of a cave-in during the time the casing string C is withdrawn therefrom. The casing string C may then be again run into the bore hole, as indicated in Figure 5. In this operation, preferably the outer casing string C will be washed over the inner casing string **76** to the bottom of the bore hole. The inner casing string **76** will then be pulled out of the bore hole and the tubing string T, together with the percussion bit P, re-run through the casing string C to the bottom of the bore hole. The drilling operation may again be started.

Referring now to Figures 6 and 7, when the bore hole **10** has been drilled to the desired depth and it is desired to run the final casing string **78**, the tubing string T with its percussion bit P is first withdrawn from the bore hole. The final casing string **78** may then be run into the bore hole. As shown in Figure 6, affixed to the lower end of the lowermost section of this inner casing string **78** is a cutting mill **80** having an outside diameter substantially equal to the inner diameter of the main body **30** of the rotary shoe R. With this arrangement, rotation of the final casing string **78** will serve to cut away the radially inwardly extending lip **38** of the bit means **22** of the rotary shoe R. Thereafter, the final casing string **78** is withdrawn from the bore hole and the mill **80** is removed. The final casing string **78** is run back into the bore hole with a plain end **82**. Finally, as illustrated in Figure 7, the outer casing string C is withdrawn from the bore hole **10** leaving the final casing string **78** in place.

It will also be apparent that various modifications and changes may be made with respect to the foregoing description without departing from the spirit of the invention or the scope of the following claims.

I claim:

1. Combined rotary and percussion drilling apparatus for use with a casing string and a tubing string arranged concentrically within said casing string in drilling a well bore, comprising: a rotary bit formed at its lower portion with rotary drill means and at its upper portion with means for attaching it to the lower end of said casing string; a fluid-actuated percussion drill having a main body, a motor and a bit element extending from the lower end of said main body, said bit element being reciprocated vertically relative to said main body by fluid forced downwardly through the interior of said tubing string to said motor; means formed on the upper portion of said main body for attaching it to the lower end of said tubing string; centralizer means interposed between said main body and said casing; packer means interposed between said main body and the inner periphery of said casing for restraining the upward flow of said fluid through the interior of said casing; and means keying said main body and said rotary bit together for concurrent rotation while permitting their relative vertical positions to be varied.

2. Combined rotary and percussion drilling apparatus for use with a casing string wherein is concentrically arranged a tubing string in drilling a well bore, with said strings being independently vertically movable, comprising: a rotary bit formed at its lower portion with rotary drill means and at its upper portion with means for attaching it to the lower end of said casing string, said rotary bit also being formed with a vertical passage therethrough; a percussion bit of smaller diameter than said rotary bit disposed within the vertical passageway of said rotary bit for vertical movement relative thereto, said percussion bit being formed with means for attaching it to the lower end of said tubing string whereby said percussion bit may be recovered by pulling said tubing string upwardly through said casing string while the latter remains within said well bore; and means keying said percussion bit and said rotary bit together for concurrent rotation while permitting their relative vertical positions to be varied.

3. Combined rotary and percussion drilling apparatus for use with a casing string wherein is concentrically arranged a tubing string in drilling a well bore, with said strings being independentdly vertically movable, compris-

ing: a rotary bit formed at its lower portion with rotary drill means and at its upper portion with means for attaching it to the lower end of said casing string; a fluid-actuated percussion drill having a main body, a motor and a bit element extending from the lower end of said main body, said bit element being reciprocated vertically relative to said main body by fluid forced downwardly through the interior of said tubing string to said motor; and means formed on the upper portion of said main body for attaching it to the lower end of said tubing string.

4. Combined rotary and percussion drilling apparatus for use with a casing string wherein is concentrically arranged a tubing string in drilling a well bore, with said strings being independently vertically movable, comprising: a rotary bit formed at its lower portion with rotary drill means and at its upper portion with means for attaching it to the lower end of said casing string; a fluid-actuated percussion drill having a main body, a motor and a bit element extending from the lower end of said main body, said bit element being reciprocated vertically relative to said main body by fluid forced downwardly through the interior of said tubing string to said motor; means formed on the upper portion of said main body for attaching it to the lower end of said tubing string; centralizer means interposed between said main body and the inner periphery of the lower end of said casing string; and packer means interposed between said main body and the inner periphery of said casing for restraining the upward flow of said fluid through the interior of said casing.

5. Combined rotary and percussion drilling apparatus for use with a casing string wherein is concentrically arranged a tubing string in drilling a well bore, with said strings being independently vertically movable, comprising: a rotary bit formed at its lower portion with rotary drill means and at its upper portion with means for attaching it to the lower end of said casing string; a fluid-actuated percussion drill having a main body, a motor and a bit element extending from the lower end of said main body, said bit element being reciprocated vertically relative to said main body by fluid forced downwardly



through the interior of said tubing string to said motor; means formed on the upper portion of said main body for attaching it to the lower end of said tubing string; and means keying said main body and said rotary bit together for concurrent rotation while permitting their relative vertical positions to be varied.

6. Combined rotary and percussion drilling apparatus for use with a casing string wherein is concentrically arranged a tubing string in drilling a well bore, with said strings being independently vertically movable, comprising: a rotary bit formed at its lower portion with rotary drill means and at its upper portion with means for attaching it to the lower end of said casing string; a fluid-actuated percussion drill having a main body, a motor and a bit element extending from the lower end of said main body, said bit element being reciprocated vertically relative to said main body by fluid forced downwardly through the interior of said tubing string to said motor; means formed on the upper portion of said main body for attaching it to the lower end of said tubing string; centralizer means interposed between said main body and the inner periphery of the lower end of said casing string; packer means interposed between said main body and the inner periphery of said casing for restraining the upward flow of said fluid through the interior of said casing; and means keying said main body and said rotary bit together for concurrent rotation while permitting their relative vertical positions to be varied.


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