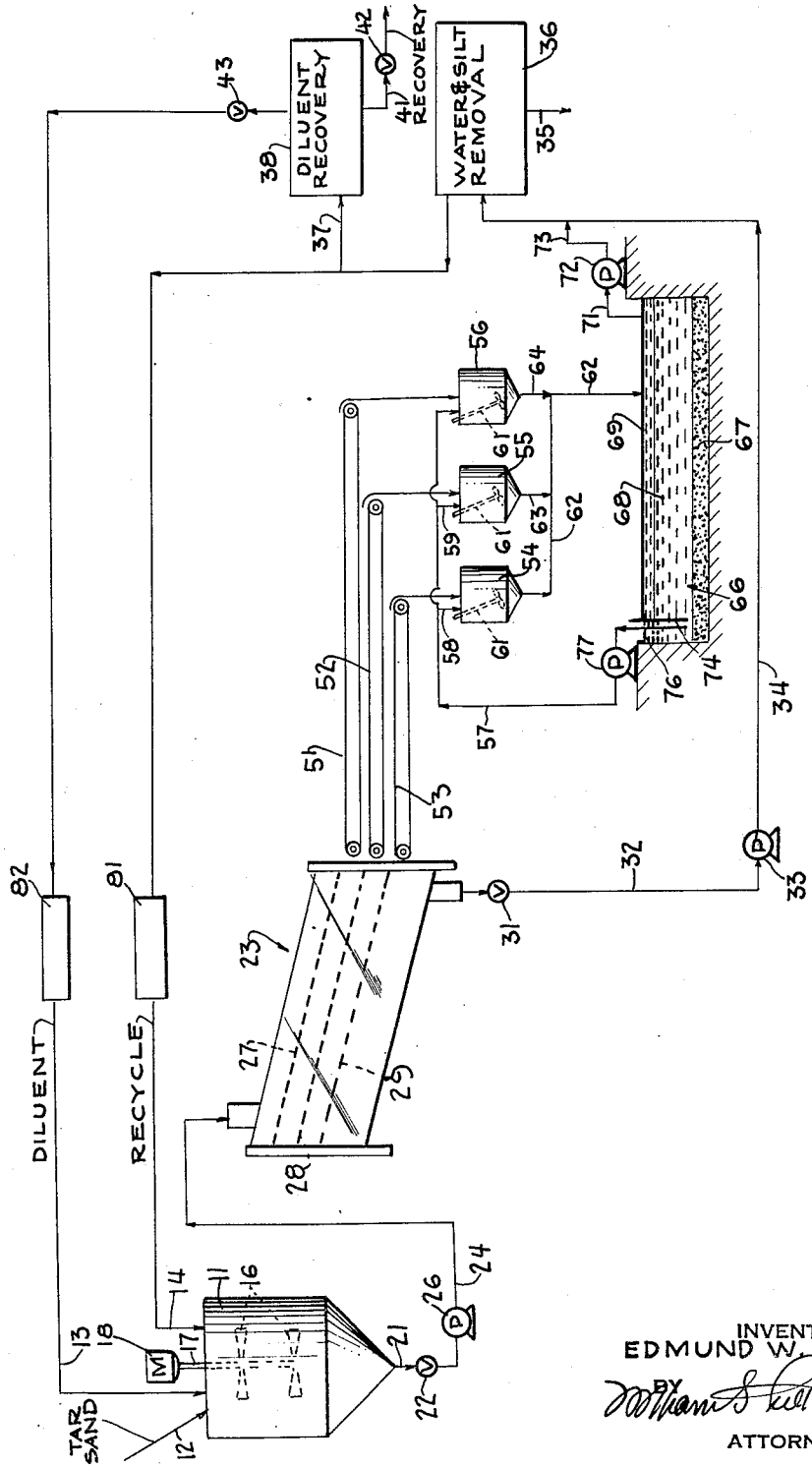
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SCREEN SEPARATION OF TAR SAND

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SCREEN SEPARATION OF TAR SAND

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This invention relates to an improved process for the recovery of hydrocarbon oil from bituminous sand containing the same.

