

Oct. 27, 1959

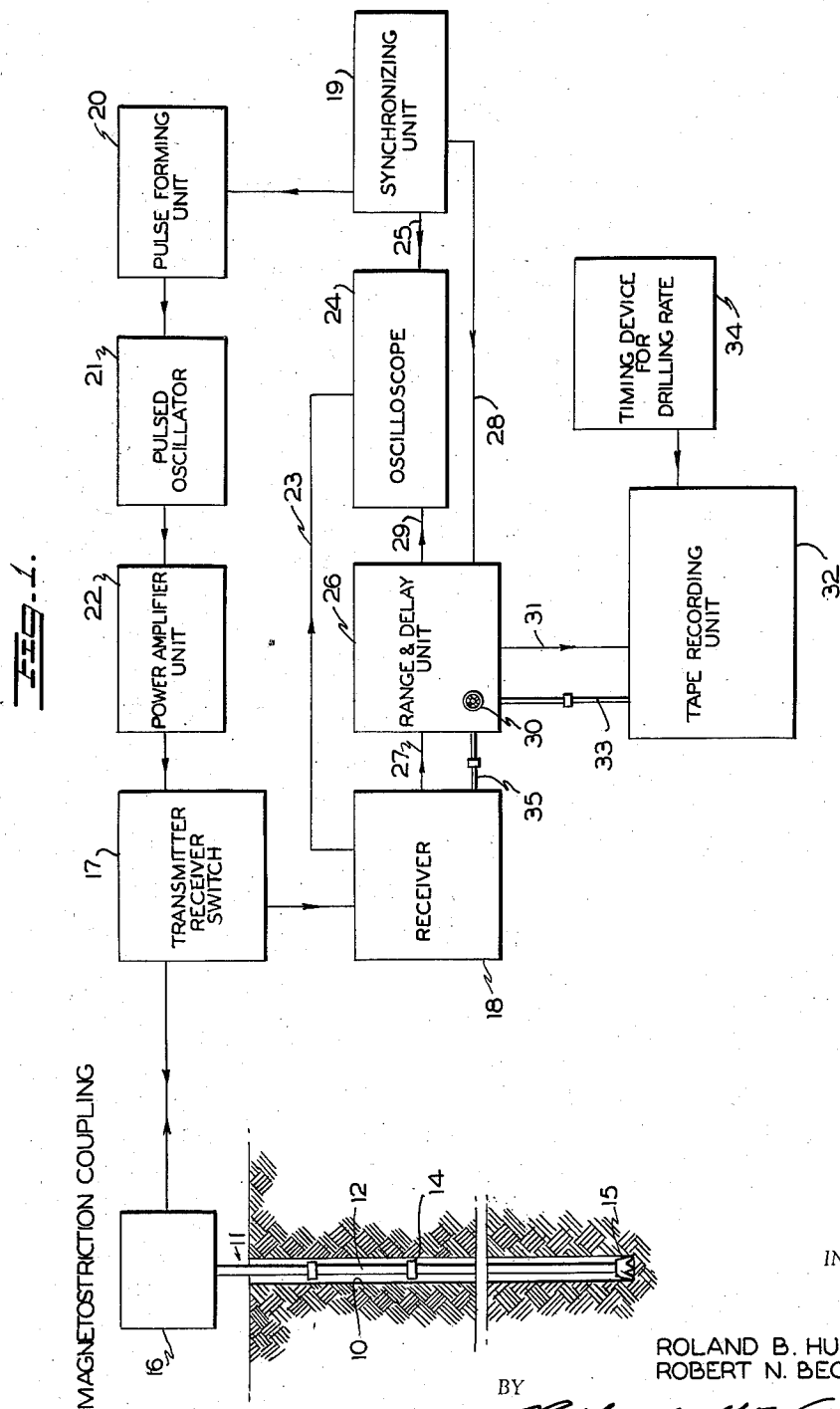
R. B. HUDSON ET AL

2,910,133

METHOD OF CONTINUOUS WELL LOGGING DURING DRILLING

Filed Dec. 11, 1952

2 Sheets-Sheet 1



INVENTOR

ROLAND B. HUDSON
ROBERT N. BECK

BY

Richard H. Wynne
ATTORNEY

Oct. 27, 1959

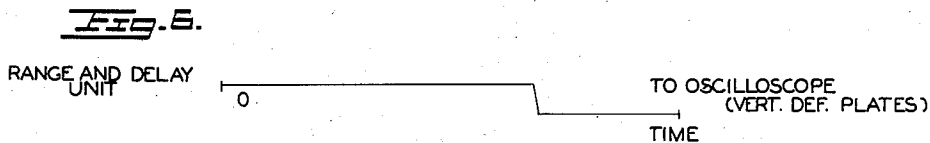
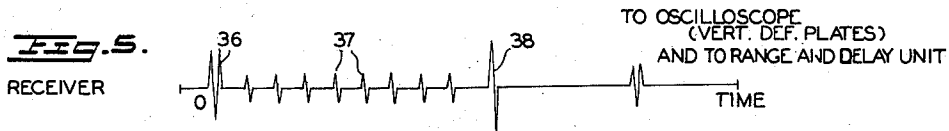
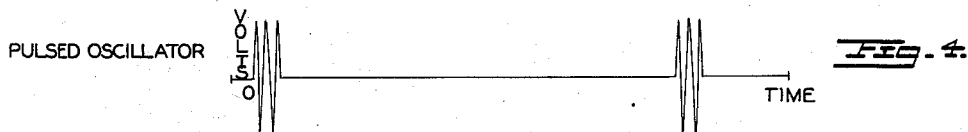
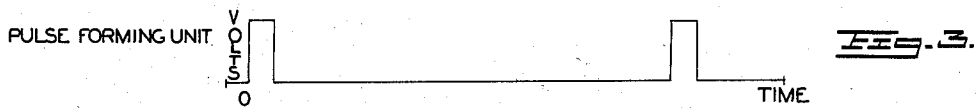
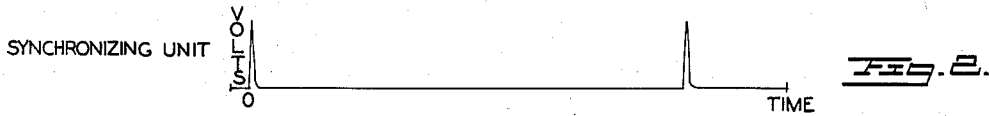
R. B. HUDSON ET AL

2,910,133

METHOD OF CONTINUOUS WELL LOGGING DURING DRILLING

Filed Dec. 11, 1952

2 Sheets-Sheet 2



INVENTOR

ROLAND B. HUDSON
ROBERT N. BECK

BY

Richard S. Wynne
ATTORNEY

1

2,910,133

METHOD OF CONTINUOUS WELL LOGGING DURING DRILLING

Roland B. Hudson and Robert N. Beck, San Angelo, Tex.

Application December 11, 1952, Serial No. 325,476

1 Claim. (Cl. 181—.5)

This invention relates to the continuous logging of oil wells concurrently with the drilling operation.

Our invention further relates to an apparatus and method for the generation of an electrical pulse, the transformation of this pulse into a sonic or ultrasonic pulse of mechanical energy, the application of this mechanical energy pulse to the upper end of a metallic member extending into the well to cause the conduction of the mechanical energy pulse by the metallic member into the well. Upon reaching a formation with which the metallic member is in direct contact, a significant echo is produced which is conducted back up the metallic member to the upper portion thereof where it is transformed into a second electrical pulse which is then received and recorded as intelligible data indicative of the earth formation at the portion of the metallic member producing the significant echo.

