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RECOVERY OF OIL FROM BITUMINOUS SANDS

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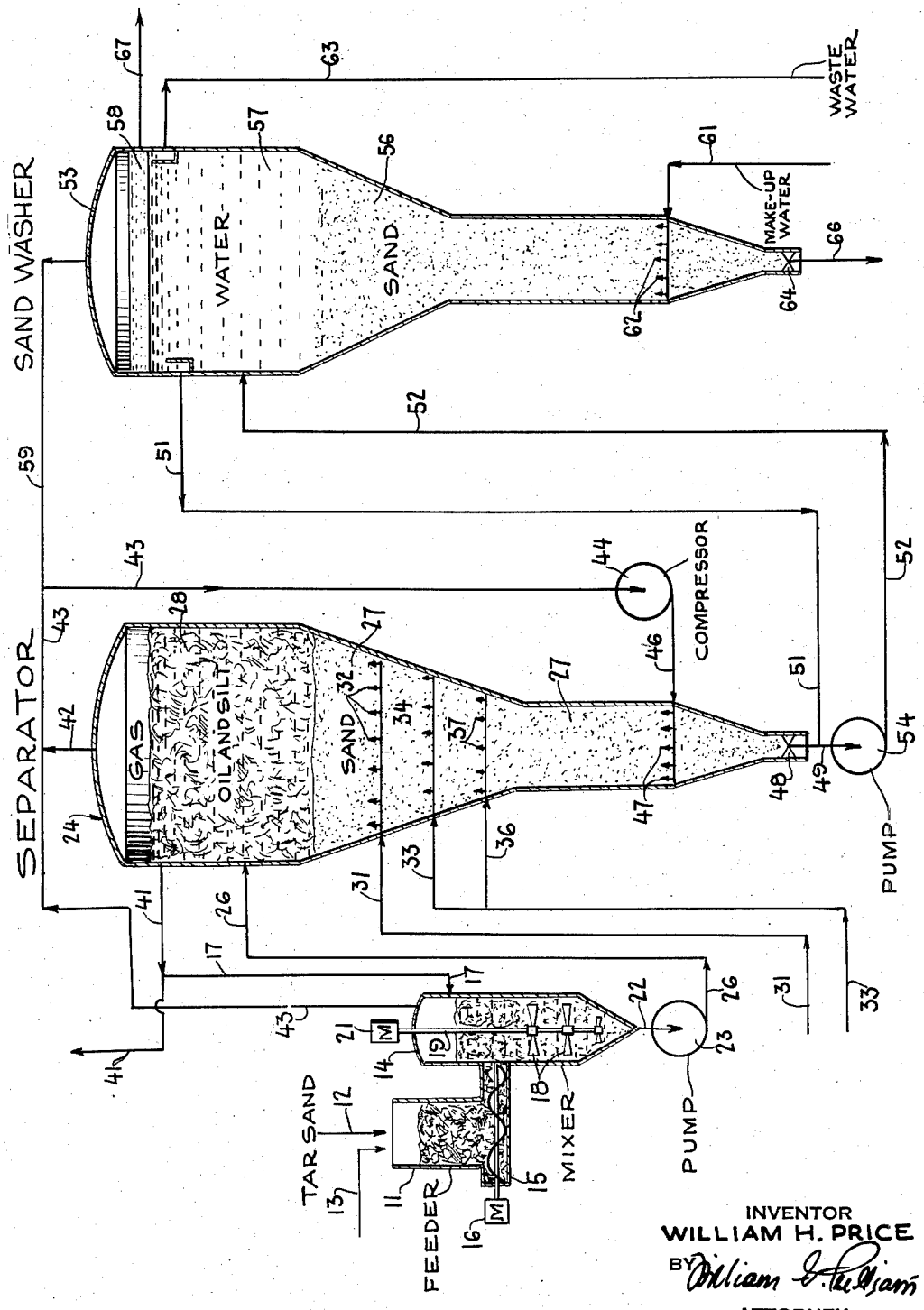

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RECOVERY OF OIL FROM BITUMINOUS SANDS

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This invention relates to an improved process for the separation of hydrocarbon oil from bituminous sands and more specially to the separation of crude oil and silt from bituminous sand containing the same.

