

Dec. 13, 1960

E. W. PETERSON
SIGNALING SYSTEM

2,964,116

Filed May 26, 1955

2 Sheets-Sheet 1

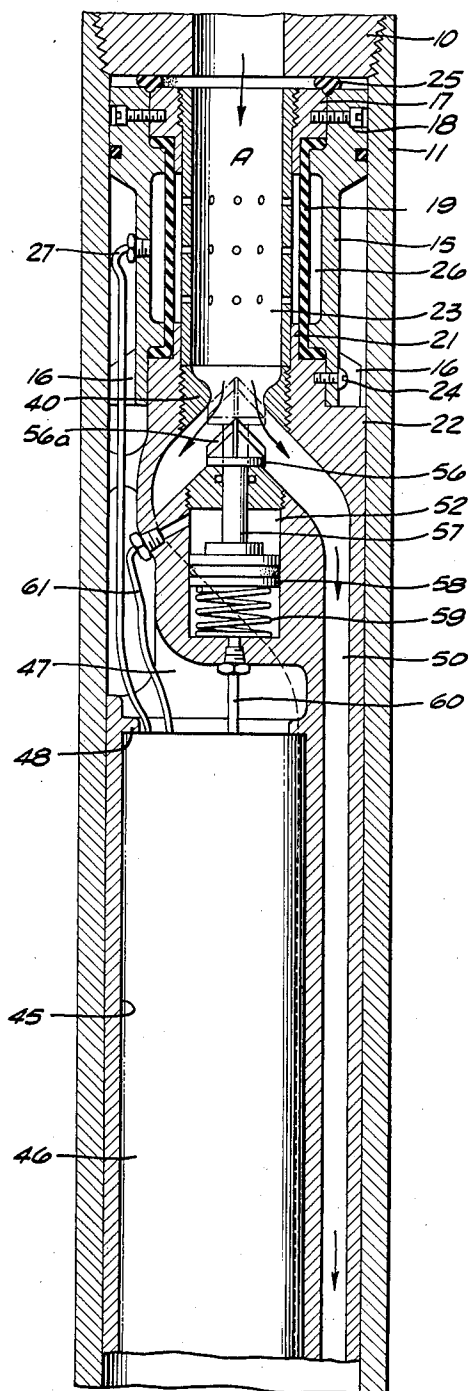
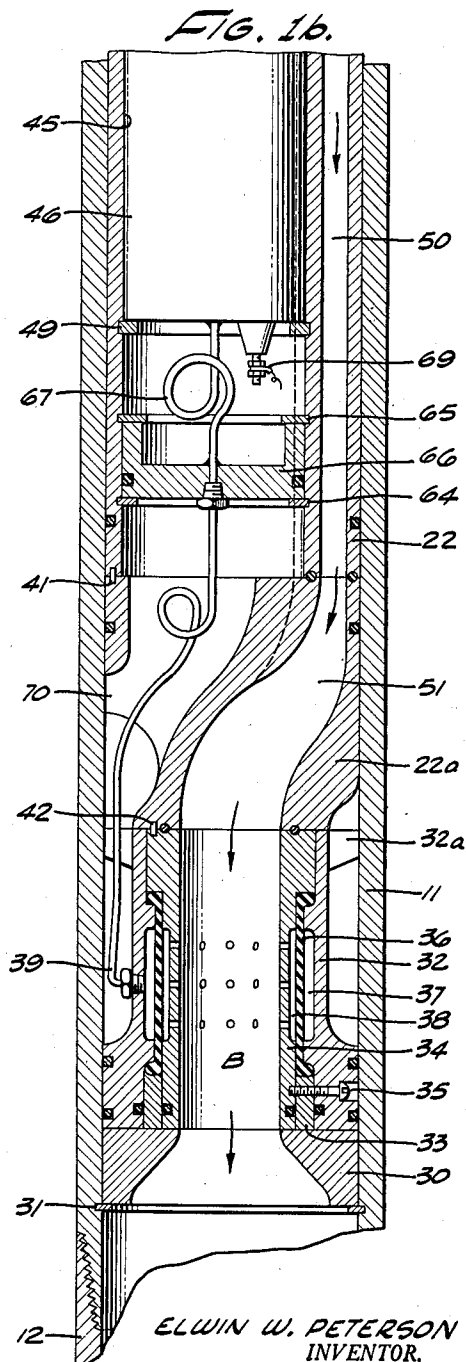


FIG. 1a.



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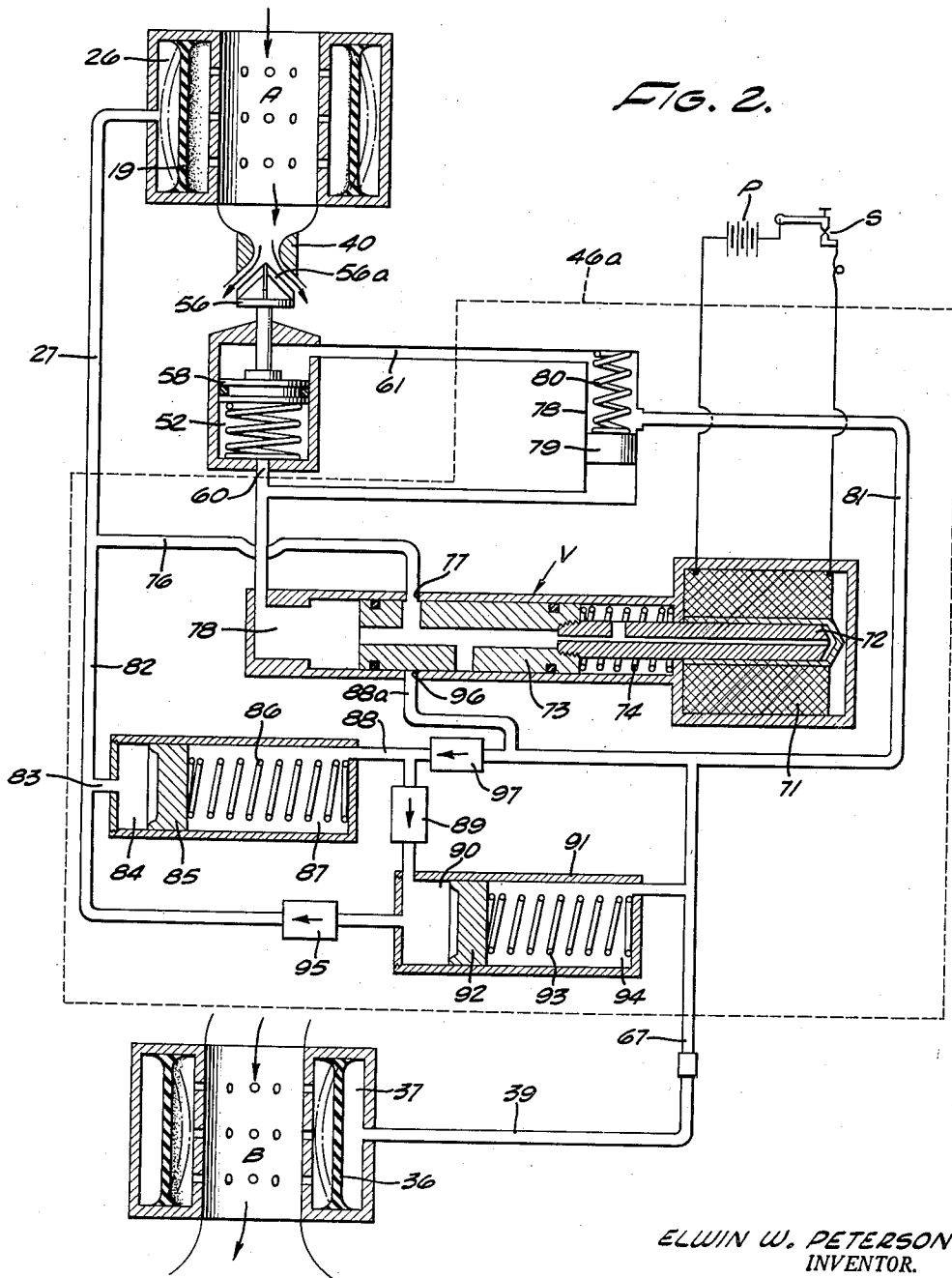
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2 Sheets-Sheet 2



