

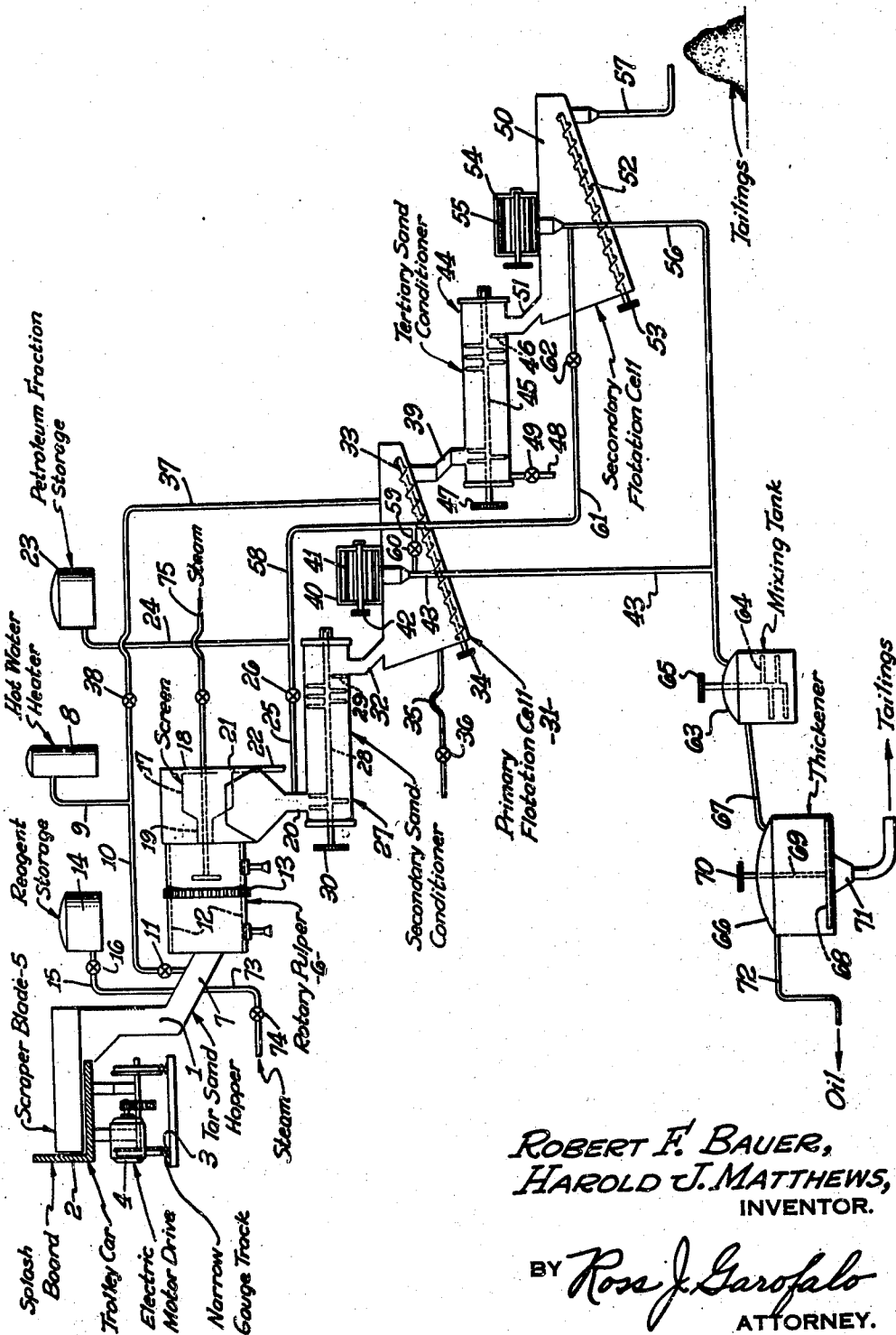
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PROCESS AND APPARATUS FOR TREATING BITUMINOUS SANDS

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PROCESS AND APPARATUS FOR TREATING
BITUMINOUS SANDS

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This invention relates to a process and apparatus for separating and treating bituminous sands and like material into its bituminous and other constituents, one of the resulting products being composed almost wholly of the bituminous constituents of the material with only a small amount of other matter and the other product being composed of the other matter in which remains only a small quantity of bitumen.

