July 12, 1966 J. K. GODBEY 3,260,111

DEVICE FOR RECORDING TEMPERATURE

Filed Aug. 5, 1963

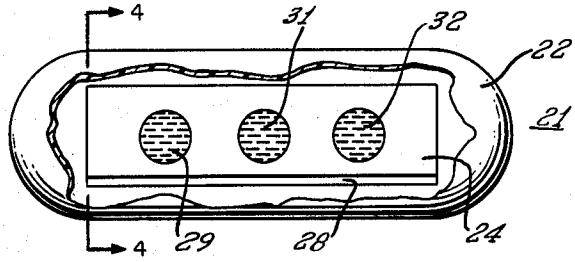


FIG 3

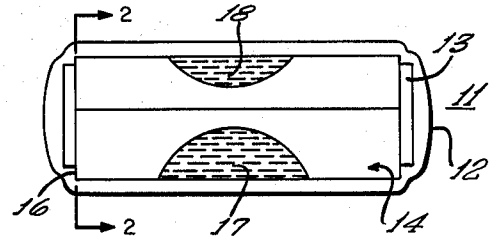


FIG 1

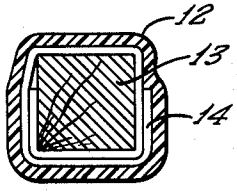


FIG 2

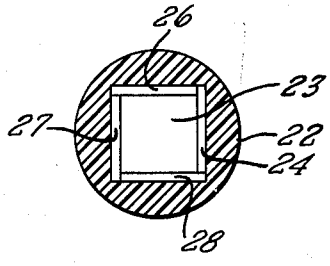


FIG 4

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DEVICE FOR RECORDING TEMPERATURE

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This invention relates to the measurement of the peak temperature of drilling fluid at dynamic circulating conditions during the drilling of a well. More particularly, it relates to a temperature-recording device and a method for determining the peak temperature of drilling fluid as it is circulated during the drilling of a well.

One important condition desired to be determined during the drilling of a well is the peak temperature of the drilling fluid as it is circulated. Usually, the drilling fluid is a mud containing bentonite. As is well known, the drilling fluid is circulated from the earth's surface down the drill pipe and through the fluid-circulating openings of the drill bit adjacent the bottom of the well. The drilling fluid returns in the annulus between the drill pipe and the side walls of the well to the earth's surface. The peak temperature in the circulating drilling fluid does not occur at the bottom of the well adjacent the drill bit. Rather, the peak temperature of the drilling fluid occurs in the annulus surrounding the drill pipe at some distance from the bottom of the well where a state of temperature equilibrium is reached. The distance from the well bottom at which this peak temperature occurs varies during drilling. For this reason, measurements of temperature taken at any particular position in the well generally will not provide reliable determinations of the peak temperature. Neither can reliable measurements be obtained under static conditions in drilling or in the circulating of drilling fluid.

Serious damage to the drilling fluid can occur as a result of continued circulation at a temperature where thermal degradation results. At present, only the results of thermal degradation can be detected at the earth's surface in the returning drilling fluid to display the presence of excessively high temperatures in the well. For this reason, the peak temperature of the circulating drilling fluid is most important. With this information, well-known steps can be used to protect the circulating drilling fluid against thermal deterioration.

Thus, the peak temperature in the circulating drilling fluid should be determined at dynamic circulating conditions as they exist during the drilling of a well. The measurement should neither require removing the drill pipe and bit from the well to the earth's surface nor changing the conditions of drilling and fluid circulation normally utilized in the drilling of the well. Further, the structures and their use in the measurement of the peak temperature in the circulating drilling fluid should be compatible with the usual equipment and procedures used in drilling a well. Additionally, the structures used for these purpose should be readily recovered from the circulating drilling fluid.

It is therefore an object of the present invention to provide for the measurement of the peak temperature of drilling fluid at dynamic circulating conditions during the drilling of a well. Another object is to provide a temperature-recording device and a method for measuring the peak temperature of drilling fluid while circulating during the drilling of a well. A further object is to provide a device and its use for measuring the peak temperature of drilling fluid that is compatible with the equipment and procedures used in drilling a well. Yet another object is to provide a temperature-recording device for measuring the peak temperature of drilling fluid that neither requires the drill pipe and bit to be removed from the well to the earth's surface nor requires a change

in the drilling and circulating conditions or equipment used in drilling a well. Another further object is to provide a temperature-recording device for measuring the peak temperature of drilling fluid that is readily recovered from the circulating drilling fluid.

