Jan. 7, 1958 J. E. ECKEL 2,819,038

RESERVOIR SAMPLING

Filed Jan. 14, 1955 2 Sheets-Sheet 1

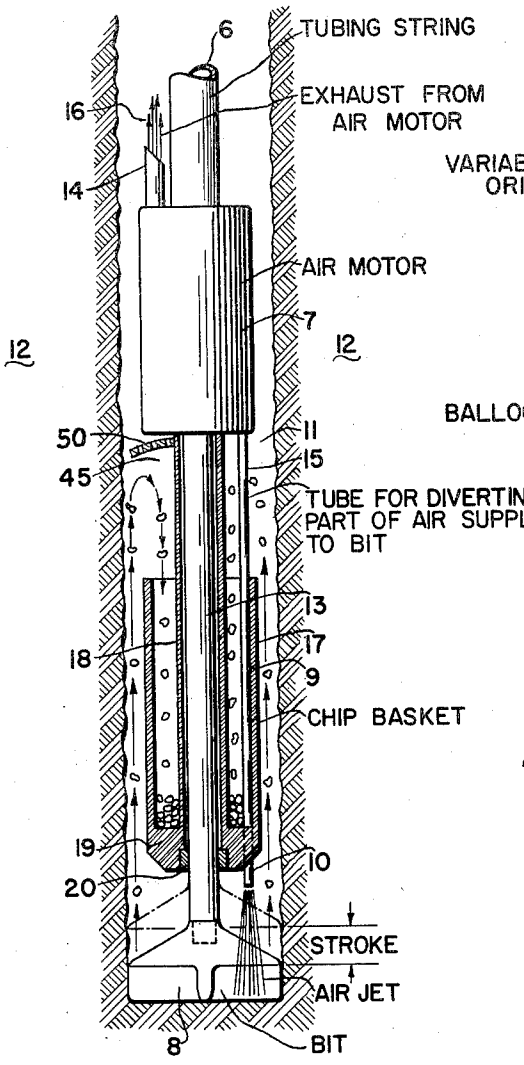


FIG. 1

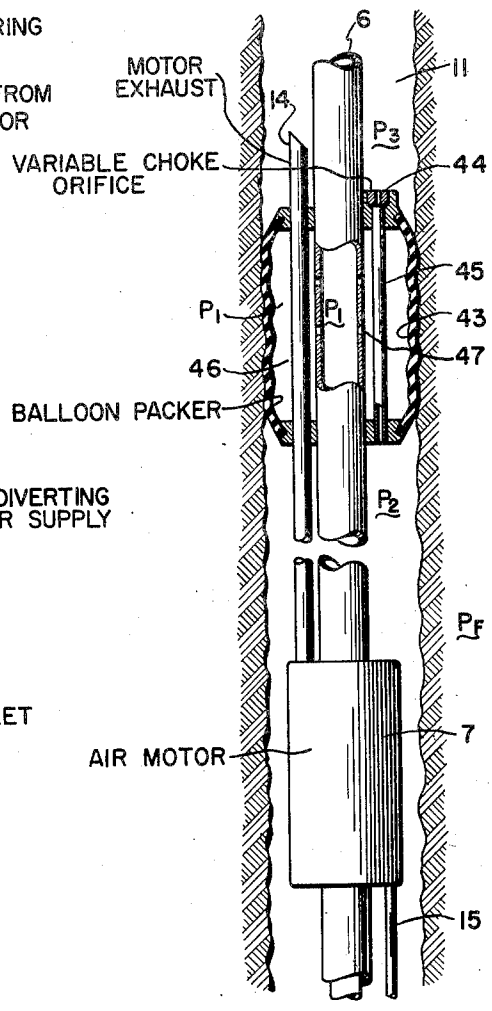


FIG. 4

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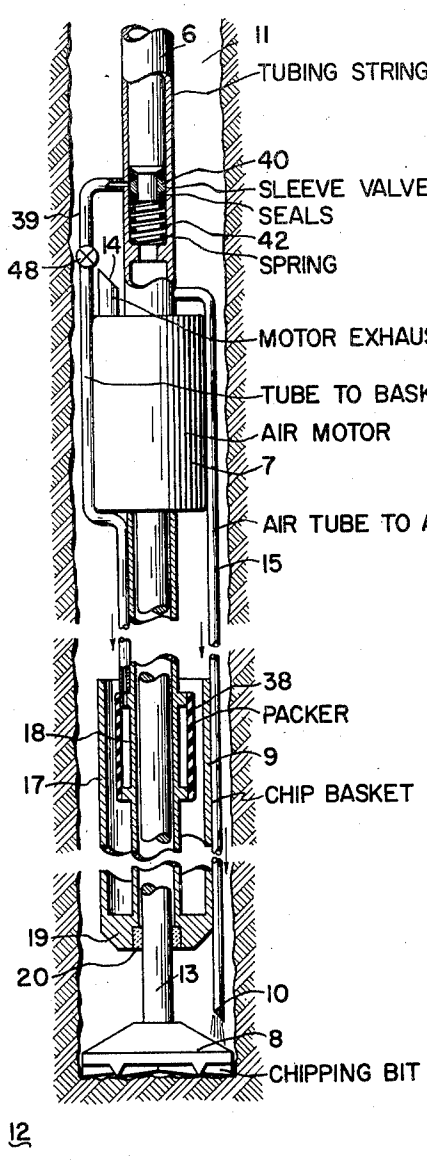


FIG. 2

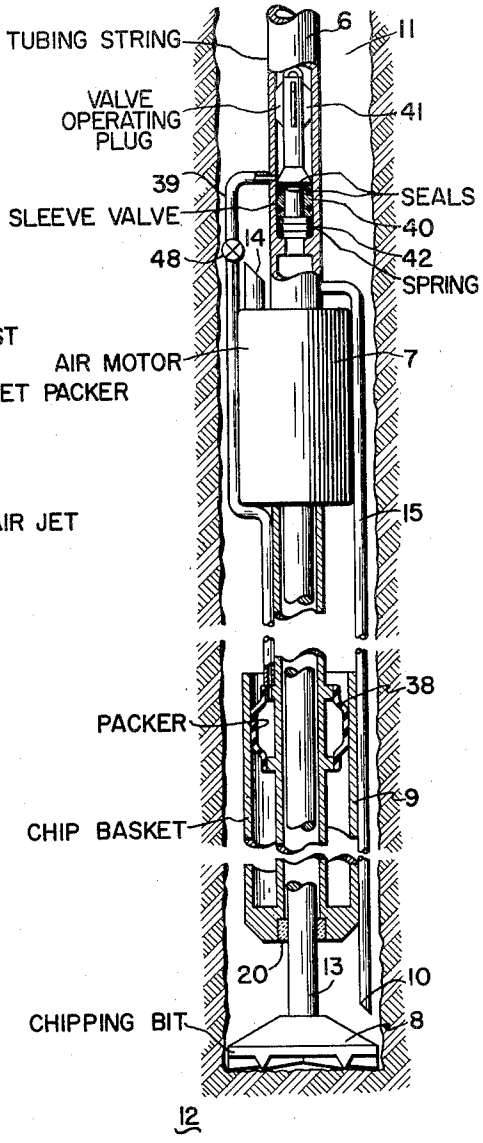


FIG. 3

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RESERVOIR SAMPLING

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4 Claims. (Cl. 255—1.4)

The present invention concerns means for obtaining an uncontaminated sample from a subterranean formation. t particularly relates to a method and apparatus for obaining an uncontaminated sample of a petroliferous formation at the bottom of a bore hole or well which penerates the formation. The method and apparatus are particularly characterized by the fact that the formation ample is obtained without employing drilling mud, the presence of which has been found to seriously contamnate such samples. The method and apparatus are urther particularly characterized by the fact that the formation sample is continuously maintained under substantially ambient formation pressure.

A serious and important problem that confronts the petroleum producing industry at the present time is one of obtaining reliable samples of petroliferous formations that lie beneath the surface of the earth. The problem has become one of particular importance in view of the ever increasing use of secondary recovery methods for obtaining additional oil from subterranean oil reservoirs that have ceased primary production. It is essential, before initiating a secondary recovery procedure in any such reservoir, to have as much information as possible about the structure, the fluid content, the pore volume, the permeability, etc. of the formation. Such information is extremely valuable in determining whether the formation is susceptible to successful exploitation using secondary recovery techniques and which techniques should preferentially be utilized.

