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(54) **System and method for analysing gas from a borehole**

(57) A system and method for analysing gas from a borehole, the system comprising:- a degasser (20,120) configured to degas drilling mud to remove at least a portion of gas therefrom; an analyser (50,150), in gas communication with the degasser(20,120), the analyser (50,150) configured to analyse gas samples and provide information relating to the gas samples; the analyser (50,150) normally being a mass spectrometer(50,150); wherein the system is configured such that drilling mud is degassed in the degasser (20,120) for at least twenty seconds before at least a portion of gas removed therefrom is transferred to the analyser(50,150). The resulting batch analysis provides a number of important benefits. A degasser (20,120), cleaning mechanism, feedback system and mud heater (16,116) are also disclosed.

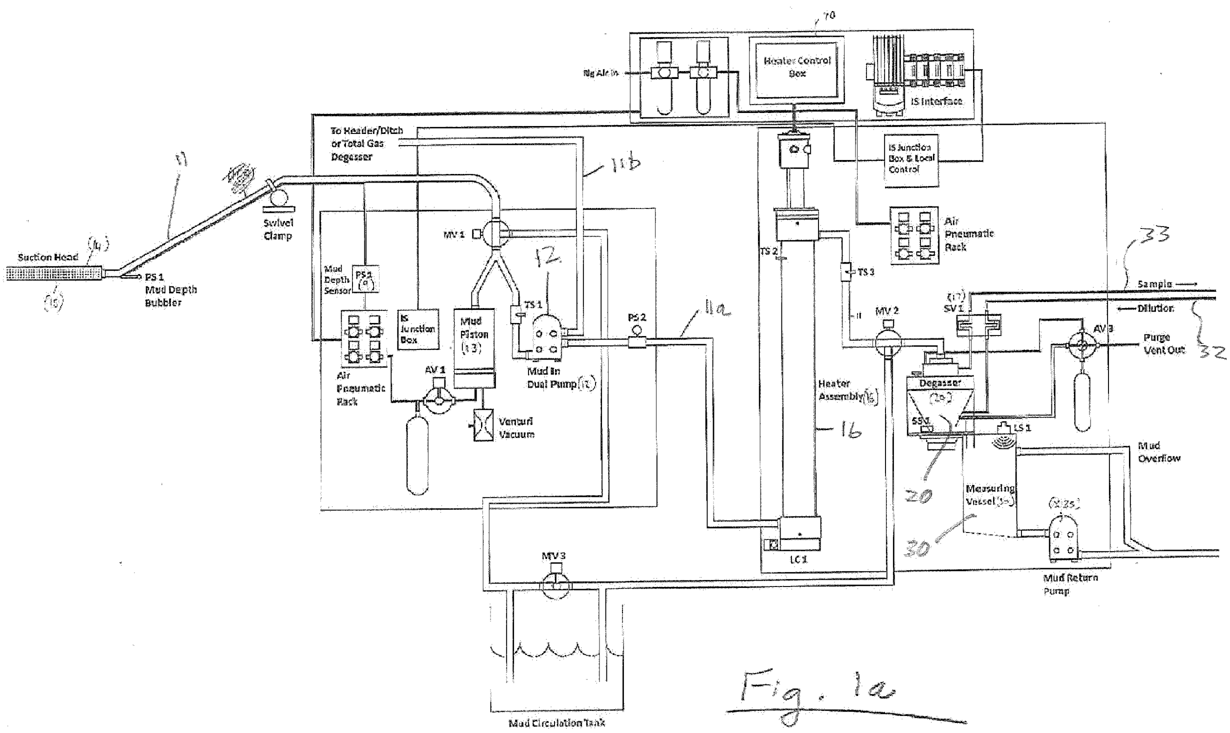

Fig. 1a

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Description

[0001] This invention relates to a system and method for analysing gas emitted from boreholes, especially using mass spectrometry.

[0002] When drilling boreholes it is conventional to circulate drilling mud to cool the drill bit and to bring the drill cuttings back to the surface in a suspension.

[0003] Gas emitted when drilling boreholes can be analysed in order to determine its characteristics and to infer properties of the formation, such as the nature of any hydrocarbons present.

[0004] The gas from the new borehole is often entrained or dissolved in the circulated drilling mud. To obtain representative data from the mud, it is important to use a process to extract the gas from the mud in a consistent and representative fashion so that the gas reflects the nature of hydrocarbons and may also correlate to the nature of the hydrocarbons at different depths of the borehole.

[0005] Traditionally, this is performed using gas chromatographs alongside other instrumentation to analyse the solids and liquids returned with drilling mud, the latter operation normally referred to as mud logging.

[0006] For the gas, traps are provided to provide a continuous gas in air flow from the borehole site to a mud logging cabin where it is analysed using a chromatograph.

[0007] More recently mass spectrometer analysis with a special continuous gas sampling system has been used to gain more data on the nature of the gas emitted when drilling the borehole. For example GB2,491,443 describes a method to extract particularly useful information from the gases emitted. Whilst generally satisfactory, the inventor of the present invention has identified aspects of this process which could be improved.

[0008] According to a first aspect of the present invention there is provided a system for analysing gas from a borehole, the system comprising:

- a degasser configured to degas drilling mud to remove at least a portion of gas therefrom;
- an analyser, in gas communication with the degasser, the analyser configured to analyse gas samples and provide information relating to the gas samples;
- the analyser being at least one of a gas chromatograph and a mass spectrometer;

wherein the system is configured such that drilling mud is degassed in the degasser for at least twenty seconds, before at least a portion of gas removed therefrom is transferred to the analyser.

[0009] The portion of gas being transferred to the analyser typically in a sampling mode may be referred to as a gas sample batch.

[0010] Thus despite the degassing of at least 20 seconds and the periodic nature of the results so obtained, the inventor has gone against accepted practise of continuous measurement of drilling mud and surprisingly found that a variety of benefits can ensue.

[0011] Preferably the analyser is a mass spectrometer.

[0012] Normally the system includes a pump to transfer mud from an input to the degasser.

[0013] The degassing normally occurs for a longer period, such as at least forty seconds , at least one minute, at least one minute twenty seconds or at least one minute forty seconds. Certain embodiments degas for around two minutes. Normally the degassing time is less than five minutes, more normally less than four minutes, and may be less than three minutes.

[0014] The degasser may have a fragmentation chamber with a mechanism to facilitate degassing of fluids. The degasser may have a rotatable cone, and mud is directed into the cone and in use centrifugal forces direct the mud outwards and over the top of the cone.

[0015] According to a further aspect of the invention there is provided a degasser for degassing drilling mud, the degasser comprising a fragmentation chamber with a mechanism to facilitate degassing of fluids and a rotatable cone.

[0016] The fragmentation chamber may be a chamber e.g. cylindrical, extending downwards from an inlet to the degasser. Normally the fragmentation chamber is, in part at least, within the cone.

[0017] The mechanism to facilitate degassing may include rotating and/or non-rotating blades, or a slotted plate. The slotted plate may be a spiral plate or may be substantially planar. A substantially planar plate may have a fin extending out of the plate. The mechanism to facilitate degassing may include at least one wiper, moveable (e.g. rotatable) with respect to a wall of the fragmentation chamber. The at least one wiper may be spaced from or in contact with the wall of the fragmentation chamber. For example spaced 0.5 - 4mm therefrom or 1.5-4mm therefrom.

[0018] The cone may have a castellated upper edge.

[0019] The system may comprise a metering vessel, normally below and in fluid communication with the degasser, being adapted to meter an amount of drilling mud, and normally an activation mechanism comprising a sensor and an activator; the sensor operable to sense an amount of drilling fluid in the metering vessel and the activator adapted to initiate the transfer at least a portion of the removed gas to the analyser, when the amount of drilling mud reaches a certain pre-determined amount.

[0020] By "amount" of drilling fluid in the metering vessel, the metering vessel is able to provide two or more successive samples with approximately the same amount of drilling mud. The amount need not be known in absolute terms, for example, by volume or litres, since its primary function is to have a consistent sample size.

[0021] In certain embodiments the sensor is a level sensor to determine when a certain level of drilling mud is present in the metering vessel.

[0022] Depending on the nature of the mud, and user preferences, the amount which triggers the activator may be changed. For example, it may be set at 50% or 25% metering vessel mud volumes/levels, for example if the mud included relatively high gas levels.

[0023] Certain sensors can also provide a rate of change in the mud level in the metering vessel and they may also be used as a mud flow measurement and this may be used as part of the mud flow control. Thus for certain embodiments, the time for the mud level to reach a certain amount, for example, 50% of the desired amount can be measured and if this is too slow or too fast, a pump can be adjusted automatically or manually to correct the vessel fill time during the remainder of the fill.

[0024] The fluid communication between the degasser and metering vessel may be adapted in use to block gas communication and allow generally liquid communication. For example a weir may be provided over which liquid can drop or otherwise proceed towards the metering vessel below. However the liquid build-up in use in front of the weir inhibits ambient gases from entering the metering vessel.

[0025] Thus the degasser may be continuously supplied with drilling mud. The system may comprise a heater, to heat the mud, typically upstream of the degasser. Said heater may be downstream of the pump.

[0026] At least part of the gas removed from the drilling mud is removed in a transfer line. Typically the system is configured such that the transfer line is closed to the degasser during degassing.

[0027] The system may also include a dilution line which is configured to have air or other dilution gas pumped into it.

[0028] Certain embodiments of the invention allow the air in the dilution line to circulate through the transfer line during the degassing mode.

[0029] In the sampling mode the system may be configured to do one or more of (i) closing any connection between the dilution line and the transfer line (ii) removing the mud from the metering vessel, (iii) opening the degasser to the transfer line, (iv) pumping gas from the degasser to the mass spectrometer.

[0030] Thereafter, the system may be configured to proceed with a purge mode. The purge mode may include adding dilution gas into the degasser. In certain embodiments this is added at a higher pressure, to cause a surge. For example the pump to circulate the gas in the dilution line may be continuously operated during the sampling mode, so as to build up pressure in the dilution line, the pressure is then released to purge the degasser.

