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(54) APPARATUS AND METHOD FOR COMMUNICATING INFORMATION BETWEEN A WELLBORE AND SURFACE

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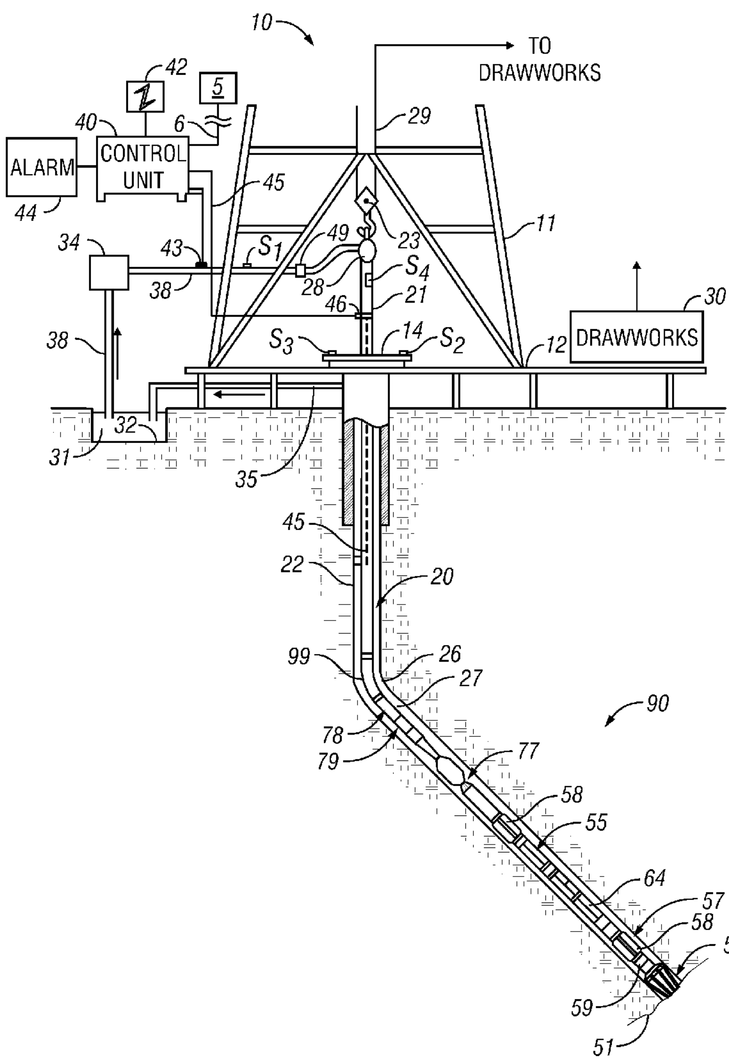
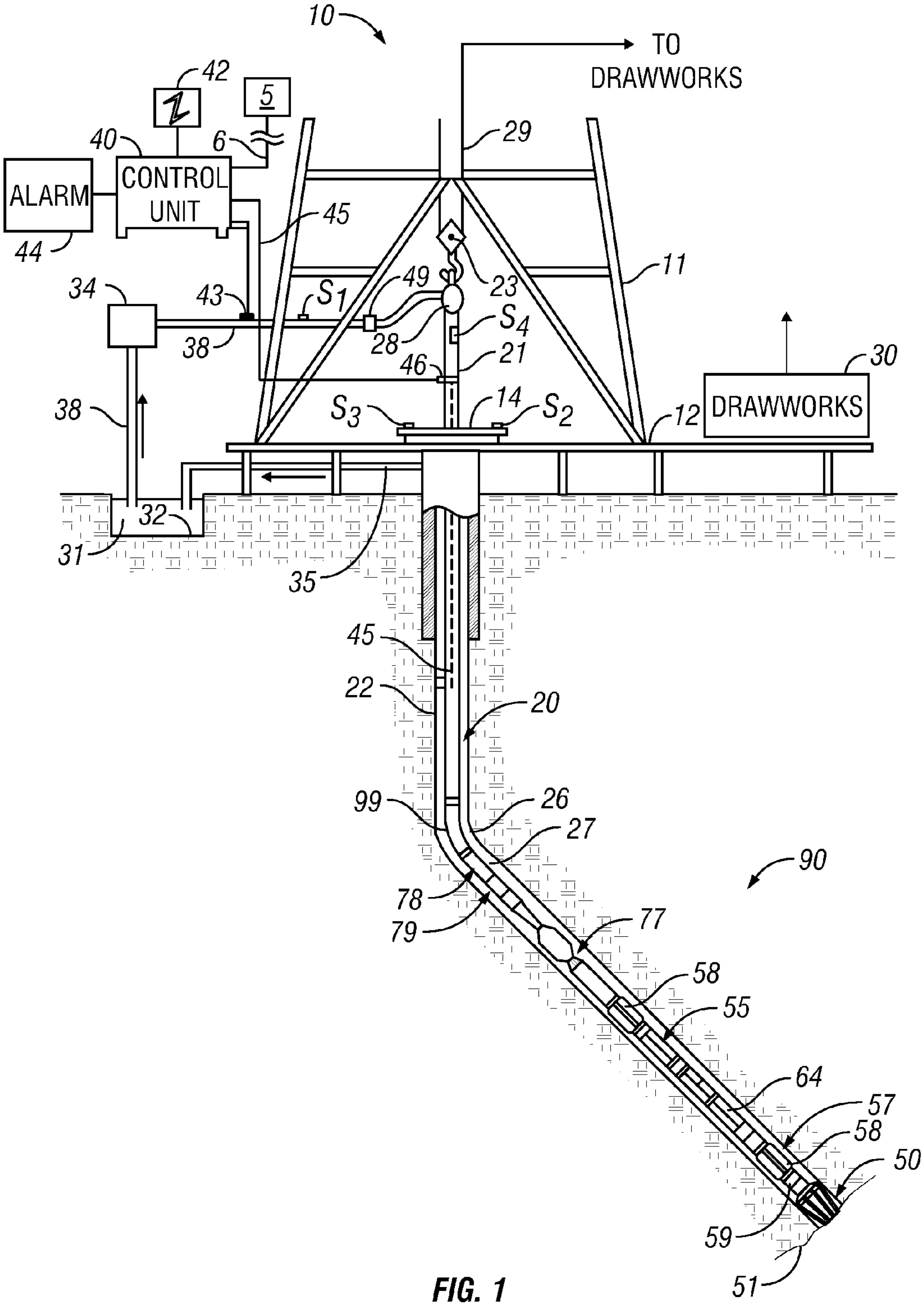
(57) **ABSTRACT**

