Jan. 5, 1943. H. D. WOODMANSEE 2,307,557

APPARATUS FOR ELEVATING FLUIDS IN WELLS

Filed May 7, 1940

Fig. 1.

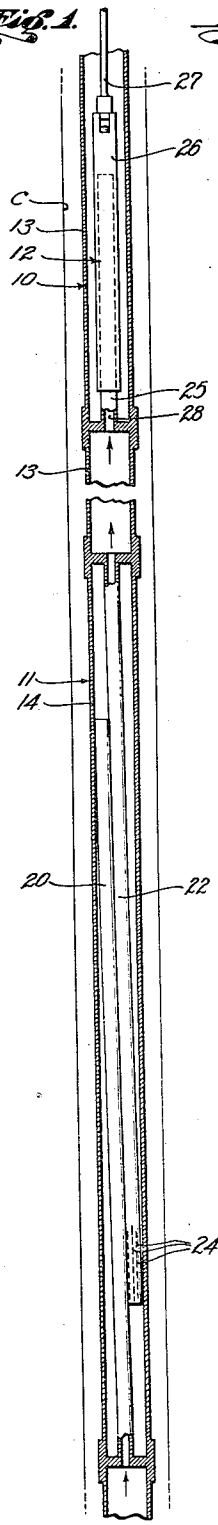


Fig. 2.

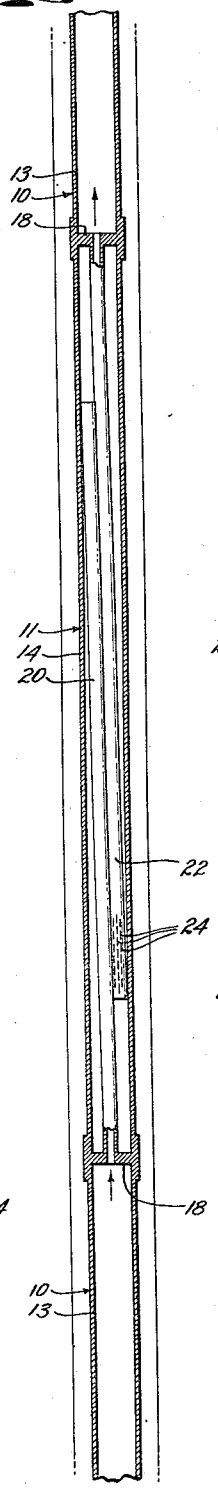


Fig. 3.

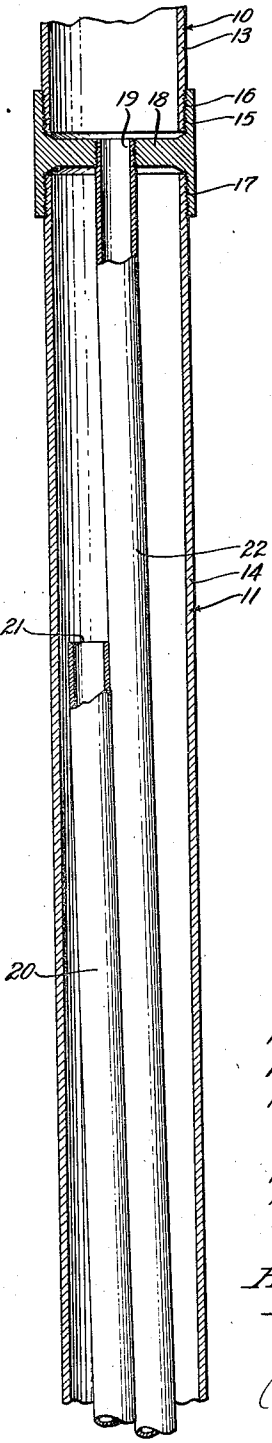
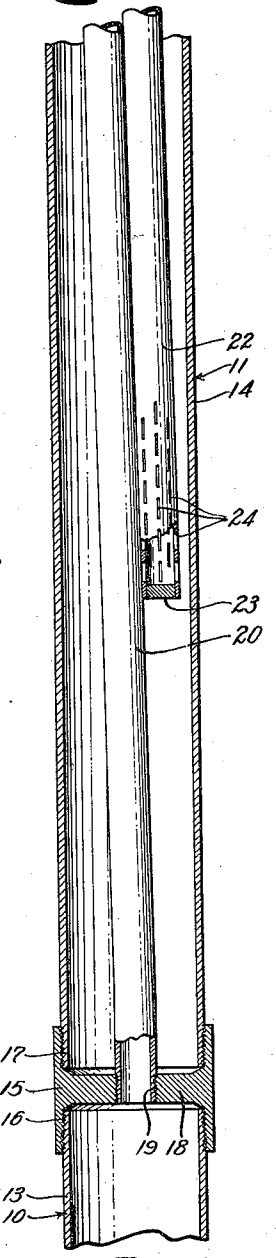