BY *E. W. Peterson*
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2,964,116

SIGNALING SYSTEM

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Filed May 26, 1955, Ser. No. 511,381

17 Claims. (Cl. 175—48)

This invention relates to a fluid pressure pulse signaling system adapted for signaling operations between a first location and a distant second location, between which locations a stream of fluid is forced under pressure through a conduit. Specifically, the invention relates to a fluid pressure pulse signaling system wherein the energy for creating the pressure pulse and for incidental operations is derived from the stream of fluid flowing through the conduit between the signal transmitting and signal receiving stations. More specifically, the invention relates to a fluid pressure pulse signaling system adapted for operation between an inaccessible location at the lower end of a drill string or conduit in an earth borehole and an accessible location adjacent the upper end of the conduit and outside the borehole.

This application is a continuation-in-part of my copending application Serial No. 413,397, filed March 1, 1954, and is in certain aspects related to the subject matter comprised in a copending application of Robert L. Alder, Serial No. 413,405, filed March 1, 1954.

In the aforementioned copending applications are explained various advantages of a signaling system operative in conjunction with the drilling of an earth borehole by a drilling means or system having a tubular drill string in which drilling fluid or "mud" is forced under pressure through a conduit formed by the drill string, from the top of the borehole to the lower end thereof. In that signaling system transmission of data or information from the lower end of the drill string to a location outside the borehole is effected during drilling, or during suspension of drilling, while fluid flow is continued. In those applications, signaling systems are disclosed wherein energy is extracted from the downwardly flowing stream of drilling fluid at a location in the vicinity of the lower end of the drill string, the energy thus extracted from the moving stream of drilling fluid being employed or utilized in the creation of pressure pulse signals in the drilling fluid stream. The signals thus created are employed to communicate information obtained at the lower end of the drill string to a location exterior of the borehole, the drilling fluid in the drill string serving as a signal transmission medium. According to the aforementioned copending application of Peterson, energy is extracted from the downwardly flowing stream of drilling fluid by diverting a portion of the drilling fluid into a flexible chamber to cause flexure of a wall of the latter in such a manner as to restrict the flow of drilling fluid therepast and thereby create a pressure change in the drilling fluid stream thereabove, the pressure change being transmitted to the top of the

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drill string and detected at a point exterior of the borehole. The diverted portion of the drilling fluid stream thus utilized to flex the flexible chamber is subsequently exhausted into the drilling fluid stream at a point below the stream restricting means, where the stream pressure is lower. In the aforementioned application of R. L. Alder, a similar system is disclosed in which energy is extracted from the drilling fluid stream at an upstream station by there causing the drilling fluid stream pressure to distend or flex a flexible diaphragm in such a manner as to displace and force a portion of a confined body of control fluid other than drilling fluid, to similarly perform the function of flexing a second flexible member into the drilling fluid stream therebelow to restrict the flow of the stream to produce a pressure change signal for transmission to a location outside the borehole. In that system the confined control fluid thus displaced by flexure of the diaphragm at the upstream location passes into a suitable receptacle at a downstream location. In both of the systems disclosed in the mentioned applications, energy is extracted from the drilling fluid stream by virtue of a pressure gradient existing therein between the upstream and downstream locations; and the energy extracted from the stream is employed to flex a flexible member into the stream path to produce a restriction in the stream at a location between the upstream and downstream locations for the purpose of producing a pressure-change signal.

The present invention contemplates certain improvements upon the inventions presented in the aforementioned copending applications. For example, the structure and structural arrangement presented by the instant invention are such that in the event of breakage or failure of the signal producing apparatus to operate there can be no disruption or stoppage of flow of the fluid through the conduit or drill string. In a fluid signaling system wherein the entire signal-producing apparatus is housed within the fluid carrying conduit this is an important feature. Additionally, the present invention provides a fluid flow restricting valve of such construction and arrangement that pressure change signals of relatively uniform magnitude are produced irrespective of variations in the fluid stream velocity within a wide range of normal operating values. It obviously is desirable that the magnitude of the pressure change signals transmitted be as nearly as possible uniform throughout a wide range of drilling fluid stream velocities and pressures. Further, it is desirable, in a system in which displacement of an auxiliary or separate captive or confined control fluid is employed in extracting energy from a liquid stream at an upstream station to be used at a location therebelow to operate a stream-restricting means, that there be provided efficient means for automatically pumping back or replacing the displaced control fluid to the upstream station subsequent to the completion of the pressure change signal, so the signaling means can continue to operate indefinitely with a minimum volume of control fluid.

In accord with the above-stated considerations, it is an object of the present invention to provide a fluid pressure change signaling system of the character noted which will eliminate the disadvantageous features of the systems described in the aforementioned applications and which is capable of producing pressure change sig-

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nals of substantially uniform magnitude regardless of changes in drilling fluid stream velocity in the drill string.

It is another object of the present invention to provide a fluid pressure change signaling system of the type indicated and comprising only means whose disruption or derangement is unlikely under any conditions and would not in any manner adversely affect the flow of drilling fluid through the drill string.

Another object of the invention is the provision of a fluid pressure change signaling system of the character indicated in which efficient means are provided for returning displaced control fluid to the upstream station following completion of a pressure pulse signal, utilizing energy extracted from the drilling fluid stream for the purpose.

It is another object of the present invention to provide a fluid pressure change signaling system of the type indicated in which automatically acting ram or pump means are provided which act to store a portion of the extracted energy derived from the drilling fluid stream at the upstream station incident to the increase in drilling fluid stream pressure at that station when a pressure change or pulse is produced, to return displaced control fluid to the upstream station subsequent to cessation or completion of the signaling pulse.

Another object of the invention is to provide a fluid pressure change signaling system of the type indicated, having a pressure change producing valve means which automatically compensates for variations in the liquid stream velocity to produce signals of substantially the same magnitude irrespective of stream velocity.

Other objects and advantages of the present invention will hereinafter be made evident in connection with a description of a preferred embodiment of apparatus according to the principles of the invention applied by way of example in the environment indicated in the parent application. It will be understood that the invention is not limited to such earth borehole environment, but is so illustrated only by way of example. In the drawings depicting a preferred form of apparatus as applied to a drill string in the stated environment:

Figure 1a is a view taken partly in vertical section through a portion of the lower end of a drill string, depicting apparatus located principally at an upstream station, certain parts of the apparatus being shown diagrammatically;

Figure 1b is a view comprising an extension or continuation of the lower end of Figure 1a; and indicating principally apparatus disposed at a downstream station in the drill string; and

Figure 2 is a hydraulic circuit diagram partially in schematic form indicating certain portions of the apparatus in sectional form for purposes of clarity of illustration, and indicating the upstream and downstream stations and the drilling fluid stream flow restricting valve in diagrammatic form, all substantially in vertical alignment.

Illustration of apparatus necessary to a practice of the invention has been limited in the interests of conciseness to that portion of the preferred form of apparatus which is situated at a first or signal transmitting location at the lower end of the drill string, it being understood that the receiver part of the signaling system, situated at a second location outside the borehole at the upper end of the drill string, may be either such as is depicted or disclosed in the aforementioned applications of Alder and Peterson or of other suitable form. The improvements effected by the instant invention relate principally to the signal creating and transmitting apparatus.