A system, tool and method of communicating data between a wellbore and the surface are provided that include the features of transmitting data from a number of tools in the wellbore to the surface at a first data rate via a communication link in a tubing that supplies fluid under pressure, detecting occurrence of a fault relating to the data communication link is below a threshold, and switching transmission of least some of the data from the tools by generating pressure pulses through the fluid in the tubing at a second data rate that is lower than the first data rate.




10
TO DRAWWORKS
42
5
40
6
29
ALARM
CONTROL UNIT
45
44
11
23
34
43
S_1
49
38
28
S_4
21
46
30
DRAWWORKS
38
S_3
14
S_2
12
32
31
35
45
22
20
99
26
27
90
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58
50
59
51

FIG. 1

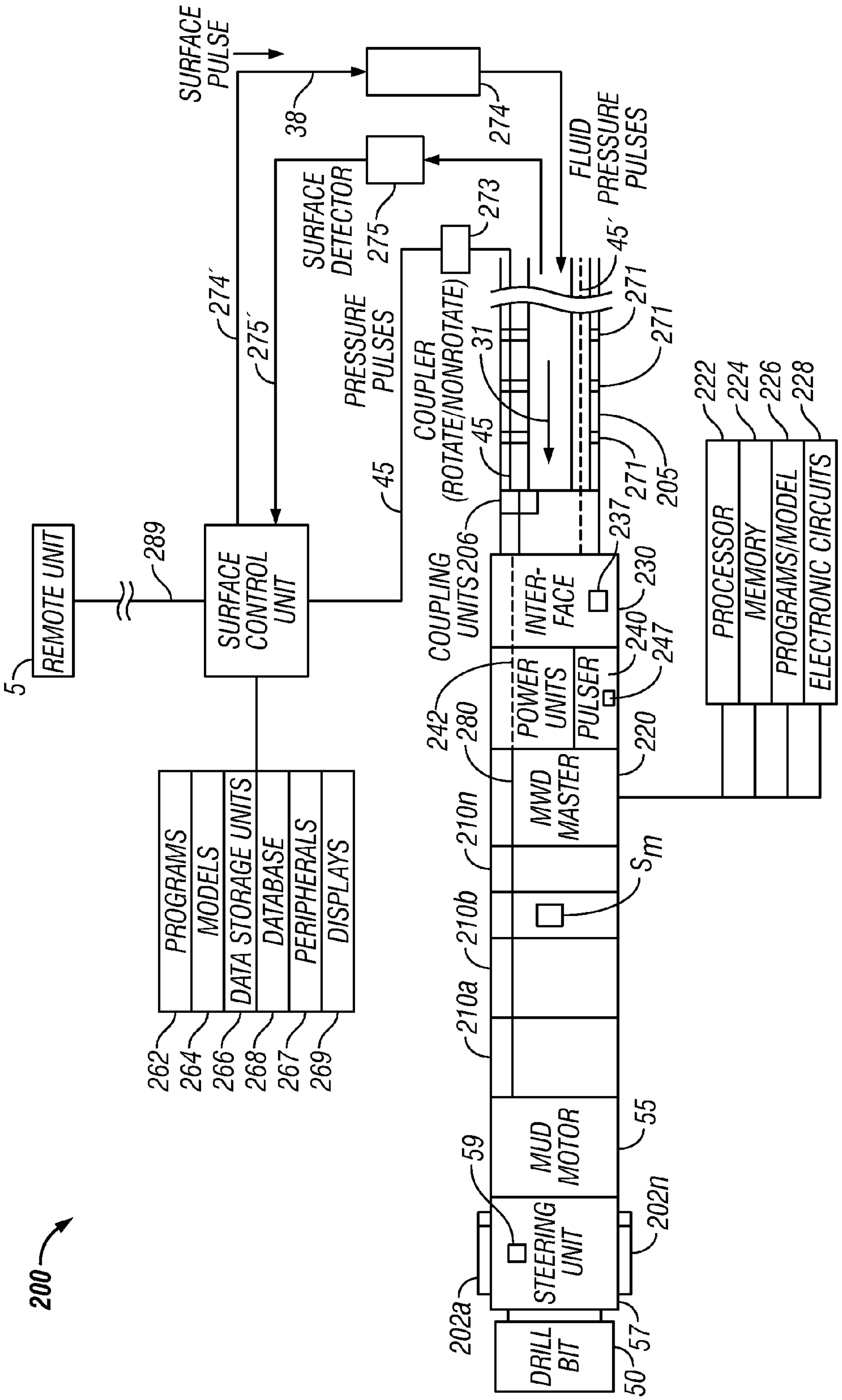
SURFACE PULSE
38
274
FLUID PRESSURE PULSES
SURFACE DETECTOR
275
273
45´
274´
275´
PRESSURE PULSES
COUPLER (ROTATE/NONROTATE)
31
45
271
271
271
271
205
REMOTE UNIT
5
289
SURFACE CONTROL UNIT
45
COUPLING UNITS
206
237
INTER-FACE
230
240
247
POWER UNITS
PULSER
242
280
220
MWD MASTER
PROCESSOR
MEMORY
PROGRAMS/MODEL
ELECTRONIC CIRCUITS
222
224
226
228
PROGRAMS
MODELS
DATA STORAGE UNITS
DATABASE
PERIPHERALS
DISPLAYS
262
264
266
268
267
269
210n
210b
210a
S_m
MUD MOTOR
55
59
STEERING UNIT
202n
202a
57
DRILL BIT
50
200

