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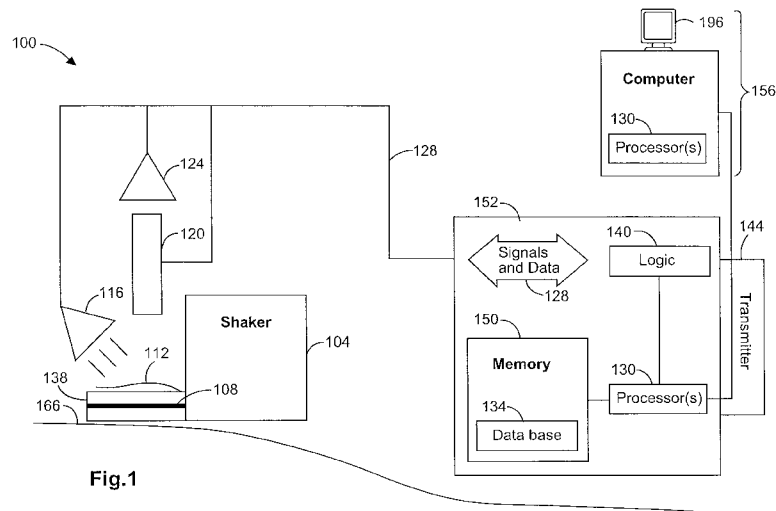


Fig.1

(57) **Abstract:** In some embodiments, an apparatus and a system, as well as a method and an article, may operate to acquire live video stream information from an imaging device, the information including down hole cuttings image information, and then to process the down hole cuttings image information to determine data that quantifies at least one of a shape, a size distribution, or a volume of the down hole cuttings. Further activities include publishing changes in the data in conjunction with probable conditions associated with a borehole drilling operation or a borehole pumping operation. Additional apparatus, systems, and methods are disclosed.

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DOWN HOLE CUTTINGS ANALYSIS

Background

[0001] Increasing the effectiveness of pumping, sweeping, and drilling
5 operations can reduce the cost of drilling wells for oil and gas exploration. One
way of determining the efficiency of these process is to observe the
characteristic features of down hole cuttings.

[0002] The traditional way of analyzing these cuttings is to catch a
representative sample of the cuttings, and to engage a human inspector in
10 visually reviewing the sample for physical changes. This method is slow, and
prone to human error.

Brief Description of the Drawings

[0003] FIG. 1 is a block diagram of an apparatus and system according to
15 various embodiments of the invention.

[0004] FIG. 2 illustrates a drilling rig system embodiment of the
invention.

[0005] FIG. 3 is a flow chart illustrating several methods according to
various embodiments of the invention.

20 [0006] FIG. 4 is a block diagram of an article according to various
embodiments of the invention.

Detailed Description

[0007] To address some of the challenges described above, as well as
25 others, apparatus, systems, and methods for automatic analysis of down hole
cuttings are described. Changes in data associated with features of the cuttings,
perhaps extracted to determine trends, can be used to provide information about
conditions surrounding drilling and pumping operations. In most embodiments,
this mechanism improves the accuracy of determining the effectiveness during
30 both types of operation, in real time. For example, monitoring real-time changes
in particle size distribution, particle shape distribution, and particle volume

changes using a relatively high data density can lead to increased sensitivity to changes in connections, sweeps, and drilling parameters.

- [0008]** More specifically, monitoring changes in formation cutting size, size distribution, shape, and volume during active drilling operations can lead to a better understanding of the current well condition, drilling effectiveness, and hole cleaning efficiency. The connection between changes in these parameters and operational conditions may be expressed in a number of ways, including:
- determining the existence of over-pressured formations by detecting an increase in cutting loads and changes in the size distribution of cuttings.
 - 10 - determining bit and drilling efficiency through analysis of cutting volume, size, and shape.
 - determining sweep efficiency by monitoring cutting volume during a sweep operation (e.g., the volume of cuttings increases with increasing sweep efficiency, and then decreases as cuttings are moved out of the hole).
 - 15 - determining changes in a geological formation composition by monitoring cutting size, size distribution, and shape.

[0009] Some further examples relate to drilling rig performance. Thus, detected changes in the baseline aspect ratio of shale, with an average diameter/length proportion of about 1/5 to 1/10, may indicate the mud weight that is too low. Changes in the shape of shale, such as its baseline angularity, with edges above 90 degrees (splinter) or below 90 degrees, or below 30 degrees, may indicate triangular/cubic/flat cuttings of fallen shale. Changes in a baseline size distribution (e.g., when 95% of shale samples are from .8 inches to 1.2 inches in average length), might indicate recirculating cuttings. Changes in size distribution may also indicate changes in morphology. Increases over the average volume of cuttings during drilling may indicate an increased rate of penetration; if the volume increases, and the rate of penetration doesn't, then a washout may have occurred. Outliers of an abnormal size may indicate drilling problems (e.g., increased metal cutting volume could indicate a broken bit).

25 **[0010]** In some embodiments, measurements of the size, shape, and volume of cuttings over time is binned, to separate and quantify the occurrence of various measurements. The binned measurements can be used to determine

an average, which is used to establish a baseline. Changes from the baseline can be alarmed at an operator's console, or displayed in conjunction with the current measurements, and used to change the execution of operations (e.g., putting more or less weight on the bit, or changing the composition of a drilling fluid) in some embodiments.

5
[0011] FIG. 1 is a block diagram of an apparatus 100 and system according to various embodiments of the invention. In many embodiments, the apparatus 100 comprises a combination of an imaging device 124 and one or more processors 130. The imaging device 124 and/or the processors 130 may be located above the surface 166 of a geological formation, perhaps forming part of a data acquisition system 152. In some embodiments, any of the components in FIG. 1 may be located below the surface 166.