Referring now to the drawings and to Figures 1a and 1b in particular, there is depicted at 10 a fragmentary portion of the lower end of a length of an otherwise conventional drill string; specifically there is shown a fragmentary portion of the lower end of a section of a

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drill collar. Secured to portion 10 is a special tubular section 11 in which is provided a drilling fluid passage and in which the signal generating and transmitting apparatus of the system of the present invention is housed.

It will be understood that the lower part of tubular section 11 appearing in Figure 1a is extended or continued as the upper part of section 11 depicted in Figure 1b. Secured to the lower end of section 11 as shown in Figure 1b is another part of the drill string which may be, for example, a sub 12, or other apparatus, as may be well understood in the art. The interior surface of drill collar section 11 is made smooth and of uniform diameter to accommodate the other parts of the signal transmitting means of the invention. Situated in the upper end of the smooth bore of section 11 is a member 15 of generally tubular form having an upper end portion which snugly engages with the bore of section 11, and a lower end portion of reduced diameter and provided with a plurality of radially extending arms or projections 16 which aid in coaxially positioning member 15 in the bore. Secured to the upper inner end portion of member 15 is a ring clamp 17 which may be secured to member 15 in any suitable manner, for example, by means of screws 18 as indicated. Ring clamp 17 is arranged to clamp between itself and member 15 a generally tubular sleeve 19 of strong flexible impermeable material such as synthetic rubber, the lower end of sleeve 19 being similarly clamped or secured between member 15 and an upper lip or projection 21 suitably produced on the upper end of a housing 22 formed preferably as a machined casting. The flexible tube is arranged to be displaced or stretched to some extent in a manner hereinafter explained. Secured inside ring clamp 17 is a perforated metal tube 23 which extends downwardly into projection 21 of housing 22. Tubular member 15 is preferably also suitably secured to the upper end of housing 22, as by means of screws 24 only one of which is shown. Ring clamp 17 and member 15 are suitably formed at their upper ends to provide an annular depression in which may be mounted a suitable sealing cushion member in the form of an elastomer ring 25. The interior of perforated tube 23 forms a continuation of the downwardly extending conduit through which a stream of drilling fluid is forced in the direction of the adjacent arrow and under pressure, by a pump located outside the borehole at the top of the drill string. The perforations in tube 23 permit access of the drilling fluid to one surface of sleeve 19, which thus is made sensitive to the stream pressure and may be displaced outwardly away from tube 23 by pressure of the drilling fluid contained in the stream. Member 15 is formed with a circumferentially extending internal recess which, together with sleeve 15, forms a closed cavity 26 which is adapted to be filled with a suitable control fluid such as oil or "hydraulic" fluid. The control fluid may accordingly be displaced from cavity 26 by outward displacement of sleeve 19, the oil or fluid being in that case forced out of cavity 26 through a tube 27 which communicates with the interior of the cavity. Conversely, sleeve 19 after having thus been outwardly displaced may be returned to normal position or condition by return flow of control fluid through tubing 27 into cavity 26. The structure comprising tube 23, sleeve 19, and member 15 are located at what will hereinafter for convenience sake be termed an upstream station, between which and a lower downstream station to be hereinafter more specifically described there is maintained a pressure gradient in the drilling fluid stream as long as drilling fluid is forced downwardly through the drill string. The upstream station, which hereinafter will be designated generally by the reference character A, is the location at which energy or a force is derived from the drilling fluid stream by outward flexure or displacement of flexible sleeve 19 and displacement of control fluid. The drilling fluid stream flows downwardly past station A and

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through apparatus therebelow in the direction indicated by the arrows in Figures 1a and 1b.

Mounted in snug fitting relationship in the lower end of section 11 of the drill collar as indicated in Figure 1b is a support ring 30 restrained against downward displacement by suitable means such as an internal lock ring 31. Ring 30 serves to support immediately thereabove certain parts of the apparatus which define or locate what is hereinafter referred to as a downstream station, which is designated by the character B. It is between this downstream station and the previously mentioned upstream station A that a pressure gradient in the drilling fluid stream exists, which gradient is utilized as a source of energy for signaling and other uses which will hereinafter be more fully explained. Resting on support ring 30 and snugly fitting in the bore of section 11 is a lower tubular member 32 in the lower interior of which is secured a ring 33 and the lower end of a lower perforated tube 34, by suitable means, such as one or more screws 35 as indicated. Perforated tube 34 forms a length of the passage through which the downwardly flowing stream of drilling fluid flows. Tubular member 32 is formed with an internal annular recess which, together with a lower resilient impervious sleeve 36, forms a closed cavity 37 generally similar in shape and size to the aforementioned cavity 26 at upstream station A. Sleeve 36, which may be formed of any suitable resilient material such as synthetic rubber, is held tightly in place at both ends between tubular member 32 and tube 34; and is adapted to act as a pressure sensing element at the downstream station B, the drilling fluid stream having access to an interior surface of sleeve 36 through the perforations formed in tube 34. Tube 34 is formed with an exterior annular recess whereby there is formed between the tube and sleeve 36 a cavity 38 as indicated in Figure 1b, the cavity being of suitable proportions to permit occurrence of actions including inward and outward displacements such as are hereinafter described. By virtue of the construction at downstream station B, resilient sleeve 36 is adapted to be displaced from or toward tube 34 by fluid pressures applied to its opposite sides in cavities 37 and 38. Cavity 37 is sealed from ingress of drilling fluid by suitable sealing means as indicated in Figure 1b and as hereinafter more fully described, and is adapted to be filled with a portion of the same body of control fluid utilized in connection with the apparatus at upstream station A. Control fluid may gain access into and egress from cavity 37 through a tube 39 which communicates with the interior of that cavity, flow of control fluid into cavity 37 forcing drilling fluid out of cavity 38 into the stream, and vice versa.

Securely fitted in the interior bore of drill collar section 11 immediately above downstream station B is an adaptor 22a forming a lower extension of housing 22. The adaptor is supported by the upper machined face of tube 34 in an evident manner. The aforementioned housing 22 is supported on adaptor 22a and is preferably formed as a casting with a drilling fluid passage commencing at its upper end at lip 21 (see Figure 1a) and extending downwardly past a throat-forming member 40 and thence along close to one wall of the central section of the housing, from where the passage discharges into a formed passageway 51 in adaptor 22a, as indicated in Figure 1b. Ring 34, adaptor 22a and housing 22 are held in proper relative positions by any suitable means, as by pins 41 and 42 mounted in mating recesses in the respective members. Escape of drilling fluid away from the drilling fluid passage through the several members thus described is prevented by provision of conventional high pressure liquid seals as indicated and as well understood in the art, and by filling other spaces with a suitable inert liquid such as oil.

Housing 22 is also provided with a longitudinally extending bore 45 in which is mounted an apparatus case

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46 to be hereinafter more fully described. Bore 45 is formed to communicate with an opening 47 at its upper end as indicated, and may be formed by boring from the lower end of housing 22 as is evident from Figure 1b.

Apparatus case 46 may be mounted in bore 45 snugly against internal upper shoulder 48, and there held by suitable means such as an internal lock ring 49 indicated in Figure 1b. Also formed in housing 22 near the upper end thereof is a downwardly extending recess 52 in which are received certain parts of a piston-actuated drilling fluid valve means to be more fully described hereinafter.

The upper end of drilling fluid passageway 50 is formed to provide a drilling fluid stream flow restriction or throat of selected diameter and shape, preferably by making member 40 in the form of a replaceable insert or threaded ring which threads into and seats within the upper interior of housing 22 as indicated in Figure 1a. Member 40 is preferably situated coaxially with and above recess 52 whereby its lower flared face may provide a liquid stream of proper configuration or shape to most effectively provide a velocity head of suitable intensity and a stream of proper configuration for cooperation with a valve means about to be described and which has a spring pressed plunger normally held down by the velocity head of the stream. The size of the throat of the insert may be varied to provide the desired amount of pressure gradient between stations A and B; and the size and shape of the cooperating valve plunger head is such as to cause a suitable but limited restriction in the flow or in the flow path, of the drilling fluid stream when the plunger is suitably moved toward the insert in a manner and by means hereinafter described.

