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(54) WELLBORE TELEMETRY SYSTEM AND METHOD

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(57) ABSTRACT

Wellbore communication systems and methods for a wellsite having a downhole tool deployed from a rig into a wellbore penetrating a subterranean formation are disclosed. One example communication system includes a first mud pulse telemetry device positioned in a downhole tool and at least one additional non-mud pulse telemetry device positioned in the downhole tool. The example system also includes at least one of a pressure transducer or a pressure sensor adapted to detect a modulated pressure provided by at least one of the telemetry devices.

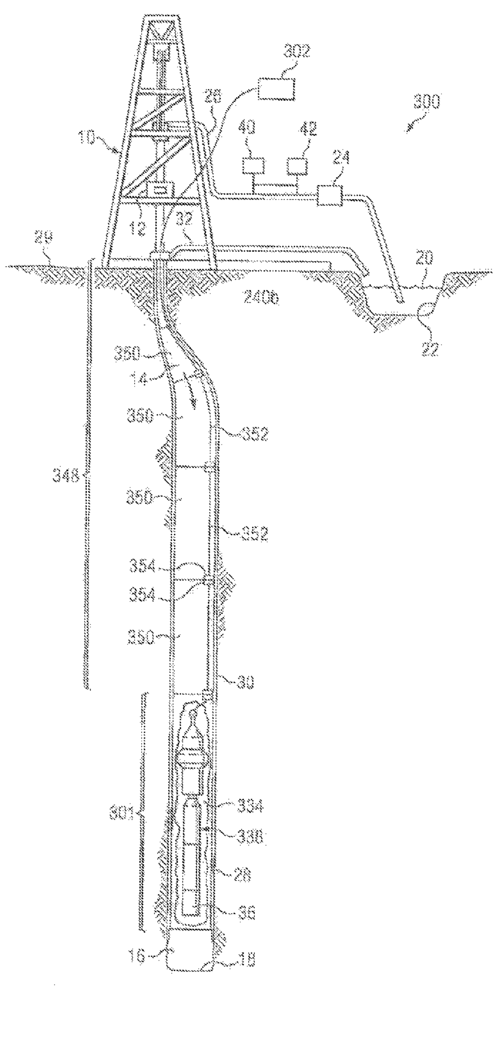


FIG. 1
(PRIOR ART)