FIG. 2

APPARATUS AND METHOD FOR COMMUNICATING INFORMATION BETWEEN A WELLBORE AND SURFACE

BACKGROUND OF THE DISCLOSURE

[0001] 1. Field of the Disclosure

[0002] This disclosure relates to apparatus and methods that provide data communication between a surface location and downhole tools during drilling of the wellbore

[0003] 2. Description of the Related Art

[0004] Wellbores or boreholes are drilled in the earth's subsurface formations for the production of hydrocarbons (such as oil and gas) utilizing a rig (land or offshore) and a drill string that includes a tubing (jointed pipe or a coiled tubing) and a drilling assembly (also referred to as a bottom hole assembly or "BHA"). The drilling assembly carries a drill bit that is rotated by a motor at the surface and/or a drilling motor (also referred to as mud motor) carried by the drilling assembly. The drilling assembly typically carries a variety of downhole tools, usually referred to as the measurement-while-drilling ("MWD") tools. Drilling fluid or mud is pumped by mud pumps at the surface into the drill string. After discharging at the drill bit bottom, the drilling fluid returns to the surface via an annulus between the drill string and the wellbore walls. The MWD tools may include a resistivity sensor, acoustic sensor, nuclear-magnetic-resonance sensor, nuclear sensors, formation testing tools, etc. for providing information about various properties of the formation surrounding the wellbore. The drilling assembly may also include tools and sensors that are useful in drilling the wellbore along a desired trajectory. Additional sensors, such as pressure sensors, temperature sensors and flow rate sensors are used to determine pressure, temperature and fluid flow rates in the wellbore.

[0005] The MWD tools and sensors are capable of providing a large amount of data that is useful for drilling the wellbore along a desired trajectory and for estimating the properties of the formations surrounding the wellbore. It is therefore desirable to send large amounts of data to the surface during drilling of the wellbore. Also, it is desirable to send data from the surface to the downhole MWD tools to cause the tools to perform in a desired manner. Wired-pipe and mud pulse telemetry have been used to transmit data between the downhole tools and the surface. Wired-pipes provide wide band data communication, while mud pulse telemetry sends a few bits per second.

[0006] The present disclosure provides an improved apparatus and methods for communicating data between the downhole tools and the surface using both the wired-pipe and the mud pulse telemetry.

SUMMARY OF THE DISCLOSURE

[0007] The present disclosure, in one aspect, provides a method for communicating data between a wellbore and the surface. The method includes the features of (i) transmitting data from tools in the wellbore to the surface at a first data rate via a communication link that is carried by a tubing that supplies fluid under pressure to the wellbore; (ii) detecting a fault condition relating to the data communication link; and (iii) switching transmission of least some of the tool data from the data communication link to a mud pulse telemetry unit that sends data by generating pressure pulses in the fluid in the tubing at a second data rate.

[0008] In another aspect, a wellbore telemetry system is provided that includes a dill pipe or tubing that carries a conductor along the length of the pipe or the conductor. A data transmission device transmits data received from the tools in the drilling assembly to the surface via the data conductor at a first data rate. A downhole controller switches sending at least some of the data from the tools to a mud pulse telemetry unit when a fault is detected with the conductor. The mud pulse telemetry unit sends the data to the surface by generating pressure pulses in the fluid in the wired pipe or tubing at a second data rate that is lower than the first data rate. A control circuit in the drilling assembly activates a pulser that generates the pressure pulses. The control circuit, in one aspect, may send commands to the tools in the drilling assembly to cause them to send data at a data rate that is compatible with the transmission of the data by the pulser.

[0009] In another aspect, a drilling assembly is provided that includes a control circuit that is configured to transmit downhole tool data via wired-pipe or tubing at a wide band data rate during normal drilling operations and to automatically switch the data transmission to a mud pulse telemetry unit when the data communication link fails or exhibits data transmission that is below a selected standard.

