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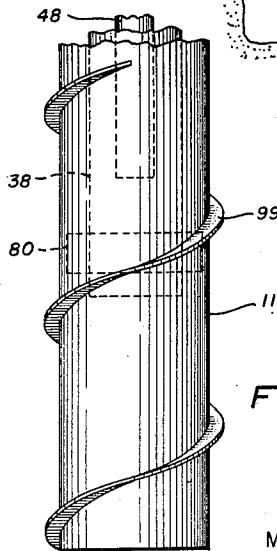
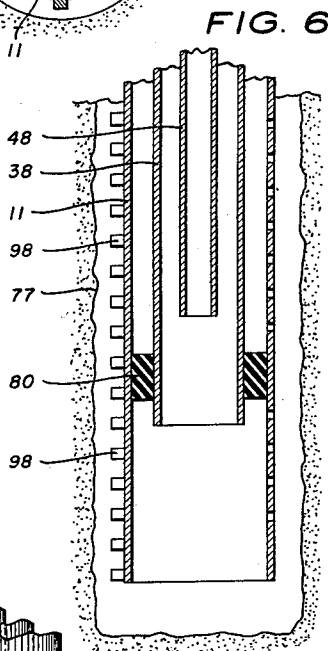
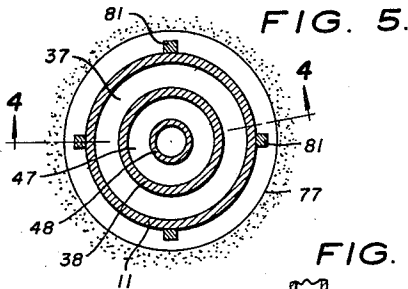
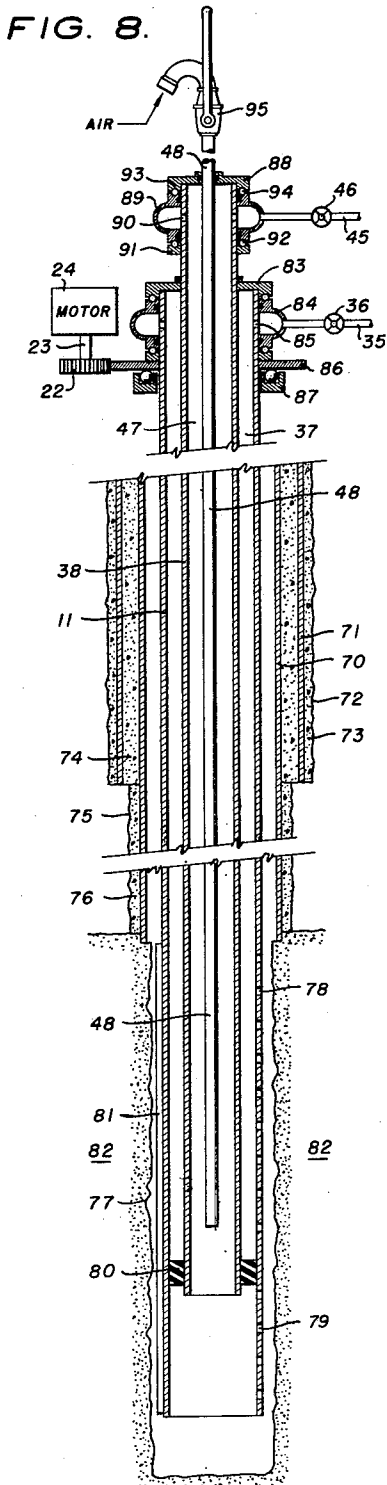
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APPARATUS FOR COMPLETING AND OPERATING SULFUR WELLS

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APPARATUS FOR COMPLETING AND OPERATING SULFUR WELLS

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The present invention is directed to apparatus for completing and operating wells. More particularly, the invention is directed to apparatus for use in combination with well casing for maintaining the well casing free of the wall of a well bore in which it is arranged. In its more specific aspects the invention is directed to apparatus for completing and operating sulfur wells in which a well casing is maintained free of the wall of the well bore as sulfur is mined.

