

Dec. 1, 1959

F. H. DEILY

2,915,285

CORING SUBTERRANEAN FORMATIONS

Filed May 23, 1956

3 Sheets-Sheet 1

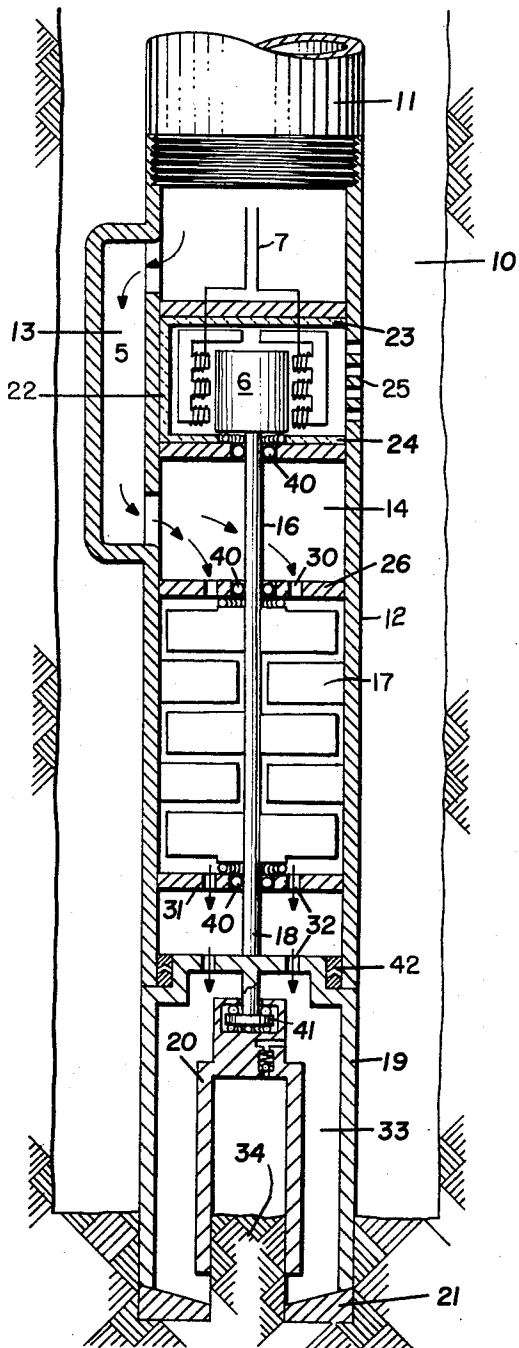


FIGURE 1

Fredric H. Deily

Inventor

By W.O. Heilman Attorney

Dec. 1, 1959

F. H. DEILY

2,915,285

CORING SUBTERRANEAN FORMATIONS

Filed May 23, 1956

3 Sheets-Sheet 2

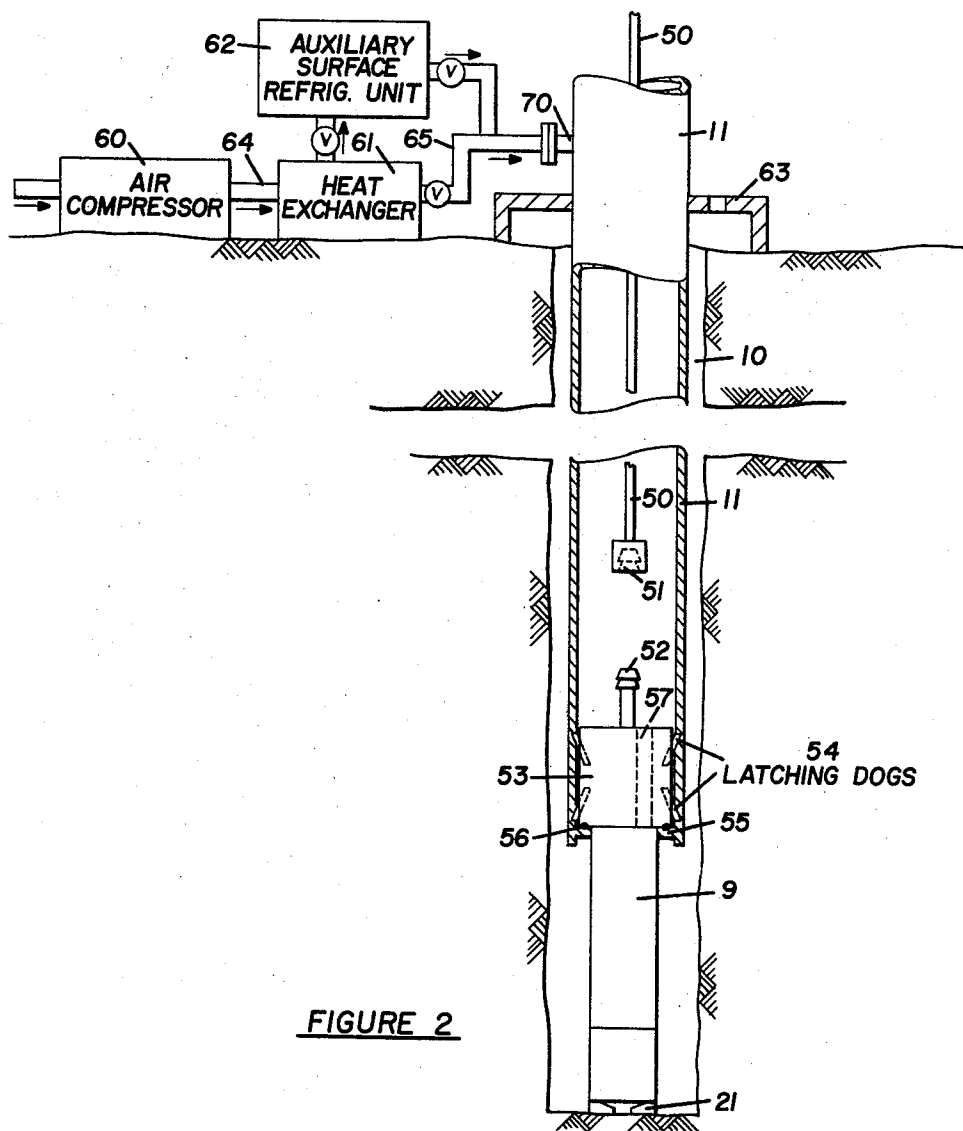


FIGURE 2

Fredric H. Deily

Inventor

By *W. O. Hilman*

Attorney

Dec. 1, 1959

F. H. DEILY

2,915,285

CORING SUBTERRANEAN FORMATIONS

Filed May 23, 1956

3 Sheets-Sheet 3

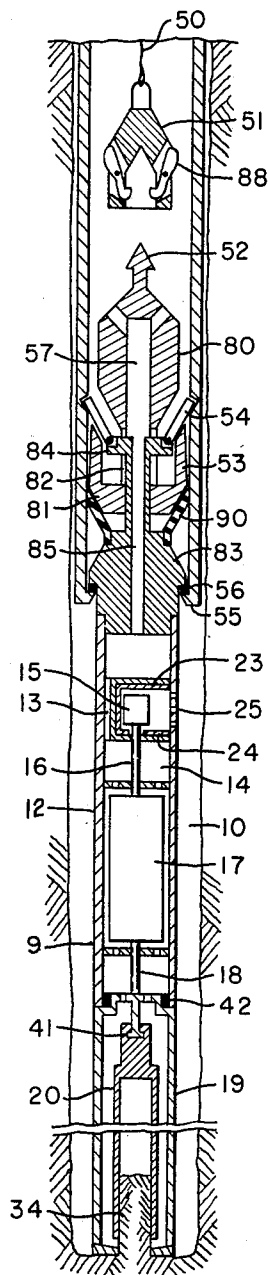


FIG. 3

1

2,915,285

CORING SUBTERRANEAN FORMATIONS

Fredric H. Deily, Tulsa, Okla., assignor, by mesne assignments, to Jersey Production Research Company

Application May 23, 1956, Serial No. 586,724

8 Claims. (Cl. 255—1.4)

The present invention broadly relates to the coring of subterranean formations. More particularly, it concerns an apparatus and method of coring a subterranean formation wherein the resulting core is chilled as it is cut and its true fluid content thereby maintained. The invention has particular application in coring subterranean oil reservoirs prior to secondary recovery operations.

