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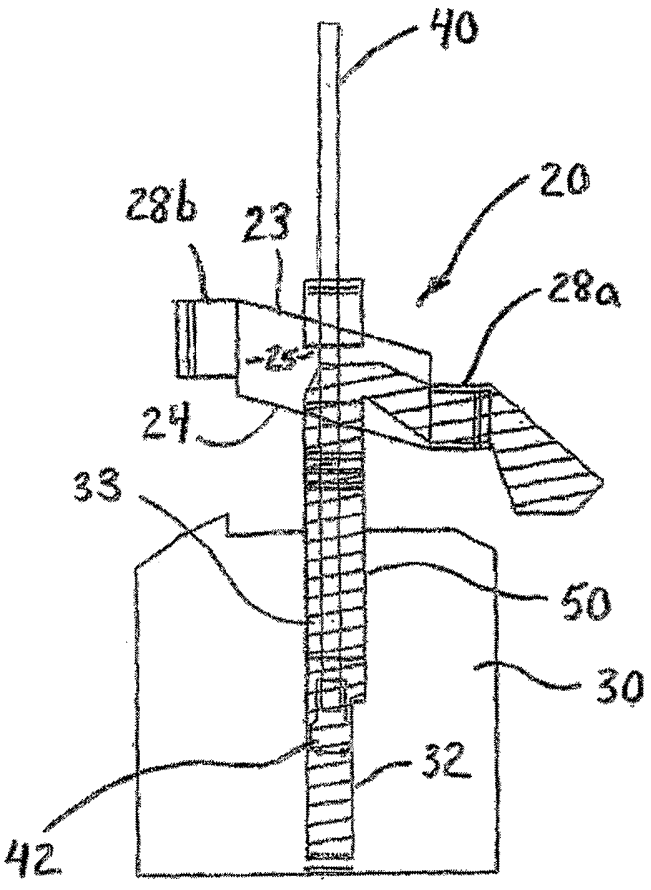
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(54) Title: DEVICE AND METHOD FOR COLLECTING BOREHOLE SAMPLES



(57) Abstract: A device and method for collecting borehole samples includes a receptacle (25) having an inlet (26b) adapted to engage with a casing (50) positioned in a drill hole (32), and at least one outlet (28a) through which a borehole sample exits from the receptacle (25). The receptacle is adapted to fit around a drill rod (40) used in drilling the drill hole (32) with the inlet (26b) providing clearance for the drill rod (40) and the receptacle (25) adapted to capture cuttings and cutting fluid entering the receptacle through the inlet (26b) during a drilling operation.

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DEVICE AND METHOD FOR COLLECTING BOREHOLE SAMPLES

[0001] This application claims the benefit under 35 U.S.C. §120 of prior U.S. Patent Application No. 10/903,184, filed July 30, 2004, which is incorporated in its entirety by reference herein.

FIELD

[0002] The present teachings relate generally to the field of mining and measurements made during the drilling of boreholes in a mining operation.

BACKGROUND

[0003] Drilling boreholes used in mining operations is generally performed using rotary drilling techniques. A rotary drill bit is coupled to one end of a drilling tool assembly, and the assembly is rotated while applying axial force to the bit. A drilling fluid is pumped through the interior of the drilling tool assembly and outward through orifices, called nozzles or jets, disposed in the body of the drill bit. The drilling fluid that is discharged through the jets performs a number of functions, including cooling and lubricating the drill bit, applying hydrostatic pressure to the earth formations that have been drilled in order to control pressure of fluids in the pore spaces of the formations, and lifting drill cuttings generated by the drill bit to the earth's surface through an annular space between the drilled borehole and the exterior of the drilling tool assembly.

[0004] Before extensive drilling, or blasting, or both, is performed in an area for mining of various minerals or other substances, it would be desirable to have an accurate idea of the composition of materials in the area that is to be mined, the size and direction of a strata or vein of a mineral that is desired to be mined, and characteristics of materials surrounding the area that is to be mined. During drilling operations using conventional longhole drilling equipment, additional drill steel or drill rods can be added as the drill percussion bit and drill rod penetrate into the earth to a depth greater than the length of the first drill rod. During the longhole drilling operation the drilling fluid continues to be pumped down through the one or more drill rods and out through the drill bit so that it can cool the drill bit during the drilling operation and then flush the cuttings back up along the borehole between the drill rod and the

borehole. The cuttings taken from various depths are representative of the mineral or other material located at that depth.