In line with the growing emphasis on secondary recovery programs, many petroleum producers are conducting extensive analyses of old reservoirs and fields that have in years past lost their reservoir pressure and been abandoned. In an effort to evaluate these old reservoirs and fields and in order to determine whether a secondary recovery procedure can be successfully applied to them, the producers are conducting extensive sampling programs. One sampling technique has been to drill and sample the bottoms or side walls of old wells that were originally producing wells associated with the reservoirs or fields. It has been determined, however, that the samples derived by this technique are quite inaccurate and not representative of the field or reservoir as a whole. Accordingly, it has become more and more the established practice to drill entirely new holes from the earth's surface down to any given petroliferous formation and to obtain samples of the formation directly from these new holes. Conventional drilling and coring methods such as rotary and cable tool have been employed for this purpose. Another frequently used method employs an electric motor suspended in the well by an electrical conductor cable which in turn operates a circulating pump and conventional rotary core barrel. This requires only enough liquid in the hole bottom to permit circulation by the pump. In all of these types of drilling, however, it is necessary to use at least a small amount of drilling mud, water or other drilling fluid in the bottom of the hole in order to properly lubricate the bit

and to dispose of the cuttings; and it is therefore conventional to have at least about 25 to 50 feet of water or other drilling fluid within a hole.

The presence of the drilling mud, water or other drilling liquid in a hole still constitutes an undesirable feature when sampling a reservoir of the type described above for the reason that the hydrostatic pressure and wetting effects of even this small amount of liquid are considered to seriously interfere with the reliability of the samples that are obtained. It is accordingly an objective of the present invention to provide an apparatus and method for obtaining reservoir samples wherein the samples are not subjected to a drilling liquid of any kind. It is a further object of the invention to provide means for sampling a formation in such a manner that the sample suffers a very limited exposure to any material that could conceivably be a source of contamination. It is a further objective of the invention to provide means for obtaining and retaining the sample under substantially ambient formation conditions.

These objectives are realized in accordance with the invention by utilizing a pneumatically powered percussion-type of bit to cut into the formation at the bottom of a bore hole. The pneumatic power unit and the associated bit may be suspended within the bore hole at the bottom of a conventional string of drill pipe which in turn may serve as a conduit for the passage of compressed air from the earth's surface to the power unit. The exhaust air from the unit is vented directly up the annular space between the drill string and the wall of the bore hole.

An additional amount of air is directed vertically downward and in proximity to the drill bit in order to cool the bit as well as the sample that is cut by the bit. The air that is directed downward in this manner also serves to blow the drill cuttings from the bottom of the bore hole upward within the annular space between the overall apparatus and the wall of the bore hole. In this way the air serves as a drilling fluid and keeps the bottom of the bore hole clear of cuttings.

At least a portion of the rock chips that are cut from the bottom of a bore hole by the present apparatus is removed from all contact with the air substantially as soon as it is cut. This precaution prevents the sample from losing any of its fluid content due to prolonged contact with the air. Once the sample has been separated from the air stream, it is then retained under substantially the same conditions of pressure that prevail within the formation. Thus, the invention provides samples of subterranean formations that are substantially uncontaminated and that are truly representative of the formations.

The above described features of the invention may be better understood by reference to the attached figures which illustrate different embodiments of the invention.

Figure 1 is a vertical, partially sectioned view of a particular embodiment of the invention wherein the sample is collected in a container located in the annular space between the drilling apparatus and the wall of the bore hole.

Figure 2 is a modified form of Figure 1 in which a packer to seal samples in the chamber is illustrated in the deflated form.

Figure 3 is identical to Figure 2 but with the inflated packer sealing the sample in the chamber.

Figure 4 is a modified form of the upper portion of the devices shown in Figures 1–3 with a pressure inflated packer and suitable orifices added to maintain controlled pressures in the vicinity of the bit during the drilling and sample collecting process.

