

Nov. 25, 1958

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2,861,780

MEANS FOR COOLING THE CUTTERS OF DRILL BITS

Filed June 20, 1956

2 Sheets-Sheet 1

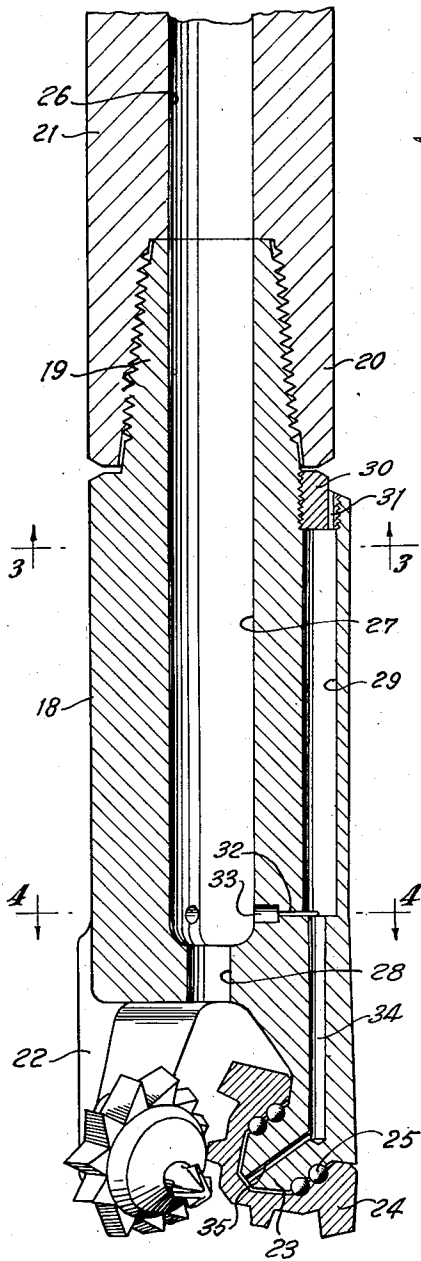


Fig. 2

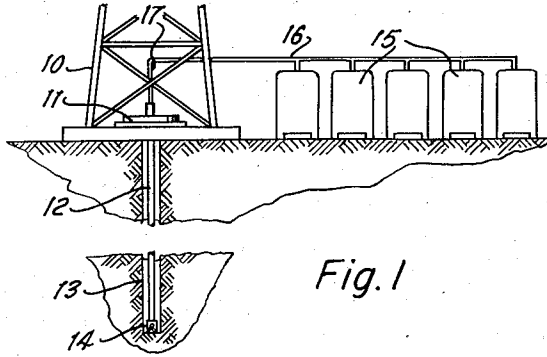


Fig. 1

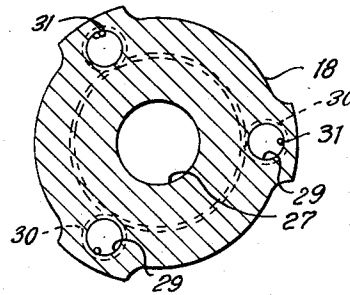


Fig. 3

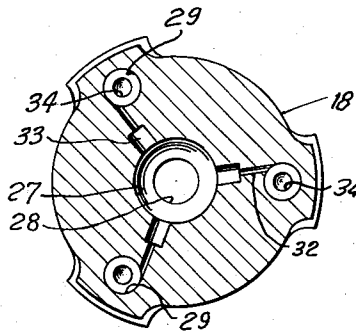


Fig. 4

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2 Sheets-Sheet 2

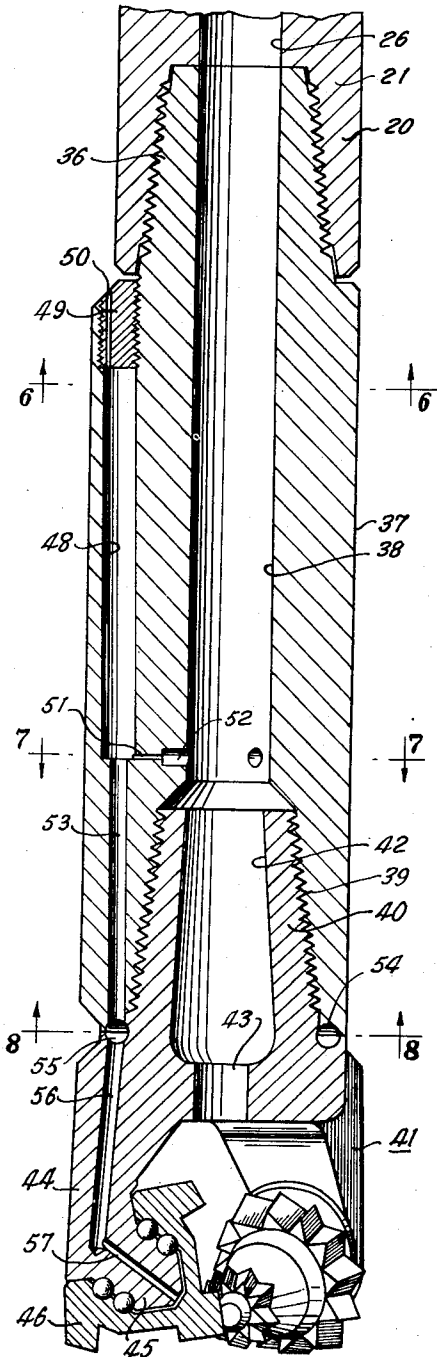


*Fig. 5*

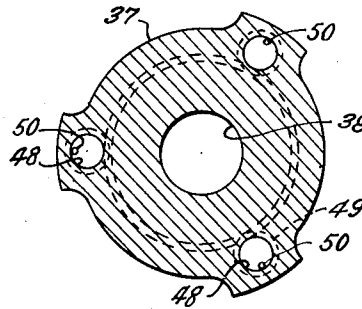


*Fig. 6*

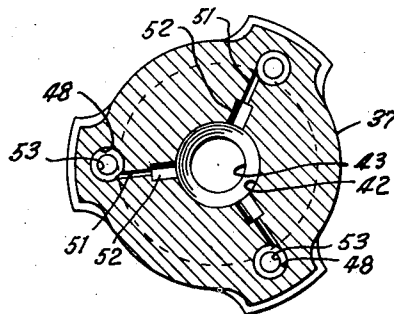


*Fig. 7*

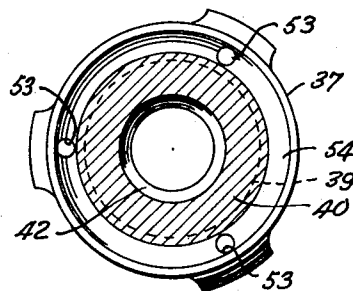


*Fig. 8*

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MEANS FOR COOLING THE CUTTERS OF  
DRILL BITS

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Application June 20, 1956, Serial No. 592,684

7 Claims. (Cl. 255—303)

This invention relates to new and useful improvements in means for cooling the cutters of drill bits.

It has become an established practice in the drilling of well bores, especially in the drilling of petroleum wells, to employ a gas under pressure as a drilling fluid in place of the usual drilling mud having an aqueous or a petroleum base. Various well known advantages are realized through the utilization of a gas, such as air, flowed under pressure down through the drill pipe to the drilling bit, rather than the usual drilling liquid having a water base and which has been used for many years. In some instances, lessened contamination of the producing formation is achieved, cleaning of the well following penetration of the desired formation is facilitated, and other well known beneficial results are obtained.

