July 8, 1969 R. TUGGLE ET AL 3,454,464

RESTRICTING PARAFFIN FORMATION IN PRODUCING WELLS

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Fig. 1.

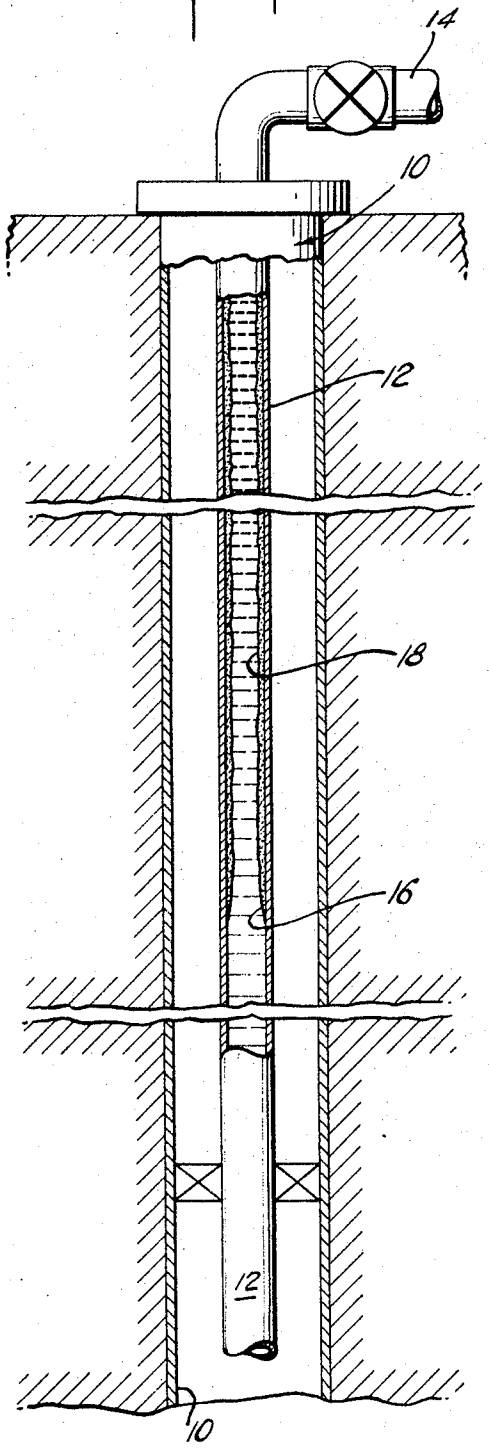
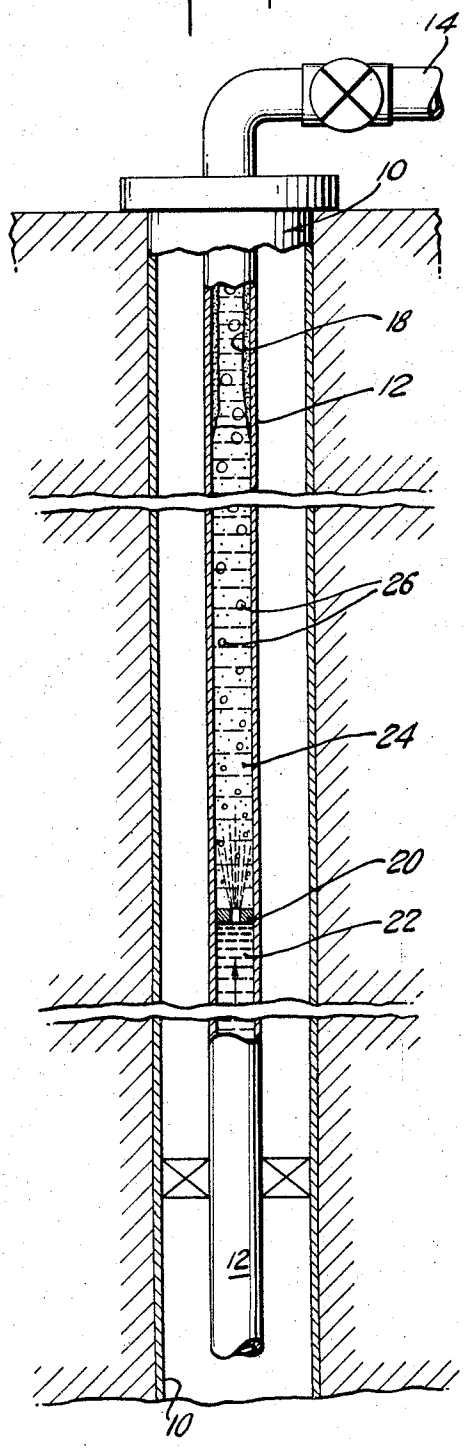


