Nov. 21, 1939. H. C. PYLE 2,181,099

GAS LIFT OR NATURAL FLOW WELL

Filed April 24, 1937

Fig. 1.

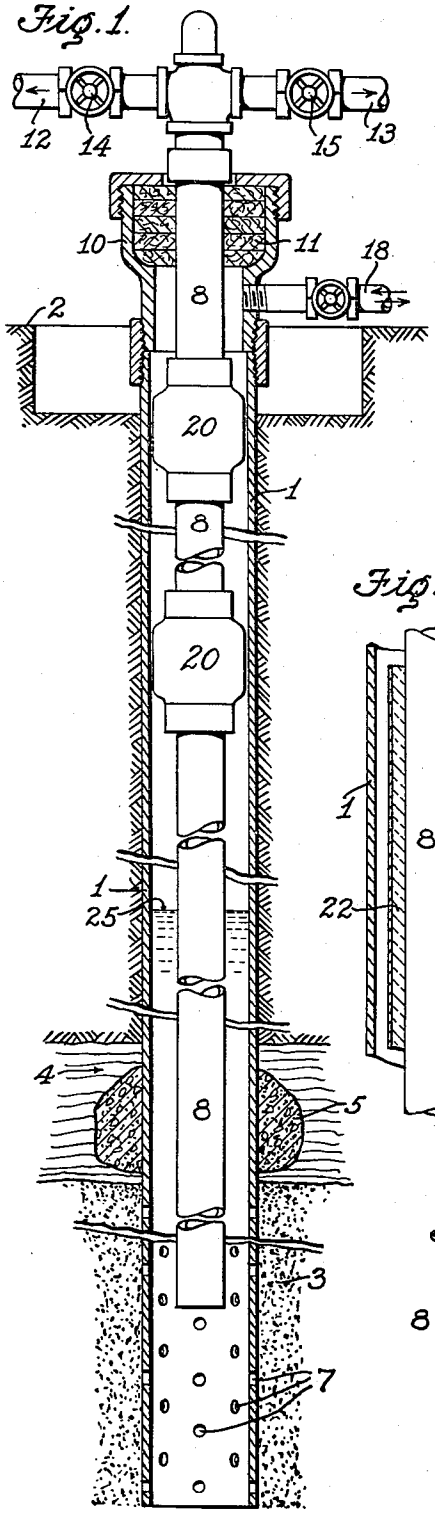


Fig. 3.

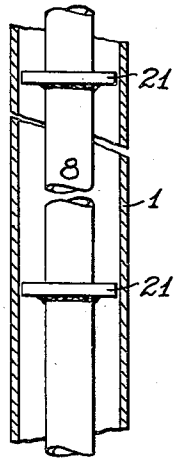


Fig. 2.

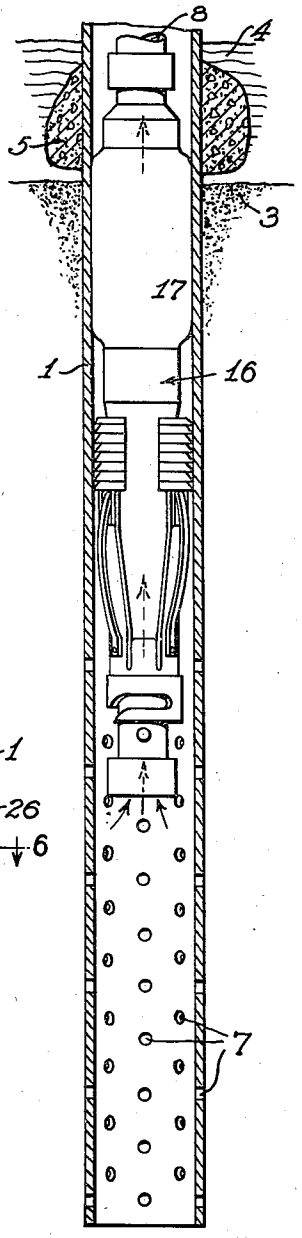


Fig. 4.

Fig. 5.