These and further objects will be more apparent when considered with the following detailed description, the appended claim, and the attached drawings, wherein:

FIGURE 1 is a perspective of a temperature-recording device having a transparent strippable outer casing;

FIGURE 2 is a section taken along line 2—2 of the device shown in FIGURE 1;

FIGURE 3 is a perspective of a modification of the temperature-recording device having its exterior partially broken away to illustrate its interior construction; and

FIGURE 4 is a section taken along line 4—4 of the device shown in FIGURE 3.

The temperature-recording device of this invention is comprised of a casing of an abrasion-resistant material having at least one dimension of a size sufficient to pass through the circulating openings in the drilling bit. A temperature-indicating means is disposed within the casing. Also, within the casing is disposed a part constructed of a material less dense than water and this part has a volume sufficient to make the unitary device float in a drilling fluid. The device is introduced into the drilling fluid circulating down through the drill pipe. The device passes through the circulating openings in the drill bit and up through the annulus of the well to the earth's surface. The circulation of the device with the drilling fluid stream carries it through the region in the well where the peak temperature of the drilling fluid is encountered. The device is retrieved from the drilling fluid at the earth's surface. The peak temperature of the drilling fluid is determined by examining the temperature-indicating means.

Referring now to the drawings, and particularly to FIGURES 1 and 2, a preferred illustrative embodiment of the temperature-recording device **11** of the present invention will be described. The device **11** is particularly suited for fabrication in the field from readily available materials which increases its utility. The device **11** has a casing **12** of an abrasion-resistant material which, of course, should not dissolve in the drilling fluid. The casing **12** has at least one exterior dimension not greater than that dimension which is adapted to pass the casing **12** with the drilling fluid through the circulating openings in the drill bit used in drilling the well. Generally, the circulating openings in a drill bit are about ⅜ inch in diameter. Thus, one exterior dimension of the casing **12** needs to be less than ⅜ of an inch under these circumstances. Preferably, the casing **12** is tubular. In such case, the maximum diameter of the tubular casing **12** is the dimension which controls passage through the circulating openings in the drill bit.

Although the casing **12** may be fabricated from any abrasion-resistant material, it has been found desirable to use a strippable vinyl film such as presently used to protect metal surfaces from marring during fabrication, handling, and assembly. Such strippable vinyl films facilitate the subsequent examination of the temperature-indicating means carried by the device **11**. The most useful strippable vinyl films are the polyvinyl ester resin films. Such films can be obtained from the resins derived from the polyvinyl acetates, polyvinyl chlorides, copolymers of vinyl chloride and vinyl acetate, and the polyvinyl acetyls. An example of a strippable abrasion-resistant material well suited for providing the casing **12** is a strippable vinyl resin paint which on air drying provides a film. This paint is available under the trademark "Delchem X–1000" from the Tennsalt Chemicals Cor-

poration. However, other abrasion-resistant plastic materials may be used. For example, various epoxy compounds may be used for the casing 12. Generally, the epoxy compounds are derived from the resins of ethylene oxide and its homologues or derivatives. The casing 12 may be transparent or opaque. If the casing 12 is opaque, it is preferably of an abrasion-resistant material that may be readily stripped from the device 11 to permit subsequent examination of the temperature-indicating means. It will be obvious to those skilled in the art that other abrasion-resistant materials may be used to provide the casing 12. However, the abrasion-resistant material must have sufficient strength to prevent the abrasive forces encountered in drilling fluid circulating systems from damaging the temperature-indicating means disposed in the casing 12. The casing 12 may be of a length, as seen in FIGURE 1, sufficiently great to permit ready visual observation as it floats on the surface of the drilling fluid in the usual mud ditches, shale shaker, and the like at the well site. Also, the casing 12 may be of a colored material, or its exterior surface painted, to increase its visibility.

Enclosed within the casing 12 is a part 13 of a material less dense than water. By material, it is meant in this disclosure a solid substance, or a cavity which may be enclosed by a water-proof housing, which is less dense than water. Preferably, the part 13 is provided by a wood such as pine, etc. For example, the part 13 may be provided by a wooden matchstick. Solid substances other than wood which are less dense than water may also be used. For example, various synthetic resins having a plurality of cellular air spaces may be used provided there are sufficient air spaces to make them buoyant in water. The part 13 has a length and cross-sectional area such as to provide a volume sufficient to make the device 11 comprised of the part 13, a temperature-indicating means, and the casing 12 to float on the surface of the drilling fluid. As a result, the device 11 will float on the surface of the drilling fluid when it reaches the earth's surface. Recovery is easily obtained by visually monitoring the various mud ditches or other exposed drilling fluid regions.

The device 11 will be readily carried along with the drilling fluid during its circulation through the well because of the fluid circulation velocities normally utilized in the drilling of a well. Such velocities of circulating drilling fluid overcome any tendency of the device 11 to move upwardly or downwardly at a rate different from that of the circulating drilling fluid. Thus, a very buoyant device 11 may be circulated in phase with any drilling fluid.

