PROCESS AND APPARATUS FOR THE SEPARATION
OF HYDROCARBONS FROM TAR SANDS

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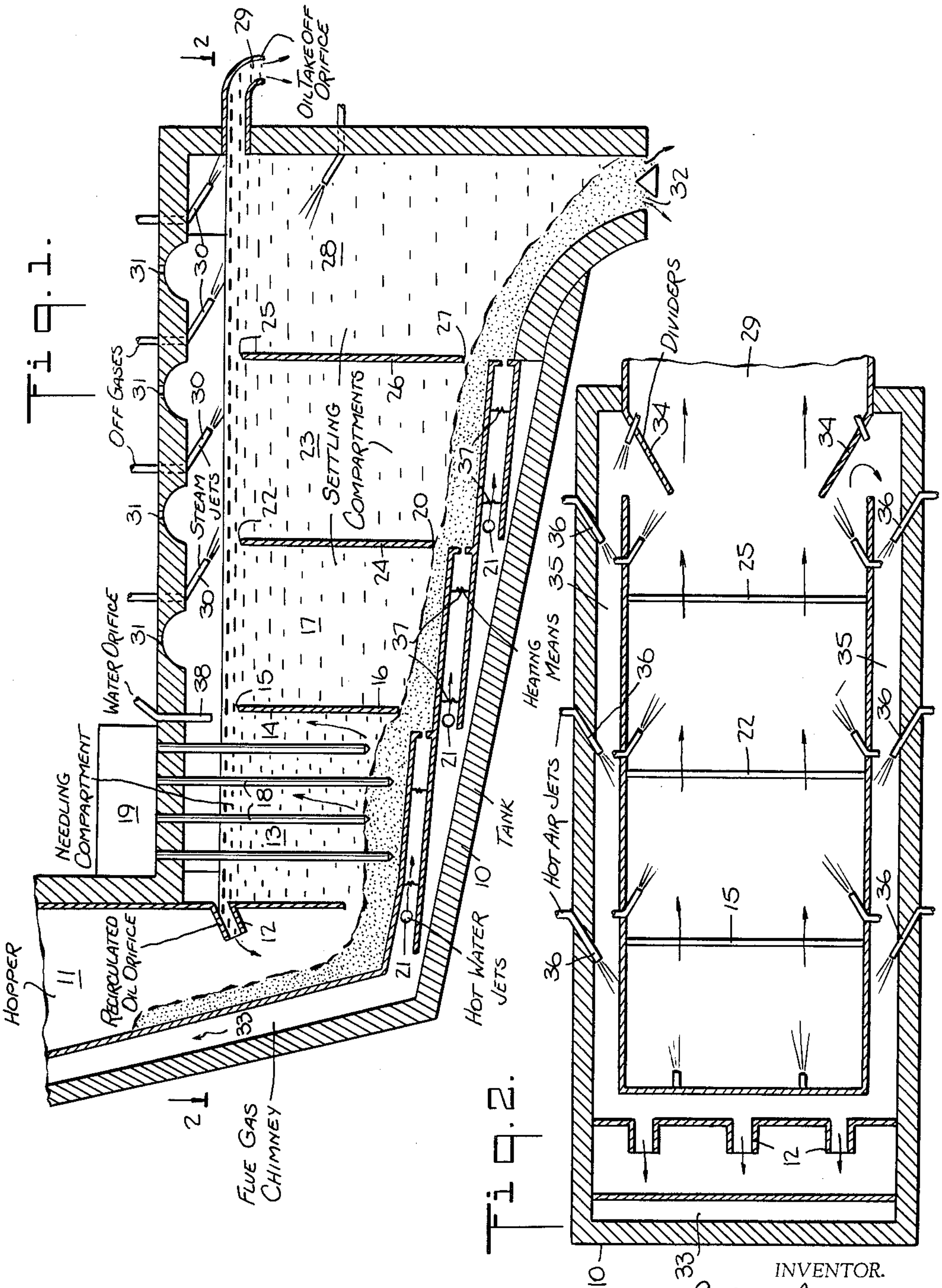

