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APPARATUS FOR SHUTTING OFF FLOW OF GASEOUS DRILLING FLUID RESPONSIVE TO TEMPERATURE IN THE BORE HOLE
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Fig. 4.

Fig. 5.

Fig. 6.

Fig. 7.

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APPARATUS FOR SHUTTING OFF FLOW OF GASEOUS DRILLING FLUID RESPONSIVE TO TEMPERATURE IN THE BORE HOLE

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This invention relates to a device for extinguishing or controlling down hole explosions or fires that often occur when drilling holes into earth formations bearing combustible fluids.

For example, it is becoming the practice to utilize compressed air or gas for the circulating medium to remove bit cuttings from the bore hole. The air or gas is supplied by compressors located at the ground at the upper end of the bore hole, and the air or gas is circulated through the drilling string under pressure for discharge through the drill bit with sufficient force to carry the cuttings to the top of the bore hole, the supply of air or gas being continuously maintained during the drilling operations.

Air or gas drilling is safe and satisfactory until the bit enters formations containing oil, condensate, gas or liquid hydrocarbons and other combustible materials. The presence of the air or gas in the large volume necessary for air drilling, together with such combustibles, produces a potentially highly explosive mixture, readily subject to spontaneous combustion or self igniting. In case of ignition, the continuous supply of incoming air or gas used as the circulating medium maintains the combustion of the hydrocarbons. Moreover, the close space in the bore hole causes the mixture to burn with great intensity, producing a furnace effect around the drill pipe, drill collars, and drill bit. In fact, the down hole temperature becomes so intense that the fire leaves a burned and destroyed mass of metal in the hole. This necessitates a very costly, and sometimes impossible, fishing job to remove it. Such fires can also cause the lower part of the hole to be completely junked, at enormous expense to the drilling contractor.

Even when the fire is controlled, the temperature exceeds the limits of the various metals of which the parts of the drilling string are constructed, and they lose their physical properties so that they cannot be reused for drilling purposes.

It is, therefore, a principal object of the present invention to provide apparatus for automatically shutting off the flow of air or gas when a set temperature is reached in the bore hole, so that the fire will go out from lack of sufficient oxygen before the drilling tools are damaged.

Other objects of the invention are to provide a simple and compact valve mechanism and a heat responsive element incorporated in a subsection of the drill pipe, which may be placed in the drilling string between tool joints near the drill bit or a plurality of the mechanisms may be positioned anywhere along the length of the drill pipe.

It is a further object of the invention to provide a valving element that can be readily removed from closed position by a simple retrieving tool that may be lowered through the drill pipe from the top of the bore hole and automatically connected with the valving element so that it may be removed upon removal of the tool.

Another object of the invention is to provide a device that holds back pressure on the compressor sufficient to pop off at set limits, and thereby warn the drilling crew that the valve element is closed and that an excessive temperature or fire exists at the bottom of the bore hole, so that the drilling operation can be shut down.

Another object of the invention is to provide an alarm system in association with the apparatus, to further warn the drilling crew that the valving element has functioned and the drilling operations must be shut down until the fire has been extinguished.

In case the invention does not utilize a retracted valving element, the valving apparatus may be provided with a bypass to provide sufficient bypass of air or gas to facilitate removal of the drilling string. It is not sufficient to maintain combustion.

In accomplishing these and other objects of the invention, I have provided improved structure, the preferred form of which is illustrated in the accompanying drawings, wherein:

FIG. 1 is a sectional view through a subsection of drill pipe equipped with an automatic valving mechanism embodying the features of the invention and showing the subsection coupled between adjacent tool joints of the drill pipe near the bottom of the bore hole, the valve being in open position.

FIG. 2 is a fragmentary view showing the valving element closed to shut off flow of air or gas through the drill pipe, as in response to the heat of a fire.

FIG. 3 is a horizontal section on the line 3--3 of FIG. 2, particularly illustrating the bypass passage, the upper end of the valve assembly as it appears when removed from the subsection of the drill pipe and showing a part thereof broken away to better illustrate the valving element in closed position.

FIG. 4 is a perspective view of a small section of the valve assembly as it appears when removed from the subsection of the drill pipe and showing a part thereof broken away to better illustrate the valving element in closed position.

FIG. 5 is a section through a modified form of the invention and showing the bypass passage, the upper end of the valve assembly as it appears when removed from the subsection of the drill pipe and showing a part thereof broken away to better illustrate the valving element in closed position.

