

United States Patent
Warren

[15] 3,701,388
[45] Oct. 31, 1972

[54] DRILLING METHOD

[72] Inventor: Jasper N. Warren, 6102 Yarwell,
Houston, Tex. 77035
[22] Filed: Feb. 11, 1970
[21] Appl. No.: 10,376

[52] U.S. Cl. 175/50, 73/154, 175/48
[51] Int. Cl. E21b 47/06
[58] Field of Search.....175/40, 48, 50, 30, 25;
73/154

[56] References Cited

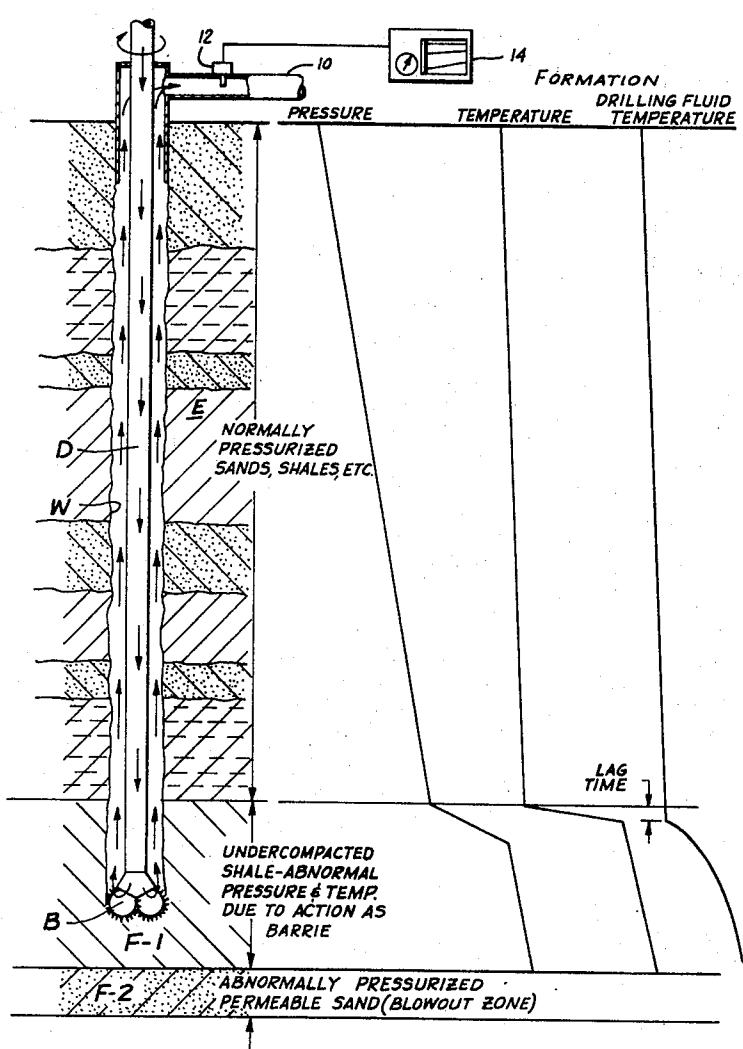
UNITED STATES PATENTS			
3,327,527	6/1967	Arps.....	73/154
3,260,112	7/1966	Godbey et al.....	175/50 X
3,455,158	7/1969	Richter et al.....	73/154