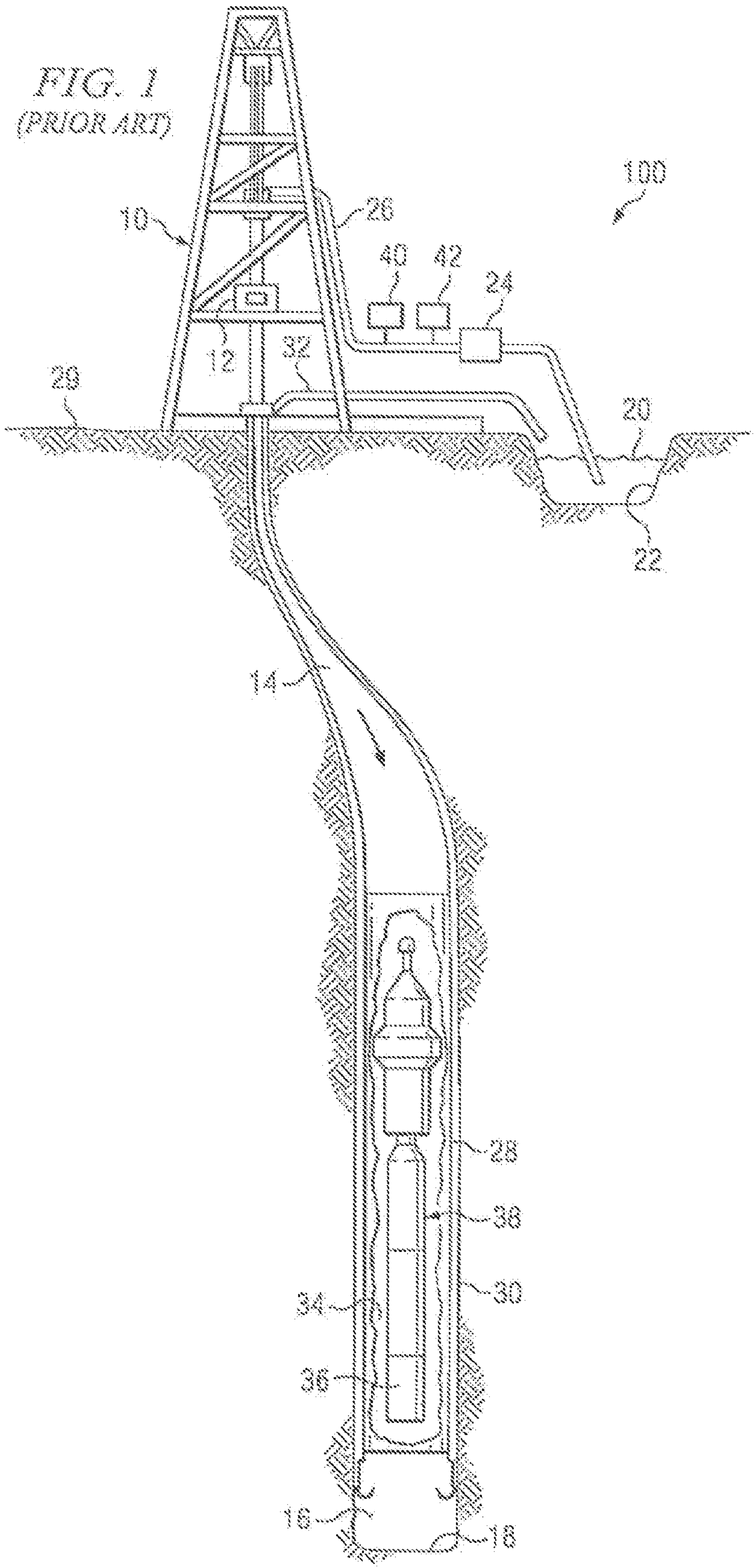


FIG. 2

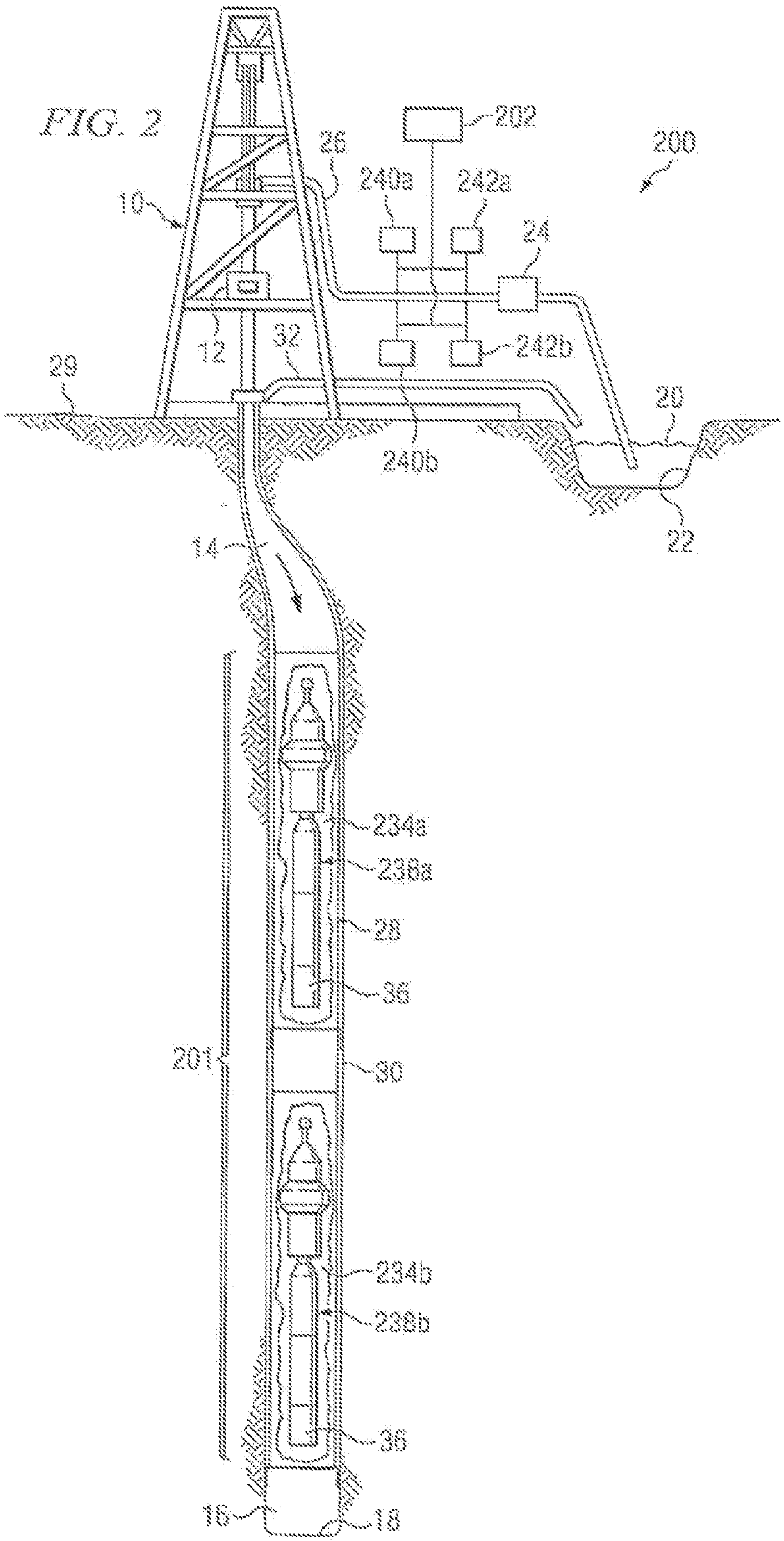
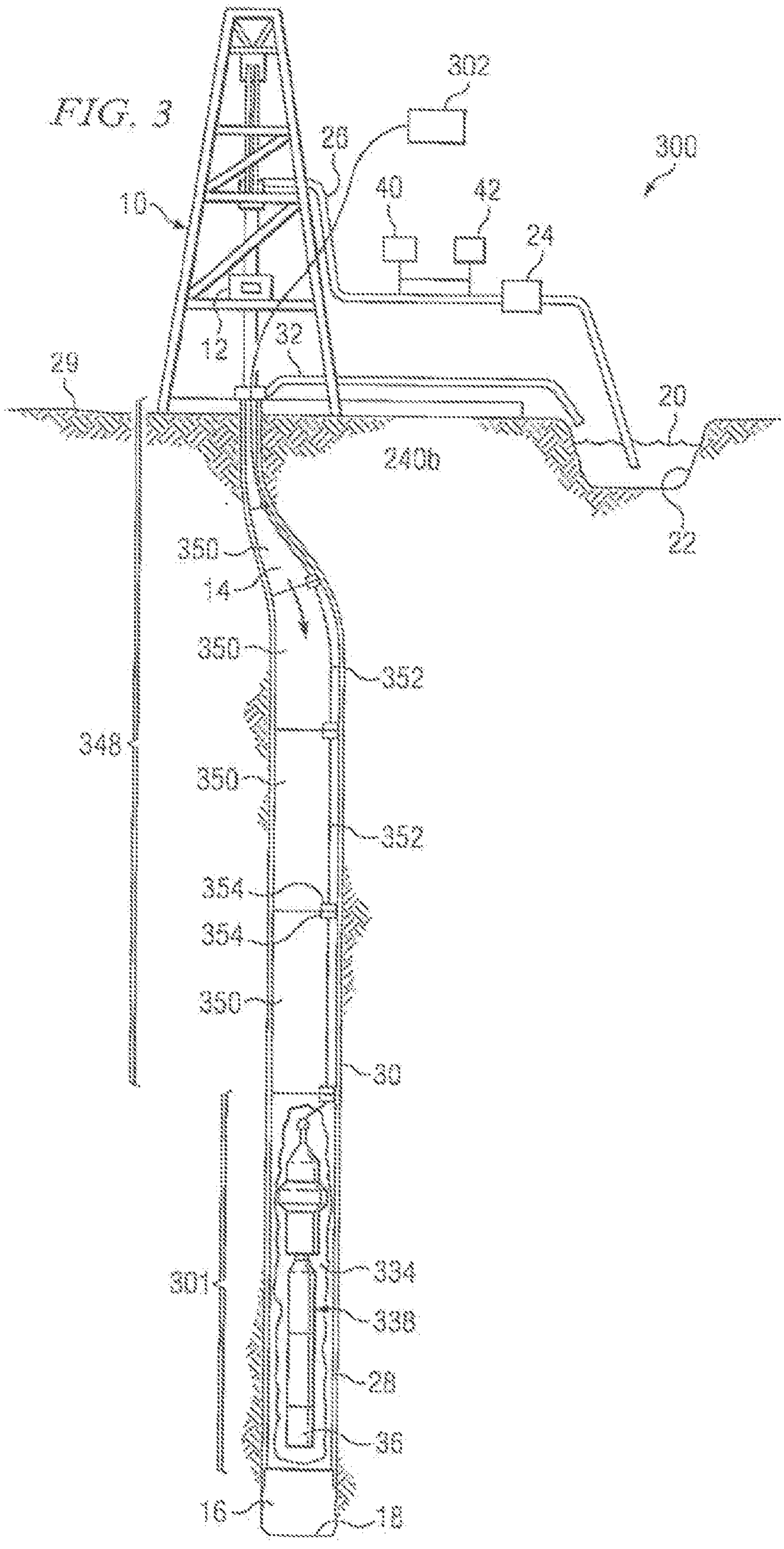

202
200
26
240a
242a
10
24
12
32
242b
29
20
240b
22
14
234a
238a
28
36
201
30
234b
238b
36
16
18

