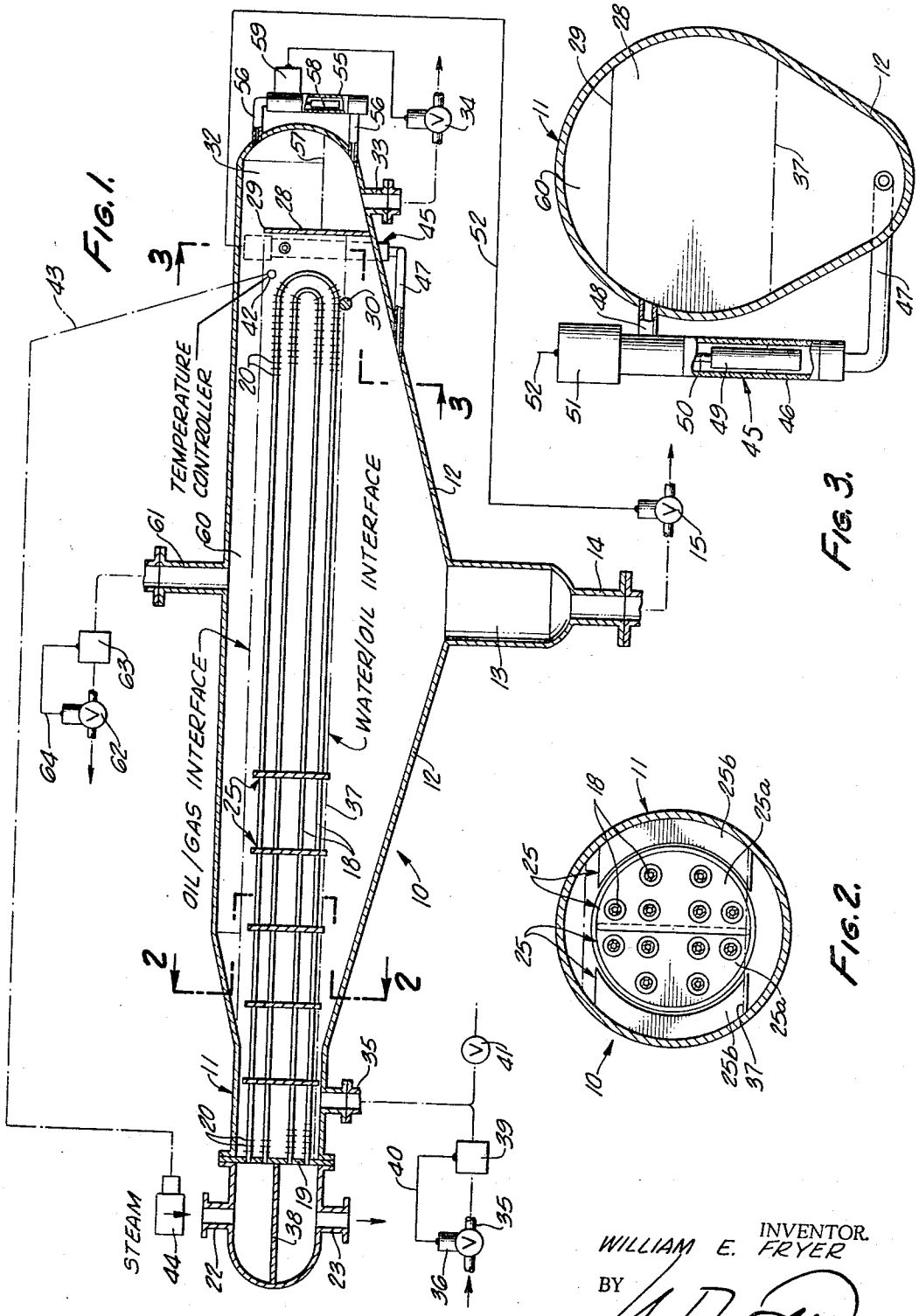
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FLUID SEPARATING AND CLEANING METHOD AND APPARATUS

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FLUID SEPARATING AND CLEANING METHOD AND APPARATUS

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This invention relates to separating and cleaning apparatus and more particularly to an improved and simplified continuously operable apparatus for the treatment of crude oil and the like and effective to remove gaseous, liquid and solid contaminants present therein as received from a producing well.

