

[54] **DATA-SIGNALING APPARATUS FOR WELL DRILLING TOOLS**

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[51] Int. Cl. **G01v 1/14**

[58] Field of Search **340/18 LD**

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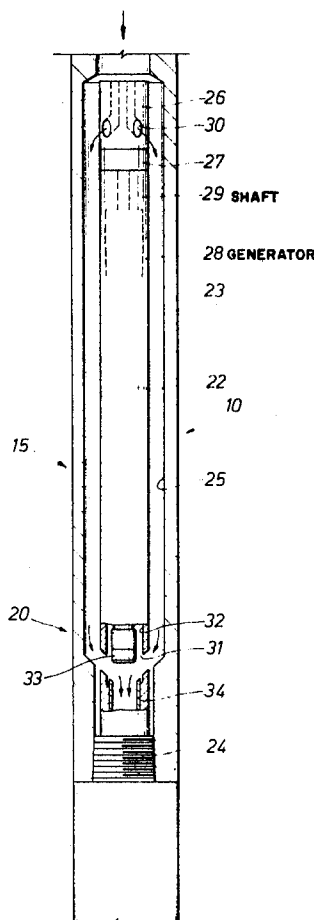
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[57]

ABSTRACT

In the preferred embodiment of the invention disclosed herein, a well tool having new and improved data-signaling apparatus and carrying a drill bit on its lower end is dependently coupled from a drill string and lowered into a borehole being excavated. During the drilling operation, measurements are successively made of selected borehole conditions, formation properties, or the like, which are converted by the data-signaling apparatus into coded electrical signals for repetitively opening and closing a valve including a valve member and a movable valve seat operatively arranged on the tool for selectively interrupting and then resuming the flow of the drilling fluid being circulated through the drill string. In this manner, the valve functions to produce a series of encoded pressure pulses in the drilling fluid which are representative of the measurements being obtained. These pressure pulses are transmitted through the drilling fluid to the surface where they are sensed and converted into meaningful indications of the measurements.

