

[54] **GRAVITY FORCE OPERATED APPARATUSES FOR GENERATION OF LONGITUDINAL PULSE DATA FROM THE BOTTOM OF A WELL**

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340/18 LD

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340/18 LD; 181/0.5 AG

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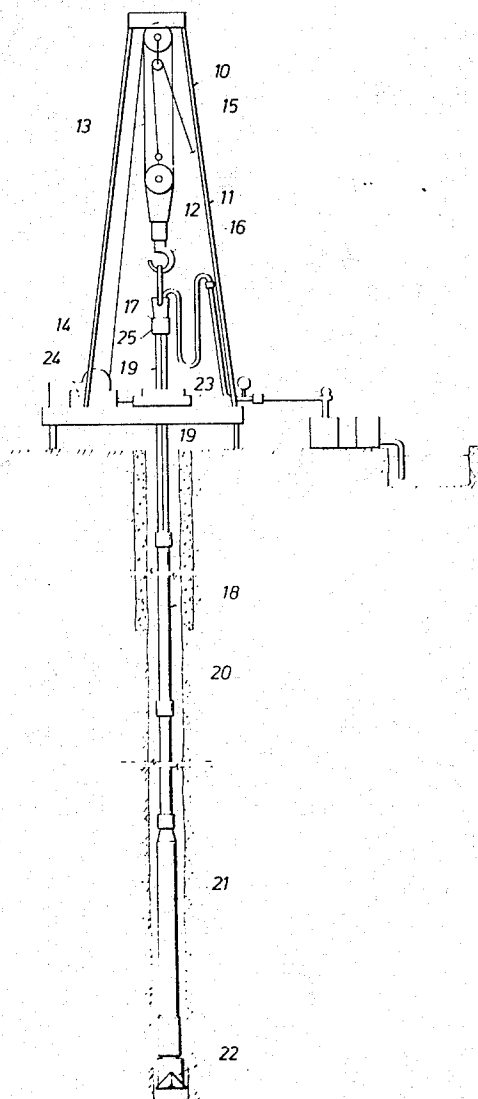
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[57] **ABSTRACT**

Two mechanisms are disclosed, one comprising a special drill collar including a controllably and telescopically slideable lower section in a drill string in a well-bore, the lower section being dropped against a stop in the special drill collar during a lull in drilling for generation of a longitudinal pulse or acoustical signal in the drilling assembly representative of data to be transmitted from the well bottom for being monitored at the surface, and the other mechanism comprising a drill string with a plurality of slideable special drill collar telescopic sections, each section being controllably dropped for generating longitudinal pulses or acoustical signals in the drilling assembly representative of well bottom data for being monitored at the surface.