SUMMARY

[0005] A device according to various embodiments is provided for collecting borehole samples in the form of cuttings and cutting fluid flushed up out of a borehole during a drilling operation. The device includes a receptacle having an inlet that is adapted to engage with a casing positioned at least partially in a borehole. At least one outlet is also provided in the receptacle, with the at least one outlet providing a passage through which a borehole sample exits from the receptacle. The receptacle is adapted to fit around a drill rod used in drilling the borehole with the inlet providing clearance for the drill bit and drill rod and the receptacle adapted to capture cuttings and cutting fluid entering the receptacle through the inlet during a drilling operation.

[0006] According to various embodiments, the receptacle can be in the form of an open catch basin that is fitted around a casing through which the drill rod passes during a drilling operation such that the catch basin collects all cuttings and cutting fluid that exit from the casing during the drilling operation.

[0007] According to various embodiments, the receptacle of the device for collecting borehole samples can be in the form of a closed container having an inlet adapted to engage with a casing in a borehole, an opening aligned with the inlet and through which the drill rod and drill bit can pass during a drilling operation, and at least one outlet from which the collected cuttings and cutting fluid in the receptacle can be removed for analysis.

[0008] According to various embodiments, a method of collecting borehole samples can include drilling a borehole into the earth for a first distance using a reaming tool on the end of a drill rod. The reaming tool can be used to form a first, larger diameter portion of the borehole. The remainder of the borehole can then be formed by a drill bit, such as the drill bit of a conventional longhole boring machine wherein a cutting fluid is passed down through the drill rod and drill bit such that cuttings generated during the drilling operation are flushed up out of the borehole around the outside of the drill rod. After drilling into the earth a desired distance using the reaming tool, the reaming tool and drill rod can be removed from the borehole, and a casing can be inserted into the borehole, with an exposed end of the casing

extending to or above ground level.

[0009] A borehole sample collector can then be attached to the exposed end of the casing or an extension thereof, with the borehole sample collector comprising a receptacle that completely surrounds the exposed end of the casing or extension thereof such that substantially all cuttings and cutting fluid generated during the drilling operation pass from the casing into the receptacle. A drill bit on the end of a drill rod can then be inserted through an opening that passes through the borehole sample collector and into the casing to continue the drilling operation.

[0010] It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory only and are intended to provide a further explanation of the present invention, as claimed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] Various embodiments of the present teachings are exemplified in the accompanying drawings. The teachings are not limited to the embodiments depicted in the drawings, and include equivalent structures and methods as set forth in the following description and as would be known to those of ordinary skill in the art in view of the present teachings. In the drawings:

[0012] Fig. 1A is a schematic diagram in partial cross-section, showing a longhole drilling apparatus with a borehole sample collector according to various embodiments in position around the drill rod.

[0013] Fig. 1B is a top plan view of the drill apparatus and borehole sample collector shown in Fig. 1A.

[0014] Fig. 2A is a perspective view of a borehole sample collector according to an embodiment, positioned over a borehole casing to which the borehole sample collector will be joined.

[0015] Fig. 2B is another perspective view of the borehole sample collector and casing to which it will be joined, as shown in Fig. 2A.

[0016] Fig. 3 shows an elevation view in partial cross-section of an alternative embodiment of a borehole sample collector.

[0017] Fig. 4 illustrates a top plan view of a borehole sample collector as shown in Fig. 3.

[0018] Fig. 5 illustrates a side view in partial cross section of a borehole sample collector and casing to which it will be attached.

DETAILED DESCRIPTION

[0019] During a mining operation it would be desirable to have an accurate picture of the types of minerals or other substances, and the locations and the quantities of the minerals or other substances located in the ground at a potential mining site. It would also be desirable during a mining operation to know the composition of the materials in the ground at a potential mining site so that the placement and quantity of explosives needed during the mining operation could be determined with a high degree of accuracy. Longhole drilling equipment can be used to drill the blast holes that can be used for placement of explosives at a potential mining site.

[0020] The longhole drilling machine can be an electric hydraulic machine that drills a hole into the ground by rotating a diamond drill bit on the end of a drill rod and by moving the diamond drill bit and drill rod in an axial direction. A longhole drilling machine can continue to drill the hole to greater depths by the continued addition of drill rods to the end of the drill rod at the opposite end from the drill bit. During the drilling operation a cutting fluid can be forced down through the center of the one or more drill rods and out through the drill bit, with the cutting fluid providing the benefits of cooling and lubricating the drill bit, as well as applying a hydrostatic pressure to the earth formations that have been drilled, and lifting the resulting drill cuttings generated by the bit back to the earth's surface through the annular space defined between the drilled borehole and the exterior of the drilling tool assembly. As the drill bit at the end of one or more drill rods continues to penetrate the earth to greater depths, the cuttings generated at each new depth are representative of the materials located in the earth at that depth.

