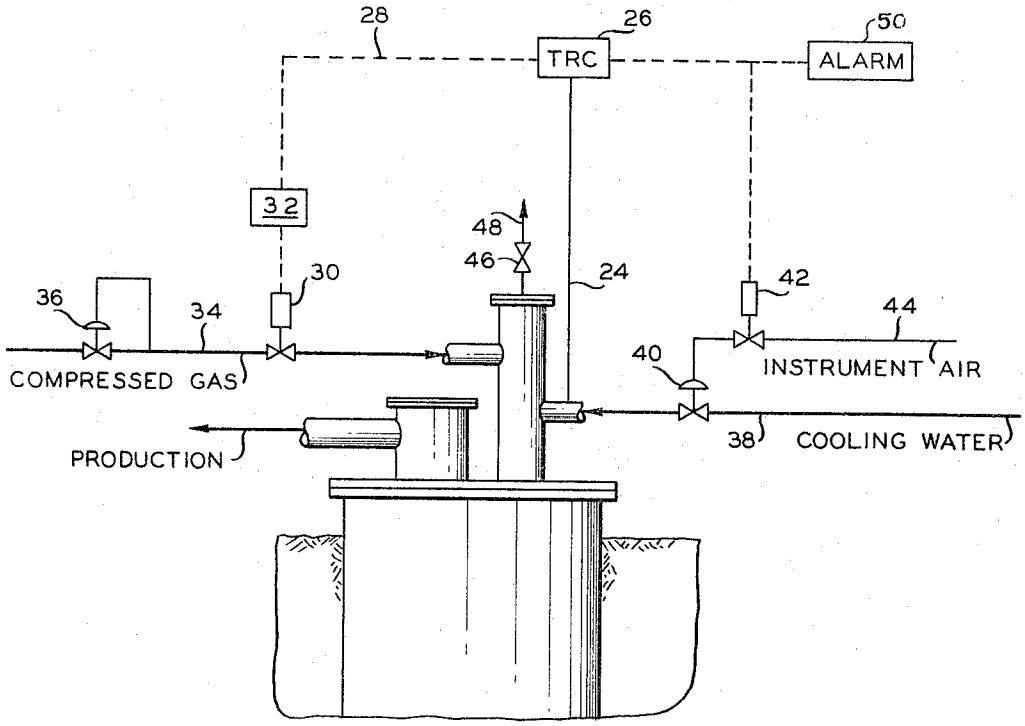
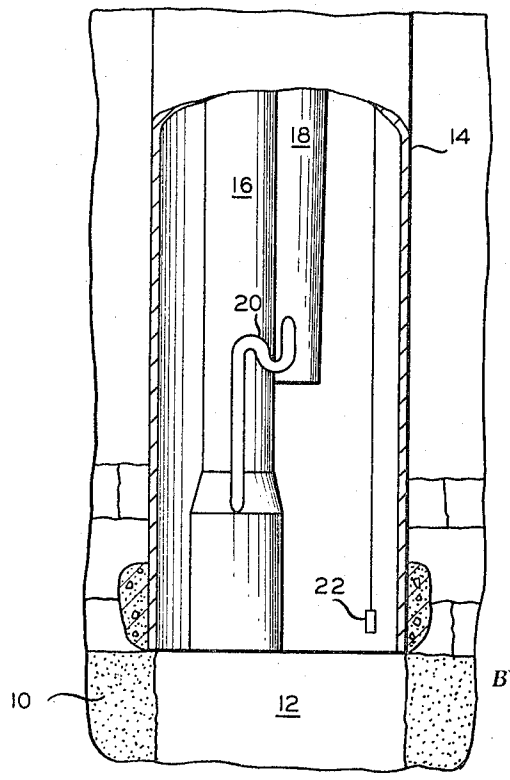
May 14, 1968 H. W. PARKER ET AL 3,382,923

EMERGENCY CONTROL OF INJECTION OF COOLING WATER INTO A HOT PRODUCTION WELL

Filed Dec. 13, 1965





INVENTORS
H. W. PARKER
R. F. MELDAU

BY Young & Quigg

ATTORNEYS

United States Patent Office 3,382,923 Patented May 14, 1968

3,382,923

EMERGENCY CONTROL OF INJECTION OF COOLING WATER INTO A HOT PRODUCTION WELL

Harry W. Parker and Robert F. Meldau, Bartlesville, Okla., assignors to Phillips Petroleum Company, a corporation of Delaware