19 Claims, 6 Drawing Figures



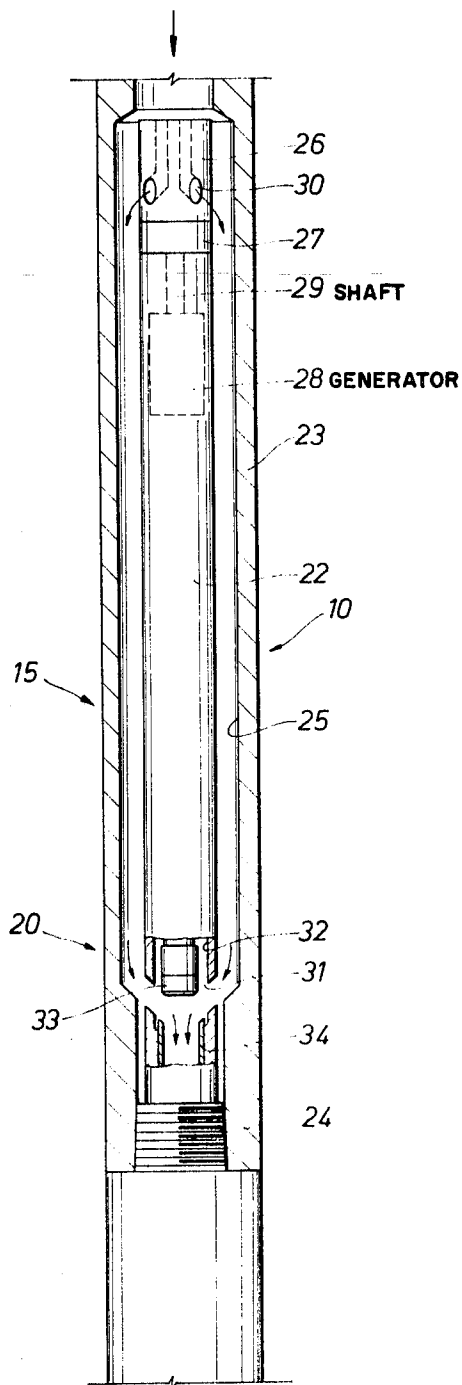


FIG. 2

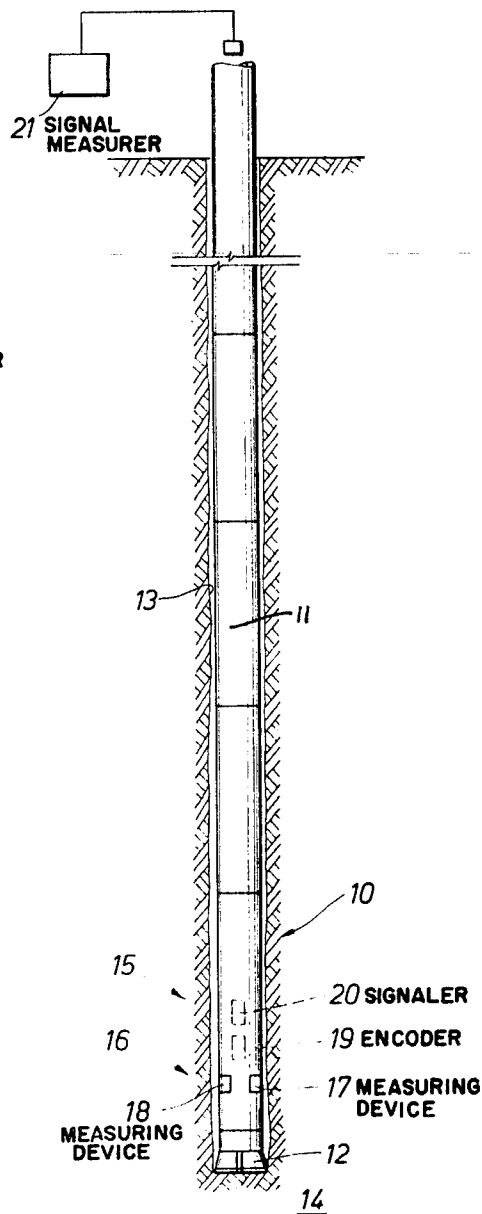


FIG. 1

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FIG. 3

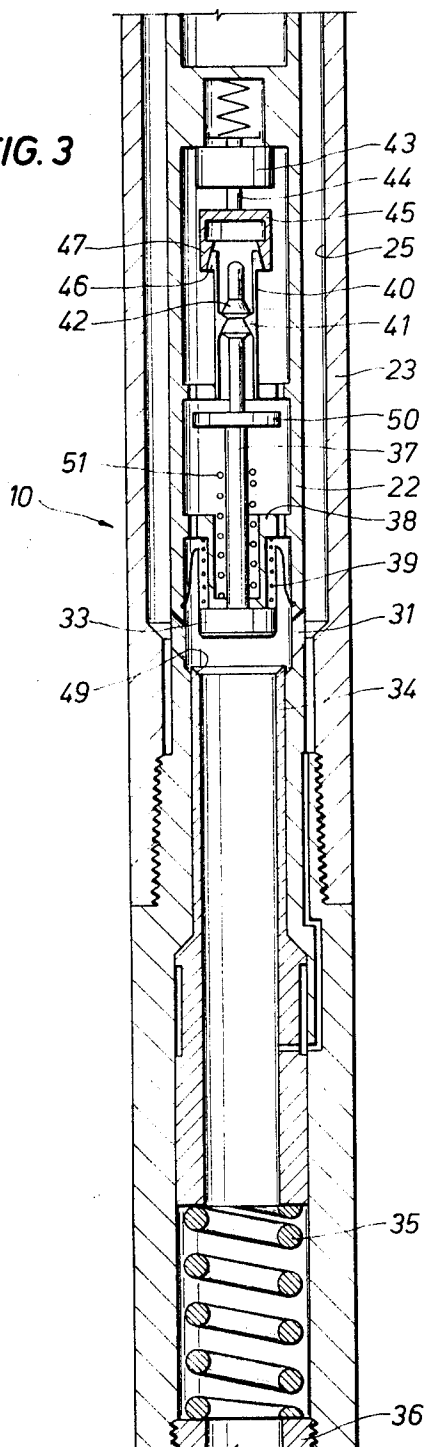
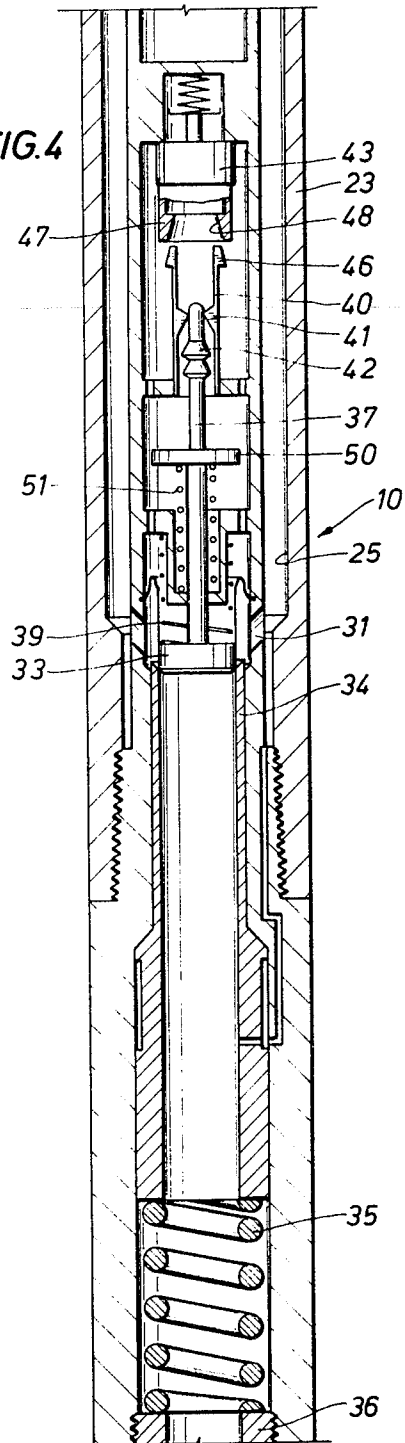