[0010] Examples of the more important features of the invention have been summarized (albeit rather broadly) in order that the detailed description thereof that follows may be better understood and in order that the contributions they represent to the art may be appreciated. There are, of course, additional features of the invention that will be described hereinafter and which will form the subject of the claims appended hereto.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] For detailed understanding of the present invention, reference should be made to the following detailed description of the embodiments, taken in conjunction with the accompanying drawing in which like elements sometimes have been assigned like numerals and; wherein:

[0012] FIG. **1** shows a schematic illustration of a drilling system that utilizes one embodiment of the present invention; and

[0013] FIG. **2** shows a functional block diagram of a telemetry system according to one embodiment of the present disclosure.

DETAILED DESCRIPTION OF THE DISCLOSURE

[0014] FIG. **1** shows a schematic diagram of a drilling system **10** in which a drill string **20** carrying a drilling assembly **90** or BHA is shown conveyed in a wellbore **26**. The drilling system **10** may include a conventional derrick **11** erected on a platform or floor **12** which supports a rotary table **14** that is rotated by a prime mover, such as an electric motor (not shown), at a desired rotational speed. The rotary table is coupled to and rotates the drill string **20**. The drill string **20** includes a tubing **22** (which may be made by joining metallic pipe sections (drill pipe sections) or a metallic or composite coiled-tubing. A drill bit **50** attached to the end of the drilling assembly **90** is rotated to disintegrate the geological formations to form the wellbore **26**. The drill string **20** is coupled to a draw works **30** via a Kelly joint **21**, swivel **28**, and line **29** through a pulley **23**. The draw works **30** controls the weight on bit, which is a parameter that affects the rate of penetration.

[0015] To drill the wellbore **26**, a suitable drilling fluid **31** (also known as "mud") from a mud pit **32** (source) is circulated under pressure through the tubing **22** by one or more mud pumps **34**. The drilling fluid **31** passes from the mud pumps **34** into the drill string **20**, fluid line **38** and Kelly joint **21**. The drilling fluid **31** discharges at the bottom of the wellbore **20** through openings in the drill bit **50**. The drilling fluid **31** lubricates the drill bit **50** and carries rock cuttings. The drilling fluid **31** then returns to the surface via an annular space **27** ("annulus") between the drill string **20** and the wellbore **26**. The rocks in the returning fluid are removed at the surface and the clean fluid is discharged in the pit **32** via a return line **35**.

[0016] A sensor or device S_1, such as a flow meter typically placed in the line **38**, provides information about the fluid flow rate. A surface torque sensor S_2 and a sensor S_3 associated with the drill string **20** respectively provide information about the torque and the rotational speed of the drill string. Additionally, a sensor (not shown) associated with line **29** is used to provide the hook load of the drill string **20**. The drill bit **50** may be rotated by rotating the drill pipe **22** or a downhole motor **55** (mud motor) disposed in the drilling assembly **90** or both.

[0017] In the exemplary embodiment of FIG. **1**, the mud motor **55** is shown coupled to the drill bit **50** via a drive shaft (not shown) disposed in a bearing assembly **57**. The mud motor **55** rotates the drill bit **50** when the drilling fluid **31** passes through the mud motor **55** under pressure. The bearing assembly **57** provides support to the drilling assembly from the radial and axial forces of the drill bit. One or more stabilizers **58** coupled to the drilling assembly **90** maintain the drilling assembly in the center of the wellbore.

[0018] A surface control unit **40** (also referred to as the "surface controller") may be used to control various operations of the drilling system **10**, including controlling the pumps **34**, draw works **30**, rotation of the rotary table **14** and operation of the various tools and sensors contained in drilling assembly **90**. In one aspect, the control unit **40** is in data communication with drilling assembly **90** via at least two separate communication channels. One such channel may provide a wide data band width and may be formed by a direct data communication link **45** that runs in or along the tubing **22**. The direct data communication link **45** may include one or more electrical conductors and/or optical fibers that run in or along the tubing **22**, as described in more detail later. A coupler **46** at the surface transfers the data to and from the stationary control unit to the rotating drill string **22**. A rotating coupler may not be needed when coiled tubing is used. The coupler **46** may be any suitable coupler, including one that provides a radio (wireless) link. The other data communication channel may utilize a relatively low data rate and may use the mud in the drill string **20** as the communication channel.

[0019] A pulser **49** may be used to generate pressure pulses in the fluid in the line **38** to send coded signals to the drilling assembly. Alternatively, the mud pumps may be used to generate pressure pulses in the mud in line **38**. The pulser may be a positive pressure pulser, such a "poppet pulser," an oscillating disc-type pulser, a "rotary pulser" (also referred to as a "siren pulser") or any other suitable pulser. The coded signals also mat be sent to the downhole tools by varying the flow rate of the drilling fluid or by momentarily diverting the drilling fluid. A bypass or venting-type device or pulser, wherein the fluid in line **38** is bypassed at selected rates for selected time periods, may be utilized to change the fluid flow rate to generate pressure pulses in the fluid in line **38**. A sensor **43**, such a pressure sensor or a flow meter, provides measurements indicative of the surface-generated pressure pulses to the controller **40**. The sensor **43** or another sensor detects pressure pulses sent from the drilling assembly **90** and provides such information to the surface controller **40**. Other sensors, such as sensors S_1, S_2, S_3, provide to the surface controller **40** information about hook load, rotational speed of the drill string, fluid flow rate, rate of penetration and any other desired parameter measured at the surface relating to the drilling of the wellbore **20**.