[0031] The sampling mode and purge mode together normally take at least 10 seconds, more normally at least 20 seconds, often more than 30 seconds. Typically they take less than two minutes, preferably less than a minute.

[0032] The system has an input, upstream of the degasser and any heater, and the input normally comprises a filter, such as a mud suction filter normally with a mounting device.

[0033] The input may be located in a line connected to a mud return line from the borehole or a mud tank.

[0034] A cleaning mechanism may be provided for the filter, the cleaning mechanism being configured to direct fluid through the filter in an opposite direction to the normal flow of fluids from the input to the degasser; thus preferably dislodging debris and/or blockages on the filter.

[0035] The cleaning mechanism may be configured to accumulate fluid from the line between the input and the pump, for example in a cylinder, and then periodically eject it through the filter in the said opposite direction.

[0036] The cylinder's stroke may use an air operated vacuum device and the discharge stroke may use compressed air from an adjacent reservoir. In alternative embodiments, other devices may be used such as a spring or weighted return.

[0037] The invention also provides a cleaning mechanism for a system for analysing gas from a borehole, the cleaning mechanism being configured to accumulate fluid from the line between a filter and a pump and periodically direct it through the filter in the opposite direction to the normal flow of fluids from the filter to the degasser.

[0038] The drilling mud is normally used drilling mud. "Used" drilling mud means drilling mud which has been used to facilitate the drilling of a borehole.

[0039] Thus certain embodiments are configured to degas at least 2 litres, and normally at most 20 litres of drilling mud.

[0040] According to a further aspect of the present invention there is provided a method for analysing gas from a borehole, the method comprising:

- providing a system comprising a degasser in gas communication with an analyser;
- in the degasser, degassing drilling mud to remove at least a portion of gas therefrom;
- transferring at least a portion of the gas removed from the drilling mud to the analyser;
- analysing at least a portion of the transferred gas, normally referred to as a sample batch, using the analyser;

the analyser being at least one of a gas chromatograph and a mass spectrometer; wherein the drilling mud is degassed in the degasser for at least twenty seconds, before being at least a portion of the gas is transferred to the analyser.

[0041] The method of the second aspect of the invention may be used with the system of the first aspect of the invention and preferred and optional features for the former and also preferred and optional features for the latter. In particular the analyser may be a mass spectrometer.

[0042] Normally the borehole is a borehole in a hydrocarbon bearing formation. Normally the gas is a hydrocarbon containing gas.

[0043] According to a further aspect of the present invention, there is provided a heater apparatus for heating drilling mud , the heater apparatus comprising:

a central heater element,

a heat exchanger with an outer mud spiral channel,

a removable cover; such that the mud spiral channel is defined, at least in part, by the cover and the spiral channel in the heat exchanger.

[0044] In use drilling mud is directed through the spiral channel, such that heat is exchanged from the heater element to the drilling mud.

[0045] The heater used in the third aspect of the invention may be used as the heater for embodiments of the first and second aspect of the invention.

[0046] The drilling mud used in the third aspect of the invention is normally a used drilling mud.

[0047] Using such a heater facilitates cleaning of the heater since the cover may be removed and direct access to the spiral channel obtained.

[0048] Thus a spiral-shaped channel may function as a heat exchanger and be provided normally as a close fit to the surface of the heater element with, in use, any air in the gaps may be displaced with heat conductive liquid such as oil. Normally the heater element is an electrically heated tube and is preferably suitable for zone 1 operation. Optionally the external surface of the heat exchanger has a machined spiral groove to form the spiral channel.

[0049] The invention also provides a feedback system for the system and method described herein, where data from one or more of the following variables is recorded:

(i) the nature of the mud;

(ii) nature and quantity of gas received;

(iii) the configuration of the sampling system;

(iv) mud sample rate;

and said data is used to optimise later uses of the system.

[0050] Two, three or four of the data variables ((i) to (iv)) categories may be used.

[0051] The nature of the mud may include its temperature, viscosity, specific gravity and content (e.g. water based or oil based).

[0052] The data regarding the gas recovered from the mud may include its quantity and chemical composition.

[0053] The data regarding the configuration of the sampling system may include the lengths of the connections between various components, for example the suction head and pump, or the degasser and suction head.

[0054] The data regarding the sampling rate may include data on the time taken to process samples of mud.

[0055] An embodiment of the present invention will now be described, with reference to the accompanying drawings, in which:

Figs. 1a and 1b are together a schematic view of an embodiment of the gas analysing system in accordance with a first aspect of the invention;

Fig. 2a and 2b are together a schematic view of a second embodiment of a gas analysing system in accordance with a first aspect of the invention;

Fig. 3 is a series of views of an embodiment of a mud heater in accordance with an embodiment of the present invention;

Fig. 4 is a front view of an embodiment of a degasser used in accordance with certain embodiments of the present invention;

Fig. 5 is a front view of a second embodiment of a degasser used in accordance with certain embodiments of the present invention;

Fig. 6a is a front view of a fragmentation assembly used in the Fig. 5 the degasser;

Fig. 6b is a side view of the Fig. 6a fragmentation assembly;

Fig. 6c is a perspective view of the Fig. 6a fragmentation assembly; and,

Fig. 6d is a plan view of the Fig. 6a fragmentation assembly.

[0056] Figs. 1a. 1b show a schematic view of a system 10 in accordance with the present invention, the system 10 is used to batch sample returned drilling mud from a wellbore being drilled, de-gas it and analyse the gas using a mass spectrometer 50. The data gained from the mass spectrometer 50 is used in turn to elicit information as to hydrocarbon content and/or nature of the borehole being drilled.

[0057] As will be described in more detail below, a mud pump 12 draws mud through a suction head input 14, which is then directed through a mud heater 16 and onto a degasser 20 and associated metering vessel 30.

[0058] When the mud in the metering vessel 30 reaches a predetermined level it defines the mud volume which has been degassed for that batch and initiates a sequence which draws off a portion of the gas and air from the degasser head and passes this to the analyser as a sample pill. The degasser is then purged to remove any gas from the previous batch and starts a new mud degassing cycle.

[0059] The inventor of the present invention has found that the use of batch sampling in this context has some important benefits, which far outweigh the periodic nature of the analysis. For example, since the well gas is accumulated within the degasser head over a period it is possible to use much lower mud flows and this in turn permits the use of much smaller well site equipment. This has a number of benefits which will be become apparent following the detailed description of the present embodiment.

[0060] Mud returning from a bore hole on a drilling rig or platform can be sampled by accessing a mud tank or a mud return pipe using suction head 14. The suction head 14 includes a filter 15 which filters out any particles greater than 3mm. The suction head 14 is located in the most suitable position in a rig mud system and has means to remove its head for inspection or replacement. The mud suction point may also incorporate an air operated device 9 which indicates if the level of the mud around the suction point is low and this may be used to stop the mud pump to avoid drawing air into the mud system.

[0061] The mud is displaced using a diaphragm pump 12 which is connected to an air pressure/ flow controller (not shown). This type of pump is very small and can therefore be located very close to the mud source, minimising suction problems. It is also inexpensive and very reliable; all in marked contrast to the accepted use of peristaltic pumps for such applications. The inventor of the present invention has gone against normal practise, and found that provision of a metering vessel 30 downstream of the pump, *inter alia,* obviates the requirement for a large and precise peristaltic pump because accurate measurement of the sample size is not controlled solely by the pump in the present system.

[0062] The mud moves through the intake line 11a from the suction head 14, by action of the pump 12 through a heater 16 and onto the degasser 20 and metering vessel 30.

[0063] A cylinder 13 is provided on a branch of the intake line 11a between the suction head 14 and pump 12, and draws a portion of mud into the cylinder 13 during normal operation. The cylinder's 13 suction stroke may use an air operated vacuum device and the discharge stroke mas use compressed air from an adjacent reservoir.

[0064] Pumped mud systems have an inherent tendency for a suction head having a filter, such as the filter 15, to block up with drill cuttings and caked mud. In the present embodiment, the cylinder 13, periodically discharges the mud collected therein back through the mud suction head 14 (referred to as "blowback") to dislodge any cuttings or mud trapped in the filter surface. As detailed later, this is particularly suitable for the batch sampling system in the present invention, since the blowback from the cylinder 13, which may include mud accumulated over a period of time and so not be representative of the nature of the mud entering the system, can be timed such that when it reaches the degasser 12, it is the small portion which is not used in the mud sample cycle. In this way, any unrepresentative mud sample from the cylinder 13, will not distort the results.

[0065] The blowback from the cylinder 13 can be used on each batch or infrequently as necessary, depending on mud or other conditions or user preferences. For certain embodiments, the mud pump 12 and cylinder 13 may be combined into one assembly which can be secured to a wall of a header tank or adjacent to a flowline.

[0066] Whilst the line from the suction head 12 and the pump 14 is preferably as short as possible the cylinder 13 may be used to draw mud into the line, part of the way towards the pump 14, and this is especially useful when the line between the suction head 12 and pump 14 s longer. This can assist in priming the pump 14.

[0067] The illustrated embodiment shows a dual pump 12. The line 11a from the suction head 14 continues on the exit side of the pump towards the heater 16. An alternative exit line 11b from the dual pump 12 is an optional addition to the system and not necessary for many embodiments of the present invention.

[0068] The diaphragm pump 12 can have two pumping chambers which for certain applications work in parallel as single pump. In the illustrated embodiment the pump has a single input but two independent but identical outputs 11a, 11b.

[0069] The second output 11b can be used for two useful operational modes: (i) a dual sampling mode and (ii) a total gas monitoring system. An added benefit of modes is that the pump can be operated in its more stable range. Indeed, diverting one of the outputs back to the mud tank this is a third option where it is still preferred to run the pump in a more stable range. Nevertheless, a variety of different pumps may be used with embodiments of the present invention and may have different optimum operating ranges.

[0070] A second embodiment of a gas analysing system is shown in Fig. 2a and Fig. 2b. Like parts share common reference numerals except prefixed with a '1' and are not described further.