The importance and desirability of obtaining cores that are truly representative of subterranean formations have long been recognized in the petroleum industry. A study of these cores provides the industry with knowledge which enables production operations to be carried out with maximum efficiency and economy. The analysis and study of core samples is becoming particularly important in those reservoirs and fields which are being considered for secondary recovery operations. The permeability, porosity, grain orientation and other characteristics of the cores provide prospective operators of the reservoir with extremely desirable information concerning the direction and rate at which a reservoir should be depleted as well as the type of secondary recovery technique which should preferably be employed.

Accordingly, it is an object of the present invention to provide an improved method and apparatus for coring subterranean formations and especially subterranean oil reservoirs that are being studied preparatory to secondary recovery programs. Briefly, the invention utilizes a stream of gasiform fluid which is expanded and caused to perform work in the vicinity of a coring tool. Thus, a stream of high pressure air may be employed to drive a gas turbine located near the bottom of a bore hole, and the gas turbine in turn employed to drive a coring tool. The stream of high pressure air in passing through the turbine is expanded rapidly and experiences a sudden and severe temperature reduction. The chilled, low-pressure air stream is then directed around the core which is cut by the coring tool; and the core is thereby chilled sufficiently to "freeze" the core and enable it to retain its true fluid content.

In the event that the power required by the coring tool is insufficient to reduce the temperature of the expanded air from the turbine to a level consistent with the desired degree of chilling, a suitable energy dissipation device may also be provided near the bottom of a bore hole to be actuated by the turbine. In this manner it is possible to thoroughly chill or freeze a core sample immediately as it is cut from a subterranean formation, independent of the amount of work which is actually required to do the cutting. The frozen core may be then lifted to the surface of the earth and further chilled and analyzed or studied as desired.

The nature and scope of the present invention may be better understood by reference to the attached drawing in which Figure 1 illustrates in vertical cross section an apparatus which is suitable for carrying out the purposes of the invention. The apparatus in this figure is particularly adapted for use in conjunction with a string of drill pipe.

2

Figure 2 illustrates schematically the apparatus of Figure 1 as it may be adapted for use in a wire line type of operation.

Figure 3 illustrates in greater detail a latching apparatus suitable for use in the apparatus of Figure 2.

Referring to Figure 1, there are illustrated therein a bore hole 10, drill pipe 11, housing 12, bypass conduit 13, air chamber 14, magnetic brake 15, brake shaft 16, turbine rotor 17, coring drive shaft 18, outer core barrel 19, inner core barrel 20 and bit 21.

Drill pipe 11 extends to the top of bore hole 10 and is secured rigidly torsionally to suitable torque resisting apparatus, not shown, such as a conventional rotary table. Also not illustrated in Figure 1 is surface apparatus for furnishing a supply of compressed and cooled air to the string of drill pipe. It will be recognized, however, that conventional air compressors may be employed to compress atmospheric air, and that conventional heat exchangers or other coolers may be used to cool the compressed air to a desired and suitable temperature for down hole use. For the purposes of the invention, it is generally desirable to employ air having a pressure of from about 600 to 900 p.s.i.a. and a temperature of about 50 to 100 degrees F. at the surface. Furthermore, with air of this pressure and temperature, it is contemplated air rates of about 600 to 1200 standard c.f.m. are sufficient to employ to provide the energy and chilling requirements of the invention in its application to substantially all coring operations.

Attached to the lower end of the string of drill pipe is elongated substantially cylindrical housing 12 which contains the energy dissipation device 15 and air chamber 14 as well as the turbine rotor 17. The portion of the housing enclosing the energy dissipation device 15—e.g. a magnetic brake—and air chamber 14 is separated from the portion of the housing enclosing the turbine rotor 17 by means of a suitable wall 26. It will be appreciated, of course, that housing 12 may be a single unitary structure; or, alternatively, it may include separate but interconnectable portions—each portion housing a separate operating component.