[0012] The apparatus 100 may also include logic 140, perhaps comprising a programmable data acquisition subsystem. The logic 140 can be used to acquire live video stream information 128, and other data, such as information from down hole, including the depth of the drill bit during a drilling operation.

[0013] A memory 150, located above or below the surface 166, can be used to store acquired image data, as well as other data (e.g., perhaps in a database 134). The memory 150 is communicatively coupled to the processor(s) 130.

[0014] In some embodiments, the imaging device 124 may comprise one or more CCD (charge coupled device) cameras, including low light or infrared cameras, to be used in conjunction with one or more sources of illumination 116, such as white light, tungsten light, infrared light, or light emitting diodes (LEDs) to illuminate cuttings 112 deposited on a shaker 104, such as on a shaker screen 108. The cameras may be focused on the screen 108 to capture images of cuttings 112 as they move across one or more shakers 104.

[0015] One or more energy modification devices 120, such as polarizers, filters, and/or beam splitters may be interposed between the cuttings 112 and the imaging device 124 to reduce the number of wavelengths seen by the device 124. The reduction in wavelengths allows drilling fluid and additives that may

be in close proximity to the cuttings 112 to become relatively transparent, so that only the cuttings 112 are visible to the imaging device 124.

[0016] Imaging devices 124 can be connected to a data acquisition system 152, perhaps including the logic 140, and then to a computer (comprising one or more processors 130), or directly to a computer. The computer may use a three-dimensional (3D) face recognition program or particle size analysis program to measure and determine characteristics of the cuttings 112, such as size, volume, shape, etc. The live data can be analyzed in real-time by the software to provide shape and size distribution, along with the volume of the cuttings 112 coming over the shaker 104.

[0017] The illumination source 116 may comprise white lights for CCD cameras or near, mid, or far wave infrared lights, depending on the type of imaging device 124 that is used. The illumination source 116 may be used to intensify the image.

[0018] Optional energy modification device(s) 120, perhaps comprising polarizers, filters, and/or beam splitters may be chosen with respect to the type of drilling fluid that is used. Polarizers can be used to align light energy in either the P or S directions (so that the processed energy is p-polarized, or s-polarized), or to give a blend of P and S polarized energy. Beam splitters can be used to reduce the spectrum of the received energy to some selected range of wavelengths. Filters can be used to further narrow the range to a select spectrum prior to image detection.

[0019] The energy modification devices 120 may be adjustable to obtain good image contrast for detection of the cuttings 112 within a drilling fluid solution that has a dynamic composition. The selection of materials to use in the energy modification devices 120 may depend on the hazards of the environment, including the chemical solutions present. These materials may include glass, polymers, and metals, among others.

[0020] After energy emitted by the cuttings 112 is processed by the energy modification devices 120 (if present), the imaging device 124, such as a camera, receives the energy. The field of view, detection wavelength sensitivity,

and resolution of the imaging device 124 may be used to determine the number and type of devices 124 that are focused on the shaker 104.

[0021] Imaging devices may comprise, for example, a pco 4000 CCD camera from Adept Turnkey Pty Ltd. with 4008 x 2672 pixel resolution for the visible light spectrum. If the conditions are such that a high sensitivity line scan camera may be useful, a Piranha HS-80-08K40 camera or Piranha HS-40-04K40 camera, also from Adept Turnkey Pty Ltd. can be used. For near infrared imaging, an XEVA-FP A-1.7-640 camera from the LOT-Oriel Group Europe with an InGaAs array at 640 x 512 resolution can be used. For mid infrared imaging, a VarioTHERM® InSb camera from JENOPTIK Optical Systems Inc. with an InSb array at 640 x 512 resolution can be used. For far infrared detection, a Photon 640 camera from FLIR Systems, Inc. can be employed. Other devices can also be used.

[0022] The video stream information 128, or a processed form of the information, can be sent to a remote workstation 156 via coaxial cable. For longer data transmission distances, and to reduce the magnitude of possible interference, the information 128 may be converted to an optical format, and sent to the remote workstation 156 via fiber optic transmission. A transmitter 144 may be used to send the information 128, or a processed form of the information, to the workstation 156 via wires, fiber optics, or wirelessly.

[0023] Programs that provide face recognition and particle size analysis are commercially available. Three-dimensional face recognition software can be used to identify more than just the general shape of cuttings - the volume distribution of the cuttings can also be determined. The software can be trained or modified to identify cutting shapes, to determine volume distribution, and to provide data in a form that various monitoring software, such as Halliburton's INSITE Anywhere® web delivery system, can process.

[0024] These recognition and analysis programs include software that is similar to or identical to PAX-it image management and analysis software by MIS Inc. of Villa Park, IL and the Split-Online® automated digital image analysis system from Split Engineering LLC, as well as the SureMatch 3D facial recognition software suite available from Genex Technologies, Inc. of Bethesda,

MD. Other software and processing instructions may be used, based on technical needs and flexibility.

[0025] The acquired video stream information 128 can be processed by programs similar to or identical to the INSITE Anywhere® web delivery system for real-time trend analysis. The processed data, which can be stored in the memory 150 (e.g., in the database 134) includes particle size distribution, particle shape distribution, and cutting volume. Thus, many embodiments may be realized.

[0026] For example, an apparatus 100 may comprise an imaging device 124 and one or more processors 130. The imaging device 124 may be configured to acquire live video stream information 128 including down hole cuttings image information. The processor(s) 130 may be configured to process the down hole cuttings image information to determine data that quantifies the shape, size distribution, and/or volume of the down hole cuttings. The processor(s) 130 may also be configured to publish changes in the data in conjunction with probable conditions associated with a borehole drilling operation or a borehole pumping operation.