Large deposits of bituminous sand are found in various localities throughout the world. The term "bituminous sand" is used herein to include those materials commonly referred to as oil sands, tar sands and the like. One of the most extensive deposits of bituminous sands occurs, for instance, in the Athabasca district of the Province of Alberta, Canada, and extends for many thousands of square miles in thicknesses ranging up to more than 200 feet.

Various methods have been proposed previously for separating crude oil from bituminous sands such as the Alberta tar sands, but none of these methods has met with any substantial success. Since the crude oil obtainable from this type of bituminous sand is a relatively viscous material having high tar content and relatively low commercial value in comparison with other crude oils, a successful commercial process must involve relatively little expense in the separation of the crude oil from the bituminous sands. Operating costs of previously conceived methods for separating the oil from bituminous sands have been sufficiently high so as to discourage commercial exploitation.

The most successful of the previously known methods for separating oil from tar sands such as the Alberta tar sands have involved the mixing of the bituminous sands with water followed by separation of sand from the mixture. In these processes it has been found that complete separation of the crude oil from the water has presented considerable difficulty due to the formation of oil-water emulsions resulting in the discarding of significant quantities of crude oil which could not be successfully separated from the water.

It is an object of the present invention to provide an improved method of separating oil from bituminous sands, which does not involve contact of the crude oil content of the bituminous sands with water and which, therefore, eliminates the problems associated with separation of such crude oil from water.

Previous processes, in attempting to separate crude oil from bituminous sands have also encountered difficulties due to the fact that the solids content of bituminous sands such as Alberta tar sands consists of particles of varying size and includes substantial amounts of silt in the form of clay and other very fine solids particles. In attempting to effect a complete separation of the crude oil from the bituminous sands these processes have attempted to retain the silt with the remainder of the solids content of the sands and as a result have usually discarded considerable quantities of crude oil along with such silt and sand. The present invention contemplates a process by which crude oil and silt may be separated from bituminous sands containing the same with essentially no loss of crude oil with waste sand.

According to a preferred embodiment of the present invention, crude oil and silt may be separated from bituminous sands containing the same by mixing the bituminous sand with a small amount of hydrocarbon diluent and introducing the resultant mixture into a separation zone in which a lower fluidized layer of sand and an upper liquid layer of oil and silt are formed. Additional hydrocarbon diluent is introduced into the lower layer of sand to aid in the separation of the original mixture into these upper and lower layers and each of the layers is separately removed from the separation zone.

For a better understanding of the invention reference should be had to the accompanying drawing, which is a diagrammatic illustration in elevation of a suitable arrangement of apparatus for carrying out a preferred embodiment of the invention.

In the drawing, bituminous sand is introduced into a feed hopper **11** as indicated by an arrow **12**. The bituminous sands treated according to the invention are bituminous sands which include crude oil and silt in addition to the coarser sand particles. For purposes of this application, silt may be defined as solids particles which pass through a two hundred mesh screen and may include, for instance, extremely fine sand particles as well as clay or other solids present in the form of particles of this size. Bituminous sands treated as described above may contain widely varying amounts of silt, but such silt frequently comprises between about 1 and about 20 volume percent of the total solids content of the bituminous sand. Similarly, the amount of oil in bituminous sands may vary widely. Typical tar sands treated in accordance with this invention frequently contain between about ten and about twenty volume percent crude oil. In addition, such tar sands frequently contain between about 1 and about 15 weight percent water. Compositions of suitable bituminous sands may, of course, vary over even wider ranges and minor amounts of other ingredients may also be present.