Turning first to Figure 1, there is illustrated in this figure an apparatus that includes a tubing string 6, and air motor 7, a percussion-type bit 8, a chip basket 9 and an air jet 10. The apparatus is depicted as drilling a hole

11 within a formation 12. The bit 8 is driven in a reciprocating up and down action by the motor 7 through the reciprocating shaft 13.

The air motor 7 may be any conventional type of reciprocating pneumatic motor—e. g. an air hammer—which is adapted to provide a vertical reciprocating action to the shaft 13. The motor or hammer is actuated by compressed air which reaches it from the earth's surface by means of tubing string 6. The air exhausted from the motor is directed through the exhaust pipe 14 and is then vented directly to the earth's surface through the annular space 16 between the tubing string 6 and the wall of the bore hole 11.

An additional amount of air is conducted to the bottom of the bore hole and is directed toward and in the vicinity of the bit 8. It will be noted that tube 15 in extending to the bottom of the bore hole passes through the chip basket 9. Where the tube pierces this basket, a tight seal is maintained by welding or otherwise securing the tube to that portion of the basket. It will further be noted that the air in tube 15 may be part of the exhaust air from the motor 7, but it is preferably derived from tubing string 6 or from a separate conduit leading to the main air supply at the earth's surface.

As in the case of the jet tubing 15, shaft 13 also must pass through the chip basket 9. In this instance, however, the shaft is preferably capable of moving vertically with respect to the basket. This feature is readily attained by constructing the basket to have an annular conformation around the outer periphery of the shaft. In other words, the basket is built with an outer cylindrical wall 17 and an inner cylindrical wall 18, both of which are sealed around their bottom peripheries to a lower end member 19. The inner wall 18 extends vertically upward to and is sealed to the air motor 7; and a bearing 20 in the end member 19 is provided to permit movement of the shaft 13 relative to the basket 9. The bearing 20 may further be provided with a suitable O-ring, stuffing box or other packing means for preventing air and/or solid particles from entering the annular space between the shaft 13 and the inner wall 18.

Drill bit 8 may be of any conventional hardened steel type that is used in cutting through rock formations and the like. A bit that is contemplated to be particularly effective in the apparatus of the figure is a star-type drill bit. As illustrated, the drill bit is flush against the bottom of the bore hole at the end of the stroke imposed upon it by the pneumatic motor 7. Dotted lines are also shown in the figure to indicate where the bit is positioned at the other end of the motor stroke. The overall stroke may conveniently be from ¼ inch to 6 inches, and it is contemplated that a stroke of about 2 inches is preferred in the greatest number of instances.

The preceding paragraphs have been devoted largely to a discussion of the structural details of the apparatus in Figure 1. These and other details are better understood by briefly considering what is contemplated to be the best manner of operating the apparatus in the figure. In presenting such a discussion, it is first assumed that bore hole 11 has been drilled in a conventional manner and that any drilling mud or other drilling fluid has been removed from the hole. It may also be assumed that the hole, if it is an old one, is substantially dry and free of any liquid. It is further assumed that the drill has been lowered within the hole for operation and that the bit is positioned roughly as shown so that it strikes the bottom of the hole on the down stroke of the motor 7.

With these conditions in mind the apparatus is started by passing compressed air from a compressor or other source of high pressure air located on the earth's surface down through the tubing string 6 to the air motor 7 and the conduit 15. The amount of air sent to the motor must be sufficient to drive the bit 8 against the bore hole bottom and to fracture the underlying formation into small chips. The amount of air that is sent through the conduit 15 in turn is governed by (1) the amount of cooling that must be realized in the vicinity of the drill bit and (2) the amount of air required to blow cuttings from the bottom of the bore hole up and above the chip basket 9. In this connection it is contemplated that the chips may range in particle size from about ¼ inch to 1½ inches and that air velocities within the range of about 40 to 100 ft. per second are required to suspend and pass these chips upward within the bore hole. Once the chips pass the annular space between the chip basket 9 and the wall of the bore hole, the velocity of the chips and air is greatly reduced due to the increased volume afforded by the annular settling chamber 45 between the inner wall 18 of the chip basket 9 and the wall of the bore hole. This reduction in velocity causes the chips to be disengaged from the air stream and to drop within the chip basket. It will be noted that it may be desirable in some instances to provide settling chamber 45 with porous screens or deflectors 50 above the chip basket in order to more positively direct the chips from the air stream into the basket. These screens, deflectors or the like may be supported in any convenient manner as by connecting them to the inner wall 18 of the basket. Furthermore, the distance between the top of the basket and the bottom of the air motor may be varied to control the volume of the settling chamber.

