This invention relates to apparatus for and method of continuously flowing gas wells in the presence of liquid accumulation at the bottom thereof, and for continuously flowing oil wells having low bottom hole pressures, without the necessity of artificially raising said bottom hole pressures, and without the use of pumps or compressors.

To those familiar with the art of producing natural gas from from wells it is well understood that the two greatest difficulties in continuous production are: first, the drop in the underground or bottom hole pressure; and second, the accumulation of water or other liquid in the bottom of the hole to such an extent that it rises and covers the inlet of the pipe or pipes thru which the gas is being produced, thus effectively preventing the production of gas alone and forcing the operator to remove the liquid from the hole bottom by pump or other means. The continuous or periodic removal of this water by pump or other means is costly, and as a consequence there are thousands of gas wells today which are non-productive and idle, simply because the cost of removing the liquid from these holes and keeping it below a certain level costs more than the value of the gas produced. Similarly there are thousands of oil wells which are not at present producing oil, simply because the cost of pumping the oil from them is greater than the value of the oil produced; and there are other thousands of oil wells which are being pumped at present, but which return their operators only a very small net profit because of the high cost of the pumping operation.

In view of these difficulties, it is the chief object of this invention to provide apparatus which will continuously raise either gas or oil or other liquid from the bottom of a well to the earth's surface, yet which requires only the existing bottom hole pressure to do so.

Another object of the invention is to provide apparatus which will maintain the liquid at the bottom of a well cavity at a selected level, thus leaving the major portion of the walls of the cavity, and of the producing formation, exposed to permit the free ingress of oil or gas into the cavity.

The details in the construction of a preferred form of my invention, together with other objects not previously mentioned, will be better understood from the following description when read in connection with the accompanying drawing, which are chosen for illustrative purposes only, and in which

Figure 1 is a diagrammatic view of a well drilled into the earth's surface, and illustrates one embodiment of the invention installed therein, parts of the invention being shown in elevation and parts in section.

Figure 2 is an enlarged vertical sectional view of a portion of the apparatus illustrated in Figure 1.

In considering the following description of the invention, it should be borne in mind that the principle on which this invention is based is: that while it takes approximately 170# per square inch bottom hole pressure to continuously flow a solid column of oil or mixed oil and water 400 feet high, a pressure of only 40# per square inch is capable of continuously flowing a 400 ft. column of a mixture of air or gas and water or oil in which mixture the liquid is atomized and makes up only 25% or less of the total mixture. In other words, by atomizing the liquid a lower pressure is capable of lifting it, though at a reduced volume of flow.

To accomplish the objects above recited I provide a packer 5 (Figure 1) of any suitable type which is placed at any desired level in the drilled well above the upper end of the cavity 4 at the well bottom, and serves to shut off the well cavity (and the producing formation) from that portion of the well above the packer, forming a closed pressure chamber therebelow.

In the well cavity 4 I position one or more ejectors of any standard type or design. In Figure 1 it will be seen that twin ejectors, designated as a whole by the numerals 8 and 7, are suspended from the lower ends of three separate strings of tubing 3, 9 and 10, each of which is suitably anchored at the earth's surface, and extends downward thru the packer 5, and into the well cavity.

The strings 8 and 9 serve as production tubing for carrying gas, gas and atomized oil, or gas and atomized water to the earth's surface. Each communicates at its upper end with a header pipe 11 which serves to deliver the production to any desired point. Volume flow thru these strings of production tubing into the pipe 11 is controlled or shut off by valves 12 and 13 respectively. The lowermost ends of each of these strings of production tubing 8 and 9 are respectively fitted with ejector sections 14 and 15, the lower ends of which are in the form of combination suction and delivery jets 16 and 17, as shown. Depending from and rigidly secured to the lower ends of both these sections 14 and 15 is a substantially cylindrical open bottomed skirt 18, the side wall of which is provided with a plurality of inlet
perforations 19. Rigidly supported within the skirt 8 are a pair of short pipe sections 20 and 21, the upper ends of which are fitted respectively with gas delivery atomizing jets 22 and 23, and the lower ends of which open communicate with the tubing string 18 through an intake pipe section 29, as shown. At some point below the packer 5 a four-way open cross joint 28 is inserted in the tubing string 18, the two open ends of the joint affording free entrance for gas into this tubing, from the interior of said closed pressure chamber. The upper end of tubing string 18 is normally closed by a control valve 24, and may also be fitted with a suitable gauge 25 for gauging the bottom hole pressure when desired.