As is well known crude oil produced by an oil well is accompanied by numerous contaminants including gases, liquids and solids and desirably removed prior to transport of the crude oil to a refining station. There have been many prior proposals for dealing with this problem but all are subject to various objections, disadvantages and shortcomings sought to be obviated by the present invention. In general such prior proposals are characterized by the discontinuous nature of the operating cycle, and shutdown from time to time being essential to remove separated contaminants and for reconditioning the apparatus generally in an effort to restore it to effective operation. The principal contaminants normally encountered are occluded gases, water, and solids including particles of foreign matter and, in particular sand. The sand constituent is particularly troublesome because of the difficulty experienced in efforts to remove quantities settling out on interior surfaces of the treating equipment.

By the present invention there is provided a single unitary housing of elongated tubular configuration disposed generally horizontally and having its bottom wall surfaces converging downwardly into a collecting sump at an angle greater than the angle of repose for the solid particles precipitating from the fluid undergoing treatment. Suitable heating facilities, such as a steam heat exchanger, are disposed in the upper part of the separating shell and employed to maintain the fluids at an appropriate elevated temperature productive of efficient separation of contaminants. Dirty crude enters near one end of the shell, flows through a circuitous passage provided by appropriate baffling with the clean oil overflowing the lip of a weir located remotely from the point of entrance. Suitable control devices are provided for monitoring conditions within the separating shell and are operable, for example, to maintain a water level or interface between the water and the oil close to and preferably below the entrance level of the incoming crude oil. Other controls include automatic means for regulating the discharge of clean oil, the back pressure in the gas collecting dome, the rate of crude oil entry and the control of the heat exchanger to maintain a desired temperature level in the crude oil layer.

A particularly important feature believed principally responsible for the continuous operating capability of the present apparatus is the method employed for initiating operation of the equipment. Thus it is found that the efficiency and effectiveness of the apparatus in continuous performance is assured by initially flooding the entire apparatus with water. Thereafter this water is brought up to the normal operating temperature of the apparatus in any suitable way such as by use of the heat exchanger forming a part of the apparatus. Once this has been accomplished water is gradually replaced by admitting crude oil at the same rate the water is withdrawn from the lower portion of the shell. In consequence it is found that the interior surfaces of the apparatus wetted initially with water display no tendency for solid constitutents, such as sand present in the crude oil, to adhere to these surfaces. Furthermore, this ability of the previously wetted surfaces to continue to shed sand readily continues unabated and so long as the apparatus is maintained in operation. This aspect of the invention not only greatly increases the efficiency of the heat exchanger but it also assures self-shedding and continuous purging of the sand from the inclined bottom surfaces of the shell into the sand and water collecting sump.

A further highly significant aspect of the referred-to preloading and preheating of the apparatus using water provides a high capacity heat storage capability for bringing the dirty fluid to be treated up to a desired optimum operating temperature substantially immediately and assures a minimum surface tension coefficient at the oil-water interface thereby further adding to the efficiency and effectiveness of the separating operation initially and continuously throughout the duration of operation of the apparatus.

Another highly important aspect of the invention is the use of one of the reject fluids, namely the water, as a conveying vehicle for carrying away a less fluid separated contaminant such as sand and the like finely divided material. Not only is the water used to provide buoyancy for these solid particles but the flow of the water is further used as a transporting medium or vehicle therefor.

Accordingly, it is the primary object of the present invention to provide an improved apparatus and method for continuously separating contaminants from crude oil and for conducting these various contaminants in separated form from the apparatus and for draining the clean oil therefrom.

Another object of the invention is the provision of a simply and economically constructed apparatus for treating crude oil to separate out contaminants leaving clean oil to be bled from another part of the apparatus.

Another object of the invention is the provision of a continuously operating mode of treating a mixture to separate out constituents thereof and utilizing a rejected one of the fluids as a medium for increasing the buoyancy of heavier rejected constituents and for carrying the same from the separating zone.

Another object of the invention is the provision of an improved mode of initiating operation of crude oil treating equipment involving preloading the equipment with hot water and utilizing the heat capacity of the latter quickly to bring crude oil to a proper separating temperature and thereby establishing and maintaining a minimum surface tension at the oil-water interface throughout the uninterrupted operation of the equipment on a continuous basis.

Another object of the invention is the provision of a unique method for initiating operation of a crude oil treating apparatus and for so conditioning the same that sand and other solid contaminants do not adhere to its interior surfaces.

Another object of the invention is the provision of a continuously operating crude oil treating and separating device capable of operating for prolonged periods without shutdown and including automatic means for maintaining proper operating levels and conditions within the apparatus.