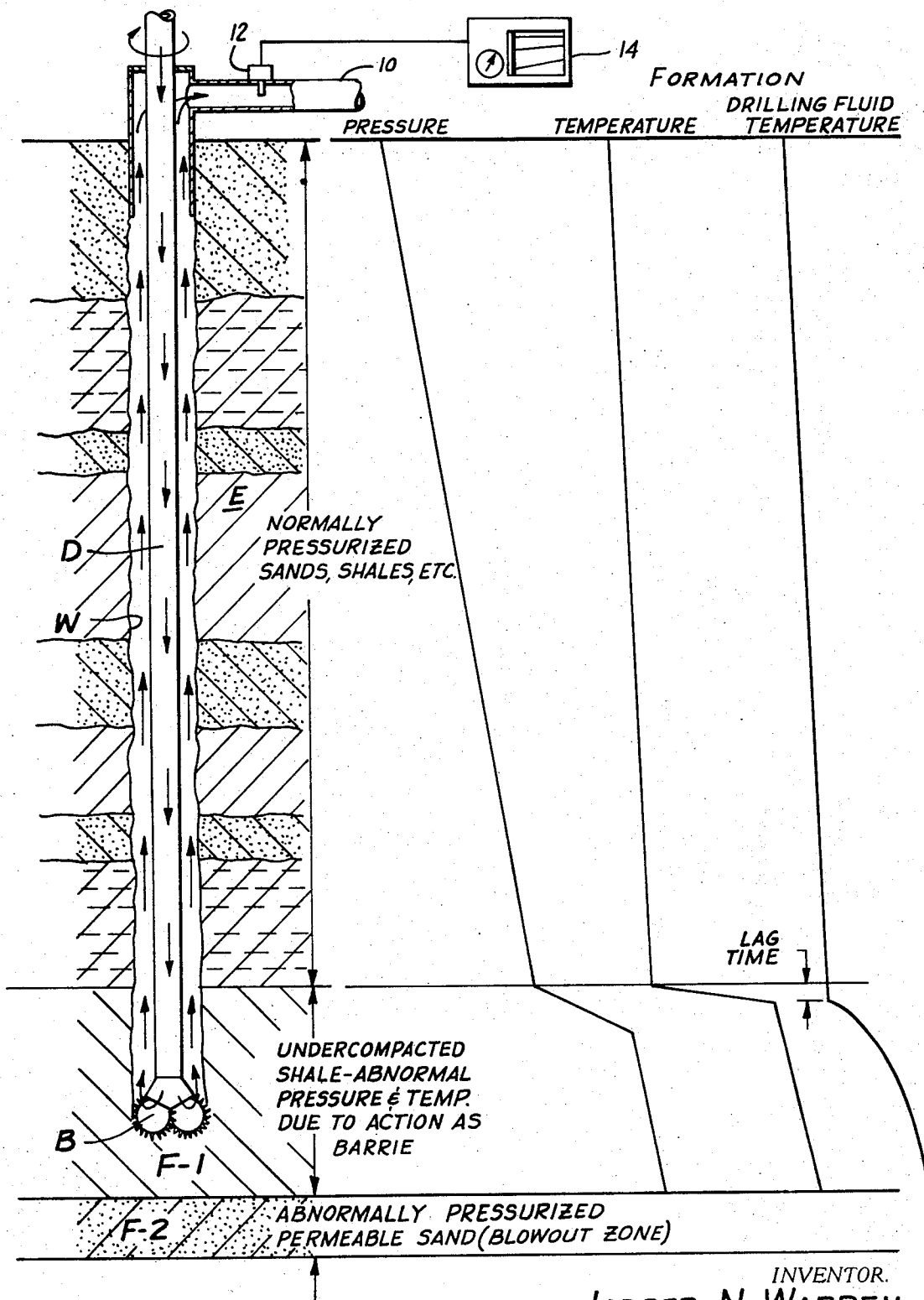
Primary Examiner—Ernest R. Purser
Attorney—J. Vincent Martin, Joe E. Edwards and Jack R. Springgate

[57] ABSTRACT

A drilling method which includes the usual steps of rotating a drill string and circulating a drilling fluid together with the steps of detecting an increase in the rate of increase of temperature of the drilling fluid and taking appropriate steps responsive to such increase in rate such as increasing the weight of drilling fluid, setting casing to allow drilling fluid weight to be increased, to prepare for a high pressure formation being approached by the drill bit or stopping the drilling to avoid drilling into the high pressure formation.

