June 1, 1965 J. C. WILSON 3,186,223

COMBINATION LOGGING SYSTEM

Filed May 12, 1961 4 Sheets-Sheet 1

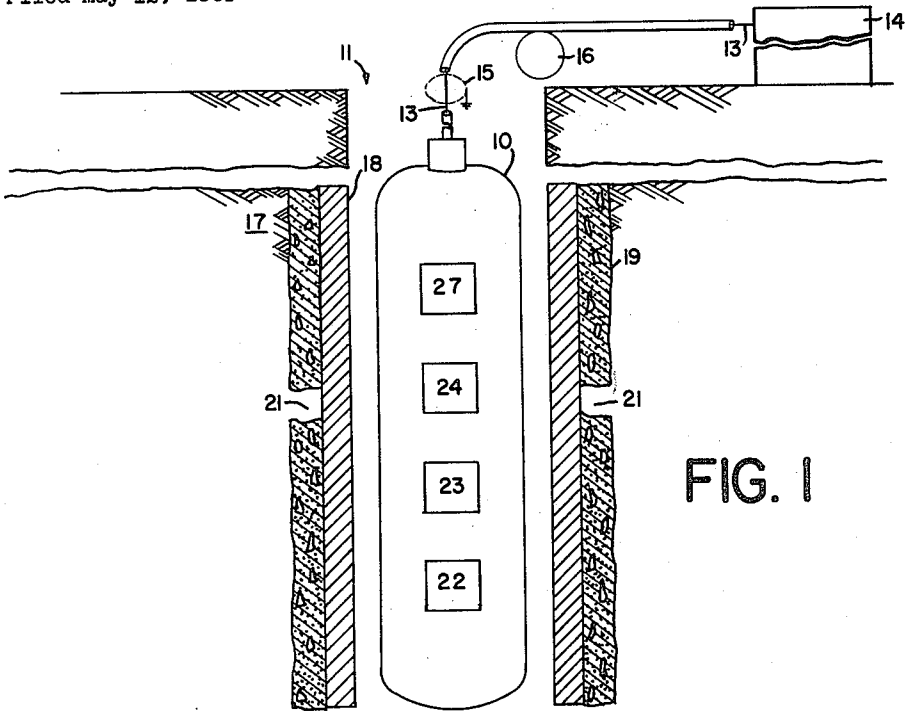


FIG. 1

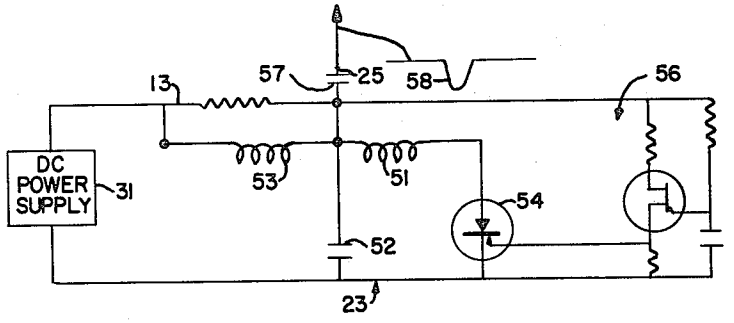


FIG. 3

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COMBINATION LOGGING SYSTEM

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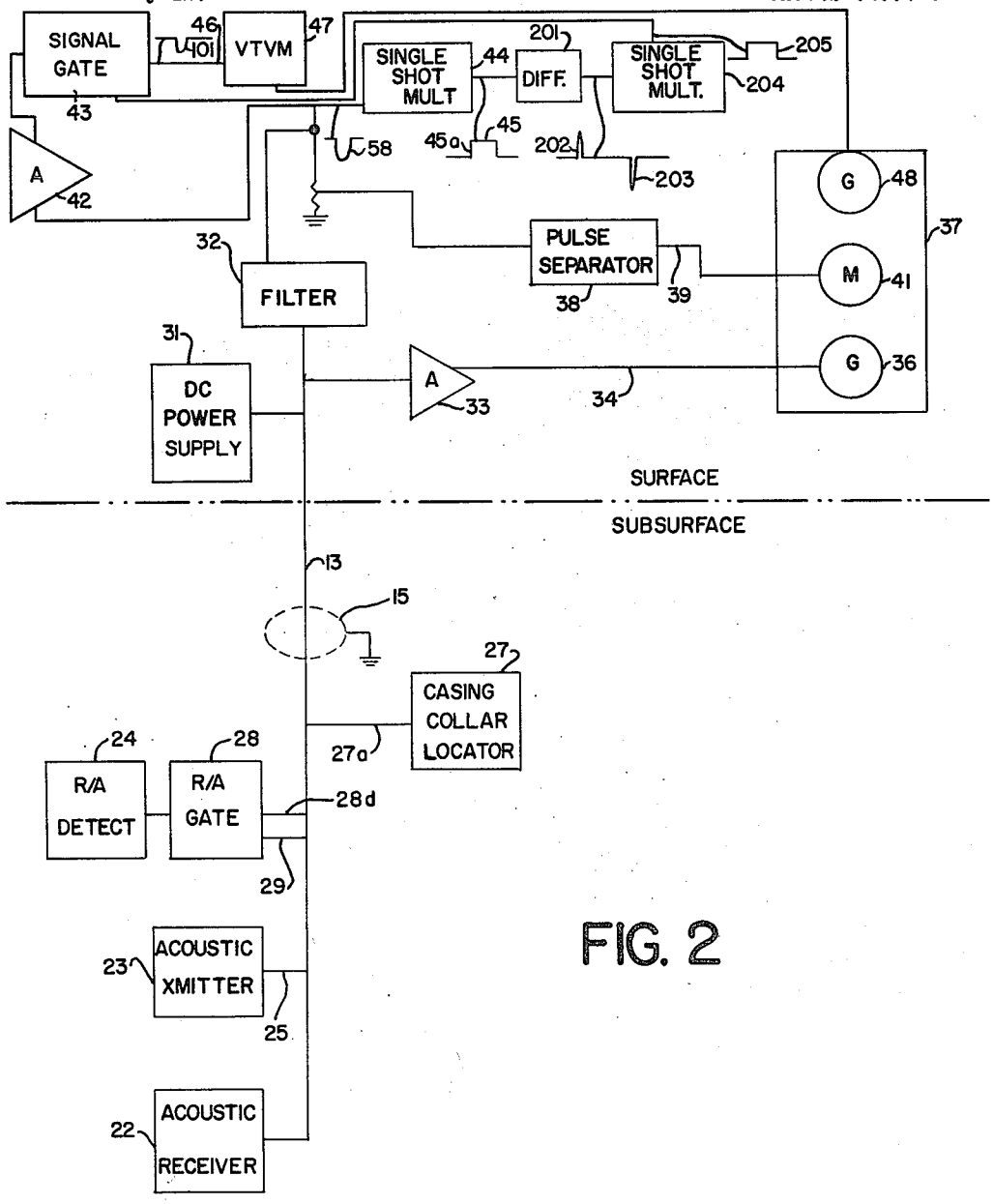