Fig. 4.



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APPARATUS FOR ELEVATING FLUIDS IN WELLS

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3 Claims. (Cl. 103—5)

This invention relates to well equipment and relates more particularly to apparatus for elevating liquids in wells where the gas pressure is insufficient to cause the well to flow and for increasing the production of flowing wells. A general object of the invention is to provide a simple, effective and economical apparatus of this character.

Another object of the invention is to provide a fluid elevating apparatus of the character referred to embodying one or more gas lifts or separators constructed and arranged to most efficiently utilize the fluid pressure or gas pressure to successively elevate the liquid.

Another object of this invention is to provide an apparatus of the character referred to in which a minimum number of separators or lift units is required.

Another object of this invention is to provide an apparatus of the character referred to in which the separators or lift units are related and located to take full advantage of the natural tendency for the gas to elevate the liquid before it separates from the liquid at given levels and the elevating units serve to remix the gas with the oil or other liquid at or below each natural level of separation to provide for the successive stages of lifting action.

Another object of this invention is to provide an apparatus of the character referred to that is simple and does not require valves or other parts liable to wear or fail.

Another object of this invention is to provide an apparatus of the character referred to embodying a pump for receiving the fluid after it leaves the uppermost lift unit or separator and before the gas is allowed to again separate from the liquid, the pump operating to discharge the fluid from the top of the well, assuring a substantially constant maximum production with a minimum expenditure of power.

A further object of the invention is to provide an apparatus of the character referred to that is effective in increasing the production of flowing wells. When the apparatus is employed in a flowing well the separator or lift units serve to reduce the separation of the gas from the oil and operate to remix the gas with the liquid or oil so that there is a greater proportion of oil produced.

The various objects and features of my invention will be fully understood from the following detailed description of a typical, preferred form and application of the invention, throughout which description reference is made to the accompanying drawing, in which:

Fig. 1 is a diagrammatic view of the upper portion of the apparatus arranged in a well with the body parts and tubing in longitudinal cross section. Fig. 2 is a view similar to Fig. 1 showing the lower portion of the apparatus in the well. Fig. 3 is an enlarged longitudinal detailed sectional view of the upper portion of one of the separators and Fig. 4 is a view similar to Fig. 3 showing the lower portion of the separator, certain parts appearing in side elevation in Figs. 3 and 4.

The apparatus of the present invention as employed in a non-flowing well may be said to comprise, generally, a tubular well string or production string 10 arranged in a well, one or more gas lift units 11 connected in the string 10 and a pump 12 for elevating the fluid after it leaves the uppermost lift unit 11.

The tubular string 10 extends into the well from the ground surface to pass through the well casing C with suitable clearance. The casing C is suspended from the usual casing head and the tubing string 10 is suspended from a suitable tubing head. Casing heads and tubing heads are conventional in the various forms of well production equipment and as the present invention is not primarily concerned with the details of these structures the heads have been omitted from the present disclosure. It is to be understood, however, that the casing head and the tubing head are provided with the usual fluid connections, etc. The string 10 of tubing extends downwardly in the well to have its lower end in receiving relation to the producing sands or productive zone of the well. In most cases there will be a column of fluid standing in the well and extending upwardly into the well casing C and the string 10 may extend a considerable distance into this fluid column. In accordance with the usual practice the string 10 may be made up of lengths of pipe or tubing 13 connected by suitable threaded couplings.

