

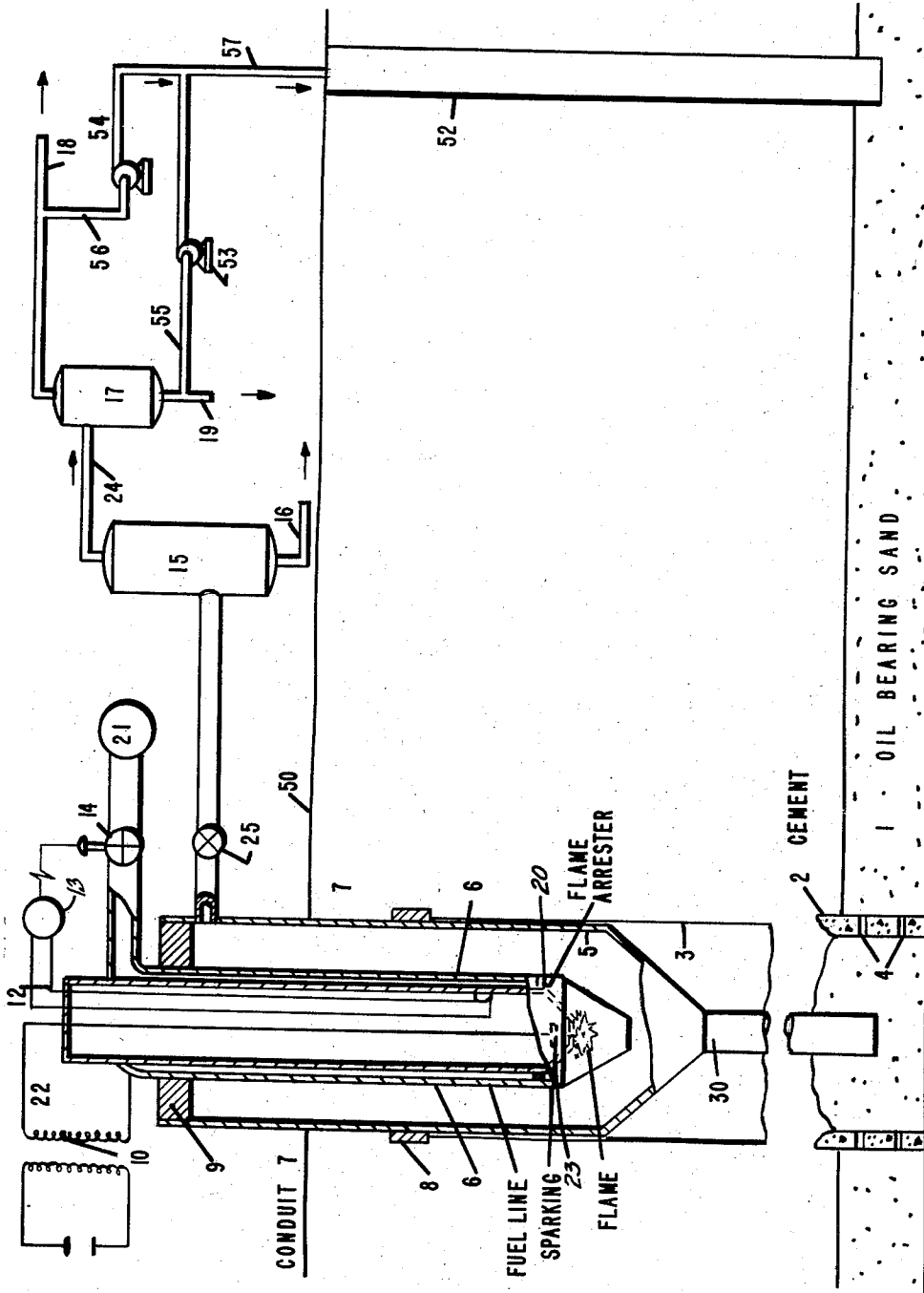
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PROCESS FOR THE RECOVERY OF OIL FROM SUBTERRANEAN RESERVOIRS

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PROCESS FOR THE RECOVERY OF OIL FROM SUBTERRANEAN RESERVOIRS

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The present invention is broadly concerned with an improved process for the recovery of crude oil from subterranean oil-bearing formations. The invention is more particularly concerned with the use of a submerged flame in processes for the recovery of crude oil. In accordance with the present invention, a submerged jet flame is utilized in a producing well to heat the oil being produced to an elevated temperature. A specific adaptation of the present invention is to reintroduce a portion of the distilled lighter products into the reservoir in order to further increase the production of oil.