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Sept. 28, 1965 S. ANDRASSY 3,208,930

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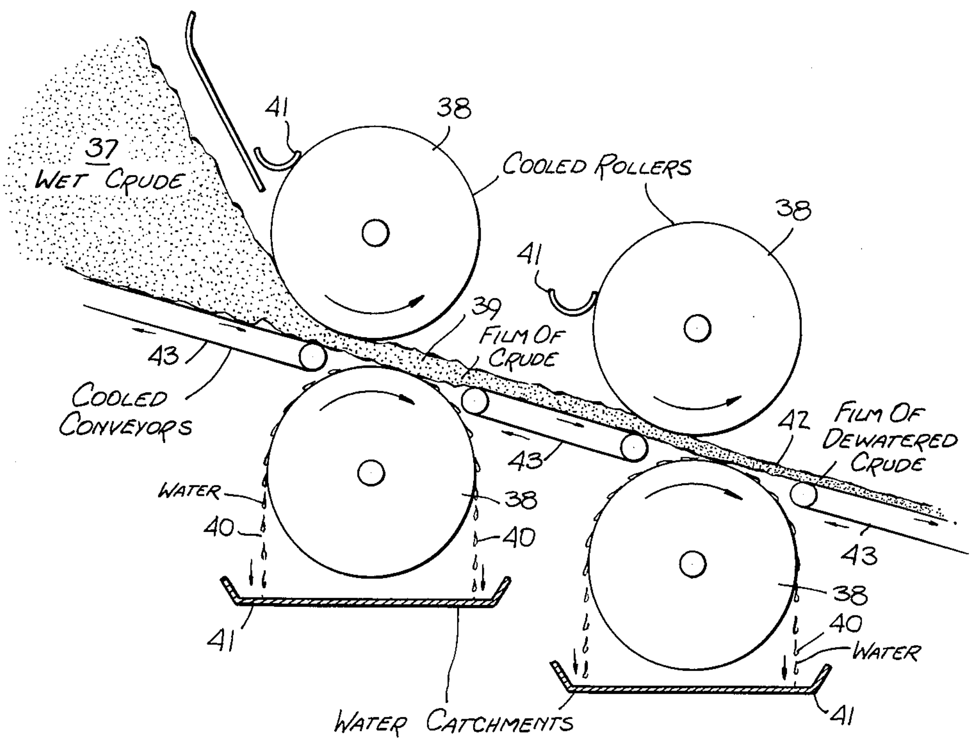

Fig. 3.

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3,208,930

PROCESS AND APPARATUS FOR THE SEPARATION OF HYDROCARBONS FROM TAR SANDS

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This application is a continuation-in-part application to my copending application Ser. No. 95,537 filed March 14, 1961, now abandoned.

This invention relates to a process for the separation of hydrocarbons from tar sands. More particularly this invention relates to a process for the extraction and recovery of oil from tar sands and to apparatus particularly adapted for carrying out the process.

The tar sands of the Athabasca region of Canada contain oil deposits estimated at up to 300 billion barrels; an amount of oil equal to the total known crude oil reserves of the entire world at the present time. The oil contained in the tar sands which lie at or near the surface has been estimated at more than 40 billion barrels of recoverable oil; an amount of oil about equal to the entire proven crude oil reserves of North America at the present time. It is therefore easy to understand why for more than 60 years the development of a simple economic process for the recovery of this oil has presented a challenge to oil technologists all over the world. In fact it has been estimated that between $60 and $100 million have been spent in the past 60 odd years to develop an economical process for the extraction of this oil. Unfortunately despite this tremendous investment in time and money, no satisfactory commercial process is in operation at the present time.

Among the processes proposed were in situ methods for the recovery of the oil by pyrolysis of the tar sands, viz U.S. Patents Nos. 2,777,679, 2,780,540 and 2,914,309. Other in situ methods involved drilling wells in the tar sands and passing solvents and cheimcals through the wells to dissolve the oil, viz U.S. Patents Nos. 1,735,481 and 2,365,591. Still another in situ method suggested was to subject the tar sands to an irradiation source, viz U.S. Patent No. 2,906,680.