The separators or gas lift units 11 are interposed in the string 10 to utilize the elevating action of the gas under pressure for the successive elevation of the oil or liquid. The number of units 11 employed depends upon numerous factors such as the depth of the well, the gas pressure, the ratio of gas and oil, etc. It is a feature of the invention that a large number of separators or units 11 is not required. The lowermost separator or unit 11 is positioned only a short distance below the plane where the gas would normally separate from the fluid flowing up in the string 10 and, in most cases, this lowermost unit 11 is spaced from the well bottom a distance equal from one-third to one-half the depth of the well. The second to the lowermost separator or lift unit 11 is located slightly below the plane where the gas would again separate from the oil or liquid flowing up through the string 10 from the first or lowermost unit 11. In many cases the second to the lowermost unit 11 will be a relatively short distance from the top of

the well although where the well is very deep the second to the lowermost unit 11 may be a substantial distance from the ground surface in which case a third or even a fourth unit 11 may be required. It is important to note that the separators or gas lift units 11 are only required at points below the planes of normal separation of the gas from the liquid flowing up in the string 10 and that these points are usually a substantial distance apart so that the minimum number of units 11 is required.

Each separator or lift unit 11 comprises a barrel or body 14. The bodies 14 of the units 11 may be lengths of tubing similar to the lengths of tubing 13. A coupling 15 is provided at each end of each body 14. The couplings 15 are screw threaded to the tubing sections 13 at 16 and are screw threaded to the bodies 14 at 17. Transverse webs or partitions 18 are provided in the couplings 15 and form the upper and lower walls of the bodies 14. The webs or partitions 18 may be integral parts of the couplings 15 or may be otherwise formed. A central vertical opening 19 is provided in each partition 18.

The separators or lift units 11 each further include an inlet tube 20 extending upwardly from its lower partition 18. The lower ends of the inlet tubes 20 are screw threaded or otherwise fixed in the openings 19 of the lower partitions 18. The inlet tubes 20 extend upwardly a substantial distance in their respective bodies 14 to have their upper ends a short distance below the upper partitions 18. The tubes 20 are preferably quite small in diameter and fluid capacity and are received in the bodies 14 with substantial clearance. The upper ends 21 of the tubes 20 are open to discharge into the bodies 14.

Each separator or lift unit 11 further includes an outlet tube 22 arranged to conduct the fluid from the body 14. The outlet tubes 22 extend downwardly from the upper partitions 18 having their upper ends screw threaded or otherwise fixed in the openings 19 in the upper partitions. The outlet tubes 22 are quite small in diameter and are of substantial length to have their lower ends spaced a short distance from the lower partitions 18. The tubes 20 and 22, arranged and proportioned as described, overlap or extend for a considerable distance in side by side relation. The tubes 20 and 22 are secured in the central openings 19 of the partitions 18 and, therefore, may engage one against the other but as the tubes are quite small in diameter and quite limber they readily lean in opposite directions as illustrated in the drawing so that this interference or engagement is of no consequence. The centralized attachment of the ends of the tubes 20 and 22 to their respective partitions 18 is desirable for obvious reasons.

The lower portions of the outlet tubes 22 are formed to receive the fluid from the lower portions of the bodies 14 and, in accordance with the invention, are constructed to effectively mix the gas with the oil or liquid when sufficient volumes of gas have accumulated in the bodies 14 to discharge through the tubes 22. Closures or plugs 23 may close the lower ends of the outlet tubes 22. The lower portion of each outlet tube 22 is provided with a plurality of slots 24 for admitting fluid from the bodies 14 to the interiors of the tubes. The slots 24 are narrow and are formed to effectively "scrub" the gas into the oil or liquid when the conditions are such that oil and gas both enter the tubes 22. The size and number of the slots 24 are such that the separators or lift units 11 have the required capacity.