FIG. 6 is a section through a further modified form of the invention and showing a retrieving tool lowered into the drill pipe for removing the valving element from valving position after a fire has been extinguished.

FIG. 7 is a diagrammatic view of a drilling string equipped with the present invention and showing the compressor connected therewith, the connection being equipped with a pressure gauge and a signal or alarm.

Referring more in detail to the drawings:

1 designates a string of drill pipe comprising a plurality of stands of pipe interconnected at the ends by tool joint members, one having a threaded pin 2 and the other an internally threaded box 3. The lower end of the string of drill pipe carries the usual drill bit (not shown) and the upper end connects with a swivel head 4 that is suspended by a tackle 5. Connected with the swivel head 4 is one end of a hose 6 having its other end connected to a manifold 7, which in turn is connected with the pressure discharge of one or more air or gas compressors, indicated at 8. The drilling string is rotated by a rotary (not shown) to cause the drill bit to chip away the formations through which the bore hole is drilled. When the compressors are in operation, air or gas, known as the drilling fluid, is supplied under high pressure to the upper end of the string of drill pipe and is discharged through the bit, to blow the cuttings made by the bit to the top of the bore hole 9.

The air or gas under pressure provides a satisfactory drilling fluid and is safe until the drill bit enters a formation containing petroleum hydrocarbons or other readily combustible materials. Further drilling through such formations is accompanied by a constant danger of fire or explosions that are set off by spontaneous combustion, temperature rises, and the like. When a bottom hole fire occurs, the air or gas, in the large volume and high pressures necessary for drilling, discharged in the relatively close confines of the bore hole, produces a furnace effect and the fire burns with such intensity that the drill pipe, drill collars, and drill bit are soon reduced to a burned mass of metal. This necessitates a very costly fishing job to remove the mass, and in fact it is sometimes impossible to remove, causing abandonment of at least the lower part of the bore hole. Such catastrophes are at the expense of the drilling contractor,
and the losses in equipment, drilling time, and fishing operations are enormous. Even when the fire is fairly well controlled, the temperature of the fire fed by the high pressure drilling fluid exceeds the limits of the various metals of which the parts of the drilling string are constructed, and they lose their physical properties so that they cannot be reused for drilling purposes.

In such a case, the present invention contemplates an automatic means for shutting off the flow of the drilling fluid, or at least throttling the flow to an amount insufficient for supporting combustion of the fire. This is accomplished by one or more valving mechanisms inserted in the drilling string at one or more points along the length thereof, so that at least one of the mechanisms will be in the zone of a fire that might occur in the bore hole.

Each mechanism includes a subsection of drill pipe 10 having an internally threaded box 11 at one end and an externally threaded pin 12 at the other, whereby the subsection may be connected with the pin 2 and box 3 of the tool joint members between which the devices are inserted. The subsections have an axial bore 13 extending from the upper end and terminating short of the lower end to provide an annular shoulder 14 encircling a small conical portion 15 of the bore.

Contained in the large bore is a valve assembly, including a cage 16, having upper and lower collar portions 17 and 18 interconnected at opposite diametrical sides thereof by leg portions 19 and 20. The upper face 21 of the lower collar portion 18 constitutes an annular valve seat 22. Figures 1 and 2 immediately encircling a port 23 in the lower collar 18. Formed on the collar 18 and projecting upward from the face 21 in outwardly offset relation with the seat 22 are spaced apart ears 24 and 25 carrying the ends of a transverse pin 26 for mounting a valving element 27.

The valving element 27 illustrated is of the flipper type and includes a generally disk shaped body 28 conforming in diameter to the outer diameter of the seat 22 and which has an offset lug 29 at one diametrical side thereof and conforming in width to the space between the ears 24-25. The lug has an opening 30 by which the valving element is mounted on the seat thereof in registry with the space between the ears 24 and 25 in a leaf spring 32. The spring 32 is secured at one end 33 to the collar 17 by fastening devices, such as screws 34, extending through suitable openings in the spring and into threaded openings 35 of the collar. The other end 36 of the leaf spring extends from the collar 17 and has a shape to exert a seating force against the valving element 27 when the valve element is in open latched position, as shown in FIG. 1. The latching mechanism for retaining the valve element in open position for passage of the drilling fluid through the port 23 includes a heat responsive element 37, now to be described.