The piston actuated valve means which is supported in recess 52 and operated by control fluid displaced in a direction away from cavity 26 at upstream station A and through tubing 27, comprises a vane member in the form of a plunger or head 56 adapted to cooperate with member 40, a piston rod 57, a piston 58 snugly reciprocable in the smooth bore of recess 52, and a normally stressed piston spring 59 seated in the base of the recess and acting against the lower face of the piston 58. The valve head 56 is adapted to be held down with spring 59 stressed, by the force exerted on the head by the kinetic head of the fluid stream, and is adopted to be raised from that normal position upwardly into a second or drilling fluid stream restricting position by upward displacement of piston 58 incident to flow of control fluid into the lower end of recess 52 through a tubing 60. Coincident with such upward movement of piston 58, control fluid is displaced from the upper portion of recess 52 above the piston, through another tubing 61. The manner in which fluid is introduced into and allowed egress from recess 52 is hereinafter explained in connection with Figure 2. Undesirable complete restriction of drilling fluid flow may be prevented by suitable means such as will limit the upward stroke of the piston, for example, vanes 56a on head 56.

Situated below apparatus case 46 in bore 45 and held fixedly in place therein by suitable means such as by internal lock rings 64 and 65 (see Figure 1b) is a sealed bulkhead 66 which may be made fluid-tight in bore 45 by suitable conventional sealing means such as are indicated. A control fluid tubing 67 sealed in the lower end of apparatus case 46 is arranged to communicate in bulkhead 66 with the aforementioned tubing 39 leading to cavity 37 at downstream station B. Also mounted on the lower end of apparatus case 46 is an insulated electrical terminal 69 to which is connected electrical apparatus per se not of the present invention, but illustrated in the aforementioned applications and diagrammatically represented by switch and power means in Figure 2. The function of this electrical apparatus is to supply to terminal 69 a short signal pulse of electrical energy each time a pressure change signal is to be created in the drilling fluid stream. Adaptor 22a is so formed as to fit snugly in the

smooth bore of section 11; and is provided with a second passageway 70 through which the aforementioned tube 39 is adapted to extend in its course to the connection in bulkhead 66. Apparatus case 46 is arranged to house hydraulic and electro-mechanical components of apparatus which are best described with references to the hydraulic diagram of Figure 2.

Referring now to Figure 2, hydraulic apparatus at upstream station A is indicated at the upper part of the figure, and apparatus situated at downstream station B is diagrammatically shown at the lower part of the figure. Portions of the hydraulic and electrical apparatus contained within apparatus case 46 are indicated in Figure 2 as enclosed within the closed dashed line 46a representing case 46. It will be understood, of course, that the apparatus shown enclosed within the dashed line is only diagrammatically depicted, and may be of any suitable form and design. Flow of drilling fluid through and past upstream station A and downstream station B is indicated by arrows as in the case of Figures 1a and 1b. Initiation of action of the valve controlling means for creation of a pressure change signal in the drilling fluid stream may be effected by any suitable signal initiating means such as those mentioned in the aforementioned copending applications and only schematically indicated in Figure 2. The signal initiating means there indicated comprises a source of power represented by a battery P, signal timing means represented by a switch S, and suitable conductors connecting the battery and switch in series with the windings of the electromagnetic coil of a three-way control fluid valve indicated generally by reference character V. Valve V forms a principal part of a control fluid governing means which operates in a manner hereinafter described. It will be understood that the means for initiating energization of the electromagnet of valve V, and herein represented by battery P and switch S may be widely varied, such means being only generally and not specifically a part of the system of the present invention. They may, for example, be such as are disclosed in the aforementioned copending applications, or other equivalent means known in the art, it being sufficient for the purposes of the invention that the electromagnet be supplied one or more short signal pulses of electrical energy of sufficient duration to permit proper action of the apparatus. The signal pulses of electrical energy may be supplied to the electromagnet by apparatus connected to terminal 69 and may be supplied in timed sequence or relationship indicative of, or representing, information to be transmitted. The information may comprise ordinary types of well-logging information such as electrical measurements of earth formation resistivity, as indicated in the patent to Silverman, No. 2,354,887, mentioned in parent application Serial No. 413,397. Valve V and the associated electrical means are employed as control means in a control system to control extraction of energy from the drilling fluid stream at upstream station A and utilization of the energy for purposes previously indicated and hereinafter more fully described.

The structure of valve V as diagrammatically shown comprises a suitable casing containing the aforementioned electromagnet coil indicated at 71, a solenoid core 72 having a small borehole axially therethrough and a lateral bore as indicated, a piston or slide 73 suitably secured to core 72 and adapted to be moved to the left as viewed in Figure 2 by a spring 74 surrounding the core and pressing against a portion of the case and the right-hand end of slide 73. Valve slide 73 is bored or formed as indicated and is adapted to be moved from a normal inactive position into the position depicted in Figure 2 upon energization of coil 71. When coil 71 is thus energized, core 72 is moved to the right to the position shown and compresses return spring 74. The latter spring acts upon subsequent deenergization of coil 71 to return slide 73 to normal position. The hydraulic and mechanical apparatus depicted diagrammatically in Figure 2 and its oper-

ation, may be as follows, it being understood that the tubing, cylinders, valves and cavities of the control fluid system are filled with control fluid and that the means represented by switch S has just closed the circuit through coil 71 to produce a coil-energizing electrical signal in response to which the apparatus is to produce and transmit a hydraulic signal in the nature of a pressure increase in the drilling fluid stream above station A.

Upon energization of coil 71 and movement of core 72 and slide 73 to the position shown, communication is established permitting flow of control fluid between upstream cavity 26 and recess 52 below piston 58, by way of tubings 27, 76, the upper port 77 of valve V, the bore of the valve slide 73, valve chamber 73', and tubing 60. The pressure in the drilling fluid stream at upstream station A then acts to outwardly displace upper flexible sleeve 19 and displace or cause migration of control fluid through the aforescribed path into the lower portion of recess 52, whereby piston 58 is forced upwardly by the displaced control fluid. Upward movement of piston 58 is permitted by egress of control fluid from the upper portion of recess 52 through the aforementioned tubing 61 which communicates with downstream cavity 37 through a pressure relief valve 78 provided for purposes hereinafter more fully explained. These movements occur under the influence of the pressure gradient in the stream between A and B. Piston 79 of relief valve 78 is normally balanced within a range of operating positions approximately centered at the position indicated by a spring 80 which acts against the pressure of control fluid applied to the lower face of the piston. The upper fluid passage through this valve is thus normally open and remains open during all normal operations of the apparatus. Fluid displaced by piston 58 from the upper portion of recess 52 through tubing 61 and the upper chamber of valve 78 exits through tubing 81, which communicates with cavity 37 at downstream station B (and another device hereinafter described), through connection with the aforementioned tubing 67 as shown. Upward motion of piston 58 moves valve head 56 from normal position into a drilling fluid stream flow-restricting position adjacent ring 40, with the result that an increase in drilling fluid pressure is produced at and above station A. This increase in pressure constitutes and is utilized as a signal which is transmitted by and upwardly through the down-flowing stream of drilling fluid in the drill string to suitable pressure transducer signal receiving means located outside the borehole. Displacement of control fluid from the upper chamber of cavity 52 by piston 58 may and normally does cause an inner, somewhat radial, flexure or displacement of lower station resilient sleeve 36, as indicated by the dotted lines at that station in Figure 2. The hereinbefore described movement and action of the control fluid occurs as a result of the outward flexure or displacement of sleeve 19 caused by the pressure gradient between upstream station A and downstream station B, in the manner thought to now be self-evident. Coincident with the increase in drilling fluid pressure at station A, more control fluid is displaced or migrates in a direction away from cavity 26 through tubing 27 into and through a tubing 82 and a tubing 83, into a cylindrical chamber 84 containing a piston 85 normally urged to the left as viewed in Figure 2 by a spring 86 as indicated. Movement of control fluid into chamber 84 results in partial compression of spring 86 incident to movement toward the right of piston 85, whereby control fluid is displaced by piston 85 from chamber 87 through a tubing 88 and a one-way or check valve 89 into the upper chamber 90 of a hydraulic cylinder 91 containing a spring-pressed piston 92 normally urged to the left by a return spring 93 as indicated. Flow of control fluid into chamber 90 and movement to the right of piston 92 causes displacement of control fluid from the lower cavity 94 of cylinder 91 into the aforementioned tubing 67. This action may result in further inward displacement of sleeve 36 at downstream station A, where the drilling

fluid stream pressure has been somewhat reduced. Movement of control fluid directly from tubing 82 into upper chamber 90 of cylinder 91 is prevented by a one-way or check valve 95 as indicated.