For the purpose of this description, it will be assumed that the energy-dissipation device 15 is a magnetic brake. As shown schematically in Figure 1, such a brake basically consists of a cylindrical iron fly wheel 6 and a plurality of electromagnets 5. Electrical power for the magnets may be supplied from the surface of the earth as by means of electrical leads 7. The magnets are electrically excited through these leads; and they create a magnetic flux which permeates the gap and the iron in the cylindrical fly wheel, causing eddy currents to be established. The fly wheel energy is converted into heat by means of these eddy currents, and the heat in turn is dissipated as described below. Pairs of brakes are preferably provided to avoid bending of the shaft 16.

Device 15 is preferably mounted above turbine rotor 17 and is driven from the motor by means of the drive shaft 16. Air chamber 14 is preferably positioned vertically intermediate the brake 15 and turbine rotor 17 and is connected directly to the interior of the drill pipe by means of bypass conduit 13. It will be apparent that the dissipation device 15 in the form of a magnetic brake or other suitable means will heat considerably in its operation, thereby making it desirable to bypass the down-flowing air stream around this portion of the overall apparatus. An insulation barrier 22 is therefore preferably provided between bypass conduit 13 and device 15 to minimize heating of down-flowing air prior to its introduction within the turbine rotor 17. Upper insulated wall 23 and lower insulated wall 24 are also preferably provided to further isolate the device 15 thermally from the down-flowing air. The housing 12 is perforated or pro-

vided with a suitable heat transfer surface 25 to enable heat generated by the action of device 15 to be dissipated into the up-flowing stream of air in the annular bore hole space surrounding the drill pipe and overall drill assembly.

Suitable ports 30 are provided in wall 26 to enable down-flowing air in air chamber 14 to flow to turbine rotor 17. These ports may be simple conduits, but they are preferably nozzles such as are employed in various types of turbines. Furthermore, turbine rotor 17 may be of a type which is employed in either impulse or reaction turbines, although it is preferred that a combined unit, consisting of a double-velocity impulse, or Curtis stage, followed by some reaction stages be used. It will be recognized that the interior surface of the housing 12 which surrounds turbine rotor 17 may be provided with conventional turbine blading or nozzles and thereby constitute a conventional turbine stator. As shown in Figure 1, a plurality of turbine blades 4 secured to the housing 12 define the turbine stator.

Immediately below the turbine section is a wall 31 which defines the lower portion of housing 12 and which separates the turbine section from the coring tool assembly—i.e., the core barrel proper. Suitable exhaust ports 32 are provided in wall 31 to enable exhaust air from the turbine section to flow to the annular space 33 between the inner and outer barrels of the core barrel.

The coring assembly or core barrel includes outer barrel 19, inner barrel 20 and coring bit 21. The bit in this instance is considered to be a multi-cutter bit, although other conventional bits such as diamond bits and the like are entirely suitable.

The interior wall surface of outer barrel 19 and the outer wall surface of the inner barrel 20 define in combination annular space 33 which provides a flow path for the air which enters the coring tool assembly through the passageways 32. The air exhausting from the lower portion of the coring tool in the vicinity of the cutter elements contacts the outer surface of the core 34, and thence flows around the cutter elements into the bore hole 10 whence it flows up to the surface of the earth.

Suitable bearings 40 are provided around the drive shaft 16 and the coring tool drive shaft 18 to enable these two shafts to turn freely within the housing 12. These bearings necessarily must be of a character to provide substantially fluid-tight relationship between these shafts and the surrounding housing. Swivel joint 41 is provided between outer barrel 19 and inner barrel 20 in order that the latter barrel may be free to rotate during the coring operation relative to the inner barrel. Rotary seals 42 are preferably provided between the outer barrel 19 and the housing 12 to properly direct the down-flowing air stream and to permit relative rotary motion between the outer barrel 19 and the housing 12.

Having briefly set forth the apparatus components of the assembly illustrated in Figure 1, attention is now directed toward a consideration of the manner in which this apparatus operates.