In conventional crude oil producing operations, situations are frequently encountered wherein oil wells cease to produce at practical rates even though it is known with certainty that all available recoverable oil has not been obtained from the field. Furthermore, there are various instances in producing operations in which it is desirable to utilize heat in order to increase the production of oil. In the past, generally, the heat has been applied in conventional equipment located on the surface. However, the cost of this equipment limits the application of heat to a relatively few operations. In accordance with the present invention, by the use of a submerged flame jet by which combustion is carried out at a high pressure, it is possible to use some of the piping in the oil well itself as a combustion chamber and thus avoid the otherwise expensive investment in heating equipment.

The employment of the submerged jet flame in accordance with the present invention has additional advantages which make its use highly desirable and effective. For instance, it is well known that the efficiency of recovering oil depends, among other factors, on its viscosity. For example, if the viscosity of the oil is high, in many operations production of only 10% of the total oil in the reservoir is secured by conventional means. One method of increasing recovery is to dilute the heavy oil in the reservoir with a lighter oil in order to reduce the viscosity and thus increase the total yield.

It is well known that liquefied petroleum gases are excellent materials for this purpose, but frequently they are not available in the desired quantities in the oil fields being produced. Another source of light oils is the light components of the crude oil itself. These light, or low boiling constituents, may be distilled off and returned to the reservoir to aid in washing out the heavy crude oil that would ordinarily be unrecoverable. If this be done by conventional means an expensive system of gathering the oil at a central location and considerable distillation equipment are required.

The present invention provides an economic and desirable means of carrying out this segregation of light ends from the crude on each individual well as it is being produced.

The process of the present invention may be fully appreciated by reference to the drawing illustrating one embodiment of the same.

Referring specifically to the drawing, a well bore is shown extending from the surface 50 to oil-producing

sand 1. The well is completed by seating casing 3 in the sand and cementing it with a grout of suitable cement 2. The cement and casing are perforated and communication is established between the oil sand and within the casing by means of bullet holes 4. The oil is produced through tubing 30 which is swedged into an enlarged section 5 in which section is located the submerged jet equipment. For example, typical casing size might be about 6 7/8 inches in diameter, while the oil is produced from a small pipe 30 which is about 2 inches in diameter. This pipe is swedged to a pipe of about 5 1/2 inches in diameter.

The tubing is connected to the casing by suitable casing head equipment 8. A fuel pipe 6 disposed within 5 carries the fuel supply for the submerged flame jet, as well as, the control equipment disposed within conduit 7. A flame arrestor 20 is located at the lower part of fuel line 6 in order to prevent flashback in the event that the air and fuel are introduced together. It is to be understood that the air and fuel may be introduced to the jet by means of separate lines.

Compressed air and fuel are supplied from a suitable source 21. A high tension wire 22 runs to an ignition sparking assembly 23 located with reference to the flame jet so that it may be used to ignite the flame. The high tension is supplied through a suitable spark coil assembly 10.

A thermocouple 12 is run into the conduit 7 to a suitable predetermined position in order to measure the temperature in the well at a selected point for control purposes. The thermocouple 12 actuates a thermometer assembly 13 which in turn regulates a controller assembly 14 which decreases the air supply when the temperature becomes excessive. When the temperature is below that desired, the air supply is increased so as to bring the oil up to the desired temperature.

In operation, the combustion gases mix with the oil and gas produced in the well, and thus heat the oil up to the desired temperature. The temperature required for optimum production will vary and is a function of the details of the particular operation being conducted. Thus, the optimum temperature must be determined based upon the variables existing in each individual field. It may be that in some fields a sufficient quantity of light ends can be obtained for the desired purpose of increasing oil recovery by a simple distillation operation. Under these conditions the required temperatures are in the neighborhood of about 450° to 550° F. On the other hand certain fields may contain very heavy oils which are deficient in light ends. Under these conditions, in order to obtain the required quantity of light ends, it may be necessary to induce some cracking of the oil. Thus, the oil temperatures are preferably in the range from about 900° to 1200° F.

The produced oil flows through the choke or bean 25 which acts as a valve and which controls the flow of the oil to an insulated separation zone 15. The crude oil is removed by means of line 16 from separation zone 15, while the volatile components and flue gases are removed overhead by means of line 24. These overhead constituents are preferably passed into a separation zone 17, wherein certain light hydrocarbon gases may be condensed and separated from the combustion gases and lower boiling hydrocarbons. If these overhead gases are to be compressed and returned to the reservoir in order to maintain the reservoir pressure, it is not necessary to provide for complete condensation of the light ends. Thus, in operation the vapors are removed overhead from zone 17 by means of line 18 and may be withdrawn from the system. However, at least a portion of these gases may be segregated by means of line 56, recompressed in compression zone 54 and reintroduced into the reservoir by means of line 57 and well bore 52 by conventional means

and equipment not specifically illustrated. The condensed liquid product is withdrawn from the bottom of zone 17 and may be withdrawn from the system by means of line 19. Here again, a portion of this condensate may be introduced into the reservoir by means of line 55, pump 53 and well bore 52.