<u>Dual sampling mode</u>

[0071] In either the Fig 1a/1b or 2a/2b embodiment, where a longer heating time is required, for example with cold muds or where degass mud at high temperatures is required, two heating and degassing loops can be run using the same pump but with the gas sampling times out of sequence. This will effectively permit the user to process one four minute heating cycle every two minutes. The only additional equipment will be a heater and the degasser/ vessel and these are relatively inexpensive.

<u>Total gas sample</u>

[0072] In certain embodiments of the present invention the system uses mass spectrometers and replaces the continuous gas chromatographs used to analyse gas from drilling mud. To facilitate this replacement, a total gas measurement should be taken. With the dual pump arrangement the second output may be diverted from the mud pump to an identical degasser and this is run in a continuous mode. Using a very low dilution flow may be able to produce an adequate sample level for the total gas and H_2S sensors.

Mud heater

[0073] Depending on the nature of the mud returned from the borehole, pre-heating may be required in order to cause more gas to be emitted from the downstream degassing stage. The mud heater can also be used to ensure that every batch of mud in an operation will have the same volume and be degassed at the same temperature.

[0074] The mud heater assembly 16 comprises an oil tank heater 40 and a heat exchanger 42 and is shown particularly in Fig. 3. The oil tank heater 40 comprises an electrically heated tube 40 and is suitable for zone 1 operation. The heat exchanger 42 slides over the heated tube and has a spiral groove on the outer surface. An external tube 44 or shell slides over the heat exchanger 42. The outer tube 44 may be a suitable plastic or steel.

[0075] The heat exchanger is a close fit to the surface of the heated tube 40 and any air in the gaps is displaced with heat conductive oil. Likewise the cover 44 is removable and is added as a close fit over the heat exchanger to define the mud passage along with an external surface of the heat exchanger which has a machined spiral groove. Thus a spiral flowpath is defined between the heater tube 40 and the outer tubular housing 44, for the returned drilling mud.

[0076] In operation the heater is controlled from a control box 70 and heat from the electrically heated tube is transferred to the heat exchanger by direct metal surface contact or through a film of heat conductive oil. The cold mud enters through an entry port, circulates along the spiral groove and exits through an exit port. In this configuration the heat from the exchanger is transferred to the mud.

[0077] An advantage of such embodiments is that they are particularly easy to clean and maintain, since the outer tubular housing 44 may be removed when off-line, and direct access to the spiral flowpath obtained. Thus blockages of drilling mud therein can easily be removed, for example by hosing down. Moreover the electrically heated tube can be an off-the-shelf heater (such as those supplied by Exheat Limited of Norfolk United Kingdom) and not require additional certification itself for use in zone 1 operations.

[0078] This arrangement provides a low cost mud heater with a diameter preferably of around 150mm and height 1600mm resulting in a very small rig footprint. The small footprint heater 16 can thus be located close to the mud pump 12 and the degasser 20, further shortening the mud lines and minimising blockage risks or process delays.

[0079] The heater is operated in a vertical orientation and it rests on a load cell. During normal operation the heater holds around 3 litres of mud and the load cell permits the operator to discriminate any changes in the weight of the mud to provide an adequate mud weight (SG) measurement which can be used within the system. This can also reduce the cost of the overall system since mud weight sensors can be very expensive and take up a lot of space . The output from a load cell can also be used to detect gas inside the heater (if the heater weight drops unexpectedly) and this can be used to limit the power to the mud heater as part the safety system.

[0080] In preferred embodiments, the complete mud heater assembly 16 is fully certified for zone 1 operations.

Degasser

[0081] A housing 29 is made from sheet steel and welded to a base plate 23 where a drive motor 24 is located. In preferred embodiments the housing is also cone-shaped to minimise the internal volume. A drive shaft 25 extends from the drive motor 24 through the base plate 23 and extends along the axis of the cone 22 and on into the fragmentation chamber area.

[0082] Best shown in Fig. 4, in degassing mode, the degasser 20 creates turbulence in the mud sample therein, aiming to remove the optimum quantity of gas entrained and dissolved in each batch; and retain this with the volume of air in the degasser until it is transferred to an analyser.

[0083] A top plate assembly is fitted to the degasser housing 29 with air seals. The mud entry port 19 is attached to the top plate 18 such that the mud will drop into a mud fragmentation chamber 21 below. There may be a top inspection port (not shown) to view the degasser internal mud flow patterns.

[0084] Inside the chamber 21 there is a spiral plate with slots and this will rotate with a cone 22. The spiral plate is designed so that the mud will be fragmented as it passes through the slots and the centrifugal force will throw it onto the chamber wall. The edge of the spiral plate will remove most of the mud but leave a mud smear on the chamber wall. The "wipe and smear" effect can release additional gas.

[0085] The fragmentation chamber may use a variety of different elements in order to assist in degassing the mud. In this embodiment a spiral shaped mesh plate 26 is provided and attached to the drive shaft 25 and spins. A bearing 6 remains stationary.

[0086] One alternative to the mesh plate26 is for the drive shaft 25 to be fitted with alternate rotating and non-rotating blades which lie within the fragmentation chamber 21 and in the case of the non-rotating blades, are secured thereon. Another alternative is profiled blades which cause the mud to switch direction. The cone 22 is also rotatably mounted on the drive shaft 25.

[0087] During normal operation, mud enters through the top of the fragmentation chamber 21 and impacts on the blades 26, 27 or slotted spiral plate and then drops into a well defined by the cone 22. The proximity of the chamber wall 21 and the cone base minimises any mud splashing outwith the fragmentation chamber 21.

[0088] The mud which reaches the cone well will start to spin along with the cone 22 and the centrifugal force will cause it to rise up the angled cone's 22 wall as a sheet and fall over a castellated top edge 28 and into the degasser base. Within the base of the degasser 30 there are studs 36 which are located in the outer wall of the cone and are used as part of the speed control system. They also spin the mud preventing debris build-up and encouraging the mud to exit through mud exit slot 37. Four circulation holes 31 spaced around the top assembly allow gas to be drawn therethrough and move above the fragmentation assembly 26.

[0089] The combined effect of the fragmentation chamber 21 and the cone 22 provides a very good degassing performance. The cone 22 also performs a secondary function as part of the sample sequence, as noted below. The mud passing through the exit slot 37 leads into a chamber with a weir plate 38. The main function of the weir 38 is to retain sufficient depth of mud within the degasser base to form an air seal and prevent loss of the gas and air inside degasser 10. The weir 38 comprises two upstanding metal plates welded to the base and the cone walls adjacent to the ends of exit slot 37. The plates then form a passageway between the mud exit slot 37 and a mud discharge hole 39 in the base plate 23. The weir 38 is fitted across the passageway with a height which maintains a suitable level of mud for the air seal. The weir 38 can have a straight edge to provide a visible mud exit flow or a V-shaped slot with a level senor above it to provide an indicator of exit mud flow.

[0090] A series of lines 32, 33 are connected to the degasser 20 via separate ports in in a sample valve 17.

[0091] Line 32 is a dilution line and will, as described below, purge the degasser of gas after a gas sample has been extracted. Line 33 connects the degasser to the mass spectrometer 50, and so delivers a gas pill thereto.

[0092] During the degassing mode ports in sample valve 17 isolate lines 32 and 33 from the degasser head and connect them together. This allows a continuous flow of clean and optionally heated air to be circulated through lines 32, 33. This conditions the lines and minimises any moisture or contamination problems. When the degasser switches back to sampling mode, the valves are operated to isolate the sample and dilution lines from each other.

[0093] Whilst the degasser 20 is operating in degassing mode, valves to lines. 32, 33 are closed and so any gas released from the mud builds up within the dilution air sealed inside the degasser 20 body. The air or gas within the degasser is continuously circulated and mixed by the action of the moving components attached to the drive shaft 25. Gas removed from the sample cannot escape from the degasser body because the fluid in the "base" is held in the body by action of the weir 38 which provides a barrier. This process continues, gas builds up within the dilution air until the metering vessel 30 reaches the correct level wherein a sensor will switch the degasser and system more generally from a degassing mode to a sampling mode.

[0094] A second embodiment of a degasser is shown in Fig. 5. Like parts share common reference numerals except prefixed with a '1' and are not described further.

[0095] Inside a chamber 121 there is a fragmentation assembly 126 located on the main drive shaft 125 which rotates within the fragmentation chamber 121.

[0096] The details of the fragmentation assembly 126 are best shown in Figs. 6a - 6d although for clarity the fragmentation chamber 121 which surrounds the fragmentation assembly 126 and is shown in Fig. 5, is not shown in Figs. 6a-6d. The fragmentation assembly 126 has three thin horizontal plates 162 welded to the hollow drive shaft 125. Two vertical metal strips 168 are welded to the edge of the rotating plates 152 and act as wipers which lift the mud off an inner wall of the fragmentation chamber 121 driving some back into the centre. The metal strips/wipers 168 are normally spaced around 2mm from the inner wall of the fragmentation chamber 121. This still functions to wipe the wall, but can also mitigates heat build-up and also provides some tolerance, and reduces wear.

[0097] Each plate has a number of segments 164 cut out. Two of the segments 166 on each plate have one edge still attached to the plate 162 but extending out of the plane thereof, such that when the attached segments 164 are bent along the attached edges, they act as fan blades/vanes to drive air and mud through holes at the top of the fragmentation chamber 121 then down and out through a gap between the fragmentation chamber 121 and the cone inner wall 122.

[0098] The combined action of "chopping" the mud via the segments 164 on the rotating plates 162 and the wiping action via the strips/wipers 168 produces a very effective mud degassing mechanism.

[0099] The fan blades 166 induce circulation of any gas and air mix down through the chamber and this will then be drawn back though the circulation holes 131. This arrangement provides a homogenous gas in air mix within the degasser whilst it is running.

[0100] The downstream functionality continues as descried for the earlier embodiment. Notably, in this embodiment, the top edge of the cone 122 does not have a castellated edge.

