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FLOW STABILIZER FOR OIL WELLS

Filed June 11, 1956

2 Sheets-Sheet 1

FIG. 1A.

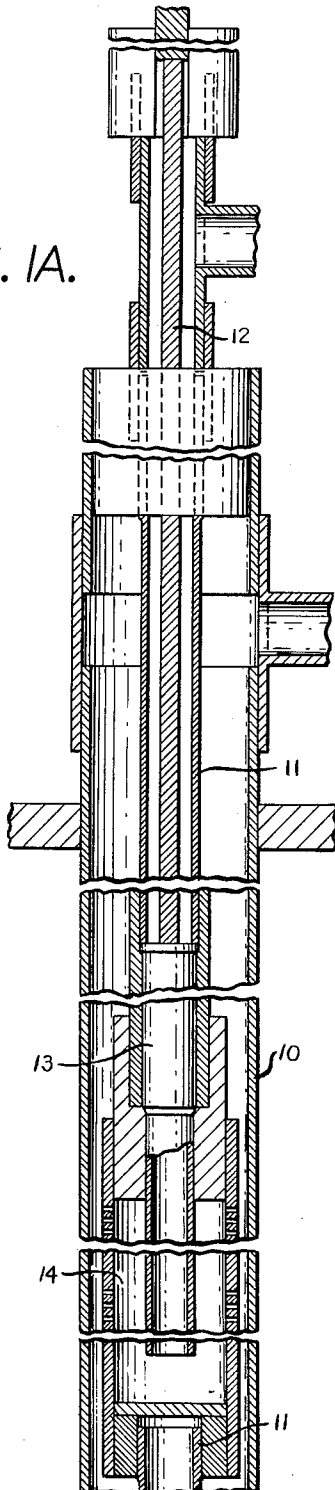
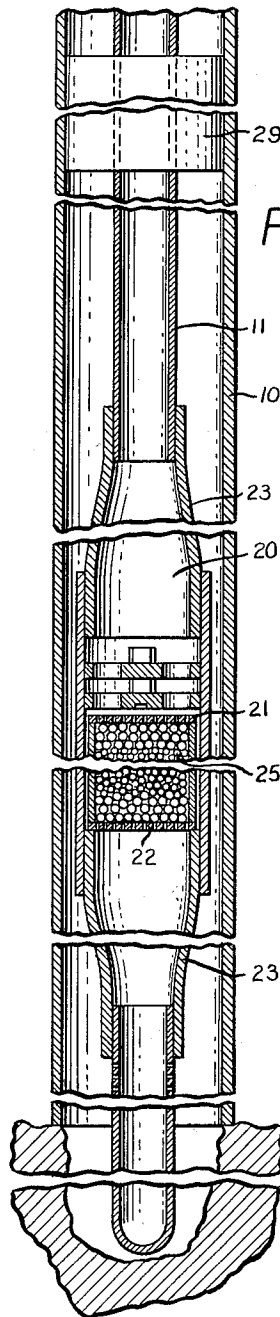


FIG. 1B.



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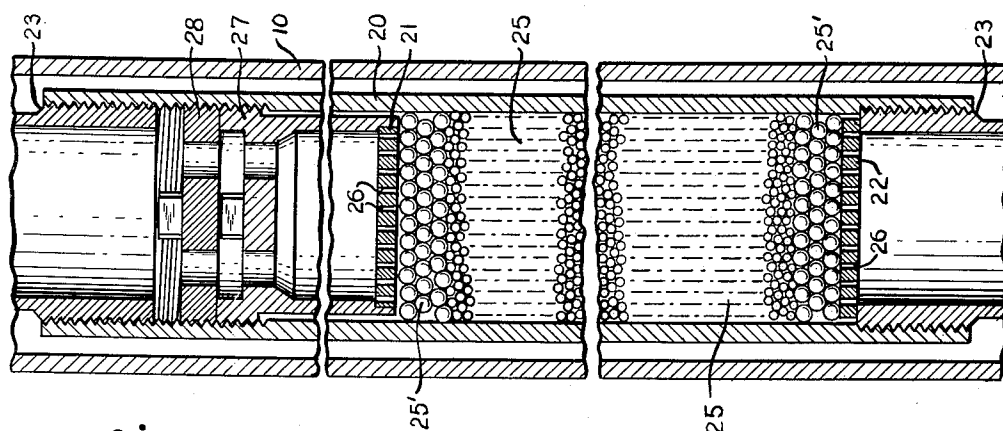
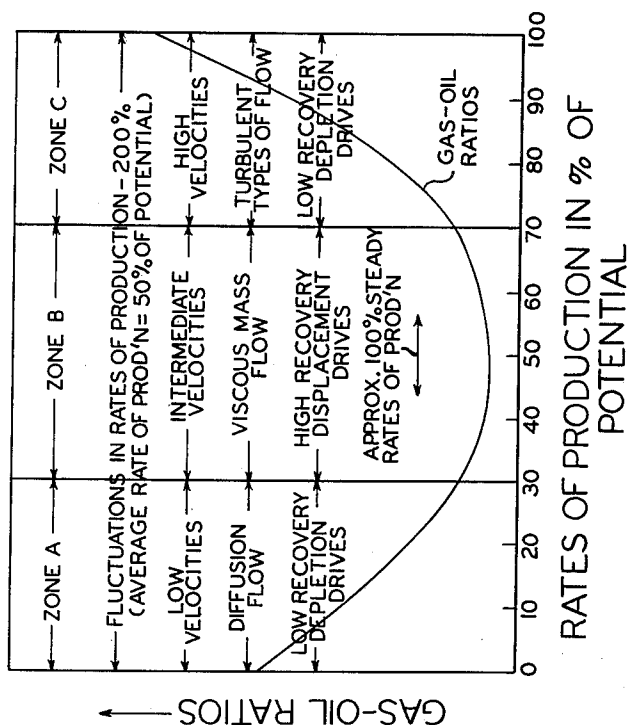


