July 22, 1969 A. J. CORNELIUS 3,456,722

THERMAL-OPERATED VALVE

Filed Dec. 29, 1966

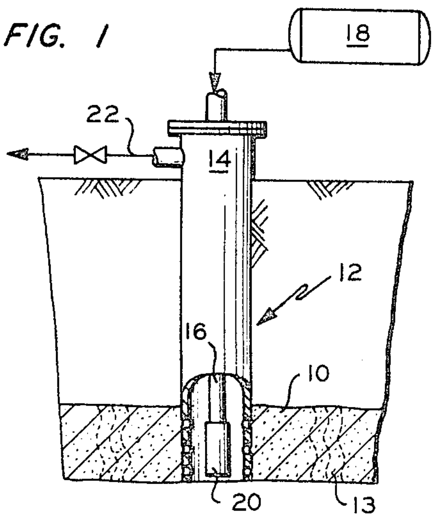

FIG. 1

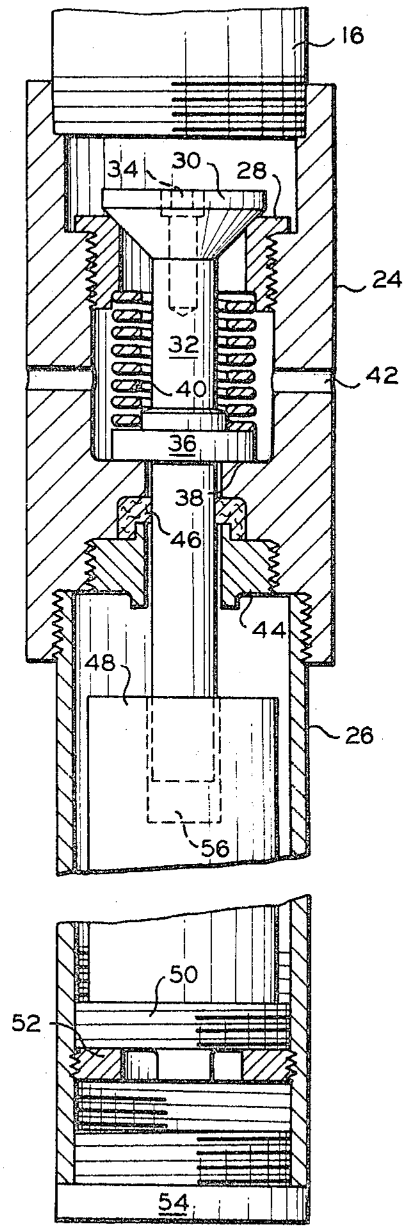

FIG. 2

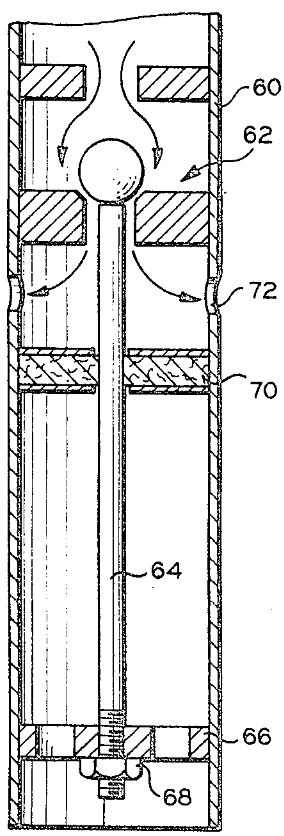

FIG. 3

INVENTOR.
A. J. CORNELIUS

BY Young & Quigg

ATTORNEYS

United States Patent Office

3,456,722

Patented July 22, 1969

1

3,456,722

THERMAL-OPERATED VALVE

Archie J. Cornelius, Bartlesville, Okla., assignor to Phillips Petroleum Company, a corporation of Delaware

Filed Dec. 29, 1966, Ser. No. 605,821
Int. Cl. E21b *43/16*; F16k *17/38*
U.S. Cl. 166—64 8 Claims

ABSTRACT OF THE DISCLOSURE

Automatic flow of a fluid coolant into an area subject to excess heating, such as in an in situ combustion oil well, is effected by a heat-operated valve on a fluid coolant line extending from a fluid pressure supply to the valve, said valve being opened by a heat expansible rod which makes contact with the valve head at a selected elevated temperature.

The invention relates to a heat-operated valve assembly and to a method of temperature control of an area subject to overheating, using the assembly.

The invention has been developed particularly for use in in situ combustion projects in oil sands wherein certain wells must be protected from excessive temperatures. Heretofore, this has been accomplished by installing a thermocouple in the well and utilizing the signal therefrom to regulate the flow of cooling fluid (usually water) into the well. The thermocouple cables are quite expensive and somewhat undependable in the downhole environment. A minimal amount of electrical instrumentation is always required to automate the system which adds to the expense, complexity, and unreliability of the method being used. Usually, a separate tubing has been used to inject the cooling water and unless special care is taken to insure that this tubing is maintained full of water, a delay occurs as the tubing is filled which sometimes results in burning out the thermocouple cables and/or damaging the well equipment.