It is customary, however, to employ in the drilling of well bores drilling bits having rotatable cutters or cutter cones, and the flow of the drilling fluid is utilized for the cooling of these cutters or cutter cones as they revolve upon the body of the drill bit and, of course, are subjected to the load which is applied to the drill bit to effect advancement of the drill into the earth formation. Usually, the cutter cones are mounted upon shanks or spindles and provided with suitable anti-friction means, such as ball bearings and the like, and the aqueous type of drilling fluid has been found sufficient for lubrication and cooling of the bearing surfaces whereby a full and effective cutting life is obtained from the drill cutters. When, however, a gaseous fluid is used for circulation through the drill pipe and to the drilling bit, insufficient cooling of the cutters and their bearings is observed, and the effective drilling life of a drill bit is often reduced quite seriously.

It is, therefore, an important object of this invention to provide an improved means for cooling the cutters of drill bits while permitting the utilization of a gaseous drilling fluid.

A particular object of the invention is to provide an improved device, of the character described, in which a portion of the gaseous drilling fluid is conducted through means for chilling the same, the cool body of gas then being passed to the cutters of the drill bit to effect the proper cooling thereof.

Another object of the invention is to provide an improved means for cooling the cutters of drill bits through which a gaseous drilling fluid is being passed, the structure utilizing one or more Hilsch tubes for producing a supply of cold gas for cooling of the drill bit cutters.

A further object of the invention is to provide a device, of the character described, in which the cooling means may be incorporated directly into the bit structure, or included in a drill sub upon which a conventional bit is mounted.

A construction designed to carry out the invention will be hereinafter described, together with other features of the invention.

The invention will be more readily understood from a reading of the following specification and by reference to

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the accompanying drawings, wherein examples of the invention are shown, and wherein:

Fig. 1 is a schematic view illustrating the general type of arrangement employed in drilling well bores with the utilization of a gaseous drilling fluid,

Fig. 2 is a longitudinal, sectional view of a drill bit constructed in accordance with this invention,

Figs. 3 and 4 are transverse, cross-sectional views taken upon the respective lines of Fig. 2,

Fig. 5 is a longitudinal, sectional view of a modified form of the invention and showing its utilization in conjunction with a substantially conventional drill bit, and

Figs. 6, 7 and 8 are transverse, cross-sectional views taken upon the respective lines of Fig. 5.

In the drawings, the numeral 10 designates a conventional drilling derrick or mast having at its lower end a rotary table or other drilling mechanism 11 through which a drill stem 12 depends into a well bore 13, a drilling bit 14 being provided at the lower end of the drill stem. Several, and usually a plurality of, air compressors 15, or other suitable means for producing large volumes of gaseous drilling fluid under pressure, are connected through a manifold 16 to the drilling fluid hose or rotary hose 17 leading to the bore of the drill stem 12. This structure and arrangement is conventional and in widespread use, the gaseous drilling fluid under pressure being supplied to the drill stem and forced downwardly therethrough at considerable pressure and velocity in order to flow through the drilling bit 14 at the bottom of the drill stem and upwardly through the annulus between the wall of the well bore 13 and the exterior of the drill stem 12. As pointed out hereinabove, difficulties have been encountered in drilling systems of this type in effecting efficient cooling of the drill bit, and especially the cutters thereof.

In the present invention, as shown in Fig. 2, an elongate drill bit body 18 is provided on its upper end with a screw-threaded pin 19 received in the screw-threaded box 20 normally provided on the lower end of the drill collar or stub 21 which, in turn, is connected upon the lower end of the drill stem 12. A plurality of depending, spaced shanks 22 extend downwardly from the lower end of the drill body 18 and carry inwardly-directed spindles 23 upon which drilling cutters or cutter cones 24 are mounted. Normally, ball bearings 25, or other anti-friction means, are provided between the cones 24 and the spindles 23.

The sub 21 is provided with an axial drilling fluid passage 26 registering with a similar passage 27 provided in the sub 18, the lower end of the passage 27 opening through a reduced port or passage 28 into the space between the spindles 22 whereby a high velocity and high volume jet of drilling fluid is directed downwardly onto the bottom of the well bore, as well as onto the cutter cones 24, and in general, the entire lower end of the drill bit.