FIG. 3


302
300
20
10
40
42
24
12
32
29
20
240b
22
350
14
350
352
348
350
352
354
354
350
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334
301
338
28
36
16
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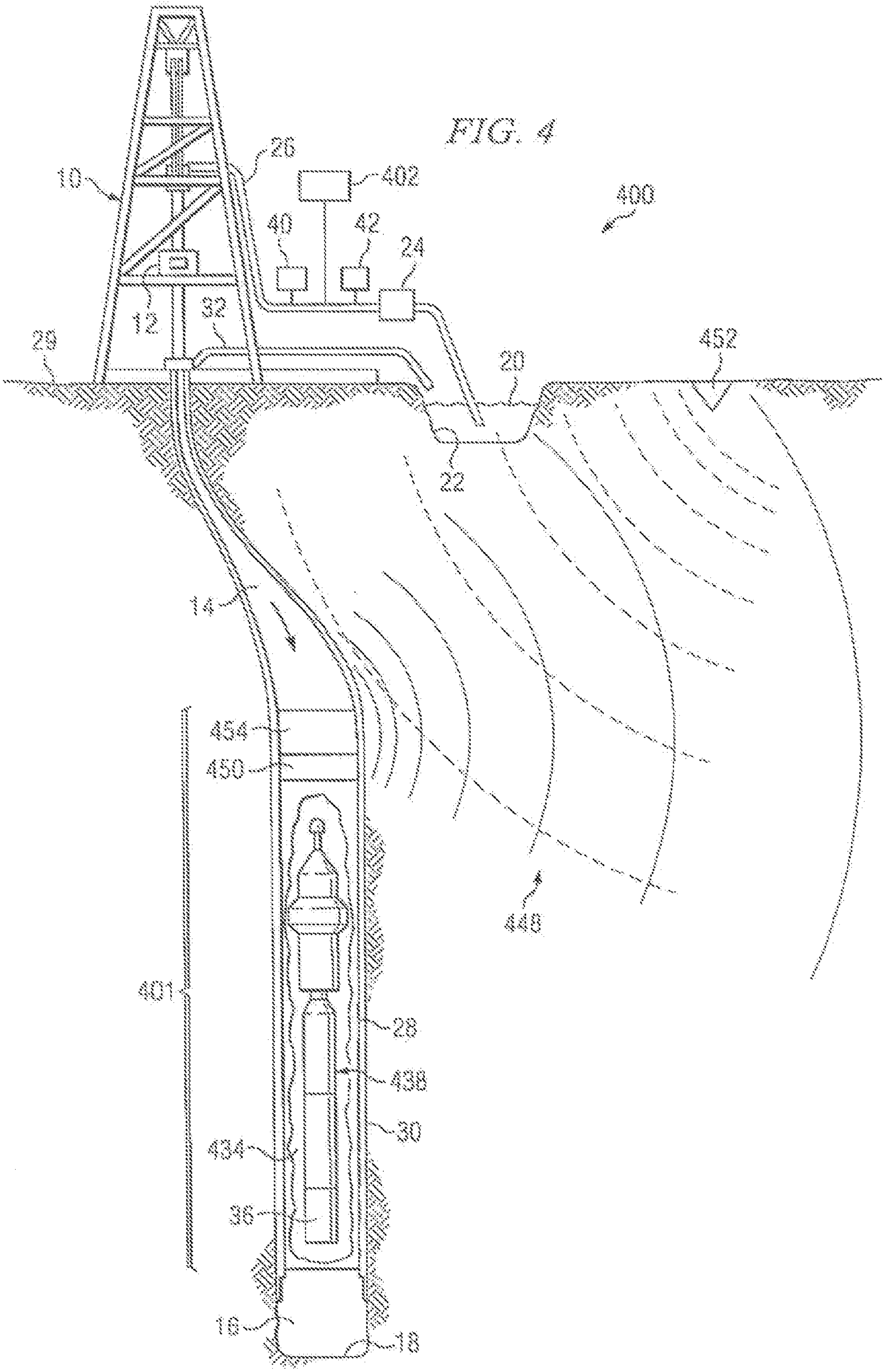
FIG. 4



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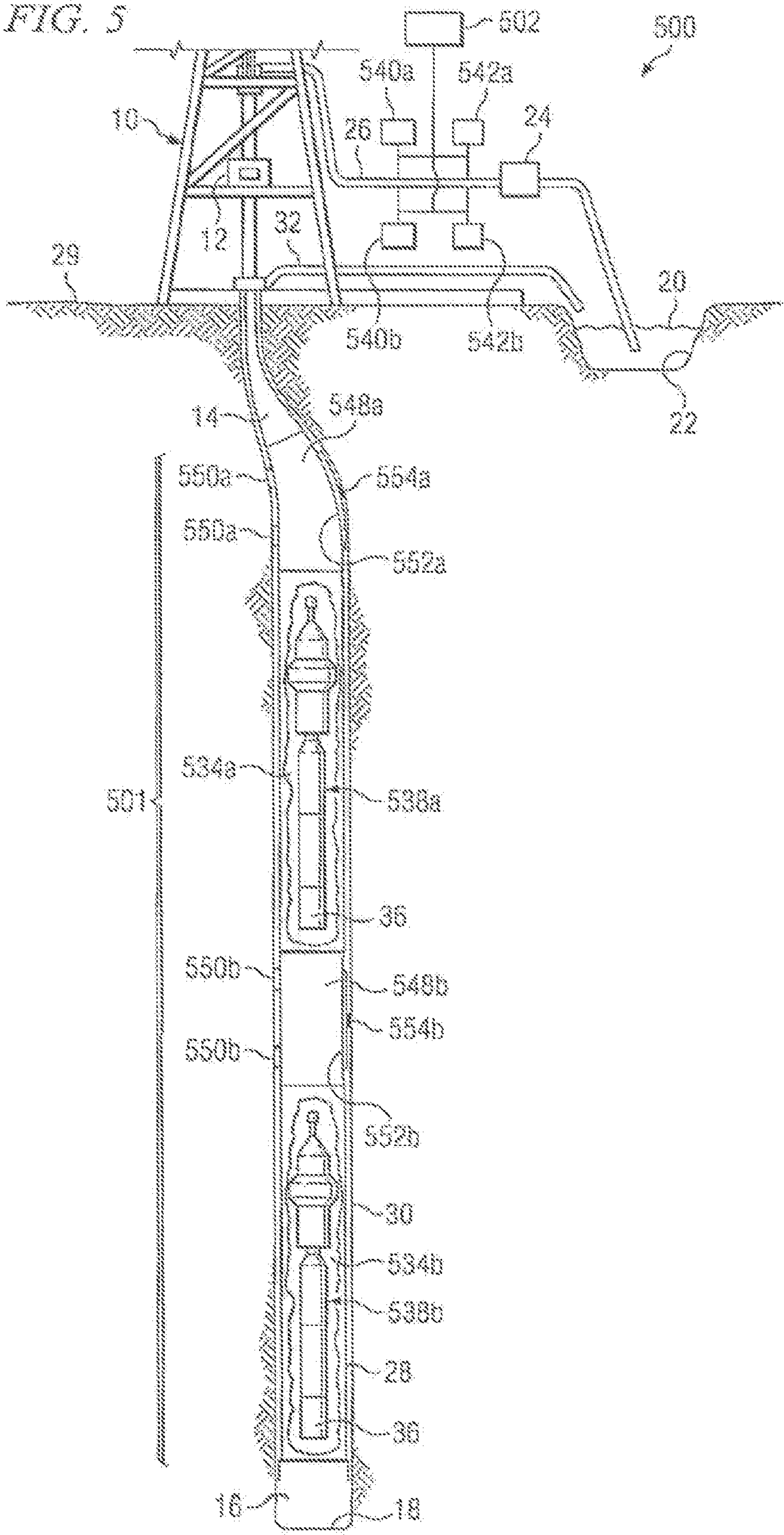
400
401
402
434
438
448
450
452
454