[0020] The surface control unit **40** may be a computer-based system that utilizes programs, models and algorithms to process information received from various tools, sensors and a remote unit to effect the drilling of the wellbore **26**. The surface control unit **40** may include one or more processors, such as microprocessors, suitable data storage media, including solid state memory, tapes, discs, disc drives, etc., and one or more displays **42**. The surface control unit **40** may communicate with one or more remote locations **5** via any suitable link, including but not limited to an Ethernet connection, a wireless connection or the Internet. The surface control unit **40** also may display any desired drilling parameters and other information on a display/monitor **42** for use an operator to control the drilling operations. The surface control unit **40** also may be configured to activate alarms **44** when certain unsafe or undesirable operating conditions are detected or determined. The rig **11** is shown as a surface rig that utilizes a rotary table to rotate the drill pipe only as an example of a rig and a drive mechanism. Top drives are often used to rotate the drill pipe. Such and other mechanisms may be equally utilized for the purpose of this disclosure. Also, for offshore drilling, an offshore platform or vessel may be utilized to implement any of the embodiments and methods described herein.

[0021] Still referring to FIG. **1**, the BHA **90** may contain a variety of MWD tools, sensors and other devices that are configured to provide a variety of measurements for estimating or determining various parameters of the formation surrounding the wellbore **97**, downhole drilling parameters, parameters relating to the behavior of the drilling assembly **90** and devices for drilling the wellbore **26** along a desired path. Such devices may include a device for measuring the formation resistivity near and/or in front of the drill bit, a gamma ray device for measuring the formation gamma ray intensity and devices for determining the inclination and azimuth of the drilling assembly, acoustic tool for estimating the porosity and permeability of the formation, nuclear toll for estimating the composition and nuclear porosity of the formation and nuclear resonance tool for estimating the composition of the formation. Formation evaluation tools may be used to take formation fluid samples and to perform PVT (pressure, volume and temperature) tests.

[0022] The MWD tools and sensors may be placed in any desirable order and some of the sensors may be placed on a common drilling assembly housing. For example, the formation resistivity measuring tool **64** may be coupled above a lower kick-off subassembly **6** that provides signals from which resistivity of the formation near or in front of the drill bit **50** may be determined. An inclinometer **74** and gamma ray device **76** may be suitably placed along the BHA for respectively determining the inclination of the BHA and the formation gamma ray intensity. In addition, an azimuth device (not shown), such as a magnetometer or a gyroscopic device, may be utilized to determine the drill string azimuth. Other tools, which are collectively designated by numeral **77**, are shown placed above (uphole) the resistivity tool, as an example. Additionally, a drilling sensor module **59** is placed near the drill bit **50**. The drilling sensor module **59** contains sensors, circuitry and processing software and algorithms relating to the dynamic drilling parameters. Such parameters may include bending moment, vibration, bit bounce, stick-slip, backward rotation, torque, shock, borehole and annulus pressure, acceleration and any other desired drilling assembly and drill bit parameter.

[0023] In the exemplary configuration of FIG. **1**, the mud motor **55** transfers power to the drill bit **50** via a hollow shaft that also enables the drilling fluid to pass from the mud motor **55** to the drill bit **50**. In an alternate embodiment of the drill string **20**, the mud motor **55** may be coupled below resistivity measuring device **64** or at any other suitable place. Each of these tools and devices may include its own processing circuits that provide the results and/or provide raw data. Some or all such data may be recorded in downhole storage media and/or transmitted to the surface control unit **40** during drilling of the wellbore **26**. A downhole telemetry system or unit **99** carried by the drilling assembly **90** provides two-way communication between the drilling assembly **90** and the surface. The downhole telemetry system **99** receives data from the various MWD tools and other sensors and devices and transmits the received data as coded signals to the surface via the data communication link **45**. The downhole telemetry system **99** also receives signals and data from the surface control unit **40** and transmits such received signals and data to the appropriate downhole devices. The downhole telemetry system **99** also is configured to transmit and receive data using the mud pulse telemetry in parallel with the data communication link **45** or to the exclusion of such link when a fault with the link **45** is detected or when the data communication quality level over the link **45** is below a selected value or threshold.

[0024] FIG. **2** shows a functional block diagram of a system **200** for communicating data between a drilling assembly and the surface for a drilling system, such as shown in FIG. **1**. The system **200** is shown to include the drill bit **50** at one end of the drilling assembly **90**. A steering unit **57** is shown to carry a plurality of force application members or "ribs" **202***a*-**202***n*, etc., wherein each rib is independently controlled to apply force on the inside of the wellbore **26** to guide the drill bit in a desired drilling direction. The steering unit may include multiple sensors **59** configured to provide measurements relating to the various physical conditions of the drilling assembly **90**, such as bending moment, vibration, stick-slip, pressure, temperature, weight-on-bit, etc. Additional sensors may be provided on the mud motor **55** housing, which may include resistivity sensors. A number of MWD tools, designated as **210***a* through **210***n* are shown placed above the mud motor **55**. For the purpose of this disclosure, any tool or sensor may be placed anywhere in the drilling assembly **90**. Each MWD tool may include a separate processor for processing the data and may store some or all such data and results in a downhole memory and/or send some or all such data and results to the surface.