The invention may be briefly described as apparatus in combination with a well casing which is positioned in a well bore. The well casing extends substantially throughout the well bore from the earth's surface. Means adjacent the upper end of the well casing is provided for rotating the well casing. A first means sealingly encloses the upper end of the well casing and a first pipe string is positioned concentrically within and spaced apart from the well casing substantially co-extensive with the well casing. The first pipe string extends sealingly through the enclosing means and a second means sealingly encloses the upper end of the first pipe string. A second pipe string is positioned concentrically within and spaced apart from the first pipe string and the second pipe string extends sealingly through the second enclosing means. A first conduit means connects to the first enclosing means for introducing fluid such as hot water into the space between the casing and the first pipe string. A second conduit means connects to the second enclosing means for removing fluid such as molten sulfur from a space between the first and second pipe strings. Means such as keys and keyways interconnect the first and second pipe strings with the casing for rotation with the casing. A fluid such as air is introduced through the second pipe string for lifting the molten sulfur through the space between the first and second pipe strings. A cutting means is arranged on the periphery of the well casing at least adjacent its lower end for maintaining the well casing free of the wall of the well bore as the well casing is rotated. The first and second enclosing means are stationary with respect to the casing and the pipe strings.

The first and second enclosing means may be separate annular members or may be arranged in a common housing and may suitably be first and second chambers in the common housing.

The second pipe string may suitably be raised and lowered within the first pipe string and the casing and the first and second pipe strings may suitably be reciprocated upwardly and downwardly and rotated in the well bore by a suitable means.

The first and second pipe strings in the casing are interconnected for rotation in the well bore.

In the mining of sulfur, a problem is frequently encountered in that as the sulfur is removed from the sulfur producing formation, the shifting formations due to removal of sulfur cause crushing loads to be imposed on the water string in the well bore. This tends to crush the casing and ultimately to cause the well bore to be

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blocked entirely requiring the drilling of new sulfur wells and resulting in a considerable economical loss in the abandonment of wells before their economic life has ended and resulting further in the loss of valuable casing and other pipe strings.

In accordance with the present invention, the well bore is maintained clean and clear of the shifting formations by rotating the well casing either by complete turning of the pipe or by oscillating rotary motion. Likewise, the water string and its associated equipment may be moved vertically as well as rotatably to free and maintain the well casing free of the formations which tend to move into the well bore. The present invention is, therefore, of considerable value and utility.

The invention will be further illustrated and described by reference to the drawing in which

Fig. 1 is a partial sectional view of apparatus for maintaining a well bore clear;

Fig. 2 is a sectional view taken along the lines 2—2 of Fig. 1;

Fig. 3 is a view taken along lines 3—3 of Fig. 1;

Fig. 4 is a view of the lower end of the apparatus of Fig. 1 showing the arrangement in a well bore;

Fig. 5 is a view taken along the lines 5—5 of Fig. 4;

Fig. 6 is a modification of the lower end of the apparatus of Fig. 4;

Fig. 7 is a further modification of the lower end of the apparatus of Fig. 4; and

Fig. 8 is a modification of the apparatus of Fig. 1.

Referring now to the drawings in which identical numerals will be employed to designate identical parts, numeral 11 designates a water string casing having a ring gear 12 connected thereto adjacent its upper end. The ring gear 12 is supported by bearings 13 in a raceway 14 and a supporting member 15 connected by means of a jack member 18 to the surface foundation, not shown, for the well. The jack member 18 is connected to the support 15 and comprises a jack arm 19 arranged in a piston cylinder 20 and having a piston 21 connected thereto. The piston cylinder 20 is provided with means for introducing hydraulic fluid thereto, these means not being shown.

The ring gear 12 connects to a drive gear 22 which, in turn, is connected by a shaft 23 to a driving motor 24 which may be an electric motor, a steam engine or an internal combustion engine.