Prior to introducing bituminous sand to a separation zone in accordance with the invention it is generally preferable to first mix the sand with liquid hydrocarbon diluent in order to obtain a slurry which is easily transferable to the separation zone. Such mixing may be done in any suitable manner such as by passing the tar sand from the feed hopper **11** into a mixing tank **14** by a conventional screw conveyor **15** driven by a motor **16**. In order to avoid unnecessary loss of valuable vaporous hydrocarbons the mixing tank **14** is preferably closed. In order to still further reduce the amount of hydrocarbon vapors escaping via the feed hopper and mixing tank, a relatively small amount of seal oil is preferably introduced with the sand feed as indicated by an arrow **13**. Introduction of seal oil into the feed hopper with the sand feed prevents the escape of any substantial amounts of hydrocarbon vapors from the mixing tank or feed hopper. Such seal oil may be used in any desired amounts but relatively small quantities such as between about 1 and about 5 volume percent of total feed usually suffice to prevent escape of hydrocarbons vapors. Suitable seal oils may cover a wide variety of hydrocarbon oils, but oils of intermediate weight such as No. 2 furnace oil are preferred.

The hydrocarbon diluent with which the sand is preferably mixed to form a slurry prior to introduction into the separation zone is introduced into the mixing tank **14** through a conduit **17**. The hydrocarbon diluent thus introduced may, if desired, be fresh diluent such as that described below but for convenience is preferably a recycle stream comprising a portion of the mixture of crude oil, hydrocarbon diluent and silt withdrawn from the separation zone as a product of the process as de-

scribed below. The recycle stream of hydrocarbon oil and silt introduced into the mixing tank 14 through conduit 17 is thoroughly mixed with the tar and by suitable means such as mixing paddles 18 carried on a shaft 19 and driven by a motor 21. A slurry of tar sand and diluent is withdrawn from the lower portion of the mixing tank 14 through a conduit 22 and passed by a pump 23 to a separator 24 via a conduit 26. In the separator 24 the slurry of tar sand and diluent separates to form a lower fluidized layer or bed 27 of sand and an upper liquid layer 28 of oil and silt. Liquid hydrocarbon diluent is introduced into the separator 24 through conduits 31, 33 and 36 and is injected into the sand bed 27 at a plurality of points as by suitable sets of nozzles 32, 34 and 37. The hydrocarbon diluent injected into the sand bed 27 through conduits 31, 33 and 36 aids in separating oil and silt from the sand and also serves to fluidize the sand bed. A mixture of this diluent together with the crude oil and silt separated from the sand forms the upper layer of oil and silt 28 while sand which is substantially free of crude oil forms the lower fluidized layer or bed 27. The sand bed 27 is a conventional bed of fluidized solids and has physical characteristics which are generally similar to those of beds of fluidized solids used in other processes such as catalytic cracking, fluid coking, etc. The fluid characteristics of the bed 27 are not substantially altered by the use of a liquid fluidizing medium rather than the more conventional gaseous fluidizing medium. The liquid fluidizing medium may be passed upwardly through the bed 27 with any suitable apparent velocity such as between about 2 and about 10 ft./sec.

The hydrocarbon diluent with which the bituminous sand is contacted in the separation zone should have a specific gravity substantially less than 1.0 and preferably has a gravity between about 55 and about 65° API. Suitable diluents are, for instance, those having boiling point ranges between about 100 and about 400° F. Hydrocarbon diluent is preferably used in the separation zone in a quantity sufficient to dilute the crude oil contained in the bituminous sands with between about one and about five barrels of diluent liquid to each barrel of crude oil with a dilution of about 3 to 1 being preferred. While fresh hydrocarbon diluent may be added to the sand in the mixing tank, it is preferred, as described above, to utilize recycle oil and silt for mixing purposes and to introduce the fresh hydrocarbon diluent into the lower fluidized sand layer in the separation zone. The diluent may be introduced at one or more points in the lower layer of sand and is preferably introduced at a plurality of points at one or more levels in order to aid in fluidizing the sand layer as well as to insure more complete separation of oil and silt from sand.