Fig. 2.



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RESTRICTING PARAFFIN FORMATION IN PRODUCING WELLS

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U.S. Cl. 166—304 4 Claims

ABSTRACT OF THE DISCLOSURE

Restricting paraffin deposition in flowing oil wells by producing a reservoir liquid containing normally liquid and gaseous fractions from which wax tends to deposit, and effecting a sharp drop in pressure sufficient to refrigerate the flow by vaporization and expansion of normally gaseous fractions and precipitate the wax as suspended particles which flow away with the produced oil.

The present invention relates to inhibiting or restricting the deposit of massive paraffin wax in producing wells which characteristically yield a stream of petroleum from which paraffin wax tends to be deposited as the production flows to the surface.

As is known, crude petroleum from subsurface reservoirs usually comprises a wide range of hydrocarbons typically extending all the way from normally gaseous components such as methane, to the normally solid materials such as paraffin waxes. In many producing wells the presence of the wax introduces no particular producing problem because, either the relatively low proportion of wax relative to the normally liquid fractions in which it is dissolved, or the nature of the solvent constituents cause it to remain in solution as it passes up through the producing string.

The present invention is particularly concerned with those crudes which while carrying both gaseous and normally solid paraffin in solution tend to commence precipitating the paraffin waxes at a temperature which normally prevails a substantial distance up to the bore-hole. From this point on up the precipitated wax continues progressively to deposit upon the interior wall of the production tubing. The deposit, therefore, builds continuously to the point where it tends to clog the tubing and may seriously interfere with the production of oil from the subsurface reservoir.

As a result it is necessary in oil fields of this character to remove such deposits, as for example, by periodically scraping the interior of the production tube to peel or cut away the deposits as particles which are hopefully carried upwardly by the produced fluids. Alternatively the well may be closed down and washed with a suitable paraffin solvent. The result in either event is costly in a directly material sense as well as in the loss of production, which results.

In accordance with the present invention we contemplate materially or substantially inhibiting or restricting wax formation by effecting a substantial and sharp chilling or refrigeration of the produced stream of petroleum through a substantial range of temperature at a point in the producing string at which wax deposition therein otherwise tends to commence. The chilling is effected instantaneously, through a range such that wax is precipitated as finely suspended particles which tend to slurry in the oil.

We have found that wax precipitation of this character can be effected by a controlled pressure drop as for instance by passing the produced stream through a choke appropriate to effect substantially instantaneous expansion of the contained normally gaseous constitutents of

the crude stream. Presumably, therefore, wax precipitation is the result of refrigeration by adiabatic expansion of the gases in accordance with the Joule-Thompson effect, as well as by the loss or evolution of the light gaseous hydrocarbons from the solvent liquid fraction, with absorption of latent heat of vaporization. There also may be a decrease in solubility of the remaining liquid fractions for normally solid waxes.

In any event, irrespective of the theoretical considerations, by which we do not propose to be bound, the produced stream is suddenly characterized by a precipitate of solid paraffins which, in the absence of the choke or restricted orifice would be built up on the wall of the tubing.