FIG. 5


502
500
540a
542a
10
26
24
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32
29
20
540b
542b
22
14
548a
550a
554a
550a
552a
534a
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538a
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550b
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554b
550b
552b
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534b
538b
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36
16
18

WELLBORE TELEMETRY SYSTEM AND METHOD

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to U.S. Provisional Application Ser. No. 60/697,073, filed on Jul. 5, 2005 and entitled "WELLBORE TELEMETRY SYSTEM AND METHOD."

FIELD OF THE DISCLOSURE

[0002] The present disclosure relates to telemetry systems and methods for use in wellbore operations. More particularly, the present disclosure relates to wellbore telemetry systems and methods for conveying signals between a surface unit and a downhole tool.

BACKGROUND

[0003] Wellbores may be drilled to locate and produce hydrocarbons. Typically, a wellbore is formed by advancing a downhole drilling tool having a drill bit at one end into the ground. As the drilling tool is advanced, drilling fluid ("mud") is pumped from a surface mud pit through a passage or passages in the drilling tool and out the drill bit. The mud exiting the drill bit flows back to the surface to be returned to the mud pit and may be re-circulated through the drilling tool. In this manner, the drilling mud cools the drilling tool, carries cuttings and other debris away from the drilling tool, and deposits the cuttings and other debris in the mud pit. As is known, in addition to the cooling and cleaning operations performed by the mud pumped into the wellbore, the mud forms a mudcake that lines the wellbore which, among other functions, reduces friction between the drill string and subterranean formations.

[0004] During drilling operations (i.e., advancement of the downhole drilling tool), communications between the downhole drilling tool and a surface-based processing unit and/or other surface devices may be performed using a telemetry system. In general, such telemetry systems enable the conveyance of power, data, commands, and/or any other signals or information between the downhole drilling tools/bottom hole assemble (BHA) and the surface devices. Thus, the telemetry systems enable, for example, data related to the conditions of the wellbore and/or the downhole drilling tool to be conveyed to the surface devices for further processing, display, etc. and also enable the operations of the downhole drilling tool to be controlled via commands and/or other information sent from the surface device(s) to the downhole drilling tool.

[0005] One known wellbore telemetry system **100** is depicted in FIG. **1**. A more detailed description of such a known system is found in U.S. Pat. No. 5,517,464, which is incorporated by reference herein in its entirety. With reference to FIG. **1**, a drilling rig **10** includes a drive mechanism **12** to provide a driving torque to a drill string **14**. The lower end of the drill string **14** extends into a wellbore **30** and carries a drill bit **16** to drill an underground formation **18**. During drilling operations, drilling mud **20** is drawn from a mud pit **22** on a surface **29** via one or more pumps **24** (e.g., reciprocating pumps). The drilling mud **20** is circulated through a mud line **26** down through the drill string **14** and the wall of the wellbore **30**. Upon reaching the surface **29**, the drilling mud **20** is discharged through a line **32** into the mud pit **22** so that rock and/or other well debris carried in the mud can settle to the bottom of the mud pit **22** before the drilling mud **20** is recirculated.

[0006] As shown in FIG. **1**, a downhole measurement while drilling (MWD) tool **34** is incorporated in the drill string **14** near the drill bit **16** for the acquisition and transmission of downhole data or information. The MWD tool **34** includes an electronic sensor package **36** and a mudflow wellbore telemetry device **38**. The mudflow telemetry device **38** an selectively block the passage of the mud **20** through the drill string **14** to cause pressure changes in the mud line **26**. In other words, the wellbore telemetry device **38** can be used to modulate the pressure in the mud **20** to transmit data from the sensor package **36** to the surface **29**. Modulated changes in pressure are detected by a pressure transducer **40** and a pump piston sensor **42**, both of which are coupled to a processor (not shown). The processor interprets the modulated changes in pressure to reconstruct the data collected and sent by the sensor package **36**. The modulation and demodulation of a pressure wave are described in detail in commonly assigned U.S. Pat. No. 5,375,098, which is incorporated by reference herein in its entirety.

[0007] In addition to the known mud pulse telemetry system **100** depicted in FIG. **1**, other wellbore telemetry systems may be used to establish communication between a downhole tool and a surface unit. Examples of known telemetry systems include a wired drill pipe wellbore telemetry system as described in U.S. Pat. No. 6,641,434, an electromagnetic wellbore telemetry system as described in U.S. Pat. No. 5,624,051, an acoustic wellbore telemetry system as described in published PCT Patent Application No. WO21004085796, all of which are hereby incorporated by reference herein in their entireties. Further examples using data conveyance or communication devices (e.g. transceivers coupled to sensors) have also been used to convey power and/or data between a downhole tool and a surface unit.

[0008] Despite the development and advancement of wellbore telemetry devices in wellbore operations, there remains a need for additional reliability and wellbore telemetry capabilities for wellbore operations. As with other many other wellbore devices, wellbore telemetry devices sometimes fail. Additionally, the power provided by many known wellbore telemetry devices may be insufficient to power desired wellbore operations. Attempts have been made to use two different types of mud pulse telemetry devices in a downhole tool. In particular, each of the different mud pulse telemetry devices is typically positioned in the downhole tool and communicatively linked to a different, respective surface unit. Such wellbore telemetry tools have been run simultaneously and non-simultaneously and at different frequencies. Attempts have also been made to develop dual channel downhole wellbore telemetry for transmitting data streams via communication channels to be interpreted independently as described in U.S. Pat. No. 6,909,667.

[0009] Despite the above-noted advancements in wellbore telemetry systems, there remains a need to provide wellbore telemetry systems capable of providing added reliability, increased speed, and increased power capabilities. As set forth in the detailed description below, the example methods and apparatus enable telemetry systems to operate at one or more desired frequencies and provide increased bandwidth. Additionally, the example methods and apparatus described below enable a plurality of different wellbore telemetry devices to be combined with a variety of one or more downhole components, such as formation evaluation tools, to provide flexibility in performing wellbore operations. Still further, the example methods and apparatus described below provide backup wellbore telemetry capability, enable the operation of multiple identical or substantially similar wellbore telemetry tools, enable the generation of comparative wellbore measurements, enable the activation of multiple wellbore telemetry tools, increase the available bandwidth and/or data transmission rates for communications between one or more downhole tools and one or more surface units, and enable adaptation of the wellbore telemetry tools to different and/or varying wellbore conditions.