Oil and silt is removed from the separator 24 through a conduit 41. From the conduit 41 a portion of the oil and silt passes to the mixing tank 14 through the conduit 17 as described above in order to slurry the incoming tar sand feed while the remainder is removed from the process through conduit 41 as a product of the process. The portion of the oil and silt removed through conduit 41 may be treated in any suitable manner for the recovery of valuable commercial products therefrom. For instance the oil and silt mixture may be treated directly as by fluid coking or some or all of the silt may be separated from the oil by suitable means such as settling tanks prior to treating the oil by suitable processes such as coking, visbreaking, hydrogenation, hydro or catalytic cracking, reforming, etc. The mixture of oil and silt removed through the conduit 41 may be subjected to further treatment as desired to produce commercial products. Gaseous hydrocarbons present in the crude oil or diluent rise to the top of the separator 24 and may be removed through a conduit 42. Likewise, vaporous hydrocarbons which accumulate in the mixing tank 14 are removed through a conduit 43.

In order to further aid in fluidizing the sand layer as well as to insure more complete separation of hydrocarbons from sand, gaseous material is preferably injected into the lower portion of the sand layer in the separation zone. Gas injected in this manner may comprise any suitable gaseous material such as nitrogen, hydrogen, helium, etc. from an appropriate source, but preferably comprises normally gaseous hydrocarbons such as those removed from the upper portions of the separation zone and mixing tank through conduits 42 and 43. Such gas, in addition to aiding in fluidizing the layer of sand, also serves to at least partially strip the sand of entrained hydrocarbons. While contact with hydrocarbon diluent as described above is usually sufficient to remove substantially all crude oil from the sand, such diluent itself frequently becomes entrained with or adsorbed on the sand at least to some extent and at least a portion of such entrained or adsorbed diluent may be removed by stripping with suitable gaseous material as just described. The gases in the conduits 42 and 43 are, therefore, passed through the conduit 43 to a compressor 44 and from the compressor 44 are passed through a conduit 46 into the lower portion of the separator 24 where they are injected into the lower portion of the sand bed 27 by suitable means such as nozzles 47. The gases thus injected into the lower portion of the sand bed through the nozzles 47 serve to at least partially strip the sand of any entrained or adsorbed hydrocarbons and also assist in fluidizing the sand bed. Relatively clean stripped sand is removed from the separator 24 through a valve 48 and a conduit 49.

Although the sand withdrawn from the lower layer of the separation zone through conduit 49 is substantially free of crude oil, such sand, even though it has been stripped as described above, contains small amounts of hydrocarbon diluent which it is usually desirable to recover. Also, in the event stripping gas is not employed, such sand will, of course, contain somewhat greater amounts of hydrocarbon diluent. Such hydrocarbon diluent is preferably recovered by passing the withdrawn sand to a sand washing zone in which it is contacted with water to form in the washing zone a lower fluidized layer of sand, an intermediate layer of water and an upper liquid layer of hydrocarbons which usually consist essentially of hydrocarbon diluent carried from the separation zone with the sand as described above. Sand withdrawn from the separation zone is conveniently transported to the washing zone in the form of a slurry. Such a slurry is preferably obtained by mixing the sand in conduit 49 with water supplied through a conduit 51. The resulting slurry of sand and water is passed through a conduit 52 to a sand washer 53 by a pump 54.

In the sand washer 53 the slurry of sand and water separates into a lower fluidized bed or layer of sand 56, an intermediate layer 57 of water and an upper liquid layer 58 of hydrocarbon liquid. The sand bed 56, like the sand bed 27, is a conventional fluidized solids bed and is preferably fluidized by means of water injected into the bed as described below.