FIG. 4



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FIG. 5

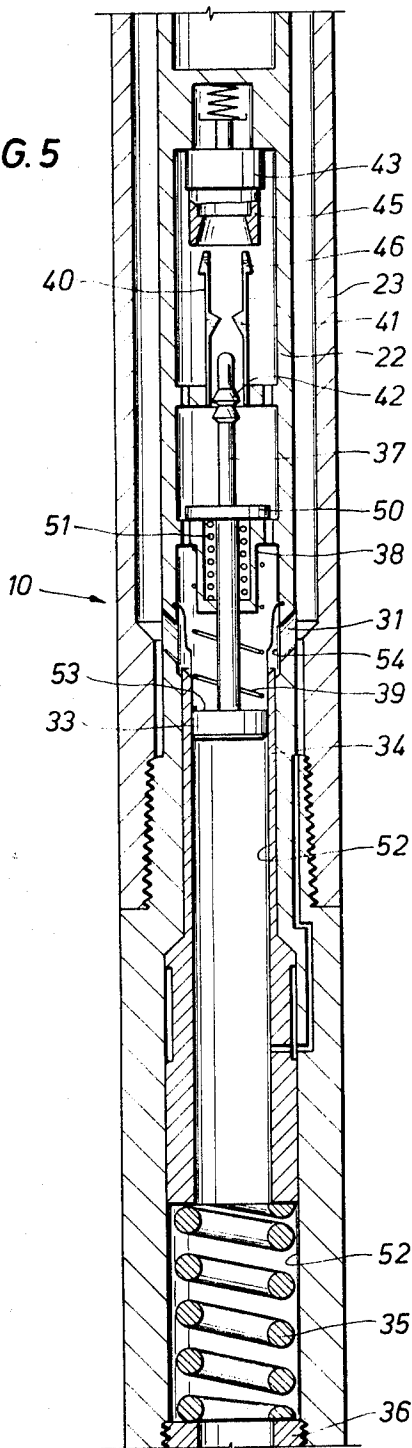
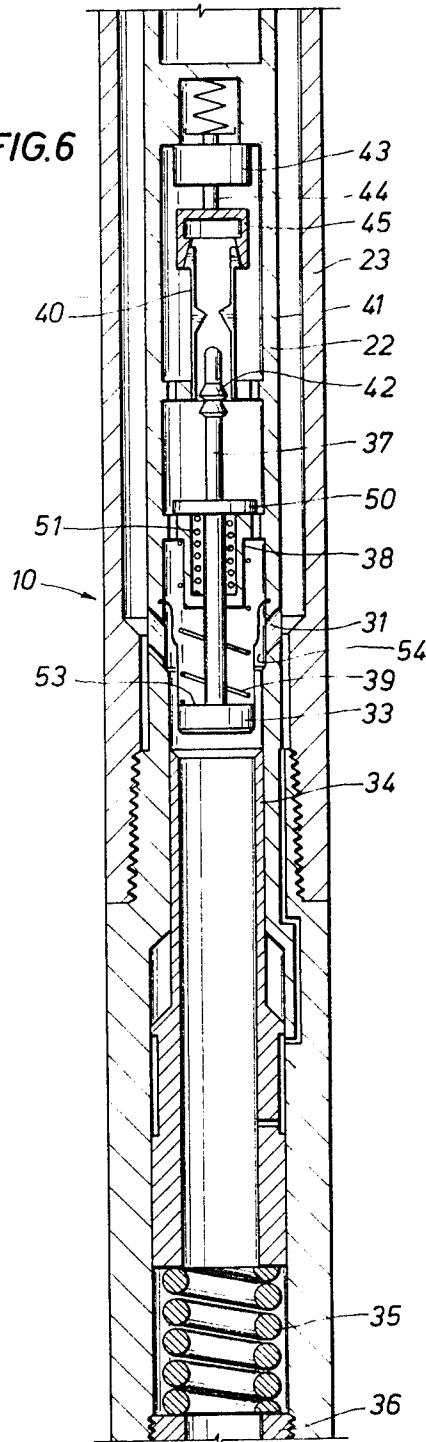


FIG. 6



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DATA-SIGNALING APPARATUS FOR WELL DRILLING TOOLS

Those skilled in the art have, of course, long recognized the benefits of obtaining various measurements at the bottom of a borehole during the course of a drilling operation. For instance, such information as the weight on the drill bit, the drill string torque, the inclination and the azimuthal direction of the borehole, bottom hole pressures and temperatures as well as various characteristics of the formations being penetrated are all measurements of significant interest.