[0025] In the system configuration of FIG. **2**, the data from each tool and sensor that is to be sent to the surface is passed on a common bus **280** associated with a master control unit **220**, also referred to as the MWD master. The MWD master, in aspect, may include one or more processors **222**, a data storage device **224**, such as a solid-state memory, programs and models **226**, and other electronic circuits **228** useful for receiving, transmitting and processing the data. The MWD master **220** provides the data to be sent to the surface via an interface **230**. The interface **230** transfers the received data to the data communication link **45** in the tubing **205** via a coupler or coupling device **206**. The interface **230** may include a processor, memory, programs and other electrical circuitry. A battery **237** may be provided to supply electrical power to the interface **230** so that data communication may be maintained and to ensure certain sensors (such as pressure sensors) remain powered when drilling fluid flow is interrupted or halted and power is unavailable from the power unit **242**. As discussed above, the data communication link **45** may be run through each section of the drilling pipe **205** via suitable electrical or optical couplers. The interface **230** communicates data with the data link **45** via a suitable coupler **206**, which in the case of an electrical conductor is an electrical connection device and in the case of an optical fiber is a suitable optical coupler. The same connection scheme may be used when the data link **45'** is in coiled-tubing. The coupling unit **206** may be the same as the coupler **271**. The data communication link **45** connects to the surface control unit **40** via a suitable coupler **273**, thereby establishing a high data rate or wide band data connection between the drilling assembly **90** and the surface control unit **40**.

[0026] Still referring to FIG. **2**, the system **200** also is shown to include a mud-pulse telemetry system. The mud pulse telemetry system includes a pulser **240** and a power unit **242**. The pulser **247** produces pressure pulses in the drilling fluid **31** flowing in the tubing **205** in response to the commands provided by the MWD master **220** and or the surface control unit **40** or instructions programmed in a memory for the pulser **240**. As noted above, any suitable pulser may be used as the downhole pulser **240**, including but not limited to, an oscillating-type pulser, a rotary pulser and a poppet-type pulser. A detector **275**, such as a pressure transducer, detects the mud pulses and sends electrical signals representative of the pulses to the surface controller **40** via link **275'** for analysis. The data from the surface is transmitted by using a surface pulser **274** in the fluid line **38**, which sends coded signals in the form of pressure pulses in the fluid **32** flowing downhole. A detector **247** detects the pressure pulses sent from the surface and provides corresponding electrical signals to the MWD master **220** for further processing. The characteristics of the downhole generated pulses, such as amplitude, pulse width, pulse shape, pulse phase and pulse frequency are normally controlled by the MWD master **220** or another downhole controller. The coded signals may also be detected by measuring the flow rate of the drilling fluid when, such as by a flow meter, when mud pulse telemetry is used. The coded signals may be detected by determining the drill string rotation when the drill pipe rotation is used to send the coded pulses. The same characteristics of the surface-generated pressure pulses are normally controlled by the surface control unit **40** or another suitable controller. The surface control unit **40** and the MWD master **220** communicate with each other via one or both of the telemetry schemes to coordinate transfer of the data between the drilling assembly and the surface.

[0027] Still referring to FIG. **2**, during drilling of the wellbore **26**, the MWD master **220** or another suitable processor transmits the data from the downhole tools and sensors to the surface control unit **40** via the direct data communication link **45**. When a wired-pipe is used to include the data link **45**, whether an electrical conductor or optical fibres, a new drill pipe section, typically about 30 meters in length, is installed after drilling such a distance, which may occur every few minutes to an hour or longer. The connection joints between pipe sections sometimes become damaged or out of alignment, due to the severe downhole drilling conditions and may not function properly to communicate data at the intended high data rate. The MWD master **220** and/or the surface controller **40** may determine the condition of the data being transmitted/and or received and determine, using a selected criterion the degradation in the performance of the data communication link **45**. The surface controller and/or the MWD master then may initiate transmission of the data using the relatively slow mud pulse telemetry. The initiation of the mud pulse telemetry system may be automatically activated by either the MWD master **220** or the surface control unit **40**, without human intervention. As noted above, the mud pulse telemetry is a relatively low rate data transmission system (typically between 2-60 bits per second, based on the pulser used and the wellbore depth) compared to the direct communication link that may transmit data at several thousand or million bits per second.

[0028] The MWD master may act as a gateway and determine the type, amount and timing of the data that will be sent from each downhole tool and device using the mud pulse telemetry. The MWD master also may receive commands from the surface control unit **40** and transmit data using the mud pulse telemetry according to the received commands. In another aspect, if it is determined that some data can be safely sent over the data link **45**, then the MWD master may send some selected data over this link and send some other data via the mud pulse telemetry. Also, optionally, the system **200** may utilize both telemetry methods simultaneously, i.e., in parallel.

[0029] In one aspect, the MWD master **220** may communicate with each tool **210***a*-**210***n* and other devices and change the amount and type of each tool's respective data to be sent to the MWD master and/or the sequence in which such data is sent. In another aspect, the MWD master **220** may cause one or more of the downhole tools **210***a*-**210***n* to stop sending data until a later time or reduce the number of bits sent over a certain period of time or the type of information that is to be sent, For example, the MWD master **220** may limit data transmission to selected results from the tools when such results are outside a norm. The MWD master **220** then may send the received data to the pulser which generates the pressure pulses according a preselected pulse sequence. The MWD master **220** may control the characteristics of the pressure pulses generated by the pulser **230**, such as shape, phase, amplitude, frequency, time between the pulses, etc. Any suitable transmission scheme may be employed, including but not limited to, gain or amplitude modulation, frequency modulation, time duration modulation or any combination of such schemes to transmit coded pulses to the surface. Fault detection, reprogramming, etc. may be accomplished by the downhole master or a separate control unit. The functions performed by the downhole master and the separate control unit may be changed over time to accomplish any desired telemetry control scheme. Also, in one mode, the mud pulse or low data rate telemetry may be run in a background mode and the control unit may switch decidable mode as desired.