The removal of bituminous constituents from native bituminous materials, such as for instance the bituminous sands found in the Athabaska region of northern Alberta consisting of a mixture of bitumen with sand, silt or clay, has been attempted on many occasions without a great deal of success. Therefore, a process and apparatus capable of recovering said bitumen on an economical, as well as a commercial scale is highly desirable.

The objects of the invention are to provide a simple and economical process and apparatus capable of operation under commercial conditions which will enable a maximum amount of bitumen to be recovered from the material treated.

Another object is to provide a simple and effective means for causing the disintegration of the sand and the separation therefrom of the bituminous products.

We have discovered a process by which bituminous products may be readily and efficiently recovered from bituminous materials in continuous agglomeration and flotation steps, wherein a pure bitumen is the resulting product leaving clean mineral matter as a residue.

The process of our invention may be readily understood by reference to the attached schematic drawing illustrating one modification of the same.

Rich bituminous sands are continuously fed into tar sand hopper 1, by means of a continuous series of trolley cars similar to that designated as 2. This series of trolley cars operates on a circular narrow gage track, such as that designated as 3. The bituminous sands are placed on the trolley cars by means of trucks, located at the arc opposite tar sand hopper 1, and when the trolley cars are full to capacity the cars are moved around the circular track motivated by electric motor 4. When bituminous sands on the moving trolley cars contact scraper blade 5 the sands are scraped off and cascaded down into hopper 1 thus providing our apparatus with a continuous feeding device. The bituminous material cascading down through hopper 1 enters rotary pulper and conditioner 6 by means of launder 7. The bitu-

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minous material during its passage through launder 7 is contacted by a heating and diluting medium by the introduction therein of hot water from hot water heater 8 via lines 9 and 10 and controlled by valve 11. The bituminous material entering rotary pulper 6 is heated therein by means of the aforementioned hot water and disintegrated therein by means of agitation effected by the rotation of the pulper and blades 12 attached to the walls of the pulper, the combined effect being to pick up and drop one lump of tar sand feed upon another and thus bring about disintegration. The pulper is rotated by means of gear 13, which could be any suitable driving mechanism, which is connected to any suitable motor, not shown here. The bituminous material during its passage through launder 7 and prior to its entrance into the rotary pulper and conditioner 6 is contacted with a conditioning reagent, such as sodium silicate, sodium carbonate or other reagent as described later. This reagent is introduced, preferably as a concentrated aqueous solution, into launder 7 from tank 14 via line 15 and controlled by valve 16. Several changes are effected in the mixture conditioned in rotary pulper 6. Such changes are brought about by the cumulative effect of the numerous variables of time, agitation and/or abrasion, temperature and concentration of reagent. Regarding the change in the character of the bituminous material effected in this primary conditioning several things may be said to occur. Of primary importance, however, is the quite fine division and dispersion of oil particles. In the process of finely dividing the oil particles, entrained sand is released from the oil matrix. If clay is present, as it is to some extent in practically all sands it is thus freed from the oil and subsequently may be held in the water either in a flocculated or a dispersed form. Whether the clay will be flocculated or dispersed is a function of the inherent chemicals in the particular sand and the water used. In either case however, it is not critical from the standpoint of the subsequent flotation step, but may be of importance in the event that it is found desirable to recycle the water used in the subsequent flotation step. In this case, it may be found desirable to add a small amount of a reagent to effect flocculation of the clays which were previously dispersed therein. Such a reagent as sodium chloride might be used for this purpose or any one of a number of other reagents known to flocculate clays might also be employed.

The hot disintegrated bituminous material and

finely divided oil particles move through pulper 6 as described above and enter screen enclosure 17 in stationary housing 18 via channel 19. Screen 17 and channel 19 rotate in conjunction with rotary pulper 6, the screen acting as a sifting device whereby the disintegrated bituminous particles and finely divided oil particles fall through the bottom of the screen and down into launder 20. The large rocks and pebbles, i. e. foreign matter too large to pass through the screen mesh pass horizontally along the screen and out through opening 21 and down through launder 22 to be disposed of in any desirable manner, not shown here. The hot mixture of disintegrated bituminous sand and water cascading down through launder 20 is known as pulp in the bituminous sand industry. The pulp in launder 20 is again conditioned, this time with an oil solvent, such as kerosene or other solvent as described below, which is introduced therein from tank 23, via lines 24 and 25 controlled by valve 26. This mixture consisting of hot bituminous pulp, and kerosene in launder 20 is then introduced into secondary sand conditioner 27, which is provided with a mixer 28 equipped with impeller blades, and weir 29 for maintaining a liquid level therein. The mixer 28 is rotated by means of gear 30 which may be any suitable driving mechanism, connected to any suitable motor, not shown here. The mixture in secondary sand conditioner 27 is conditioned by means of the introduced solvent and the agitation provided by the swiftly revolving shaft and impeller blades, so that the tar and solvent are aerated and tend to separate by flotation from the sand and water.