Various proposals have, of course, been made heretofore for transmitting such measurements from the bottom of a borehole to the surface. Of the many different tools proposed, perhaps the most promising of all utilize a condition-responsive valve for selectively interrupting the flow of the circulating drilling fluid in a predetermined coded sequence representative of the measurements to produce a series of momentary pressure surges which are successively transmitted through the drilling fluid to the surface for detection by appropriate sensing devices. These proposed tools have, therefore, generally employed a typical solenoid-operated valve which is coupled to one or more condition-sensing devices by means of appropriate electronic circuitry operatively arranged for opening and closing the valve in accordance with this coded sequence.

For various reasons, however, these prior proposals have generally been considered to be unacceptable for commercial drilling operations. For instance, since the signaling valves in such prior tools have customarily been directly operated by solenoids, the mechanical forces required just for operating these valves are so large that the power requirements for these solenoids become excessive in even relatively shallow wells. Moreover, by virtue of their substantial power requirements, the physical size of such solenoids make them impractical for the usual sizes of drilling tools.

Accordingly, it is an object of the present invention to provide new and improved data-signaling apparatus for use with well-drilling tools and which is specially adapted for rapidly transmitting downhole measurements to the surface with minimum electrical requirements.

This and other objects of the present invention are attained by providing a well tool adapted to be connected in a drill string having a drill bit dependently coupled thereto for excavating a borehole as a drilling fluid is circulated through the drill string and a fluid passage arranged in the tool. Data-signaling means are arranged on the tool and include condition-measuring means which are coupled to measurement-encoding means adapted for producing coded electrical signals indicative of one or more selected downhole conditions which may be experienced during the course of a drilling operation. To generate distinctive pressure pulses in the circulating drilling fluid representative of such measurements, the measurement-encoding means operatively drive pressure-signaling means arranged on the tool and including valve means which are releasably retained from movement to a passage-closing position by electrically responsive latch means adapted for selective operation in response to the electrical signals produced by the measurement-encoding means for initiating the closure of the valve means. Pressure-responsive means are operatively associated with the

valve means and adapted for utilizing the circulating drilling fluid as a motive force to positively operate the valve means as well as to energize biasing means operatively arranged for returning the valve means to a passage-opening position to await the next electrical signal.

The novel features of the present invention are set forth with particularity in the appended claims. The invention, together with further objects and advantages thereof, may be best understood by way of the following description of exemplary apparatus employing the principles of the invention as illustrated in the accompanying drawings, in which:

FIG. 1 shows a well tool arranged in accordance with the present invention as it will appear while coupled in a drill string during the course of a typical drilling operation;

FIG. 2 is a schematic representation of a preferred embodiment of the tool shown in FIG. 1; and

FIGS. 3-6 schematically depict certain successive operating positions of a preferred embodiment of data-signaling apparatus incorporating the principles of the present invention.

Turning now to FIG. 1, a new and improved well tool 10 arranged in accordance with the present invention is depicted coupled in a typical drill string 11 having a rotary drill bit 12 dependently coupled thereto and adapted for excavating a borehole 13 through various earth formations as at 14. As the drill string 11 is rotated by a typical drilling rig (not shown) at the surface, substantial volumes of a drilling fluid or co-called "mud" are continuously pumped downwardly through the tubular drill string and discharged from the drill bit 12 to cool the bit as well as to carry earth borings removed by the bit to the surface as the mud is returned upwardly along the borehole 13 exterior of the drill string. As is typical, the mud stream is circulated by employing one or more high-pressure mud pumps (not shown) which continuously draw the fluid from a storage pit or vessel for subsequent recirculation by the mud pumps. It will be appreciated, therefore, that the constantly circulating mud stream flowing through the drill string 11 serves as a transmission media that is well suited for transmitting pressure surges or pulses to the surface.

In accordance with the principles of the present invention, data-signaling means 15 are arranged on the well tool 10 and include condition-measuring means 16 such as one or more condition-responsive devices, as at 17 and 18, which are coupled to an appropriate measurement encoder 19 operatively arranged to produce a series of coded electrical signals that are representative of the measurements being obtained by the condition-responsive devices. Pressure-signaling means 20 coupled to the encoder 19 are operatively arranged to respond to these coded signals for selectively generating a corresponding series of pressure pulses in the circulating fluid by momentarily and rapidly interrupting the flow of the drilling fluid through the drill string 11. It will be appreciated, of course, that these transitory pressure pulses or surges will be similar to those caused by a so-called "water hammer." Thus, these pressure waves will be transmitted to the surface by way of the mud stream flowing within the drill string 11 and at the speed of sound in the particular drilling fluid. Accordingly, as will subsequently be explained in greater detail, the pressure-signaling means 20 produce these

pressure pulses to provide encoded representations or data indicative of the one or more downhole conditions sensed by the condition-measuring devices 17 and 18. This data is, in turn, successively transmitted to the surface in the form of these pressure pulses for detection and conversion into meaningful indications or records by suitable surface-located pressure-transducing apparatus 21 such as those disclosed in either U.S. Pat. No. 3,488,629 or a copending application Ser. No. U.S. Pat. No. 3,555,504.