Actually, the entire tubing string 18 is not essential to the operation of the apparatus, and that portion of it which extends from the packer to the earth’s surface may be completely eliminated. When installed, however, it may be used for gauging the bottom hole pressure, for “cleaning out” liquid from the well cavity after a shut-down, or for continuously supplying pressure to the ejectors either to supplement, or to replace bottom hole pressure. The last mentioned operations are accomplished by connecting the discharge line from a compressor to the nipple 28, and opening the valve 24. In case it is desired to continuously supply pressure from the earth’s surface, the cross joint 28 may be eliminated, or, as shown, the operation may be facilitated by the installation of a pipe 21 (Figure 2) in the line at the four-way cross joint 28 at the time the tubing string is assembled. This pipe serves to conduct air or gas at high speed to a point well past the open intake ports in this cross joint, and well into the pipe section 29 below, which feeds the ejectors. This arrangement prevents any great loss of the air or gas being forced to the ejectors.

The apparatus illustrated and described is primarily for use in comparatively shallow wells, or in wells of medium depth in which the bottom hole pressure is still fairly high, but in which the inflow of liquid is excessive. When installed in such wells it will be seen that the gas which collects above the liquid in the closed pressure chamber will enter the open ports in the cross joint 28, pass downward thru the pipe section 29, thru the jets 22 and 23, will pick up and atomize a certain amount of liquid at this point, and will carry these tiny droplets of liquid upward thru the tubing strings 14 and 15 to the earth’s surface. Naturally, the jet sizes vary both according to the bottom hole pressure and according to the rate at which the liquid accumulates in the cavity.

By using a relatively small opening in the jets, and increasing the number of jets used, the liquid can naturally be removed at a greater rate, and can be lifted a greater distance. The number of jets required and the passage area required can be determined mathematically after the bottom hole pressure and the rate of accumulation of liquid has been, and can be determined by measurement. Naturally, the capacity of the jets to raise liquid from the well should be greater than the flow of liquid into the well. Thus the liquid would never completely cover the jet intake openings, and the raising or lowering of the jets in the well would determine the maximum permitted liquid level. Should the rate of accumulation of liquid decrease after prolonged continuous production, one or more of the strings of production tubing may be taken out of operation by simply closing one or more of the control valves 12 or 13, therefore conserving the gas pressure. If water, alone, is accumulating at the well bottom, and gas is the sole valuable product being produced, then the more strings of production tubing in operation, the better. By lowering the jets 22 and 23 to a point near or just below the bottom surface of the lowermost producing sand, the liquid is kept off the sand, and a much greater area of the producing sand is thus freed of any obstruction to the inflow of gas or liquid into the well cavity.

This is an extremely important result produced by the invention, and has, in actual use, raised the gas production of a well by as much as 500%. While I have described and illustrated only one specific embodiment of my invention I am aware that numerous alterations and changes may be made therein without transcending the invention disclosed, and I do not wish to be limited except by the prior art and by the scope of the appended claim.

I claim:

Apparatus for utilizing natural bottom hole gas pressure to raise liquid from a well cavity to the earth’s surface, comprising: a string of production tubing for conducting gas and oil from the well cavity to the earth’s surface; packing means between said production tubing and the wall of the well forming a closed chamber below it for the accumulation of gas and liquid; a liquid atomizing jet positioned to discharge upwardly into the lower end of said production tubing; an open feeder pipe for continuously feeding gas from the space above the liquid in said closed chamber to said jet; and a conduit extending from the earth’s surface through said packing means into said closed chamber, its open lower end extending well into the open upper end of said feeder pipe to form an injector.

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