These and other more specific objects will appear upon reading the following specification and claims and upon considering in connection therewith the attached drawing to which they relate.

Referring now to the drawing in which a preferred embodiment of the invention is illustrated:

FIGURE 1 is a longitudinal cross-sectional view of a typical and preferred embodiment of a crude oil treating apparatus according to the present invention.

FIGURE 2 is a cross-sectional view taken along line 2—2 on FIGURE 1; and

FIGURE 3 is a cross-sectional view on an enlarged scale taken along the broken line 3—3 on FIGURE 1.

Referring to FIGURE 1, there is shown a preferred embodiment of a dirty fluid treating apparatus designated generally **10**. The apparatus has an elongated generally tubular main body shell **11** closed at its opposite ends. A feature of the main body shell is the provision of downwardly converging bottom walls **12, 12** opening into a tubular water and sand collecting sump **13**. The bottom of the latter also converges into a vertically-disposed outlet conduit **14** for conveying the sand and water to a point of disposal through a regulatable flow valve **15**. Of importance is the fact that the angle of inclination of bottom **12** is somewhat in excess of the angle of repose of submerged sand and other solid materials settling out of the fluids undergoing treatment in the separator. By reason of this design the solid contaminants are continuously self-draining under gravity along the inclined bottom into the centrally-disposed collecting sump **13**.

The upper portion of the main body of the shell is provided with a suitable heat exchanger such as a plurality of hairpin-shaped tubes **18, 18** having their opposite ends disposed adjacent one another and welded or otherwise suitably secured in openings in a header **19** on the opposite sides of a partition wall **38**. Tubes **18** are preferably provided with fins **20** for increasing the heat exchange capability of the tubes through which any suitable heating medium, such as steam, may be supplied by way of inlet conduit **22** and carried away through an outlet conduit **23**.

In a preferred arrangement internal partitions and baffle means are provided in at least that portion of entrance half of the main separating chamber occupied by the oil layer. Such baffle means indicated at **25** project alternately from the opposite sides of the shell and each includes a baffle portion **25***a* pierced by the heat exchange tubes **18**, and a separate and additional portion **25***b* embracing the sides of the tube bundle and positioned to supplement portion **25***a* in blocking oil flow between the shell wall and the outer rim edge of portion **25***a*, in a manner best shown in FIG. 2.

A weir **28** extends across the outlet end of the separator with its upper edge **29** terminating somewhat below the top wall of the shell. A supporting bracket **30** extends crosswise of the shell and aids in supporting the reverse bend end of heat exchanger tubes **18**. Clean oil overflowing weir lip **29** collects in chamber **32** and is withdrawn through an outlet conduit **33** having a regulatable control valve **34**.

Crude oil containing contaminants enters shell **11** by way of conduit **35** at the end thereof remote from weir **28** and at a level even with or slightly below the water-oil interface **37**. The rate of crude oil inflow is preferably regulated by any suitable flow rate control device **39** having a control connection **40** to valve **36** and operating in known manner to maintain a substantially uniform flow of contaminated crude oil into the apparatus.

Maintenance of a desired uniform operating temperature in the oil-flooded portion of the separator is provided by a temperature sensing thermostat **42** submerged in the oil near weir lip **29** and connected by a control line **43** with a steam flow regulating valve **44** located in steam inlet pipe **22**.

A particularly important controller is one employed to maintain a substantially constant oil-water interface level **37** despite widely varying quantities in the oil of foreign particles and other contaminants. This control will be best understood by consideration of FIG. 3 illustrating a dual-gravity liquid-level controller device **45** having a generally tubular main housing **46**. This housing has a connection **47** in communication with the water layer existing below interface **37** and a second tubular connection **48** with the oil layer overlying this interface. It will be apparent from FIG. 3 that the same interface level **37** exists in housing **46** as within shell **37**. The dual-gravity interface sensing float **49** is submerged partly in the oil and partly in the water layers and is connected by an actuator **50** with known valve controller mechanism located in housing **51** and having an operating connection through line **52** with the water and sand flow control valve **15**. In consequence it will be understood that any change in the level of interface **37** from a predetermined level is effective through connection **52** to conveyor a corrective regulating signal to valve **15**. Thus if the interface level rises valve **15** is opened slightly to increase the water withdrawal rate and the converse is true if the interface level tends to fall below the predetermined value.