Turning now to FIG. 2, a schematic view is shown of the new and improved well tool 10 just prior to the production of a pressure surge or pulse which is to be transmitted to the surface by way of the drilling fluid being circulated through the drill string 11. As illustrated, the well tool 10 is comprised of an elongated tubular member 22 that is coaxially arranged within a thick-wall tubular housing 23 which is tandemly coupled in the drill string 11 just above the drill bit 12.

Although the inner member 22 could just as well be releasably secured to the outer housing 23, it is preferred to permanently mount the inner member within the housing as illustrated. In this manner, by securing the lower end of the inner member 22 to the outer housing 23 as by threads at 24, an annular space 25 will be defined between the interior wall of the housing and the exterior of the inner member.

Although a self-contained power supply could be employed, it is preferred to utilize the flowing mud stream as a motivating source for generating electrical power for operation of the new and improved well tool 10. Accordingly, in the preferred manner of accomplishing this, a reaction turbine 26 is journaled, as by a bearing 27, to the upper end of the inner member 22 and operatively arranged to be rotatively driven by the downwardly flowing drilling fluid for driving a generator 28 coupled to the turbine by an elongated shaft 29. Thus, as the mud stream flows through the turbine 26, the fluid will be discharged from the outlet ports 30 of the turbine into the upper portion of the annular space 25. It will be appreciated, therefore, that during the operation of the well tool 10, the circulation of the drilling fluid or mud will be effective for continuously driving the turbine 26 and the generator 28 coupled thereto to produce electrical power for operating the data-signaling means 15.

As depicted in FIG. 3, at least a substantial portion of the mud stream flowing through the annular space 25 enters one or more downwardly inclined lateral ports 31 formed near the lower end of the inner member 22. The fluid entering the ports 31 will then pass through the longitudinal bore 32 of the inner member and on through the lower portion of the outer housing 23 therebelow. To produce the aforementioned pressure pulses, the pressure-signaling means 20 include a valve member 33 coaxially mounted within the inner member 22 and adapted for axial movement therein between an elevated position as depicted in FIG. 3 and a lower port-closing position where the valve member is co-operatively received within the upper end of a tubular valve seat 34. As will subsequently be explained, the valve seat 34 is slidably mounted in the inner member 22 and normally retained in its depicted elevated position by biasing means such as a compression spring 35 supported on an inwardly directed shoulder 36 on the outer housing 23 and engaged with the lower end of the valve seat. To support the valve member 33 for

reciprocating movement within the inner member 22, an upright extension or rod 37 is secured to the valve member and extended upwardly through an annular guide 38 arranged thereabove within the inner member. Biasing means, such as a compression spring 39 compressed between the guide 37 and the valve member 33 are operatively arranged for urging the valve member downwardly toward its port-closing position.

It will be recognized that so long as the valve member 33 remains in its elevated position depicted in FIG. 3, the drilling fluid can freely circulate from the annular space 25 through the lateral ports 31 and the tubular valve seat 34 and pass without significant restriction on through the lower portion of the outer housing 23 to the drill bit 12 therebelow. On the other hand, it will be appreciated that once the valve member 32 is released for downward movement into engagement with the valve seat 34, the fluid circulation through the fluid ports 31 will be at least blocked or closed momentarily and produce a corresponding pressure surge or pulse which will be transmitted back up the mud stream in the drill string 11 for detection at the surface.

To releasably retain the valve member 32 in its elevated position, latching means are provided such as one or more upright leaf springs or yieldable fingers 40 which are secured within the inner member 22 and releasably coupled to the rod 37 by inwardly directed lugs as at 41 on the mid-portion of each finger which are adapted to remain engaged under one or more outwardly enlarged shoulders 42 spaced along the upper portion of the elongated rod so long as the fingers are retained in their respective inwardly contracted positions illustrated in FIG. 3. To retain the fingers 40 in their latching positions, a solenoid 43 is coaxially mounted within the inner member 22 and includes a vertically reciprocating armature 44 carrying a downwardly opening cup-like member 45 which is adapted for movement between an elevated position above the latch fingers and the lower position depicted in FIG. 3 where the cup at least partially encloses the upper end of the fingers.

In the preferred embodiment illustrated, upwardly directed wedge-shaped heads, as at 46, are mounted on the upper ends of each of the several fingers 40 and an annular ring 47 is arranged around the cup 45 to define an internal downwardly directed wedge-like surface 48 which is complementary to the opposed surfaces of the wedge-shaped heads. Thus, so long as the cup 45 is disposed over the upright fingers 40, the ring 47 will cooperatively engage the wedge-shaped heads 46 to restrain the fingers against moving outwardly from their respective positions shown in FIG. 3. In this manner, so long as the fingers 40 are retained from moving outwardly, the inwardly directed lugs 41 will be maintained in engagement under one of the enlarged shoulders 42 on the elongated rod 37. It will, therefore, be recognized that the spring 39 is urging the valve member 33 and the rod 37 downwardly and that it is only the coaction of the lugs 41 under the shoulder 42 which maintain the valve member in its elevated position.