For the purpose of this part of the description of the invention, it will be assumed that the apparatus has previously been assembled and lowered to the bottom of a bore hole. With the cutting elements of the coring bit 21 resting on the hole bottom, high pressure air is transmitted from the earth's surface down through drill pipe 11 to the interior of the top portion of housing 12. The down-flowing air then passes through bypass conduit 13 into air chamber 14 and thence through passageways 30 to the turbine rotor 17. Flow of the air past the rotor blades and/or nozzles causes rotary movement of the turbine rotor and resulting expansion and temperature reduction of the air. It will be apparent, of course, that the upper end of the drill string is held stationary or rotated slowly to avoid sticking at the surface of the earth in order to enable the turbine rotor to rotate the coring bit.

Rotation of the turbine causes corresponding rotation

of the energy dissipation device (e.g. the rotor portion of magnetic brake 15) as well as the outer barrel 19 of the coring tool.

The exhaust air from the turbine rotor 17 travels through passageways 32 into the annular space between the inner barrel 20 and the outer barrel 19 of the coring tool. The air then flows down the annular space, contacts the core as it is cut by the cutting elements and then flows upwardly within the bore hole 10.

Since the exhaust air from the turbine blades has been expanded and therefore chilled by the work it performs on the turbine rotor, it is capable of chilling the core as it is cut to a very low temperature. The up-flowing air within the bore hole, being still relatively cool, provides a cooling effect for the energy dissipation device 15 via the perforations 25 or equivalent heat transfer means. It will be recalled at this point that device 15 is insulated by means of insulating members 23, 22 and 24 from the down-flowing air stream; and the cooling effect of the up-flowing air within the bore hole is therefore very desirable in keeping the device at a safe operating temperature.

When a sufficient amount of core has been cut and lodged within the inner core barrel 20, the operation of the turbine and the coring tool may be interrupted; the core broken and retained in the core barrel; and the entire assembly removed to the surface of the earth.

It will be recognized that the size or power rating of the turbine portion of the apparatus described above will be governed by the size of the coring tool among other factors. For presently conventional operations, it is contemplated that a turbine producing about 40 horsepower transmitting about 30 horsepower to the dissipation device and some 10 horsepower to the coring tool will be amply suitable.

It will be recognized at this point that numerous modifications of the apparatus in Figure 1 may be employed without departing from the spirit or scope of the invention. For example, energy dissipation devices other than a magnetic brake—e.g. a Prony brake—may be used. Similarly, the entire assembly may be constructed to be lowered inside drill pipe or casing by means of a wire line in much the same manner as presently conventional electric drills. Furthermore, the apparatus may be wire-line operated or employed in a drilling-with-casing technique. This system, which has attractive possibilities, is schematically illustrated in Figure 2 and Figure 3.

Referring to Figure 2 and Figure 3, it will be seen that the apparatus in these figures comprises an air compressor 60, heat exchanger 61, auxiliary refrigeration unit 62, wire line 50, well pipe or casing 11, retractable gas turbine and coring means 9 and rotary table 63. It will further be seen that the turbine and coring assembly 9 with its attached coring bit 21 is equivalent to the apparatus which is illustrated in detail in Figure 1. In other words, the assembly 9 may be considered to be a structure like that in Figure 1—including a housing which embraces an energy dissipation device, an air chamber and a gas turbine—and a core barrel which is supported from the housing.

As indicated above, the turbine and coring assembly 9 in Figures 2 and 3 differs from the apparatus illustrated in Figure 1 primarily in that the former apparatus is of a character to be wire line operated. Thus, referring to Figure 2, it will be seen that the assembly 9 is secured at its upper end to a latching assembly 53 which is adapted to engage the inner surface of the well pipe 11 when the assembly 9 is lowered to a drilling position within the pipe. The use of a latching assembly for lowering drilling equipment within a string of well pipe and for thereafter retracting the equipment from the pipe has been previously described at length in the art—e.g., in U.S. Patents No. 2,330,083 and 2,338,670 and in pending U.S. patent applications Serial No. 268,891 (filed January 29, 1952) now Patent No. 2,764,388, and Serial No. 268,894 (also