Large deposits of bituminous sands 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 substantial success. Since the crude oil obtainable from this type of bituminous sand is relatively viscous material having high tar content and relatively low commercial value in comparison with other crude oils, successful commercial processes must involve relatively little expense in the separation of 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 hydrocarbon oil from tar sands such as the Alberta tar sands have employed the mixing of the bituminous sand 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 a significant quantity of crude oil which could not be successfully separated from the water.

In attempting to separate crude oil from bituminous sands considerable difficulty has also been experienced due to the fact that the solids content of bituminous sands such as the Alberta tar sands consists of particles of varying size and includes substantial amount sof 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 previous 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.

It is an object of the present invention to provide an improved process for the recovery of crude oil from bituminous sand containing the same.

It is another object of the invention to provide an improved process by which crude oil and silt may be separated from bituminous sand containing the same with essentially no loss of crude oil with waste sand.

According to a preferred embodiment of the present invention hydrocarbon oil is recovered from bituminous sand containing the same by the process which includes the steps of mixing said sand with liquid hydrocarbon diluent to form a slurry, passing said slurry through a first separating screen to thereby separate therefrom a first portion of sand particles too large to pass through the openings of said screen and containing entrained hydrocarbon liquid passing the remainder of said slurry through a second

separating screen having smaller openings than said first screen to thereby separate from said slurry a second portion of sand particles too large to pass through the openings of said second screen and containing entrained hydrocarbon liquid, separately mixing each of the thus separated portions of sand with water to form slurries of water, hydrocarbons liquid and sand, and treating said last mentioned slurries for removal of hydrocarbon liquid therefrom.

For a better understanding of the invention reference should be had to the accompanying drawing which is a diagrammatic illustration in which equipment is shown 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 mixing vessel **11** as indicated by an arrow **12**. The bituminous sands treated according to the invention are bituminous sands which contain crude oil and which usually contain silt in addition to the coarser sand particles. For purposes of this application silt may be defined as solids particles which pass thru a 150 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 of this type may contain widely varying amounts of silt, but such silt frequently comprises between about 1 and 20 weight percent of the total solids content of the bituminous sand. Similarly the amount of oil in the bituminous sand may vary widely. Typical tar sands from which crude oil is obtained in accordance with this invention frequently contain between about 5 and about 20 weight 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.

In the mixing vessel **11**, the tar sand introduced as indicated by the arrow **12** is thoroughly mixed with hydrocarbon diluent introduced through a conduit **13** and recycle oil introduced through a conduit **14** by suitable means such as conventional mixing paddles **16** carried on a shaft **17** and rotated by a motor **18**. Any suitable amount of diluent may be used in forming the slurry in the mixing vessel **11** but between about 1 and about 5 barrels of diluent per barrel of crude oil is preferably employed. Such hydrocarbon diluent should have a specific gravity substantially less than 1.0 and preferably has a gravity between about 20 and about 65 degrees API. Likewise any suitable amount of recycle oil may be used with recycle rates of between about 1 and about 10, more usually between about 4 and about 6 barrels of recycle oil per barrel of crude oil being preferred. If desired additional diluent may, of course, be used in place of the recycle oil, but use of recycle oil is preferred in order to reduce the amount of diluent which must be separated from crude oil.

Slurry formed in the mixing vessel **11** is withdrawn through a conduit **21** and valve **22** and passed to a screen separation vessel **23** through a conduit **24** by a pump **26**. The screen separation vessel **23** contains two or more screens such as **27**, **28** and **29** having successively smaller openings. A portion of the solid material passing through the screen **27** will thus be retained on the screen **28** while a portion of the material passing through the screen **28** will be retained on the screen **29**, etc. The screens **27**, **28** and **29** are preferably oscillated to facilitate passage of the slurry therethrough and to prevent bridging or plugging by retained sand. Solids particles sufficiently small to pass through all of the screens in the screen separation vessel **23** as well as most of the liquid contained in the slurry introduced through the conduit **24** pass through