[0101] The mud passing through the exit slot 137 leads into a chamber with an adjustable weir pipe 138. The weir area comprises three upstanding plates (not shown) with the weir pipe 138 as a screw fit into the base 123. As the mud rises within the passageway it falls over the top of the weir 138 and discharges into a measuring vessel below. The height of the weir pipe 138 can be adjusted to suit different types of mud or conditions.

[0102] Whilst the degassers disclosed herein are typically used in a batch sampling system as described herein, they may also be used to degas fluid in a continuous measurement operation.

Metering Vessel

[0103] The metering vessel 30 is located directly below the degasser's base plate and the following description applies to both Fig. 4 and Fig. 5 embodiments, unless otherwise noted.

[0104] During the degassing mode, the mud exiting over the degasser weir 38 shown in the Fig. 4 embodiment will drop through a hole 39 in the degasser base plate and into the metering vessel 30 via a narrow vertical chamber terminating near its base. Similarly, in the Fig. 5 embodiments, the mud exits the degasser via the weir pipe 138 and discharges into the metering vessel 30 via a narrow vertical chamber terminating near its base.

[0105] At the other side of the metering vessel 30 there is a further chamber with a level measuring sensor mounted at the top. The combined effect of the two chambers provides a flat mud surface which is necessary for accurate ultrasonic level measurement. The base of the metering vessel 30 has a slope leading down to a mud return pump 35.

[0106] During the gas sampling mode and the purge period as described below the metering vessel 30 is emptied using a mud return pump 35 which drives the mud back to the ditch or the mud tanks.

[0107] Thus, as described above, the mud proceeds through the degasser 20, is degassed, and then proceeds into the metering vessel 30. This whilst the degasser 20 is degassing, the mud builds up in the vessel 30 until it reaches a pre-determined level where a sensor (not shown) triggers the gas sample batch sequence as detailed below. Thus the metering vessel 30 meters a fixed volume of mud , independent of any minor changes in the mud flow rate, and therefore provides a quantitative gas sample.

Gas Sampling Mode

[0108] When the sensor is triggered by the metering vessel 30, an activator in the system switches from degassing mode to sampling mode, and a number of different events occur.

[0109] Ports in the sample valve block 17 isolate the dilution 32 and sample 33 lines from each other and connect the sample line 33 to the degasser's head. A sample pump 52 then initiates the transfer of a volume of gas and air mixture as a sample pill from the degasser 10 to the mass spectrometer 50 in, for example, a logging cabin.

[0110] Meantime, the drive shaft 25 stops or slows causing the continuous flow of mud into the degasser 20 to accumulate in the cone 22. Since this is either rotating slowly or not rotating, there is less centrifugal force to direct the mud over the castellations 28. Also the continued flow of mud into the cone 22 and replaces the volume of gas extracted through line 33, keeping the pressure inside the degasser 20 constant.

[0111] As noted above the mud return pump 35 operates during the gas sampling and purge period to empty the metering vessel 30 and return the mud back to a ditch or tank.

[0112] During this period, the dilution line 32 is closed but a dilution pump (51) continues to run, thus causing pressure to build up in the line.

[0113] The system may be configured to also extract sufficient gas from the sample line 32 for an ISO tube 54 sample as well as the analyser buffer. The ISO tube sample is a reference sample which can be used to take back onshore and check on much larger analysers in order to confirm the results from the onsite mass spectrometer 50 or other analyser. When the gas sampling mode is complete, the system then switches from the sampling mode to a purge mode. The degasser 20 restarts and the rotation displaces the mud which has collected inside the cone 22. The dilution line 32 opens to allow the pressure which has built up therein to partially purge the degasser 20 and replace any mud volume displaced from the cone 22. After all the mud has been displaced from the cone 22 the dilution line 32 will continue to purge the degasser 20 for a period of time with the sample pump extracting the remains of the previous sample batch.

[0114] For certain embodiments, as an option we may use a clean air purge with a high flow to minimise the purge time and shorten the overall cycle time. This is timed to operate just as the cone 22 speeds up and when the volume of gas and air in the head is at the minimum level.

[0115] At the end of the purge mode the degasser line 33 is closed and returned to degassing mode and so isolate the head. The mud return pump 35 is stopped and a new degassing cycle commences. The sampling and purge mode may take, together, around 40 seconds.

[0116] Immediately before the new degassing batch commences a small quantity of a known gas may be injected into the head of the degasser using a metering valve. This is detected at the analyser and provides a useful gas sample time or quantity bench mark.

[0117] As part of this sequence a portion of the mud is not degassed or analysed and serves to pressure balance the system. In preferred embodiments, the blowback functionality described above, to clear the suction head 14, is timed to act such that the mud used (which may have accumulated over time and not be representative of the mud going through the system at that present time) is the mud which is not analysed. Thus there is no effect from the periodic blowback operation on the portion of the mud sample which is used as the sample batch.

Total gas monitoring option

[0118] As well as providing details on the qualitative characteristics of the gas obtained, the system may also include the facility to monitor the quantitative amount of gas, referred to as a "total gas" facility 60. Such embodiments are particularly suitable where this system is to be used in place of a full chromatography service (gas analysis and total gas monitoring) in a mud logging cabin.

[0119] In this arrangement the system can operate with a twin diaphragm mud pump such as the dual pump 12 shown in Fig. 1a. One mud stream exiting the pump will be directed to the batch degassing system as normal and the other mud stream will be directed to a degasser (not shown) which will operate in continuous mode. In this arrangement the continuous degasser will be located immediately above the header tank or the mud ditch such that the mud exiting the continuous degasser will drop into the tank or ditch.

[0120] The continuous degasser is optionally connected via a sample line to an adjacent box housing a zone 1 total gas (IR) detector and an H2S detector. A sample pump or an air venturi within the box draws air from a clean location and through the degasser head where it will mix with the gas extracted from the continuous mud flow. The gas and air mix passed through detectors inside the box and vent to a safe area. The output from the detectors can be connected to the system field interface and the data link to the instrument panel.

[0121] A significant advantage of this arrangement will be a correlation between the gas which is analysed as a batch and the gas which is measured continuously since they both use mud from a common pump.

[0122] In another arrangement the output from the detectors can be connected to a local control panel to provide a standalone service in the zone 1 area.

[0123] Thus for certain embodiments of the present invention may be used in lieu of the traditional gas chromatograph measurements, thus avoiding the requirement for two systems, the chromatographs also use substantial quantities of bottled hydrogen incurring space and logistic costs which can be avoided by utilising embodiments of a batch sampling mass spectrometer arrangement as described herein.

Mud Circulation Loop

[0124] During extended breaks in the drilling operations there may be insufficient mud at the suction point and the pumped mud system is stopped to avoid air being drawn into the system. Embodiments of the present invention provide a mud circulation tank 17 which the main pump 12 can use to circulate mud through the system intermittently or continuously. This can help to clean out the circulation system and also prevents the mud gelling. Under normal circumstances when only the mud already in the system is to be circulated, the mud in the tank 17 is not accessed, and the system operates with a bypass valve at the tank 17 open. The mud circulation can also assist with pump priming if mud is lost at the inlet filter during drill connections.

Control and Monitoring System

[0125] A control and monitoring system is provided which operates with a dedicated process control package with a connection to a system computer 60. The control function is used for process loops such as mud flow, mud temperature and mud volume. It also controls the gas sample sequencing routines.

[0126] Embodiments of the invention also have the ability to learn from operating experience and to develop a number of routines or set-ups for specific rig locations and mud conditions. For example special mud conditions, rig layouts or rig locations.

[0127] The monitoring function permits the operator to set normal operating and alarm levels for specific parameters or control loops. Any deviation outside the set limits can also be used as part of a dual level control system. A schematic display is provided for an operator or others who need to monitor the system, with a simple view of the system integrity and failure modes. The display has a slave option to permit the operator to work in another location if the logging unit is unsuitable. The monitoring function can be an important element for permitting single man operation with associated cost savings.

[0128] The monitoring system can also pass information such temperature, control loop status or standard operating routine numbers to the main computer 60 if it is necessary to annotate these on service logs.

[0129] Embodiments of the present invention are particularly useful because they can be used with a variety of different muds or drilling rig conditions. This provides a universal system compared to existing systems which tend to be bespoke depending in the type of mud or drilling rig with which they intend to be used.

[0130] For example, for deep drilled wells, the mud may be very cold and require more heating to provide a suitable sample for analysis.

[0131] In some instances it may be necessary to degas a quantity of mud at high temperatures. This can be achieved by holding a batch in the heater or operating with very low mud flows for short periods.

[0132] Another option is to process a batch of the mud which is being pumped into the well (mud in). This can use a separate mud pump accessing the active mud tank with a circulation and return loop which connects through the main mud system loop. When a 'mud in' analysis is required a quantity of mud will be diverted from the loop and through the main loop during a drill connection break. The monitoring and control system will be able to handle the data as a separate function.

[0133] In this way the difference between the gas present i n the mud before entry to the well and the gas present afterwards provides more accurate data on the gas obtained from the well and the nature of the well. An advantage of certain embodiment is that a single system may be used, and switched to analyse mud-in, during drill pipe connections. Thus in contrast to continuous systems the present batch system does not require a separate stand-alone system for analysing mud-in.

[0134] Such embodiments can easily compensate and increase the heating of the mud sample. Another example is where the mud has more gas than average, and the sensor on the metering vessel can be set to trigger the sampling sequence when less mud has been measured. Accordingly certain embodiments benefit in that a single adaptable system may be provided and its use modified in order to suit the particular conditions or requirements of the user.

[0135] Improvements and modifications may be made without departing from the scope of the invention. For example the analyser could be a gas chromatograph instead of a mass spectrometer. Nevertheless mass spectrometers are preferable. One advantage of a mass spectrometer compared to gas chromatograph is that they can discriminate inert gases such as helium as well as hydrocarbon gases. Moreover mass spectrometers can also pick up the isotopes in the sample, thus providing even more data to the user.