Even so, the flow of gaseous drilling fluid over the cutter cones is not sufficient to cool the same adequately, and especially to cool the internal portions of the cones and the bearing surfaces between the cones and the spindles 23. Accordingly, in the present invention, Hilsch tubes are employed for supplying an auxiliary flow of cold gaseous drilling fluid to the internal surfaces of the cones 24 and the bearing surfaces of the spindles 23.

This type of tube is known variously as a Hilsch tube and as a Hilsch vortex tube and employs the Hilsch or Ranque-Hilsch effect which is obtained when air or other gas under pressure is directed tangentially into an elongate tube or chamber. The gas under pressure entering the tube tends to flow circumferentially or helically within the tube and to divide itself into a relatively warm outer layer and a quite cold core or axial portion. The

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warm air or gas may be withdrawn at one end of the tube, usually from the marginal portion thereof, and a flow of cold air or gas may be withdrawn axially from the opposite end of the tube. Normally, the point of cold air withdrawal is located at the end of the tube into which the inlet gas is being flowed tangentially, the dimensioning and contour of the outlets for the warm and cold gas portions, as well as of the inlet port for the supply gas, being regulated in accordance with the operating conditions at hand. Normally, a fairly high volume of flow is required, and the inlet gas must be under considerable pressure. The cooling effect obtained is not simply one of expanding a body of gas as exemplified by the Joule-Thompson effect, but rather is a separate and distinct phenomenon whereby a body of flowing gas may be divided into a warm and a cold portion, and these portions withdrawn separately.

In the present invention, a Hilsch tube is incorporated into the body 18 of the drill bit, one or more of the tubes being employed and the cold fluid therefrom being conducted to the internal surfaces of the cutter cones 24. Obviously, a single tube could be employed and its cold gas delivery divided and directed to the several cutter cones, or in the alternative, one or more tubes may be provided for supplying cold gaseous drilling fluid to each of the drilling cutters. For simplicity and effectiveness, it is preferable to provide a Hilsch tube for each of the cutter cones and to flow the cold gas from each of these tubes to a single one of the cutters.

This objective is readily obtained by providing in the drill body 18 above each of the spindles 22 an elongate bore or cylindrical passage 29 extending from the upper end of the body 18, beneath the level of the pin 19, to a point near the lower end of the passage 27. The upper end of each of the chambers 29 is closed by a screw-threaded plug 30 having a longitudinal warm gas outlet or passage 31 positioned adjacent the periphery of the plug 30 so as to result in the withdrawal of warm gas from a point near the wall of the chamber 29. An inlet port 32 opens tangentially into the lower end of each of the chambers 29 and communicates with the lower end of the passage 27 above the restricted portion 28 through an enlarged counter bore 33. A longitudinal flow passage 34 extends downwardly and axially from the lower end of each of the chambers 29 and opens through an inclined lateral passage 35 to the end of each of the shanks 23. Thus, a flow path for cold gas is provided leading from each of the shanks 23, and opening into the space between the outer surfaces of the shanks 23 and the inner bearing surfaces of the cutters 24.

In the operating of this structure, gaseous drilling fluid is supplied through the passage 26 to the passage 27, the bulk of the fluid passing through the port 28 onto the exterior surfaces of the cutter cones 24. Because of the restriction and back pressure created by the reduced port 28, a portion of the gaseous drilling fluid is caused to flow through passages 33 and 32 tangentially into the chambers 29 wherein such portions of the gaseous drilling fluid resolve themselves into warm and cold portions. The cold portions flow downwardly through the passages 34 and 35 to the interior of the cutter cones 24 to cool the bearing surfaces thereof as well as the anti-friction means 25. The gaseous drilling fluid exhausting from between the cutters 24 and cones 23 simply rejoins the bulk of the drilling fluid and passes upwardly therewith around the outside of the drill bit and of the drill stem 12.