[0027] Elements can be added to the path of energy travel to selectively reduce the amount of energy received by the imaging device 124. Thus, the apparatus 100 may comprise polarizers, filters, or beam splitters to intercept energy reflected or emitted by the down hole cuttings 112, and to reduce the amount of the energy received by the imaging device 124.

[0028] One or more cameras can be used as the imaging device. Thus, the imaging device 124 may comprise one or more visible light cameras and/or infrared cameras. Additional embodiments may be realized.

[0029] For example, in FIG. 2 it can be seen how a system 264 may also form a portion of a drilling rig 202 located at the surface 204 of a well 206. Drilling of oil and gas wells is commonly carried out using a string of drill pipes connected together so as to form a drilling string 208 that is lowered through a rotary table 210 into a wellbore or borehole 212. Here a drilling platform 286 is equipped with a derrick 288 that supports a hoist.

5 [0030] The drilling rig 202 may thus provide support for the drill string 208. The drill string 208 may operate to penetrate the rotary table 210 for drilling the borehole 212 through subsurface formations 214. The drill string 208 may include a Kelly 216, drill pipe 218, and a bottom hole assembly 220, perhaps located at the lower portion of the drill pipe 218.

10 [0031] The bottom hole assembly 220 may include drill collars 222, a down hole tool 224, and a drill bit 226. The drill bit 226 may operate to create a borehole 212 by penetrating the surface 204 and subsurface formations 214. The down hole tool 224 may comprise any of a number of different types of tools including MWD tools, LWD tools, and others.

15 [0032] During drilling operations, the drill string 208 (perhaps including the Kelly 216, the drill pipe 218, and the bottom hole assembly 220) may be rotated by the rotary table 210. In addition to, or alternatively, the bottom hole assembly 220 may also be rotated by a motor (e.g., a mud motor) that is located down hole. The drill collars 222 may be used to add weight to the drill bit 226. The drill collars 222 may also operate to stiffen the bottom hole assembly 220, allowing the bottom hole assembly 220 to transfer the added weight to the drill bit 226, and in turn, to assist the drill bit 226 in penetrating the surface 204 and subsurface formations 214.

20 [0033] During drilling operations, a mud pump 232 may pump drilling fluid (sometimes known by those of ordinary skill in the art as "drilling mud") from a mud pit 234 through a hose 236 into the drill pipe 218 and down to the drill bit 226. The drilling fluid can flow out from the drill bit 226 and be returned to the surface 204 through an annular area 240 between the drill pipe
25 218 and the sides of the borehole 212. The drilling fluid may then be returned to the mud pit 234, where such fluid is filtered. In some embodiments, the drilling fluid can be used to cool the drill bit 226, as well as to provide lubrication for the drill bit 226 during drilling operations. Additionally, the drilling fluid may be used to remove subsurface formation 214 cuttings created by operating the drill
30 bit 226. It is the images of these cuttings that many embodiments operate to acquire and process.

[0034] Thus, referring now to FIGs. 1-2, it may be seen that in some embodiments, a system 264 may comprise a drilling mud screen 108 to receive drilling mud, and one or more image processing apparatus 100 as described previously. The image processing apparatus 100 may be configured to have a
5 field of view that includes the drilling mud screen 108, wherein the apparatus 100 includes one or more imaging devices 124 and one or more processors 130, operating as described previously.

[0035] The drilling mud screen may form part of a shaker deck, such as a shale shaker deck. Thus, the drilling mud screen 108 may be included in a
10 shaker deck 138.

[0036] The processed data (e.g., cutting shape, size, volume) can be displayed to show changes that have occurred, and the operational conditions that are likely to be associated with those types of changes. Thus, the system 264 may comprise a display 196 to display the changes and the probable
15 conditions. These conditions may be used to implement real-time control in some embodiments (e.g., if falling shale is indicated by a dramatic increase in cutting size and volume, the weight on the bit may be reduced, or drilling may be halted entirely).

[0037] A transmitter can be used to send the data (e.g., cutting shape, size, volume) to a remote location, such as a workstation 156, perhaps for
20 alarming, further processing/analysis, or real-time operational control. Thus, a system 264 may comprise a transmitter 144 to transmit at least a portion of the data to a remote processor. Many embodiments may thus be realized.

[0038] The apparatus 100, shaker 104, screen 108, cuttings 112, illumination sources 116, energy modification devices 120, imaging device 124, processors 130, database 134, shaker deck 138, logic 140, transmitter 144, memory 150, data acquisition system 152, workstation 156, display 196, drilling rig 202, well 206, drilling string 208, rotary table 210, borehole 212, Kelly 216, drill pipe 218, bottom hole assembly 220, collars 222, down hole tool 224, drill
30 bit 226, mud pump 232, hose 236, system 264, drilling platform 286, and derrick 288 may all be characterized as "modules" herein. Such modules may include hardware circuitry, and/or a processor and/or memory circuits, software program

modules and objects, and/or firmware, and combinations thereof, as desired by the architect of the apparatus 100 and system 264, and as appropriate for particular implementations of various embodiments. For example, in some embodiments, such modules may be included in an apparatus and/or system operation simulation package, such as a software electrical signal simulation package, a power usage and distribution simulation package, a power/heat dissipation simulation package, a communications simulation package, and/or a combination of software and hardware used to simulate the operation of various potential embodiments.

10 **[0039]** It should also be understood that the apparatus and systems of various embodiments can be used in applications other than for pumping and drilling operations, and thus, various embodiments are not to be so limited. The illustrations of apparatus 100 and systems 264 are intended to provide a general understanding of the structure of various embodiments, and they are not intended to serve as a complete description of all the elements and features of apparatus and systems that might make use of the structures described herein.