all of the screens and may be withdrawn from the vessel **23** through a valve **31** and conduit **32**. It is preferred that the last separating screen through which the slurry passes have openings sufficiently large so that most of the silt passes through with the hydrocarbon liquid. This material may then be passed via a pump **33** and conduit **34** to suitable purifying equipment shown here as a water and silt removal system. The silt and water removal system **36** may take any suitable form such as one or more conventional settling tanks, electrostatic separating equipment, etc. Water and silt removed by the system **36** may be withdrawn through a conduit **35**. From the water and silt removal equipment **36** a portion of the purified hydrocarbon oil passes through the conduit **14** to the mixing vessel **11** as recycle oil for use as described above while the remainder of the purified oil from the water and silt removal equipment passes through the conduit **14** and a conduit **37** to diluent recovery equipment **38**. The diluent recovery equipment may take any suitable form such as conventional distillation towers and serves to separate hydrocarbon diluent from crude oil recovered from the tar sand. Crude oil product may be withdrawn through a conduit **41** and valve **42** while diluent may be withdrawn through a valve **43** and conduit **13** for use in forming the original slurry as described above.

The portions of sand separated from the slurry by the screens **27**, **28** and **29** are removed from the screens and passed by suitable means such as conveyor belts **51**, **52** and **53** to suitable mixing vessels such as **54**, **55** and **56**. Each of these portions of sand has a different size range of particles due to the different sized openings in the screens **27**, **28** and **29**. Each of portions of sand also contains entrained hydrocarbon liquid and small amounts of water and silt. It should be noted, however, that the vast majority of the silt present in the original bituminous sand passes through all of the screens **27**, **28** and **29** and is withdrawn with the hydrocarbon liquid through the valve **31**. It should also be noted that the amount of hydrocarbon oil entrained with the sand removed on the screens, while significant from an economic standpoint, represents only a small portion of the oil present such as up to about 0.5 percent. Further, this small amount of crude oil is diluted with recycle oil and diluent as described above.

In the mixing vessels **54**, **55** and **56** the separate portions of sand containing entrained hydrocarbon oil are thoroughly mixed with suitable quantities of water introduced through conduits **57**, **58** and **59** to form slurries of sand, water and hydrocarbon oil. Any suitable mixing apparatus may be employed such as conventional stirring rods **61**. By separately slurrying the portions of sand removed by the various separating screens as described above it is possible to vary the slurrying conditions for each batch of sand so as to insure sufficient slurrying without unnecessary waste of water or of the power required for mixing. In order to insure complete mixing and thereby insure complete removal of entrained hydrocarbons from the sand particles it is desirable that all of the sand be suspended in the water during the mixing operation. To achieve this it is necessary that the upward velocities in the mixing chamber exceed the terminal settling velocity of the individual sand particles. Since relatively larger sand particles require substantially higher upward mixing velocities than do relatively smaller sand particles, it is obvious that the minimum amount of mixing which would suffice to slurry a relatively fine sand will not suffice to satisfactorily slurry a coarser sand. By separately mixing the individual portions of sand in accordance with the present invention it is possible to slurry each portion under conditions of minimum mixing power and water consumption to assure sufficient slurrying while avoiding wasted power such as would be the case if the relatively fine sand particles and relatively coarser sand particles are slurried together. This is especially true if the sizes of the openings in the separating screens are so chosen that the majority of sand is separated following initial separation of the relatively coarser sand particles which require relatively more mixing power for proper slurrying with water. The relatively finer particles separated on the remaining screens such as **28** and **29** may then be slurried with a minimum amount of power appropriate to the size ranges of particles in these respective portions of sand.

The slurries of water, sand and entrained hydrocarbon oil formed in the mixing vessels **54**, **55** and **56** are then treated for removal of hydrocarbon oil therefrom in any suitable manner. As shown in the drawing these slurries may be withdrawn through conduits **62**, **63** and **64** respectively and passed to a settling pond **66** in which the slurries are allowed to settle to form a lower layer **67** of sand, an intermediate layer **68** of water and an upper layer **69** of hydrocarbon oil. Separate settling ponds for each of the slurries may, of course, be used. The sand may then be removed at intervals by suitable means such as a conventional drag line while the hydrocarbon oil may be removed from the surface of the pond through a conduit **71** and passed via a pump **72** and conduit **73** to the conduit **34** and thence to the water and silt removal equipment **36** described above. The pond **66** is preferably provided with a baffle such as **74** which serves to prevent entry of hydrocarbon oil into the portion of the pond from which water is withdrawn as through a conduit **76** and pump **77** for passage through conduit **57** to the mixing vessels **54**, **55** and **56** as described above.