Accordingly, it is an object of the invention to provide an inexpensive, effective, and reliable means for delivering fluid coolant to an area subject to overheating, when a set or selected temperature limit is exceeded. A further object is to provide a sure and effective process or method for controlling the temperature of an area subject to overheating. Another object is to provide a device and method for controlling downhole temperature in an in situ combustion well. Other objects of the invention will become apparent to one skilled in the art upon consideration of the accompanying disclosure.

A broad aspect of the invention comprises a heat-operated valve comprising a check valve in conjunction with an actuating rod which expands upon heating to open the check valve. The valve is positioned in a fluid coolant line terminating in the area in which heat control is desired with the check valve opening upstream in the valve body and the elongator extending from a fixed point downstream to the proximity of the check valve head so that upon expansion of the actuator rod the valve head is pushed off its seat to allow flow of coolant into the hot area to be cooled.

Thus, according to the invention, there is provided a heat-operated valve assembly comprising, in combination: an elongated hollow valve body having an axial inlet port in one end, a transverse valve seat in said inlet port, at least one outlet port thru its wall downstream of said seat, and means at said inlet port for attaching said valve body to a cooling fluid supply tube; a valve head disposed across said valve seat in said valve body, normally seated on said seat, and movable off said seat toward said inlet end to permit fluid flow thru said valve body to said outlet port; a housing attached to the other end of said valve body coaxially therewith; and an elongated axially disposed heat expansible actuator rod, of substantially higher coefficient of expansion than said housing, fixed within said housing to a section thereof remote from said valve head, and expansible at elevated temperatures into actuating contact with said valve head.

2

The valve assembly is particularly suitable for use in in situ combustion wells but it is also adaptable to any situation in which overheating of an area is likely to occur and prevention thereof is desired. Basically, it makes use of a differential coefficient of thermal expansion to unseat a check valve when the set temperature limit is reached or exceeded using an actuating rod of higher coefficient of expansion than that of the supporting structure.

A more complete understanding of the invention may be had by reference to the accompanying schematic drawing of which FIGURE 1 is an elevational view thru a well equipped with the apparatus of the invention; FIGURE 2 is a detailed longitudinal sectional view of one embodiment of the valve of the invention; and FIGURE 3 is a similar view to FIGURE 2 showing another embodiment of the invention.

Referring to FIGURE 1, an oil stratum **10** is penetrated by a production well **12** in use in an in situ combustion operation. Well **12** is equipped with a perforated casing **14** extending thru stratum **10** and with a water line **16** leading from a water supply tank **18** to a heat-operated check valve **20** positioned downhole. A production line **22**, above ground, connects with the well annulus for withdrawal of a production effluent containing oil. It is also feasible to run a separate production tubing string in the well instead of producing thru the annulus and line **22**.

Referring to FIGURE 2, valve body **24** is threaded onto water line **16** at the upper end and at the other end to a housing or skirt **26**. Valve seat **28** is threaded into valve body **24** across the axial opening thru the valve body. Valve head **30** seats on valve seat **28** and is connected to a valve stem **32** by means of a screw **34** or other means. Stem **32** is provided with a flange **36** spaced a substantial distance from valve head **30** and this flange seats on shoulder **38** in the valve body. The check valve is biased in the closed position by a compressed spiral spring **40**.

One or more outlet ports **42** for fluid coolant are provided thru the wall of valve body **24**. In order to prevent flow of coolant thru the valve body below ports **42** a threaded insert **44** is screwed into the valve body against packing **46**. Valve stem or push rod **32** extends a substantial distance below insert **44** and the lower end thereof is surrounded by or telescopes with elongator or actuator rod **48** which is enclosed within skirt or housing **26** to which it is secured at its lower end by threaded disc **50** seated against lock nut **52**. Rod **48** is welded, or otherwise fixed, to disc **50** as shown and is adjustable longitudinally within housing **26** to provide the desired temperature level for operation of the valve. A cap **54** is threaded into the lower end of housing **26** to prevent ingress of water, oil, etc. Actuator rod **48** is of substantially smaller diameter than the internal diameter of housing **26** to facilitate the elongation of the rod without undue friction with the housing. Drilled hole **56** in the upper end of rod **48** is of larger diameter than the diameter of valve stem or push rod **32** for the same purpose.

Referring to FIGURE 3, a tubular housing or valve body **60** encloses a ball check valve **62** of conventional construction and the ball is actuated (removed from its seat) by an elongator or actuator rod **64** which is threaded into a spider arrangement **66** and locked thereto by a nut 68. A packer arrangement 70 just below outlet port 72 prevents flow of coolant into the lower end of the device so as to force the coolant thru ports 72.