[0021] According to various embodiments, such as shown in Figs. 1A and 1B, a borehole sample collector 20 for collecting borehole samples can be provided to fit around a drill rod and drill bit that extends through a casing and into a borehole in the earth 30, with the

borehole 32 being generated by the rotational and axial movements of a drill bit 42 at the end of drill rod 40.

[0022] A top portion 33 of the borehole 32 can be drilled or reamed to a larger diameter using a reaming tool (not shown) such that a casing 50 can be fitted into the top portion of the borehole, with the casing 50 having a large enough inner diameter to allow passage of the drill bit 42 and drill rod 40. The casing 50 extending into the borehole at the larger diameter portion 33 can extend to or above the surface of the ground 30, and can be provided with a fitting at its top end such that the borehole sample collector 20 can be joined with the top end of the casing 50.

[0023] As shown in Figs. 2A, 2B, and 5, the top end of casing 50 can be grooved and provided with an elastomeric fitting 52 that will mate with a similar fitting 26b' on the inlet fitting 26b of the borehole sample collector 20. According to various embodiments, such as shown in Figs. 2A, 2B, and 5, the borehole sample collector 20 can be in the form of an outer, larger diameter cylindrical housing 22 having parallel top plate 23 and bottom plate 24 connected to the outer larger diameter cylindrical housing 22 at an angle relative to the central axis of the housing 22, a smaller diameter cylindrical inlet fitting 26b connected to and penetrating through the bottom plate 24, and a second smaller diameter cylindrical fitting 26a connected to and penetrating through the top plate 23 and aligned with the inlet fitting 26b such that a drill rod and drill bit can pass through the top fitting 26a and through the inlet fitting 26b when the borehole sample collector is attached at the top end of a casing. Outlet fittings 28a and 28b can be joined to the larger diameter cylindrical housing 22 at positions on the housing 22 that are approximately diametrically opposed and axially offset relative to each other in the direction of the central axis of the housing 22.

[0024] The inlet fitting 26b and aligned fitting 26a, as shown in Fig. 2B, can be provided with substantially identical diameters and with universal fittings 26a' and 26b' such that the borehole sample collector 20 can be reversed with fitting 26a becoming the inlet fitting to be connected to casing 50. The outlet fittings 28a and 28b can be the same or different diameters, and provide a means for extracting any cuttings or cutting fluid collected in the borehole sample collector 20 during a drilling operation while the borehole sample collector is joined to the downhole casing 50, as well as allowing for flushing of the borehole sample collector 20 or removal of anything that may clog the fittings 28a and 28b.

[0025] During a drilling operation, the borehole sample collector 20 can be joined to the top end of casing 50 by clamping the fitting 52 at the top end of casing 50 to a mating fitting 26b' on inlet fitting 26b of the sample collector 20. As the drill bit 42 at the end of drill rod 40 penetrates further into the earth, cuttings are flushed by the cutting fluid pumped down through drill rod 40 and out through drill bit 42 back up around the drill rod 40 through the inlet 26b and into the borehole sample collector 20. In the embodiment shown in Figs. 1A, 1B, 2A, 2B, and 5, with the drill rod 40 oriented at approximately a 90° angle to the earth's surface, and with the borehole sample collector 20 positioned around the drill rod 40 as shown in Fig. 1A, cuttings and cutting fluid that enter the borehole sample collector 20 will flow down the sloped bottom surface 24 of the borehole sample collector 20 and exit from the lower fitting 28a as a result of gravitational flow. The enclosed collecting area 25 of the borehole sample collector 20 ensures that substantially all of the cuttings and cutting fluid coming from the borehole 32 and up through the casing 50 will be collected in the borehole sample collector 20. The enclosed design of the borehole sample collector 20, according to embodiments such as shown in Figs. 1A, 1B, 2A, and 2B, as well as the reversible nature of the borehole sample collector 20 allowed by the aligned fittings 26a and 26b, enables the use of the borehole sample collector 20 in drilling operations where the drill rod 40 and resulting borehole 32 extend into the earth at angles other than 90°.