In the form of the invention which has been described, the Hilsch tube structure is incorporated directly into the body of the drill bit. In some instances, however, it may be desirable to incorporate the Hilsch tube structure into a separate unit in the nature of a short drill collar or sub which may be attached to the lower end of the usual drill collar, and carry upon its lower portion a more or less conventional drilling bit.

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Such a modification is shown in Fig. 5 in which the sub 21 receives in its box 20 the upstanding pin 36 provided upon the upper end of a relatively short drill collar or sub 37. The sub 37 is provided with an axial bore 38 communicating with the bore 26 of the sub 21 and opening at the lower end of the sub 37 into a screw-threaded box 39 which receives the screw-threaded, upstanding pin 40 of a drill bit 41. The pin 40 has an axial bore 42 registering with the bore 38 and opening downwardly through a restricted passage 43 into the space between the shanks 44 at the lower end of the drill bit. The usual spindles 45 are provided on the shanks 44 and carry cutter cones 46.

One or more Hilsch tube structures are provided in the relatively short sub 37 by providing in the wall of the sub one or more elongate bores or chambers 48 extending from the upper end of the sub downwardly to a point adjacent the upper end of the box 39. The upper ends of the chambers 48 are closed by screw-threaded plugs 49 similar to the plugs 30 and provided with marginal outlet passages 50. Tangential inlet passages 51 are provided at the lower end of the chamber 48 and open through counterbores 52 into the passage 38.

For conducting the cold drilling gas downwardly to the drill bit, elongate vertical passages 53 extend from the lower ends of the chambers 48 to the lower extremity of the box 39. At their upper ends, the passages 53 open axially into the chambers 48, and at their lower ends, they communicate with a circumferential groove 54, of semi-circular cross-section, cut in the lower end or face of the box 39.

The drill bit 41 is provided on its upper end with a circumferential groove 55, of semi-circular cross-section, the groove 55 registering with the groove 54 when the pin 40 of the drill bit is screwed into the box 39, and thus forming with the groove 54 a circumferential enclosed passage into which all of the passages 53 open. The bit is also provided with longitudinal passages 56 extending downwardly from the groove 53 through the shanks 44, there being a bore 57 opening into the lower end of each of the passages 56 and extending downwardly at an angle through the spindles 45. Thus, the cold gaseous drilling fluid is conducted downwardly through the passages 53 into the grooves 54 and 55 and thence through the passages 56 and 57 to the inner surfaces of the cutter cones 46 and the bearing surfaces of the spindles 45.

The drill bit 41 is conventional in structure with the exception of the groove 54 and the passages 56 and 57, and when the bit becomes worn in use, it is readily replaced without necessitating replacement of the sub and Hilsch tube structure 37. The sub 37 is not subject to any particular degree of wear and may outlast a considerable number of the drill bits 41. Hence, in this modification, the expendable portion of the drilling structure, i. e. the drill bit, is made readily replaceable and the cost of that portion of the drilling structure which must often be replaced is held to a minimum.

In the operation of this drilling structure, the drilling fluid is pumped downwardly through the drill stem in the usual manner and flows to the cutter cones and over the bottom of the well bore in the usual manner. In both modifications, a portion of the drilling fluid is drawn off into one or more Hilsch tube units and therein resolved into bodies of warm gas and of cold gas. The warm gas is exhausted upwardly around the exterior of the drill stem, while the cold gas is taken downwardly to the interior of the cutter cones for cooling the same for proper operation. By this means, the advantages of drilling well bores with a gaseous drilling fluid may be realized, and at the same time, adequate and efficient cooling for the cutting structure, and especially the cutting cones, is obtained. Of course, the invention is not to be limited to use with any particular type of drill bit, the cutter cone type of bit which has been illustrated merely being an example of a drill bit to which the in-

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vention may be applied. Obviously, other types and designs of drill bits may readily be adapted to include the teachings of this invention.