Thus it is seen that the increased pressure at station A is balanced by the increased force exerted on pistons 85 and 92 by springs 86 and 93. That is, the upstream station pressure is substantially equal to the sum of the downstream station pressure plus the pressure exerted as a result of the compression of springs 86 and 93. The compression of springs 86 and 93 constitutes a storage of energy extracted from the drilling fluid stream; the stored energy being used in a manner hereinafter described to return toward station A, control fluid previously displaced away from that station.

As a consequence of the hydraulic actions thus far described the increase in pressure in the drilling fluid stream at upstream station A causes movement of pistons 85 and 92 to the right with concurrent storage of energy in springs 86 and 93. Upon subsequent deenergization of coil 71 incident to termination of the electric signal, spring 74 acts to return valve slide 73 to the left or normal position, connecting chamber 73' and recess 52 with port 95 of control fluid valve V. Free flow of control fluid through the bores formed in solenoid core 72 permits of rapid action of valve V. Upon movement of valve slide 73 to the left, upstream control fluid pressure at station A is cut off from the lower part of recess 52, permitting downward return movement of piston 58 and valve head 56 under the influence of the kinetic head of the drilling fluid stream on head 56. This return movement of the plunger head results in a drop in stream pressure at station A to normal and is accompanied by upward migration or movement of control fluid from downstream cavity 37 through tubing 67, and tubing 81, through valve 78 and tubing 61 into the upper portion of recess 52 above piston 58. Concurrently, control fluid flows from the lower part of recess 52 into chamber 73' and out through port 96 and through tubing 88a and check valve 97 into cavity 87, previously compressed spring 86 at this time forcing piston 85 to the left in response to the decreasing pressure in chamber 84 which is in open communication with upstream cavity 26 at station A. Additionally, control fluid is forced from chamber 90 through check valve 95 into tubing 82 by the action of previously compressed spring 93 and piston 92, in a self-evident manner; control fluid at the same time being drawn into chamber 94 from downstream cavity 37 through tubing 39, 67. It will be seen as a consequence of this second phase of hydraulic operations that control fluid previously displaced in a direction away from upstream cavity 26 during and incident to extraction of energy from the drilling fluid stream at station A, is returned to cavity 26, whereby the apparatus there located is returned to normal condition. Further, at the same time, flexible sleeve 36 at downstream station B is similarly returned to normal condition as the pressure at A decreases and that at B increases to normal. Upon subsequent reenergization of coil 71 in response to another electrical signal, and movement of valve slide 73 to the position indicated in Figure 2, another fluid pressure increase signal will be created by upward movement of valve plunger 56 under the influence of control fluid displaced from cavity 26 to the lower chamber of recess 52, with concurrent displacement of control fluid from the upper chamber of recess 52 through tubing 61, valve 78, tubing 81 and 67 to lower cavity 37. Again incident to the increase in drilling fluid stream pressure at station A, piston 85 will be displaced to the right, accompanied by displacement of control fluid from chamber 87 through check valve 89 into chamber 90, and displacement of piston 92 to the right. These movements of pistons 85 and 92 again compress springs 86 and 93 to store energy. Upon subsequent deenergization of coil 71 and movement of slide 73 to the left to normal position, valve piston 58 will be lowered again by the drilling fluid stream

pressure on valve head 56, with incident migration of control fluid from recess 52 into chamber 73' through port 96 and check valve 97 and tubing 88 into chamber 87 as piston 85 moves to the left under the influence of spring 86. The latter spring is at this time opposed by the decreasing pressure in chamber 84 which is in communication with cavity 26. Thus it is seen that at each cycle of the hereinbefore described hydraulic operations, piston 85 displaces control fluid from chamber 87 through tubing 88 and check valve 89 into chamber 90, followed by subsequent movement of displaced fluid from chamber 90 through check valve 95 and tubing 82 and 27 into cavity 26 in a manner now evident. Also, at each cycle there is an oscillatory movement of control fluid from above piston 58 toward and into downstream cavity 37 and return; a second oscillatory movement of control fluid from upstream cavity 26 into chamber 84, and return; and a third oscillatory movement of fluid from chamber 94 toward cavity 37 and return. Piston 92 and spring 93 act as ram or pump means to produce a cyclic or intermittent pumping of control fluid back toward station A. It will be understood that the proportions of the apparatus are such as to accommodate the described control fluid movements. Operation of the apparatus thus may be continuous under the influence of repetitive electric signal energizations of coil 71, pistons 85 and 92 operating through ranges of intermediate positions determined by the constants of springs 86 and 93 and the pressure gradient between upstream station cavity 26 and downstream station cavity 37, and valve plunger 56 automatically assuming a normal rest position dependent upon the velocity of the drilling fluid stream through station A and the constant of the piston spring acting on piston 58. The rate of return pumping of control fluid is automatically regulated by the somewhat variable strokes of pistons 85 and 92, which tend to assume positions such that the pressure in chamber 26 would be equalized by the pressure in chamber 37 plus the pressure provided by the combination of springs 86 and 93 and check valves 89 and 95. The variation in the pressure gradient between stations A and B as pressure change signals are created is employed as a source of energy for operating the ram or pump means for returning displaced control fluid upwardly toward station A.

As a result of the aforedescribed construction and operation of the apparatus it will be seen that in the event of the rupture or disintegration of any of the flexible elements of the hydraulic apparatus or the impairment of the operation of the signal producing valve, including plunger 56, or the malfunctioning of any of the other parts of the apparatus, normal flow of the drilling fluid stream downwardly through the drill collar will be in no way affected. Further, it will be seen that due to the automatic yielding movement of plunger 56 and piston 58 under the action of its spring means, the drilling fluid stream restricting valve will automatically accommodate itself to any velocity of drilling fluid stream flow through the drill collar and produce pressure change signals of substantially uniform magnitude.

It is to be noted that in the specific disclosed environment in which the illustrative and preferred embodiment of apparatus according to the invention is placed, namely, in a drill string in an earth borehole, the fluids employed to remove the rock chips and debris from the borehole comprise drilling "mud," oil emulsions, gases such as hydrocarbons, air, and solutions and suspensions of various solutes or solids in liquids and/or gases.

In this specification and the appended claims, it is intended that the expressions "flow restriction," "flow path restriction" and derivatives of such and similar expressions employed, be given substantially synonymous interpretations or meanings, the net result of a flow restriction or a flow path restriction being an increase in liquid pressure above the point of restriction.