5 Claims, 1 Drawing Figure





INVENTOR.
JASPER N. WARREN
 BY *Vincent Martin*
Joe C. Edwards
Jack R. Spriggs
 ATTORNEYS

DRILLING METHOD**SUMMARY**

The present invention relates to an improved drilling method and to an improved method of detecting the approach of the drill bit to a high pressure formation.

An object of the present invention is to provide an improved drilling method which avoids blow-outs.

A further object is to provide an improved drilling method which allows circulation of a light weight drilling fluid until the drill string approaches a high pressure formation.

Still another object of the present invention is to provide an improved drilling method having improved efficiency of drilling a well bore in areas where the drill string is expected to encounter high pressure formations.

The present invention includes the normal drilling steps of rotating a drill string and circulating a drilling fluid down through the string and up the annulus around the string and further includes the steps of measuring the temperature of the drilling fluid returned to the surface and taking appropriate action in response to an increase in the temperature increase rate such as increasing the weight of the drilling fluid, setting casing to allow for an increase in weight of drilling fluid or terminating all further drilling steps, in anticipation of the approach of the drill string to a high pressure formation.

BRIEF DESCRIPTION OF THE DRAWING

These and other objects and advantages of the method of the present invention are hereinafter set forth and explained with reference to the drawing wherein:

The FIGURE is a schematic drawing illustrating the drilling of a well bore, showing the formations through which it extends and also showing a plot of the formation pressure and temperature and the temperature of the drilling fluid as the drilling proceeds through such formations.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In the drawing the well bore W is shown having been drilled through a plurality of formations F by rotating the drill string D with the drill bit B on the lower end of the string D. Drilling fluid is circulated down through the drill string D, is discharged at the bottom of the well bore W and is returned to the surface through the annulus A around the drill string D. The line 10 is connected into the annulus A at the wellhead to conduct the drilling fluid to the shaker screens (not shown) and to the drilling fluid storage pits (not shown). A means for measuring the temperature of the drilling fluid flowing through line 10 is provided. Such means includes the temperature sensing device 12 installed on the line 10 at a suitable location such as the shaker or other location protected from atmospheric conditions at the surface, and the indicating and controlling device 14 to which the temperature sensing device 12 is connected.

The rate of penetration of drilling is increased with the lighter drilling fluids being circulated. When drilling is in an area known to have high pressure formations the drilling fluid is usually made considerably

heavier than needed well in advance of the drilling reaching the predicted depth of such high pressure formations since to reach the formation with a lightweight drilling fluid is to invite a blow-out and its attendant problems. Thus, in the drilling methods of the past, the weight of the drilling fluid has been increased and drilling has consequently been slowed as a result thereof in order to assure that sufficient weight of drilling fluid is present in the well bore to assure that the danger of a blow-out is minimized. To be able to predict the near approach to a high pressure formation during drilling of a well bore can greatly increase the drilling rate since the more efficient lighter weight drilling fluid can be used until the high pressure formation is being approached.

The earth transmits heat toward its surface at a substantially constant rate. Thus, there is a gradual increase in temperature with depth. Also, pressure increases at a normal gradient greater than 0.435 psi per foot of depth. If the material of the earth were fairly uniform both temperature and pressure would be straight line functions of depth. Because of the non-uniformity of materials many barriers occur which cause variation in heat transfer characteristics and under certain conditions, abrupt changes of temperature and pressure occur in very short intervals of depth. Such barriers may result from undercompacted shales, faults, variation in porosity and permeability, variation in material in pore spaces, variations in rock and soil content and other variables.

In a majority of wells drilled which have encountered abnormal pressures, such conditions have been related to undercompacted shale. Density measurements of shale from a shaker screen have been used to indicate the presence of abnormal pressure.