SUMMARY

[0010] In accordance with one disclosed example, a wellbore communication system for a wellsite having a downhole tool deployed in a wellbore penetrating a subterranean formation includes a first mud pulse telemetry device disposed in the downhole tool. The example system may also include at least one additional telemetry device other than a mud pulse telemetry device and disposed in the wellbore. Additionally, the example system may include at least one of a pressure transducer or a pressure sensor adapted to detect a modulated pressure provided by at least one of the telemetry devices.

[0011] In another disclosed example, a wellbore communication system for a wellsite having a downhole tool deployed in a wellbore penetrating a subterranean formation includes a plurality of wellbore telemetry systems. At least one of the wellbore telemetry systems may comprise a wired drill pipe telemetry system. The example system may also include at least one surface unit in communication with at least one of the plurality of wellbore telemetry systems.

[0012] In yet another disclosed example, a wellbore communication system for a wellsite having a downhole tool deployed in a wellbore penetrating a subterranean formation includes at least one formation evaluation component to measure at least one wellbore parameter. The example system may also include a plurality of wellbore telemetry systems. At least one of the wellbore telemetry systems may be in communication with the at least one formation evaluation component to receive data therefrom and to transmit the data to a surface unit.

[0013] In still another disclosed example, a method of communicating between a surface location and a downhole tool deployed in a wellbore penetrating a subterranean formation evaluates a subterranean formation using at least one downhole component positioned in the downhole tool. The downhole tool may comprise a plurality of wellbore telemetry systems. The example method may also selectively transmit data from the at least one downhole component to a surface unit via at least one of the wellbore telemetry systems.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] FIG. **1** is a schematic view, partially in cross-section, of a known measurement while drilling tool and wellbore telemetry device connected to a drill string and deployed from a rig into a wellbore.

[0015] FIG. **2** is a schematic view, partially in cross-section, of an example telemetry system including a downhole tool having multiple mud pulse telemetry devices.

[0016] FIG. **3** is a schematic view, partially in cross-section, of another example telemetry system including a downhole tool having a wired drill pipe wellbore telemetry device.

[0017] FIG. **4** is a schematic view, partially in cross-section, of yet another example telemetry system including a downhole tool having a mud pulse telemetry device and an electromagnetic wellbore telemetry device.

[0018] FIG. **5** is a schematic view, partially in cross-section, of still another example telemetry system including a downhole tool having multiple downhole components and multiple wellbore telemetry devices.

DETAILED DESCRIPTION

[0019] Certain examples are shown in the above-identified figures and described in detail below. In describing these examples, like or identical reference numbers are used to identify common or similar elements. The figures are not necessarily to scale and certain features and certain views of the figures may be shown exaggerated in scale or in schematic for clarity and/or conciseness.

[0020] Referring now to FIG. **2**, a mud pulse wellbore telemetry system **200** having multiple telemetry devices is shown. In contrast to the known system **100** of FIG. **1**, the example wellbore telemetry system **200** includes two MWD tools **234*a*** and **234*b***, two mud pulse telemetry devices **238*a*** and **238*b***, two transducers **240*a*** and **240*b***, and two sensors **242*a*** and **242*b***. Additionally, the MWD tools **234*a*** and **234*b*** may communicate with a single surface computer or unit **202** via the mud pulse telemetry devices **238*a*** and **238*b***. As can be seen in the example system **200** of FIG. **2**, the mud pulse telemetry devices **238*a*** and **238*b*** are identical or substantially identical, the MWD tools **234*a*** and **234*b*** are identical or substantially identical, and the devices **238*a*** and **238*b*** and the tools **234*a*** and **234*b*** are positioned within a single downhole tool **201** (i.e., the same downhole tool). The surface unit or computer **202** may be implemented using any desired combination of hardware and/or software. For example, a personal computer platform, workstation platform, etc. may store on a computer readable medium (e.g., a magnetic or optical hard disk, random access memory, etc.) and execute one or more software routines, programs, machine readable code or instructions, etc. to perform the operations described herein. Additionally or alternatively, the surface unit or computer **202** may use dedicated hardware or logic such as, for example, application specific integrated circuits, configured programmable logic controllers, discrete logic, analog circuitry, passive electrical components, etc. to perform the functions or operations described herein.

[0021] Still further, while the surface unit **202** is depicted in the example of FIG. **2** as being relatively proximate to the drilling rig **10**, some part of or the entire surface unit **202** may alternatively be located relatively remotely from the rig **10**. For example, the surface unit **202** may be operationally and/or communicatively coupled to the wellbore telemetry system **200** via any combination of one or more wireless or hardwired communication links (not shown). Such communication links may include communications via a packet switched network (e.g., the Internet), hardwired telephone lines, cellular communication links and/or other radio frequency based communication links, etc. using any desired communication protocol.

[0022] Returning in detail to FIG. **2**, the MWD tools **234***a* and **234***b* may be implemented using the same device(s) used to implement the MWD tool **34** of FIG. **1**. Similarly, the mud pulse telemetry devices **238***a* and **238***b* may be implemented using the same device(s) used to implement the mud pulse telemetry device **38** of FIG. **1**. An example of a mud pulse telemetry device that may be used or otherwise adapted to implement the devices **38**, **238***a*, and **238***b* is described in U.S. Pat. No. 5,517,464, which has previously been incorporated by reference.

[0023] In operation, the example wellbore telemetry system **20** of FIG. **2** uses the mud pulse telemetry devices **238***a* and **238***b* to generate signals (e.g., modulated pressure signals) in the mud **20** flowing in the annulus **28** of the wellbore **30**. These generated signals (e.g., modulated or varying pressure signals) may be sensed by one or more of the pressure transducers **240***a* and **240***b* and/or the pressure sensors **242***a* and **242***b* and analyzed by the surface unit **202** to extract or otherwise obtain data or other information relating to the operational condition(s) of the downhole tool **201** (e.g., one or both of the MWD Tools **234***a* and **234***b*), conditions in wellbore **30**, and/or any other desired downhole information. In this manner, communications may be established between the downhole tool **201** and, thus, between the MWD tools **234***a* and **234***b*, and the surface unit **202**. More generally, such communications between the downhole tool **201** and the surface unit **202** may be established using uplink and/or downlink systems. Further, while mud pulse telemetry devices **238***a* and **238***b* are described in connection with the example telemetry system **200** of FIG. **2**, other types of wellbore telemetry devices may be employed instead of or in addition to the mud pulse telemetry devices **238***a* and **238***b*. For example, one or more mud sirens, positive pulse mud flow telemetry devices, and/or negative pulse mud flow telemetry devices may be used.