A stream of recycled water is withdrawn from the water layer and passed through conduit 51 to form the slurry of sand and water as described above. Any hydrocarbon vapors which accumulate in the sand washer 53 are removed through a conduit 59 and passed through the conduit 43 for use in stripping sand in the separator 24 as described above. Fresh make-up water is preferably introduced to the sand washer 53 through a conduit 61 and injected into the lower portion of the sand bed 56 through nozzles 62 in order to fluidize the sand bed and also to aid in stripping hydrocarbons from the sand. Excess water is removed from the sand washer through a conduit 63 while clean sand substantially free of hydrocarbon material is removed through a valve 64 and a conduit 66. Hydrocarbon liquid which has been separated from the sand in the sand washer is removed

from the hydrocarbon layer 58 through a conduit 67 for use in any suitable manner.

When sand withdrawn from the separation zone is washed as described above it is especially important to avoid the use of excessively high boiling hydrocarbon diluent in the separation zone and to avoid retaining any of the crude oil in the sand since such higher boiling hydrocarbons have a strong tendency to form emulsions with water and such emulsions are extremely difficult to control. If the preferred hydrocarbon diluent described above is used there is substantially no tendency for emulsions to form in the washing zone and the entire process may be carried out without the necessity for chemical or mechanical treatment to break or remove emulsions. This results not only in a process which requires no emulsion breaking or removing equipment but also results in greater recovery of usable hydrocarbons since the formation of emulsions almost inevitably results in loss of valuable hydrocarbons to waste water.

While there is no special temperature requirement for successful separation of oil and silt from bituminous sand in accordance with the present invention the processes described herein are preferably carried out at temperatures approximating normal room temperatures such as between about 40 and about 100° F., more usually between about 60 and 80° F. If substantially lower temperatures are used difficulty is sometimes experienced in obtaining a proper separation of crude oil since crude oils associated with bituminous sands frequently congeal at such lower temperatures while if substantially higher temperatures are used considerable expense is usually required to raise the temperature of the large mass of bituminous sands to operating temperature and additional difficulties are experienced in disposing of the hot sand from the process. Many bituminous sand deposits such as the Alberta tar sands occur in areas where normal temperatures are below the preferred operating temperatures for most of the year and it is contemplated that in such instances preferred operating temperatures may be obtained by the use of hydrocarbon diluent which is at a suitable elevated temperature or by other suitable means. It is especially convenient to utilize relatively hot hydrocarbon diluent to raise the temperature of the bituminous sands since such diluent is frequently obtained from process units such as reformers or fluid cokers and can be utilized without further heating.

The following specific example illustrates a practical application of the present invention using the process described and shown in the drawing.

An Alberta tar sand having the properties shown in Table I below is fed to the feed hopper 14 at the rate 100,000 barrels per day (b.p.d.).

TABLE I

Composition and properties of bituminous sand feed

Composition of bituminous sand:		
Water	vol. percent	2.1
Mineral matter	do	82.8
Crude oil	do	15.1
Density	lb./ft.^{3}	125
Composition of crude oil:		
Carbon	vol. percent	83.3
Hydrogen	do	10.4
Sulfur	do	4.7
Nitrogen	do	0.4
Oxygen	do	1.2
Carbon/hydrogen ratio		8.0
Specific gravity at 77° F.		1.007
Sieve analysis of mineral matter after ignition retained on:		
50 mesh	wt. percent	18.3
80 mesh	do	49.9
100 mesh	do	13.3
200 mesh	do	11.0
Passing 200 mesh	do	7.5

No. 2 furnace oil is also added to the feed hopper as seal oil. Gasoline having a gravity of 59° API is added to the separator 24 through conduit 31 and nozzles 32 at the rate of 130,000 b.p.d. as hydrocarbon diluent. Hydrocarbon diluent consisting of gasoline having a gravity of 60° API and a boiling range of 125–350° F. is also added to the separator 24 through conduit 33 and nozzles 34 at the rate of 100,000 b.p.d. and through conduits 33 and 36 and nozzles 37 at the rate of 70,000 b.p.d. Liquid hydrocarbons withdrawn from the upper hydrocarbon layer of the sand washer 53 have a gravity of 60° API.

While the invention has been described in detail with respect to a preferred embodiment it will be understood by those skilled in the art that various changes and modifications may be made without departing from the spirit and scope of the invention and it is intended to cover all such changes and modifications in the appended claims.