FIG. 2

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COMBINATION LOGGING SYSTEM

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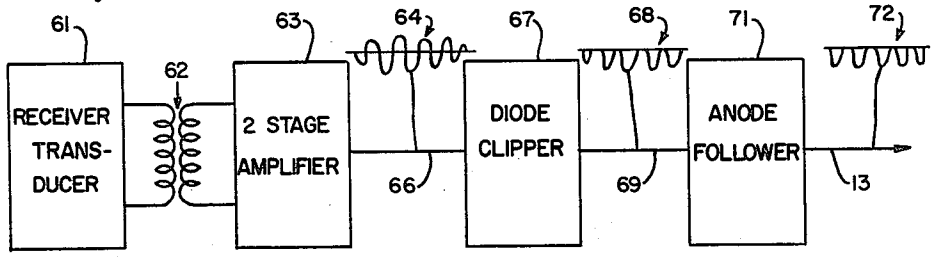


FIG. 4

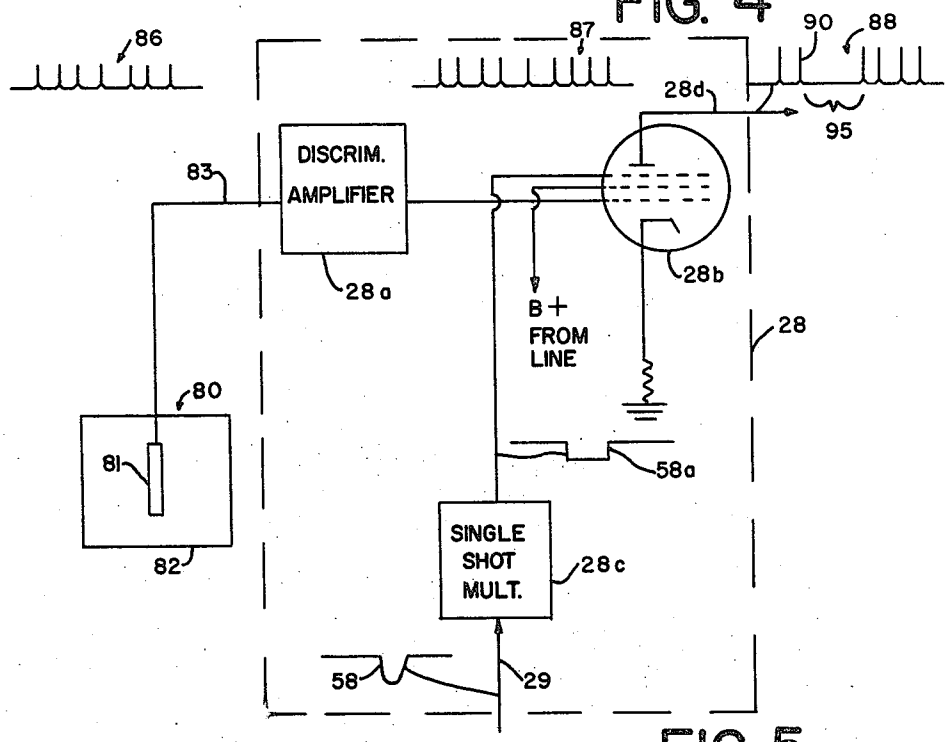


FIG. 5

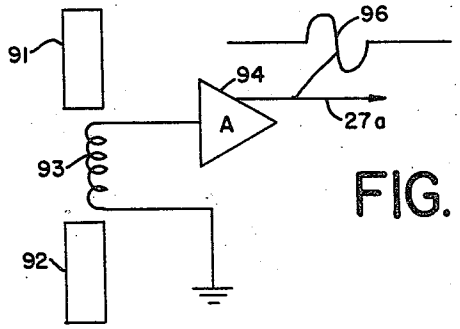


FIG. 6

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COMBINATION LOGGING SYSTEM

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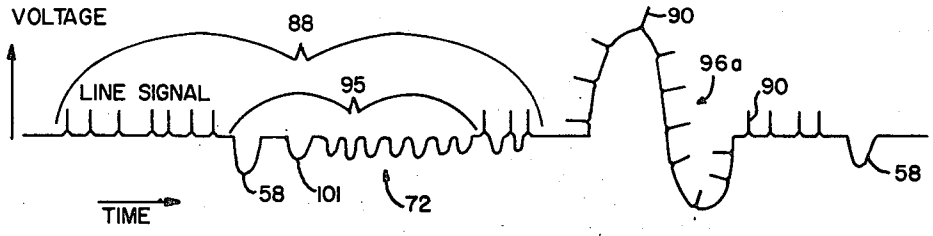


FIG. 7a

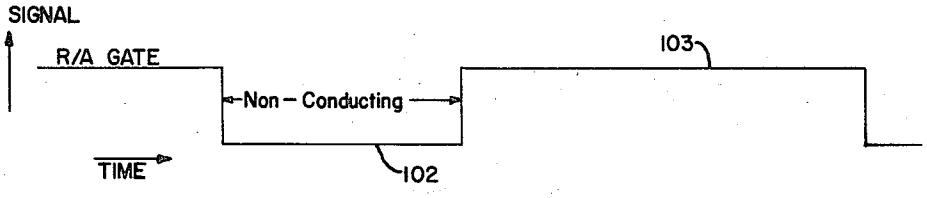


FIG. 7b

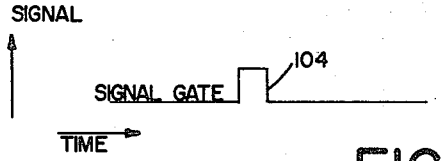


FIG. 7c

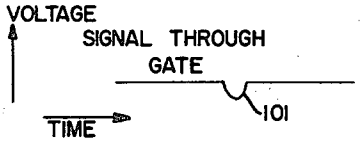


FIG. 7d

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3,186,223

COMBINATION LOGGING SYSTEM

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Filed May 12, 1961, Ser. No. 109,637
6 Claims. (Cl. 73—152)

This invention relates to well logging apparatus and more particularly to a well logging system adapted to be operated in cased boreholes in conjunction with well completion equipment.

The completion of oil and gas wells involves the positioning of steel casing within the well bore and the introduction of cement into the annular space between the bore and the outside of the casing to permit selective production from a particular level or levels. In order to produce the well, the operator perforates the casing and the cement annulus, usually by explosives, at levels believed to be adjacent oil or gas bearing formations. The location of the zones of probable productivity is frequently determined before the setting of the casing by the running of an electric log, but it is usually desirable to correlate the electric log with a radioactivity log subsequent to the setting of the casing and prior to perforation. It is also desirable to perforate in those portions of the productive zone wherein a good bond has been formed between the casing