One early approach to the problem involved powdering the tar sands and heating the powdered sands with water followed by heating the recovered mixture of sand and bitumen to 600° C. to purify the mixture, viz U.S. Patent No. 918,628. Other approaches involved heating the tar sands and water under high pressure, viz U.S. Patent No. 1,520,752; passing superheated steam and a hydrocarbon gas through the tar sands and then mixing the sands with water, viz U.S. Patent No. 1,592,179; passing a mixture of cold water and milled tar sands through a conduit which is subjected to vibration, viz Canadian Patent No. 543,493; heating tar sands and subjecting the heated sands to the action of propellers, viz U.S. Patent No. 1,529,505.

Other proposed solutions to this problem involved chemical treatments of the tar sands such as milling the sands in the presence of sodium hydroxide, viz U.S. Patent No. 1,820,917, or by the addition of alkali metal silicates and diluents to a water slurry of the sands, viz U.S. Patent No. 2,924,566.

Still other approaches to the solution of the problem involved the addition of solvents to the tar sands to dissolve the oil and recovery of the oil from the solvent, viz U.S. Patents Nos. 1,487,541, 1,502,261, 1,615,121, 2,453,060, 2,825,677 and 3,041,267.

The most promising approach according to the Research Council of Alberta in an article entitled "Athabasca Oil Sands, Historical Review and Summary of Technical

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Data" by K. A. Clark published in the Quarterly Edmonton Geological Society, volume 1, Nos. 1 and 2, 1957, involved the hot water washing method of separation. According to this method the oil sand was pulped and mixed with a large quantity of hot water and heated to 185° F. An oil froth containing oil, about 25% mineral matter and 30% water collected at the surface and was skimmed off. However, separation and purification problems together with the waste of heat involved demonstrated that the process was uneconomical. According to the Research Council of Alberta, the Canadian Bureau of Mines then turned to a cold water approach which involved the use of a solvent as well as washings with cold water. However, plant results showed that this process was even more costly than the hot water process despite the fact that up to 95% recovery of the oil from the tar sands was obtained.

Consequently despite the enormous effort undertaken to date to find a cheap and simple method for the separation of oil from tar sands, the prior art methods have not provided a satisfactory solution to the problem.

It is therefore an object of this invention to provide a simple cheap process for the recovery of oil from tar sands in a good yield. It is a further object of this invention to provide a process for the separation and recovery of oil from tar sands by means of simple efficient apparatus. It is still a further object of this invention to provide simple efficient apparatus for the separation, extraction and recovery of oil from tar sands. It is still a further object of this invention to provide a process for the separation and recovery of oil from tar sands which eliminates the necessity for the use of solvents, pyrolysis and other prior art practices. These and other objects of the invention will become apparent from the following detailed description of the invention.

Therefore according to this invention there is provided a process for the separation of oil from tar sands which comprises forming a mixture of tar sands, oil of the same constituency as the oil in the tar sands and water in an amount sufficient to form a water layer on top of said tar sands, needling said water and oil-tar sand mixture and heating the water-oil-tar sand mixture to the boiling point of water thereby causing oil trapped in the tar sands to separate from said tar sands and float to the top of the water layer, maintaining the temperature at about 190–200° F. so as to allow the separated oil to accumulate on the top of the water layer, and recovering the oil from the water layer.

One of the essential features in my process as described above is the addition to the tar sands of oil of the same constituency as the oil trapped in the tar sands. I have found that the addition of this oil, preferably oil previously extracted from the tar sand itself, as will be described in greater detail hereinafter, has a profound effect upon the oils present in the tar sands and allows for virtually complete stripping of the oil trapped in the tar sands so as to leave clean white tailings of sand behind. Generally I have found that the best results are obtained when about 15–25% of oil based on the weight of the tar sands is added to the tar sands prior to heating the mixture. When less than 15% oil is added, the process takes longer, and when more than 25% oil is added no particular advantages were found.