In the oil well drilling art there have been a number of developments which have assisted in the logging of the formations drilled through by the bit. The well-known devices which must be lowered into the well have very serious disadvantages due to the costly withdrawal of the drill string and the drilling shut-down loss. A further disadvantage of this technique is that the geologist depends upon the cuttings circulated to the surface to give information of the formations being drilled through in order that he may have a sound basis for determining the need for a logging of the well. This is no easy task and is very nearly impossible when the oil bearing formation is of small thickness due to the fact that the cuttings lose their identity upon circulation to the surface. This sometimes results in the failure of the geologist to locate the oil bearing formation. At great depths circulation of the cuttings also involves a costly shut-down period. Of interest also in this regard is that present equipment and techniques make somewhat impractical the drilling of wells of the order of 15,000 to 20,000 feet and deeper. The above-discussed well logging technique is ineffectual at such extreme depths because the lower portion of the well tends to fill in before the logging equipment can be lowered. It will be appreciated that the time consumed in logging at these depths by the above technique is great and therefore causes severe shut-down losses.

Attempts to overcome this situation have resulted in the placement of logging devices in the drill string near the drilling bit. When one considers the extreme forces encountered at the bit and also the delicate nature of the instruments involved, it will be appreciated that the cost of such devices and the maintenance thereof would make them highly impractical.