On the other hand, as will subsequently be explained in further detail, it will be appreciated that once the solenoid 43 is energized to withdraw the cup 45 from engagement with the enlarged heads 46, the cooperative camming action between the enlarged shoulder 42 and the inwardly directed lugs 41 will be effective for momentarily springing the fingers 40 outwardly to free the

elongated rod 37 and the valve member 33 for downward movement. Thus, once the solenoid 43 is energized, the compression spring 39 will be effective for forcefully driving the valve member 33 downwardly once the enlarged shoulder 42 has expanded the mid-portions of the fingers 40 sufficiently to disengage the enlarged shoulder from the inwardly directed lugs 41.

Accordingly, as depicted in FIG. 4, once the valve member 33 enters the valve seat 34, the circulating drilling fluid will be momentarily halted so as to produce a transitory pressure surge or pressure pulse in the nature of a water hammer. Those skilled in the art will, of course, appreciate that the dynamic pressures produced by such water hammers are quite substantial. Thus, by virtue of the rapid movement of the valve member 33 into seating engagement within the valve seat 34, the substantial dynamic pressure force which is developed will be imposed on the upper end 49 of the valve seat and will be effective for urging the valve seat downwardly in relation to the outer housing 23. In view of the substantial magnitude of this pressure force acting on the effective cross-sectional area of the upper end 49 of the valve seat 34, the valve seat will be shifted downwardly to begin compressing the spring 35.

It will be noted from FIG. 5 that as the valve seat 34 begins moving downwardly, the valve member 33 will be abruptly halted as an enlarged shoulder 50 on the elongated rod 37 engages the guide 38. Thus, the dynamic pressure force imposed on the upper end 49 of the valve seat 34 will be effective for shifting the valve seat away from and out of engagement with the momentarily halted valve member 33. Moreover, once the valve seat 34 is withdrawn from over the valve member 33 as depicted in FIG. 6, a spring 51 arranged between the guide 38 and the shoulder 50 will now have been compressed so as to quickly return the valve member 33 and the elongated rod 37 upwardly toward their initial elevated position.

During this same time interval, it will be noted by comparison of FIGS. 5 and 6 that the solenoid 43 has now been de-energized so as to reposition the cup 45 back over the enlarged heads 46 of the latch fingers 40. Thus, once the upper ends 46 of the fingers 40 are again reconfined, it will be appreciated that as the enlarged shoulders 42 on the elongated rod 37 move upwardly past the inwardly directed lugs 41, the mid-portions of the fingers will be momentarily cammed outwardly. Then, once one or more of the shoulders 42 are above the lugs 41, the mid-portions of the fingers 40 will again contract to resecure the elongated rod 37 and the valve member 33 in their elevated positions as depicted in FIG. 3. Similarly, the downwardly acting dynamic pressure forces acting on the valve seat 34 will be quickly terminated as the valve member 33 is withdrawn therefrom so that the compression spring 35 will rapidly return the valve seat upwardly to its elevated position as illustrated in FIG. 3.

Referring again to FIGS. 1 and 2, once the well tool 10 is in position within the borehole 13 the measuring devices 17 and 18 will function to provide measurements of the particular conditions which are being monitored and cause the measurement encoder 19 to produce the series of electrical signals representative of these conditions. Each of these signals will, therefore, momentarily energize the solenoid 43 to initiate the operation of the pressure-signaling means 20 as in FIGS. 3 and 4. Thus, each time the solenoid 43 is energized,

the valve member 33 will be released so as to move into seating engagement within the upper end of the valve seat 34 as shown in FIG. 5. Then as depicted in FIG. 6, the downwardly acting pressure forces imposed on the impingement surface 49 on the valve seat 34 will carry the valve seat further downwardly for withdrawing the valve seat from over the valve member 33 as well as for simultaneously compressing the spring 35. Once the springs 35 and 51 are energized, the valve member 33 and the valve seat 34 will be returned to their initial elevated positions as depicted in FIG. 3.

To understand the underlying principle of the operation of the pressure-signaling means 20, references should be made to FIG. 4. At this point in the sequence, the valve member 33 has just moved into the upper end of the valve seat 34. This movement will, of course, interrupt the downward flow of the circulating drilling fluid to produce a substantial positive dynamic pressure which is imposed on the impingement surface 49. At the same time, the continued flow of the drilling fluid that is then below the valve member 33 and the valve seat 34 will simultaneously produce a reduced pressure in the longitudinal bore 52 below the valve seat. As a result, a substantial downwardly acting pressure force will be imposed on the upper surface 53 of the valve member 33 to drive it further downwardly into the valve seat 34 until the shoulder 50 engages the guide 38 (FIG. 5). It will, of course, be appreciated that a substantial downwardly acting pressure force is also imposed on the surface 49 which will be equal to the pressure differential imposed on the effective cross-sectional area of the valve seat 34 which will also drive the valve seat downwardly.