15 Claims, 4 Drawing Figures



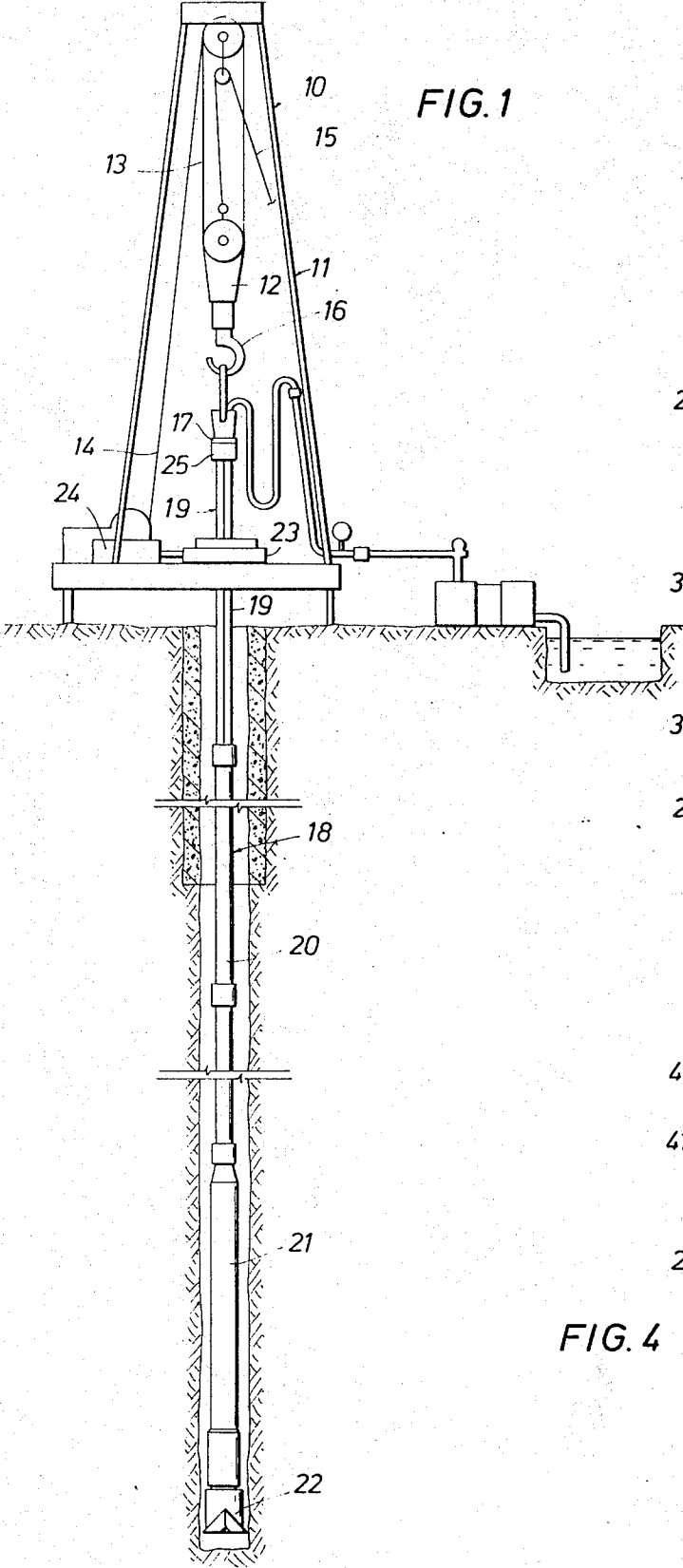
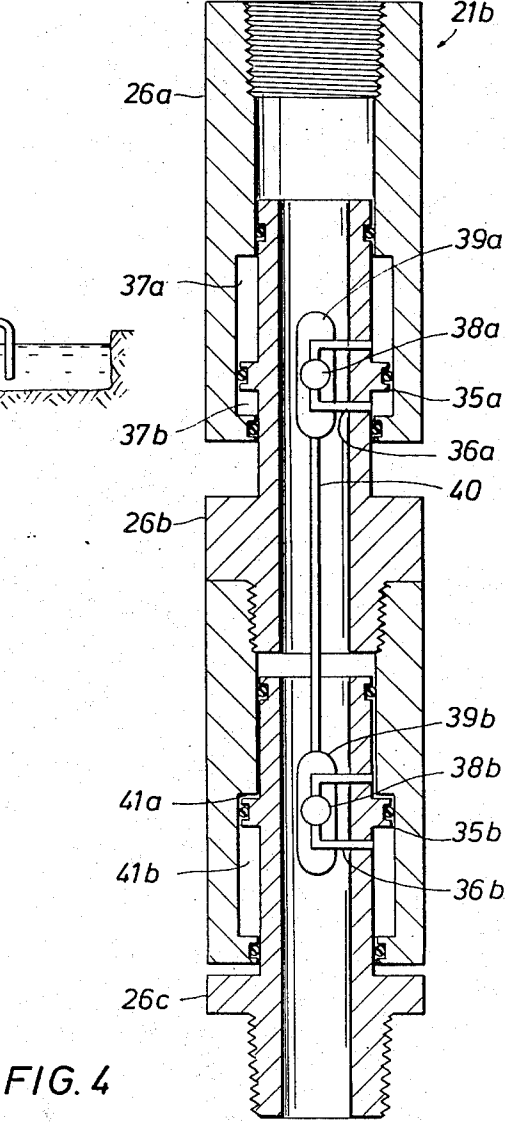