and the surrounding cement sheath. This is because imperfections, such as the presence of voids or channels, in the cement sheath permits fluids from adjacent zones to flow into the perforations and mix with the desired fluids or, in some cases, substantially inhibit their production. It is advantageous, therefore, to run a test of the effectiveness of the cement bond around the casing prior to perforation.

The running of radioactivity and cement bond logs prior to perforation of a well is fairly expensive because separate mobile units have heretofore been necessary for running the radioactivity and cement bond logs on one hand and the perforating equipment on the other. This is because perforating trucks are equipped with a sheathed cable containing only a single insulated conductor, such cable being used to support and actuate the perforating equipment whereas combination logging equipment normally requires the use of a multiconductor cable.

An object of this invention is to provide an apparatus for simultaneously running two different types of logs using a tool supported by a sheathed cable containing but a single insulated electrical conductor.

Another object of this invention is to provide a combination logging tool for simultaneously conducting a radioactivity well survey within a cased borehole and continuously indicating the effectiveness of cement bonding around the casing.

Another object is to provide a combination radioactivity and cement bond logging tool operated from a single conductor cable of the type used in connection with electrically actuated casing perforating equipment.

A further object is to provide an effective and economical apparatus for transmitting intelligence derived from a radioactivity well survey and a cement bond log simultaneously on a single insulated electrical conductor without substantial interference therebetween.