Filed Dec. 13, 1965, Ser. No. 513,469
4 Claims. (Cl. 166—39)

ABSTRACT OF THE DISCLOSURE

In controlling downhole temperature in an in situ combustion production well to prevent damage to the downhole equipment, water is injected at a controlled rate thru a water conduit extending to the downhole area in response to sensed pressure or temperature downhole. When a sudden temperature and pressure condition occurs downhole in a deep well and the demand for water is suddenly greatly increased, the pressure downhole prevents flow of water into the downhole area for a substantial period and damage to the casing and production tubing is apt to occur. To assure almost immediate delivery of the required water under emergency conditions of this nature, high pressure gas is injected into the upper end of the water conduit at sufficient pressure to overcome the downhole pressure and force water out of the lower end of the water conduit.

This invention relates to a process and arrangement of apparatus for controlling cooling-water injection into a hot production well downhole during emergency conditions.

Copending application Ser. No. 430,000 of R. F. Meldau et al., filed Feb. 3, 1965, now Patent No. 3,343,598, discloses and claims a process and arrangement of apparatus for controlling the injection of cooling water downhole in a well adjacent a hot stratum during in situ combustion operation. The invention in said application is effective under all normal operating conditions to control the downhole temperature so as to avoid overheating the wellbore and downhole equipment. However, under emergency conditions wherein the wellbore temperature and pressure rapidly rise for any reason, such as wellbore ignition downhole in the production well, there may be a period of 5 minutes or more during which water does not enter the wellbore downhole from the water injection conduit. When this happens, the temperature rises sufficiently to damage or destroy downhole equipment for effective use in the production process.

When producing from a stratum such as one about 2000' below surface level, the water level in the water injection conduit is well below the wellhead because the pressure in the upper end of this conduit is substantially below atmospheric. This causes no problem in normal operation; however, with wellbore ignitions occuring accompanied by pressure surges, increased pressure reduces water flow into the injection conduit or shuts off water flow entirely until the water level in the tubing rises sufficiently to balance the new, higher pressure. Since this may take 5 minutes or more to transpire, the hot exhaust gases are certain to damage the casing and tubing in the well.

This invention is concerned with a process and apparatus for avoiding the problem described above and preventing damage to downhole equipment during emergency conditions downhole when the temperature tends to rise unduly from normal operating temperatures.

Accordingly, it is an object of the invention to provide a process and apparatus for maintaining the flow of water into a hot production wellbore downhole during temperture and pressure surges which tend to disrupt the normal flow of water into the well downhole from a water injection conduit. A further object is to provide an improvement in the process and apparatus of said application Ser. No. 430,000. Another object is to provide an arrangement of apparatus and a process for compensating for pressure and temperature surges during water injection into a hot production well thru a water injection conduit and restoring normal gas pressure in the water injection conduit after temperature and pressure conditions downhole have returned to normal. 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, as applied to the injection of water thru a water conduit extending downhole in a production well in an oil stratum under production by in situ combustion with hot gases being produced thru said well, flow of injected water being controlled in response to sensed temperature or pressure downhole, wherein temperature and pressure suddenly rise to establish emergency conditions which tend to damage well equipment, comprises injecting high pressure gas into the upper end of the water conduit to force water into the downhole area of the well against the higher downhole pressure during emergency conditions to reestablish normal conditions downhole. High pressure gas in the water conduit is bled off the upper end thereof as normal conditions are established.

In accordance with the invention, a gas injection conduit or line, connecting with a source of high pressure gas is tapped or otherwise connected into the upper end of the water injection conduit and provided with a normally closed valve. A device downhole for sensing either the temperature or the pressure at this locus and connected with a controller at ground level is provided. This controller is sensitive to the signal emitted by the downhole device and is in control of the valve in the gas injection line so that when above normal temperature or pressure downhole occurs, the controller opens the valve in the high pressure gas line which allows high pressure gas to invade the upper end of the water injection conduit and apply this high pressure to the column of water to overcome excessive downhole pressure and force cooling water into the wellbore adjacent the hot stratum to protect the casing and tubing in the hot area of the well.

A more complete understanding of the invention may be had by reference to the accompanying schematic drawing which is an elevation in partial section of equipment in and associated with a production well for effecting the invention.

Referring to the drawing, an oil sand or other combustible carbonaceous stratum **10** is penetrated by a well **12** which is provided with a casing **14**, a tubing string **16** and a water injection conduit **18** having a trap **20** and leading into the lower end of the production tubing **16**. The related structure of the water injection conduit **18**, tubing string **16**, and trap **20** is preferably that shown in the above-identified copending application.