[0024] In general, the example wellbore telemetry systems described herein may use telemetry devices arranged or positioned in various configurations relative to the downhole tool. In the example of FIG. **2**, one or both of the telemetry devices **238***a* and **238***b* may be operatively or communicatively coupled to the same (i.e., a single) MWD tool (e.g., the tool **234***a* or the tool **234***b*). Alternatively, each of the telemetry devices **238***a* and **238***b* may be operatively or communicatively coupled to different respective tools. For example, the telemetry device **238***a* may be communicatively or operatively coupled to the MWD tool **234***a* and the telemetry device **238***b* may be communicatively or operatively coupled to the MWD tool **234***b*, as depicted in FIG. **2**. As described in greater detail below, one or both of the telemetry devices **238***a* and **238***b* may be communicatively or operatively coupled to one or more additional downhole components.

[0025] Turning again to the operation of the example system **200** of FIG. **2**, the mud pulse telemetry devices **238***a* and **238***b* may send uplink signals (e.g., varying or modulated pressure signals to be conveyed up along the annulus **28** to the surface **29**) by altering the flow of mud through the telemetry devices **238***a* and **238***b*. Such uplink signals (e.g., varying or modulated pressure signals) are sensed or detected by the pressure transducers **240***a* and **240***b* and/or the pressure sensors **242***a* and **242***b*. In particular, the uplink signals generated by the telemetry device **238***a* may be detected or sensed by the transducer **240***a* and/or the pressure sensor **242***a*. Similarly, the uplink signals generated by the telemetry device **238***b* may be detected or sensed by the transducer **240***b* and/or the pressure sensor **242***b*. The pressure transducers **240***a* and **240***b* may be implemented using devices identical or similar to that used to implement the pressure transducer **40** of FIG. **1**, and the sensors **242***a* and **242***b* may be implemented using devices identical or similar to that used to implement the sensor **42** of FIG. **1**.

[0026] FIG. **3** is a schematic view, partially in cross-section, of another example telemetry system **30** including a downhole tool **301** having a wired drill pipe wellbore telemetry system or device **348**. In contrast to the known mud pulse telemetry system **100** depicted in FIG. **1**, the example telemetry system **300** utilizes a mud pulse telemetry device **338** that is housed in a MWD tool **334** and includes the wired drill pipe telemetry system **348**.

[0027] As shown in FIG. **3**, the MWD tool **334** and the mud pulse telemetry device **338** may be positioned in the downhole tool **301**. The MWD tool **334** may be implemented using a device that is similar or identical to that used to implement the MWD tool **34** of the FIG. **1** and/or the MWD tools **234***a* and **234***b* of FIG. **2**. Similarly, the mud pulse telemetry device **338** may be implemented using a device that is similar or identical to that used to implement the mud pulse telemetry device **38** of FIG. **1** and/or the mud pulse telemetry devices **238***a* and **238***b* of FIG. **2**. Additionally, the surface unit or computer **302** may be implemented in a manner similar to the surface unit or computer **202** described in connection with FIG. **2**. Thus, the surface unit **302** may be operatively or communicatively coupled to the MWD tool **334** via the mud pulse telemetry device **338** and/or may be operatively or communicatively coupled to the wired drill pipe telemetry system **348** via one or more communication links (not shown). As with the example system **200** of FIG. **2**, the surface unit or computer **302** may be proximate the drilling rig **10** or, alternatively, some or all of the surface unit or computer **302** may be remotely located relative to the drilling rig **10**.

[0028] Turning in detail to the wired drill pipe wellbore telemetry system **348**, it can be seen in the example of FIG. **3** that the system **348** extends substantially entirely through the drill string **14**. An example of a wired drill pipe wellbore telemetry system that may be used to implement the system **348** is described in U.S. Pat. No. 6,641,434, which has been previously incorporated by reference herein. As depicted in FIG. **3**, the wired drill pipe wellbore telemetry system **348** includes a plurality or series of wires **352** positioned in each drill pipe **350** that forms or composes the drill string **14**. A coupler **354** is positioned at the end of each of the drill pipes **350** so that when the pipes **350** are connected, joined, or otherwise coupled, the drill string **14** provides a hardwired communication link extending through the drill string **14**. While the wired drill pipe telemetry system **348** is depicted in FIG. **3** as extending substantially entirely through the drill string **14** to the MWD tool **334**, the wired drill pipe telemetry system **348** may instead extend only partially through the drill string **14**.

[**0029**] During operation, either or both of the mud pulse telemetry device **338** and the wired drill pipe system **348** may be used to enable communications between the downhole tool **301** (e.g., the MWD tool **334**) and the surface unit **302**. Depending on the particular operational mode of the rig **10** and/or downhole or other environmental conditions, the device **338** or the system **348** may be best suited to convey data to the surface unit **302**. Alternatively or additionally, both the device **338** and the system **348** may be used to convey information between the surface unit **302** and the downhole tool **301** at the same time. In such a case, the conveyed information may concern the same downhole parameter(s) or condition(s) or different parameter(s) or condition(s).

[**0030**] FIG. **4** is a schematic view, partially in cross-section, of yet another example telemetry system **400** including a downhole tool **401** having a mud pulse telemetry device **438** and an electromagnetic wellbore telemetry device **448**. Similar to the systems **200** and **300** depicted in FIGS. **2** and **3**, respectively, the system **400** includes a surface unit or computer **402** that can communicate with the downhole tool **401** and/or other downhole components and analyze information obtained therefrom. In this manner, the surface unit **402** may be operationally or otherwise coupled to a MWD tool **434** via, for example, the mud pulse telemetry device **438**. Still further, as with the other systems **200** and **300**, the surface unit **402** may be proximate the drilling rig **10** as shown, or some or all of the surface unit **402** may be remotely located relative to the drilling rig **10** and communicatively coupled via, for example, any desired combination of wireless and hardwired communication links to the system **400**.

[**0031**] The mud pulse telemetry device **438** is position in the downhole tool **401** and may be implemented using the same device or a device similar to the device used to implement the device **38** of FIG. **1**, the device **238***a* and **238***b* of FIG. **2**, and/or the device **338** of FIG. **3**. Also, the MWD tool **434** is positioned in the downhole tool **401** and may be implemented using the same device or a device similar to the device used to implement the device(s) used to implement the tools **234***a* and **234***b* of FIG. **2**, and/or **334** of FIG. **3**.

[**0032**] The electromagnetic wellbore telemetry system **448** includes a downhole transceiver **454** and a surface transceiver **452**. An example of an electromagnetic wellbore telemetry system that may be used to implement the system **448** of FIG. **4** is described in U.S. Pat. No. 5,624,051, previously incorporated by reference herein. As depicted in the example of FIG. **4**, the electromagnetic wellbore telemetry system **448** is also provided with a gap collar **450**, which is position in the downhole tool **401** to enhance the electromagnetic signals conveyed between the transceivers **452** and **454**. An example of a gap collar that may be used to implement the collar **450** is described in U.S. Pat. No. 5,396,232.

[**0033**] While the example systems depicted in FIGS. **2-4** include certain combinations of mud pulse telemetry, wired drill pipe telemetry, and electromagnetic telemetry systems, other combinations of such systems may be employed to achieve the same or similar results. For example, a wellbore telemetry system using a mud siren, positive and/or negative pulse telemetry devices, an acoustic telemetry device, a tortional wave telemetry device, or any other telemetry device(s) could be used instead of or in addition to those depicted in FIGS. **2-4** to communicate with a surface unit or computer. Additionally, various combinations of communication links (e.g., wireless, hardwired, etc.) may be employed to provide selective communications between the surface unit and the telemetry devices to suit the needs of particular applications.