It will be evident to those skilled in the art that modi-

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fications of the apparatus depicted may readily be effected without change of the concept or principles of operation, and accordingly, I do not wish to be limited to the details of the particular embodiment of apparatus described, but what I claim is:

1. In a system for simultaneously logging and drilling earth bore holes employing a drill string having a drilling fluid flow passage therethrough, down through which passage circulating drilling fluid is forced to flow under pressure, the combination comprising: signaling means in said drill string including a flow resistance member movable between a normal position and a flow resisting position within said passage, a cylinder and a plunger in said cylinder with said plunger being operatively connected to said flow resistance member so as to be actuable by transfer to its first side of a quantity of control fluid under pressure to cause the flow resistance member to be moved to its flow resisting position and produce a pressure rise signal within said fluid flow passage and by transfer to its opposite side of said control fluid to cause the flow resistance member to be moved to its normal position; a first separate body of control fluid contained in said drill string; a first sensing means to pick up and transfer to said first body of control fluid the pressure of said circulating fluid in said passage at a point spaced upstream from said flow resistance means; a second separate body of control fluid contained in said drill string; a second sensing means to pick up and transfer to said second body of control fluid the pressure of said circulating fluid of said passage at a point downstream from said flow resistance means, the pressure picked up and transferred to said first body of control fluid being greater than the pressure picked up and transferred to said second body of control fluid; and signal control means in said drill string actuable first to admit a quantity of control fluid under the pressure of said circulating fluid at said upstream point from said first body of control fluid to the first side of said plunger to thereby effect movement of said flow resistance member to its flow resisting position, and actuatable secondly to exhaust said thus-supplied quantity of said control fluid from the first side of said plunger into said second body of control fluid whereby a quantity of said first body of control fluid is transferred into said second body of control fluid to thereby permit said flow resistance member to return to its normal position.

2. In a system for simultaneously logging and drilling earth bore holes employing a drill string having a drilling fluid flow passage therethrough, down through which passage circulating drilling fluid is forced to flow under pressure, the combination comprising: signaling means in said drill string including a flow resistance member movable between a normal position and a flow resisting position within said passage, a cylinder and a plunger in said cylinder with said plunger being operatively connected to said flow resistance member so as to be actuable by transfer to its first side of a quantity of control fluid under pressure to cause the flow resistance member to be moved to its flow resisting position and produce a pressure rise signal within said fluid flow passage and by transfer to its opposite side of said control fluid to cause the flow resistance member to be moved to its normal position; a first separate body of control fluid contained in said drill string; a first sensing means to pick up and transfer to said first body of control fluid the pressure of said circulating fluid in said passage at a point spaced upstream from said flow resistance means; a second separate body of control fluid contained in said drill string; a second sensing means to pick up and transfer to said second body of control fluid the pressure of said circulating fluid of said passage at a point downstream from said flow resistance means, the pressure picked up and transferred to said first body of control fluid being greater than the pressure picked up and transferred to said second body of control fluid; signal con-

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trol means in said drill string actuatable first to admit a quantity of control fluid under the pressure of said circulating fluid at said upstream point from said first body of control fluid to the first side of said plunger to thereby effect movement of said flow resistance member to its flow resisting position, and actuatable secondly to exhaust said thus-supplied quantity of said control fluid from the first side of said plunger into said second body of control fluid while removing the pressure of said first body of control fluid therefrom whereby a quantity of said first body of control fluid is transferred into said second body of control fluid to thereby permit said flow resisting member to return to its normal position; and transfer means energized by the said pressure rise in said first body of control fluid resulting from said pressure rise signal in said circulating fluid to return a quantity of the second body of control fluid to the first body of control fluid sufficient to compensate for the quantity of control fluid exhausted into said second body of control fluid.

3. The combination of claim 2 wherein said first and second sensing means include a barrel member and a resilient tubular sleeve coaxially arranged therein to provide a closed cavity therebetween with an inner surface of said tubular sleeve encircling and providing a boundary for the drilling fluid stream and said barrel and tubular sleeve providing therebetween around a portion of the exterior of said tubular sleeve a fluid-tight cavity which is exposed to said first and second bodies of control fluid.

4. The combination of claim 2 wherein said transfer means include a pair of cylinders; a piston in each cylinder; biasing means urging said pistons towards one end of said cylinders; conduit means, said conduit means connecting said one end of the first and second cylinders with said first body of control fluid, said one end of the second cylinder with the opposite end of said first cylinder and said second body of control fluid, and the opposite end of the second cylinder with said second body of control fluid; and check valve means in said conduit means admitting fluid into the first end of said second cylinder but restraining fluid flow out of said first end of said second cylinder except towards said first body of control fluid.

5. In a system for simultaneously logging and drilling earth bore holes employing a drill string having a drilling fluid flow passage therethrough, down through which passage circulating drilling fluid is forced to flow under pressure, the combination comprising: signaling means in said drill string including variable fluid flow resistance means fixed in said drill string in the vicinity of the lower end thereof, actuatable by transfer thereto of a quantity of control fluid under pressure to effect a variation in resistance to flow therethrough of said circulating fluid to produce a pressure rise signal therein; a first separate body of control fluid contained in said drill string; a first sensing means to pick up and transfer to said first body of control fluid the pressure of said circulating fluid in said passage at a point spaced upstream from said flow resistance means; a second separate body of control fluid contained in said drill string; a second sensing means to pick up and transfer to said second body of control fluid the pressure of said circulating fluid in said passage at a point downstream from said flow resistance means, the pressure thereby picked up and transferred to said first body of control fluid being greater than the pressure picked up and transferred to said second body of control fluid; signal control means in said drill string actuatable firstly to supply a quantity of control fluid under pressure from said first body of control fluid to said flow resistance means to thereby actuate said fluid flow resistance means to produce a pressure rise signal in said circulating fluid upstream of said flow resistance means, and actuatable secondly to exhaust said thus supplied quantity of said first control fluid from said fluid flow resistance means into said second body

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of control fluid whereby a quantity of said first body of control fluid of higher pressure is transferred into said second body of control fluid of lower pressure, thereby to actuate said fluid flow resistance means to terminate said pressure rise signal in said circulating fluid; and transfer means including a pair of cylinders, a plunger in each cylinder, biasing means urging said plunger towards one end of said cylinders, conduit means, said conduit means connecting said one end of the first and second cylinders with said first body of control fluid, said one end of the second cylinder with the opposite end of said first cylinder and said second body of control fluid, and the opposite end of the second cylinder with said second body of control fluid, and check valve means in said conduit means admitting fluid into the first end of said second cylinder but restraining fluid flow out of said first end of said second cylinder except towards said first body of control fluid.

6. The combination of claim 5 wherein said first and second sensing means include a barrel member and a resilient tubular sleeve coaxially arranged therein to provide a closed cavity therebetween with an inner surface of said tubular sleeve encircling and providing a boundary for the drilling fluid stream and said barrel and tubular sleeve providing therebetween around a portion of the exterior of said tubular sleeve a fluid-tight cavity which is exposed to said first and second bodies of control fluid.

7. In a system for simultaneously logging and drilling earth bore holes employing a drill string having a drilling fluid flow passage therethrough, down through which passage circulating drilling fluid is forced to flow under pressure, the combination comprising: signaling means in said drill string including a flow resistance member movable between a normal position and a flow resisting position within said passage, a cylinder and a plunger in said cylinder with said plunger being operatively connected to said flow resistance member so as to be actuable by transfer to its first side of a quantity of control fluid under pressure to cause the flow resistance member to be moved to its flow resisting position and produce a pressure rise signal within said fluid flow passage and by transfer to its opposite side of said control fluid to move the flow resistance member to its normal position; an upstream pressure take-off member having a flexible wall exposed to said stream; a downstream pressure take-off member having a flexible wall exposed to said stream, said signaling means being positioned between said pressure take-off members; an isolated body of control fluid; conduit means for said control fluid interconnecting said pressure take-off members and both ends of said cylinder; and signal control means interposed in said conduit means to direct said control fluid in and out of both ends of said cylinder so as to effect movement of said flow resistance member between its normal and flow resisting positions under the influence of the energy gradient existing in said stream between said pressure take-off stations.