As the valve seat 34 is driven downwardly, the spring 35 will, of course, be compressed to develop corresponding upwardly acting spring forces tending to return the valve seat to its elevated position. Once the valve seat 34 is moved downwardly away from the valve member 33 (FIG. 6), the positive pressure in the longitudinal bore 54 above the valve member 33 will be reduced so as to be equalized with the pressure below the valve seat (by way of the space between the valve member and the valve seat), the spring force provided by the now-compressed spring 35 will be effective for driving the valve seat upwardly. This upward travel of the valve seat 34 will, therefore, reposition the valve seat in its initial position as the valve member 33 is also returned to its initial elevated position by the spring 51.

It will be appreciated, therefore, that each time the solenoid 43 is energized, the valve member 33 will be released for movement to its port-closing position and the valve seat 34 will thereafter move to re-establish communication so that a momentary pressure surge will be produced without unduly retarding the continued circulation of the drilling fluid. As previously mentioned, the pressure pulses which are sequentially produced by the repetitive closing and opening of the valve member 33 will be transmitted to the surface by way of the stream of drilling fluid being circulated downwardly through the drill string 11. Thus, as these pressure pulses sequentially arrive at the surface, the surface apparatus 21 will detect them to produce a meaningful record which is indicative of the conditions being monitored by the condition-responsive devices 17 and 18.

Accordingly, it will be appreciated that the new and improved data-signaling apparatus of the present invention is particularly adapted for producing pressure

pulses which are selectively coded for transmitting information through the drilling fluid from a borehole to the surface. To produce these pressure pulses, an electrically actuated release mechanism is operatively arranged for releasably retaining valve means in an inactive position so that once the latch means are operated by an electrical signal to release the valve means for movement to a fluid-blocking position, the valve means will be operative for employing the circulating drilling fluid as a motive force for operating the valve means and momentarily interrupting the flow of the circulating drilling fluid so as to produce a pressure pulse for transmission to the surface.

While a particular embodiment of the present invention has been shown and described, it is apparent that changes and modifications may be made without departing from this invention in its broader aspects; and, therefore, the aim in the appended claims is to cover all such changes and modifications as fall within the true spirit and scope of this invention.

What is claimed is:

1. Apparatus adapted for determining at least one downhole condition while excavating a borehole and comprising: a tubular drill string having a borehole-excavating device dependently coupled thereto and defining a flow passage for circulating drilling fluids between the surface and said borehole-excavating device; data-signaling means on said drill string adapted for producing electrical signals indicative of at least one downhole condition; and pressure-signaling means on said drill string adapted for developing pressure pulses in drilling fluids flowing through said drill string for transmission through said flow passage to the surface and including valve means adapted for selective movement between first and second open positions and at least one intermediate closed position between said open positions, actuating means operable in response to said electrical signals for selectively moving said valve means from said first open position to said closed position for closing said valve means to produce said pressure pulses, and fluid-responsive means operatively associated with said valve means and operable only upon closing of said valve means for utilizing said pressure pulses for moving said valve means from said closed position to said second open position to reopen said valve means.

2. The apparatus of claim 1 further including means adapted to be located at the surface and responsive to said pressure pulses for providing indications of said pressure pulses.

3. The apparatus of claim 2 further including biasing means operable only upon movement of said valve means to said second open position for returning said valve means to said first open position to await subsequent electrical signals to said actuating means.

4. The apparatus of claim 1 wherein said actuating means include an electrical solenoid operatively associated with said valve means to normally latch said valve means in said first open position and adapted for releasing said valve means for movement to said closed position upon energization of said solenoid by said data-signaling means; and biasing means adapted for moving said valve means to said closed position upon energization of said solenoid to release said valve means.

5. The apparatus of claim 4 further including biasing means operable only upon movement of said valve means to said second open position for returning said

valve means to said first open position in latching association with said solenoid to await subsequent electrical signals to said actuating means.

6. Apparatus adapted for transmitting data to the surface during the drilling of a borehole and comprising: a body adapted for connection in a tubular drill string and having a flow passage arranged to carry drilling fluids between the surface and a borehole-drilling device dependently coupled therebelow; and pressure-signaling means on said body and including valve means adapted for cyclical movement between first and second passage-opening positions and at least one passage-obstructing position to obstruct the flow of drilling fluids through said flow passage and produce pressure pulses in such fluids for transmission there-through to the surface, first means operatively associated with said valve means and adapted for moving said valve means from a first passage-opening position to said passage-obstructing position, valve-operating means selectively responsive to electrical signals operatively associated with said first means and said valve means and adapted for only initiating each operating cycle of said valve means, and second means including fluid-responsive means operatively associated with said valve means and adapted for utilizing said pressure pulses in said flow passage to move said valve means from said passage-obstructing position to a second passage-opening position.

7. The apparatus of claim 6 further including electrical signaling means on said body coupled to said valve-operating means and adapted for producing electrical signals representative of at least one downhole condition to repetitively operate said valve-operating means.