Claims

1. A system for analysing gas from a borehole, the system comprising:

    a. a degasser configured to degas drilling mud to remove at least a portion of gas therefrom;
    b. an analyser, in gas communication with the degasser, the analyser configured to analyse gas samples and provide information relating to the gas samples;
    c. the analyser being at least one of a gas chromatograph and a mass spectrometer; wherein the system is configured such that drilling mud is degassed in the degasser for at least twenty seconds, before at least a portion of gas removed therefrom is transferred to the analyser.

2. A system as claimed in claim 1, wherein the system is configured such that degassing occurs for at least forty seconds, optionally at least one minute.

3. A system as claimed in claim 1 or claim 2, wherein the system is configured such that the degassing occurs for less than five minutes.

4. A system as claimed in any preceding claim, wherein the analyser is a mass spectrometer.

5. A system as claimed in any preceding claim, wherein the degasser comprises a rotatable cone, and in use mud is directed into the cone.

6. A system as claimed in any preceding claim, wherein the degasser comprises a fragmentation chamber with a mechanism to facilitate degassing of fluids.

7. A system as claimed in claim 6 when dependent upon claim 5, wherein the fragmentation chamber is, in part at least, within the cone.

8. A system as claimed in claim 6 or claim 7, wherein the mechanism to facilitate degassing fluids includes rotating and/or non-rotating blades.

9. A system as claimed in any one of claims 6 or 8, wherein the mechanism to facilitate degassing fluids includes a slotted plate, optionally a spiral slotted plate.

10. A system as claimed in any preceding claim, comprising a metering vessel being adapted to meter an amount of drilling mud.

11. A system as claimed in claim 10, comprising an activation mechanism having a sensor and an activator; the sensor operable to sense an amount of drilling fluid in the metering vessel and the activator adapted to activate the transfer at least a portion of the removed gas to the analyser, when the amount of drilling mud reaches a certain pre-determined amount.

12. A system as claimed in claim 12, wherein the sensor is a level sensor to determine when a certain level of drilling mud is present in the metering vessel.

13. A system as claimed in any one of claims 10 to 12, which provides a rate of change of the mud level in the metering vessel.

14. A system as claimed in any one of claims 10 to 13, wherein in a sampling mode the system is configured to remove mud from the metering vessel.

15. A system as claimed in any preceding claim, comprising a pump to transfer mud from an input to the degasser.

16. A system as claimed in any preceding claim, comprising a heater apparatus to heat the mud, typically upstream of the degasser.

17. A system as claimed in claim 16, wherein the heater apparatus comprises a central heater element, an outer mud passage and a removable cover; such that the mud passage is defined, at least in part, by the removable cover and the central heater element.

18. A system as claimed in claim 17, wherein the mud passage is a spiral passage.

19. A system as claimed in any preceding claim, configured such that a transfer line to remove at least part of the gas from the degasser is closed to the degas-

ser during a degassing mode.

20. A system as claimed in any preceding claim, including a dilution line connected to the degasser, which is configured to have dilution gas pumped into it.

21. A system as claimed in claim 20 when dependent on claim 19, configured to allow the gas in the dilution line to circulate through the transfer line normally during a degasing mode.

22. A system as claimed in claim 20, when dependent on claim 19, configured to close any connection between a dilution line and a transfer line in a sampling mode.

23. A system as claimed in any one one of claims 20 to 22, wherein a pump to circulate the gas in the dilution line is configured to continuously operate during a sampling mode when the connection to the degasser is blocked, so as to build up pressure in the dilution line.

24. A system as claimed in any preceding claim, wherein during a purge mode, the system is configured to add dilution gas into the degasser.

25. A system as claimed in claim 24 configured such that a sampling mode and the purge mode together take more than 30 seconds, optionally less than a minute.

26. A system as claimed in any preceding claim, comprising an input upstream of the degasser, the input comprising a filter and a cleaning mechanism for the filter, the cleaning mechanism being configured to direct fluid through the filter in an opposite direction to the normal flow of fluids from the input to the degasser.

27. A system as claimed in claim 26, wherein the cleaning mechanism is configured to accumulate fluid from a line between the input and the degasser and periodically eject it through the filter in the said opposite direction.

28. A system as claimed in claim 26 or 27, wherein the cylinder's stroke uses an air operated vacuum device and the discharge stroke uses compressed air from an adjacent reservoir.

29. A system as claimed in any preceding claim, configured to degas at least 2 litres of drilling mud.

30. A system as claimed in any preceding claim, configured to degas at most 20 litres of drilling mud.

31. A system as claimed in any preceding claim, comprising a total gas monitoring facility.

32. A system as claimed in claim 31, comprising a pump which is configured to supply the degasser and the total gas monitoring facility.

33. A method for analysing gas from a borehole, the method comprising:

a. providing a system comprising a degasser in gas communication with an analyser;
b. in the degasser, degassing drilling mud to remove at least a portion of gas therefrom;
c. transferring at least a portion of the gas removed from the drilling mud to the analyser;
d. analysing at least a portion of the transferred gas using the analyser;
e. the analyser being at least one of a gas chromatograph and a mass spectrometer.

34. A method as claimed in claim 33, wherein the drilling mud is degassed in the degasser for at least twenty seconds, before being at least a portion of the gas is transferred to the analyser.

35. A method as claimed in claim 33 or claim 34, wherein the degasser is continuously supplied with drilling mud.

36. A method as claimed in any one of claims 33 to 35, wherein the borehole is in a hydrocarbon bearing formation.

37. A method as claimed in any one of claims 33 to 36, wherein the gas comprises hydrocarbon gas.

38. A degasser for degassing drilling mud, the degasser comprising a fragmentation chamber with a mechanism to facilitate degassing of fluids and a rotatable cone.

39. A cleaning mechanism for a system for analysing gas from a borehole, the cleaning mechanism being configured to accumulate fluid from the line between a filter and a pump and periodically direct it through the filter in the opposite direction to the normal flow of fluids from the filter to the degasser.

40. A heater apparatus for heating drilling mud , the heater apparatus comprising:

a central heater element,
an outer mud passage,
a removable cover; such that the mud passage is defined, at least in part, by the cover and the central heater element.

41. A feedback system for the system and method described herein, where data from one or more of the following variables is recorded:

(i) the nature of the mud;
(ii) nature and quantity of gas received;
(iii) the configuration of the sampling system;
(iv) mud sample rate;
wherein and said data is used to optimise later uses of the system.

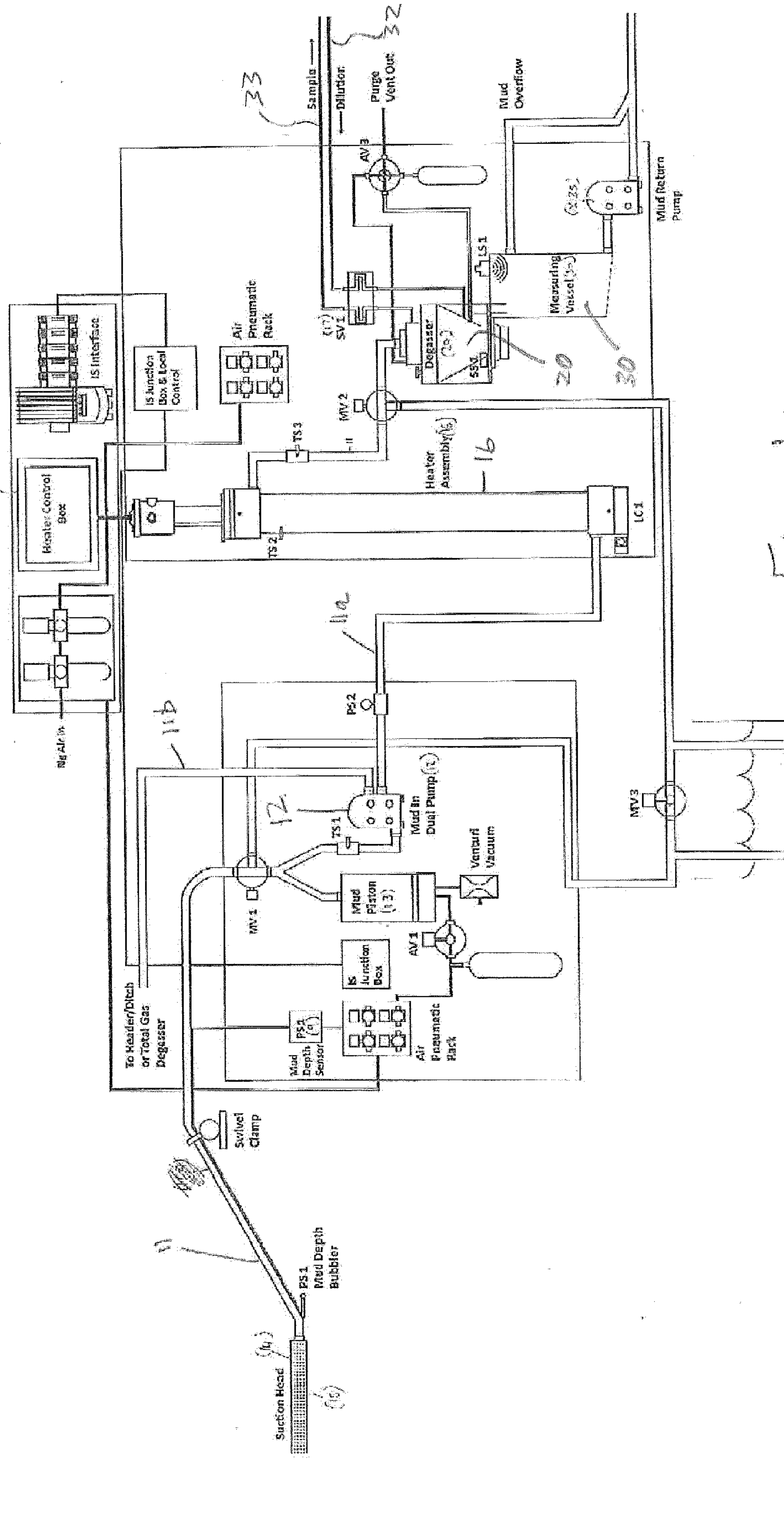
42. A feedback system as claimed in claim 41, wherein two, three or four of the data variables (i) to (iv) are used.