[0030] Still referring to FIG. **2**, the surface control unit **40** includes or has access to various computer programs **262**, model **264**, data storage devices **266** and data base **268** and utilizes such computer programs, models and data base to interact with the MWD master **220** to provide effective data communication between the drilling assembly **90** and the surface. The surface control unit **40** may communicate with any remote computer-based systems via any suitable link, such as the Ethernet, Internet, wirelessly or direct connection and operate the telemetry systems described herein in response to any instructions received from the remote unit **5**. The control unit **40** also displays the results relating to the drilling of the wellbore **26** on one or more displays **269** at the rig site for the use of the operator. The MWD master and/or surface control unit **40** may be configured to automatically switch and/or allocate data transfer between the high data transmission rate communication link **45** and the mud pulse telemetry channel in response to the condition of the data link **45**. The parallel telemetry system described herein may achieve higher reliability compared to a single telemetry system. For example, assuming a mud pulse telemetry system has a mean time between failure (MTBF) of 500 hours and a wired pipe system has an MTBF of 200 hours, then the parallel telemetry system will have an MTBF of 10,000 hours.

[0031] Thus, in one aspect, a method for communicating data between a wellbore and the surface during drilling of the wellbore is provided. The method may include the features of: (i) transmitting data from a plurality of tools in the wellbore to the surface at a first data rate via a data communication link in a tubing that supplies fluid under pressure; (ii) detecting occurrence of a fault relating to the data communication link; and (iii) in response to the detection of the fault, switching transmission of selected tool data to a mud pulse telemetry unit that sends the data to the surface by generating pressure pulses through the fluid in the tubing at a second data rate that is lower than the first data rate. The method may further include the feature of sending command signals to the downhole tools to cause them to send data in a manner that is compatible with transmitting the data at the second data rate through the fluid. The data communication link may be any suitable hard link, such as an electrical conductor or an optical fiber that runs the length of the drill string. The method may automatically switch sending data between the communication link and the fluid. It also may automatically cease to transmit data using the pressure pulses when the fault has been corrected or cease sending data via the communication link when a fault or unacceptable condition for the link has been determined. The method also provides for activating a pulser downhole to generate the pressure pulses upon detecting the fault. The pressure pulses to the surface may be sent by any suitable pulsing scheme, such as amplitude, phase, frequency, duration and timing between pulses modulation schemes or a combination thereof. The method also may include the feature of controlling flow of data from the various downhole tools and devices upon the detection of the fault. The data communication link may be any suitable link, including but not limited to one or more electrical conductors, one or more optical fibers, one or more conductors containing carbon nano-tubes that are aligned in a direction along the longitudinal axis of the conductor. The pulses downhole may be generated by any suitable pressure pulser, including but not limited to a rotary pulser, poppet pulser, piezoelectric device or an oscillating shear-valve pulser

[0032] The disclosure in another aspect provides a wellbore telemetry system in which a tubing of the drill string carries a data communication link along the length of the tubing to a drilling assembly that carries a plurality of tools. A first data transmission device in the drilling assembly transmits data received from the downhole tools to the surface via the data communication link at a first data rate. The wellbore telemetry system further includes a downhole pulser that is configured to send data to the surface by producing pressure pulses in the fluid at a second data rate that is lower than the first data rate. A control circuit in the drilling assembly activates the downhole pulser to transmit at least some of the data from the tools at the second data rate when a fault is detected with the data communication link. A control unit in the drilling assembly may send commands to the downhole tools to cause them to send data at a data rate that is compatible with the transmission of the data by the pulser. In one aspect, the control unit may include a processor that utilizes one or more programs, models and database stored in suitable data storage medium to determine when data from a particular tool is below a standard and then may control the flow of data from that tool for further transmission to the surface. An interface circuit may be used to receive the data from the downhole control unit, such as a MWD master, to transfer the data to the data communication link. The wellbore telemetry system may further include a surface mud pulse telemetry unit that is activated when the downhole pulser is activated to establish two-way mud pulse telemetry. A detector downhole detects pressure pulses downhole that correspond to the surface sent signals and generates electrical signals responsive to the detected pressure pulses. A processor downhole processes the electrical signals generated by the detector to ascertain the surface signals.

[0033] In another aspect, a downhole drilling assembly is provided that is configured to connect to a data communication link carried by a wired-pipe. A control circuit is configured to transmit tool data via the communication link during normal operations. The control circuit switches the transmission of at least some of the data via a mud pulse telemetry unit when the data communication link fails or when the data transmission is below a selected standard.

[0034] The data communication link may be any direct communication link, including but not limited to an electrical conductor, an optical fiber or a conductor using aligned carbon nano-particles. The downhole tools may include any combination of the tools, such as a resistivity tool, an imaging tool, a nuclear tool, a nuclear magnetic resonance tool, an acoustic tool, a formation testing tool and a directional drilling tool

[0035] While the foregoing disclosure is directed to certain disclosed embodiments and methods, various modifications will be apparent to those skilled in the art. It is intended that all modifications that fall within the scopes of the claims relating to this disclosure are deemed to be a part of the foregoing disclosure.

What is claimed is:

1. A method of communicating data between a wellbore and the surface, comprising:

transmitting data from at least one tool in the wellbore to the surface at a first data rate via a communication link in a tubing that supplies fluid to the wellbore;

detecting occurrence of a fault relating to the data communication link; and

switching transmission of at least some of the data from the at least one tool from the data communication link to a mud pulse telemetry unit that sends the at least some of the data by generating pressure pulses through in the fluid in the tubing at a second data.