15 **[0040]** Applications that may include the novel apparatus and systems of various embodiments include electronic circuitry used in high-speed computers, communication and signal processing circuitry, modems, processor modules, embedded processors, data switches, and application-specific modules. Such apparatus and systems may further be included as sub-components within a variety of electronic systems, such as televisions, cellular telephones, personal computers, workstations, radios, video players, vehicles, signal processing for geothermal tools and smart transducer interface node telemetry systems, among others. Some embodiments include a number of methods.

20 **[0041]** For example, FIG. 3 is a flow chart illustrating several methods 311 according to various embodiments of the invention. The methods 311 may comprise processor-implemented methods, and may include, in some embodiments, acquiring down hole cuttings image information, and processing the information to produce data that quantifies or assists in characterizing selected drilling/pumping operational conditions. Changes in the data may be published and/or used to adjust the conduct of the operations in real-time,

perhaps using feedback control, the general concept of which is well-known to those of ordinary skill in the art.

5 [0042] Publishing can mean displaying data in human-readable form (on a screen or hardcopy printout), recording the data on an electronic medium (memory or disk), and/or transmitting the data to another location, where the data is received, and remotely displayed, stored, etc. The publication of changes may be based on variations in values of the received data, as compared to thresholds, and a look-up table correlating the type and amount of change in the data to the expected conditions that are associated with that type of change.

10 [0043] Pumping operations may occur along with drilling operations, or separately, to include sweeping operations that return solids from down hole to the surface. Drilling operations may comprise drilling cement, milling casing, or drilling into a new formation. In many cases, the apparatus, systems, and methods described herein will be active when mud pumps are turned on at the well site, and fluid is flowing over the shakers. Sweeps can be used to push cuttings along the wellbore, while gels and the positive lift from drilling fluids move the cuttings to the shakers where they can be imaged. Some examples of such operations will now be described.

15 [0044] Real Time Operations (e.g., active drilling or pumping): in these embodiments, use of the apparatus, systems, and methods may focus on mitigating well control issues (e.g., changes in cutting size can serve as an early indicator of pressure shales). Well cleaning issues, such as low volume cutting clearance, may be indicated by the volume of cuttings falling off, so that sweeps are adjusted in frequency, mud gel viscosity is changed, or the rate of penetration is adjusted, as is known to those of ordinary skill in the art. Thus, real time operations can make use of various apparatus, systems, and methods to change the operations based on the changes that are discovered. Drilling parameters can be corrected to mitigate well control, to lessen wellbore damage, and to assess the efficacy of hole cleaning.

25 [0045] Review Operations (e.g., post well review): in these embodiments, a historical record of how well the bit cut the formation can be used to influence future bit/cutter selection. BHA (bottom hole assembly)

design and well planning can be assisted by assessing the effectiveness of reamer/bit BHA configuration, in view of the historical cuttings record, including changes. Mud properties design can also be determined by the historical record. Thus, reviews can be used to assist in planning the creation of similar wells in similar fields better and faster, with less down time, along with mitigating known risks. Other embodiments may be realized.

5 [0046] For example, the cuttings can be swept from the bore hole to appear before the imaging device (e.g., on a shaker screen). Thus, a method 311 may begin at block 321 with pumping fluid into a borehole to move the down hole cuttings into the field of view of a selected imaging device.

[0047] The method 311 may continue on to block 325 with acquiring live video stream information from the imaging device, the information including down hole cuttings image information. The cuttings image information can be acquired as the cuttings pass over a drilling mud screen.

15 Thus, the activity at block 325 may comprise acquiring the information from the imaging device having a field of view that includes a drilling mud screen.

[0048] The energy received by the imaging device can be adjusted, prior to receipt. Thus, the method 311 may continue on to block 329 to include reducing the number of the wavelengths of light used to create the live video stream information, prior to further processing. For example, the energy received by the imaging device can be adjusted to reduce or eliminate the contribution of drilling mud to the image feed, and increase the contribution of the down hole cuttings to the image feed. Therefore, when the live video stream information includes drilling mud image information, the activity at block 329

20 may include reducing the number of the wavelengths of light to separate the drilling mud image information from the down hole cuttings image information.

[0049] The method 311 may continue on to block 333 to include processing the down hole cuttings image information to determine data that quantifies at least one of a shape, a size distribution, or a volume of the down hole cuttings.

25 30

[0050] Quantifying data can be determined by supplying the down hole cuttings information to a particle size analysis program. Thus, the activity at

block 333 may comprise processing the information using a particle size analysis algorithm.

[0051] Quantifying data can also be determined by supplying the down hole cuttings information to a face recognition program. Thus, the activity at
5 block 333 may comprise processing the information using a three-dimensional facial recognition algorithm. In some embodiments, particle size analysis and recognition are combined.

[0052] The data (e.g., values of shape, size, volume) can be segregated into bins to more easily determine the distribution of the data in real time. Thus,
10 the activity at block 333 may comprise binning the data to provide the size distribution of the cuttings, for example.

[0053] The data (e.g., values of shape, size, volume) can be sent on a continuous basis to other locations. Thus, the method 311 may continue on to
15 block 337 to include substantially continuously transmitting at least a portion of the data to a remote location.

[0054] The data can be sent directly to a logging program, such as the log viewer software provided in conjunction with Halliburton's INSITE Anywhere® service. Thus, the activity at block 337 may comprise transmitting
at least a portion of the data to a real time log monitoring application program.

[0055] The existence of changes in the data may be evaluated at block
20 341. If no substantial changes are detected in the monitored values of data that that quantify the shape, size distribution, and/or volume of the down hole cuttings, the method 311 may return back to block 321. On the other hand, if data change thresholds have been crossed, as determined at block 341, the
25 method 311 may continue on to block 345, with accessing a decision table.