43. A feedback system as claimed in any one of claims 41 to 42, wherein the nature of the mud includes its temperature, viscosity, specific gravity and content.

44. A feedback system as claimed in any one of claims 41 to 43, wherein the data regarding the gas recovered from the mud includes its quantity and chemical composition.

45. A feedback system as claimed in any one of claims 41 to 44, wherein the data regarding the configuration of the sampling system includes the lengths of the connections between various components.

46. A feedback system as claimed in any one of claims 41 to 45, wherein the data regarding the sampling rate includes data on the time taken to process samples of mud.


Suction Head
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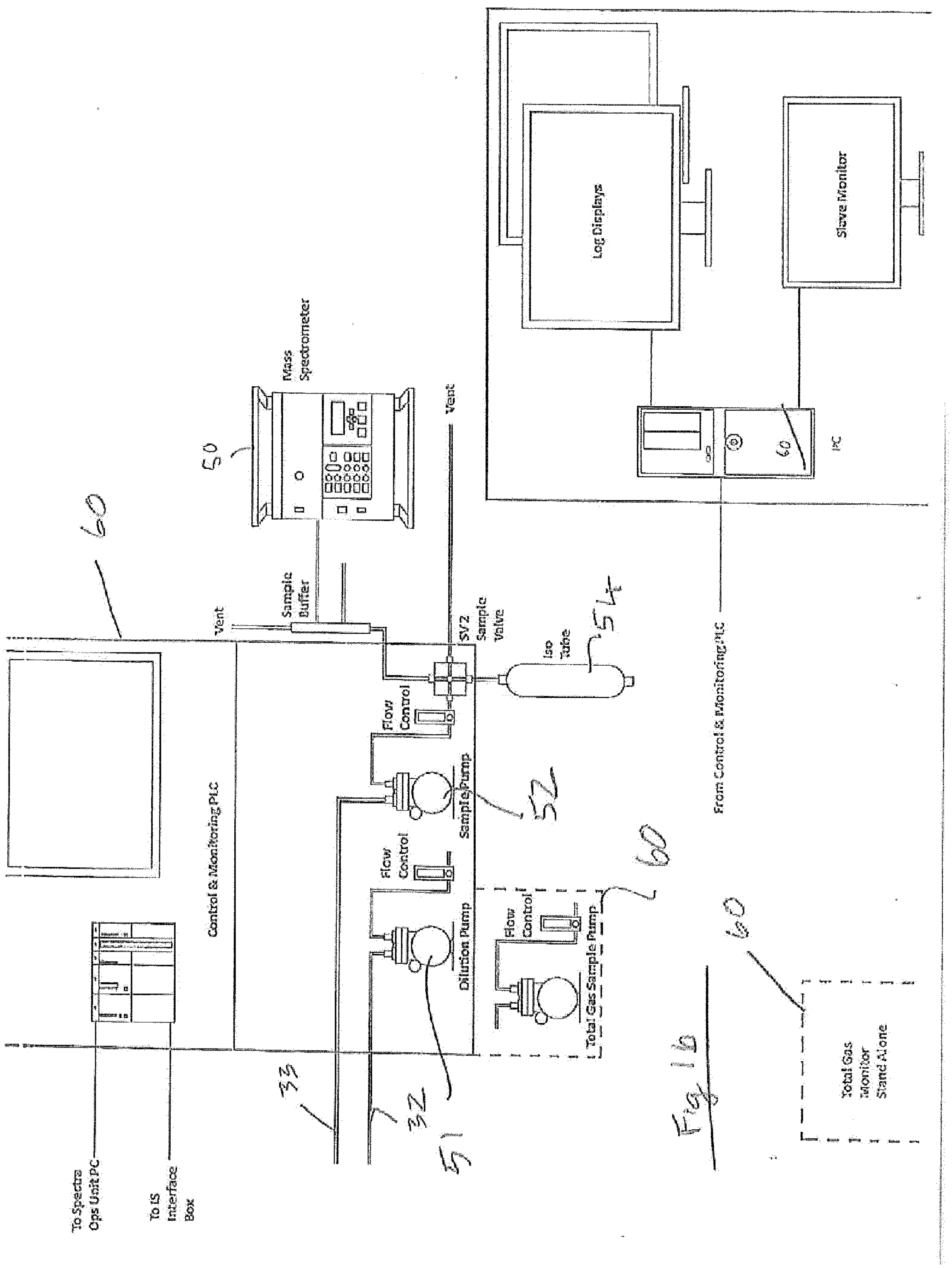
Swivel Clamp
To Header/Ditch or Total Gas Degasser
Mud Depth Sensor
Air Pneumatic Rack
IS Junction Box
Mud Piston
Venturi Vacuum
Mud In Dual Pump
Mud Circulation Tank
Rig Air in
Heater Control Box
IS Junction Box & Local Control
IS Interface
Air Pneumatic Rack
Heater Assembly
Degasser
Measuring Vessel
Mud Return Pump
Mud Overflow
Sample
Dilution
Purge Vent Out

Fig. 1a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Slave Monitor
PC
60
Mass Spectrometer
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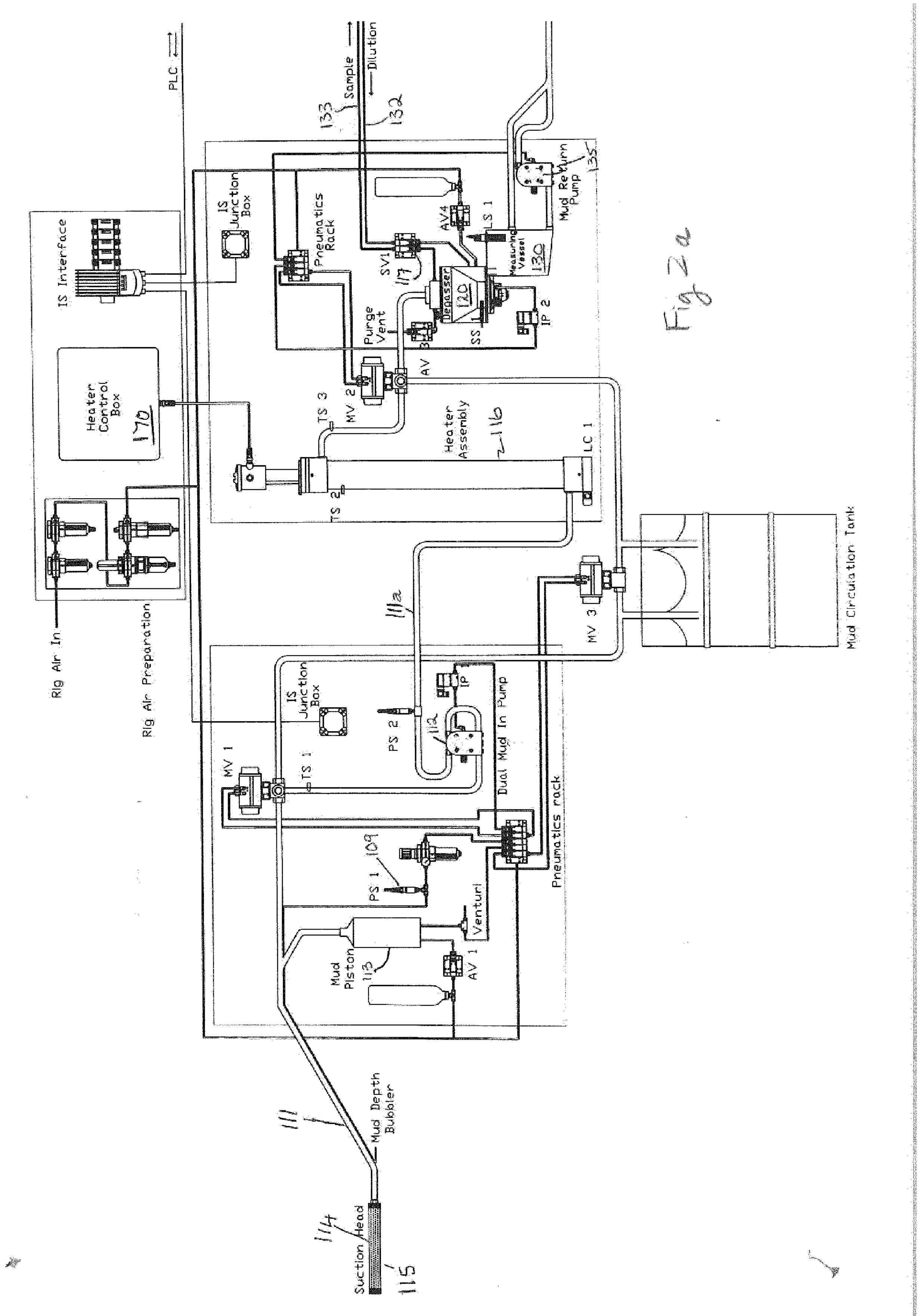
Vent
60
Vent
Sample Buffer
SV2 Sample Valve
Iso Tube
54
Flow Control
Sample Pump
52
Flow Control
Dilution Pump
Control & Monitoring PLC
Flow Control
Total Gas Sample Pump
60
From Control & Monitoring PLC
60
Total Gas Monitor Stand Alone
33
32
51
To Spectra Ops Unit PC
To IS Interface Box