The upper end of the casing 11 has attached thereto by mating threads 25 a shoulder 26 provided with a keyway 27 and having sealing means 28 on its outer periphery. Other attaching and sealing means may be provided. The sealing means 28 may suitably be mounted in a ring member 29 forming part of the shoulder 26. The upper end of the casing 11, including the shoulder 26, is arranged in a housing 30, the housing 30 having a first chamber 31 and a second chamber 32 with the shoulder 26 being arranged in the chamber 31. The two chambers communicate by means of a passageway 33.

The shoulder 26 is rotatably arranged in the chamber 31 on bearing members 34.

Connecting to the chamber 31 in the housing 30 is a conduit 35 provided with a control valve 36 wherein water is introduced into the chamber 31 and into the space 37 between the casing 11 and a first pipe string 38 arranged concentrically within the casing 11 and extending through the chamber 31 and the passageway 33 into chamber 32. The pipe string 38 is provided with keys 39 which are arranged in the keyways 27 and allow the pipe string 38 to be rotated with the casing 11.

The upper end of the pipe string 38 has a shoulder 40 threadedly connected thereto by mating threads 41 and is provided with sealing means 42 arranged in an annular member 43 which is connected to and forms part

of the shoulder 40. The shoulder 40 is rotatably arranged in the chamber 32 on bearing members 44.

A conduit 45 provided with a control valve 46 is connected to the housing 30 and communicates fluidly with the chamber 32 and with the space 47 between the pipe string 38 and a second pipe string 48 which extends concentrically within and spaced apart from the pipe string 38. The pipe string 48 extends through the upper end 49 of the housing 30 in sealing relationship therein. The pipe string 48 is provided with a key or keys 51 arranged in keyways 52 in the shoulder 40 which allows the pipe string 48 to be rotated with the pipe string 38 in the casing 11. A swivel connection 48a is provided for this purpose.

The pipe string 38 is sealingly positioned in the passageway 33 with seals 53 arranged in a ring member 54 forming part of a wall member 55 between the chambers 31 and 32. Seals 56 are arranged in a ring member 57 forming part of a cover plate 58 closing the upper end 49 of the housing 30 and sealing about pipe 48. The pipe 48 may be slidably positioned within the passageway 50 and the pipe 38 for movement vertically therein but may be arranged in a fixed position by providing an annular stop member 59 connected to the pipe string 48. The stop member 59 may be omitted as desired.

The pipe string 48 is provided with a control valve 61 and connects to a compressor 62 for supplying air to the pipe string 48.

Referring now to Fig. 4, it will be seen that the casing 11 is arranged within a surface casing 70. The surface casing 70 is, in turn, arranged within a conductor casing 71 in the large well bore 72. The conductor casing 71 is suitably driven into place and then may be cemented in place by cement 73 as may be desired; the surface casing may be cemented in the conductor casing by cement 74. The surface casing 11 extends through a smaller portion 75 of the well bore and is cemented therein by cement 76.

The surface casing 11 extends into the open hole 77 substantially throughout the length of the total well bore.

It is to be noted that the water string 11 is provided with upper perforations 78 and lower perforations 79, the perforations being separated within the annular space 37 by a suitable packing member such as 80 arranged adjacent the lower end of the water string 11.

Arranged on the periphery of the water string 11 at least adjacent its lower end in the open hole 77 are a plurality of longitudinally extending hard surface cutter members 81. These cutter members as they rotate or oscillate in the open hole 77 maintain the open hole 77 free of the cap rock formation 82 which may tend to migrate into the open hole 77 by virtue of the removal of sulfur from the rock.

Referring now to Fig. 6, it will be seen that the water string 11 is provided with a plurality of spaced apart hard surface cutters 98 which may be in the form of prongs or bristles to cause cutting or crushing of any rock which may move into the open hole 77.