The pump 12, while not required in every installation, is usually desirable as it provides for a substantially constant flow from the well and relieves the lift units 11 of a dampening or choking pressure that might otherwise develop. In accordance with the invention any suitable or selected form of well pump may be employed. The pump 12 is arranged in the string 10 above the uppermost lift unit 11 and in accordance with the invention is arranged slightly below the plane where the gas would normally separate from the oil or liquid after leaving the uppermost unit 11. This uppermost plane of gas and liquid separation may be a substantial distance above the uppermost unit 11 and may be only a short distance from the top of the well. Accordingly, the pump 12 may not be required to lift the fluid a great distance and may be operated with a minimum expenditure of power.

In the diagrammatically illustrated apparatus the pump 12 is of the standing plunger and working barrel type having a plunger 25 suitably anchored in the string 10 and having a barrel 26 reciprocating down over the plunger. The barrel 26 is operated by a pump rod 27 extending to the ground surface and the pump embodies the usual standing and working valves. The inlet 28 of the pump 12 directly receives the fluid from the interior of the string 10 below the pump. The pump 12 may operate to elevate the fluid through the upper portion of the string 10 or, if desired, a second or inner string may be employed to conduct the pump fluid upwardly from the pump to the ground surface.

In use or operation the apparatus is installed as above described to have the lowermost lift unit 11 slightly below the plane of separation of the gas from the fluid flowing through the string 10 and the second to the lowermost unit 11 is likewise arranged a short distance below the plane of natural separation of the gas from the oil or liquid passing upwardly through the string 10 after leaving the lowermost unit 11. Where more than two units 11 are employed the units are, in each case, arranged a short distance below the plane of natural separation of the gas from the liquid flowing upwardly through the string 10. Because of this positioning of the units 11 the full natural lifting action of the entrained gas is utilized and a maximum delivery of liquid to the units is assured. With the lowermost unit 11 positioned a substantial distance from the bottom of the well or the production zone the fluid is free to flow upwardly through the string 10 to said unit 11 and there is no choking action or retarding action due to the installation of lifts or separators in the lower part of the string 10.

The gas is delivered to the units 11 while still mixed or entrained with the oil or liquid and separates from the liquid only upon the discharge of the fluid into the bodies 14. This separation of the gas from the oil or liquid is not, of course, necessarily complete and a substantial proportion of the gas may remain mixed with the oil which falls into the lower portions of the bodies 14. The liquid discharging from the upper ends of the inlet tubes 20 falls into the lower portions of the bodies 14, which are closed by the lower partitions 18. A substantial body of liquid soon accumulates in the lower portion of each body 14 and this liquid rises above the lower end of the outlet tube 22 and its slots 24.

The gas under pressure accumulates in the upper portions of the bodies 14. The liquid accumulating in the lower portions of the body 14 is forced through the perforations or slots 24 and upwardly through the outlet tubes 22 by the gas pressure accumulating in the upper portions of the body 14. In practice, there may be a substantial prolonged delivery of oil or liquid from a unit 11 by the action just described. The gas, delivered to the units 11 with the liquid, accumulates in the upper portions of the bodies 14 and the accumulations of the gas increase. In time the lower level of an accumulation of gas in a body 14 reaches the slots 24 so that gas as well as liquid is delivered to the related outlet tube 22. The slots 24 are narrow so that this gas is thoroughly mixed with the liquid leaving the unit 11. Thus the gas that separates from the liquid in the units 11 is remixed with the liquid to assist in the stage elevation or successive lifting of the liquid through the string 10. The liquid and gas levels in the units 11 may fluctuate from time to time as the ratio of gas and oil changes. However, it will be apparent that the gas separating from the oil or liquid as it passes through the units 11 is ultimately substantially entirely remixed with the oil or liquid for the next lifting stage.