Our invention in its preferred form overcomes these problems and provides a method and apparatus for logging a well concurrently with the drilling operation capable of supplying data indicative of the formation being drilled. The mechanical vibrations applied to the upper end of the drill string produce a series of echoes from every drill stem joint or obstruction of any type constituting a non-linear impedance, the echo received from

2

the point at which the drill bit is in contact with the earth being drilled providing a most significant echo. The condition of this point can be stated as follows. The drill string and bit represent a homogeneous conducting medium for the transmitted signal, the velocity of transmission in this medium being constant. The velocity of transmission of sound in the various media encountered in the process of drilling the well will be variable. Hence the boundary between the bit and the formation on which it rests will represent a discontinuous conducting path or a non-linear impedance, giving rise to a reflection of part of the energy of the transmitted pulse, the amplitude of this echo being dependent upon the nature of the discontinuity, that is, on the velocity of the sound in the two media. The variable media are therefore identified by measuring the amplitudes of the reflected echoes and comparing the amplitudes with previously obtained information.

Other advantages and objects of our invention will be apparent from a study of the following specification and the accompanying drawings wherein:

Fig. 1 is a diagrammatic view illustrating a typical well cross-section and the equipment required for the continuous logging of the well;

Fig. 2 is a wave form graph of the pulse produced by the synchronizing unit;

Fig. 3 is a wave form graph of the pulse produced by the pulse forming unit;

Fig. 4 is a wave form graph of the pulse produced by the pulsed oscillator;

Fig. 5 is a wave form graph of the pulse sent by the receiver to the oscilloscope and the range and delay unit;

Fig. 6 is a wave form graph of a pulse produced by the range and delay unit and sent to the oscilloscope; and

Fig. 7 is a wave form graph of the pulse sent by the range and delay unit to the recording unit.

Referring now to Fig. 1, it will be seen that the well contains a drill string 11 which includes the pipe lengths 12, collars 14, and an earth formation contacting member such as bit 15 which is shown in direct cutting engagement with the formation at the bottom of the well. The usual derrick, mud circulation system, etc. are not shown. It will be understood that the well is filled with the usual drilling mud. At the upper end of the drill string 11 is mounted a magnetostriction coupling device 16 which serves to couple the electrical pulse received from the electrical transmitter system to the drill string 11 and to pick up echoes of the transmitted pulse for reception and recordation. The magnetostriction coupling means 16, which may be of known construction, transforms a selected electrical pulse of a frequency within the sonic and ultra-sonic range received from the transmitter system into mechanical vibrations at the upper end of the drill string 11. These mechanical vibrations are then conducted in the drill string 11 to the bottom of the well where a significant echo is produced by the formation existing immediately under the bit 15. This echo is then conducted to the upper end of the drill string 11 where it is transformed into a second electrical pulse by the magnetostriction coupling means 16.

The transmitter-receiver switch means 17 may be of suitable well-known design for connecting the transmitter system to the magnetostriction coupling means 16 during transmission while disconnecting the input to the receiver means 18 during the transmission period, and for connecting the receiver means 18 to the magnetostriction coupling means 16 during the period between receipt of pulses from the transmitter system.

The transmitter system may be composed of units of well-known design combined to produce a first electrical pulse having a selected frequency falling within the sonic and ultra-sonic range. A synchronizing unit 19 puts out

a wave form as represented in Fig. 2 having a sharp pip of suitable voltage for firing a pulse forming unit 20, the repetition rate of the synchronizing unit 19 being in accordance with the time required for reception of echoes of a transmitted pulse from the drill bit at the maximum intended drilling depth.

The pulse forming unit 20 is of the one shot multi-vibrator type. The output of the pulse forming unit 20 is shown in Fig. 3 as being a square wave output of short duration which is used to fire the pulsed oscillator 21. The output from the pulsed oscillator 21, shown in Fig. 4, is amplified by the power amplifier unit 22 which is connected through the transmitter receiver switch 17, previously described, to the magnetostriction coupling means 16 which transforms the electrical pulse into mechanical vibrations in the drill string 11.

The echoes conducted up the drill string 11 are transformed to a second electrical pulse by the magnetostriction coupling device 16 and connected by the transmitter-receiver switch 17 to the receiver 18 where it is amplified sufficiently for transmission through line 23 to the vertical deflection plates of an oscilloscope 24. As noted in Fig. 5, the wave form of the pulse received from the receiver 18 enables the monitoring of the entire length of the drill string 11. The sweep of the oscilloscope 24 is synchronized by the synchronizing unit 19 through line 25 such that the sweep starts at the time each pulse is transmitted.