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

EXAMPLE

An Alberta tar sand having the properties shown in Table 1 below is fed to the mixing vessel **11** at the rate of 71,760 tons per day.

Table 1

COMPOSITION AND PROPERTIES OF BITUMINOUS SAND FEED

Crude oil	9.6 weight percent.
Water	4.1 weight percent.
Solids	86.3 weight percent.
Density	120 lbs. per cubic foot.

SIEVE ANALYSIS OF SOLIDS

	Weight percent
Retained on 80 mesh	22.8
Retained on 100 mesh	43.7
Retained on 150 mesh	13.9
Passing 150 mesh	19.6

Hydrocarbon diluent having a gravity of 25° API is introduced into the mixing vessel **11** through the conduit **13** at the rate of 73,640 barrels per day (b.p.d.) at a temperature of 181° F. Recycle oil is supplied to the mixing vessel **11** through the conduit **14** at the rate of 157,300 b.p.d. at a temperature of 181° F. Slurry is withdrawn from the mixing vessel **11** and passed through the conduit **24** to the separation vessel **23** at a temperature of 150° F.

In the vessel **23** the separating screens **27**, **28** and **29** having openings of 80 mesh, 100 mesh and 150 mesh respectively. Material retained on the screen **27** is passed via the conveyor belt **51** to the mixing vessel **56** as follows:

	Tons per day
Solids too large to pass through 80 mesh screen	13,390
Hydrocarbon oil	115
Silt	30
Water	425

Likewise material retained on the screen **28** is passed by the conveyor belt **52** to the mixing vessel **55** as follows:

	Tons per day
Solids too large to pass through 100 mesh screen	25,650
Hydrocarbon oil	230
Silt	65
Water	1,840

Similarly material retained on the screen **29** is passed via the conveyor belt **53** to the mixing vessel **54** as follows:

	Tons per day
Solids too large to pass through 150 mesh screen	8,170
Hydrocarbon oil	90
Silt	25
Water	565

In the mixing vessels **54**, **55** and **56** the material carried from the screens by the conveyor belts is slurried with a proper amount of water under optimum conditions for thorough mixing in order to separate and drain hydrocarbon oil from the solids particles. In this respect water is introduced to the mixing vessels as follows:

	Tons per day
Mixing vessel **56**	1,200
Mixing vessel **55**	2,720
Mixing vessel **54**	980

As mentioned above it is one of the advantages of the present invention that the solids materials to be slurried in the mixing vessels **54**, **55** and **56** are of different size ranges. Thus the solids to be slurred in the mixing vessel **56** are almost entirely solids too large to pass through an 80 mesh screen while the solids to be slurried in the mixing vessel **55** comprise mostly solids capable of passing through an 80 mesh screen but not capable of passing through a 100 mesh screen. Likewise the solids to be slurried in the mixing vessel **54** are almost entirely those solids which passed through the 100 mesh screen but were unable to pass through the 150 mesh screen. It is obvious that the smaller solids particles present in the mixing vessels **54** and **55** will not require the same mixing conditions as the relatively larger particles present in the mixing vessel **56**. The savings in energy required for mixing slurries in these mixing vessels may be appreciated when it is considered that the terminal settling velocity of the solids particles present in the mixing vessel **54** is only about 1.0 foot per second while the terminal settling velocity of the solids present in the mixing vessel **55** is about 1.8 feet per second and the terminal settling velocity of the solids present in the mixing vessel **56** is about 2.0 feet per second. It is thus apparent that considerably less agitation is necessary to properly slurry the solids in the mixing vessels **54** and **55** than would be needed if the relatively larger particles were present in these vessels.