While it is preferable to utilize the gaseous drilling fluid as the source of supply of gas under pressure for the Hilsch tubes, there may be instances, such as need for a gas supply under higher pressure, or for other reasons, when a separate gas supply for the Hilsch tubes may be desirable. In such cases, the separate gas supply may readily be conveyed to the tubes through a separate conductor extending downwardly in the well bore through the drill pipe or exteriorly thereof and opening into the inlets of the Hilsch tubes.

The foregoing description of the invention is explanatory thereof and various changes in the size, shape and materials, as well as in the details of the illustrated construction may be made, within the scope of the appended claims, without departing from the spirit of the invention.

What I claim and desire to secure by Letters Patent is:

1. A drill bit structure including, a body member having a longitudinal drilling fluid passage, at least one rotatable drilling cutter carried by the body member, at least one Hilsch tube chamber in the body member, the body member having an inlet for gaseous drilling fluid extending between the drilling fluid passage and the chamber and a warm fluid outlet extending from the chamber to the exterior of said body member at a point removed from said drilling cutter, the body having a cold fluid passage between the chamber and the interior of the drilling cutter for supplying cool drilling fluid to the cutter.

2. A drill bit structure including, a body member having a longitudinal drilling fluid passage with a restricted outlet at its lower end, at least one rotatable drilling cutter carried by the body member, at least one Hilsch tube chamber in the body member, the body member having an inlet for gaseous drilling fluid extending between the drilling fluid passage above the restricted outlet thereof and the chamber and a warm fluid outlet extending from the chamber to the exterior of said body member at a point removed from said drilling cutter, the body member having a cold fluid passage between the chamber and the interior of the drilling cutter for supplying cool drilling fluid to the cutter.

3. A drill bit structure including, a body member having a longitudinal drilling fluid passage with a restricted outlet at its lower end, at least one rotatable drilling cutter carried by the body member, at least one Hilsch tube chamber in the body member, the body member having an inlet for gaseous drilling fluid extending between the drilling fluid passage above the restricted outlet thereof and the lower portion of the chamber and a warm fluid outlet extending from the chamber to the exterior of said body member at a point removed from said drilling cutter, the body member having a cold fluid passage between the chamber and the interior of the drilling cutter for supplying cool drilling fluid to the cutter.

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4. A drill bit structure including, a body member having a longitudinal drilling fluid passage, at least one rotatable drilling cutter carried by the body member, at least one Hilsch tube chamber in the body member, the body member having an inlet for gaseous drilling fluid extending between the drilling fluid passage and the lower portion of the chamber and a warm fluid outlet extending from the upper end of the chamber to the exterior of said body member at a point removed from said drilling cutter, the body member having a cold fluid passage between the chamber and the interior of the drilling cutter for supplying cool drilling fluid to the cutter.

5. A drill bit structure including, a heavy-walled body member having a longitudinal drilling fluid passage with a restricted outlet at its lower end, rotatable drilling cutters carried by the body having internal bearing surfaces, Hilsch tube chambers in the body member, the body member having inlets for gaseous drilling fluid extending from the drilling fluid passage to the chambers and warm fluid outlets extending from the chambers to the exterior of the body member at points removed from said drilling cutters, the body member having cold fluid passages from the Hilsch tubes to the bearing surfaces of the drilling cutters.

6. A drill bit structure including, a heavy-walled body member having a longitudinal drilling fluid passage, a drilling bit on the lower end of the body member having depending spindles, drilling cutters rotatably mounted on the spindles, Hilsch tubes in the wall of the body member having inlets for gaseous drilling fluid from the drilling fluid passage and warm gas outlets extending from their upper ends to the exterior of said body member at points removed from said drilling cutters, the body member having cold gas outlets from the lower ends of the Hilsch tubes, and the spindles having cold gas passages communicating with the cold gas outlets and leading to the space between the cutters and the spindles.

7. A drill bit structure as set forth in claim 6 wherein the body member and drilling bit are joined by a screw-threaded box and pin joint, the body member and bit having grooves registering in the joint, the cold gas passages communicating with the cold gas outlets through said grooves.

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