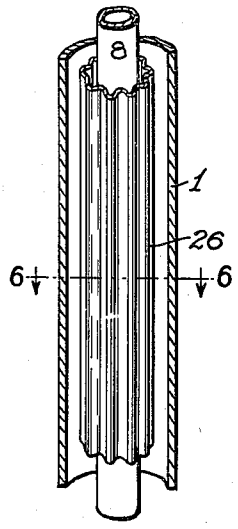
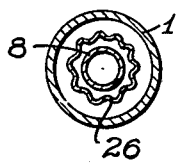


Fig. 6.



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Patented Nov. 21, 1939

2,181,099

UNITED STATES PATENT OFFICE

2,181,099

GAS LIFT OR NATURAL FLOW WELL

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Application April 24, 1937, Serial No. 138,769

3 Claims. (Cl. 166—1)

This invention relates to naturally flowing and gas lift wells, and particularly to naturally flowing deep oil wells.

In naturally flowing deep oil wells the force available for expelling the oil from the subsurface petroliferous reservoir comprises the combined hydrostatic liquid and gas pressure heads within the formation. The heat energy stored in the liquid in the producing formation by reason of the natural geothermal temperature gradient in the earth formations penetrated by the well bore also contributes to the energy of expulsion and lifting of the oil to the earth surface, and it is the particular object of this invention to present a means for more efficiently utilizing this available heat energy.

Other objects and features of the invention will be evident hereinafter in the description of the process and apparatus of a preferred embodiment.

In the drawing,

Fig. 1 illustrates a sectional elevation of a typical cased oil well. Figs. 2, 3, 4 and 5 illustrate optional arrangements of Fig. 1. Fig. 6 is a cross sectional view of the structure shown in Fig. 5 taken along the line 6—6 looking in the direction indicated.

The apparatus of the typical embodiment of the invention by way of illustration referring to Fig. 1 comprises a casing 1 extending from the ground surface 2 into an oil containing formation 3. A dense shale body which usually overlies producing formations and acts as the cap rock to confine the oil and gas under pressure in the producing sands 3 is illustrated at 4. The casing 1 is cemented at 5 in the shale body 4 in the manner conventional in oil well drilling practice to effect fluid tight connection with the oil formation and to exclude ingress of water and to prevent escape and loss of oil and gas to adjacent formations. The casing is thus put into direct communication with the petroliferous reservoir and subject to the pressure thereof.

The lower portion of the casing 1 which extends below the shale body 4 and into the oil sand formation 3 is perforated in suitable manner as shown at 7 to allow ready entrance of oil and gas while excluding to a large measure the surrounding sandy material.

An oil tubing 8 of a diameter substantially less than that of the surrounding casing is suspended therein and reaches from the casing head 10 to the region in the well behind or adjacent the before mentioned perforated section 7. The tubing 8 extends through the top of the casing, makes a gas-tight seal there and is partially supported by the packing 11 in the casing head 10. The tubing branch lines 12 and 13 are thus in communication through valves 14 and 15 with the oil producing formation.

As shown in an optional arrangement in Fig. 2, the tubing 8 may be connected at or near the bottom of the well to a tubing or casing wall packer 16 which closes off or seals the annular space between the casing 1 and the tubing 8 at a point 17 above the perforated section. The formation pressure may thus be excluded from the annular space in the casing and be confined to the inside of the tubing. Gas and oil will thus be forced to flow upward through the tubing 8 under the formation pressure.

The casing may be vented, exhausted or supplied with gas or other fluids by way of pipe 18. A plurality of spacers 20 serve to center the tubing in the casing, or to seal the annular space to form a plurality of substantially closed gas spaces.

In Fig. 3 an optional type of tubing spacer 21 in the form of a flange or disc is illustrated. In Fig. 4 a means for placing heat insulation 22 on the outside of the tubing is shown.