The heat responsive element 37 may be a fusible plug 38 adapted to melt at a preset temperature and before a fire has time to damage the drilling string. The plug 38 is mounted in an internally threaded socket 39 that is formed in the side of the subsection with the axis thereof substantially on the plane of the valve seat 22. The socket 39 terminates short of the inner face of the subsection on the pin 26. The socket 39 encircles an opening 41 which continues through the wall of the subsection as shown in FIG. 1. The fusible plug 38 has an externally threaded body 42 for engaging the internal threads of the socket and has an inner face 43 for contact with a gasket 44 seated in the shoulder 40 and encircling the opening 41. The outer face of the plug has a socket wrench engaging portion 45 by which the plug may be turned. The inner face of the plug has a central substantially axial lug 46 that projects through the opening 41 and engages a tongue 47 on the valving element projection 48 in the lug 29, to hold the valving element in open position and against action of the spring 32, as shown in FIG. 1.

The cage 16 is seated in the bore of the subsection on a gasket ring 48 that is seated upon the shoulder 44. Formed in the inner annular face of the subsection at the upper end of the cage is an annular groove 49 for accommodating a split retaining ring 50 that is insertable in the recess and has an inner portion extending over the upper end of the cage to retain the cage in seated position on the gasket.

The modified form of the invention (FIG. 5) employs a different type of valve and is for holding the valving element in open position. In this form of the invention, the tongue 47 on the valving member is omitted and the upper end of the valve when in open position is engaged by the hooked end 51 of a latch bar 52 which is anchored in a fusible plug 53. In this instance, the fusible plug 53 is mounted in a threaded socket 54 that is formed in the wall of the subsection with the axis thereof above the upper end of the valving element so as to support the latch bar 52 in its desired position. The threaded socket 54 terminates short of the inner face of the subsection to provide an annular shoulder 55 encircling an opening 56 of the inner face of the subsection and extending over the latch bar 52. The bar 52 has a threaded end 51 imbedded in the metal of the plug. The annular shoulder 55 seats a coil spring 57 having the other end bearing against the inner face of the fusible plug 53 to eject the metal of the plug and release the latch bar to the action of a coil spring 58. The spring 58 is sleeved over the latch bar and has one end engaging the inner face of the subsection and its other end engaging a collar 59 on the latch bar and in position to engage the valve element and push it against the inner face of the subsection and the upper end of the insert 60 that is provided with a port 65 for passing the fluid in a normal drilling operation.

The valve 62 comprises a thin, waferlike disk 66, having a dome shaped projection 67 on the inner face thereof and adapted to pass into the port 65 for centering the valve when the valve is released in case of a fire. The valve is supported by a fusible plug 68 that is threaded into a socket 69 opening inwardly of the wall of the subsection from the exterior face thereof. Formed on the inner face of the subsection is a reversely arranged recess 70 for containing a coil spring 71. A partition 72 between the socket 69 and the recess 70 has an opening 73 for passing a shank of the fusible plug and which has a threaded end 75 engaging in an internally threaded opening 76 that is formed in the center of the waferlike disk 66. When the parts are in assembly with the valve threaded onto the shank, the spring 71 is retained in compression between the partition 72 and the waferlike disk, so that when the fusible plug and shank portion thereof melt, as in the case of a fire, the spring forces the valve away from the fused metal to cause the valve to drop onto the seat 63 and close the port 65,
thereby shutting off the flow of drilling fluid into the fire. After the fire has been extinguished, the valving element may be readily retrieved through the length of the drill pipe by a tool 77 that is lowered by means of a cable 78. The tool 77 carries a permanent magnet 79 to attract the valve disk thereto when the tool comes into contact with the valve disk. Upon lifting of the tool by means of the cable, the valve disk will be lifted therewith and withdrawn through the upper end of the drill pipe. The drilling fluid may then be discharged through the drill pipe in full flow through the port 65, in case the drill pipe should become stuck in the bore hole during removal thereof.

Assuming that the device constructed in accordance with the form of the invention illustrated in Figs. 1 to 4, inclusive, is assembled in a subsection 10 of drill pipe, and that the valve 27 is locked in open position on insertion of the fusible plug 38, the subsection is inserted between adjacent tool joint connections 2 and 3, preferably near the lower end of the drill pipe and just above the bit. Other of the devices of like construction may be similarly inserted along the length of the drill pipe during interconnection of the drill pipe sections and running thereof into the bore hole.