FIG. 2.

FIG. 3.



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FLOW STABILIZER FOR OIL WELLS

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3 Claims. (Cl. 138—43)

This invention relates to a flow stabilizer for the reduction by absorption of fluctuations in velocities of fluids in oil wells, of which the reduction of fluctuations in velocities at sand faces of a selected type of oil wells and resulting fluctuations in production rate is considered, below, as an example.

It has been recognized for some time that control of rate of production of oil wells, and particularly with reference to controlling the ratio of gas and oil production, is of vital importance in maintaining optimum production rate and maximum yield. Thus, a recent authoritative industry report states: "Control of production rate is essential to any effective method for improving production efficiency and, therefore, production rate is perhaps the most important single factor which must be regulated." (Progress Report by the Special Study Committee of The American Petroleum Institute, [Dallas, 1942], pp. 18—19.) Suitable flow control devices have been demonstrated to produce production improvements of the order of twenty percent. Because head pressures in oil sands are approximately steady over brief periods of time, production rates are controllable by control of back pressures at sand faces. For example, in 55 wells in the Pecos County, Texas, oil field, average gas-oil ratios were reduced approximately 25% by the use of tapered tubing, which reduced the adverse influence of fluctuating back pressures, created by uniform sizes of tubing. In my previous Patent 2,251,244, issued July 29, 1941, for Pressure Regulator, there is disclosed a pressure regulating device incorporating means for automatically leveling out fluctuations in the back pressure at the sand face of a well, but this mechanism involves operational difficulties and liabilities to failure which are unavoidable in automatic pressure regulating devices and the equipment is difficult to service due to its placement at a rather deep point within the well. In general, control methods heretofore available have affected essentially only the average working conditions, whereas the actual conditions at the sand face fluctuate in a very marked manner due to pressure variations with each stroke of the pump, in pumping installations, or pressure variation with slippage of gas in natural flow or gas lift installations. Usually, a petroleum deposit is a sandy structure containing petroleum with dissolved and undissolved gas, and defined by a clay or rock dome or other interface on the top and water on the bottom. Too rapid withdrawal of oil and gas may permit the entrance of water adjacent the well and ahead of the major part of the otherwise recoverable oil supply. In other cases, dissolved and other gas which should be available for forcing the oil into the well from the surrounding sand structure, may be dissipated, or excessive production rate may produce pressure depletion even where the gas-oil ratio is initially not excessive. In many cases, there is an optimum pressure at the sand face and an optimum rate of production, which should be steady for best results. When this rate is exceeded, depletion will occur, typically, first at the sand face and then progressively further and further into the sand structure, ultimately causing one of the above-mentioned difficulties.

It is an object of the present invention to provide an improved method and means for controlling the pressure conditions at the sand face in an oil well.

It is also an object of the invention to provide such a

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method and means by which substantially constant conditions at the sand face may be maintained.

In the drawing:

FIGS. 1-A and 1-B are, respectively, upper and lower central axial sections of an oil well embodying the invention in a preferred form;

FIG. 2 is an enlarged fragmentary axial section showing a pressure absorption chamber; and

FIG. 3 is a chart illustrating variation in production of gas-oil ratio and rates of production.