We have observed that whereas the solution of wax at or above the cloud point tends to deposit upon and adhere to the walls of the tubing, wax accumulations that have been removed, as for example by scrapping, do not tend to redeposit. The same appears to be true of wax which is precipitated or crystallized out of solution by autogenous cooling as above. Moreover, wax does not tend to deposit on surfaces at a materially greater temperature than the chilled liquid. In any event the precipitated paraffin wax remains as a slurry or suspension in the produced oil and is carried to the recovery facilities at the surface.

To the extent that the wax is precipitated it accordingly represents a corresponding decrease in wax deposition on the walls of the production tubing and a corresponding decrease in the costs attributable to removal of wax deposits in the production tubing.

It is furthermore important to note that the particles of wax thus precipitated and suspended in the produced stream, provide nuclei of considerable surface for the deposition of solid paraffin insofar as conditions of wax deposition may subsequently be again reached. That is to say, even though conditions of wax deposit are reestablished at some remotely elevated point in the tubing, the overall tendency toward deposition on the tubing string is greatly reduced, because the dissolved wax has a new and additional surface on which to build in lieu of depositing on the interior surfaces of the tubing. As a result it is contemplated that the massive wax deposits will be inhibited to an extent greater than indicated by the mere temperature drop effected at the orifice.

It follows from the foregoing that the orifice or choke is placed at an elevation not lower than the approximate region of incipient wax deposition in the absence of the orifice, that is to say, at the elevation where the solid or massive paraffin deposit commences to form on said tubing. Location at a point substantially lower than this obviously fails in some measure to meet the problem of wax deposition.

The flowing petroleum therefore passes through the choke directly into a region or zone of substantially lower pressure at which a substantial portion of the normally gaseous fraction is spontaneously released from solution with concomitant autogenous cooling of the stream and precipitation of finely divided particles of paraffin wax.

In order to more completely understand the operation of the present invention, reference is had to the attached drawing wherein FIG. 1 is a more or less diagrammatic elevation and sectional view of an oil well plagued by paraffin deposition commencing at an intermediate level between the reservoir and the surface, and FIG. 2 is a corresponding view indicating the condition of the well after the installation of the restrictive orifice.

Referring to FIG. 1 crude petroleum flowing from a subsurface petroleum reservoir reached by the well **10** is carried by way of a production tube or string **12** to the surface as at **14**, where it is distributed to collecting and treating means not shown.

As the hydrocarbon stream reaches point **16** the gradual cooling which has occurred during its flow to the surface has brought the stream to its cloud point. As a result, the production tubing thereabove is continuously coated with solid paraffin **18** which progressively builds up into a flow restricting mass to the obvious detriment of the producing operation.

Referring now to FIG. 2 the well disclosed in FIG. 1 has been supplemented by a choke represented by the reference numeral **20**. As a result of appropriate size selection, which may preferably be arrived at by trial and error, flow of the petroleum stream is sharply constricted so that it, on the lower or upstream side of the orifice **20**, as indicated at **22**, remains at a pressure and temperature sufficient to maintain the crude essentially in the liquid phase. On the upper or downstream side of the choke, however, the product, as indicated at **24**, is at a substantially lower pressure determined by the orifice size of the choke as well as the flow rate of the well, and the pressures both in the reservoir and at the surface. As a result the flowing product stream at **24** comprises liquid hydrocarbons interspersed with substantial quantities of released gas **26** which tend to form globules or bubbles of increasing size. In addition, as also indicated more or less diagrammatically, the autogenous cooling resulting from adiabatic expansion effects substantial precipitation of the wax as a precipitate or slurry which, as above explained, tends to pass to the surface without depositing on the tubing.

It is to be understood that the wells in question may comprise various other adjunctive equipment which is of no interest except insofar as it may indirectly impair the operation of the present invention. For example, the provision of pumping equipment in the well or even the conventional use of a choke to control the rate of production or to protect the well against accident have no significance or effect upon the present invention insofar as they are conventionally arranged at locations remote from the present critical location for wax inhibition.

On the other hand, a typical surface choke placed at or near the surface for storm protection may adversely limit the benefits available from the present invention by restricting the pressure drop otherwise available through the wax choke. That is to say, a surface choke applied to the well in FIG. 2 might and probably would impose a back-pressure on the produced stream, which could undesirably decrease the effect of choke **20**.