I have found it desirable to employ an amount of water sufficient to form a layer of water on top of the tar sands. Care must be taken so as not to employ so much water as to form a very pulpy mixture which would substantially increase the heat requirements of the process. At the same time care should be taken so as not to employ too little water if a good separation of oil from silt is to be obtained. I prefer to use an amount of water about equal in weight to the weight of the tar sands being processed although the amount of water employed may vary within the limits specified above.

In carrying out the process, I prefer to first blend the tar sands and oil together followed by addition of the water. However, many modifications of this sequence of steps are possible. For example, the oil and water may first be mixed together, followed by addition of the tar sands; or the tar sands and water may first be mixed together followed by addition of the oil; or the oil, tar sands and a small amount of water may be mixed together and heated followed by addition of the remainder of the water.

In carrying out the process, the tar sand-oil and water mixture is agitated and the temperature of the mixture is raised to the boiling point of water. As the temperature increases and approaches the boiling point of water, the mixture of oil and tar sands softens appreciably and decreases in viscosity. Clear sand begins to appear on the bottom of the chamber as the heating progresses. The oil separating from the sand forms a layer on top of the sand layer. As the boiling point of water is approached, the oil layer floats to the top of the water layer forming a clearly separated layer of black oil. The water layer is somewhat muddy while the bottom sand layer is a clean white layer of sand.

After the boiling point of water is reached, the heating is diminished so as to permit complete recovery of the oil from the sands. However, I have found that it is essential to maintain the temperature of the mixture below the boiling point of water and preferably in the range of about 190–200° F. If the temperature falls below this point, the oil begins to settle to the bottom of the tank. The oil layer on the surface of the water can be recovered by any conventional method, such as by being floated or skimmed off.

In applying heat during the process, I have found it particularly desirable to apply the heat continuously from underneath the reaction chamber and not from the sides of the vessel. Heating the mixture in this manner not only contributes to the floating of the separated oil to the surface, but also assists in freeing the oil from the tar sands by the constant grinding action of the sands constantly kept in motion by the heat.

I have found it particularly desirable to provide needling means which agitate the mixture during the heating operation. The needling means may be spikes, needles, plungers, etc. which not only aid in disintegrating the sands, but also bring the film of oil around the sand grains in contact with the free oils and aids in causing the oil trapped in the grains to unite with the free oil. This affinity of the oil trapped in the sand grains for the free oil is facilitated by the action of the needling means which help to lift the oil to the surface of the water.

As the oil is removed from the surface a portion of the separated oil is recirculated for mixing with the incoming untreated tar sands. Simultaneously the sand tailings are removed and discarded. The ejected water is filtered and reused. The heat content of the sand tailings is recovered by means of a heat exchanger or through washing with cold water. Water lost during the process, is continuously replaced and the process is continuously repeated as described above.

In addition to providing a simple economical method for the separation of the oil from the tar sands, my process also has the distinct advantage of being extremely quick and only requires heating the tar sands for a short period of time, i.e. from about one minute to about one hour. Preferably the heating is continued for about five minutes after the tar sand mixture has reached the boiling point. The temperature is then lowered to about 190–200° F. to permit accumulation of the oil on the top of the water layer.

Oil, which has been separated with the water method, contains considerable amounts of water, which must be removed from the oil before refinery treatment is possible. The water may be removed from the oil either before or after the oil has been treated to remove sulfur and other impurities. To distill out this high content of water is both costly and time-consuming. I have found that since the water is entrapped, not mixed with the oil, it is possible, under certain conditions, to press out the water. After the separated oil has cooled below 70° F., its physical properties are changed from that of a liquid to a rather elastic state, soft enough to be deformed mechanically. Thus in order to expel the water from the oil, I cool the oil to a temperature below 70° F. and then pass the cooled oil through a series of rollers placed in a slanted position with the first roller uppermost to permit the drainage of water as it is pressed from the oil as it passes through the rollers. The dewatered oil may then be treated by conventional methods and refined.