Another flow regulator is connected to the clean oil discharge from shell **15** and includes a float housing **55** having connections **56** with the shell on the opposite sides of the clean oil level **57**. A float **58** partially submerged in the oil operates a corrective signal transmitting device **59** to control the operation of valve **34**. The object of this device is to assure a proper liquid head of clean oil within the chamber at all times as well as to provide a liquid seal at the oil outlet to maintain a desired back pressure on the gas collecting dome **60** formed in the upper part of the shell. The gas separating from the liquid constituents rises into this collecting dome and is withdrawn from the apparatus through a gas outlet duct **61** under the control of a regulating valve **62** provided with a known type of pressure control regulator **63** having an operating connection **64** with valve **62**.

To place the described liquid treating and contaminant separator apparatus in operation, the operator floods and preloads the entire main body of the apparatus with water through water inlet valve **41** up to the top or lip edge **29** of weir **28**. Steam or other suitable heating medium is admitted to the heat exchange tubes **18** and the entire apparatus is brought up essentially to its normal operating temperature most appropriate for effective operation with the particular type of crude oil being processed. This having been done, the apparatus is in readiness to receive dirty crude oil introduced through conduit **35** and regulating valve **36** therefor. As the oil is admitted water is withdrawn at substantially the same rate through valve **15**.

It will be recognized from the foregoing that the oil is quickly brought up to the temperature of the water charging the apparatus and that the apparatus thereafter operates with a substantially constant interface level between the oil and gas, that is a level generally opposite the upper edge of weir lip **29**. Owing to the fact that all interior surfaces ever in contact with the crude oil are first wetted with water before being contacted with the oil, it is found that there is no tendency for sand or other foreign particles to cling to the metal surfaces. Furthermore, any foreign matter tending to settle on these surfaces is easily detached whereas quite the contrary is true if the metal surfaces are first wetted with oil. Furthermore, it is found that the inclined bottom walls of the shell easily shed precipitating foreign particles and allows these to gravitate easily and with certainty into collecting sump **13**.

Once the apparatus becomes flooded with oil the described automatic controls provided for the various out-

lets operate as described above to maintain appropriate liquid levels despite considerable fluctuation in the quantity of foreign contaminants present in the entering crude oil. The equipment is found to operate for prolonged and continuous periods with negligible supervision without need for shutdown for cleaning and reconditioning typically characteristic of prior crude oil treating equipment.

The apparatus operates with a minimum pressure drop between its inlet and outlet owing to the substantially open and unobstructed nature of its interior. The operating efficiency is unusually high for various reasons including the important fact that it is unnecessary to maintain the temperature of the very considerable quantity of separated water present below interface 37. In other words, once the water constituent gravitates below this interface it may be and preferably is allowed to cool to ambient temperature without in anywise adversely affecting the operating efficiency or effectiveness.

While the particular fluid separating and cleaning apparatus herein shown and disclosed in detail is fully capable of attaining the objects and providing the advantages hereinbefore stated, it is to be understood that it is merely illustrative of the presently preferred embodiment of the invention and that no limitations are intended to the details of construction or design herein shown other than as defined in the appended claims.

I claim:

1. A crude oil separator comprising a generally-tubular horizontally disposed main chamber having a bulbous extension projecting downwardly from said main chamber and having walls which converge into the top of a sand and water receiving sump, said converging walls downwardly sloping at an angle in excess of the angle of repose of submerged sand precipiating from the crude oil undergoing treatment, heat exchange means in the upper portion of said main chamber connected to header means at one end of said main chamber, a clean oil overflow weir across the other end of said main chamber, means for maintaining said bulbous extension flooded with water and maintaining an interface between oil in the upper portion of said main chamber and water in the lower portion thereof, said heat exchange means being disposed in said oil, means for introducing oil to be treated near said one end of the main chamber at a level closely spaced to the interface between said oil in the upper portions of said chamber and the water filling the lower portion thereof, and separate means for conducting sand and water from said sump and clean oil from the downstream side of said weir.

2. A continuously operating separator for treating freshly produced crude oil, said apparatus comprising a generally horizontally disposed tubular shell having a downwardly converging bottom on its underside opening into a sump, said bottom walls sloping at an angle in excess of the angle of repose of submerged sand precipitating from the crude oil undergoing treatment, valve means for maintaining the lower portion of said shell flooded with water, means for maintaining a body of crude oil substantially filling the upper portion of said shell and supported by flotation on water flooding the lower portion of said shell to form an oil-water interface, heat exchange means positioned to be submerged in said oil, an overflow weir for clean oil at one end of said shell, a level, controlled drain valve for oil on the downstream side of said weir, means for withdrawing gas from the top portion of said shell, and said means for maintaining a body of oil in said shell including means for introducing crude oil to be treated near the oil-water interface and at the end of said shell remote from said weir.