In general, the foregoing objects are attained by providing a logging system which includes a logging tool adapted to be moved through a borehole, a sheathed cable containing a single insulated conductor supporting said tool and electrically connecting it to surface equipment and an acoustic cement bond logging section within the tool. The acoustic logging section is provided

with means producing successive, time-spaced acoustic shock waves which pass along the casing and with an acoustic receiver including means for transmitting intelligence regarding the effectiveness of the cement bond, as indicated by the amplitude of one or more of the received acoustic shock waves, in the form of a series of voltage pulses of a given polarity. A radioactivity logging section is contained in the same tool and adapted to produce an output signal consisting of voltage pulses of the opposite polarity from the pulses of the cement bond signal. Means responsive to the operation of the shock wave producing means are provided in the tool for blanking out a portion of one of the signals during a selected interval so that the signal pulses of one polarity will not interfere with those of the opposite polarity and thus will avoid distortion of the information transmitted. Surface equipment, also responsive to the operation of the shock wave producing means, is provided for separating from the combined logging signals only a selected portion of the acoustic logging signal which is significant with respect to the particular factor under investigation, for example, the effectiveness of the cement bond around the casing.

In the system comprising this invention, the acoustic shock wave transmitter performs not only its conventional function of producing the acoustic shock waves but also produces an electric pulse, formed simultaneously with the acoustic shock wave, that prevents the transmission of potentially interfering radioactivity logging signals and further controls the reception by the surface equipment of electric signals produced by the acoustic logging section so that only the significant portion of the signal is received. The utilization of such trigger or control pulse in this way enables the combination of the acoustic and radioactivity logging sections to perform a function in addition to the sum of the functions of these logging sections operating individually, namely, that of automatic suspension of transmission of potentially interfering electrical signals from the radioactivity section with the result that both logging sections can be successfully operated in a tool supported by a sheathed cable containing a single insulated conductor.

In the accompanying drawings:

FIG. 1 is a diagrammatic view showing a logging tool embodying the system of the present invention positioned within a cased well bore;

FIG. 2 is a block diagram illustrating the connection of the various elements of the subsurface and surface portions of the system;

FIG. 3 is a schematic circuit diagram of the acoustic transmitter included in the combination logging tool;

FIG. 4 is a block diagram of the acoustic receiver portion of the combination logging tool;

FIG. 5 is a block diagram illustrating the arrangement of the elements of the receiver portion of the radioactivity well logging section of the tool;

FIG. 6 is a block diagram illustrating the arrangement of the various elements of the casing collar locator portion of the tool; and

FIGS. *7a–7d* illustrate graphically the electrical outputs of various portions of the system with respect to time to illustrate their relation with respect to one another.

FIG. 1 illustrates an elongated, generally cylindrical logging tool **10** supported within the well bore **11** by cable **12**. Cable **12** contains a single insulated electrical conductor **13** which provides electrical connection between the various parts of the tool **10** and the surface electronic equipment generally indicated at **14**. The cable sheath or armor, indicated schematically at **15**, serves as a return path for current in conductor **13**. As is con-

ventional in well logging, the tool 10 is moved through borehole 11 by movement of the cable 12 which passes over the measuring wheel 16.

Borehole 11 traverses an earth formation indicated at 17 and has set therein a section of steel casing 18. An annular cement sheath 19 grips the outside of the casing, such sheath having been formed by pumping liquid cement into the annular space between casing 18 and formation 17. Frequently, the cement will not fill the annular space perfectly and there will be formed various voids or channels such as those indicated at 21. It is possible to detect the presence of imperfections, such as the channels 21, by measuring the amplitude of a selected sound wave pulse or pulses transmitted through a section of the casing 18. The amplitude of vibration of casing 18 when subjected to an acoustic shock wave is a function of the tightness with which it is held in place by the cement sheath 19 which, in turn, is effected by the presence or absence of voids such as 21. In conducting cement bond logging, a series of acoustic shock waves are emitted from a logging tool, transmitted through a section of adjacent casing and the ampitude of a selected acoustic shock wave is measured as received at a longitudinally spaced portion of the tool after having been transmitted through the casing. This measurement is transmitted electrically to equipment at the top of the borehole and is continuously recorded and correlated with the position of the tool in the well to produce a cement bond log.

In accordance with the embodiment of the invention illustrated, the tool 10 includes an acoustic receiver section 22, an acoustic transmitter section 23, a radioactivity detector section 24, and a magnetic casing collar locator 27. In accordance with principles well known in the art, means (not shown) are provided for acoustically insulating acoustic transmitter 23 from acoustic receiver 22 so that acoustic shock waves will not be transmitted directly through the body of the tool from the former to the latter.

FIG. 2 illustrates in block diagram form the electrical connection of the various surface and subsurface sections of the system. The subsurface elements, all of which are included in the tool 10 shown in FIG. 1, are connected to the single insulated conductor 13 of cable 12. A gate 28 is connected between the radioactivity detector section 24 and conductor 13 and serves to prevent certain signals from detector 24 from being transmitted to the surface equipment. Cable conductor 13, conductor 25 and conductor 29 connect the electrical output of acoustic transmitter section 23 to the input of gate 28.