While I do not wish to be bound by any theory, I believe that one of the primary reasons for the efficacy of this process is that the added oil has an affinity for the entrapped oil thereby helping to strip the entrapped oil from the sands. The increased volume of the oil, which changes the proportions of the basic material, may also be a contributing factor. During the heating process, the specific gravity of the crude oil trapped in the sand becomes less than that of the water itself and consequently floats to the surface of the water where it may be easily removed.

Water at 60° F. has a specific gravity of 0.9990 and at 212° F. has a specific gravity of 0.9584. The crude oil trapped in the sands generally has a specific gravity at 60° F. of about 1.002 to 1.02 and has a specific gravity at 212° F. of from about 0.926 to about 0.944. Thus the addition of excess oil from a previous extraction plus the increase in temperature to near the boiling point of water causes the specific gravity of the oil trapped in the sands to decrease below that of water and consequently permits it to rise to the surface.

The fact that the addition of previously extracted oils to the tar sands causes the process to operate so efficaciously is indeed surprising since it is well known that the addition of boiling water alone to the tar sands over a long period of time, only provides for a partial stripping of the oil entrapped in the tar sands despite the fact that at the boiling point of water, the oil from the tar sands has a specific gravity below that of water.

As I mentioned previously, I prefer to use as the oil to be mixed with the tar sands, oil which has been previously extracted from the sands. In order to obtain the first batch of oil for use in my process, I prefer to use a chemical extraction method that I have found to be superior to those proposed in the prior art. In carrying out this method, the tar sands are mixed with any one or a mixture of the following solutions and heated to the boiling point:

	Concentration per percent
Trisodium phosphate	10 to 15
Disodium phosphate	10 to 20
Sodium bicarbonate	10 to 20
Sodium tetraborate (borax)	10 to 30

After heating the tar sands with any one or a mixture of the above solutions for a short period of time, i.e. about three minutes, the oil layer floats to the top, the heating is stopped and the oil layer is removed for use in recovering oil from tar sands in subsequent operations. The hot solution can be drained off and used on other batches of tar sands. The sand may be washed with water and the wash water used in subsequent processing steps. Amongst the distinct advantages of using my chemical treatment process for obtaining an initial recovery of oil for use in subsequent operations is the fact that I do not find it necessary to grind, or mill, or centrifuge the chemical-tar sand mixture as is necessary in the pror art procedures. Upon recovery of this initial oil fraction, I then switch to my preferred process as described previously for subsequent treatment of the tar sands.

The following examples are illustrative of the results which may be obtained using my process and of some of the modifications thereof which may be employed. Many other modifications will be apparent to those skilled in the art.

Example I

100 parts by weight of Athabasca oil sands were mixed with 20 parts by weight of oil previously extracted from oil sands and with 100 parts by weight of water. The mixture was heated to the boiling point of water and held at 212° F. for two minutes. The heating was thereupon stopped and the oil which had floated to the surface of the water was skimmed off. 46 parts by weight of the oil and water were skimmed off. Upon drying the same, 37 parts by weight were obtained. This yielded 17 parts by weight of the recovered oil on a dry basis. The Athabasca tar sand deposits have an oil content of 10–17% (D. S. Pasternak, Chem. Eng. Progress, Vol. 56, April 1960). On the basis of the tar sands tested, the recovery appears practically theoretical.

Example II

25 parts of oil recovered from a previous batch of tar sands were mixed with 300 parts of water and heated until the oil floated to the surface. The mixture was then cooled to slightly below 190° F. and 100 parts of tar sands were added to the mixture. The mixture was then needled and heated to 212° F. until the oil began to separate from the tar sands and rise to the surface. The temperature was then decreased to between 190–200° F. and maintained until the oil accumulated on its surface of the water. The separation of the oil from the tar sands took somewhat longer than usual and was not as effective since some oil still remained in the tar sands.

The temperature was thereupon decreased and the free oil permitted to settle to the bottom of the reaction chamber. The mixture was then reheated with needling in the manner previously described. A clean separation of the oil from the tar sands was obtained.