Referring now to Fig. 7, the water string 11 may be suitably equipped with a hard surface cutter member in the form of helically extending lands or cutter members 99 which may be continuous or partial segments of a spiral and which are arranged on the periphery of the water string 11 and extend at least the distance encompassed by the open hole 77.

Referring now to Fig. 8, a surface casing 70 is arranged in a conductor casing 71 and arranged in the surface casing 70 is a water string or casing 11 which extends into the open hole 77 penetrating the cap rock 82. Arranged within the water string or casing 11 is a pipe string 38 and arranged within pipe string 38 is a second pipe string 48. A packing member 80 isolates the upper perforations 78 from the lower perforations 79.

The upper end of the water string or casing 11 is closed by a closure member 83 and connects into the pipe string 38. Forming part of the enclosing means is

an annular member 84 arranged stationarily on the upper end of the casing 11 and communicating therewith by a passageway 85 to allow water injection into the space 37 by conduit 35 controlled by valve 36.

The annular member 84 is arranged on and connected to a rotary gear 86 which is arranged on a rotary gear support member 87. The rotary gear 86 is connected to a drive gear 22 which, in turn, is driven by motor 24 interconnected by shaft 23.

Enclosing the upper end of the pipe 38 is a closure member 88 and forming part thereof is a second annular member 89 which communicates with the space 47 by means of ports 90. The annular member 89 is stationarily arranged on a retainer ring 91 provided with bearings 92 while the closure member 88 provides a second retainer ring 93 with the annular member being rotatably arranged on bearings 94. A conduit 45 controlled by valve 46 communicates the annular member 89 to allow sulfur to be removed from the space 47.

The lower end of the water string 11 is provided with longitudinal cutter members such as 81 also shown in Figs. 4 and 5.

The apparatus of Figs. 1 to 5 operates as follows: Hot water at a temperature within the range of 315° to 340° F. is introduced by line 35 controlled by valve 36 into chamber 31 and then passes downwardly through the annular space 37 and outwardly through perforations 78 to contact the sulfur bearing formation 82. The molten sulfur then flows through the perforations 79 and upwardly through the annular space 47 into the chamber 32 and outwardly through valve 46 in conduit 45. Since air lift may be necessary to lift the sulfur, compressed air is flowed downwardly from compressor 62 through pipe 48 to aid in lifting the sulfur in annular space 47.

As the sulfur is mined from the cap rock, the compressive forces tend to cause the rock to migrate toward and shift into the open hole 77 and cause crushing of the water string 11 and ultimate destruction thereof. In accordance with the present invention, this is prevented by rotating the casing string 11, the pipe string 38 and the air string 48 by operating the gears 12 and 22 through energization of motor 24. Since the pipe 38 is connected to the casing 11 and since the pipe 48 is connected to the pipe 38, rotation of the casing 11 rotates the pipe 48, the pipe 38 and the casing 11 with respect to the housing 30 which remains stationary. This allows the cutters 81 to crush the rock which would tend to bind the water string 11 and allows it to be maintained free of the wall of the open hole 77. It is also possible to raise and lower the assembly with respect to the housing 30 by means of the jack assembly 18. By introducing hydraulic fluid into the piston cylinder 20, the piston 21 may be raised to cause raising of the support 15. Likewise, the assembly may be raised and lowered by means of the usual hoisting equipment commonly employed in the drilling and servicing of wells. When the jack assembly 18 is used, the housing 30 may suitably be spaced from the driving gears 12 and 22 and the support 15 therefor.

The apparatus of Fig. 8 operates in a similar fashion with respect to the introduction of hot water and with respect to the withdrawing of the molten sulfur. It is to be noted specifically with respect to Fig. 8 that the pipe 48 is suitably provided with a swivel connection 95 which allows the pipe 48 to be moved vertically either upwardly or downwardly. This is desirable in case the heavy input of water does not clear the hole of cuttings resulting from the reciprocating or rotation of the water string and attendant pipes. Lowering of the air line 48 will provide sufficient air and velocity and power for flushing the cuttings from the bottom of the water string.