For instance, a typical case may be that of a well producing about 20 bbls. of oil per hour with 500 cu. ft. per bbl. of natural gas. This oil will be heated to about 500° F. in order to distill off about 10% of the low boiling constituents for reinjection into the reservoir. In order to do this, about 1,700,000 B. t. u. per hour is required. This is obtained by the combustion of about 2300 cu. ft. per hour of natural gas or about ¼ of that produced with the oil. Approximately 20,000 cu. ft. per hour of air is required to burn this amount of fuel.

The combustion of the jet is again determined by the individual requirements. From the standpoint of economy in air compression, the jet should be located relatively near the surface in a zone of low pressure. On the other hand, the combustion space is limited and in order to liberate heat at the high rates required in accordance with the present process, high pressure combustion is necessary. Generally, a pressure in the range of about 175 to 225 lbs. per sq. in. gauge represents a desired balance between the various economic and physical factors which determine the best pressure for the jet operation. The jet, therefore, is located at the point in the well where in normal operation this optimum pressure is encountered.

In a well smoothly flowing, this is usually a few hundred feet below the surface. This is desirable since if the operation is started after considerable pressure in the field has been dissipated, the present process serves as a gas lift and replaces mechanical pumping in lifting the oil. On the other hand, if the well produces with well head pressures in excess of the optimum pressure, it may be desirable to locate the submerged jet in the flow line at the surface shortly before the oil and gas enter the separator 15. The return of gas and produced light ends to the reservoir maintains the pressures so that the reservoir pressure remains approximately constant through the major part of the producing life of the oil field. As the operation is conducted, the light ends commingle with the heavy oil, and dilute it. By continually recycling a comparatively small fraction, about 5 to 15%, of the lighter components of the oil, it is possible to wash out a very large percentage of the oils in the reservoir and recoveries by this operation will range from about 40 to 90% as compared to 10 to 30% commonly encountered in fields producing heavy crude oil.

It is within the concept of the present invention to employ the flame jet to injected fluids in order to raise the temperature of these fluids to the desired temperature just before they enter a producing formation. One disadvantage heretofore encountered in the use of hot injection fluids was the heat loss encountered while these hot fluids were pumped from the surface to the producing formation. Thus, if the flame jet is employed as described to heat the fluids just before these fluids enter the

formation, these heretofore encountered heat losses are eliminated.

What is claimed is:

1. An improved process for increasing the production of oil from a producing well that extends from the surface of the earth to a subterranean oil reservoir which comprises providing a well bore laterally spaced from the producing well and also extending down to the reservoir, maintaining a submerged jet flame within the stream of petroleum which is present within the producing well at an intermediate point within the well above the oil-bearing strata, regulating the magnitude of the flame so as to vaporize hydrocarbons within the oil stream boiling up to about 550° F., withdrawing unvaporized oil, gaseous combustion products, and vaporized hydrocarbons from the producing well, separating the liquid hydrocarbons from the gaseous combustion products and vaporized hydrocarbons, condensing and separating the vaporized hydrocarbons from the gaseous combustion products, and returning at least a portion of the condensed hydrocarbons to the subterranean reservoir via said well bore.

2. A method as defined in claim 1 in which the submerged jet flame is positioned at a point within the producing well where the well pressure is within the range from about 175 to 225 pounds per square inch gauge.

3. A method of increasing the production of an oil well that extends from the earth's surface to a subterranean oil reservoir which comprises introducing a stream of light petroleum gases and a stream of an oxygen-containing gas down within the producing well, mixing and igniting the gases at a point within the well above the oil-bearing strata where the well pressure is between 175 and 225 p. s. i. g. in a manner to form a submerged flame within the stream of oil that exists within the well, regulating the supply of oxygen-containing gas whereby the heat released by the flame is sufficient to vaporize the portion of the oil boiling up to about 550° F., withdrawing the vaporized oil portion, the liquid oil portion and gaseous combustion products from the producing well, separating the liquid oil portion from the withdrawn mixture, and returning at least a portion of the combustion products and vaporized oil portion to the subterranean reservoir at a point laterally removed from the producing well.

4. A process as defined in claim 3 in which the stream of oil within the producing well is heated by the submerged flame to cracking temperatures in the range from about 900–1200° F. in order to form the required portion of vaporized oil.

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