The operation is as follows:

Referring to Fig. 1, as the oil from the formation 3 flows through the perforations 7 in the casing, it will accumulate and rise in the tubing and the annular space between tubing 8 and casing 1 until an accumulated liquid level is reached as shown for example at 25. When the hydrostatic head of the accumulated liquid column extending to the liquid level 25 in the annular space between the tubing and the casing together with the gas pressure head confined in the casing thereabove acting upon the said accumulated liquid surface 25 becomes equal to or greater than the corresponding combined liquid and gas pressure head inside the tubing, upward flow in the tubing and expulsion of the accumulated and incoming oil from the producing formation will be initiated.

As the oil enters the lower end of the tubing it is generally laden with gas in solution and/or in the form of minute bubbles. As the oil rises in the tubing the hydrostatic head is progressively reduced, resulting in progressive release of additional gas from solution and expansion of the gas already present. This continues during the upward flow of the fluid in the tubing, until the oil reaches the top and flows from the well usually in the form of a highly gasified foam.

As stated hereinabove, the oil leaving the producing formation and entering the bottom end

of the well tubing contains a very substantial quantity of energy in the form of heat by reason of the geothermal temperature of the formation with which it has been associated. For example, the oil leaving the oil sand at a depth of 5000 feet will have a temperature of approximately 170° F. As this heated oil rises through the well tubing a portion of the heat is dissipated in the form of useful work upon the oil-gas column by release and expansion of the gas from solution in the oil and a portion is lost or wasted to the cooler surrounding formations by conduction and convection. It has been found that in wells of the depth mentioned hereinbefore the quantity of heat energy lost to the cooler surrounding formations in this manner may amount to as much as approximately four or five times the energy actually utilized in lifting the oil from the bottom of the well to the surface.

It is apparent, therefore, that this dissipation of heat from the upward flowing stream of oil to the penetrated formations constitutes a substantial loss which it would be highly desirable to conserve for the following reasons: First, a loss of heat from the upward flowing oil stream in the well results in a lower average fluid temperature and a resultant reduction of the volume to which the gas released from the oil can expand in its upward flow through the tubing. This in turn results in reduction of the velocity of the oil-gas mixture leaving the tubing at the top of the well. This means then that the over-all density or the average density of the upward-flowing oil-gas mixture throughout the length of the tubing is necessarily greater for any given rate of production by reason of the loss of heat to the formation than it would be under ideal conditions, for example, under adiabatic expansion where the total energy in the oil-gas mixture remains constant.

While this change in average density of the upward flowing oil does not alter the total energy necessary to lift a unit quantity of oil from the producing formation in the well to the earth surface, it does, however, directly affect the bottom hole pressure necessary to maintain the production of a given quantity of oil. In other words, under ideal conditions where no heat is lost to the formation either the well could be flowed at a higher rate of production for a given surface pressure or it could be made to maintain a given rate of flow at a lower bottom hole pressure than would be possible where heat is lost to the surrounding formations. It is evident, therefore, that the prevention of loss of heat from the upward flowing oil-gas mixture in the tubing of a well enables the well to be produced under flowing conditions from formations having lower pressures than is possible where the loss of heat is allowed to take place, and that the well would therefore have a longer life and produce a greater quantity of oil under natural flowing conditions, before artificial means would be necessary to continue its production. It is also evident that conservation of the heat in the upward flowing oil-gas mixture would similarly allow a higher rate of production for a given formation pressure by either natural flow or gas-lift method.

It is an object of this invention, therefore, to present a means for conserving the heat energy of the upward-flowing oil in a producing well.

These heat losses to the surrounding formation have been found to take place principally by conduction and convection. In deep oil wells drilled even under the best of conditions the downward course usually follows a more or less divergent path which results, in the absence of especial means to prevent it, in contact between the tubing and casing throughout a substantial length thereof. This allows a ready conduction of the heat from the contents of the tubing to the formation through the casing. A minor portion of the heat loss from the tubing also passes from the tubing to the casing by conduction through the gaseous contents of the annular space therebetween.