[0056] The decision table can be used to direct pumping and/or drilling operations. For example, changes of less than a preselected degree may be ignored. Changes of a greater magnitude may result in the method 311
continuing on to block 349 with publishing the changes in the data, in
30 conjunction with probable conditions associated with a borehole drilling operation or a borehole pumping operation.

[0057] Trends in the data (e.g., consistent changes in shape, size, volume, according to threshold amounts of change of a selected time interval or intervals) can indicate progress or problems in an operation. Thus, the changes in data can be monitored as trends, and the trends can also be published for
5 observation and action. Thus, the activity at block 349 may comprise publishing trends in the data.

[0058] The changes in shape, size distribution, or volume of the down hole cuttings can be correlated to a number of operational conditions. Thus, the conditions associated with the borehole drilling or borehole pumping operations
10 may comprise one or more of rate of penetration, formation pore pressure, weight on bit, drill pipe torque, or drilling angle.

[0059] The changes in shape, size distribution, or volume of the down hole cuttings can also be correlated to operational efficiency, such as drill bit cutting efficiency, or sweeping efficiency. Thus, a running indication of
15 efficiency can be published, if desired. Therefore, the activity at block 349 may comprise indicating an efficiency of a borehole drilling operation or a borehole pumping operation as a sweeping operation, based on the data.

[0060] It should be noted that the methods described herein do not have to be executed in the order described, or in any particular order. Moreover,
20 various activities described with respect to the methods identified herein can be executed in iterative, serial, or parallel fashion. The various elements of each method (e.g., the methods shown in FIG. 3) can be substituted, one for another, within and between methods. Information, including parameters, commands, operands, and other data, can be sent and received in the form of one or more
25 carrier waves.

[0061] Upon reading and comprehending the content of this disclosure, one of ordinary skill in the art will understand the manner in which a software program can be launched from a computer-readable medium in a computer-based system to execute the functions defined in the software program. One of
30 ordinary skill in the art will further understand the various programming languages that may be employed to create one or more software programs designed to implement and perform the methods disclosed herein. The programs

may be structured in an object-orientated format using an object-oriented language such as Java or C#. Alternatively, the programs can be structured in a procedure-orientated format using a procedural language, such as assembly or C. The software components may communicate using any of a number of mechanisms well known to those skilled in the art, such as application program interfaces or interprocess communication techniques, including remote procedure calls. The teachings of various embodiments are not limited to any particular programming language or environment. Thus, other embodiments may be realized.

10 **[0062]** For example, FIG. 4 is a block diagram of an article 400 according to various embodiments of the invention, such as a computer, a memory system, a magnetic or optical disk, or some other storage device. The article 400 may include one or more processors 416 coupled to a machine-accessible medium such as a memory 436 (e.g., removable storage media, as well as any tangible, non-transitory memory including an electrical, optical, or 15 electromagnetic conductor) having associated information 438 (e.g., computer program instructions and/or data), which when executed by one or more of the processors 416, results in a machine (e.g., the article 400) performing any actions described with respect to the methods of FIG. 3, the apparatus of FIG. 1, and the systems of FIG. 2. The processors 416 may comprise one or more processors sold by Intel Corporation (e.g., Intel® Core™ processor family), Advanced Micro Devices (e.g., AMD Athlon™ processors), and other semiconductor manufacturers.

[0063] In some embodiments, the article 400 may comprise one or more processors 416 coupled to a display 418 to display data processed by the processor 416 and/or a wireless transceiver 420 (e.g., a down hole telemetry transceiver, or a local transmitter coupled to a data acquisition system) to receive and transmit data processed by the processor to another (remote) system.

20 **[0064]** The memory system(s) included in the article 400 may include memory 436 comprising volatile memory (e.g., dynamic random access memory) and/or non-volatile memory. The memory 436 may be used to store data 440 processed by the processor 416.

[0065] In various embodiments, the article 400 may comprise communication apparatus 422, which may in turn include amplifiers 426 (e.g., preamplifiers or power amplifiers) and one or more antenna 424 (e.g., transmitting antennas and/or receiving antennas). Signals 442 received or
5 transmitted by the communication apparatus 422 may be processed according to the methods described herein.

[0066] Many variations of the article 400 are possible. For example, in various embodiments, the article 400 may comprise a down hole tool, including the apparatus 100 shown in FIG. 1. In some embodiments, the article 400 is
10 similar to or identical to the apparatus 100 shown in FIG. 1.

[0067] Using the apparatus, systems, and methods disclosed herein may provide the ability to monitor changes in down hole cuttings, so that the impact of drilling fluid properties and activities in the field can be assessed immediately. This ability may be used to increase efficiency by redirecting pumping and
15 drilling operations in real-time, perhaps as part of a closed-loop control system. Greater customer satisfaction may result.

[0068] The accompanying drawings that form a part hereof, show by way of illustration, and not of limitation, specific embodiments in which the subject matter may be practiced. The embodiments illustrated are described in
20 sufficient detail to enable those skilled in the art to practice the teachings disclosed herein. Other embodiments may be utilized and derived therefrom, such that structural and logical substitutions and changes may be made without departing from the scope of this disclosure. This Detailed Description, therefore, is not to be taken in a limiting sense, and the scope of various embodiments is
25 defined only by the appended claims, along with the full range of equivalents to which such claims are entitled.

[0069] Such embodiments of the inventive subject matter may be referred to herein, individually and/or collectively, by the term "invention" merely for convenience and without intending to voluntarily limit the scope of
30 this application to any single invention or inventive concept if more than one is in fact disclosed. Thus, although specific embodiments have been illustrated and described herein, it should be appreciated that any arrangement calculated to

achieve the same purpose may be substituted for the specific embodiments shown. This disclosure is intended to cover any and all adaptations or variations of various embodiments. Combinations of the above embodiments, and other embodiments not specifically described herein, will be apparent to those of skill
5 in the art upon reviewing the above description.