I claim:

1. The process for recovering oil and silt from bituminous sand containing the same which comprises mixing the bituminous sand with hydrocarbon diluent, introducing the resultant mixture into a separation zone to form therein a lower fluidized layer of sand substantially free of added water and an upper liquid layer of oil and silt, introducing hydrocarbon diluent into said lower layer, and separately removing each of said layers from said separation zone.

2. The process for separating oil and silt from bituminous sand containing the same which comprises mixing the bituminous sand with a small amount of hydrocarbon diluent, introducing the resultant mixture into a separation zone to form therein a lower fluidized layer of sand substantially free of added water and an upper liquid layer of oil and silt, injecting hydrocarbon diluent into said lower layer to maintain same in a fluidized condition and to aid in separating said introduced mixture into said layers, and separately removing each of said layers from said separation zone.

3. The process for recovering oil and silt from bituminous sand containing the same which comprises mixing the bituminous sand with a small amount of a first hydrocarbon diluent, introducing the resultant mixture into a separation zone in which a lower fluidized layer of sand and an upper liquid layer of oil and silt is formed, introducing a second hydrocarbon diluent into said lower layer to assist in maintaining same in a fluidized condition and to aid in separating said introduced mixture into said layers, introducing gas into the lower portion of said lower layer to strip said sand and to aid in fluidizing said layer, removing stripped sand from said lower layer, removing a mixture of oil and silt from said upper layer, and recycling a portion of the thus removed mixture of oil and silt for use as said first hydrocarbon diluent.

4. The process for separating oil and silt from bituminous sand containing the same which comprises mixing the bituminous sand with a small amount of a first hydrocarbon diluent, introducing the resultant mixture into a separation zone in which a lower fluidized layer of sand and an upper layer of oil and slit is formed, introducing hydrocarbon diluent into said lower layer to assist in maintaining same in a fluidized condition and to aid in separating said introduced mixture into said layers, introducing gas into said lower layer to strip said sand and to aid in fluidizing said layer, removing stripped sand from said lower layer, and removing a mixture of oil and silt from said upper layer.

5. The process for separating oil and silt from bituminous sand containing the same which comprises mixing the bituminous sand with a small amount of a first hydrocarbon diluent, introducing the resultant mixture into a separation zone in which a lower fluidized layer of sand and an upper layer of oil and slit is formed, introducing a second hydrocarbon diluent into said lower

layer to assist in maintaining same in a fluidized condition and to aid in separating said introduced mixture into said layers, introducing gas into said lower layer to strip said sand and to aid in fluidizing said layer, removing strip sand from said lower layer, removing a mixture of oil and silt from said upper layer, and recycling a portion of the thus removed mixture of oil and silt for use as said first hydrocarbon diluent.

6. The process for removing oil and silt from bituminuous sand containing the same which comprises mixing the bituminous sand with a small amount of a first hydrocarbon diluent, introducing the resultant mixture into a separation zone to form therein a lower fluidized layer of sand and an upper liquid layer of oil and silt, introducing a second hydrocarbon diluent into said lower layer to assist in maintaining same in a fluidized condition and to aid in separating said introduced mixture into said layers, removing sand from said lower layer, removing a mixture of oil and silt from said upper layer, and recycling a portion of the thus removed mixture of oil and silt for use as said first hydrocarbon diluent.

7. The process for removing oil and silt from bituminous sand containing the same which comprises introducing the bituminous sand into a separation zone to form therein a lower fluidized layer of sand and an upper liquid layer of oil and silt, introducing hydrocarbon diluent into said lower layer, removing a mixture of oil and silt from the upper layer of the separation zone, removing sand containing entrained hydrocarbons from the lower layer of the separation zone and passing same to a sand washing zone in which it is contacted with water to form in said washing zone a lower fluidized layer of sand, an intermediate layer of water and an upper liquid layer of hydrocarbons, and separately removing each of said layers from said washing zone.