The surface equipment of the system includes a conventional direct current power supply 31 which supplies direct current voltage to the various sections of the subsurface equipment through conductor 13. The remainder of the surface equipment separates and records the signals transmitted from the subsurface sections of the system. It includes a high pass filter 32 which blocks out the low frequency signals from the casing collar locator 27 so that they will pass only through the amplifier 33 and conductor 34 to galvanometer 36 of the recorder 37. Amplifier 33 includes a conventional filter network which then permits the low frequency signals from the casing collar locator 27 to pass to galvanometer 36. The mixture of high frequency radioactivity and cement bond log signals, which are of opposite polarity, are separated at the pulse separator 38 which permits the positive radioactivity pulses to pass through conductor 39 to the rate meter 41 of recorder 37. Pulse separator 38 may be any one of the several types of pulse separators known to those skilled in the art, such as the circuitry disclosed in U.S. Patent 2,942,112, issued June 21, 1960, to D. P. Hearn. Inasmuch as the rate meter 41 responds equally to pulses of either polarity, the pulse separator 38 functions to block the negative cement bond logging signal pulses from the rate meter 41. The negative cement bond log pulses are amplified by amplifier 42 and a selected portion of this signal is passed, by the action of acoustic signal gate 43, through conductor 46 to vacuum tube voltmeter 47 and thence to galvanometer 48 in recorder 37. Single shot multivibrators 44 and 204 in conjunction with differentiating means 201 control the action of gate 43 as will be described in detail subsequently. All of the measurements made in recorder 37 are continuously correlated with the depth of the tool 11 to produce a continuous log, as is well known in the art.

Turning next to a more detailed description of the various sections of the downhole equipment, FIG. 3 is a schematic circuit diagram of the acoustic transmitter section 23. This includes a magnetostrictive transducer represented by the coil 51 which is periodically actuated by a high voltage pulse resulting from the discharge of capacitor 52. Capacitor 52 is connected in series with inductor 53 and both are connected through cable conductor 13 to surface direct current power supply 31. The capacitance of capacitor 52 and the inductance of inductor 53 are chosen with relation to the resistance of the circuit path in which they appear to provide a transient oscillatory circuit when they are connected across the power supply 31. The silicon controlled rectifier 54, which serves as a switch and is periodically turned on by pulses received from the transistor oscillator circuit 56, permits the circuit branch including capacitor 52 and inductor 53 to be periodically connected and disconnected across direct current power supply 31. Each connection produces a transient voltage overshoot across capacitor 52, i.e., the appearance of a voltage higher than that of power supply 31. The timing of oscillator 56 is chosen so that the pulses it emits turns silicon controlled rectifier 54 to its conductive state at times coinciding with the presence of such overshoot so that an amplified voltage appears across capacitor 52 and discharges through coil 51 amplifying the power input to the transducer of which the coil is a part.

The discharge of the capacitor 52 produces a negative voltage pulse 58 in conductor 25 through capacitor 57. The occurrence of trigger pulse 58 is thus substantially simultaneous with the production of each acoustic shock wave. This trigger pulse is transmitted through conductor 25, cable conductor 13 and conductor 29 to the radioactivity gate 28 and the surface equipment as will be explained subsequently. According to a preferred embodiment of the invention, acoustic shock waves and trigger pulses are transmitted at the rate of 50 per second.

The acoustic shock wave output of acoustic transmitter section 23 is transmitted through the body of tool 10 (FIG. 1), through the fluid (not shown) contained in borehole 11 and to the casing 18, the cement sheath 19 and the formation 17. These various media conduct it to the receiver section 22 where it is picked up in the form of a complex acoustic shock wave train. As illustrated in FIG. 4, the acoustic receiver section 22 is made up of a receiver transducer 61 which converts the acoustic energy received into an alternating current voltage signal transmitted through transformer 62 to the two-stage amplifier 63. Here it is amplified to an alternating current voltage wave train, indicated at 64, transmitted through conductor 66 to the diode clipper 67 which rectifies the signal and converts it to the form of a train of negative direct current voltage pulses as indicated at 68. These pass through the conductor 69 to the anode follower 71 which provides impedance matching to the cable conductor 13 so that the output of the receiver section 22 as impressed on the conductor 13 has the form of pulse train 72.

FIG. 5 illustrates in block diagram form the radioactivity detector section 24 of the tool shown in FIG. 1. In the specific embodiment of the invention described, the detector section 24 contains a scintillation counter 80 made up of a scintillation crystal 81 and a container 82.

The natural gamma radiation emitted from the adjacent earth formation and impinging on the crystal 81 (which is typically sodium iodide) produces a wave train of irregularly spaced positive voltage pulses 86 transmitted through conductor 83 to the electronic equipment designated collectively as "gate" 28. This assembly performs the function of a gate in that it blocks the passage of voltage pulses 86 during a selected interval. The assembly includes the discriminator—amplifier combination 28*a*, the pentode vacuum tube 28*b* and control means for the gate assembly in the form of the single shot multivibrator 28*c*. The discriminator—amplifier 28*a* is conventional in radioactivity logging and serves to amplify only those pulses transmitted through conductor 83 which are above a predetermined energy level. The output of discriminator—amplifier 28*a* in the form of amplified pulses 87 is fed to the grid of pentode vacuum tube 28*b*. The suppressor grid of this tube is connected to the output of a single shot multivibrator 28*c* which is connected in turn through conductor 25, cable conductor 13 and conductor 29 to the electrical output of acoustic transmitter 23. Multivibrator 28*c* is thus actuated by negative voltage pulses 58 generated in connection with the production of the acoustic shock wave and shapes each trigger pulse, which is about 20 microseconds in duration, to a wider negative voltage pulse 58*a* of about 500 microseconds in width which is applied through conductor 30 to the supressor grid of vacuum tube 28*b*. Application of pulses 58*a* serves to bias the tube to a non-conductive state for a period corresponding to the width of the biasing pulse, i.e., 500 microseconds. The output of the vacuum tube 28*b* on conductor 28*d* thus consists of a train of irregularly spaced positive voltage pulses 90 with periodically blanked out spaces 95 between groups of pulses as indicated by the waveform 88. Such output is fed over conductor 28*d* into cable conductor 13 and is transmitted to the surface along with the electrical outputs of acoustic receiver 22 and acoustic transmitter 23. Although the entire assembly 28 may be referred to for convenience as a "gate" the tube 28*b* may be considered as the gating means with the multivibrator 28*c* as the control means.