It will be seen from the foregoing description taken with the several figures of the drawing that a new and improved device which has considerable utility in freeing

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stuck pipe in a well bore and maintaining pipe free of the well bore has been provided.

The nature and objects of the present invention having been completely described and illustrated, what I wish to claim as new and useful and to secure by Letters Patent is:

1. In combination with a well casing positioned in a well bore and extending substantially throughout the well bore from above the earth's surface, means adjacent the upper end of said well casing for rotating said well casing, first means sealingly enclosing the upper end of the well casing, a first pipe string positioned concentrically within and spaced apart from said well casing and substantially co-extensive therewith and extending sealingly through the first enclosing means, second means sealingly enclosing the upper end of said first pipe string, a second pipe string positioned concentrically within and spaced apart from said first pipe string and extending sealingly through the second enclosing means, a first conduit means connected to the first enclosing means for introducing fluid into the space between the casing and the first pipe string, a second conduit means connected to the second enclosing means for removing fluid from the space between the first and second pipe strings, means interconnecting said first and second pipe strings with said casing for rotation therewith, and cutting means arranged on the periphery of said well casing at least adjacent its lower end for maintaining said well casing free of the wall of said well bore, said first and second enclosing means being stationary with respect to said casing and pipe strings.

2. Apparatus in accordance with claim 1 in which the first and second enclosing means are separate annular members.

3. Apparatus in accordance with claim 1 in which the first and second enclosing means are arranged in a common housing.

4. In combination with a well casing positioned in a well bore and extending substantially throughout the well bore from above the earth's surface, means adjacent the upper end of said casing for rotating said well casing, a housing enclosing the upper end of said well casing, said casing having its upper end positioned sealingly in the housing, a first pipe string positioned concentrically within and spaced apart from said well casing and substantially co-extensive therewith having its upper end positioned sealingly in the housing above said casing, a second pipe string positioned concentrically within and spaced apart from said first pipe string and substantially co-extensive therewith extending sealingly through the upper end of said housing, fluid conduit means connected to said housing and communicating with said well casing for introducing fluid into the space in the well casing between the well casing and the first pipe string, fluid conduit means connected to said housing and communicating with the space between the first and second pipe strings for removing fluid material therefrom, means for introducing fluid into the second pipe string, means interconnecting said first and second pipe strings with said casing for rotation therewith, and cutting means arranged on the periphery of said well casing at least adjacent its lower end for maintaining said well casing free of the wall of said well bore, said housing being stationary with respect to said casing and pipe strings.

5. In combination with a well casing positioned in a well bore and extending substantially throughout the well bore from above the earth's surface, means adjacent the upper end of said casing for rotating said well casing, a housing enclosing the upper end of said well casing provided with a lower first chamber and an upper second chamber and having a concentric passageway communicating said chambers, said casing having its upper end positioned sealingly in the first chamber, a first pipe string positioned concentrically within and spaced apart from said well casing and substantially co-extensive therewith having its upper end positioned sealingly in the second

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chamber and in said passageway, a second pipe string positioned concentrically within and spaced apart from said first pipe string and substantially co-extensive therewith extending sealingly through the upper end of said housing, fluid conduit means communicating with said first chamber for introducing fluid into the space in the well casing between the well casing and the first pipe string, fluid conduit means communicating with the second chamber for removing fluid material from the space between the first and second pipe strings, means for introducing fluid into the second pipe string, means interconnecting said first and second pipe strings with said casing for rotation therewith, and cutting means arranged on the periphery of said well casing adjacent its lower end for maintaining said well casing free of the wall of said well bore, said housing being stationary with respect to said casing and pipe strings.