With the drill pipe 1 in place and under rotation from the rotary (not shown) at the top of the bore hole 9, air is discharged under pressure of the compressor 8 through the drill pipe, through the cage 16 and port 23 thereof, to discharge through the bit (not shown) for dislodging the cuttings and forming the annulus upwardly of the bore hole 9 on the exterior side of the drill pipe 1. If for any reason the temperature should rise above the melting point of the fusible plug 38, as in the case of a fire in the bore hole caused by ignition of combustible fluids on penetration of the drill bit into a formation bearing such fluids, the fusible element 38 will melt as soon as the temperature reaches the melting point of the material thereof. However, immediately upon melting of the fusible plug, the spring 32 pressing on the valve 28 urges the valve toward a position where it closes by gravity the axial port 23, to block the discharge of the drilling fluid into the fire. The blocking of the discharge causes the pressure to increase in the drill pipe, so as to actuate the alarm or give visual notice by the rise in pressure shown by the pressure gauge. With these signals the driller will shut down the compressors so as to suspend the flow of the drilling medium, and prevent the disasters that would be produced by the combustible mixture resulting from feeding a high volume of high velocity air into the combustible fluids. If the driller should fail to shut down the compressors, the pressure will be released by way of the popoff valve, but the valve 27 will remain closed.

The fire is extinguished, usually because of insufficient air to maintain combustion, one or more of the compressors may be started to deliver air to the bit through the small port 61. Some air will probably escape through the opening left by the fuse plug, however, the opening is substantially closed by the hinged lug 29 of the valve and the lugs 24 and 25 on the cage, since they substantially close entrance to the opening formerly occupied by the fusible plug. This escape of air is important to loosen the bit in the bore hole and to loosen the debris that may result from a fire. After withdrawal of the drilling string from the bore hole, the subsection 10 which contains the cage and bar from the fusible plug may be inserted upon lifting of the valve and urging the valve against the spring 32, so that the lug 46 on the plug is in position to engage the tongue 47 on the valve and hold the valve in open position. After replacement of the fusible plug to cock the valve in open position, the subsection may be reconnected into the drilling string and the drilling string is returned to the bore hole to continue the drilling operation.

The form of the invention shown in FIG. 5 operates in a similar manner, but in case of dangerous temperature rise the fusible plug 53 will melt to release the latch bar 52. After melting of the fusible plug, the spring 57 will discharge any metal of the plug that might tend to hold the latch bar, after which the spring 58 is effective to retract the hooked end of the latch bar from engagement with the valve element 27, so that the valve element is free to drop on its seat.

In the form of invention shown in FIG. 6, the valving element 62, being bodily supported on the shank 74 of the fusible plug, is freed upon melting of the plug and the spring 71 forces the valve in its seat 63. The valve disk is centered thereon by the dome shaped projection 67. In this form of the invention, the valve disk may be removed through the drill pipe by lowering a retracting device, such as a magnet 79, through the drill pipe by means of a cable 78 until the magnet engages the disk, after which the cable may be withdrawn to carry the valve disk therewith.

It will be noted that in each instance the fusible element of the present invention is directly exposed to the heat of a fire of the combustible mixture which occurs in the upflow passageway, so that the action of the heat responsive element effects an immediate shutoff of flow of the gaseous fluid from the drill pipe into the upflow passageway except for the small amount escaping through the small port 61 in the valves, and this in itself is insufficient to support combustion of the inflammable fluids escaping from the formation. However, this small amount is also shut off after shutting down the compressor.

What I claim and desire to secure by Letters Patent is:

1. A device for blocking downward flow of a gaseous medium through a drill pipe, including a subsection of drill pipe for connection into said drill pipe, means within the subsection for providing an upwardly facing seat encircling the flow of gaseous medium, a valve for said seat, said subsection having an opening through a side wall thereof at a point above said seat, a fusible element closing the opening and subject to temperature surrounding the subsection, means connected with the fusible element for normally holding said valve in open position, and resilient means for ejecting the fusible element upon melting thereof and for releasing the holding means to seat the valve.

2. A device for blocking downward flow of a gaseous medium through a drill pipe, including a subsection of drill pipe for connection into said drill pipe, a cage within the subsection and having an upwardly facing seat encircling the flow of gaseous medium, a valve for said seat, means for hinging the valve to the cage at one side of the seat, said subsection having an opening through a side wall at said side of the valve seat, a fusible element closing the opening and subject to temperature surrounding the subsection, latch means carried by the fusible element for normally holding said valve in open position, and resilient means for ejecting the fusible element upon melting thereof and for releasing the latch means for gravity seating of the valve.