[0026] One of ordinary skill in the art will recognize that although an embodiment such as shown in Fig. 2B includes the borehole sample collector 20 being made from a larger diameter pipe section or housing 22, sloped top and bottom disk surfaces 23 and 24, and smaller diameter pipe sections 26a, 26b, 28a, and 28b, many other alternative embodiments are contemplated within the scope of the appended claims. As one example, the outer housing 22 of the borehole sample collector 20 could have a variety of different cross-sections other than a circular cross-section, including but not limited to a square cross-section, a rectangular cross-section, or a trapezoidal cross-section. The borehole sample collector 20 can be of a number of different shapes, with at least one inlet fitting, such as fitting 26b shown in Fig. 2B, that will mate with a casing 50 extending from a borehole, an aligned opening or fitting such as fitting 26a in Fig. 2B that allows for passage of the drill rod and drill bit through the borehole sample collector 20, and one or more outlets such as outlets 28a and 28b in Fig. 2B, that provide an exit for the cuttings and cutting fluid collected in the borehole sample collector

20 during a drilling operation.

[0027] According to various embodiments, such as shown in Figs. 3 and 4, a borehole sample collector 120 can be provided in the form of a catch basin that fits around a drill rod during a drilling operation and is configured to mate with the top end of a casing protruding from a drill hole. As shown in an exemplary embodiment in Fig. 3, the catch basin can be formed by an outer cylindrical housing 122 surrounding an inner smaller diameter cylindrical sleeve 126, through which the drill rod can pass during a drilling operation. The inner cylindrical sleeve 126 can include a bottom portion 126b that will mate with a casing extending from a drill hole, and a top portion 126a. An annular plate 123 can be joined between the inner sleeve 126 and the outer cylindrical housing 122.

[0028] In the exemplary embodiment of Fig. 3, the top end of the borehole sample collector 120 is open such that cuttings and cutting fluid entering the inner cylindrical sleeve 126 from between the drill rod and the casing in the drill hole will flow over the top end 126a of the inner sleeve 126 and be collected in the annular catch basin 125 formed between the inner sleeve 126 and the outer cylindrical housing 122. Cuttings and cutting fluid within this annular catch basin 125 will then flow downward as a result of gravity to the low point at the connection between the annular plate 123 and the outer housing 122. One or more fittings 128a can be provided through the outer housing 122 at the intersection of the annular plate 123 and the outer housing 122. Accordingly, the embodiment shown in Fig. 3 can be used in an application where the drill rod passes through the borehole sample collector 120 in a vertical orientation such that substantially all of the cuttings and cutting fluid flowing up out of the casing in the drill hole will enter the annular space 125 between the inner sleeve 126 and the outer housing 122. As shown in Fig. 4, the borehole sample collector 120 can also be provided with handles 127a and 127b connected to the outer housing 122 for ease in handling the borehole sample collector 120.

[0029] Borehole sample collectors such as those discussed above with regard to various embodiments, provide a means for collecting the cuttings and cutting fluid produced at a known depth of a borehole during a drilling operation. By allowing for the capture of all cuttings and cutting fluid produced during a drilling operation at selected depths of the drill hole, the borehole sample collectors according to various embodiments as discussed above, allow for the collection of cuttings at various depths or positions of the drill hole while using

conventional longhole drilling machinery, and provide a convenient means for collecting only cuttings and cutting fluid at particular desired locations to provide an accurate map of the composition of materials in the mine site. The amount of various minerals or other materials found at various depths and locations in the mine site, as obtained by drilling holes and collecting cutting samples using a borehole sample collector according to various embodiments, yields information valuable in deciding where to mine for a particular mineral, and where to place explosives if blasting will be used to mine desired minerals.

[0030] Applicants specifically incorporate the entire contents of all cited references in this disclosure. Further, when an amount, concentration, or other value or parameter is given as either a range, preferred range, or a list of upper preferable values and lower preferable values, this is to be understood as specifically disclosing all ranges formed from any pair of any upper range limit or preferred value and any lower range limit or preferred value, regardless of whether ranges are separately disclosed. Where a range of numerical values is recited herein, unless otherwise stated, the range is intended to include the endpoints thereof, and all integers and fractions within the range. It is not intended that the scope of the invention be limited to the specific values recited when defining a range.

[0031] Other embodiments of the present invention will be apparent to those skilled in the art from consideration of the present specification and practice of the present invention disclosed herein. It is intended that the present specification and examples be considered as exemplary only with a true scope and spirit of the invention being indicated by the following claims and equivalents thereof.