FIG. 2

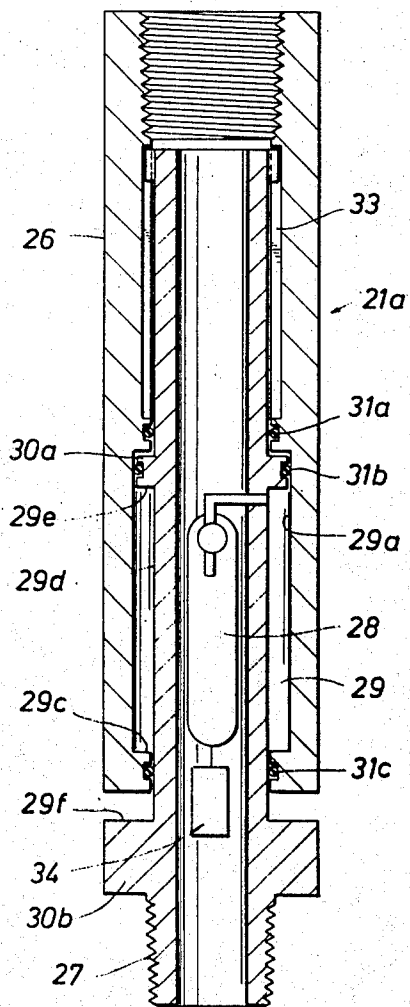
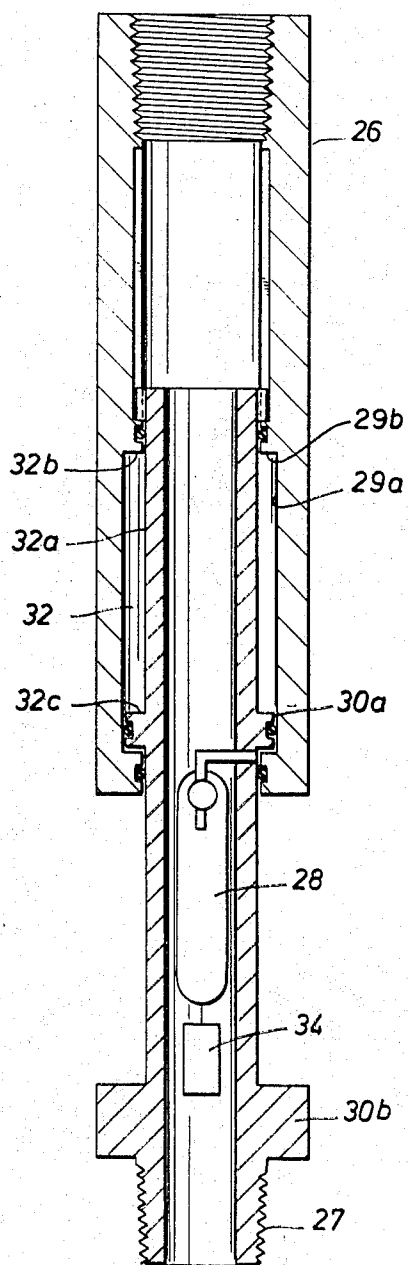


FIG. 3



GRAVITY FORCE OPERATED APPARATUSES FOR GENERATION OF LONGITUDINAL PULSE DATA FROM THE BOTTOM OF A WELL

BACKGROUND OF THE INVENTION

While drilling wells, such as wells for the recovery of petroleum from subsurface petroleum containing formations, there are many measurements which are desired by people doing the drilling for determining the lithology being encountered as the wellbore progresses deeper and deeper into the earth. The usual practice today during the drilling of oil and gas wells is to interrupt the drilling operation periodically, to pull the entire drill string from the wellbore, and to run logging tools down into the wellbore for determining the types of earth formations which have been penetrated by the wellbore and the characteristics of such formation layers indicative of the presence of petroleum deposits, and for collecting other information as desired prior to running the entire drill string back into the wellbore. As the well gets deeper and deeper, the time required for the removal and rerunning of this drill string, known in the industry as a trip, becomes greater and greater. Some wells are so deep as to require twenty-four hours to make a trip, plus many additional hours for the running of a logging tool into the formation. Further it has long been realized that it would be highly desirable to perform certain basic logging operations during the course of the drilling operation, and to transmit such information back up to the surface either periodically or continually. If this were possible, it would permit a complete record of the subsurface lithology to be accumulated as the drilling proceeds and would not necessitate the delay of drilling operations for the running of logs.

Thus it would be very advantageous, during drilling operations of a wellbore, to possess a signal system for the transmission of information from the area of the bottom of the wellbore or the drill bit to the surface using the most convenient continuous communications line available, the drill string, as the communication medium. For many types of information, the signal does not have to be transmitted continuously during drilling, but can be transmitted at certain intervals. Exemplary information that is needed very urgently at the surface during drilling are borehole deviation, information from drilling tests stored in a memory unit or a warning signal, as a pressure difference detected and stored when drilling through a gas zone. Thus during drilling it would be desirable to obtain this information as soon as possible.