8. In a system for simultaneously logging and drilling earth bore holes employing a drill string having a drilling fluid flow passage therethrough, down through which passage circulating drilling fluid is forced to flow under pressure, the combination comprising: signaling means in said drill string including a flow resistance member movable between a normal position and a flow resisting position within said passage, a cylinder and a plunger in said cylinder with said plunger being operatively connected to said flow resistance member so as to be actuable by transfer to its first side of a quantity of control fluid under pressure to cause the flow resistance member to be moved to its flow resisting position and produce a pressure rise signal within said fluid flow passage and by transfer to its opposite side of said control fluid to cause the flow resistance member to be moved to its normal position; a first separate body of control fluid contained in said drill string; a second separate body of control fluid contained in said drill string; a first sensing means to pick

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up and transfer to said first body of control fluid the pressure of said circulating fluid in said passage at a point spaced upstream from said flow resistance means, said first sensing means including a barrel member and a resilient tubular sleeve coaxially arranged therein to provide a closed cavity therebetween with an inner surface of said tubular sleeve encircling and providing a boundary for the drilling fluid stream, and said barrel and tubular sleeve providing therebetween around a portion of the exterior of said tubular sleeve a fluid-tight cavity which is exposed to said first and second bodies of control fluid; a second sensing means to pick up and transfer to said second body of control fluid the pressure of said circulating fluid of said passage at a point downstream from said flow resistance means, the pressure picked up and transferred to said first body of control fluid being greater than the pressure picked up and transferred to said second body of control fluid, said second sensing means including a barrel member and a resilient tubular sleeve coaxially arranged therein to provide a closed cavity therebetween with an inner surface of said tubular sleeve encircling and providing a boundary for the drilling fluid stream, and said barrel and tubular sleeve providing therebetween around a portion of the exterior of said tubular sleeve a fluid-tight cavity which is exposed to said first and second bodies of control fluid; and signal control means in said drill string actuable first to admit a quantity of control fluid under the pressure of said circulating fluid at said upstream point from said first body of control fluid to the first side of said plunger to thereby effect movement of said flow resistance member to its flow resisting position, and actuable secondly to exhaust said thus-supplied quantity of said control fluid from the first side of said plunger into said second body of control fluid whereby a quantity of said first body of control fluid is transferred into said second body of control fluid to thereby permit said flow resistance member to return to its normal position.

9. In a system for simultaneously logging and drilling earth bore holes employing a drill string having a drilling fluid flow passage therethrough, down through which passage circulating drilling fluid is forced to flow under pressure, the combination comprising: signaling means in said drill string including a flow resistance member disposed in said passage and normally forced by said circulating drilling fluid to a normal position wherein it offers minimum restriction to the flow of said drilling fluid, said flow resistance member being movable to a flow resisting position wherein it offers appreciable resistance to the flow of said drilling fluid to thereby produce a pressure rise signal within said passage, normally stressed resilient means acting to apply a force tending to move said flow resistance member into its flow resisting position with said force normally being less than the force exerted by the flow of said circulating drilling fluid upon said flow resistance member, a cylinder and a plunger in said cylinder with said plunger being operatively connected to said flow resistance member so as to be actuable by transfer to its first side of a quantity of control fluid under pressure to cause the flow resistance member to be moved to its flow resisting position and produce a pressure rise signal within said fluid flow passage and by transfer to its opposite side of said control fluid to cause the flow resistance member to be moved to its normal position; a first separate body of control fluid contained in said drill string; a first sensing means to pick up and transfer to said first body of control fluid the pressure of said circulating fluid in said passage at a point spaced upstream from said flow resistance means; a second separate body of control fluid contained in said drill string; a second sensing means to pick up and transfer to said second body of control fluid the pressure of said circulating fluid of said passage at a point downstream from said flow resistance means, the pressure picked up and transferred to said first body of control fluid

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being greater than the pressure picked up and transferred to said second body of control fluid; and signal control means in said drill string actuable first to admit a quantity of control fluid under the pressure of said circulating fluid at said upstream point from said first body of control fluid to the first side of said plunger to thereby effect movement of said flow resistance member to its flow resisting position, and actuable secondly to exhaust said thus-supplied quantity of said control fluid from the first side of said plunger into said second body of control fluid whereby a quantity of said first body of control fluid is transferred into said second body of control fluid to thereby permit said flow resistance member to return to its normal position.

10. In a system for simultaneously logging and drilling earth bore holes employing a drill string having a drilling fluid flow passage therethrough, down through which passage circulating drilling fluid is forced to flow under pressure, the combination comprising: signaling means in said drill string including a flow resistance member disposed in said passage and normally forced by said circulating drilling fluid to a normal position wherein it offers minimum restriction to the flow of said drilling fluid, said flow resistance member being movable to a flow resisting position wherein it offers appreciable resistance to the flow of said drilling fluid to thereby produce a pressure rise signal within said passage, normally stressed resilient means acting to apply a force tending to move said flow resistance member into its flow resisting position with said force normally being less than the force exerted by the flow of said circulating drilling fluid upon said flow resistance member, a cylinder and a plunger in said cylinder with said plunger being operatively connected to said flow resistance member so as to be actuable by transfer to its first side of a quantity of control fluid under pressure to cause the flow resistance member to be moved to its flow resisting position and produce a pressure rise signal within said fluid flow passage and by transfer to its opposite side of said control fluid to cause the flow resistance member to be moved to its normal position; a first separate body of control fluid contained in said drill string; a first sensing means to pick up and transfer to said first body of control fluid the pressure of said circulating fluid in said passage at a point spaced upstream from said flow resistance means; a second separate body of control fluid contained in said drill string; a second sensing means to pick up and transfer to said second body of control fluid the pressure of said circulating fluid of said passage at a point downstream from said flow resistance means, the pressure picked up and transferred to said first body of control fluid being greater than the pressure picked up and transferred to said second body of control fluid; signal control means in said drill string actuable first to admit a quantity of control fluid under the pressure of said circulating fluid at said upstream point from said first body of control fluid to the first side of said plunger to thereby effect movement of said flow resistance member to its flow resisting position, and actuable secondly to exhaust said thus-supplied quantity of said control fluid from the first side of said plunger into said second body of control fluid whereby a quantity of said first body of control fluid is transferred into said second body of control fluid to thereby permit said flow resistance member to return to its normal position; and transfer means energized by the said pressure rise in said first body of control fluid resulting from said pressure rise signal in said circulating fluid to return a quantity of the second body of control fluid to the first body of control fluid sufficient to compensate for the quantity of control fluid exhausted into said second body of control fluid.

11. The combination of claim 10 wherein said transfer means include a pair of cylinders; a piston in each cylinder; biasing means urging said pistons towards one

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end of said cylinders; conduit means, said conduit means connecting said one end of the first and second cylinders with said first body of control fluid, said one end of the second cylinder with the opposite end of said first cylinder and said second body of control fluid, and the opposite end of the second cylinder with said second body of control fluid; and check valve means in said conduit means admitting fluid into the first end of said second cylinder but restraining fluid flow out of said first end of said second cylinder except towards said first body of control fluid.