[0070] The Abstract of the Disclosure is provided to comply with 37 C.F.R. § 1.72(b), requiring an abstract that will allow the reader to quickly ascertain the nature of the technical disclosure. It is submitted with the understanding that it will not be used to interpret or limit the scope or meaning
10 of the claims. In addition, in the foregoing Detailed Description, it can be seen that various features are grouped together in a single embodiment for the purpose of streamlining the disclosure. This method of disclosure is not to be interpreted as reflecting an intention that the claimed embodiments require more features than are expressly recited in each claim. Rather, as the following claims
15 reflect, inventive subject matter lies in less than all features of a single disclosed embodiment. Thus the following claims are hereby incorporated into the Detailed Description, with each claim standing on its own as a separate embodiment.

20

Claims

What is claimed is:

1. A processor-implemented method, comprising:
 - acquiring live video stream information from an imaging device, the information including down hole cuttings image information;
 - processing the down hole cuttings image information to determine data that quantifies at least one of a shape, a size distribution, or a volume of the down hole cuttings; and
 - publishing changes in the data in conjunction with probable conditions associated with a borehole drilling operation or a borehole pumping operation.
2. The method of claim 1, wherein the acquiring further comprises:
 - acquiring the information from the imaging device having a field of view including a drilling mud screen.
3. The method of claim 1, wherein the processing comprises:
 - processing the information using a particle size analysis algorithm.
4. The method of claim 1, wherein the processing comprises:
 - processing the information using a three-dimensional facial recognition algorithm.
5. The method of claim 1, further comprising:
 - substantially continuously transmitting at least a portion of the data to a remote location.
6. The method of claim 5, wherein the transmitting further comprises:
 - transmitting at least a portion of the data to a real time log monitoring application program.

7. The method of claim 1, further comprising:
 - pumping fluid into a borehole to move the down hole cuttings into a field of view of the imaging device.
8. The method of claim 1, further comprising:
 - reducing a number of the wavelengths of light used to create the live video stream information, prior to the processing.
9. The method of claim 8, wherein the live video stream information includes drilling mud image information, and wherein the reducing further comprises:
 - reducing the number of the wavelengths of light to separate the drilling mud image information from the down hole cuttings image information.
10. The method of claim 1, wherein the processing comprises:
 - binning the data to provide the size distribution of the cuttings.
11. The method of claim 1, wherein publishing the changes comprises:
 - publishing trends in the data.
12. The method of claim 1, wherein the conditions comprise at least one of:
 - rate of penetration, formation pore pressure, weight on bit, drill pipe torque, or drilling angle.
13. The method of claim 1, further comprising:
 - indicating an efficiency of the borehole drilling operation or the borehole pumping operation as a sweeping operation, based on the data.
14. An apparatus, comprising:
 - an imaging device to acquire live video stream information including down hole cuttings image information; and

a processor to process the down hole cuttings image information to determine data that quantifies at least one of a shape, a size distribution, or a volume of the down hole cuttings, and to publish changes in the data in conjunction with probable conditions associated with a borehole drilling operation or a borehole pumping operation.

15. The apparatus of claim 14, further comprising:

at least one of a polarizer, a filter, or a beam splitter to intercept energy reflected or emitted by the down hole cuttings, and to reduce an amount of the energy received by the imaging device.

16. The apparatus of claim 14, wherein the imaging device comprises:

at least one of a visible light camera or an infrared camera.

17. A system, comprising:

a drilling mud screen to receive drilling mud; and

an image processing apparatus having a field of view including the drilling mud screen, the apparatus including an imaging device to acquire live video stream information including down hole cuttings image information, and a processor to process the down hole cuttings image information to determine data that quantifies at least one of a shape, a size distribution, or a volume of the down hole cuttings, and to publish changes in the data in conjunction with probable conditions associated with a borehole drilling operation or a borehole pumping operation.

18. The system of claim 17, wherein the drilling mud screen is included in a shaker deck.

19. The system of claim 17, further comprising:

a display to display the changes and the probable conditions.

20. The system of claim 17, further comprising:

a transmitter to transmit at least a portion of the data to a remote processor.