3. A device for blocking flow of gaseous medium through a drill pipe as described in claim 2, wherein the valve element has a port therethrough for passing a fraction of the flow.

4. A device for blocking downward flow of a gaseous medium through a drill pipe, including a subsection of drill pipe for connection into said pipe, a cage within the subsection and having an upwardly facing seat encircling the flow of gaseous medium, a valve for said seat, means for hinging the valve to the cage at one side of the seat, a tongue projecting from said valve, said subsection having an opening through a side wall at said hinged side of the valve and in registry with said tongue, a fusible element closing the opening and subject to temperature surrounding the subsection, a lug carried by the valve element and engaging the tongue for normally holding said valve in open position, and resilient means for flip-
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5. In an apparatus for drilling bore holes into earth formations including a drill pipe extending into the bore hole and having a flow passageway therethrough and compression means connected with the flow passageway in the drill pipe for supplying a gaseous fluid under pressure into the bore hole for blowing cuttings from the bottom of the bore hole and carrying them upwardly of the bore hole exteriorly of the drill pipe, and which gaseous fluid creates the hazard of forming a combustible mixture with inflammable fluids escaping from the earth formations,

means for controlling burning of the inflammable fluids within the bore hole by automatically shutting off the flow of gaseous fluid through the drill pipe to that insufficient for maintaining combustion of the inflammable fluids, said means comprising

a valve seat means encircling the flow passageway in the drill pipe,

a valve for said seat,

a heat responsive element carried by the drill pipe and having a portion thereof in direct contact with the upflowing mixture in the bore hole to cause functioning thereof upon rise in temperature of the upflow, and

means supported by the heat responsive element and connected with the valve for holding said valve from said seat and to release said valve onto its seat when the heat responsive element functions upon rise in temperature of the upflow mixture to shut off flow of the gaseous fluid in the drill pipe and establish a back pressure between the valve and said compression means, and

means responsive to said back pressure for producing a signal indicating that the valve is closed responsive to the temperature rise of the upflow mixture.

9. In an apparatus for drilling bore holes into earth formations including a drill pipe extending into the bore hole and having a flow passageway therethrough and compression means connected with the flow passageway in the drill pipe for supplying a gaseous fluid under pressure into the bore hole for blowing cuttings from the bottom of the bore hole and carrying them upwardly of the bore hole exteriorly of the drill pipe, and which gaseous fluid creates the hazard of forming a combustible mixture with inflammable fluids escaping from the earth formations,

means for controlling burning of the inflammable fluids within the bore hole by shutting off flow of gaseous fluid through the drill pipe, said means comprising

a valve seat means encircling the flow passageway in the drill pipe,

a valve for said seat,

a fusible plug carried by the drill pipe and having a portion thereof in direct contact with the upflowing mixture in the bore hole to melt when the temperature of the upflow reaches the melting point of the fusible element,

means carried by the fusible element and having connection with the valve for holding said valve from said seat as long as the fusible element is intact,

means pressing upon the fusible element for ejecting the fusible element on fusing thereof to free said connecting means, and

means for flipping the valve onto its seat upon release of said connecting means.

10. In an apparatus for drilling bore holes into earth formations including a drill pipe extending into the bore hole and having a flow passageway therethrough and compression means connected with the flow passageway in the drill pipe for supplying a gaseous fluid under pressure into the bore hole for blowing cuttings from the bottom of the bore hole and carrying them upwardly of the bore hole exteriorly of the drill pipe, and which gaseous fluid creates the hazard of forming a combustible mixture with inflammable fluids escaping from the earth formations,

means for controlling burning of the inflammable fluids within the bore hole by automatically shutting off the flow of gaseous fluid through the drill pipe to that insufficient for maintaining combustion in the bore hole, said means comprising

a valve seat encircling the flow passageway in the drill pipe,

a valve for said seat,

a heat responsive element carried by the drill pipe at said seat and having a portion thereof in direct contact with the upflowing mixture in the bore hole to cause functioning thereof upon rise in temperature of the upflow mixture, means supported by the heat responsive element and connected with the valve for holding said valve from said seat and to release said valve onto its seat when the heat responsive element functions upon rise in temperature of the upflow mixture to shut off flow of the gaseous fluid in the drill pipe and establish a back pressure between the valve and said compression means, and

means responsive to said back pressure for producing a signal indicating that the valve is closed responsive to the temperature rise of the upflow mixture.
said seat and to release said valve onto its seat when the heat responsive element functions in case the upflow starts to burn, and means for retrieving the valve from the seat.

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