filed January 29, 1952) now Patent No. 2,771,275. All of these patents and patent applications generally relate to drilling procedures and apparatus that utilize retractable bits. In view of the very complete description of suitable latching assemblies in these U.S. patents and patent applications, it is considered that a lengthy discussion of such items would be superfluous in the present description. It will be noted, however, that any latching assembly 53 will generally include one or more latching dogs 54 which are adapted to engage recesses disposed within the inner surface of the well pipe 11. Furthermore, these recesses are spaced from the lower end of the well pipe a distance such that the drill bit 21 extends beyond the well pipe and engages the bottom of the bore hole 10 when the latching dogs are engaged within the recesses. Conveniently, a shoulder 55 is provided along the inner periphery of the well pipe 11 to support and stabilize the turbine and drill assembly 9 in its drilling position. Furthermore, an annular seal 56 is preferably provided as indicated to cause down-flowing gas within drill pipe 11 to flow down through the turbine and drill assembly 9 and thereby not bypass the assembly. One or more conduits 57 are provided within assembly 53 to transmit air or other gas from the drill pipe to the assembly 9. The necessity and nature of such provisions will be readily apparent to persons skilled in the art.

A conventional rotary table 63 or other suitable means is provided at the surface of the earth for maintaining the drill pipe in a stationary position and thereby enabling it to resist torsional forces that are developed by operation of the assembly 9. Suitable hoisting and lowering equipment, not shown, is also provided for operating the wire line 50. A packing gland or other suitable blowout prevention means is preferably provided where wire line 50 passes through the upper termination of the well pipe 11. A latching overshot 51 is provided at the lower end of the wire line 50 for engaging the latch or spearhead 52 which is provided at the upper end of the latching assembly 53.

To aid in understanding the nature of a latching assembly suitable for the practice of the present invention, attention is next directed to Figure 3. This figure shows a latching structure in greater detail than is done in Figure 2. As in Figure 2, the structure in Figure 3 includes wire line 50, turbine and coring means 9, overshot 51, spearhead 52, latching assembly 53, seal 56, latches 54, flange 55 and coring bit 21. All of these components are disposed within a borehole 10 and within the well pipe 11.

Latching assembly 53 comprises an upper body member 80 and a lower body member 83. Upper member 80 has a spearhead 52 at its upper end and a passageway 57 which extends throughout its length. The middle portion of the upper member is reduced in diameter and contains a plurality of circumferentially spaced ports or slots 82. The lower end of the upper member terminates in a flange 81 which is up-turned at its outer periphery to define a cup-like structure.

Lower member 83 fits and slides within the passageway 57 of upper member 80 and has at its upper end a plurality of latch pivot supports 84 which extend radially outward through the ports 82. A separate latch 54 is secured to each pivot support and is adapted to engage with the recess in the well pipe. A central passageway 85 extends the length of the lower member 83 and provides fluid communication between passageway 57 and the upper end of the turbine and core barrel assembly. A suitable packer—e.g., a cup-type packer—is provided on lower member 83 and cooperates with the flange 81 of the upper member to effect a fluid-tight seal around the inner surface of the well pipe 11.

The apparatus of Figure 3, it will be noted, is shown in its drilling position with overshot 51 detached from the spearhead 52. It will also be noted that the individual components of the apparatus in Figure 3 may be threaded or otherwise joined together as may be necessary to effect easy assembly and disassembly of the apparatus.

To retract the apparatus of Figure 3, the overshot 51 is lowered into position over the spearhead 52, whereupon the dogs 88 engage the spearhead. An upward thrust on the wire line then causes upper member 80 to move upward relative to the lower member 83. The up-turned portion of the flange 81 causes dogs 54 to be retracted from the recess in pipe 11, and it also releases the load on the packer 90. The apparatus is then free to be lifted and removed from the borehole.

Having briefly described the apparatus components that are present in Figure 2, attention is now directed toward a consideration of the manner in which the apparatus of this figure may be operated. It will be assumed, for the sake of convenience, that the hole 10 has been drilled into the earth using a drilling-with-casing technique such as is set forth in the patents and patent applications mentioned earlier in this description. It will further be assumed that the retractable bit used for drilling the bore hole itself has been removed from the hole and that it is now desired to take a core sample of the formation underlying the hole.