With reference to one installation in accordance with the present invention concerning a well producing from a relatively deep reservoir, investigation indicated that the paraffin deposition zone commenced at about 1875 feet from the surface. That is to say, wax deposition occurred throughout a zone extending from 1875 feet, to the surface. Further investigation indicated a cloud point approximately 101° F.

A 6 choke was set at a depth of 200 feet, the choke being sufficient to substantially restrict the flow of produced oil and introduce a localized pressure drop. Experimental investigation thereafter indicated a reduction or decrease in the paraffin deposition zone of over 400 feet. This result is believed phenonemal in view of among other things, the relatively poor location of the choke in proximity to the zone of wax initiation and the fact that the well in addition employed a surface choke which obviously imposed a back pressure which severely limited the available pressure drop at the wax controlling choke.

Various modifications and variations of the invention as hereinbefore set forth may be made without departing from the spirit and scope thereof and therefore only such limitations should be imposed as are indicated in the appended claims.

We claim:

1. In a producing well comprising means for conducting a stream of produced petroleum liquid, containing, in solution, a substantial normally gaseous fraction and a normally solid paraffin hydrocarbon fraction, from a subsurface petroleum reservoir to surface recovery facilities, said petroleum liquid having a cloud point substantially below reservoir temperature and above well head temperature such that solid paraffin deposit normally commences to form on the surface of said conducting means at an intermediate level in the well as a result of cooling of said stream as it travels to the surface, the improvement which comprises a restrictive orifice installed in said conducting means at an elevation not substantially below the point where said solid paraffin normally commences to form in the absence of said orifice, said orifice being selected and located to maintain a pressure and a temperature on the reservoir side thereof sufficient to retain said petroleum stream in substantially single phase condition and discharging said stream at a substantially lower pressure on the downstream side at which a substantial portion, at least, of the normally gaseous fraction of the petroleum is released from solution with concomitant autogenous cooling of the stream and precipitation of finely divided particles of wax therein.

2. A producing well as defined in claim **1** wherein the restrictive orifice is disposed at an elevation just below the point in the producing stream where the solid paraffin deposit commences to form in the absence of said orifice.

3. In the production of petroleum liquid containing a normally gaseous fraction and a normally solid paraffin fraction wherein said stream of petroleum is conducted from a subsurface reservoir to the surface turn well tubing with progressive pressure decrease and cooling as a result of which solid waxy hydrocarbon deposit on the walls of said tube beginning at an intermediate level therein, the steps which comprise effecting a sharp drop in the pressure of said stream at a point in said tube located at an intermediate level therein not substantially below the region at which the deposit of normally solid paraffin normally tends to be initiated, conducting said stream to said point of pressure change at a pressure and a temperature sufficient to retain said stream in a substantially liquid phase condition, discharging said stream therefrom at a materially lower pressure at which a substantial portion at least, of the normally gaseous fraction is released from solution therein with concomitant autogenous cooling and precipitation of finely divided particles of wax as a precipitate in the stream and conducting said stream to the surface without adherence of any substantial portion of said precipitated particles of wax to the well surfaces, such that wax formation on the walls of said tube is at least substantially diminished.

4. The method according to claim **3** wherein the pressure drop in such stream is effected just below the point in the producing stream where the solid paraffin deposit commences to form in the absence of said pressure drop.

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U.S. Cl. X.R.

166—224, 314; 208—370

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,454,464 July 8, 1969

Ray Tuggle et al.

It is certified that error appears in the above identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, line 40, "paraffin" should read -- paraffins --; line 42, cancel "to". Column 2, line 18, "scrapping" should read -- scraping --. Column 3, line 56, after "A" insert -- # --; same line 56, "200" should read -- 2000 --; line 61, "phenonemal" should read -- phenomenal --.

Signed and sealed this 2nd day of June 1970.

(SEAL)
Attest:

Edward M. Fletcher, Jr.
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Commissioner of Patents