The tool 10 illustrated in FIG. 1 also includes a conventional casing collar locator 27 illustrated schematically in FIG. 6. The locator illustrated includes a pair of longitudinally spaced-apart magnets 91 and 92 on either side of a coil 93 having one side connected to a ground and the other to the input of an amplifier 94. As is well known, this type of casing collar locator operates by disturbance of the magnetic field associated with magnets 91 and 92. Each time the tool 10 is moved past a discontinuity in the casing string, such as that formed by a collar joint, disturbance of the field causes flux lines to cut coil 93. The voltage signal thus created is amplified through the amplifier 94 as a low frequency (about 2 cycle) voltage pulse 96 appearing on output conductor 27*a*. This is impressed on conductor 13 and transmitted to the surface with the electrical outputs of acoustic receiver 22, acoustic transmitter 23 and radioactivity gate 28.

FIG. 7*a* illustrates the waveform of the signal on conductor 13 as received by the surface equipment. The portion shown includes a negative trigger pulse 58, a negative voltage pulse wave train 72 representing the electrical output of acoustic receiver 22 and including initial signal wave pulse 101, and a positive voltage pulse wave train 88 made up of individual pulses 90 the output of radioactivity detector section 24 as controlled by gate 28. The low frequency collar signal 96 is of much greater amplitude than any of the pulses 90, 58, 101, etc. It appears on conductor 13 in the form shown at 96*a*, that is, with the smaller amplitude pulses superimposed upon it. Because the time separating individual pulses 90 is in the order of a few microseconds while the collar signal 96 is about one-half second in duration, FIG. 7*a* is distorted as to its time scale. The trigger pulse 58 which occurs substantially simultaneously with the production of an acoustic shockwave at transmitter section 23 (FIG. 2), is fed into the radioactivity gate 28 and, as previously explained, prevents positive signal pulses 90 from being impressed upon the line signal where, because of their positive polarity, they might interfere with and cancel out negative signals of the wave train 72 transmitted by the acoustic receiver section 22. It has been found that of these pulses, the amplitude of initial pulse 101 is most representative of the acoustic energy transferred directly through the casing and, therefore, gives an indication of the tightness of the bonding of the cement sheath. Later pulses in wave train 72 which are representative of acoustic waves transmitted through the mud column, the formation, etc., are of less significance with respect to the cement bond. It is particularly important that this initial negative pulse not be interferred with by the coincidence of a radioactivity pulse of the opposite polarity which might occur at precisely the same time. For this reason, the duration or width of the output pulse 58*a* from multivibrator 28*c* is selected to correspond to the period 102 indicated in FIG. 7*b*, that is, until the acoustic shockwave, which is transmitted at the time signal pulse 58 occurs, has been received at the receiver section 22 in the form of the initial portion of wave train 72. This period 102 represents the non-conducting period of gate 28 and thus corresponds exactly in time with the duration of blanked out space 95 of FIG. 5. Because only the initial pulse 101 of wave train 72 is significant, it is not necessary to blank out the radioactivity signal to coincide with the receipt of the entire wave train, but, as shown, the gate 28 is returned to conductive condition (by termination of pulse 58*a*) during the period 103 coinciding with receipt of the latter part of the wave train 72 but after receipt of the initial negative pulse 101.

It must be understood that FIG. 7*a* is greatly distorted with respect to its time scale in order that all the information presented may appear in the space available. The time during which gate 28 is non-conductive is only about 3% of the total time the system is in operation so that only about 3% of the radioactivity pulses 90 are blanked out and not received by the surface recording equipment. Similarly, the size and shape of the casing collar signal 96*a* has been distorted for convenience of presentation. This signal may occur any time with respect to the conductivity of the gate 28 or the reception of acoustic signals of wave train 72. During the course of the survey made with the system of the invention only about 50 casing collars will be encountered in the casing string and a corresponding number of signals in the form of 96*a* will appear upon the line 13. Hundreds of thousands of wave trains 72 and pulses 90 will be transmitted during a typical survey.