Example III

100 parts of tar sands and 300 parts of water were heated together with agitation until the oil from the tar sands rose to the surface. The mixture was cooled to slightly below 190° F. and 25 parts of free oil recovered from a previous batch of tar sands were added to the mixture. The mixture was then needled and heated in the manner previously described. A clear separation of oil from tar sands was obtained although the process took somewhat longer than usual.

Example IV

25 parts of oil previously extracted from the tar sands were added to 100 parts of tar sands to which was added a small amount of water. The mixture was needled and heated to 190° F. whereupon the remainder of the water was added bringing the total amount of water in the vessel up to 300 parts. The mixture was placed in another vessel and violently agitated. Some separation of oil from the tar sands was observed. However, it was only after the mixture was returned to the original vessel and subjected to the usual needling and heating steps that a clear separation took place.

I have found that the separation and extraction of the oil from the tar sands may be accomplished most expeditiously in apparatus which I have especially designed for this process. Basically the apparatus is automatic in design and of simple construction and consists of a tank equipped with dividers which direct portions of the separated oil into channels by means of hot-air jets, flowing backward to the hopper where the oil is mixed with the incoming tar sands. The tank has a slanting bottom, a needling chamber with plungers, several compartments equipped with partitions and a deep drop with a standard sand discharge orifice.

The apparatus can be stationary, or it can be semi-mobile for field operation. The only moving parts are the plungers, which are so constructed that they cannot become clogged. The water level is regulated to permit intermittent discharge of the oil as the sand is removed.

The heat to be supplied to the apparatus may be any source of heat, although since natural gas is available in large amounts in the oil-sand regions, it provides the most economical source of heat available. When heat is applied continuously and from underneath the apparatus at the necessary rate, the separation of oil from the sand takes place within a few minutes after the water is brought to its boiling point. I have found that the tank employed should be constructed such as to have an extended surface area in order to permit the accumulation of a thin layer of oil. The large surface area also accelerates the separation of minute sand particles and silt from the oil which are carried up to the surface with the oil. The dividers can be adjusted in accordance with the character of the oil sand which is to be treated.

The separated oil is homogeneous and of a shiny character, and is not frothy as is generally the case when separated by conventional hot water methods. The oil as it leaves the apparatus is almost completely free from foreign matter. The sand tailings, as finally removed, are generally free of bitumen.

Reference should now be had to FIG. 1 of the accompanying drawings which show a cross-sectional view of the apparatus of this invention and to FIG. 2 which is a sectional view of the apparatus of this invention taken along line **2—2** of FIG. 1.

FIG. 3 is a cross-sectional view of apparatus designed to remove water from the recovered crude oil.

Tar sand is introduced into a hopper **11** which is connected directly to the tank **10**. Prior to introducing the oil sands into the hopper, the sands are heated by discharging hot gases (not shown). From the inner side of the hopper through orifice **12**, excess oil is charged to the hopper and mixes with the tar sands. Water is continuously introduced into the tank through orifice **38** and is maintained at the desired level. The oil enriched tar sands fall by gravity into the partly water-filled needling compartment **13**. Plungers **18** are individually sprung so that in case they hit stones, etc., they will not break. These plungers which are driven by motor means **19**, needle the oil enriched tar sand-water mixture to form a homogeneous mass and facilitate floatation of oil to the surface. Heat is applied from the bottom of the tank by heating means **37** and the temperature is raised to the boiling point of water. At this temperature, the added oil is helpful in stripping the oil from the sands. As soon as the boiling starts, the oil rises to the surface and flows to settling compartment **17**. The gradual flow of the oil enriched tar sands into compartment **17** is somewhat retarded by partition wall **14** which has an opening on both the top **15** and the bottom **16**. The heavier than water particles sink to the bottom of this compartment and move toward the bottom exit **20** of partition wall **24** conveyed by hot water jets **21** while the oil floats over the top opening **22** to the next compartment **23**. In compartment **23**, additional oil separates from the pockets of tar sands remaining in the heavier sand being freed by the constant grinding action induced by the bottom heating and flows over top opening **25** of partition wall **26** while the sand particles move through bottom opening **27**. In FIG. 1, three compartments are shown but this number can be increased if desired. In the last compartment **28**, no heat is applied from the bottom of the tank thereby permitting settling of fine particles and silt. The separated sand is continuously pushed by water jets **21** into compartment **28**. The solids and water are discharged through outlet **32** and removed by conventional means.