6. In combination with a well casing positioned in a well bore and extending substantially throughout the well bore from above the earth's surface, means adjacent the upper end of said casing for rotating said well casing, a housing enclosing the upper end of said well casing provided with a lower first chamber and an upper second chamber and having a concentric passageway communicating said chambers, said casing having its upper end positioned sealingly in the first chamber, a first pipe string positioned concentrically within and spaced apart from said well casing and substantially co-extensive therewith having its upper end positioned sealingly in the second chamber and in said passageway, said first pipe string being connected to said casing for rotation therewith, a second pipe string positioned concentrically within and spaced apart from said first pipe string and substantially co-extensive therewith extending sealingly through the upper end of said housing, said second pipe string being connected to said first pipe string for rotation with the first pipe string and the casing, fluid conduit means communicating with said first chamber for introducing fluid into the space in the well casing between the well casing and the first pipe string, fluid conduit means communicating with the second chamber for removing fluid material from the space between the first and second pipe strings, means for introducing fluid into the second pipe string and cutting means arranged on the periphery of said well casing adjacent its lower end for maintaining said well casing free of the wall of said well bore, said housing being stationary with respect to said casing and pipe strings.

7. In combination with a well casing positioned in a well bore and extending substantially throughout the well bore from above the earth's surface, means adjacent the upper end of said casing for rotating said well casing, a housing enclosing the upper end of said well casing provided with a lower first chamber and an upper second chamber and having a concentric passageway communicating said chambers, said casing having a shoulder on its upper end positioned sealingly in the first chamber, said shoulder being provided with a keyway, a first pipe string positioned concentrically within and spaced apart from said well casing and substantially co-extensive therewith having a shoulder on its upper end positioned sealingly in the second chamber and in said passageway, a keyway on the shoulder of said first pipe string, a key on said first pipe string arranged in the keyway on the casing shoulder connecting the first pipe string to the casing for rotation therewith, a second pipe string positioned concentrically within and spaced apart from said first pipe string and substantially co-extensive therewith extending sealingly through the upper end of said housing, a key on said second pipe string arranged in the keyway on the first pipe string shoulder connecting the second pipe string to the first pipe string for rotation therewith, fluid conduit means communicating with said first chamber for introducing fluid into the space in the well casing between the well casing and the first pipe

string, fluid conduit means communicating with the second chamber for removing fluid material from the space between the first and second pipe strings, means for introducing fluid into the second pipe string and cutting means arranged on the periphery of said well casing adjacent its lower end for maintaining said well casing free of the wall of said well bore, said housing being stationary with respect to said casing and said pipe strings.

8. In combination with a well casing positioned in a well bore and extending substantially throughout the well bore from above the earth's surface, means adjacent the upper end of said casing for rotating said well casing, a housing enclosing the upper end of said well casing provided with a lower first chamber and an upper second chamber and having a concentric passageway communicating said chambers, said casing having a shoulder on its upper end positioned sealingly in the first chamber, said shoulder being provided with a keyway, a first pipe string positioned concentrically within and spaced apart from said well casing and substantially co-extensive therewith having a shoulder on its upper end positioned sealingly in the second chamber and in said passageway, a keyway on the shoulder of said first pipe string, a key on said first pipe string arranged in

the keyway of the casing shoulder connecting the first pipe string to the casing for rotation therewith, a second pipe string positioned concentrically within and spaced apart from said first pipe string and substantially co-extensive therewith extending sealingly through the upper end of said housing, a key on said second pipe string arranged in the keyway on the first pipe string shoulder connecting the second pipe string to the first pipe string for rotation therewith, said shoulders on said casing and first pipe string being rotatably arranged on bearing members in said chambers, fluid conduit means communicating with said first chamber for introducing fluid into the space in the well casing between the well casing and the first pipe string, fluid conduit means communicating with the second chamber for removing fluid material from the space between the first and second pipe strings, means for introducing fluid into the second pipe string, and cutting means arranged on the periphery of said well casing adjacent its lower end for maintaining said well casing free of the wall of said well bore, said housing being stationary with respect to said casing and said pipe strings.

No references cited.