After the casing collar signals 96 have been effectively removed from the line signal by the filter 32 (FIG. 2), the resulting combined signal is separated according to pulse polarity with the positive pulses indicative of the radioactivity signal being transmitted by a pulse separator 38, while the negative pulses 58 and 72 indicative of the trigger pulse and the various components of the received acoustic signals, respectively, are rejected and provide the input to the amplifier 42. The positive radioactivity pulses 90 are counted by ratemeter 41 to provide a continuous indication of natural radioactivity correlated with depth of tool 10 within the borehole in conventional fashion well known to those skilled in the art.

In addition to controlling the radioactivity gate, the signal pulse 58 controls the operation of the signal gate 43 both as to its time and duration of opening. The pulse 58 is initially received at the pulse forming control means 44, which is a negatively triggered single shot multivibrator producing a square wave output pulse 45 of predetermined width. Pulse 45 passes through dif-

ferentiating means 201 which converts it to a pair of voltage pulses 202 and 203 which are of opposite polarity and which coincide with the leading and trailing edges respectively of the square wave pulse 45. It should be noted that pulse 45 and the other wave forms of FIG. 2 are shown as they would appear on an oscilloscope so that the leading edge of pulse 45 is at 45*a*. The pulse forming control means 204 is a single shot multivibrator triggered by the trailing negative pulse 203 so that its actuation follows the actuation of multivibrator 44 by a period corresponding to the width of the square wave pulse 45. This delay is selected to correspond to the arrival time of the acoustic shockwave transmitted from the acoustic transmitter directly through the casing 18 to the acoustic receiver, i.e., the transmitted wave corresponding to initial pulse 101. The delay interval is necessary because the transmission of the acoustic shock wave along the steel casing 18 from the transmitter 22 to the receiver 23 requires a finite and known time period. But for the delay interval thus provided for, acoustic waves traveling by way of another path might reach the receiver 23 first, and this would confuse the measurement.

Actuation of the multivibrator 204 produces an output pulse 205 which is transmitted to conventional semiconductor diode signal gate 43 and turns it on for a period corresponding to the width of the triggering pulse. This period determines the number of pulses in the wave train 72 that will be transmitted to vacuum tube voltmeter 47 which provides an output indicative of the amplitudes of the received pulses. This output is continuously recorded on galvanometer 48 and correlated with the depth of the tool. Where it is desired to measure only the amplitude of the initial pulse 101, the width of pulse 205 is typically about 50 microseconds. Of course, the conductivity period of signal gate 43 may be adjusted to pass additional pulses of the wave train 72 if so desired by increasing the width of pulse 205.

FIGS. 7*a* through 7*d* illustrate the time sequence of operation of the radioactivity gate 28 and of the acoustic gate 43 with respect to the various types of pulses on the conductor or line signal. Thus, FIGS. 7*a* and 7*b* show that the beginning of nonconducting period 102 of radioactivity gate 28 corresponds in time with the occurrence of trigger pulse 58 and that the blanked out space 95 in radioactivity pulse wave train 88 corresponds with the duration of such non-conducting period. With the beginning of conducting period 103, positive radioactivity pulses 90 again appears on the line signal. Signal gate 43, as shown in FIG. 7*c*, becomes conductive during a relatively short period 104 (about 50 microseconds) within the longer non-conducting period 103 (about 500 microseconds) of the radioactivity gate and subsequent to the occurrence of trigger pulse 58. The interval between the beginning of conducting period 104 of the signal gate 43 and the occurrence of trigger pulse 58 corresponds to the width of the output pulse 45 from single shot multivibrator 44. This pulse width corresponds to the time required for an acoustic shockwave to be transmitted directly through the casing between transmitter and receiver and is thus a function of the spacing between transmitter and receiver. The occurrence of the conducting period 104 of signal gate 43 corresponds in time to the occurrence of initial pulse 101 and is wide enough to bracket this pulse so that it appears as the output of gate 43 as shown in FIG. 7*d*. It will be seen that the duration of blanked out period 95 is chosen to include that period in which the initial portion of an acoustic signal including 101 will occur.

From the foregoing description it is apparent that independent operation of the acoustic and radioactivity logging sections in a tool using a cable containing a single insulated conductor would produce a composite signal in which much significant information would have been cancelled out by coincidence of pulses of opposite polarity. This invention, by its employment of a trigger or control signal produced by the acoustic transmitter to control transmission of radioactivity signals, permits efficient use of both systems with such a cable and thus facilitates the integration of the combination logging service with perforating and other completion services. In addition, the control system used in selecting the portion of the acoustic signal to be measured improves the flexibility and increases the utility of the acoustic logging system.

Although the present invention has been described in terms of a specific embodiment thereof including particular radioactivity detectors as well as conventional casing collar locators and gating means, it will be understood that equivalent electronic circuitry to perform the same functions may be substituted therefor without departing from the spirit of the invention as defined in the following claims:

I claim:

1. A logging system for use in a borehole comprising;
a logging tool adapted to be moved through said borehole;
a sheathed cable attached to and supporting said tool;
a single insulated electrical conductor in said cable;
surface equipment, including signal receiving means and a direct current power supply, electrically connected to said conductor;
an electrically actuated acoustic shock wave transmitter in said tool electrically connected to said conductor for producing periodic acoustic shock waves for transmission axially of said borehole;
an acoustic shock wave receiver in said tool spaced from said transmitter, including means for converting received acoustic energy into an electrical signal made up of a series of pulses of selected polarity;
means electrically connecting said receiver to said conductor;
radioactivity detector means in said tool for receiving gamma radiation emitted from earth formations traversed by said borehole, said radioactivity detector means effective to convert such received radiation into an electrical signal made up of a series of pulses of polarity opposite that of the acoustic electrical signal;
first gating means effective to prevent transmission of the aforesaid radioactivity signals to said conductor during transmission of at least a portion of the aforesaid acoustic electrical signal;
means electrically connecting said radioactivity detector means through said first gating means to said conductor;
first control means electrically connected to and actuated by said shock wave transmitter to actuate said first gating means;
second gating means effective to permit reception of only a selected portion of the aforesaid acoustic electrical signal by said surface equipment; and
second control means actuated by said shock wave transmitter to actuate said second gating means.

2. A logging system for use in a cased borehole in which the casing is at least partially surrounded by a cement sheath comprising:
a logging tool adapted to be moved through said borehole;
a sheathed cable supporting said tool;
a single insulated electrical conductor in said cable;
surface equipment, including signal receiving means and a direct current power supply, electrically connected to said conductor;
an electrically actuated acoustic shock wave transmitter in said tool electrically connected to said conductor for producing periodic acoustic shock waves for transmission axially of said borehole;
an acoustic shock wave receiver in said tool spaced from said transmitter, including means for converting re-

ceived acoustic energy into an electrical signal made up of a series of pulses of varying amplitude and selected polarity with the amplitude of selected pulses of said series indicative of the tightness of bonding of said cement sheath to said casing;

means electrically connecting said receiver to said conductor;

radioactivity detector means in said tool for receiving gamma radiation emitted from earth formations traversed by said borehole, said radioactivity detector means including means effective to convert such received radiation into an electrical signal made up of a series of pulses of polarity opposite that of the acoustic signal;

first gating means effective to prevent transmission of the aforesaid radioactivity signals to said conductor during transmission of at least a portion of the aforesaid acoustic electrical signal;

means electrically connecting said radioactivity detector means through said first gating means to said conductor;

first control means electrically connected to and actuated by said shock wave transmitter to actuate said first gating means;

second gating means effective to permit reception of only said selected pulses of the aforesaid acoustic electrical signal by said surface equipment; and

second control means actuated by said shock wave transmitter to actuate said second gating means.

3. A logging system for use in a cased borehole in which the casing is at least partially surrounded by a cement sheath comprising:

a logging tool adapted to be moved through said borehole;

a sheathed cable supporting said tool;

a single insulated electrical conductor in said cable;

surface equipment, including signal receiving means and a direct current power supply, electrically connected to said conductor;

an electrically actuated acoustic shock wave transmitter in said tool electrically connected to said conductor for producing periodic acoustic shock waves for transmission axially of said borehole;

an acoustic shock wave receiver in said tool spaced from said transmitter, including means for converting received acoustic energy into an electrical signal made up of a series of pulses of varying amplitude and selected polarity with the amplitude of the initial pulse of said series indicative of the tightness of bonding of said cement sheath to said casing;

means electrically connecting said receiver to said conductor;

radioactivity detector means in said tool for receiving gamma radiation emitted from earth formations traversed by said borehole, said radioactivity detector means including means effective to convert such received radiation into an electrical signal made up of a series of pulses of polarity opposite that of the acoustic electrical signal;

first gating means effective to prevent transmission of the aforesaid radioactivity signals to said conductor during transmission of at least a portion of the aforesaid acoustic electrical signal;

means electrically connecting said radioactivity detector means through said first gating means to said conductor;

first control means electrically connected to and actuated by said shock wave transmitter to actuate said first gating means;

second gating means effective to permit reception of only said initial pulse of the aforesaid acoustic electrical signal by said signal receiving means; and

second control means actuated by said shock wave transmitter to actuate said second gating means.

4. In a logging system for making subsurface measurements of a plurality of subsurface conditions, the improvement comprising:

a logging tool adapted to be moved through a borehole;

a sheathed supporting cable connected to said tool, said cable containing a single insulated conductor;

first logging means positioned in said tool for obtaining and transmitting through said conductor a first logging signal as a pulsating direct current signal made up of a series of pulses of one polarity with the amplitude of said pulses providing significant information;

second logging means positioned in said tool for obtaining and transmitting through said conductor a second logging signal as a series of pulsating direct current signals made up of a series of pulses of the opposite polarity, with the frequency of occurrence of the pulses of said second signal being substantially greater than the frequency of pulses of said first signal and with such frequency of occurrence of pulses of said second signal providing significant information;

first receiving means for making a measure of the pulse amplitude of said first signal;

second receiving means for making a measure of the pulse rate of said second signal;

first gating means connected between said conductor and second logging means for interrupting said second logging signal;

means responsive to said first logging means for actuating said first gating means during transmission of said first logging signal on said conductor.

5. The system according to claim 4 further comprising:

second gating means actuated by said first logging means electrically connected to said first receiving means effective to permit reception of a predetermined portion only of said first logging signal.

6. The system according to claim 5 wherein:

said first logging means is an acoustic logging means; and

said second logging means is a radioactivity logging means.

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