[**0034**] Still further it should be understood that the telemetry devices, or any combination thereof, used with the example systems described herein may be positioned in various configurations about the downhole tool. For example, the devices may be positioned adjacent to each other or, alternatively, at some desired distance or spacing apart, with or without components disposed therebetween. The telemetry devices may be oriented vertically as shown in the examples, or one or more of the devices may be inverted.

[**0035**] FIG. **5** is a schematic view, partially in cross-section, of still another example telemetry system **500** including a downhole tool **501** having multiple downhole components and multiple wellbore telemetry devices. As depicted in the example system **500** of FIG. **5**, the downhole tool **501** includes two MWD tools **534***a* and **534***b*, two mud pulse telemetry devices **538***a* and **538***b*, two pressure transducers **540***a* and **540***b*, and two sensors **542***a* and **542***b*.

[**0036**] A surface unit or computer **502**, which may be similar or identical to one or more of the example surface units **202**, **302**, and **402** of FIGS. **2**, **3**, and **4**, respectively, may be communicatively and/or operationally coupled to the telemetry devices **538***a* and **538***b* and/or downhole components **548***a* and **548***b*. As with the other example surface units **202**, **302**, and **404**, the example surface unit **502** may be proximate (e.g., onsite) or remotely situated (e.g., offsite) relative to the rig **10** and operationally and/or otherwise coupled to the telemetry systems, MWD tools **534***a* and **534***b*, and/or mud pulse telemetry devices **538***a* and **538***b* via any desired communication links (not shown). The MWD tools **534***a* and **534***b* may be implemented using devices similar or identical to those used to implement the MWD tools **34**, **234***a*, **234***b*, **334**, and/or **434**. Similarly, the mud pulse telemetry devices **538***a* and **538***b* may be implemented using devices similar or identical to those used to implement the mud pulse telemetry devices **38**, **238***a*, **238***b*, **338**, and/or **438**.

[**0037**] As depicted in FIG. **5**, the downhole tool **501** houses the MWD tools **534***a* and **534***b*, the mud pulse telemetry devices **538***a* and **538***b*, and downhole components **548***a* and **548***b*. In the example of FIG. **5**, the downhole components **548***a* and **548***b* are depicted as formation evaluation tools, which may be used to test and/or sample fluid from a surrounding formation. Examples of such formation valuation tools that may be used to implement the tools **548***a* and **548***b* are described in published U.S. Patent Application No. 2005/01109538, which is incorporated by reference herein in its entirety. As shown, the downhole components **548***a* and **548***b* include stabilizer blades **552***a* and **552***b* with proves **554***a* and **554***b* for drawing fluid into the downhole tool **501**, and backup pistons **550***a* and **550***b* to assist in driving the proves **554**a and **554**b into position against the wall of the wellbore **30**. The formation evaluation components **548**a and **548**b may enable various pressure testing and/or sampling procedures to be performed. Although the example of FIG. **5** depicts two formation evaluation components in the downhole tool **501**, one or more than two formation evaluation components may be used instead.

[**0038**] In the example of FIG. **5**, the wellbore telemetry devices **538**a and **538**b are operationally coupled to the respective downhole components **548**a and **548**b. However, one or more wellbore telemetry devices may be coupled to one or more formation evaluation components. For example, two wellbore telemetry devices may be coupled to the same downhole component or, alternatively, each wellbore telemetry device may be coupled to a single, respective downhole component. Additionally, a variety of formation evaluation components may be coupled to one or both of the wellbore telemetry devices **538**a and **538**b. As used herein, "formation evaluation component" refers to a device for performing formation evaluation such as, for example, sampling, detecting formation pressure while drilling, measuring resistivity, nuclear magnetic measurements, or any other downhole tool used to evaluate a subterranean formation.

[**0039**] Multiple wellbore telemetry devices and/or systems such as those described in connection with the example systems herein may be used to provide downhole tools with the ability to perform independent or integrated downhole operations. For example, one wellbore telemetry system and/or telemetry device may be used in conjunction with a downhole formation evaluation component to perform various testing operations, while a second telemetry device may be used to perform resistivity operations. Additional wellbore telemetry systems and/or devices may be provided as desired. In some cases it may be desirable to use certain wellbore telemetry systems or devices in conjunction with certain downhole components to perform certain downhole operations.

[**0040**] Measurements taking using the wellbore telemetry devices may be compared and analyzed. In this manner, duplicate or redundant measurements may be taken for calibration and/or verification purposes. Additionally, duplicate or redundant measurements may be taken at different positions (at the same or different times) to determine differences in the formation at various downhole locations. Measurements taken by different components may also be analyzed to determine, for example, performance capabilities and/or formation properties.

[**0041**] The separate or individual functionality of the wellbore telemetry devices may also be used to supply and/or enhance power capabilities for instruments or tools downhole/in the BHA as needed to perform continuous or additional operations. For example, embodiments of the systems disclosed herein may be implemented with a power source (e.g. batteries) or power generator (e.g. mud turbine), as known in the art, to provide the desired energy. Yet other embodiments may be implemented for power transmission via electromagnetic energy conveyance using the wired drill pipe systems disclosed herein.

[**0042**] Multiple wellbore telemetry devices may also be used to increase data transmission rates to the surface and/or to eliminate the need for batteries in the downhole tool. The use of multiple wellbore telemetry devices may also provide a backup system in a case where one of the wellbore telemetry systems fails or is otherwise unable to function properly. Further, in cases where two different wellbore telemetry systems and/or devices are used, alternative types of communications may be employed as desired or needed to provide more effective communications between a downhole tool and a surface unit. Still further, any desired communication medium (e.g., gas/gas mixtures including air, methane, nitrogen, mud, etc.) or combination of media may be used to implement the telemetry systems described herein. For example, any combination of wireless and/or hardwired media may be used to suit the needs of particular applications. More specifically, wireless media may include drilling mud, electromagnetic signals, acoustic signals, etc., and hardwired media may include wired drill pipe and/or any other media using electrical conductors. In some cases, especially when running under-balanced drilling, inert gas like nitrogen, methane or air is mixed to reduce the weight of the mud. If there is an excessive amount of gas in the mud system, mud pulse telemetry systems often fail to work. In some cases only pressurized gas is used for drilling. In these cases electromagnetic and/or wired drill pipe telemetry systems of the invention may be used. A combination of these telemetry systems or multiple electromagnetic or other telemetry devices can also be used as disclosed herein.