The floating oil is continuously moved toward the oil off-take **29** by hot air or steam jets **30**. Gaseous products are withdrawn at off-take **31**. The flue gases generated by the burners are discharged through flue gas duct or chimney **33** and are used to preheat the incoming tar-sands. The feed water is preheated through a heat exchanger (not shown) using the heat of the sand tailings.

Referring now to FIG. 2 which discloses a top view of the apparatus of this invention, it will be seen that before the separated oil flows out of the tank **10**, a regulated quantity of oil is returned to the hopper **11** through excess oil orifice **12** (FIG. 1). This is accomplished by causing a portion of the oil to flow through dividers **34** positioned in the front of the tank adjacent oil off-take **29** and channels **35** located along the sides of tank **10**. Hot air or live steam jets **36** positioned in the channels **35** keep the oil moving in the desired direction towards excess oil orifice **12**. In the hopper, the hot and purified oil is continuously fed into the incoming stream of raw material thus providing a continuous self-feeding and self-enriching system for the recovery of oils from the tar sands.

The recovered wet crude oil is cooled to below 70° F. or until it becomes semi-rigid but still of plastic consistency. Referring now to FIG. 3, it will be seen that the plastic mass of wet crude oil **37** is passed between a system of slanted cooled rollers **38** where it pressed into a thin film **39**. During this process, the water **40** which is entrapped in the oil, is pressed out and discharged to receptacle **41**. The dewatered film **42** is then conveyed to storage or further treatment on slanted conveyor **43**. This process may be repeated, if necessary, to remove additional water from the crude oil.

Having thus provided a written description of the present invention and provided specific examples thereof, it should be understood that no undue restrictions or limitations are to be imposed by reason thereof but that the present invention is defined by the appended claims.

I claim:

1. A process for the separation of oil from tar sands comprising forming a mixture of tar sands, recirculated oil recovered from a previous extraction and having substantially the same constituency as the oil in said tar sands and hot water in an amount sufficient to form a water layer on top of said tar sands, agitating said water-oil-tar sand mixture so as to bring the tar sands into contact with free oil and heating said mixture to the boiling point of water thereby causing oil trapped in the tar sands to separate from said tar sands and float to the top of the water layer, lowering and maintaining the temperature of the mixture to about 190–200° F. so as to allow the separated oil to accumulate on the top of the water layer, recirculating part of the floating oil for mixture with untreated tar sands and removing the remainder of the floating oil from the water layer.

2. A process for the separation of oil from tar sands comprising forming a mixture of tar sands, recirculated oil recovered from a previous extraction and having substantially the same constituency as the oil in said tar sands and hot water in an amount sufficient to form a water layer on top of said tar sands, needling said water-oil-tar sand mixture so as to bring tar sands into contact with free oil and heating said mixture to the boiling point of water by applying heat to the bottom surface of said mixture thereby causing oil trapped in the tar sands to separate from said tar sands and float to the top of the water layer, lowering and maintaining the temperature of the mixture to about 190–200° F. so as to allow the separated oil to accumulate on the top of the water layer, separating the oil from the water layer and recirculating part of the recovered oil for mixture with untreated tar sands.

3. A process for the separation of oil from tar sands comprising forming a mixture of tar sands, recirculated oil recovered from a previous extraction and having substantially the same constituency as the oil in said tar sands and hot water in an amount sufficient to form a water layer on top of said tar sands, needling said water-oil-tar sand mixture so as to bring tar sands into contact with free oil, heating said mixture to the boiling point of water by applying heat to the bottom surface of said mixture thereby causing oil trapped in the tar sands to separate from said tar sands and float to the top of the water layer, lowering and maintaining the temperature to about 190° F. so as to allow the separated oil to accumulate on the top of the water layer, recirculating part of the floating oil for mixture with untreated tar sands, and separating the remainder of the oil from the water layer.