While the invention has been described above with respect to a preferred embodiment thereof 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 the recovery of hydrocarbon oil from bituminous sand containing the same which comprises forming a slurry of said bituminous sand and liquid hydrocarbon diluent, passing said slurry over a first separating screen to thereby separate a first portion of solids too large to pass through the openings of said screen from the remaining solids and hydrocarbon liquid, passing said remaining solids and hydrocarbon liquid over a second separating screen having smaller openings than said first screen to thereby separate a second portion of solids too large to pass through the openings of said second screen, separately slurrying said portions of solids with water to remove entrained hydrocarbon liquid therefrom, and treating said slurries of solids, hydrocarbon liquid and water for recovery of hydrocarbon liquid therefrom.

2. The process for treating bituminous sand containing hydrocarbon oil which comprising mixing said bituminous sand with liquid hydrocarbon diluent to form a slurry, passing said slurry through at least two separating screens having progressively smaller openings to thereby separate on said screens portions of sand having progressively smaller particles sizes and containing entrained hydrocarbon liquid, separately mixing each of said portions of sand with water to form slurries, and treating said last mentioned slurries for recovery of hydrocarbon liquid therefrom.

3. The process for the recovery of hydrocarbon oil from bituminous sand containing the same which comprises forming a slurry of said bituminous sand and liquid hydrocarbon diluent, passing said slurry through a first separating screen to thereby separate from said slurry a first portion of sand having particle sizes too large to pass through the openings of said screen, passing the remainder of said slurry through a second separating screen having smaller openings than said first screen to thereby separate from said slurry a second portion of sand having particle sizes too large to pass through the openings of said second screen, separately mixing each of said separated portions of sand with water under optimum conditions to form slurries of water, solids and hydrocarbon liquids which were entrained in said separated portions of solids, passing said last mentioned slurries to a settling zone in which the same are allowed to settle to form a lower layer of sand, an intermediate layer of water and an upper layer of liquid hydrocarbons and removing said upper layer of hydrocarbon liquid from said settling zone.

4. The process for treating bituminous sand containing hydrocarbon oil, water and silt which comprises mixing said bituminous sand with liquid hydrocarbon diluent to form a slurry, passing said slurry through at least two oscillating screens having progressively smaller openings to thereby separate on said screens portions of sand having progressively smaller particle sizes and containing entrained hydrocarbon liquid, water and silt, separately mixing each of said portions of sand with added water to form slurries, passing at least one of said last mentioned slurries to a settling zone to form therein a lower layer of sand, an intermediate layer of water and an upper layer of hydrocarbon liquid containing silt, withdrawing said layer of hydrocarbon from said settling zone and treating same for removal of silt therefrom.

5. The process for treating bituminous sand containing hydrocarbon oil, water and silt which comprises mixing said bituminous sand with liquid hydrocarbon diluent to form a slurry, passing said slurry through at least two oscillating screens having progressively smaller openings to thereby separate on said screens portions of sand having progressively smaller particle sizes and containing entrained hydrocarbon liquid, water and silt, separately mixing each of said portions of sand with added water to form slurries, passing at least one of said last mentioned slurries to a settling zone to form therein a lower layer of sand, an intermediate layer of water and an upper layer of hydrocarbon liquid containing silt, withdrawing said layer of hydrocarbon liquid from said settling zone and treating same for removal of silt therefrom, and treating the remainder of said first mentioned slurry for removal of silt therefrom.

6. The process for the recovery of hydrocarbon oil from bituminous sand containing the same which comprises forming a slurry of said bituminous sand and liquid hydrocarbon diluent, passing said slurry through a first oscillating screen to thereby separate from said slurry a first portion of sand having particles too large

to pass through the openings of said screen, passing the remainder of said slurry through a second oscillating screen having smaller openings than said first screen to thereby separate from said slurry a second portion of sand having particles too large to pass through the openings of said second screen, separately mixing each of said separated portions of sand with water under different optimum mixing conditions to form slurries of water, solids and hydrocarbon liquids which were entrained in said separated portions of solids, passing said last mentioned slurries to a settling zone in which the same are

allowed to settle to form a lower layer of sand, an intermediate layer of water and an upper layer of liquid hydrocarbons, and separately removing each of said layers from said settling zone.

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