12. In a system for simultaneously logging and drilling earth bore holes employing a drill string having a drilling fluid flow passage therethrough, down through which passage circulating drilling fluid is forced to flow under pressure, the combination comprising: signaling means in said drill string including a flow resistance member disposed in said passage and normally forced by said circulating drilling fluid to a normal position wherein it offers minimum restriction to the flow of said drilling fluid, said flow resistance member being movable to a flow resisting position wherein it offers appreciable resistance to the flow of said drilling fluid to thereby produce a pressure rise signal within said passage, normally stressed resilient means acting to apply a force tending to move said flow resistance member into its flow resisting position with said force normally being less than the force exerted by the flow of said circulating drilling fluid upon said flow resistance member, a cylinder and a plunger in said cylinder with said plunger being operatively connected to said flow resistance member so as to be actuable by transfer to its first side of a quantity of control fluid under pressure to cause the flow resistance member to be moved to its flow resisting position and produce a pressure rise signal within said fluid flow passage and by transfer to its opposite side of said control fluid to cause the flow resistance member to be moved to its normal position; a first separate body of control fluid contained in said drill string; a second separate body of control fluid contained in said drill string; first sensing means to pick up and transfer to said first body of control fluid the pressure of said circulating drilling fluid in said passage at a point spaced upstream from said flow resistance means, said first sensing means including a barrel member and a resilient tubular sleeve coaxially arranged therein to provide a closed cavity therebetween with an inner surface of said tubular sleeve encircling and providing a boundary for the drilling fluid stream, and said barrel and tubular sleeve providing therebetween around a portion of the exterior of said tubular sleeve a fluid-tight cavity which is exposed to said first and second bodies of control fluid; a second sensing means to pick up and transfer to said second body of control fluid the pressure of said circulating fluid of said passage at a point downstream from said flow resistance means, the pressure picked up and transferred to said first body of control fluid being greater than the pressure picked up and transferred to said second body of control fluid, said second sensing means including a barrel member and a resilient tubular sleeve coaxially arranged therein to provide a closed cavity therebetween with an inner surface of said tubular sleeve encircling and providing a boundary for the drilling fluid stream, and said barrel and tubular sleeve providing therebetween around a portion of the exterior of said tubular sleeve a fluid-tight cavity which is exposed to said first and second bodies of control fluid; and signal control means in said drill string actuable first to admit a quantity of control fluid under the pressure of said circulating fluid at said upstream point from said first body of control fluid to the first side of said plunger to thereby effect movement of said flow resistance member to its flow resisting position, and actuable secondly to exhaust said thus-supplied quantity

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of said control fluid from the first side of said plunger into said second body of control fluid whereby a quantity of said first body of control fluid is transferred into said second body of control fluid to thereby permit said flow resistance member to return to its normal position.

13. In a system for simultaneously logging and drilling earth bore holes employing a drill string having a drilling fluid flow passage therethrough, down through which passage circulating drilling fluid is forced to flow under pressure, the combination comprising: signaling means in said drill string including a flow resistance member disposed in said passage and normally forced by said circulating drilling fluid to a normal position wherein it offers minimum restriction to the flow of said drilling fluid, said flow resistance member being movable to a flow resisting position wherein it offers appreciable resistance to the flow of said drilling fluid to thereby produce a pressure rise signal within said passage, normally stressed resilient means acting to apply a force tending to move said flow resistance member into its flow resisting position with said force normally being less than the force exerted by the flow of said circulating drilling fluid upon said flow resistance member, force-applying means in said drill string operatively connected to said flow resistance member, said force-applying means being actuable by admission thereto of a control fluid under pressure to move said flow resistance member to said flow resisting position, said force-applying means being actuable upon exhaust of said control fluid therefrom to permit said flow resistance member to be returned to its normal position; a first separate body of control fluid contained in said drill string; a first sensing means to pick up and transfer to said first body of control fluid the pressure of said circulating fluid in said passage at a point spaced upstream from said flow resistance means; a second separate body of control fluid contained in said drill string; a second sensing means to pick up and transfer to said second body of control fluid the pressure of said circulating fluid of said passage at a point downstream from said flow resistance means, the pressure picked up and transferred to said first body of control fluid being greater than the pressure picked up and transferred to said second body of control fluid; signal control means in said drill string actuable first to admit a quantity of control fluid under the pressure of said circulating fluid at said upstream point from said first body of control fluid to said force-applying means to thereby effect movement of said flow resistance member to its flow resisting position, and actuable secondly to exhaust said thus-supplied quantity of said control fluid from said force-applying means into said second body of control fluid while removing the pressure of said first body of control fluid therefrom whereby a quantity of said first body of control fluid is transferred into said second body of control fluid to thereby permit said flow resisting member to return to its normal position; and transfer means energized by the said pressure rise in said first body of control fluid resulting from said pressure rise signal in said circulating fluid to return a quantity of the second body of control fluid to the first body of control fluid sufficient to compensate for the quantity of control fluid exhausted into said second body of control fluid.

14. The combination of claim 13 wherein said first and second sensing means include a barrel member and a resilient tubular sleeve coaxially arranged therein to provide a closed cavity therebetween with an inner surface of said tubular sleeve encircling and providing a boundary for the drilling fluid stream and said barrel and tubular sleeve providing therebetween around a portion of the exterior of said tubular sleeve a fluid-tight cavity which is exposed to said first and second bodies of control fluid.

15. The combination of claim 13 wherein said transfer means include a pair of cylinders; a piston in each cylinder; biasing means urging said pistons towards one

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end of said cylinders; conduit means, said conduit means connecting said one end of the first and second cylinders with said first body of control fluid, said one end of the second cylinder with the opposite end of said first cylinder and said second body of control fluid, and the opposite end of the second cylinder with said second body of control fluid; and check valve means in said conduit means admitting fluid into the first end of said second cylinder but restraining fluid flow out of said first end of said second cylinder except towards said first body of control fluid.

16. In a system for simultaneously logging and drilling earth bore holes employing a drill string having a drilling fluid flow passage therethrough, down through which passage circulating drilling fluid is forced to flow under pressure, the combination comprising: signaling means in said drill string including a flow resistance member movable between a normal position and a flow resisting position within said passage, a cylinder and a plunger in said chamber with said plunger being operatively connected to said flow resistance member so as to be actuable by transfer to its first side of a quantity of control fluid under pressure to cause the flow resistance member to be moved to its flow resisting position and produce a pressure rise signal within said fluid flow passage and by transfer to its opposite side of said control fluid to move the flow resistance member to its normal position; an upstream pressure take-off member having a flexible wall exposed to said stream; a downstream pressure take-off member having a flexible wall exposed to said stream, said signaling means being positioned between said pressure take-off members; an isolated body of control fluid in said drill string; conduit means for said fluid interconnecting said pressure take-off members and both ends of said cylinder; and signal control means to provide a series of pressure rise increases in said circulating drilling fluid, said signal control means being interposed in said conduit means to successively direct said control fluid in and out of both ends of said cylinder so as to automatically effect movement of said flow resistance member between its normal and flow resisting positions under the influence of the energy gradient existing in said circulating drilling fluid between said pressure take-off stations.

17. In a system for simultaneously logging and drilling earth bore holes employing a drill string having a drilling fluid flow passage therethrough, down through which passage circulating drilling fluid is forced to flow under pressure, the combination comprising: signaling means in said drill string including a flow resistance member disposed in said passage and normally forced by said circulating drilling fluid to a normal position wherein it offers minimum restriction to the flow of said drilling fluid, said flow resistance member being movable to a flow resisting position wherein it offers appreciable resistance to the flow of said drilling fluid to thereby produce a pressure rise signal within said passage, normally stressed resilient means acting to apply a force tending to move said flow resistance member into its flow resisting position with said force normally being less than the force exerted by the flow of said circulating drilling fluid upon said flow resistance member, a control fluid-receiving chamber and a pressure responsive wall in said chamber with said wall being operatively connected to said flow resistance member so as to be actuable by transfer to its first side of a quantity of control fluid under pressure to cause the flow resistance member to be moved to its flow resisting position and produce a pressure rise signal within said fluid flow passage and by transfer to its opposite side of said control fluid to move the flow resistance member to its normal position; an upstream pressure take-off member having a flexible wall exposed to said stream; a downstream pressure take-off member having a flexible wall exposed to said stream, said signaling means being positioned between said pressure take-off members; an isolated body of control fluid in said

drill string; conduit means for said control fluid inter-
connecting said pressure take-off members and both ends
of said control fluid-receiving chamber; and signal control
means to provide a series of pressure rise increases
in said circulating drilling fluid, said signal control means
being interposed in said conduit means to successively
direct said control fluid in and out of both ends of said
control fluid-receiving chamber so as to automatically
effect movement of said flow resistance member between
its normal and flow resisting positions under the influ-
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