The chip basket 9 should be of a length and volume sufficient to contain the amount of sample desired. For the purposes of the present invention, it is particularly contemplated that samples of about 300 lbs. be provided for. When the desired amount of sample has been taken, the flow of compressed air may be stopped and the entire apparatus withdrawn from the hole.

At this point it is well to note that a number of modifications may be made to the apparatus of Figure 1 without departing from the spirit or scope of the invention. Thus, it may be desirable on occasions to case and cement the bore hole 16 in order to obtain more satisfactory operation and results. Furthermore, the size of the chip basket, the size of the chips, the velocity of the air, etc. may be modified as desired to suit the particular type of formation being drilled.

Attention is now directed toward Figures 2 and 3 which illustrate a preferred embodiment of the invention. The apparatus in these figures includes all of the critical features illustrated in the apparatus of Figure 1 and in addition provides means for sealing the chip collecting basket 9. Thus, the apparatus in Figure 2 includes a percussion bit 8, a chip basket 9, an air motor 7, a tubing or drill string 6 and furthermore includes a packer 38, a sleeve valve 40 and a packer conduit 39. The packer 38 may be mounted on the inner wall portion 18 of the chip basket 9 and upon inflation extends outwardly to and engages the outer wall 17 of the basket. The packer itself may be constructed of the usual elastic and deformable materials that are employed in inflatable packers.

As illustrated in Figure 2, packer 38 is connected to drill string 6 and air is supplied therein by means of an interconnecting packer conduit 39. At the upper end of conduit 39 (where this conduit enters the drill string 6) there is provided sleeve valve 40 which normally is positioned laterally opposite the conduit 39 thereby sealing the same from air in the drill string. The sleeve valve is maintained in this normal position throughout a drilling and sampling operation. When these operations have been completed, however, air is admitted to the packer 38 whereby the packer is inflated as in Figure 3 and the basket 9 thereby completely sealed. The admission of the air to the packer is realized by merely dropping a go-devil operating plug, or other suitable weight down the drill string 6 and against the top of the valve 40. The go-devil forces the sleeve valve 40 to move in a downward direction against spring 42 thereby uncovering the

entrance conduit **39** and directing air through that conduit into the packer **38**. This action is particularly well illustrated in Figure 3 where a valve operating plug **41** is depicted as having forced valve **40** down against spring **42** thereby opening conduit **39** to a flow of air from drill string **6**.

Once packer **38** has been expanded and basket **9** thereby sealed, the supply of air to the drill pipe may be cut off and the pressure in the drill pipe lowered essentially to atmospheric pressure without breaking the seal on the basket **9**. The maintenance of the basket seal may be achieved by selection of a spring **42** which is adapted to close the sleeve valve **40** when the pressure in the drill string has been lowered but before the packer **38** has become deflated. Alternatively and preferably, the seal may be maintained by providing a small check valve **48** within conduit **39** which is adapted to permit the flow of air into the packer but to prevent any back flow of air from the packer. In either case, once the packer has been expanded and sealed against the outer wall of the chip basket, the basket may be safely raised to the earth's surface without contamination of the sample in the basket.

In those instances where it is desirable to make sure that the sample which is collected in the chip basket of the apparatus hereinbefore described is under at least the same pressure as the surrounding formation, additional apparatus features of a type shown in Figure 4 may be utilized. Turning to Figure 4, there is illustrated a packer assembly **46** which is located above the air motor **7**—corresponding to the air motors in Figures 1 to 3—and which surrounds and is supported by the drill string **6**. Packer assembly **46** includes a balloon-type packer **43**, a conduit member **45** and a variable choke orifice **44**. The conduit **45** extends vertically from one end of the packer assembly **46** to the opposite end and is essentially a vent connection providing for the flow of air from a point beneath the packer to a point above the packer. The interior of the packer itself is connected directly to the interior of the drill string **6** by one or more passageways **47**. Conduit **14** carrying the exhaust air from air motor **7** passes directly through packer assembly **46** and is adapted to vent exhausted air from the air motor to a point above the packer assembly.