With these assumptions in mind, the turbine and drill assembly 9 is latched to the latching overshot 51 at the surface of the earth; and the assembly is lowered within the well pipe 11 until the latching dogs 54 engage recesses disposed within the inner wall surface of the well pipe near the bottom of the hole. The latching overshot 51 is then detached from the latch 52, raised at least some distance from the latch and preferably removed entirely from the borehole. At this point, it will be noted that the overshot 51 shown in Figure 3 is more suited for raising equipment than for lowering it into drilling position. There are numerous overshots, however, available for either or both types of operation; and a detailed description of additional overshots is therefore not considered to be vital for clear understanding of this invention.

Air or other gas is then supplied to conduit 70 which in turn conveys the air to the interior of the well pipe. The air is conveniently withdrawn from the atmosphere by means of air compressor 60 and pumped via line 64 to heat exchanger 61 where it is cooled to a predetermined desired temperature. From this point, the cooled compressed air or other gas is then conveyed by means of line 65 to conduit 70 and thence to well pipe 11.

If the compressed air in line 65 is not at a low enough temperature for desirable operation, at least a part of the compressed air from heat exchanger 61 may be further cooled by passing it through an auxiliary surface refrigeration unit 62. The air issuing from the latter unit is combined with the air in line 65 as desired and thereafter supplied to the drill pipe as by means of conduit 70.

Once within the well pipe 11, the compressed cooled air flows down the pipe and thence through conduit 57 into the turbine and drill assembly 9. Bypassing of the turbine and drill assembly is conveniently prevented as by means of an annular seal ring 56 as mentioned previously. Packer 90 is also effective for preventing by-passing.

The compressed air upon entering the assembly 9 serves the same function or functions as were enumerated and described in connection with the apparatus in Figure 1. Thus, the air drives a turbine which in turn simultaneously drives the coring bit 21 and an energy dissipation device. The latter device, as in the apparatus of Figure 1, operates to lower the temperature of the air exhausting from the turbine of assembly 9 to a temperature low enough to chill or "freeze" the core which is cut by the coring bit 21. Exhaust air flowing past the bit escapes from the well by flowing in an upward direction within the annular space between the wall of the bore hole and the outer wall surface of the well pipe 11. Suitable passageways of a convenient type are provided at the top of the well pipe to enable the uprising gas to escape from the hole.

As in conventional drilling, the well pipe and the attached drilling assembly are advanced as a core is cut;

and suitable surface equipment may be used to apply the desired portion of the drill string weight to the hole bottom.

When a sufficient core has been cut by the coring bit, the core may be parted and retained within the core barrel in any conventional manner. For example, suitable core catchers, with or without pressure core barrel facilities may be employed as desired.

Following this, the wire line 50 is lowered until the latching overshot 51 engages the latch 52; and the assembly 9 may then be withdrawn from the well by pulling upwardly on the wire line. The latching dogs 54 are retracted by an upward thrust on the wire line, enabling the latching assembly and the attached turbine and drill assembly to be raised and removed from the bore hole.

It is apparent from the foregoing description that numerous modifications of the apparatus may be employed without departing from the spirit or scope of the invention. For example it will be recognized that other suitable means for latching or securing the turbine and core barrel assembly to the inside surface of a well pipe may be used. Furthermore, the latching means may be supported from the turbine or other portion of the assembly rather than constituting a single added feature of the overall structure such as is illustrated in the drawing.

As pointed out earlier in this description, energy dissipation devices of various types may be employed. Where a particular type requires the use of electrical energy, such energy may be transmitted to or from the device by means of electrical cables and the like which are run down the bore hole. Hydraulic lines or other conduits for transferring fluids may also be used as desired. Indeed, it is contemplated—although not preferred—that the present apparatus may be used in the presence of or in conjunction with a reduced level of drilling liquid within a bore hole. In this instance, flexible tubing or other type conduits may be employed as necessary.