3. A crude oil separator as defined in claim 2 characterized in the provision of staggered baffle means projecting toward one another alternately from the opposite interior sides of said shell adjacent the crude oil inlet end of said shell and effective to cause the oil to flow in a horizontal sinuous path from said oil inlet toward the weir-equipped end of said shell.

4. That improved method of continuously treating crude oil to separate out foreign constitutents including sand and gas which comprises, initially flooding with water substantially all portions of a separator chamber of the type having a downwardly converging bottom and equipped with baffled heat exchange means in its upper portion, passing a heating medium through said heat exchanger to heat said water to a predetermined temperature, introducing untreated crude oil near one end of said chamber adjacent the mid-height of said chamber while lowering the water level and forming an oil-water interface by withdrawing hot water from the bottom of said chamber at substantially the same rate at which the oil is entering said chamber and while passing a heating medium through said heat exchanger, decreasing the rate of water withdrawal as the water level drops to the mid-portion of the chamber so as to maintain a generally steady level of the oil-water interface, skimming clean oil from the top of said chamber at the end thereof remote from the point of entry of untreated crude oil, draining separated sand by gravity across the bottom of said chamber into a sand and water collecting sump, and withdrawing sand and water from said sump..

5. That method as defined in claim 4 characterized in that said chamber is generally tubular and disposed with its longer axis horizontal, and including the step of withdrawing gas from the top of said chamber and introducing crude oil to be treated below the upper level of liquid in said chamber and at a level close to but above the oil-water interface.

6. That method of placing crude oil separator apparatus in operation initially which comprises flooding with water all interior surfaces to be contacted by contaminated crude oil to be subjected to cleaning treatment, heating said water to a temperature approximating normal operating temperature for said apparatus thereby assuring that the apparatus surfaces are first wetted with hot water, and gradually introducing dirty oil to the upper portion of the apparatus to float the oil on said water and form an oil-water interface while lowering the water level by withdrawing water from the bottom portion at a rate coordinated with the rate of crude oil introduction until the oil-water interface between oil floating on the water has fallen to the desired operating level for normal use of said apparatus.

7. That method defined in claim 6 characterized in causing said crude oil to flow in a general horizontal but tortuous path from a point adjacent one interior side thereof to a point of clean oil withdrawal remotely spaced from the point of contaminated oil entry.

8. A continuously operating crude oil separator apparatus having an elongated tubular shell having walls and closed at its ends and supported with its axis disposed horizontally, means for maintaining the lower portions of said shell flooded with water and the upper portions thereof flooded with oil to form an oil-water interface, finned steam heating pipes extending horizontally through the top portion of said shell above the normally-prevailing oil-water interface and connected with header means therefor in one end of the shell, clean oil skimming weir means across the other end of said shell with its upper edge close to the top thereof, said shell having an oil and sand collecting sump and having upwardly diverging walls merging at their upper portions thereof with the lower portion of the walls of said shell, said diverging walls sloping at an angle in excess of the angle of repose of submerged sand therein whereby substantially all sand settling out of said crude oil gravitates readily along said sloping walls directly into said sump, and means for withdrawing oil and water from said sump.

9. Separator apparatus as defined in claim 8 characterized in the provision of dual-gravity float means sub-

merged in prt in the water-flooded portions of said apparatus and in part in oil-flooded portions thereof and connected with means controlling the oil-water interface level within said apparatus.

10. Separator apparatus as defined in claim **9** characterized in that said sand and water collecting sump is substantially centrally of said shell between the opposite ends thereof.

11. That method of preloading and initiating operation of a crude oil cleaning, separating and treating apparatus which method comprises, preloading the apparatus with water to a level corresponding substantially to the highest liquid level under normal operation to clean crude oil; bringing the water up to a desired operating temperature for said apparatus thereby to wet the interior surfaces of the apparatus with hot water and to provide stored heat for quickly bringing crude oil to its intended separating temperature substantially as soon as it enters said apparatus thereby to lower the surface tension of the later formed oil-water interface, and withdrawing water from the lower portion of said apparatus to lower the initial water level to a normal water-operating level while introducing an equivalent volume of crude oil to be treated and forming said oil-water interface.

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