Fig 1b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Dilution
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Pneumatics Rack
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Rig Air In
Rig Air Preparation
SV1
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AV4
LS 1
Mud Return Pump
135
Measuring Vessel
130
Degasser
120
Purge Vent
SS
IP 2
AV
MV 2
TS 3
Heater Assembly
116
LC 1
TS 2
Mud Circulation Tank
MV 3
111a
IS Junction Box
PS 2
112
IP
Dual Mud In Pump
MV 1
TS 1
Pneumatics rack
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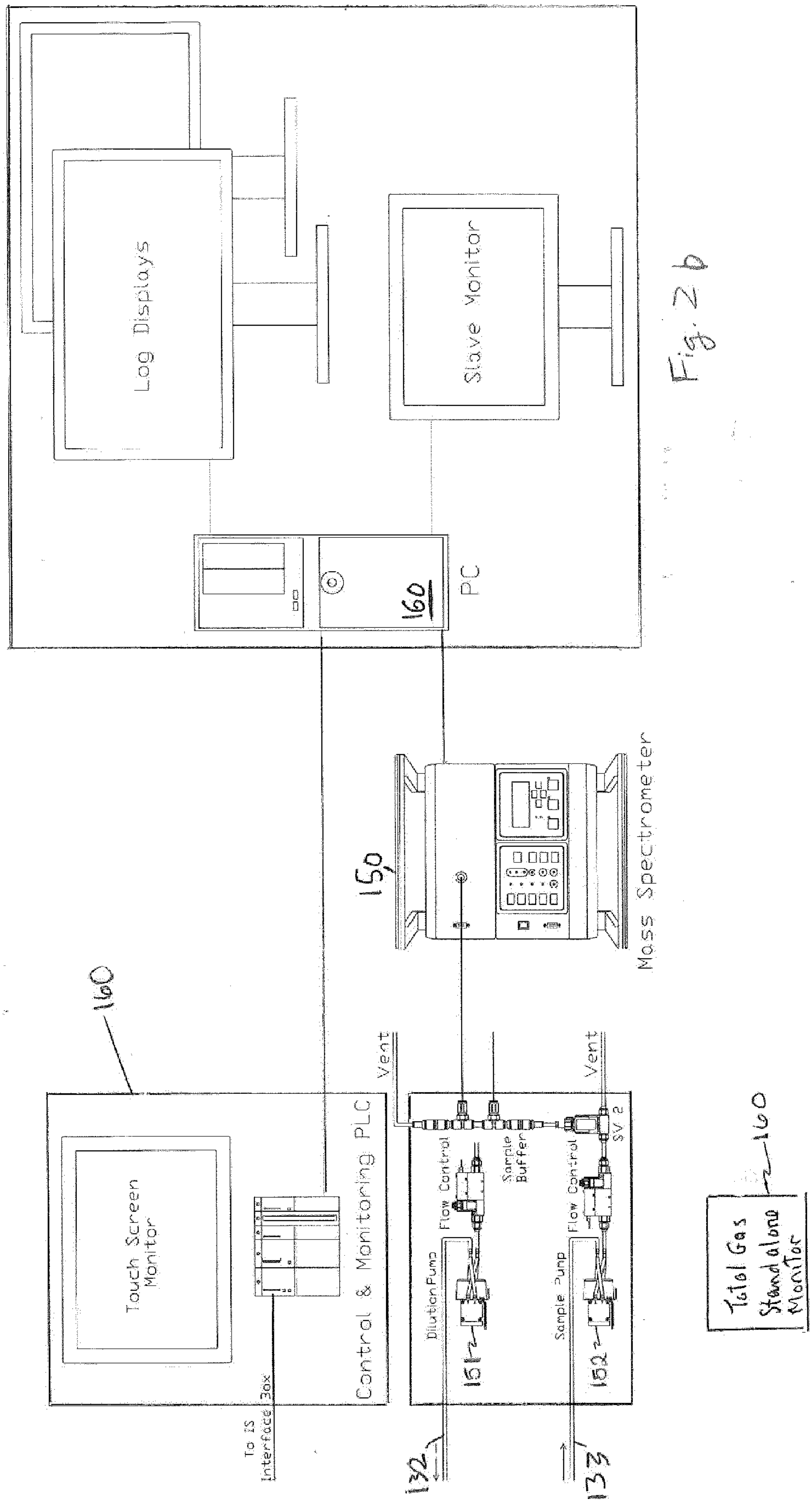
PS 1
Venturi
Mud Piston
113
AV 1
111
Mud Depth Bubbler
114
Suction Head
115
Fig 2a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Touch Screen Monitor
Control & Monitoring PLC
Vent
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Sample Pump
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To IS Interface Box
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Total Gas Standalone Monitor
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Fig. 2b