Numeral **22** designates either a pressure sensor or a temperature sensor, such as a thermocouple, positioned

downhole adjacent stratum **10**, preferably, at the most sensitive temperature and pressure control spot. This device **22** is connected by a lead line **24** to a controller **26** which is either a temperature recorder controller or a similar pressure controller. Controller **26** is connected by lead line **28** with an open coil solenoid valve **30** thru a time delay switch **32**. Valve **30** is positioned in high pressure gas line **34** which is connected with a source of high pressure gas such as air, nitrogen, flue gas, CO_2, etc. A pressure regulator **36** may be positioned in line **34** upstream of valve **30**. A cooling water supply line **38** containing a motor valve **40** connects with the upper end of water injection conduit **18** and with a suitable source of cooling water. Motor valve **40** is controlled by controller **26** operating thru valve **42** in instrument air line **44** so as to control the introduction of cooling water, under normal operating conditions in well **12** downhole, in order to maintain a predetermined normal temperature and/or pressure downhole.

When emergency conditions occur downhole such as ignition of the carbonaceous material in the sand around the well bore or of produced hydrocarbon vapors, utilizing bypassed O_2 occurring in the production well, the pressure builds up so as to prevent the influx of water from conduit **18**. Under emergency conditions with a rapid rise in temperature and pressure, the introduction of water at a faster rate thru valve **40** is not sufficient to take care of the emergency condition because it takes too long to build up the column of water in conduit **18** against the pressure therein to provide immediate relief for the elevated temperature condition downhole. In this case, device **22** senses the surge in temperature or pressure and transmits a proportional signal to controller **26** which actuates valve **30** thru time delay switch **32** to allow high pressure gas to invade the upper end of the water injection conduit, thereby providing a slug of high pressure gas which supplies the necessary pressure to force water out the lower end of the conduit **18** into the wellbore until the normal temperature and pressure conditions are restored. During this time in which high pressure gas is in the upper end of conduit **18**, normally closed bleed valve **46** in vent line **48** gradually restores normal gas pressure, this valve being selected and constructed to operate above a selected normal pressure.

Time delay switch **32** is positioned in the circuit from the controller **26** to motor valve **30** so as to prevent operation of this valve in introduction of pressurizing gas during minor fluctuations in pressure or temperature sensed by device **22**. This switch is designed to operate after a delay of a short period from several seconds to 30 seconds or more.

Alarm **50** is connected with controller **26** which operates

the alarm when excessive pressure or temperature occurs downhole as sensed by device **22**.

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.

We claim:

1. In a process for controlling the flow of cooling water downhole into a production well penetrating a relatively deep oil stratum undergoing in situ combustion with hot gases entering said well from said stratum and ascending a tubing string therein, comprising maintaining flow of water thru a separate conduit to the downhole area of said well and regulating the flow of water in said conduit in response to a sensed value of one of the temperature and pressure downhole by increasing said flow as said sensed value increases and vice versa, wherein a sudden surge in gas temperature and pressure occurs downhole exceeding water pressure in the lower end of said conduit and a substantial period normally elapses before water pressure in said lower end of said conduit is increased sufficiently to overcome said gas pressure, the method of increasing said water pressure to immediately force water into the downhole gases comprising the steps of:

(1) injecting a high pressure gas into the upper end of said conduit at pressure substantially greater than the downhole gas pressure so as to force water from said conduit into the downhole area and restore normal temperature and pressure conditions;

(2) terminating the injection of said high pressure gas as normal downhole conditions are restored; and

(3) thereafter, bleeding off any resulting excess gas pressure from the upper end of said conduit.

2. The process of claim **1** wherein the temperature is sensed.

3. The process of claim **1** wherein the pressure is sensed.

4. The process of claim **1** wherein the injected gas is air.

References Cited

UNITED STATES PATENTS

Re. 26,220	6/1967	Records	175—205 X
2,347,769	5/1944	Crites	166—53
2,973,812	3/1961	MacSporran	166—11
3,135,324	6/1964	Marx	166—11 X
3,136,359	6/1964	Graham	166—11 X
3,202,219	8/1965	Parker	166—53
3,240,270	3/1966	Marx	166—11 X

CHARLES E. O'CONNELL, *Primary Examiner.*

I. A. CALVERT, *Assistant Examiner.*