WHAT IS CLAIMED:

1. A device for collecting borehole samples, comprising:

a receptacle including an inlet adapted to engage with a casing positioned in a borehole, and at least one outlet through which a borehole sample exits from the receptacle; and

the receptacle adapted to fit around a drill rod used in drilling the borehole with the inlet providing clearance for the drill rod and the receptacle adapted to capture cuttings and cutting fluid entering the receptacle through the inlet during a drilling operation.

2. The device of claim 1, wherein the inlet of the receptacle is a section of pipe adapted to engage with the casing in a borehole, the section of pipe being attached to a housing of the receptacle and extending into the housing with the housing surrounding the section of pipe to capture the cuttings and cutting fluid coming from the casing during a drilling operation.

3. The device of claim 1, wherein the receptacle is defined by an outer housing, the inlet extending into the outer housing on one side of the outer housing and a drill rod clearance opening provided on the opposite side of the outer housing aligned with the inlet.

4. The device of claim 3, wherein the at least one outlet is formed through the outer housing at a level lower than a level where a borehole sample enters the outer housing from the inlet so the sample will flow out of the at least one outlet.

5. The device of claim 1, wherein the receptacle is formed with the inlet aligned with an opening through the opposite side of the receptacle, the inlet and the aligned opening adapted to receive a drill rod therethrough, and the at least one outlet providing fluid communication from a collection volume of the receptacle surrounding the drill rod to outside the receptacle.

6. The device of claim 1, wherein:

the receptacle is formed with an outer periphery of the receptacle defined by a larger diameter pipe section;

a first disk joined across one end of the larger diameter pipe section forming a top of the receptacle and a second disk joined across the opposite end of the larger diameter pipe section forming a bottom of the receptacle;

a first smaller diameter pipe section joined to and penetrating through the top of the receptacle;

a second, smaller diameter pipe section joined to and penetrating through the bottom of the receptacle, the second, smaller diameter pipe section being substantially aligned with the first smaller diameter pipe section; and

the at least one outlet being formed by one or more smaller diameter pipe sections joined to the larger diameter pipe section.

7. The device of claim 6, wherein two of the at least one outlet are joined to the larger diameter pipe section on approximately diametrically opposed sides of the larger diameter pipe section and are axially offset relative to each other in the direction of an axis through the substantially aligned first and second smaller diameter pipe sections.

8. The device of claim 7, wherein:

the first and second disks forming the top and bottom of the receptacle are substantially parallel to each other and form an acute angle with the axis through the substantially aligned first and second smaller diameter pipe sections.

9. The device of claim 1, wherein:

the receptacle comprises an inner portion including the inlet and a passageway for a drill rod used in drilling a borehole; and

an outer portion surrounding the inner portion and forming a catch basin in which cuttings and cutting fluid entering the receptacle from the inlet during a drilling operation are collected before exiting the receptacle through the at least one outlet.

10. The device of claim 9, wherein the inner portion is at least partially defined by a smaller diameter pipe section and the outer portion is at least partially defined by a larger diameter pipe section concentrically disposed around the smaller diameter pipe section.

11. The device of claim 10, where the outer portion is further defined by an annular plate joined between the smaller diameter pipe section and the larger diameter pipe section.

12. The device of claim 11, wherein the annular plate is joined to the smaller diameter pipe section and the larger diameter pipe section at an acute angle relative to the centerlines of the smaller diameter pipe section and larger diameter pipe section such that the cuttings and cutting fluid entering the receptacle from the inlet during a drilling operation will flow as a

result of gravity toward a lower one of the at least one outlet which is provided through the larger diameter pipe section near the intersection of the annular plate and the larger diameter pipe section.

13. A method of collecting borehole samples, comprising:

drilling a borehole into the earth for a first distance using a drilling or reaming tool bit on the end of a drill rod wherein a cutting fluid is passed down through the drill rod and bit such that cuttings generated during the drilling operation are flushed up out of the borehole around the outside of the drill rod;

removing the drill rod and bit from the borehole;

inserting a casing into the borehole with an exposed end of the casing extending to or above ground level;

attaching a borehole sample collector to the exposed end of the casing or an extension thereof;

the borehole sample collector comprising a receptacle that completely surrounds the exposed end of the casing or extension thereof such that substantially all cuttings and cutting fluid generated during the drilling operation pass from the casing into the receptacle; and

reinserting a drill rod and bit through an opening through the borehole sample collector and into the casing to continue drilling.