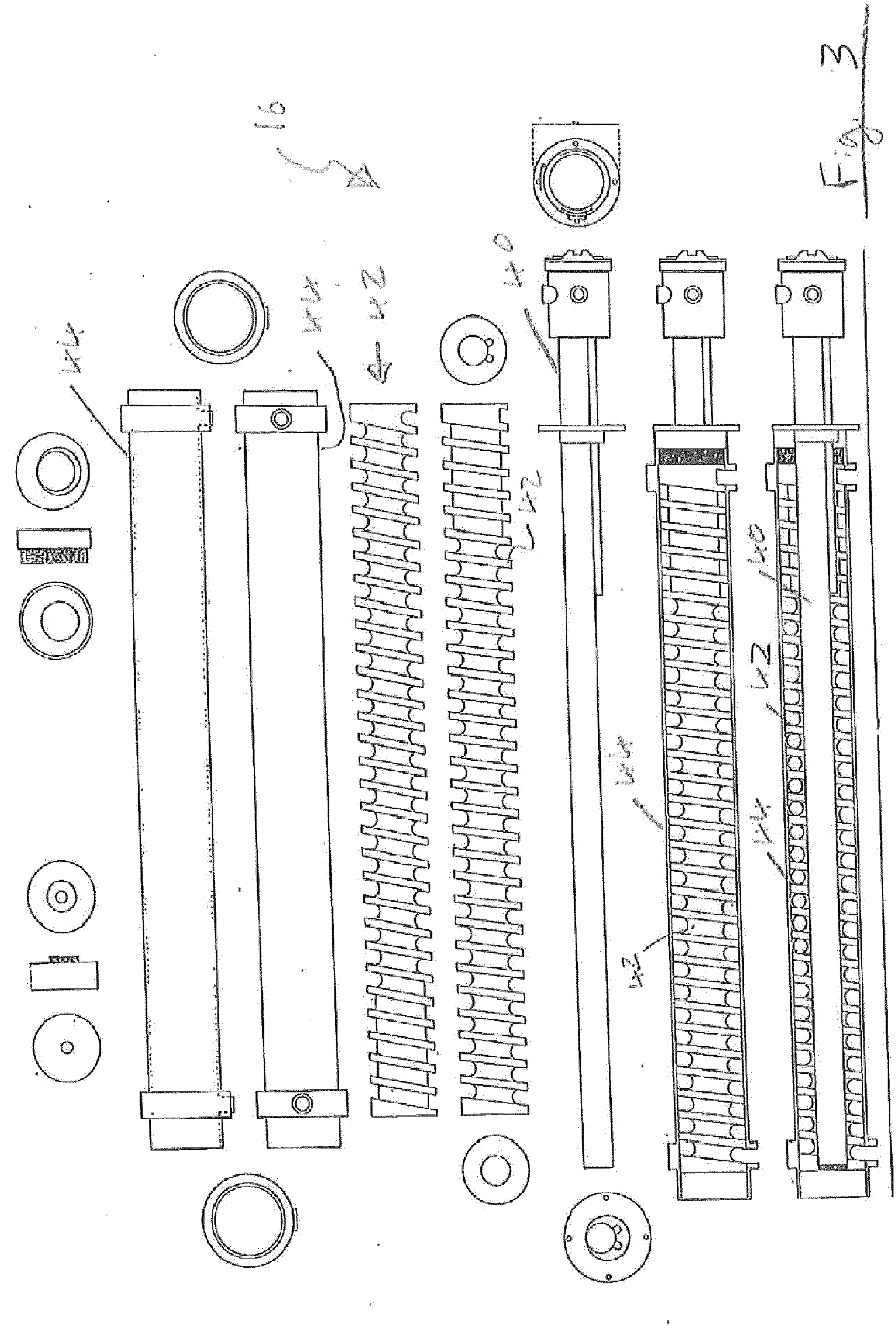

Fig. 3

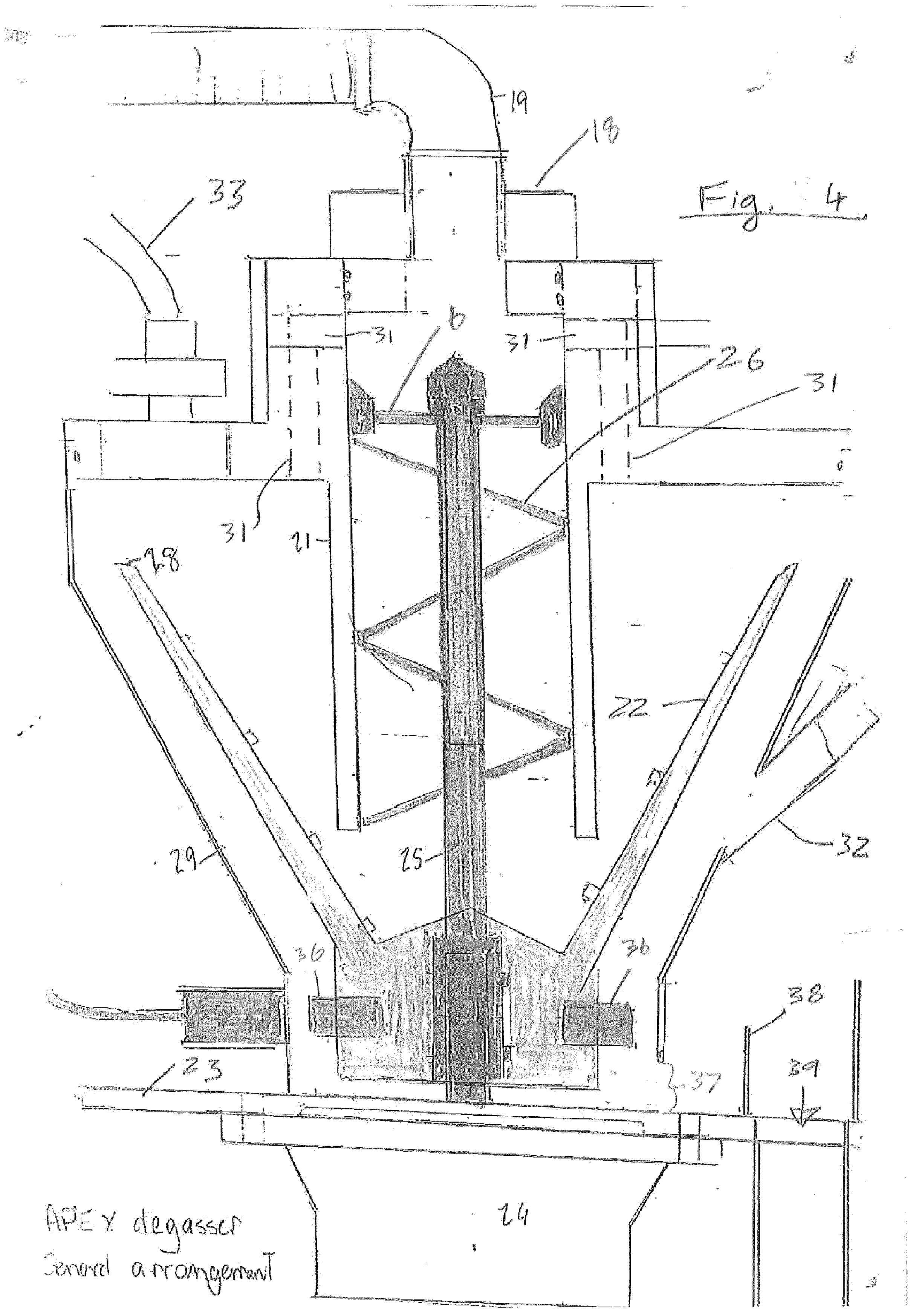
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Fig. 4
31
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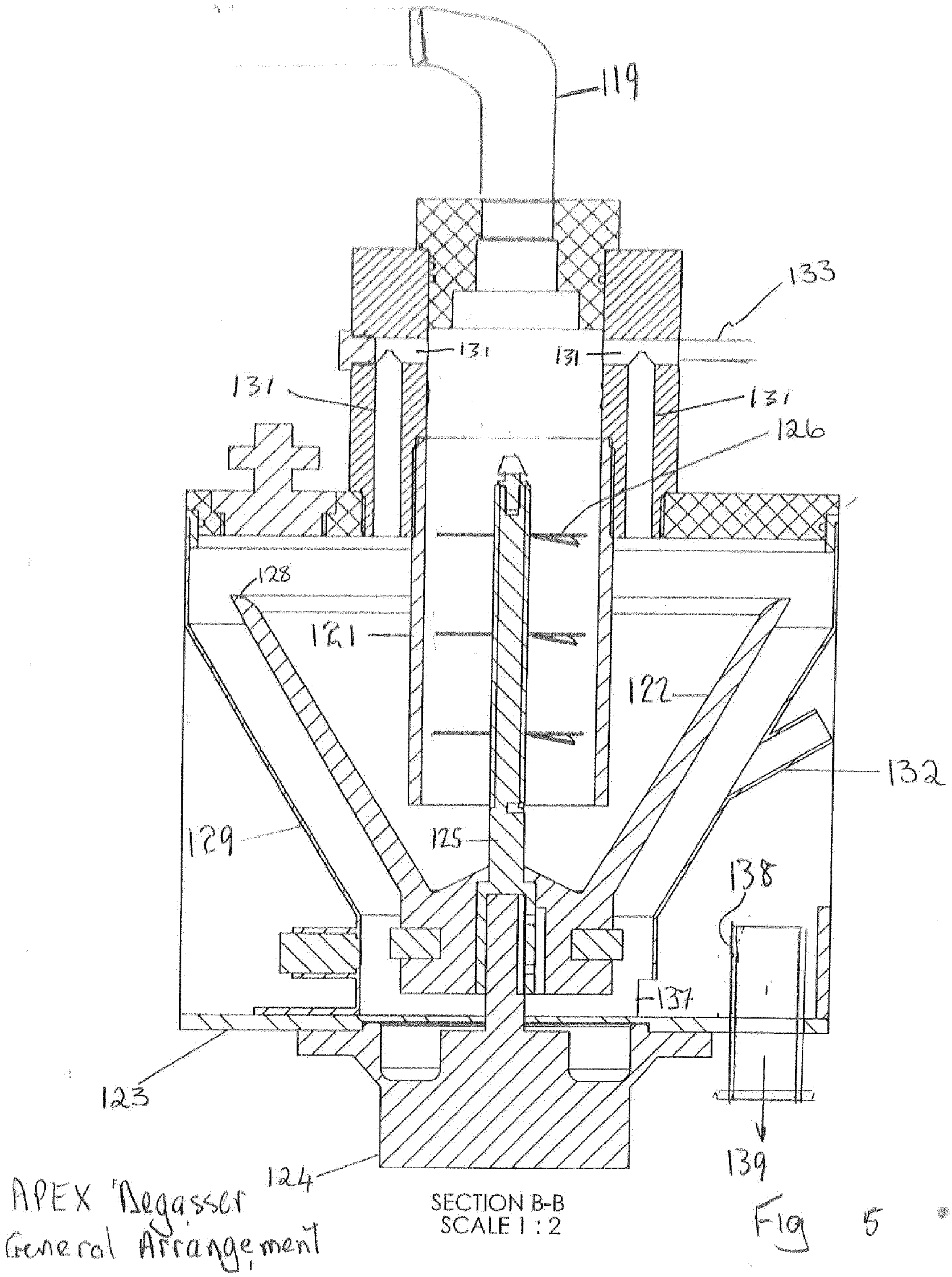
APEX degasser
General arrangement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APEX 'Degasser
General Arrangement
SECTION B-B
SCALE 1 : 2

Fig 5

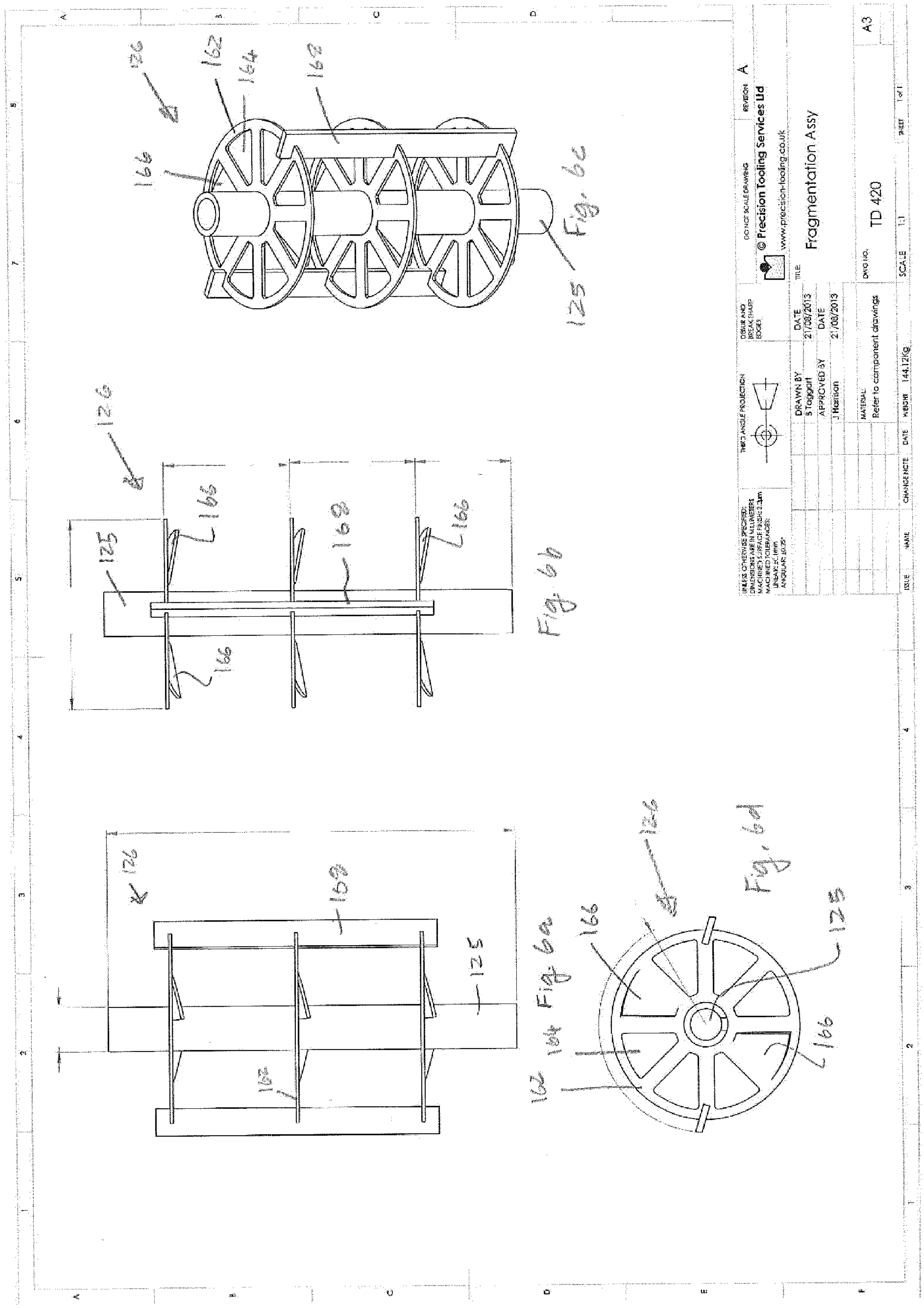
Fig. 6a
Fig. 6b
Fig. 6c
Fig. 6d
© Precision Tooling Services Ltd
www.precision-tooling.co.uk
Fragmentation Assy
TD 420
DRAWN BY
S Taggart
APPROVED BY
J Harrison
21/08/2013
Refer to component drawings
144.12Kg
A3

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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