While prior signal transmission systems comprise modulation of mud pressure or mud flow by a variable valve in the mud conduit in the bottom of the drill pipe, as in U.S. Pat. Nos. 2,930,137; 2,978,634; or 3,327,527; these systems are not reliable due to sticking of the valve because of the solids in the mud and due to failure of the valve because of the abrasion thereof by the mud per se. Another prior but different data transmission system comprises a controllable wellbore wall engaging means extendable transversely from the sides of the drill stem for momentarily increasing the drag or torque in the drill pipe while rotating the drill pipe for sending torque pulses to the surface through the drill string. This latter system is disclosed in patent application Ser. No. 279,899 filed Aug. 11, 1972, now U.S. Pat. No. 3,788,136 to Jack H. Park, by

Assignee of record. Another transmission system in a drill string utilizing energy pulses generated by a drill collar rotatable over bumps on the top of a drill bit is disclosed in Assignee's patent application Ser. No. 293,610, filed Sept. 29, 1972 by Dr. Joe R. Fowler. Others, as in U.S. Pat. No. 3,520,375, have detected the mechanical characteristics of rocks being drilled by comparing the vertical vibrations and axial movement of the drilling assembly for comparison with known rock properties and apparently any resultant torsional accelerations as the drill bits roll over and grind up the rocks.

OBJECTS OF THE INVENTION

Accordingly, a primary object of this invention is to provide a data transmission system utilizing a gravity force longitudinal pulse or acoustical signal generator that may be coupled and uncoupled to the drill string for precise modulation of pulses generated therein during a lull in drilling for transmission to the top of the drill string for detection.

Still another object of this invention is to provide an acoustical data transmission system utilizing a special drill collar that is coupled and uncoupled to a conventional drill pipe in a drill string for dropping against stops during a lull in drilling.

Another object of this invention is to provide a data transmission system utilizing a special drill collar having several interconnected sections for being dropped consecutively for generating longitudinal pulses or acoustical signal in the drilling assembly during a lull in drilling.

A further object of this invention is to provide an acoustical data transmission system that eliminates the requirement for a large downhole power source by utilizing the forces of gravity as the primary energy source.

A still further object of this invention is to provide a data transmission system for transmission of data from a downhole tool during a lull in drilling which is easy to operate, is of simple configuration, is economical to build and assemble, and is of greater efficiency for generating longitudinal pulses or acoustical signals in the drilling assembly from a free falling special drill collar section deep in a well to the surface.

BRIEF DESCRIPTION OF THE DRAWINGS

The drawings diagrammatically illustrate by way of example, not by way of limitation, two forms or mechanisms of the invention wherein like reference numerals have been employed to indicate similar parts in the several views in which:

FIG. 1 is a schematic vertical view of the invention when incorporated in an oil or gas well being drilled;

FIG. 2 is a schematic vertical sectional view of the invention as mounted in a drill collar of the drill string of FIG. 1 illustrating two telescopic sections in contracted position;

FIG. 3 is the mechanism of FIG. 2 illustrating the telescopic sections in extended position; and

FIG. 4 is a schematic vertical sectional view of a modification of FIGS. 2 and 3, comprising a plurality of controllable telescopic special drill collar sections for generating time modulated longitudinal pulses or acoustical signals.

DESCRIPTION OF THE INVENTION

The invention disclosed herein, the scope of which being defined in the appended claims, is not limited in its application to the details of construction and arrangements of parts shown and described, since the invention is capable of other embodiments and of being practiced or carried out in various other ways. Also, it is to be understood that the phraseology or terminology employed herein is for the purpose of description and not of limitation. Further, many modifications and variations of the invention as hereinbefore set forth will occur to those skilled in the art. Therefore, all such modifications and variations which are within the spirit and scope of the invention herein are included and only such limitations should be imposed as are indicated in the appended claims.

DESCRIPTION OF APPARATUSES OF SYSTEMS OF DATA TRANSMISSION FROM A WELLBORE

The drawings disclose two embodiments of the invention for transmitting intelligence from the bottom of a wellbore of conditions at the bottom to the surface during a lull in drilling.

FIG. 1 discloses schematically the disclosed system for data transmission from a wellbore during a lull in drilling operations.