The addition of the solvent to the above pulp will effect a coagulation or agglomeration of the dispersed oil particles. The solvent will also dissolve the oil or tar present in the bituminous sands and reduce its viscosity and density. The thus conditioned mixture comprising agglomerated oil, solvent, sand, sodium silicate, and water in the secondary sand conditioner 27 is introduced into primary flotation cell 31 via launder 32. The flotation cell may be any one of the recognized flotation cells used in the mining industry, but is preferably one with screw lifts such as 33, positioned on the bottom of the flotation cell, and operated by means of gear 34 which is motivated by any suitable means, not shown here, so as to operate in such a manner that the sand particles are carried up the inclined bottom surface to outlet 39 as shown in the drawing. A water level is maintained in the flotation cell preferably below outlet 39, by means of overflow 35 which may also be controlled by valve 36. Hot water is introduced into the flotation cell from hot water heater 8 via lines 9 and 37 and controlled by valve 38. The conditioned pulp mixture entering primary flotation cell 31 through launder 32 deposits the solvent and agglomerated oil upon the water surface therein in the form of a froth and the heavy mineral particles of sand sink to the bottom of the cell and deposit on rotary screw 33 which continuously removes the sand particles up the inclined bottom of the cell and cascades it down through launder 39. When the agglomerated oil-solvent froth reaches the level of skimmer housing 40, skimmers 41 in skimmer housing 40 are revolved by means of gear 42 which is motivated by any suitable means, not shown, through the froth and pick up the top surfaces and cascade same down through launder 43. The sand released from the previously prepared pulp, which may still contain a certain percent of bituminous material, is de-

posited on screw conveyors 33 and carried up the bottom of said flotation cell, as aforementioned, and is then introduced into tertiary sand conditioner 44, provided with mixer 45, weir 46, and gear 47 similar to those described in secondary sand conditioner 27. The sand slurry in tertiary sand conditioner 44 is diluted with water and solvent if desired, and is again violently agitated as in secondary sand conditioner 27. After this violent agitation the aerated slurry is introduced into secondary flotation cell 50 via launder 51, wherein the clean mineral matter is precipitated upon screw conveyor 52 which is rotated by gear 53 connected to suitable motivating means not shown, and the bitumen froth floated on the water surface as described in primary flotation cell 31. Revolving skimmer 54 in housing 55 removes the bituminous froth from said water surface and cascades it down the launder 56. The mineral matter or tailings free of bitumen is removed from secondary flotation cell 50 by means of line 57 and deposited on tailings dump. The oil froth in launders 43 and 56 is diluted by additional solvent, preferably a petroleum fraction, introduced into the launders from tank 23 via lines 24 and 58 and through line 59 controlled by valve 60 and line 61 controlled by valve 62, respectively. The diluted bituminous froths in lines 43 and 56 are blended together and introduced into mixing tank 63 which is provided with agitating paddles 64 which are rotated by means of gear 65 which is connected with any suitable motivating power, not shown. The thoroughly mixed bitumen and petroleum fraction is then introduced into thickener 66 by means of line 67, wherein the mixture is allowed to settle. Said thickener is equipped with rake 68 which is rotated by means of shaft 69 and gear 70 motivated by any suitable means, not shown in the drawing. After a designated period of time the fine tailings in the mixture will settle to the bottom of said thickener where rake 68 will scrape the fine tailings into line 71 which leads to the tailings pile. The bitumen and petroleum fraction in thickener 66 is removed from the top of the thickener via line 72 and pumped to any suitable site, not shown, wherein the bitumen is separated from the added solvent, for example by distillation. If desired the separated solvent may be recirculated to tank 23.