8. The apparatus of claim 6 wherein said first means include biasing means operative only upon operation of said valve-operating means for moving said valve means to said passage-obstructing position.

9. The apparatus of claim 6 wherein said first means include first biasing means operative only upon operation of said valve-operating means for moving said valve means to said passage-obstructing position; and said second means include second biasing means operative only upon movement of said valve means to said last-mentioned passage-opening position for returning said valve means to said first-mentioned passage-opening position to await the next electrical signal to said valve-operating means.

10. Apparatus adapted for transmitting data to the surface during the drilling of a borehole and comprising: a body adapted for connection in a tubular drill string and having a flow passage arranged to carry drilling fluids between the surface and a borehole-drilling device dependently coupled therebelow; and pressure-signaling means on said body and including an annular valve seat movably disposed in said flow passage and adapted for movement therein between first and second spaced positions, first biasing means normally retaining said valve seat in its said first position, a valve member movably disposed on said body and adapted for movement between a non-obstructing position and a flow-obstructing position in said flow passage where said valve member is received within said valve seat when said valve seat is in its said first position, valve-operating means normally retaining said valve member in its said non-obstructing position and responsive to electrical signals for selectively moving said valve member to its said flow-obstructing position within said

valve seat to produce pressure pulses in drilling fluids flowing through said flow passage for transmission to the surface, means on said valve seat and responsive to said pressure pulses for moving said valve seat against said first biasing means from its said first position to its said second position to re-establish unobstructed flow of drilling fluids through said flow passage after said valve member is moved to its said flow-obstructing position, and second biasing means adapted for returning said valve member to its said non-obstructing position to await another electrical signal.

11. The apparatus of claim 10 further including means in said flow passage dividing said flow passage into spaced upper and lower portions and defining at least one port between said positions of said valve member and communicating said upper and lower portions of said flow passage so that movement of said valve member to its said flow-obstructing position within said valve seat will at least substantially block the flow of drilling fluids through said flow passage to produce said pressure pulses.

12. The apparatus of claim 10 wherein said valve-operating means include third biasing means normally urging said valve member toward its said flow-obstructing position, latch means releasably retaining said valve member in its said non-obstructing position, and electrical means operatively associated with said latch means and responsive to said electrical signals for actuating said latch means to release said valve member for movement to its said flow-obstructing position.

13. The apparatus of claim 12 further including means in said flow passage dividing said flow passage into spaced upper and lower portions and defining at least one port between said positions of said valve member and communicating said upper and lower portions of said flow passage so that movement of said valve member to its said flow-obstructing position within said valve seat will at least substantially block the flow of drilling fluids through said flow passage to produce said pressure pulses.

14. The apparatus of claim 12 further including electrical signaling means on said body coupled to said electrical means and adapted for producing electrical signals representative of at least one downhole condition to repetitively operate said electrical means.

15. The apparatus of claim 14 wherein said electrical means include an electrical solenoid operatively associated with said latch means and adapted for actuating said latch means to release said valve member in response to said electrical signals by said electrical signaling means.

16. Apparatus adapted for transmitting data to the surface during the drilling of a borehole and comprising: a tubular drill string having a borehole-drilling de-

vice dependently coupled thereto and defining a flow passage for circulating drilling fluids between the surface and said borehole-drilling device; data-signaling means on said drill string adapted for producing electrical signals indicative of at least one downhole condition; and pressure-signaling means on said drill string adapted for selectively developing pressure pulses in drilling fluids flowing through said fluid passage for transmission through said drill string to the surface and including an annular valve seat movably disposed in said flow passage and adapted for movement therein between first and second spaced positions, first biasing means normally retaining said valve seat in its said first position, a valve member movably arranged on said drill string and adapted for movement between a non-obstructing position and a flow-obstructing position in said flow passage where said valve member is received within said valve seat when said valve seat is in its said first position, valve-operating means normally retaining said valve member in its said non-obstructing position and responsive to electrical signals for selectively moving said valve member to its said flow-obstructing position within said valve seat to produce pressure pulses in drilling fluids flowing through said flow passage for transmission to the surface, means on said valve seat and responsive to said pressure pulses for moving said valve seat against said first biasing means from its said first position to its said second position to re-establish unobstructed flow of drilling fluids through said flow passage after said valve member is moved to its said flow-obstructing position, and second biasing means adapted for returning said valve member to its said non-obstructing position to await another electrical signal.

17. The apparatus of claim 16 further including means adapted to be located at the surface and responsive to said pressure pulses for providing indications of said pressure pulses.

18. The apparatus of claim 12 wherein said valve-operating means include third biasing means normally urging said valve member toward its said flow-obstructing position, latch means releasably retaining said valve member in its said non-obstructing position, and electrical means operatively associated with said latch means and responsive to said electrical signals for actuating said latch means to release said valve member for movement to its said flow-obstructing position.

19. The apparatus of claim 18 wherein said electrical means include an electrical solenoid operatively associated with said latch means and adapted for actuating said latch means to release said valve member in response to said electrical signals by said data-signaling means.

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