In the drilling rig illustrated in FIG. 1, a drilling assembly 10 is disclosed comprising a derrick 11 for supporting a traveling block 12 with lines 13 having a dead line 14 and a fast line 15. A hook 16 on the bottom of the traveling block has a swivel 17 on the bottom of thereof for supporting the drill string 18, the latter comprising a kelly 19 slideable therethrough, and many interconnected drill pipes 20 for supporting a drill collar 21 having a drill bit 22 connected to the bottom thereof. Drill string 18 is rotated by rotary table 23 driven by a suitable rotary drive or engine 24. A sensitive force meter, such as but not limited to a suitable conventional vertical accelerometer 25 is connected between the kelly 19 and the swivel 17 for detection of longitudinal pulses or acoustical signals through the drill string 18.

MODIFICATION OF FIGS. 2 AND 3

FIGS. 2 and 3 illustrate in section one modification of the drill collar 21a comprising two telescopic sections 26, 27 illustrated in contracted or cocked position in FIG. 2 and in expanded position FIG. 3. It is held in either contracted or extended position by the high pressure fluid supplied from electrically controlled valve and reservoir 28.

An annular chamber 29 is formed by an enlarged annular groove 29a in the outer cylindrical section 26 having upper and lower shoulders 29b, FIG. 3, and 29c, FIG. 2, and by a corresponding contiguous enlarged annular groove 29d on the outer surface of the inner cylindrical telescopic section 27 having upper and lower shoulders 29e and 29f on rings 30a and 30b, respectively. Suitable seals 31a, 31b, and 31c are provided around the upper end, the middle, and the lower end of the inner telescopic section 27 for making the telescopic sections fluid tight, relative to each other, intermediate and lower seals 31b, and 31c seal the ends of chamber 28.

A second annular chamber 32, FIG. 3, is formed with the telescopic sections in extended position by the an-

nular groove 29a internally of the cylindrical section 26, an annular groove or surface 32a externally of the upper end of cylindrical section 27, upper shoulder 32b on cylinder section 26, and a lower shoulder 32c on the upper side of ring 30a on cylinder 27. The upper and middle seals 31a and 31b seal upper annular chamber 32, likewise. Splines 33, FIG. 2, are formed on inner telescopic section 26 for preventing relative rotational movement while allowing free telescopic longitudinal movement between the two telescopic sections 26 and 27. While these splines are preferred in the disclosed embodiments, they may be omitted in other embodiments if the design so provides. Electrically controlled valve and reservoir 28 may be either closed, opened for expelling high pressure fluid into chamber 29, or open for receiving fluid from chamber 29. Thus the controlled valve and reservoir 28 may be considered a locking means for maintaining the cylindrical sections 26 and 27 locked in either the fully extended position or the fully contracted position.

Controller 34 mounted in the inner telescopic section 26 of the drill collar is a data measuring means or conventional detector of temperature, pressure, weight on the bit, and of other logging parameters such as SP (self potential) or resistivity for operating the electrically controlled valve and reservoir 28 for allowing the inner drill bit section to drop to extended position to generate a longitudinal pulse or acoustical signal in the drill string for being received at the surface with the conventional vertical accelerometer 25. Likewise, the controller may incorporate therein any suitable downhole tape recorder system as disclosed in U.S. Pat. No. 3,566,597, for playback when desired. While the valve and reservoir 28 and the controller 34 are illustrated schematically, obviously they are mounted in the walls of the inner telescopic section 27 for non-interference with the drilling mud flow therethrough.

The drill bit 22 (not shown in FIGS. 2 and 3) is secured to the bottom of inner telescopic section 27.

Thus in operation of the modification of FIGS. 2 and 3, after the valve 28 is closed to prevent escape of fluid from the annular chamber 29, the drilling assembly is raised a foot or so off the well bottom, followed by a sudden opening of the reservoir valve 28 in response to controller 34 for permitting the inner telescopic section 27 and the drill bit attached thereto to freely drop to the fully extended position of FIG. 3 where upper shoulder 29e, FIG. 2, on ring 30a integral with cylindrical section 27 contacts lower shoulder 29c formed on the lower end of cylindrical section 26 with all the weight of the drill bit and cylindrical section 27. The longitudinal energy pulse so generated is detectable at the upper end of the drill string in the drilling assembly with the vertical accelerometer 25. As controlled by controller 34, reservoir valve 28, FIG. 3, is opened to refill the annular chamber 29, FIG. 2, to raise the drill bit, or the drill string is lowered to the well bottom to contract the telescoping sections, the valve 28 closed, and the drill string raised again for dropping the drill bit a second time or not dropping it, depending on the coded intelligence being transmitted and the modulation of time between pulses.