4. A process for the separation of oil from tar sands comprising forming a mixture of tar sands, about 15–25% based on the weight of the tar sands of recirculated oil recovered from a previous extraction and having substantially the same constituency as the oil in said tar sands and hot water in an amount sufficient to form a water layer on top of said tar sands, needling said water-oil-tar sand mixture so as to bring tar sands into contact will free oil and heating said mixture to the boiling point of water by applying heat to the bottom surface of said mixture thereby causing oil trapped in the tar sands to separate from said tar sands and float to the top of the water layer, lowering and maintaining the temperature of the mixture to about 190–200° F. so as to allow the separated oil to accumulate on the top of the water layer, recirculating part of the floating oil for mixture with untreated tar sands, separating the remainder of the oil from the water layer, separating the hot water from the discharged sands and recirculating the hot water for mixture with untreated tar sands and recirculated oil.

5. A process for the separation of oil from tar sands comprising forming a mixture of tar sands, about 15–25% based on the weight of the tar sands of recirculated oil recovered from a previous extraction and having substantially the same constituency as the oil in said tar sands and hot water in an amount sufficient to form a water layer on top of said tar sands, needling said water-oil-tar sand mixture so as to bring tar sands into contact with free oil, heating said mixture to the boiling point of water by applying heat to the bottom surface of said mixture thereby causing oil trapped in the tar sands to separate from said tar sands and float to the top of the water layer, lowering and maintaining the temperature to about 190° F. so as to allow the separated oil to accumulate on the top of the water layer, recirculating part of the floating oil for mixture with untreated tar sands, separating the remainder of the floating oil from the water layer, separating the hot water from the discharged sands and recirculating the hot water for mixture with untreated tar sands and recirculated oil, washing the oil stripped tar sands with cold water to recover some of the heat content of the tar sands, separating the water from the tar sands and recirculating the water for use in the process.

6. Apparatus for separating oil from tar sands comprising a sloping tank having heating means in the bottom thereof, said tank having a needling compartment and at least one settling compartment, means associated with said tank for introducing crude tar sands into said tank, means in said tank for introducing hot water into said tank, means positioned near the front of said tank for introducing excess oil into said tank, needling means in said needling compartment for mixing said tar sands, water and excess oil, an opening in the top of said settling compartment for allowing the passage of said oil and an opening in the bottom of said settling compartment for allowing the passage of sands to be discharged from said compartment, means positioned in the bottom of said tank for conveying said tar sands through the tank and means positioned in the top of said tank for moving the floating oil towards a discharge means, means

adjacent said discharge means for diverting a portion of said floating oil to channels in said tanks and means positioned in said channels for moving said oil to said excess oil introducing means.

7. Apparatus for separating oil from tar sands comprising a sloping tank having heating means in the bottom thereof, said tank having a needling compartment and at least one settling compartment, a hopper associated with said tank for introducing crude tar sands into said tank, an excess oil orifice positioned near the front of said tank for introducing excess oil into said tank, means in said tank for introducing hot water into said tank, plungers in said needling compartment for mixing said tar sands, water and excess oil, an opening in the top of said settling compartment for allowing the passage of said oil and an opening in the bottom of said settling compartment for allowing the passage of sands to be discharged from said compartment, jets positioned in the bottom of said tank adapted to convey said tar sands through said tank and jets positioned in the top of said tank adapted to move the floating oil towards a discharge orifice, dividers adjacent said discharge orifice

for diverting a portion of the floating oil towards channels positioned along the sides of said tank and jet means positioned in said channels for moving said portion of oil to said excess oil orifice, and outlet means in the bottom of said tank for removing the treated tar sands.

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ALPHONSO D. SULLIVAN, *Primary Examiner.*