It has been found that this loss of heat from the upward flowing contents of the well tubing to the surrounding cooler formations, can be materially reduced in a number of ways. For example, a plurality of spacers may be employed throughout the length of the well to center the tubing in the casing, thereby preventing the contact of one with the other. These spacers preferably may take the form of rubber protectors such as those well known in drilling operations for preventing frictional contact of the drill pipe with the casing in the well. These rubber protectors may be spaced at regular intervals throughout the length of the tubing and supported by any suitable means such as for example, the tubing joint collars as shown at **20** in Fig. 1. The advantage of employing rubber spacers lies in the fact that such material is a poor conductor of heat. Other similar suitable materials, such as duprene, may be employed.

The tubing spacers may also take any other suitable form, such as, for example, large annular shaped cut washers made of sheet steel as shown at **21** in Fig. 3. These steel spacers may also be supported by the tubing joints as in the case of the rubber protectors or they may be attached to the tubing at frequent intervals by spot welding. The spacers in their preferable form are of such size and shape as to substantially close the annular space between the tubing and casing in such a manner as to divide the said annular space throughout the depth of the well into a plurality of separated cells. It is also desirable that these cells be as short as possible between spacers commensurate with the allowable weight to be supported upon the tubing and the cost of such installation. The reduction of the size of the cells is advantageous in reducing the length of convection current paths which, as is well known, results in an increase in the heat insulating properties of such gas spaces.

It may also be desirable as an alternative or in combination with the above described tubing spacing means, to provide the tubing with an insulated coating material as illustrated at **22** in Fig. 4. This insulating covering may take the form of any well known insulating material such as, for example, mineral wool, held in place by suitable metallic binding.

As described hereinbefore in connection with Fig. 2, the tubing may be provided with a bottom hole casing wall packer which is adapted upon manipulation well known by those skilled in oil well production art to seal off the space between the tubing and the casing, thus substantially preventing ingress of oil or gas from the producing zone into the annular space between the tubing and casing thereabove. The casing wall packer thus enables the space in the casing surrounding the tubing to be maintained at a lower pressure than would otherwise be possible. The gas pressure in the casing may therefore be reduced by venting it to the atmosphere through the casing

heat outlet pipe 18. The pressure in the casing may even be reduced to subatmospheric pressure by connecting the vent pipe 18 to a suitable vacuum gas line. The reduction in pressure in the gases in the casing with the attendant lowering of the gas density therein results in a corresponding reduction in loss of heat by conduction through gas from the contents of the well tubing to the surrounding formation.

An alternative method of compensating for heat losses from the well to the surrounding formations and thereby prolonging the flowing life of a gas lift well, comprises introducing heated injection gas through pipe 18 at a temperature sufficiently high to compensate for the heat losses to the formation in the well. By this method the period or life of the well in which it will continue to flow satisfactorily under gas lift will be materially increased before it is necessary to resort to other methods of production such as pumping. In the case of the latter method of introducing heated injection gas, the above mentioned spacers and insulating materials are either omitted or constructed to provide adequate clearance for the flow of such gases down the casing. The bottom hole packer would of course be omitted under these conditions.

The foregoing is merely illustrative of a preferred embodiment of the invention and is not to be limited thereby, but may include any process and apparatus which accomplishes the same results within the scope of the claims.

I claim:

1. Means for reducing the bottom-hole back-pressure required for a given rate of production in a naturally flowing or gas lift well comprising in combination a well containing tubing and casing and means supported by said tubing near the bottom of said casing to substantially seal the annular spacing therebetween and means to maintain a reduced gas pressure in the annular space between the tubing and the casing above said sealing means.

2. Means for reducing the bottom-hole back pressure required for a given rate of production in a naturally flowing gas-lift well comprising in combination a well containing tubing and casing means supported by said tubing near the bottom of said casing to substantially seal the annular space therebetween, spacing means supported by said tubing to prevent contact between said casing and said tubing and means to maintain a reduced gas pressure in the annular space between the tubing and the casing above said sealing means.

3. Means for reducing the bottom-hole back pressure required for a given rate of production in a naturally flowing or gas lift well comprising in combination a well containing tubing and casing means supported by said tubing near the bottom of said casing to substantially seal the annular space therebetween, spacing means supported by said tubing to prevent contact between said casing and said tubing and means to control the gas pressure in the annular space between the tubing and the casing above said sealing means.

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