Alternatively, while the drill string is resting on the well bottom with the telescopic sections in extended position, the reservoir valve 28 may be operated to open position at a predetermined moment to permit gravity forces due to the total weight of the drill string

to move the telescopic sections to contracted position and generate the longitudinal energy pulse for being monitored at the surface with the vertical accelerometer 25. The valve would be programmed by the controller 34 to either open or not open at the predetermined moment to send a "yes" or "no" signal.

MODIFICATION OF FIG. 4

The FIG. 4 embodiment of the drill collar 21b comprises a plurality of telescopic cylindrical sections, with only portions of some of the three sections 26a, 26b, and 26c being illustrated in the FIGURE, for being dropped consecutively to generate a series of time modulated energy pulses. While the intermediate section 26b is shown dropping, the lower section 26c has not yet been released.

In greater details, on the upper end of the middle cylindrical section 26b is an annular projection or ring 35a and around which is a passage 36a for interconnecting the upper and lower chambers 37a and 37b. A conventional electro-hydraulic control valve 38a in conventional control unit 39a controls the passage of hydraulic fluid from one chamber to the other when rapid extension or contraction is desired or when it is desired to drop one cylindrical section relative to the other, responsive to well bottom data from conventional data measuring means in sections 26, to generate a longitudinal energy pulse in the drill string 18, FIG. 1. Suitable O-ring seals and splines are utilized between the telescopic sections.

An electrical control conduit and line 40, FIG. 4, interconnects the electro-hydraulic valve control unit 39a of the intermediate section 26b with a similar electro-hydraulic valve control unit 39b of the next lower section 26c for operation thereof in properly timed sequence so that the units 39a and 39b are time modulated pulse generators. Here likewise, the upper end of lower cylindrical section 26c has a ring 35b therearound for forming the two hydraulic chambers 41a and 41b between the telescopic sections 26b and 26c, respectively, with a passage 36b interconnecting the two chambers. While a drill bit 22 (not shown in FIG. 4) is securely connected to the lower end of lower single cylindrical telescopic section 26c, FIG. 4, if so desired, one or more cylindrical telescopic sections may be inserted.

In operation of the modification of FIG. 4, after all sections 26a, 26b, and 26c are telescoped or contracted within each other while resting on the well bottom in drilling position, all electro-hydraulic control valves 38a and 38b are closed and the drill string raised off the bottom just sufficiently to clear the bottom when all sections are extended. Then, as controlled by control units 39a and 39b, the electro-hydraulic valves are opened in sequence to permit first the intermediate section 26b to drop due to force of gravity to its extended position for generation of the first energy pulse or acoustical, and then the lower section 26c is allowed to drop with predetermined timing or time modulation for generation of the second energy pulse or acoustical signal. Thus by controlling either the number of pulses and/or the time sequence between them, data is transmitted from the drill bit section to the surface detector.

An alternate method of dropping the telescopic sections in sequence includes having the control units drop the lower section 26c first, then drop the intermediate

section 26b, and finally drop the upper section 26a in proper time sequence to provide the time modulated acoustical signals.

Another method of dropping the sections for generating the energy longitudinal pulses comprises after hanging the drill string just off the well bottom with all sections extended and valves closed, then the drill string is lowered until it is resting on the bottom. Then the control valves are opened in time modulated succession, either starting with the lowest one and working up or working down. Starting with opening the top valve first, for working down, after the weight of the drill string above the first valve telescopes its two sections against their stops, then the next or intermediate valve is opened to allow the total weight of the drill string above this valve to telescope sections 26a and 26b, and then as the lower valve is opened to permit the total weight of the drill string above the lower valve to telescope sections 26b and 26c, the third pulse is generated in the predetermined timed sequence to provide time modulated acoustical signals.

While electro-hydraulic valves are used, obviously other types of valves as pneumatic, or the like, may be used, depending on the requirements of the particular installation.

Thus by modulating the time sequence or number of pulses generated as a function of the measured parameter, as temperature or pressure of the formation, wellbore deviation, etc., intelligent data from the bottom of the wellbore is easily and efficiently transmitted to and received at the surface.