[**0043**] As noted above in connection with the examples of FIGS. **2**, **3**, **4**, and **5**, the surface units **202**, **302**, **402**, and/or **502** may be located onsite or offsite (e.g., relative to the rig) and may be communicatively and/or operationally coupled to one or more respective downhole tools via communication links (not shown). The communication links may be implemented using any desired wireless and/or hardwired link capable of transmitting data between wellbore telemetry devices and surface units or computers. In some examples, the communication link may be coupled to a wellbore telemetry device via an intermediary device such as, for example, a pressure transducer. The communication link provides means for passing signals such as command, data, power or other signals between the wellbore telemetry devices and the surface computer. These signals may be used to control the downhole tool and/or to retrieve data collected by the downhole tool. Preferably, but not necessarily, signals are passed in real time to provide fast and efficient data collection, tool operation and/or response to wellbore conditions.

[**0044**] One or more communication links may be provided to operatively couple the wellbore telemetry system(s) and/or device(s) to one or more surface unit(s). In this manner, each wellbore telemetry device and/or system can selectively communicate with one or more surface unit(s). Alternatively, such links may couple the wellbore telemetry system(s) and/or device(s). The telemetry device(s) may communicate with the surface via a wellbore telemetry system. Various communication links may be provided so that the wellbore telemetry devices and/or systems may communicate with each other and/or the surface unit(s) independently, simultaneously or substantially simultaneously, alternately (e.g., while one telemetry device is actively communicating, other telemetry devices are not actively communicating), and/or during selected (e.g., predetermined) time frames or intervals.

[0045] The signals and/or other communications conveyed via the example wellbore telemetry systems described herein may be used or manipulated to enable the efficient flow of data or information. For example, the example telemetry devices and/or systems may be selectively operated to pass data from the downhole tool to the surface unit or computer. Such data may be passed from the telemetry devices and/or systems at similar or different frequencies, simultaneously or substantially simultaneously, and/or independently. The data and/or signals may be selectively manipulated, analyzed, or otherwise processed to generate an optimum and/or desired data output. The data (e.g., the output data) may be compared (e.g., to reference values, threshold values, etc.) and/or analyzed to determine wellsite conditions, which may be used to adjust operating conditions, locate valuable hydrocarbons, and/or perform any other desired wellsite operations or functions.

[0046] It will be understood from the foregoing description that the example systems and methods described herein may be modified from the specific embodiments provided. For example, the communication links described herein may be wired or wireless. The example devices described herein may be manually and/or automatically activated or operated to perform the desired operations. Such activation may be performed as desired and/or based on data generated, conditions detected, and/or results from downhole operations.

[0047] The foregoing description and example systems and methods provided thereby are for purposes of illustration only and are not to be construed as limiting. Thus, although certain apparatus and methods have been described herein, the scope of coverage of this patent is not limited thereto. To the contrary, this patent covers all embodiments fairly falling within the scope of the appended claims either literally or under the doctrine of equivalents.

What is claimed is:

1. A wellbore communication system for a wellsite having a downhole tool deployed in a wellbore penetrating a subterranean formation, the communication system comprising:

a first mud pulse telemetry device disposed in the downhole tool;

at least one additional telemetry device other than a mud pulse telemetry device disposed in the wellbore; and

at least one of a pressure transducer or a pressure sensor to detect a modulated pressure provided by the mud pulse telemetry device.

2. The communication system of claim 1, further comprising a surface unit to communicate with at least one of the telemetry devices.

3. The communication system of claim 1, further comprising at least one formation evaluation component to perform a downhole operation.

4. The communication system of claim 3, wherein at least one formation evaluation component is to be operatively coupled to at least one of the telemetry devices.

5. The communication system of claim 1, wherein at least one additional telemetry device comprises a telemetry system.

6. The communication system of claim 5, wherein the at least one additional telemetry system comprises an electromagnetic wellbore telemetry system.

7. The communication system of claim 5, wherein the at least one additional telemetry system comprises a wired drill pipe telemetry system.

8. The communication system of claim 1, further comprising at least one additional mud pulse telemetry device positioned in the downhole tool.

9. A wellbore communication system for a wellsite having a downhole tool deployed from a rig into a wellbore penetrating a subterranean formation, the communication system comprising:

a plurality of wellbore telemetry systems, wherein at least one of the wellbore telemetry systems comprises a wired drill pipe telemetry system; and

at least one surface unit in communication with at least one of the plurality of wellbore telemetry systems.

10. The communication system of claim 9, wherein the plurality of wellbore telemetry systems comprises one or more of another wired drill pipe telemetry system, a mud pulse telemetry system, or an electromagnetic telemetry system.

11. The communication system of claim 9, further comprising at least one formation evaluation component to perform a downhole operation.

12. The communication system of claim 11, wherein the at least one formation evaluation component is to be operatively coupled to at least one of the wellbore telemetry systems.

13. A wellbore communication system for a wellsite having a downhole tool deployed in a wellbore penetrating a subterranean formation, the communication system comprising:

at least one formation evaluation component to measure at least one wellbore parameter; and

a plurality of wellbore telemetry systems, wherein at least one of the wellbore telemetry systems is to be in communication with the at least one formation evaluation component to receive data therefrom and to transmit the data to a surface unit.

14. The communication system of claim 13, wherein the wellbore telemetry systems comprise one or more of a mud pulse telemetry system, an electromagnetic telemetry system, or a wired drill pipe telemetry system.

15. The communication system of claim 13, wherein each formation evaluation tool is to be operatively coupled to a respective wellbore telemetry device.

16. A method of communicating between a surface location and a downhole tool deployed in a wellbore penetrating a subterranean formation, the method comprising:

evaluating a subterranean formation using at least one downhole component positioned in the downhole tool, wherein the downhole tool comprises a plurality of wellbore telemetry systems; and

selectively transmitting data from the at least one downhole component to a surface unit of at least one of the wellbore telemetry systems.

17. The method of claim 16, wherein the data is transmitted simultaneously from each downhole component.

18. The method of claim 16, wherein the data is transmitted at different times from at least two downhole components.

19. The method of claim 16, further comprising transmitting the data between wellbore telemetry devices.

20. The method of claim 16 further comprising analyzing data collected from the at least one formation evaluation component.

21. The method of claim 20, wherein the data from each formation evaluation component is compared.

22. The method of claim 16, further comprising supplying power to a downhole tool using one of the plurality of wellbore telemetry systems.

23. A wellbore telemetry system, comprising:

a first wellbore telemetry device coupled to a downhole tool and adapted to use a communication medium to communicate with a surface computer; and

a second wellbore telemetry device coupled to a downhole tool and adapted to use one of the communication medium, a wired drill pipe communication link, or an electromagnetic communication link to communicate with the surface computer.

24. The wellbore telemetry system of claim 23, wherein the downhole tool comprises at least two measurement while drilling tools.

25. The wellbore telemetry system of claim 23, wherein the communication medium comprises mud in a wellbore.

26. The wellbore telemetry system of claim 23, wherein the communication medium comprises a mixture of mud and gas in a wellbore.

27. The wellbore telemetry system of claim 23, wherein the communication medium comprises a gas consisting substantially of nitrogen, methane, or air in a wellbore.

28. The wellbore telemetry system of claim 24, wherein the first and second wellbore telemetry devices comprise at least one of mud pulse telemetry devices, sirens, positive pulse devices, or negative pulse devices.

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