In the important class of wells which have substantial free gas at sand faces, low production rates create a diffusion type of flow, characterized by high gas-oil ratios and relatively low oil recoveries, as illustrated in FIG. 3. High production rates, in percent of potential, create excessive production rates, i.e., produce fluid out of oil zones at rates greater than fluid is replaced into the critical zones closely adjacent to the sand faces. This continuous phenomenon creates excessive rates of pressure depletion, initially at sand faces, with resulting turbulent types of flow (meaning thereby turbulence, gas-slippage and/or flow through gas-channel flow-paths), with up-stream spreading, excessive gas oil ratios and relatively low oil recoveries. The optimum flowing conditions are between the above described low and high production rates. It has not heretofore been recognized that the conditions applicable to over all average production rate of an oil well apply also and even more forcibly to the instantaneous condition within the well and particularly at the sand face and in the adjoining structure. Thus, if at any given time, the sand face back pressure is too low, a turbulent type of flow conditions described above is created, resulting in the blowing and wastage of gas, while if the pressure is too high, a diffusion flow condition may result, in either case increasing rate of pressure depletion and the gas-oil ratio above the optimum values which will necessarily occur at some intermediate sand face back pressure. In point of fact, where the sand face pressure fluctuates, as it commonly does, the flow conditions adjacent the sand face may periodically be reversed, creating a condition, so far as energy loss is concerned, which is worse than any condition of diffusion or of a mere turbulent type of flow.

Even where the fluctuation in pressure at the sand face is apparently small, and of the order of 1% or thereabouts, as, for example, a fluctuation of about 5 p.s.i. with a total average pressure of 500 p.s.i., the effect on production may be quite large, since the fluctuation is large with relation to the pressure drop from sand pore to sand pore in the structure adjacent the sand face. The best available estimates as to the extent to which the pressure fluctuation will transmit back into the sand-oil structure at a typical fluctuation frequency such as 5 seconds, is about 80—90%, leaving an untransmitted fluctuation of the order of 0.5 to 1.0 p.s.i. This compares with an average pressure drop from adjacent sand pore to sand face of perhaps 0.1 p.s.i. and it is quite apparent that the disturbance of flow conditions will be substantial.

In a well operated according to the present invention, there is interposed between the source of pressure fluctuation, whether a pump or gas-oil column, and the sand face, a pressure regulating or absorbing device consisting essentially of a large number of pores or interstices communicating with each other through restricted flow passages, whereby the pressure fluctuation must transmit back through a large number of gas-filled cells and intermittently oil filled restricted orifices, which are arranged in series. It is apparent that a structure of this character will even out pressure fluctuation to any desired extent. The pressure regulator of the invention most conveniently takes the form of a chamber filled with balls, preferably

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spherical and uniform in size. The balls may be of glass, ceramic, metallic, or other suitable substances, depending on the particular conditions, and their precise size will not ordinarily be too critical.

In the drawing, there is indicated a well embodying the invention as applied to a pumping well, FIGS. 1-A and 1-B being, respectively, upper and lower sections of the well. The structure in general is conventional. The outer casing 10, inner tubing 11, sucker rod 12, working barrel 13 and gas anchor 14 are all conventional. In the absence of pressure regulating means according to the invention, pressure fluctuation such as above discussed would exist in a well of this character. However, in the lower part of the tubing 11, there is positioned a somewhat enlarged chamber 20 containing upper and lower perforated diaphragms or headers 21 and 22, between which is contained and, preferably, packed, a mass of balls through which the oil and hitherto unseparated gas must flow on the way to the pump.

The balls 25 may conveniently be an eighth inch to one inch in diameter and the chamber containing the same may be of any desired length, depending upon operating conditions, a chamber ten to twenty feet in length being suitable in many cases. The pressure fluctuation absorption chamber is best shown in FIG. 2. The enlarged tube or chamber 20 may be advantageously as large as is conveniently accommodated by the outer casing 10, being connected to the inner tubing 11 by suitable reducers 23. The parts will be screwed together or fastened together in any other convenient manner, so as to exert the pressure through partitions 21, 22 on the mass of balls 25. These balls are preferably of uniform diameter, except for the top and bottom layer 25' or two, which may be considerably larger for the purpose of preventing blocking of the holes 26 in the headers or diaphragms 21, 22. While the adjustment of distance between headers 21 may be made in various ways, the upper header 21 is conveniently carried by a threaded sleeve member 27

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which is screwed into the tubing 20, as indicated, and may be held in place by the threaded locking member 28.

As will be understood, the parts are preferably dimensioned so as to position the entire chamber between headers 21 and 22 as well as the packer 29, below the solid fluid level.

What is claimed is:

1. In an oil well installation, pressure fluctuation absorbing means comprising a tubing section forming part of the gas-oil flow path, perforated headers at the top and bottom of said section, and a mass of balls in the space between said headers and filling said space, confining and restricting the flow path therebetween to a large number of relatively small interstices connected by restricted flow passages.

2. In an oil well installation, pressure fluctuation absorbing means according to claim 1, comprising open tubing sections above and below said headers and continuing the first said tubing section.

3. In an oil well installation, pressure fluctuation absorbing means comprising a tubing section forming part of the gas-oil flow path, perforated headers at the top and bottom of said section, and a mass of balls in the space between said headers, confining and restricting the flow path therebetween to a large number of relatively small interstices connected by restricted flow passages, the said mass of balls filling said chamber and being pressed together between said headers.

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