In the practice of my invention, the logging instrument or other measuring device performs the desired measurement and the data are converted into electrical analog signals with the measurements represented by the length of time between the pulse signals. This is a common form of modulation frequently employed in transmitting scientific data. Power for operation of the measurement devices and electronics is supplied by conventional batteries (not shown). If desired, the measurement and data transmission operation may continue more or less continually during the drilling operation, with the periodic signal pulses being generated and transmitted to indicate the desired parameters being monitored. Actually drilling is interrupted momentarily during actual transmission. In some instances it is desirable to interrupt the normal drilling operation and activate the subsurface equipment to have it make measurements and transmit the measurements back to the surface by the signal pulses. One very satisfactory method of accomplishing this is to include a centrifugal switch in the measurement and electronics assembly, which senses the cessation of rotation of the drill string. When a measurement is desired, the pumps are stopped and the drill bit rotation is stopped. The centrifugal switch will close when the drill string rotation is stopped, and the measurement devices are activated thereby. Thereafter the measurement is encoded into pulsed analog electrical signals which are used to activate the wellbore engaging apparatus as is described hereinabove.

Still another method of activating the measurement and data transmission systems, where it is not desired to transmit data continually during the drilling cycle, involves the use of conventional strain gauges applied to a section of the drill collar to sense the amount of weight being applied to the bit, which are activated

when the drill string is raised a sufficient distance so that the bit no longer contacts the bottom of the wellbore. Either type of switch or both may be used to activate the measurement and data transmission functions.

Thus in operation of the embodiment of FIG. 4 in practicing the method set forth above of transmitting data from the bottom of a wellbore during drilling to a detector at the surface, controllers 39a and 39b detect or receive the information to be transmitted, as pressure, average weight on the drill bit, deviation, etc., which is measured and electrically stored and transmitted at the predetermined time set in the system.

Additional advantages are:

1. A mechanical mechanism is provided for generating longitudinal waves or acoustical signals in the drill string with a minimum of moving parts, i.e., only the control valve and telescoping cylinders.

2. A self contained transmitting system is disclosed that requires a minimum of external power (only batteries to operate the control valve).

3. A data transmission system is provided which is completely divorced or separated from the mud stream.

4. A data transmission system is described which utilizes the forces of gravity as the primary energy source and accordingly eliminates the requirement for a large downhole power source.

5. A data transmission system is disclosed which utilizes electronics to control the signal sending mechanism.

Obviously other methods may be utilized for transmission of signals with the embodiments of either FIG. 2 or FIG. 4 than those listed above, depending on the particular information desired to be transmitted.

Accordingly, it will be seen that while drilling is in progress, the disclosed two data transmission systems will transmit information from the bottom of a wellbore to the surface and will operate in a manner which meets each of the objects set forth hereinbefore.

While only two mechanisms have been disclosed, it will be evident that various other modifications are possible in the arrangement and construction of the disclosed data transmission systems without departing from the scope of the invention and it is accordingly desired to comprehend within the purview of this invention such modifications as may be considered to fall within the scope of the appended claims.

We claim:

1. A system for transmission of data from the lower end of a drilling assembly in a wellbore to the surface comprising,

- a. a drilling assembly having a drill string,
- b. data measuring means on the lower end of said drill string,
- c. gravity force means for generating acoustical signal pulses in the lower end of the drill string, and

d. means for monitoring the gravity force generated acoustical signal pulses in the drill string at the surface.

2. A system for transmission of data from the lower end of a drill string in a wellbore to the top of the wellbore at the surface comprising,

- a. a drilling assembly having a drill string,
- b. data measuring means on the lower end of said drill string,

c. controllable gravity longitudinal pulse acoustical signal generating means on the lower end of said drill string for generating longitudinal pulse acoustical signals in said drill string, and

d. acoustical signal monitoring means on the upper end of said drill string for monitoring said controlled gravity longitudinal pulse acoustical signals in said drill string at the surface.

3. A system as recited in claim 2 wherein the controllable gravity longitudinal pulse acoustical signal generating means comprises,

a. special drill collar means on said lower end of said drill string comprising two sections for generating longitudinal pulse acoustical signals,

b. controllable coupling means between said two sections of said special drill collar means,

c. control means for said controllable coupling means, and

d. said coupling means being responsive to said control means for uncoupling one of said sections of said special drill collar means from said other section for dropping a predetermined distance for generating said controllable gravity longitudinal pulse acoustical signal in the drill string for being monitored at the surface.

4. A system as recited in claim 2 wherein,

a. means for time modulating said acoustical signals, and

b. said acoustical signal monitoring means is responsive to said controlled gravity longitudinal pulse acoustical signal generating means for monitoring the time modulation between said longitudinal pulses in said drill string.

5. A system as recited in claim 2 wherein said controllable gravity longitudinal pulse acoustical signal generating means comprises,

a. drill collar means on the lower end of said drill string,

b. said drill collar means having a first section slideable therein, and

c. said first section being slideable in said drill collar means to a stop therein for generating a longitudinal pulse acoustical signal in the drill string for being monitored at the surface.