2. The method of claim **1** further comprising:

sending command signals to the at least one tool to send data in a manner that is compatible with transmitting the data at the second data rate.

3. The method of claim **1**, wherein the data communication link is one of an electrical wire and an optical fiber.

4. The method of claim **1** further comprising continuing to transmit data from the at least one tool via the data communication link.

5. The method of claim **1** further comprising ceasing to transmit the at least some of the data by the mud pulse telemetry unit when the fault has been corrected.

6. The method of claim **1** further comprising activating a pulser downhole to generate the pressure pulses upon detecting the fault.

7. The method of claim **6**, wherein the at least one tool comprises a plurality of tools and wherein the method further comprises controlling flow of data from each of the plurality of tools to the data communication link and the pulser.

8. The method of claim **7** further comprising controlling flow of data from a particular tool in the plurality of tools to the data communication link and the pulser when the particular tool exhibits a malfunction.

9. The method of claim **1**, wherein the data communication link is selected from a group consisting of: (i) an electrical conductor; (ii) an optical fiber; and (iii) a conductor that contains nano carbon tubes aligned along the length of the conductor.

10. A wellbore telemetry system, comprising:

a drill string in a wellbore having a tubing that carries a data communication link and supplies fluid under pressure during drilling of the wellbore;

a drilling assembly at a bottom end of the tubing, the drilling assembly carrying a plurality of tools;

a first data transmission device that transmits data received from each tool in the plurality of tools during drilling of the wellbore to the surface via the data communication link at a first data rate;

a downhole pulser that is configured to send data to the surface by producing pressure pulses in the fluid at a second data rate that is lower than the first data rate; and

a control circuit that activates the downhole pulser to transmit at least some of the data from the plurality of tools at the second data rate when a fault is detected with the data communication link.

11. The wellbore telemetry system of claim **10**, wherein the control circuit sends a command to each tool in the plurality of tools to send data at a rate that is compatible with transmission of the data by the pulser.

12. The wellbore telemetry system of claim **10**, wherein the downhole pulser is one of a: (i) poppet-type pulser; (ii) rotary pulser; (iii) a piezoelectric device; (ix) magnetostrictive device.

13. The wellbore telemetry system of claim **10**, wherein the control circuit comprises a processor that utilizes a program to determine when a particular tool is performing below a set standard and in response thereto controls flow of the data from the particular tool for transmission to the surface.

14. The wellbore telemetry system of claim **10** further comprising an interface circuit that receives the data from the control circuit and transfers the received data to the data communication link.

15. The wellbore telemetry system of claim **14**, wherein the data communication link is selected from a group consisting of: (i) an electrical conductor; (ii) a fiber optic link; (iii) a link that includes carbon nano-particles.

16. The wellbore telemetry system of claim **10** further comprising a surface telemetry unit that is configured to activate when the control circuit activates the downhole pulser to start sending surface signals in the form of pressure pulses through the fluid.

17. The wellbore telemetry system of claim **16** further comprising a detector in the drilling assembly that detects pressure pulses received downhole that relate to the surface signals and generates electrical signals responsive to the detected pressure pulses.

18. The wellbore telemetry system of claim **17** further comprising a processor that processes the electrical signals generated by the detector to ascertain the surface signals.

19. The wellbore telemetry system of claim **10**, wherein the control circuit includes a processor and a data storage device and wherein the processor establishes a two-way data communication between the drilling assembly and the surface via the fluid when the fault is detected with the data communication link.

20. A drilling assembly for use during drilling of a wellbore, comprising:

a data connection configured to connect to a data communication link carried by a tubing that supplies fluid under pressure to the downhole assembly during drilling of the wellbore;

a plurality of tools in the drilling assembly, wherein each tool provides data to be transmitted to a surface location during drilling of the wellbore;

a first data transmission device that transmits data received from each tool in the plurality of tools during drilling of the wellbore to the data communication link via the data connection at a first data rate;

a downhole pulser that is configured to produce pressure pulses in the fluid at a second data rate that is lower than the first data rate during drilling of the wellbore; and

a control circuit configured to control the downhole pulser to transmit data from each tool in the plurality of tools at the second data rate when a fault is detected with the data communication link during drilling of the wellbore.

21. The drilling assembly of claim **20** further comprising an interface circuit that is configured to transfer data between the control circuit and the data communication link.

22. The drilling assembly of claim **21**, wherein the control circuit includes a processor that is programmed to stop sending data from the tools to the interface circuit when the control circuit activates the pulser.

23. The drilling assembly of claim **20**, wherein the control circuit comprises a processor and a program, wherein the processor determines performance of at least one tool in the plurality of tools during the drilling of the wellbore and controls flow of data to the communication link and the pulser when the determined performance is below a threshold.

24. A method of communicating data between a wellbore and the surface, comprising:

transmitting data between at least one tool in the wellbore and the surface at a first data rate via a first wired-communication link;

detecting occurrence of a fault relating to the wired-data communication link; and

switching transmission of at least some of the data between the at least one tool and the surface from the data wired-communication link to a second telemetry unit that sends data at a second data rate that is lower than the first data rate.

25. The method of claim **24**, wherein the second telemetry unit transmits data using one of electromagnetic signals and acoustic signals.

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