The operation of the device described and shown in the drawing requires the use of a material in actuator rod 48 or 64 which has a substantially higher coefficient of expansion than the tubing or skirt from which the actuator rod is supported at its lower end. The amount of clearance provided between the elongator or actuator rod and the point of contact with the valve for any given combination of materials in the actuator rod and the supporting housing determines the temperature at which the valve is opened by pushing the valve head off its seat. In other words, the spacing between the rod and its contact point with the valve is adjusted so that the rod will just contact the check valve at the selected maximum temperature limit to be tolerated in the particular application. A further temperature rise causes the metal rod to expand more than the case or housing, thereby unseating the check valve. The packing and side ports are provided so that the injected coolant does not cool the metal rod too quickly, which would cause the flow to fluctuate unduly. When the metal rod and sub-assembly cool below the set temperature, the check valve closes and shuts off the flow of coolant. The valve will continue to operate indefinitely without maintenance but can be made so that it can be retrieved from the well with a wire line when the set temperature limit is to be changed.

The housing for the actuator rod is preferably made of ordinary carbon steel and the actuator rod itself is preferably made of stainless steel which has a substantially higher coefficient of expansion. While stainless steel is the preferred material for the actuator rod, it may also be made of aluminum. Other materials for use in fabricating the actuator rod and its housing may be utilized, it being essential that the rod have a substantially higher coefficient of expansion than the supporting housing.

In one embodiment of the invention, valve body 24 was constructed to attach to a line 16 having an external diameter of 2⅜", housing 26 was fabricated of a 2⅜" seamless tube of ordinary carbon steel and actuator rod 48 was formed of a stainless steel rod 1¾" in diameter and 36" long. In this arrangement the temperature at which the valve operates is regulated by adjustment of the position of threaded disc 50 in the lower end of the housing or tube.

Certain modifications of the invention will become apparent to those skilled in the art and the illustrative details disclosed are not to be construed as imposing unnecessary limitations on the invention.

I claim:

1. A heat-operated valve assembly comprising, in combination:

an elongated hollow valve body having an axial inlet port in one end, a transverse valve seat in said inlet port, at least one outlet port thru its wall downstream of said seat, and means at said inlet port for attaching said valve body to a cooling fluid supply tube;

a valve head disposed across said valve seat in said valve body, normally seated on said seat, and movable off said seat toward said inlet end to permit fluid flow thru said valve body to said outlet port;

a housing attached to the other end of said valve body coaxially therewith;

sealing means disposed in said valve body downstream from said outlet port to prevent fluid flow into said housing from the interior of said valve body; and

an elongated axially disposed heat expansible actuator rod, of substantially higher coefficient of expansion than said housing, fixed within said housing to a section thereof remote from said valve head, and expansible at elevated temperatures to cause movement of said valve head off said valve seat.

2. The valve assembly of claim 1 wherein said sealing means is disposed between a section of said actuator rod and the surrounding wall.

3. The valve assembly of claim 1 wherein said valve head is mounted on a stem extending downstream into said housing and telescopes with the adjacent end of said actuator rod; and a spiral spring is disposed around said valve stem downstream from said valve head for biasing said valve head to said normally closed position on said seat.

4. The valve assembly of claim 3 wherein the end of said actuator rod which is remote from said valve body is fixed to a plug threaded into the inner wall of said housing to provide longitudinal adjustment of said rod to control the actuating temperature level of said valve assembly.

5. The valve of claim 3 attached at said inlet port to the bottom end of a coolant pipe extending from a fluid coolant supply above ground to an oil stratum thru a well penetrating said stratum for production of oil therefrom by in situ combustion wherein hot gases flow into said well.

6. The valve assembly of claim 1 wherein said valve head is a ball check valve held on its seat by fluid pressure and said actuator rod expands into contact with said ball.

7. The valve of claim 6 attached at said inlet port to the bottom end of a coolant pipe extending from a fluid coolant supply above ground to an oil stratum thru a well penetrating said stratum for production of oil therefrom by in situ combustion wherein hot gases flow into said well.

8. The valve of claim 1 attached at said inlet port to the bottom end of a coolant pipe extending from a fluid coolant supply above ground to an oil stratum thru a well penetrating said stratum for production of oil therefrom by in situ combustion wherein hot gases flow into said well.

References Cited

UNITED STATES PATENTS

306,352	10/1884	Prentiss	137—79 X
386,098	7/1888	Whitner	137—59
2,060,994	11/1936	Kindervater	137—79 X
2,213,950	9/1940	Crites.	
2,436,727	2/1948	Murphy	137—79 X
2,956,575	10/1960	Ammann	137—79
3,120,267	2/1964	Bayless	166—224 X
3,240,270	3/1966	Marx	166—11 X
3,343,598	9/1967	Meldav et al	166—11
3,343,598	9/1967	Meldau et al.	166—11

FOREIGN PATENTS

670,728	4/1952	Great Britain.

ERNEST R. PURSER, Primary Examiner

IAN A. CALVERT, Assistant Examiner

U.S. Cl. X.R.

137—79; 166—224