8. The process for separating oil and silt from bituminous sand containing the same which comprises introducing the bituminous sand into a separation zone to form therein a lower fluidized layer of sand and an upper liquid layer of oil and silt, introducing hydrocarbon diluent into said lower layer, introducing gaseous material into said lower layer, removing a mixture of oil and silt from the upper layer of the separation zone, removing sand containing entrained hydrocarbons from the lower layer of the separation zone and passing same to a sand washing zone in which it is contacted with water to form in said washing zone a lower fluidized layer of sand, an intermediate layer of water and an upper liquid layer of hydrocarbons, and separately removing each of said layers from said washing zone.

9. The process for separating oil and silt from bituminous sand containing the same which comprises mixing the bituminous sand with a small amount of hydrocarbon diluent, introducing the resultant mixture into a separation zone to form therein a lower fluidized layer of sand and an upper liquid layer of oil and silt, introducing hydrocarbon diluent into said lower layer to assist in maintaining same in a fluidized condition and to aid in separating said introduced mixture into said layers, removing a mixture of oil and silt from the upper layer of the separation zone, removing sand containing entrained hydrocarbon diluent from the lower layer of the separation zone, mixing said removed sand with water and passing same to a sand washing zone in which it is contacted with additional water to form in said washing zone a lower fluidized layer of sand, an intermediate layer of water and an upper liquid layer of hydrocarbons, and separately removing each of said layers from said washing zone.

10. The process for separating oil and silt from bituminous sand containing the same which comprises mixing the bituminous sand with a hydrocarbon diluent, introducing the resultant mixture into a separation zone in which a lower fluidized layer of sand and an upper liquid layer of oil and silt is formed, introducing hydrocarbon diluent into said lower layer, removing a mixture of oil and silt from the upper layer of the separation zone, removing sand containing entrained hydrocarbons from the lower layer of the separation zone, mixing said removed sand with water and passing same to a sand washing zone in which it is contacted with additional water to form in said washing zone a lower fluidized layer of sand, an intermediate layer of water and an upper liquid layer of hydrocarbons, removing said layers from said washing zone and mixing a portion of the thus withdrawn water with sand from the separation zone.

11. The process for recovering hydrocarbon oil and silt from bituminous sand containing the same which comprises introducing the sand into a mixing zone, in said mixing zone, mixing said sand with a small amount of a first hydrocarbon diluent, introducing the resultant mixture into a separation zone in which a lower fluidized layer of sand and an upper liquid layer of oil and silt is formed, introducing a second hydrocarbon diluent comprising hydrocarbon liquid having a gravity between about 55 and about 65° API into said lower layer of sand to assist in maintaining same in a fluidized condition and to aid in separating said introduced mixture into said layers, introducing gas into said lower layer to strip said sand of hydrocarbons and to aid in fluidizing said layer, removing stripped sand from said lower layer, removing a mixture of oil and silt from said upper layer, recycling a portion of said removed oil and silt from said upper layer to said mixing zone as said first hydrocarbon diluent, mixing the sand withdrawn from said separation zone with water and passing same to a sand washing zone in which is formed a lower layer of fluidized sand, an intermediate layer of water and an upper liquid layer of hydrocarbons, introducing make-up water into the lower portion of said lower layer of sand in the washing zone to aid in fluidizing same, separately removing each of said layers from said washing zone and mixing a portion of the thus withdrawn water with said sand withdrawn from the separation zone prior to passing same to the washing zone as described above.