The packer assembly **46** in Figure 4 insures that the chip samples formed and collected by the apparatus of Figures 1 to 3 are maintained under at least formation pressure in the following manner. Air passing down through drill string **6** flows through passageways **47** into the interior of balloon packer **43** thereby inflating this packer and creating a seal against the inner surface of the bore hole. This seal thus separates the portion of the bore hole beneath the packer from the portion above the packer.

Air to the motor **7** flows as before through drill string **6** directly to the motor and is then exhausted to the atmosphere through vent conduit **14**. The air that is jetted through conduit **15** to the bottom of the bore hole, however, upon cooling the drill bit and upon lifting the drill cuttings into the sample basket, now must flow through conduit **45** and orifice **44** before it vents to the atmosphere. Thus, by selecting or adjusting the size of the orifice **44**, it is possible to maintain a pressure below the packer assembly **46** which is at least equal to the pressure in the surrounding formation. The control of the pressure below the packer assembly may be further aided by the use of an additional orifice not illustrated which is provided in the air jet at the bottom of the bore hole.

It will be noted in Figure 4 that the pressure within the drill string **6** and the balloon packer **43** has been designated as P_1, while the pressures below and above the packer assembly are designated as P_2 and P_3 respectively. The pressure of the formation has also been identified by a character P_F. With these legends in mind, it is particularly contemplated that the apparatus in Figure 4 be operated such that P_1 is greater than P_2 and P_2 is greater than both P_F and P_3. By employing these pressure differentials, the sample obtained by the apparatus is protected against the loss of any fluids.

In operating the apparatus in Figures 1–4, it is contemplated that percussions of about 50 to 300 per second should be imparted to the core bit. The precise number may vary somewhat within that range depending upon the type of formation encountered in any given case. It is further contemplated that the bore hole may be of any desired size, as for example, from about 5 to 10 inches in diameter. In most instances it is preferred that the bore hole diameter be about 8 inches in size. During the drilling operation tubing **6** may be rotated slowly from the surface to index the star bit **8** in a slightly different poistion after each stroke, enhancing the cutting of chips.

As mentioned earlier, the apparatus in the figures may be modified in many respects without varying from the spirit or scope of the invention. It is possible to use various metals and alloys in the construction of the equipment illustrated, and it is possible to use the apparatus in combination with many conventional forms of drilling equipment such as rotary drill pipe, flow tubing, surface rotary drive equipment, etc.

What is claimed is:

1. An apparatus for obtaining an uncontaminated sample from a subterranean formation immediately below a borehole which comprises a percussion-type bit, a reciprocating-type pneumatic motor adapted to drive said bit against the formation and to break the formation into small particles, first conduit means adapted to supply compressed air to said motor and to operate said motor, said first conduit means also being adapted to supply a separate stream of air to the bottom of the borehole in the vicinity of the bit to lift said particles above the bit, a basket attached to said apparatus above said bit and adapted to collect the particles lifted above the bit, means to vent the exhaust air from the motor and from the bottom of the borehole to the surface of the earth, and means for sealing the collected particles within the basket.

2. An apparatus as defined in claim 1 including means for maintaining the pressure at the bottom of the borehole at a value at least equal to the formation pressure.

3. An apparatus as defined in claim 1 in which the sealing means is an inflatable packer disposed within the entrance to the basket.

4. An apparatus as defined in claim 2 in which the pressure-maintaining means is an inflatable packer supported by the apparatus above the pneumatic motor and in the annular space between the apparatus and the wall of the borehole.

References Cited in the file of this patent

UNITED STATES PATENTS

1,250,103	Gilman	Dec. 11, 1917
1,753,339	Hencken	Apr. 8, 1930
1,870,696	Taylor	Aug. 9, 1932
1,881,258	Bayles	Oct. 4, 1932

FOREIGN PATENTS

2,576	Australia	Nov. 10, 1900