It has been discovered that the measuring of the temperature of the returned drilling fluid provides more effective warning of the approach to an abnormally high pressure formation than the shale density method and other methods previously used. The temperature of the drilling fluid reflects such high pressure formations in advance since such formations usually have an undercompacted shale formation above them. These undercompacted shale formations create the temperature anomaly (an abrupt increase in the rate of temperature increase with depth) which is usually observed before blow-out zones are drilled.

These conditions are illustrated in the drawing. The pressure in the formations F increases relatively uniformly with depth to the formation F-1 in which the drill bit B is drilling. This formation is depicted to be an undercompacted shale having an abnormal pressure and temperature. The plot of the drilling fluid temperature generally parallels the formation temperature but will lag behind the actual penetration of the drill bit B into the particular formations since the drilling fluid temperature is measured at the surface and the movement of the drilling fluid from the bottom of the well bore W to the surface takes time (time lag). When the formation F-1 is reached, the pressure and temperature thereof increase rapidly with the rate of increase being considerably greater than the normal increase with depth. The temperature of the drilling fluid at the surface after the time lag due also rapidly increases at a rate much greater than the normal rate of temperature

increase of the drilling fluid previously plotted. When this substantial increase in the rate of change of the temperature of the drilling fluid as measured at the wellhead is indicated on device 14, suitable action is taken in the drilling steps in response thereto.

The approach of the drill bit to a high pressure formation indicates that some action should be taken to modify the drilling procedure depending upon the circumstances of each particular location. In some wells where it is desired to drill into the high pressure formation and the formations previously drilled will support additional weight of drilling fluid, such action is taken by adding weight compounds to the drilling fluid as is well known in the art. If formations previously traversed in the drilling might not support the planned increase in mud weight, it is desirable to set casing down to the level at which an increase in drilling fluid weight can be made without danger of lost circulation. In some locations, the anticipation of approach to a high pressure formation may minimize the expense of drilling where the high pressure formation is not a producing formation and where further drilling below such formation is not expected to have any reasonable chance of encountering a producing formation which would justify the increased cost of drilling through the high pressure formation.

In summary the steps which may be taken responsive to an indication of approach to a high pressure formation during drilling may include stopping drilling to abandon the well, increasing the weight of drilling fluid to allow drilling into the high pressure formation without danger of blow-out and if desirable, setting casing before the increase of weight of drilling fluid to assure continued circulation of drilling fluid.

With a record of drilling fluid temperature during drilling, the approach of the drill bit B to the high pressure formation F-2 is predicated and the drilling fluid weight increased to insure against a blow-out or other appropriate action is taken when the drill bit B reaches the high pressure formation F-2. The device 14 func-

tions to provide a record or chart of the drilling fluid temperature with respect to the depth of penetration of the drilling. The device 14 in addition to providing such temperature record may function to sound an alarm when the temperature rate changes appreciably or could control the mud weight by releasing weight material into the drilling fluid to thereby assure that the drilling fluid weight is increased.

The foregoing disclosure and description of the invention are illustrative and explanatory thereof, and various changes in the size, shape and materials, as well as in the details of the illustrated construction, may be made within the scope of the appended claims without departing from the spirit of the invention.

What is claimed is:

1. The drilling method including the steps of, rotating a drill string with a drill bit thereon to drill a well bore, circulating drilling fluid to the bottom of the well bore and back to the surface, detecting the temperature of the drilling fluid returned to the surface, and preventing a well blow-out responsive to the detection of an increase in the rate of increase of the detected temperature of the drilling fluid.
2. The drilling method according to claim 1, wherein said preventing step includes, increasing the weight of the drilling fluid.
3. The drilling method according to claim 1, wherein said preventing step includes, setting casing within the well bore.
4. The drilling method according to claim 1, wherein said preventing step includes, stopping the drilling steps to avoid entry of the drill bit into the anticipated high pressure formation.
5. The method according to claim 1, wherein the temperature measuring step is taken at a surface location which minimizes the influence of surface atmospheric conditions on the temperature measured.

* * * * *

45

50

55

60

65