Temperature-indicating means 14 are disposed within the casing 12. Preferably, the temperature-indicating means 14 provide a permanent indicia change which is visually detected after being subjected to a known temperature. Usually for best results, the permanent change is one of color. As can be seen in FIGURE 2, the temperature-indicating means 14 may be rolled lengthwise onto the part 13 for ready disposition within the casing 12. The temperature-indicating means 14 may be secured to the part 13 by any suitable means. For example, it may be tied on the part 13 by a string or the like (not shown). Thereafter, the casing 12 may be placed about the part 13 and the temperature-indicating means 14. However, other ways for disposing the temperature-indicating means 14 and part 13 within the casing 12 may be used, if desired. Referring to FIGURE 1, the temperature-indicating means 14 used in the preferred embodiment are comprised of a relatively thin member 16 on which is deposited a quantity of carbon black. Disposed on the carbon black coating are one or more fusible temperature-indicating materials 17 and 18. The temperature-indicating materials 17 and 18 are of a color which is different from the carbon black, for example,

the color may be white. Preferably, the temperature-indicating materials 17 and 18 are selected so that each changes color at a different temperature. For example, the temperature-indicating materials 17 and 18 may be arranged to change color from white to black at the temperatures of 170° F. and 180° F., respectively. Thus, a temperature between 170° F. and 180° F. would result in the temperature-indicating material 17 changing color to black, while the temperature-indicating material 18 remains white in color.

The temperature-indicating means 14 described above may be provided by the Temperature Indicator disclosed in United States Patent 3,002,385. The temperature-indicating means 14 in this reference may be more generally described as comprising a backing material, a metallic base member disposed on the backing material, and a colored pigment material disposed on the base member. A fusible temperature-indicating material is disposed on the colored material with the temperature-indicating material being of a collar which is different from the color of the colored pigment material. A transparent cover material disposed adjacent the temperature-indicating material is bonded to the base member, thereby enclosing the temperature-indicating material and the colored material between the base material and the cover material. A metallic cover member having perforations therein is disposed adjacent the cover material. The perforations serve as view holes for observing the temperature-indicating material. The metallic cover member is bonded to the backing material, thereby enclosing the base member, color-indicating material, and transparent cover material between the backing material and the cover member.

The temperature-indicating means 14 heretofore described are well suited for the purposes of this invention. The temperature-indicating means 14 are not affected or altered by the usual drilling fluids used in drilling wells. Further, they are neither damaged by being flexed or creased during mounting on part 13 or disposition within the casing 12 nor by their subsequent examination at the earth's surface. Thus, the temperature-indicating means 14 do not need to be enclosed within a fluid-tight structure for the purposes of this invention. If desired, other suitable temperature-indicating means may be used, as is apparent to one skilled in the art.

A modification of the device 11 is shown in FIGURES 3 and 4. This modification, as device 21, may be found more desirable for commercial production than device 11. In FIGURE 3 there is shown the device 21 which is provided with a casing 22 of an abrasion-resistant material. This material may be the same as the abrasion-resistant materials previously described with respect to the device 11. The casing 22 is preferably of a transparent abrasion-resistant material to permit the temperature-indicating means to be viewed directly. The casing 22 has hemispherical ends for providing a more streamlined body which is less likely to be damaged during its circulation with the drilling fluid in a well. Enclosed within the casing 22 is a part 23 of a material less dense than water. The part 23 is of like materials such as described for part 13 of the previously described device 11. Preferably, part 23 will be of a synthetic foamed plastic having a very low density for a unit volume. The part 23 is provided with a sufficient volume, in consideration of its cross-sectional area and length, so that the device 21 comprised of the casing 22, part 23, and a temperature-indicating means enclosed therein will be sufficient to make the device 21 float in a drilling fluid. The part 23 may be elongated to a length of approximately ¾ inch to increase its visibility. Preferably, the part 23 has a polygonal cross section taken transversely to its longitudinal axis as best seen in FIGURE 4. For example, with reference to FIGURE 4, it can be seen that the cross section of the part 23 shows it to be rectangular. Thus, there are 4 planar sides on which may be secured one or more temperature-indicating means 24, 26, 27, and 28, respectively. The temperature-

indicating means 24, 26, 27, and 28 may be mounted on the side exterior surfaces of the elongated part 23 by any suitable means, for example, by the means previously described with respect to the embodiment shown in FIGURE 1. Also, the temperature-indicating means 24, 26, 27, and 28 may have an adhesive backing to adhere directly to the side exterior surfaces of the elongated part 23. Thereafter, the casing 22 may be placed about the temperature-indicating means 24, 26, 27, and 28, and the part 23. The casing 22 may be molded to encapsulate these items, if desired.