12. The process for removing hydrocarbon oil and silt from bituminous sand containing the same which comprises introducing the sand into a mixing zone, in said mixing zone mixing said sand with a first hydrocarbon diluent, introducing the resultant mixture into a separation zone in which a lower fluidized layer of sand and an upper liquid layer of oil and silt is formed, introducing a second hydrocarbon diluent comprising hydrocarbon liquid having a gravity between about 55 and 65° API into said lower layer of sand to assist in maintaining same in a fluidized condition and to aid in separating said introduced mixture into said layers, removing sand containing small amounts of said second hydrocarbon diluent from said lower layer, removing a mixture of oil and silt from said upper layer, recycling a portion of said removed oil and silt from said upper layer to said mixing zone as said first hydorcarbon diluent, mixing the sand withdrawn from said separation zone with water and passing same to a sand washing zone in which is formed a lower layer of fluidized sand, an intermediate layer of water and an upper liquid layer of said second hydrocarbon diluent, introducing water into the lower portion of said lower layer of sand in the washing zone to aid in fluidizing same and in separating said second hdyrocarbon diluent from said sand, and separately removing each of said layers from said washing zone.

13. The process for separating hydrocarbon oil and silt from bituminous sand containing the same which comprises introducing the sand into a mixing zone, in said mixing zone mixing said sand with a first hydrocarbon diluent, introducing the resultant mixture into a separation zone in which a lower fluidized layer of sand and an upper liquid layer of oil and silt is formed, introducing a second hydrocarbon diluent comprising hydrocarbon liquid having a gravity between about 55 and about 65° API into said lower layer of sand to assist in maintaining

same in a fluidized condition and to aid in separating said introduced mixture into said layers, introducing gas into the lower layer to partially strip said sand of hydrocarbons and to aid in fluidizing said layer, removing stripped sand containing small amounts of said second hydrocarbon diluent from said lower layer, removing a mixture of oil and silt from said upper layer, recycling a portion of said removed oil and silt from said upper layer to said mixing zone as said first hydrocarbon diluent, mixing the sand withdrawn from said separation zone with water and passing same to a sand washing zone in which is formed a lower layer of fluidized sand, an intermediate layer of water and an upper liquid layer of said second hydrocarbon diluent, introducing make-up water into the lower portion of said lower layer of sand in the washing zone to aid in fluidizing same and in separating said second hydrocarbon diluent from said sand, separately removing each of said layers from said washing zone and mixing a portion of the thus withdrawn water with said sand withdrawn from the separation zone prior to passing same to the washing zone as described above.

14. The process for separating hydrocarbon oil and silt from Athabasca tar sand which comprises introducing said tar sand into a mixing zone, in said mixing zone mixing said sand with a first hydrocarbon diluent, introducing the resultant mixture into a separation zone maintained at a temperature between about 40 and about 100° F. in which a lower fluidized layer of sand and an upper liquid layer of oil and silt is formed, introducing a second hydrocarbon diluent comprising hydrocarbon liquid having a boiling point range between about 100 and about 400° F. into said lower layer of sand at a plurality of points to assist in maintaining same in a fluidized condition and to aid in separating said introduced mixture into said layers, introducing gas into the lower portion of said lower layer to partially strip said sand of entrained hydrocarbons and to aid in fluidizing said layer, removing partially stripped sand containing small amounts of said second hydrocarbon diluent from said lower layer, removing a mixture of oil and silt from said upper layer, recycling a portion of said removed oil and silt from said upper layer to said mixing zone as said first hydrocarbon diluent, mixing the sand withdrawn from said separation zone with water and passing same to a sand washing zone in which is formed a lower layer of fluidized sand, an intermediate layer of water and an upper liquid layer of said second hydrocarbon diluent, introducing make-up water into the lower portion of said lower layer of sand in the washing zone to aid in fluidizing same, separately removing each of said layers from said washing zone and mixing a portion of the thus withdrawn water with said sand withdrawn from the separation zone prior to passing same to the washing zone as described above.

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UNITED STATES PATENT OFFICE

CERTIFICATION OF CORRECTION

Patent No. 2,965,557 December 20, 1960

William H. Price

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 3, line 3, for "and" read -- sand --; column 6, lines 24 and 25, and line 34, strike out "substantially free of added water", each occurrence, and insert the same after "zone" in lines 23 and 33, same column 6, each occurrence.

Signed and sealed this 30th day of May 1961.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

DAVID L. LADD
Commissioner of Patents