The pump 12 may be in continuous operation and serves to elevate the fluid through the upper portion of the well. As above described, the pump 12 is located a short distance below the plane of natural separation of the gas from the liquid that has been lifted from the uppermost unit 11 and there is little or no free gas delivered to the pump 12. Accordingly, the pump 12 operates without a gas lock condition developing. The pump 12 operating to pump away fluid delivered to it by the uppermost unit 11 greatly assists the units 11 in their stage elevation of the fluid.

In applying the invention to a flowing well the pump 12 is not necessary. When a well is flowing from natural causes there is usually a marked tendency for the gas to separate from the liquid or oil so that the well produces liquid and free gas. When the apparatus of the present invention is utilized in a flowing well the gas is held in the oil and there is a much greater proportion of oil produced than there would be if the well was allowed to flow naturally. In the case where the apparatus is installed in a flowing well the separators or units 11 are installed and located as above described, that is, they are positioned adjacent and slightly below the planes where the separation of the gas would normally occur. The gas that separates from the liquid accumulates in the upper portions of the bodies 14 and the pressure of the gas in the bodies builds up and operates, as above described, to assist in elevating the liquid through the string 10. Further, the gas pressure thus maintained in the units 11 keeps the fluid under a substantial pressure and prevents, or at least greatly reduces, the separation of the gas from the oil. The gas leaving the bodies 14 remixes with the liquid or oil when the fluids pass through the slots 24, this action being described above. The fluid is produced from the well with a minimum of gas separation and the production is proportionately increased.

Having described only a typical preferred form and application of my invention, I do not wish to be limited or restricted to the specific details herein set forth, but wish to reserve to myself any variations or modifications that may appear to those skilled in the art or fall within the scope of the following claims.

Having described my invention, I claim:

1. Apparatus for elevating fluid in a well producing liquid and gas under pressure comprising a tubular string extending into the well to conduct the fluids therefrom, a plurality of vertically spaced fluid lift units interposed in the string, the lowermost unit being adjacent and below the plane of separation of the gas from the liquid rising in the lower portion of the string, the other units being adjacent and below the planes of separation of the gas from the liquid rising in the string from the units next below them, and a pump adjacent and below the plane of separation of the gas from the liquid rising from the uppermost unit for elevating the fluid to the ground surface.

2. Apparatus for elevating fluid in a well producing liquid and gas under pressure comprising a tubular string extending into the well to conduct the fluids therefrom, a fluid lift unit interposed in the string adjacent and below the plane of separation of the gas from the liquid rising through the lower portion of the string and operable to elevate the liquid through the string by the pressure of the accumulating freed gas, and a fluid lift unit interposed in the string adjacent and below the plane of separation of the gas from the liquid rising from the first named lift unit and operable to further elevate the liquid in the string by the pressure of the accumulating freed gas, the portion of the string between the units being free and unrestricted, each of said units including a body having a chamber, an inlet tube for carrying the fluid upwardly from the portion of the string below the body to the upper portion of the chamber, and an outlet tube for carrying the fluid upwardly from the lower portion of the body to the part of the string above the body.

3. Apparatus for elevating fluid in a well producing liquid and gas under pressure comprising a tubular string extending into the well to conduct the fluids therefrom, a fluid lift unit interposed in the string adjacent and below the plane of separation of the gas from the liquid rising through the lower portion of the string and operable to elevate the liquid through the string by the pressure of the accumulating freed gas, and a fluid lift unit interposed in the string adjacent and below the plane of separation of the gas from the liquid rising from the first named lift unit and operable to further elevate the liquid in the string by the pressure of the accumulating freed gas, the portion of the string between the units being free and unrestricted, each of said units including a body having a chamber, an inlet tube for carrying the fluid upwardly from the portion of the string below the body to the upper portion of the chamber, and an outlet tube for carrying the fluid upwardly from the lower portion of the body to the part of the string above the body, the lower portion of the outlet tube having slots for admitting the fluid from the body and serving to mix the gas with the liquid as the fluids enter the outlet tube.

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