6. A system as recited in claim 5 wherein,

a. said drill collar means of the controllable gravity longitudinal pulse acoustical signal generating means comprises also a second section,

b. said drill collar second section being slideable in said drill collar first section to a stop therein for generating a second longitudinal pulse acoustical signal in said drill string for being monitored at the surface.

7. A system as recited in claim 5 wherein,

a. said drill collar means comprises a plurality of slideably interconnected sections, each section having stop means for limiting each to a fully extended position, and

b. said drill collar means being responsive to a gravity control means for being extended, one section at a time, to each stop means for generating a plurality of longitudinal pulse acoustical signals in the drill string for being monitored at the surface.

8. A system for transmission of data from the lower end of a drill string in a wellbore to an acoustical signal monitor in the top of the drill string comprising,

- a. a drilling assembly having a drill string,

- b. an acoustical signal monitor connected to the top of said drill string,
 - c. a drill collar in the lower end of the drill string comprising a first drill collar section,
 - d. said first drill collar section being telescopically connected to said drill collar for relative movement therewith between a telescopically contracted position wherein said first drill collar section is in a raised position, and a telescopically extended position wherein said first drill collar section is in a lowered position,
 - e. locking means for locking said first drill collar section in one of said two positions,
 - f. data measuring means on the lower end of said drill string, and
 - g. gravity control means responsive to said data measuring means for unlocking said locking means for permitting gravity forces to move said drill collar and said first drill collar section relative to each other from one position to the other position for generating a first longitudinal pulse acoustical signal at the lower end of the drill string for being received by the acoustical signal monitor at the top of the drill string.
9. A system as recited in claim 8 wherein,
- a. a second drill collar section is telescopically connected to said first drill collar section for relative movement between a telescopically contracted position wherein said second drill collar section is in a raised position and a telescopically extended position wherein said second drill collar section is in a lowered position,
 - b. second locking means for locking said second drill collar section in one of said two positions, and
 - c. said control means having means for unlocking said second locking means for permitting gravity forces to move said first drill collar section and said second drill collar section relative to each other from one position to the other position for generating a second longitudinal pulse at the lower end of the drill string in consecutive relationship with the first longitudinal pulse.
10. A system as recited in claim 8 wherein,
- a. said drill collar comprises a plurality of drill collar sections,
 - b. said locking means comprises means for locking each adjacent pair of drill collar sections together, and
 - c. said locking means is responsive to said gravity control means for unlocking said drill collar sections in succession starting with the bottom section first and progressing to the top drill collar section.
11. A system as recited in claim 8 wherein,

- a. said drill collar comprises a plurality of drill collar sections,
 - b. said locking means comprises means for locking each adjacent pair of drill collar sections together, and
 - c. said locking means is responsive to said gravity control means for unlocking said drill collar sections in succession starting with the top section first and progressing to the bottom section.
12. A system as recited in claim 8 wherein further,
- a. said drill collar comprises a plurality of drill collar sections,
 - b. said locking means comprises means for locking each adjacent pair of drill collar sections together,
 - c. stop means for limiting movement of each drill collar section between a fully contracted position and a fully extended position, and
 - d. said stop means being responsive to said gravity control means for unlocking said drill collar sections in succession for generating a plurality of longitudinal pulse acoustical signals in said drill string for being monitored at the surface.
13. A data transmission system for generating longitudinal energy pulses in the bottom of a drill string in a wellbore for being monitored at the surface comprising,
- a. a drilling assembly having a drill string,
 - b. data measuring means on the lower end of said drill string,
 - c. means for connecting a drill bit section to a drill pipe section in said drill string for relative longitudinal movement therebetween a fully contracted position and a fully extended position,
 - d. said sections being movable relative to each other between said two positions due to the forces of gravity, and
 - e. said sections being responsive to said connecting means and gravity forces for generating a gravity force induced energy pulse acoustical signal in the drill string for being monitored at the surface.
14. A data transmission system as recited in claim 13 wherein,
- a. said relatively movable sections are responsive to said connecting means and gravity forces for being moved relatively to each other from said fully contracted position to said fully extended position.
15. A data transmission system as recited in claim 13 wherein,
- a. said relatively movable sections are responsive to said connecting means and gravity forces for being moved relatively to each other from said fully extended position to said fully contracted position.
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