Each of the temperature-indicating means 24, 26, 27, and 28 may be provided with one or more temperature-indicating materials 29, 31, and 32. Thus, for the modification shown in FIGURES 3 and 4 it is possible to have up to 12 temperature-indicating materials carried on the part 13 and each arranged to change color at a different temperature from the others. For example, the temperature-indicating materials 29, 31, and 32 may be arranged to change color from white to black at the temperatures of 150° F., 160° F., and 170° F., respectively. Thus, a temperature between 160° F. and 170° F. would result in a temperature-indicating material 29 changing color to black, while the temperature-indicating materials 31 and 32 remain white in color. The remaining temperature-indicating means 26, 27, and 28 may be provided with temperature-indicating materials which change color at other temperatures. Thus, the device 21 can be used with great facility for providing a wide range of peak temperature indications. Of course, one or more of the temperature-indicating means 24, 26, 27, and 28 carried on the exterior surfaces of part 23 may be provided with a keyed indicia so that the orientation of the device 21 may be ascertained as to which of the temperature-indicating materials is being viewed. The temperature-indicating means 24, 26, 27, and 28 may be provided by the same means as disclosed for the device 11 shown in FIGURES 1 and 2 and previously described.

The device 11 or 21 may be used with great facility in the following manner. As a first step, the device 11 or 21 is introduced into the drilling fluid circulated down the drill pipe into the well. The device 11 or 21 is passed from the drill pipe through the circulating openings of the drill bit into the well. Preferably, as another step, the drill bit is slightly raised from the bottom of the well during the actual passage of the device 11 or 21 through the circulating openings of the drill bit. Continued circulation of the drilling fluid carries the device 11 or 21 upwardly through the annulus of the well to the earth's surface. The device 11 or 21 circulates in phase with the circulating drilling fluid. As another step, the device 11 or 21 is retrieved from the drilling fluid at the earth's surface. For example, the device 11 or 21 may be retrieved from the surface of the drilling fluid as it passes down the mud ditch from the well to the mud shaker, or at other suitable exposed areas of drilling fluid found at the well site. The temperature-indicating means 14 in device 11, or the equivalent means 24, 26, 27, and 28 within device 21, are examined to determine the peak temperature of the circulating drilling fluid. For example, where the device 21 has a transparent casing 22, visual observation may be made of the temperature indicia change in the temperature-indicating means 24, 26, 27, and 28. Where the casing 12 is of an opaque abrasion-resistant material such as a strippable vinyl film, the casing 12 may be readily removed from about the temperature-indicating means 14. The temperature indicia change in the temperature-indicating means 14 may be then readily determined by examination. Thus, a strippable vinyl resin is preferred as the casing 12 where the device 11 is

fabricated in the field. However, where the device 21 of the present invention is to be manufactured in commercial production, the use of a transparent material, such as a clear or colored plastic, for the casing 22 is preferred since the indicia change in the temperature-indicating means 24, 26, 27, and 28 may be readily determined by visual observation.

From the foregoing it will be apparent that there has been provided a device and a method for its use which is well suited for measuring the peak temperature of drilling fluid at dynamic circulating conditions during the drilling of a well. No changes are required in the procedures or equipment used in drilling wells. The peak temperature of the circulating drilling fluid can be determined in only slightly more than the time it takes for the device of the present invention to be circulated through the well with the drilling fluid. Other advantages will be apparent to those skilled in the art as will be other embodiments and methods for utilizing the present invention.

Various changes may be made to the device, and to the method of its use, of this invention by those skilled in the art. For example, several temperature-indicating means may be placed into the casing of the device so that a range of specific temperatures may be surveyed. Further, the casing and the means for disposing the temperature-indicating means therein may be provided by various modes and materials as will be apparent to those skilled in the art. It is intended that such changes be within the scope of the present invention. Further, it is intended that the foregoing description be taken as illustrative and not limitative; the only limitations to be applied to the scope of the present invention are those found in the appended claim.

What is claimed is:

A device for measuring the peak temperature of a drilling fluid at dynamic circulating conditions during the drilling of a well with a fluid-circulating drill bit on a drill pipe comprising:

(a) a casing of an abrasion-resistant material with sufficient strength to prevent the abrasive forces encountered in fluid circulation in a well from damaging a temperature-indicating means carried therein, said casing having at least one dimension of a size sufficient to pass the casing through the circulating openings in a drill bit,

(b) a temperature-indicating means enclosed within the casing, said means providing a permanent change in indicia when subjected to a predetermined temperature, and

(c) a solid wooden part less dense than water disposed within the casing, said temperature-indicating means carried within said casing adjacent the exterior surface of said part, and said part having a volume sufficient to make the device float in a drilling fluid.

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