Another output of the receiver unit 18 having the wave form shown in Fig. 5 is transmitted to the range and delay unit 26 through line 27. This unit 26 is synchronized by the synchronizing unit 19 through line 28. A range step output as shown in Fig. 6 is fed by the range and delay unit 26 through line 29 to the vertical deflection plates of the oscilloscope for selecting the echo to be recorded. This selection is manually made by means of hand wheel 30 which drives a potentiometer (the variable voltage of the potentiometer corresponding to the variable range of the system) in the range and delay unit 26 which moves the step to the proper position on the wave form on the oscilloscope 24.

Although all echoes received by the receiver 28 are fed into the range and delay unit 26, this unit 26 is designed to recover echoes at the selected range only, this being a function of the time elapsed after time zero. In other words, the output of the range and delay unit 26 may be adjusted to any selected echo received between pulses. Fig. 7 shows the wave form of the selected pulse which is transmitted through line 31 to the recording unit 32 where the amplitude is then recorded on tape in the usual manner. The recording unit 32 records the magnitude of an electrical signal by means of an inking stylus which leaves a trace on a moving paper tape.

The hand wheel 30 is geared through coupling 33 to the tape moving mechanism of the recording unit 32 such that an increase of the voltage selected at a potentiometer in the range and delay unit 26, corresponding to an increase in range or depth, is accompanied by a corresponding advance of the recorder tape. The recording unit 32 is equipped with a timing device 34 which is suitably designed to place a trace or spot on the moving tape at regular time intervals. From the spacing of these traces or spots an estimate of the drilling rate at every depth can be made. The recording unit 32 therefore accomplishes the two-fold function of permanently recording the amplitude of the selected echo which can be interpreted in the light of known information to indicate the

formations in the well and permanently recording the drilling rate.

The echoes received will be effected by the progressively increasing attenuation of the mechanical vibrations in the drill string 11 as the length thereof is increased. Suitable well-known compensating techniques and devices may be utilized to provide for the uniform recordation of the information received. Such a device may involve a mechanical gearing and coupling 35 between the hand wheel 30 and the gain control of the receiver 18 which will increase the gain of the receiver at a predetermined rate.

The oscilloscope shows a continuous wave form representative of the condition of the complete drill string 11. This wave form is similar to the wave form shown in Fig. 5 and includes the transmitted pulse 36, successive drill string collar echoes 37, and the significant bottom formation echo 38 from the drill bit level. If circulation of drilling fluid is lost, such as when the drilling fluid flows into low pressure formations causing a lowering of elevation of the drilling fluid in the bore hole, our invention will indicate the true level of the drilling fluid. This is of great advantage in this situation as well as in other situations where a level of liquid need be determined.

If the drill string 11 should break, the oscilloscope 24 would give an indication of the depth of the break and on adjustment the recording unit 32 will also indicate the break location.

It will be understood that the usual power supply unit for supplying the necessary A.C. and D.C. voltages and a power control unit for turning the equipment "On" and "Off" and for protecting the equipment from overload and personnel from shock will be used.

While we have illustrated and described the preferred embodiment of our invention, we do not desire to be limited to any of the details and uses illustrated and described herein except as defined in the appended claim.

We claim:

A method for continuously logging a well concurrently with drilling the well to depths of the order of 15,000 to 20,000 feet and more, said well containing a drill string having a bit for contacting the earth formation, including the steps of generating a first electrical pulse having a selected frequency falling within the sonic and ultra-sonic range, transforming said first electrical pulse at the upper end of said drill string into mechanical vibrations in said drill string which travel down said drill string to said bit and are reflected by the earth formation in contact with said bit up said drill string, transforming the reflected vibrations into a second electrical pulse, recording said second electrical pulse as intelligible data in a continuous manner, said intelligible data being indicative of the earth formation at the bit, and coordinating the resultant data with previously obtained data to determine the nature and characteristics of the earth formation being contacted by the bit.

References Cited in the file of this patent

UNITED STATES PATENTS

1,654,819	Kinley	Jan. 3, 1928
2,277,110	Johnson	Mar. 24, 1942
2,280,226	Firestone	Apr. 21, 1942
2,452,515	Athy	Oct. 26, 1948
2,461,543	Gunn	Feb. 15, 1949
2,601,779	Firestone	July 1, 1952
2,656,714	Cartier	Oct. 27, 1953
2,694,461	Martin	Nov. 16, 1954
2,713,263	Turner	July 19, 1955