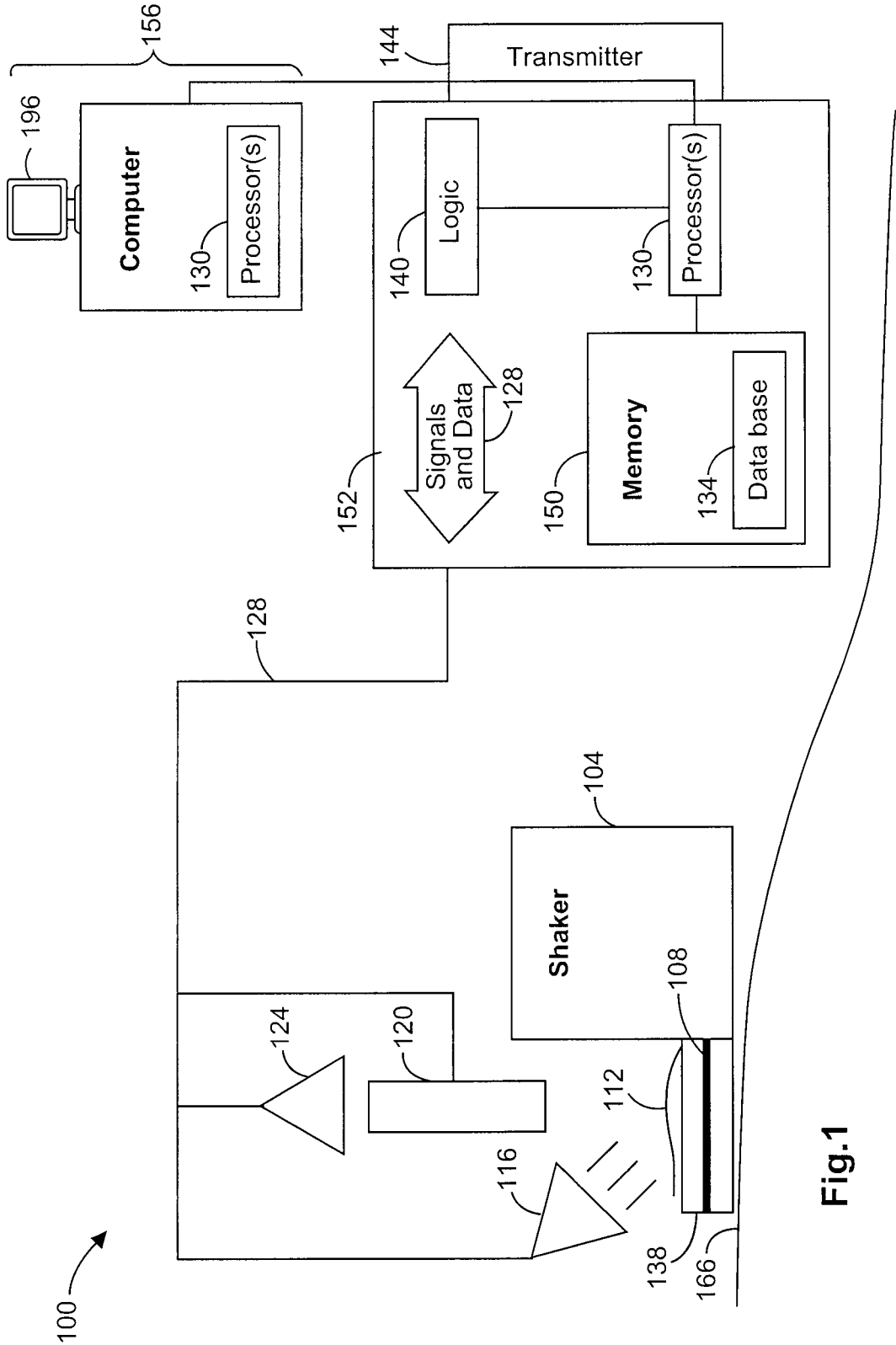


Fig.1

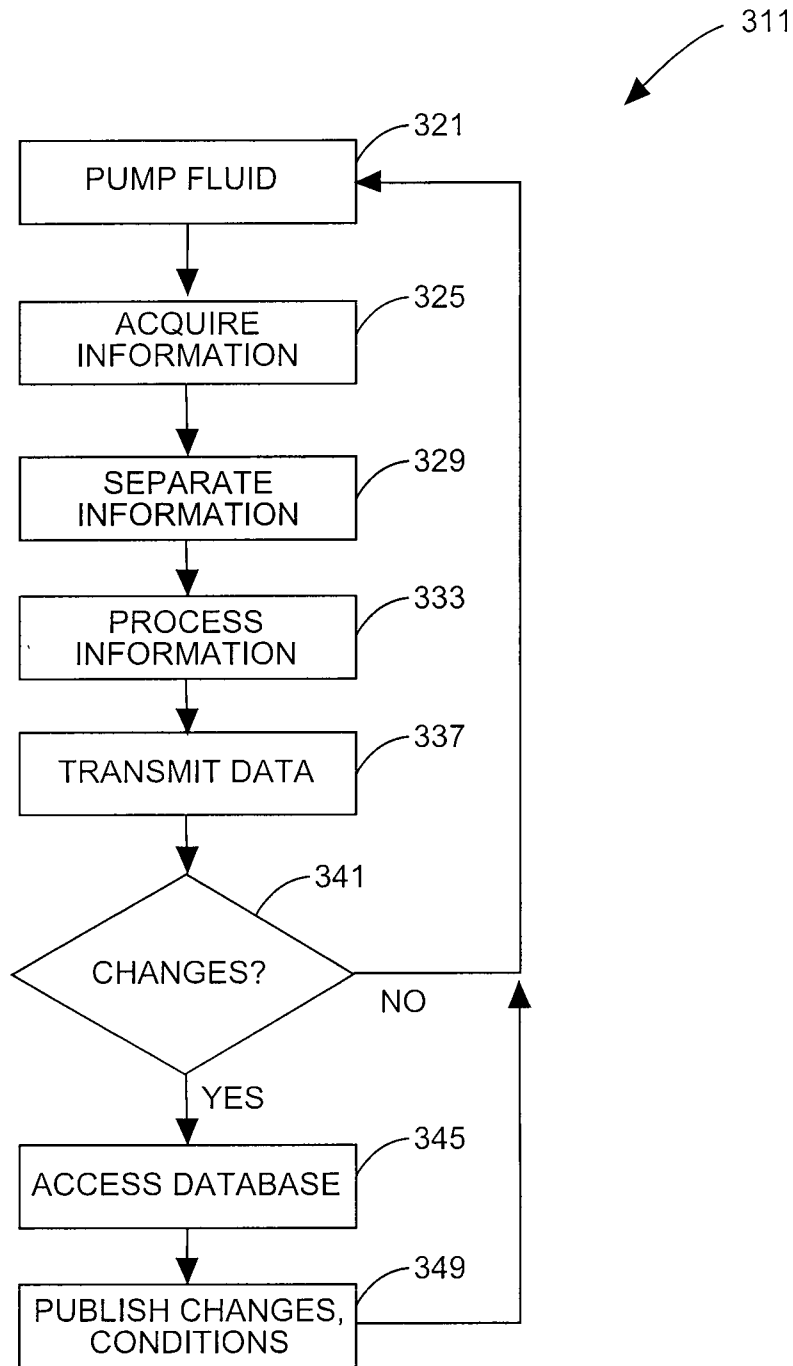


Fig.3

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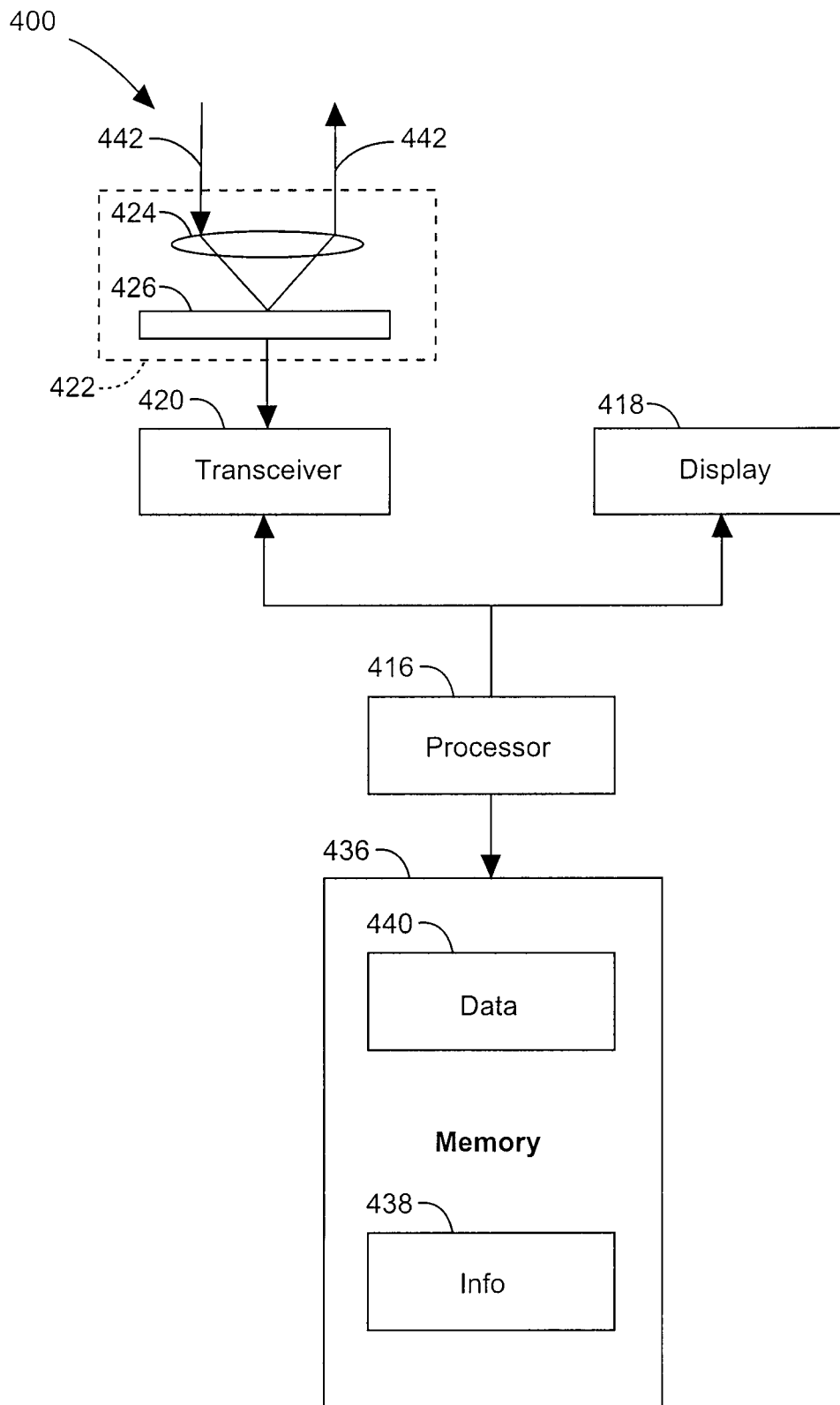


Fig.4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US201 1/0646 44

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - H04N 7/1 8 (201 2.01)
USPC - 348/85

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(8) - E21B 43/16, 43/26, 47/00, 47/002; H04N 7/18 (2012.01)
USPC - 166/250.01 ; 348/85, E07.085

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 practicable, search terms used)

PatBase, Google Patents, Google Scholar

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2009/008791 1 A 1 (RAMOS) 02 April 2009 (02.04.2009) entire document	1-20
Y	US 201 1/0272144 A 1 (BELCHER et al) 10 November 201 1 (10.1 1.201 1) entire document	1-20
Y	US 2007/0165225 A 1 (TRAINER) 19 July 2007 (19.07.2007) entire document	3, 10
Y	US 7,835,568 B2 (PARK et al) 16 November 2010 (16.1 1.2010) entire document	4
Y	US 7,446,885 B2 (ZABOLITZKY et al) 04 November 2008 (04.1 1.2008) entire document	13
A	US 2005/0216197 A 1 (ZAMORA et al.) 29 Sempiember 2005 (29.09.2005) para 0007, 0015, 0033, 0035, 0043, 0066-0069, fig 5, 7	1-20
A	US 6,386,297 B 1 (COOLEY et al) 14 May 2002 (14.05.2002) col 3, lines 9-22	1-20

Further documents are listed in the continuation of Box C.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

23 March 2012

Date of mailing of the international search report

29 MAR 2012

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