It is further contemplated that the apparatus of the invention—while preferably employed in combination with a string of well pipe—may also be employed in a bore hole which is devoid of rigid piping. In this case, the retractable latching means may be adapted to engage or clamp against the wall of the bore hole itself; and a conduit, preferably in the form of a reelable flexible hose, may be used to transmit gas down the bore hole to drive the turbine.

I claim:

1. A drilling apparatus adapted to be used within the lower end of a string of well pipe which comprises a housing adapted to be supported from the well pipe, a turbine mounted within said housing, an energy dissipation device mounted above said turbine within said housing and adapted to be driven by said turbine, a core barrel positioned below said housing and supported from the shaft of said turbine, said core barrel including an inner stationary barrel and an outer rotating barrel, a coring bit supported at the bottom of said outer barrel, means for turning said outer barrel responsive to movement of said turbine shaft, conduit means adapted to convey fluid from within said well pipe to said turbine, and means for maintaining said housing in a stationary rotational position.

2. An apparatus as defined in claim 1 in which the housing and core barrel are adapted to pass vertically within the well pipe, and the means for maintaining the housing in a stationary rotational position is a retractable latching means adapted to engage and lock with recesses disposed within the well pipe.

3. A coring apparatus adapted to be lowered within a string of well pipe and to be supported therefrom which comprises a gas-powered turbine and core barrel assembly, said assembly including said turbine and an energy dissipation device connected to and driven by said turbine, said energy dissipation device being disposed above said turbine, and said core barrel being disposed below said turbine, latching means connected to said assembly and adapted to engage latching recesses disposed within said well pipe, means to supply a stream of compressed gas to said turbine, a coring bit supported by said core barrel and adapted to be driven by said turbine, and conduit means adapted to transmit expanded exhaust gas from said turbine to said coring bit.

4. An apparatus as defined in claim 2 in which the energy dissipation device is a magnetic brake.

5. A coring apparatus adapted to obtain a core sample from the bottom of a bore hole which comprises in combination a gas-powered type turbine adapted to be lowered within the bore hole, means to transmit a compressed gas down the bore hole to the turbine and to drive the turbine, an energy dissipation device disposed above and connected to said turbine, a core barrel including an outer rotatable barrel and a stationary inner core receiving barrel disposed below said turbine, said outer rotatable barrel adapted to be driven by said turbine, means to maintain the housing of said turbine in a stationary position rotationally, a coring bit secured to the lower end of said outer barrel and adapted to be rotated with said outer barrel by said turbine, and conduit means adapted to direct the gas exhaust from the turbine to the surface of a core which is cut by said bit.

6. An apparatus as defined in claim 5 in which the means to maintain the housing of said turbine in a stationary position rotationally is retractable.

7. In a coring operation wherein a bit is driven into a formation underlying a bore hole, the method of preserving the core which comprises maintaining a gas-driven motor within the bore hole, supplying cool compressed air to the motor and thereby driving the motor, transmitting at least a portion of the energy from the motor to the bit and thereby driving the bit into the formation, dissipating at least a portion of the energy available from the motor, directing the expanded exhaust gas from the motor against the surface of the core as it is cut by the bit, controlling the total amount of energy withdrawn from the motor so as to cool the exhaust gas and chill the core, exhausting the gas from the bore hole after it has been directed against the core, parting the chilled core from the formation, and withdrawing the core from the bore hole.

8. A process as defined in claim 7 in which the energy which is dissipated from the motor is dissipated at a point above the motor.

References Cited in the file of this patent

UNITED STATES PATENTS

1,864,113	Anderson	June 12, 1932
2,034,257	Hampton	Mar. 17, 1936
2,338,670	Sewell	Jan. 4, 1944
2,717,762	McGregor	Sept. 13, 1955
2,779,195	Simon	Jan. 29, 1957
2,783,971	Carle et al.	Mar. 5, 1957
2,812,160	West et al.	Nov. 5, 1957
2,819,038	Eckel	Jan. 7, 1958

FOREIGN PATENTS

329,896	Germany	Dec. 1, 1920
---------	---------	--------------