14. The method of claim 13, wherein:

a borehole sample from a desired depth is collected by emptying the borehole sample collector of substantially all contents when the drill bit is approximately at the desired depth;

continuing the drilling operation at the desired depth and collecting the resulting cuttings in the borehole sample collector.

15. The method of claim 13, wherein the borehole is drilled into the earth at an angle relative to the ground surface of approximately 90°.

16. The method of claim 13, wherein the borehole is drilled into the earth at an angle relative to the ground surface that is different than 90°.

17. The method of claim 13, wherein the drilling comprises rotating the drill rod and drill bit and moving the drill rod and drill bit in an axial direction.

18. The method of claim 13, wherein the drilling operation is performed by a longhole drilling apparatus.

19. The method of claim 13, wherein additional drill rods are connected to the drill rod to drill to a desired length of borehole, and a borehole sample is taken at the bottom of the borehole by collecting the cuttings and cutting fluid that enter the borehole sample collector during the drilling operation at the bottom of the borehole.

20. The method of claim 13, wherein the cuttings collected in the borehole sample collector are analyzed to determine at least one of type, location, or quantity of materials that exist in the ground at a potential mining site.

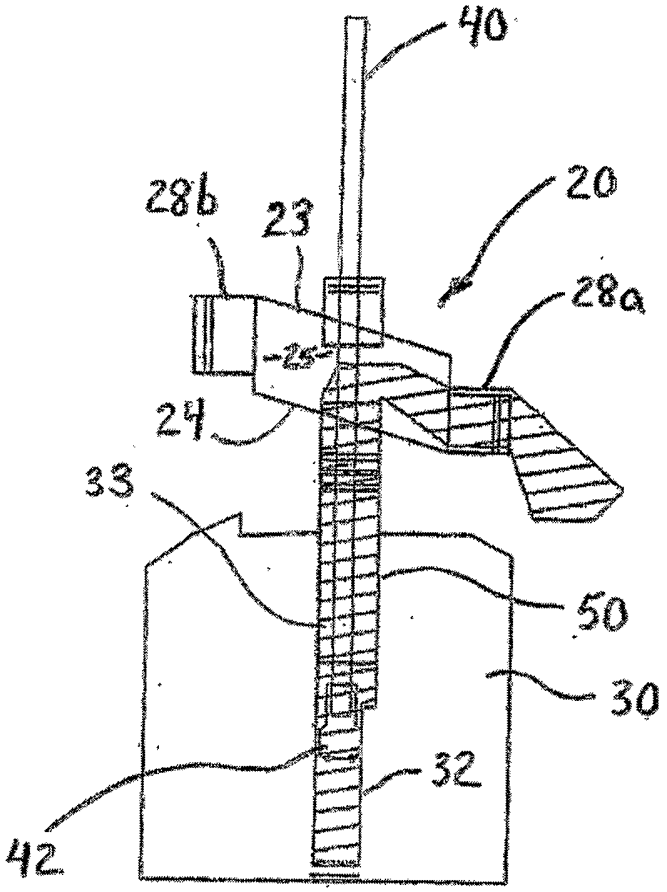


Fig. 1A

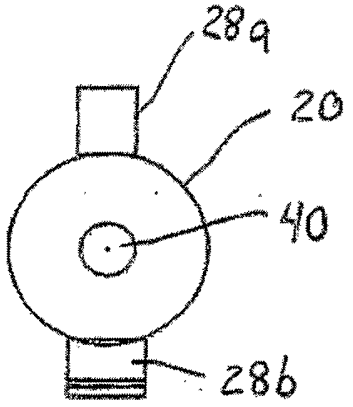


Fig. 1B

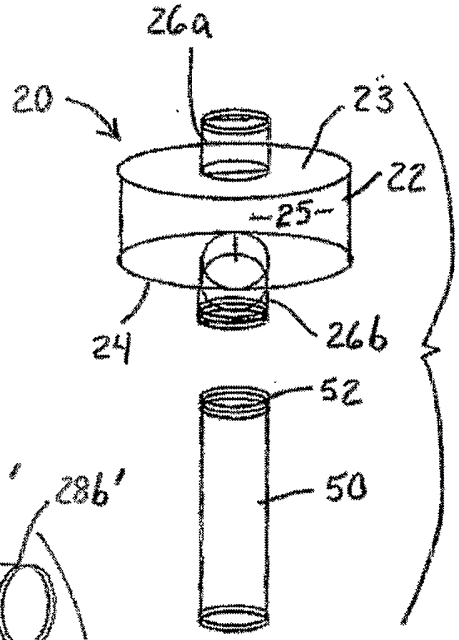

26a
20
23
22
25
24
26b
52
50

Fig. 2A

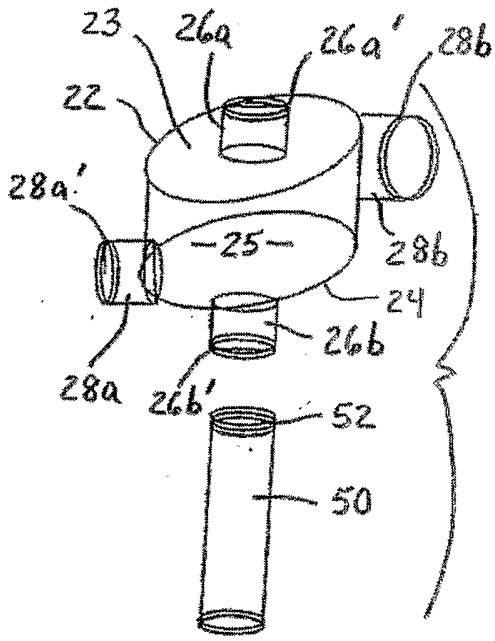

23
26a
26a'
28b'
22
28a'
25
28b
24
26b
28a
26b'
52
50

Fig. 2B

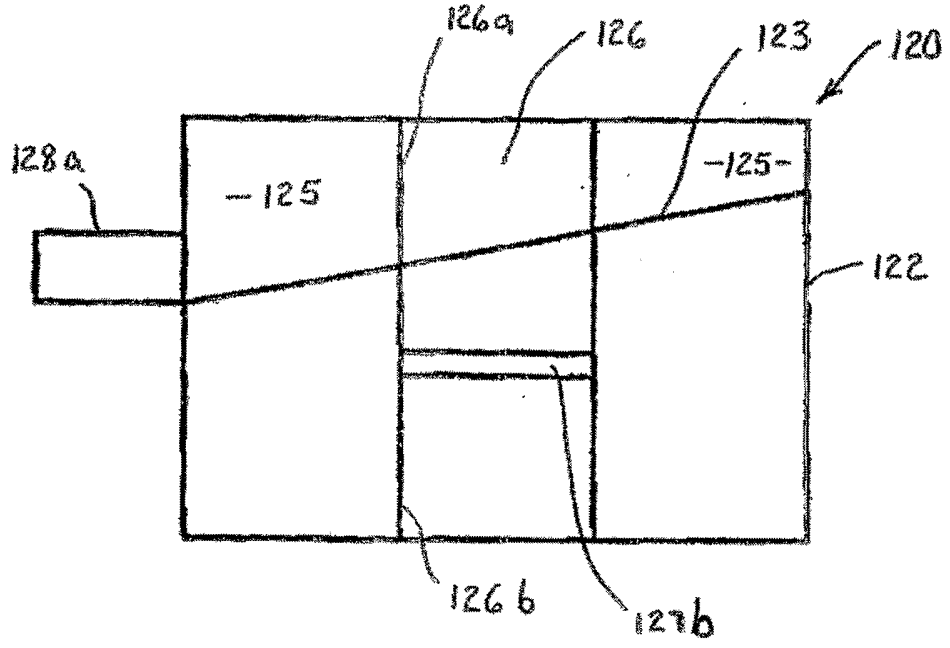


Fig. 3

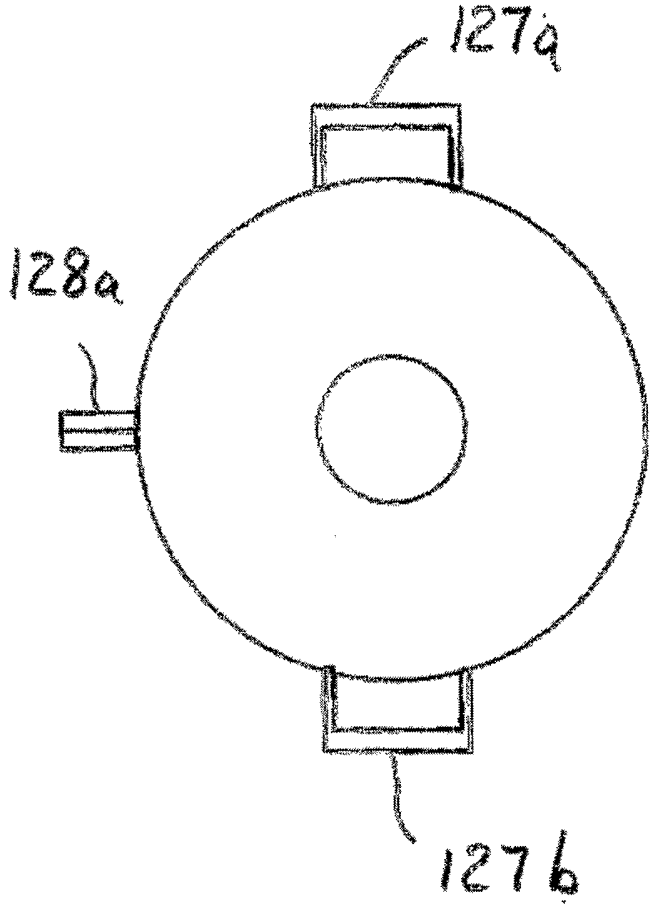


Fig. 4

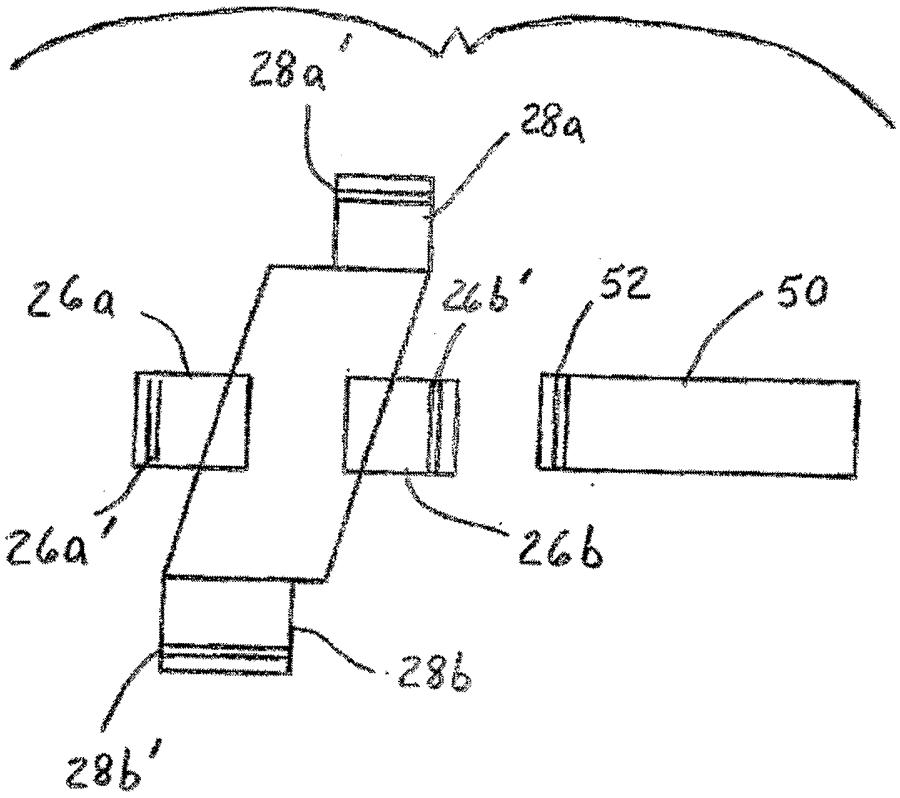


Fig. 5

INTERNATIONAL SEARCH REPORT

ıational Application No
PCT/US2005/027130

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 E21B21/015 E21C39/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 E21B E21C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 792 632 A (AKTIEBOLAGET SEPARATOR) 2 April 1958 (1958-04-02) page 3, lines 8-14 page 4, lines 18-58	1-5, 13-20
X	GB 425 736 A (WILLIAM COLLIER) 20 March 1935 (1935-03-20) the whole document	1-5,13, 15-19
X	DE 25 57 354 A1 (BERGWERKSVERBAND GMBH; BERGWERKSVERBAND GMBH, 4300 ESSEN) 7 July 1977 (1977-07-07)	1-7
Y	the whole document	8-12
Y	US 3 055 743 A (ANDERSON GEORGE L) 25 September 1962 (1962-09-25) column 2, line 66 - column 3, line 4	8-12

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
31 October 2005	07/11/2005

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INTERNATIONAL SEARCH REPORT

International Application No
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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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