In the process as illustrated, hot water is introduced into launder 7 and therein contacting the bituminous sands to act as a diluent and a heating medium for the purpose of furthering the disintegration of the bituminous sands. The degree of dilution of the bituminous material with hot water in this step plays a very important part in this process. Therefore, when the amount of hot water introduced therein is limited to amounts insufficient to raise said bituminous material to the proper temperature, steam is introduced into said launder by means of line 73 controlled by valve 74, in order to correct this deficiency. Steam may also be introduced into rotary pulper 6 by means of line 75.

A proposed modification of the above process is the substitution of an independent sand conditioner similar to sand conditioner 27 instead of using pulper 6 for the dual purpose of pulping and primary conditioning.

Another modification of the above process is the elimination of the tertiary and secondary steps, i. e. tertiary sand conditioner 44 and secondary flotation cell 50 and all the appurtenances thereto. The use of this modification is dependent upon the efficiency and economy of the pri-

mary flotation cell, i. e. the purity of the resulting bituminous product. In this modification the clean tailings from flotation cell 31 would go direct to the tailings pile.

The optimum operating conditions in primary sand conditioning step in pulper 6, i. e. conditioning time, agitation and/or abrasion, temperature, concentration of reagent and tar sand-water ratios must be established for each given mill and bituminous sand. In general, however, the optimum values should be within the following limits:

Conditioning time—10 sec. to 30 minutes.

Degree of agitation—fairly violent to very violent.

Temperature of pulp—130° F. to 210° F.

Concentration of reagent—0-10 lbs. per ton of tar sands.

Tar sand-water ratio—10:1 to 1:3 by weight.

The optimum operating conditions in secondary conditioner 27, i. e. pulp retention, temperature, type of agitation, and quantity of solvent used should also be determined for each particular tar sand. Ultimately, however, the magnitude of each of the above factors should lie within the following limits:

Retention period—10 seconds to 30 minutes.

Temperature of conditioning—100° F. to 212° F.

Type of agitation—fairly violent to very violent.

Quantity of solvent—.01 lb./bbl. of tar to 700 lbs./bbl.

Quality of solvent—(see following discussion).

Regarding the characteristics to be desired in the solvent to be used we set forth the following:

1. A low viscosity to minimize the viscosity of the resulting mixture and thereby facilitate the settling of solids and/or mineral matter from the froth.

2. A low specific gravity to minimize the specific gravity of the resulting mixture and thereby facilitate the settling of solids and/or mineral matter from the froth.

3. A high solvent power, or ability to dissolve the tar in a minimum amount of solvent.

4. A tendency to maintain or improve the hydrophobic condition of the tar, and also to maintain or improve the hydrophilic condition of the sand, so as to make the sand more easily water-wettable, and the tar more susceptible to flotation.

As solvents, petroleum fractions such as cleaner's solvent, kerosene and gas oil distillates have been used successfully. It is to be noted, however, that certain solvents perform much more efficiently than others. Aromatic type hydrocarbons have greater solvent power for most tars than do the non-aromatic hydrocarbons, so for many operations benzene, toluene, coal tar fractions, and aromatic extracts from petroleum fractions, such as Edeleanu extract from kerosene and the like, are very useful. Non-hydrocarbons, such as organic oxygen and sulfur compounds including alcohols, ketones, mercaptans, sulfides, thiophenes, and the like are excellent. Basic organic compounds such as the nitrogen bases, especially quinoline, are generally to be avoided, however. Of the non-hydrocarbon solvents we prefer small amounts of alcohols containing 6 to 12 carbon atoms, especially octyl or lauryl alcohol which produce a very clean froth. We may also use mixtures of different solvents, an especially good mixture being one of an intermediate petroleum fraction such as kerosene distillate and a very small amount of the more expensive octyl alcohol.

In the description of the drawing sodium silicate and sodium carbonate are designated as the conditioning reagents, but the invention is not limited to the use of these two. Other conditioning reagents which may be used are inorganic alkaline compounds such as metal hydroxides or metal salts of a strong base and a weak acid. Compounds of the alkali metals, sodium, potassium, lithium and caesium, especially sodium, are greatly preferred. In many instances however, we may also use compounds of other metals such as the alkaline earth metals calcium, barium and strontium and other heavy metals. Ammonium hydroxide may also be used. The preferred salts of these metals are those having polyvalent anions, especially the carbonates and silicates. The phosphates are also excellent, and the pyrophosphates, phosphites, sulfites, arsenates, sulfides, and the like may be employed.

The foregoing description of our invention is not to be taken as limiting our invention but only as illustrative thereof since many variations may be made by those skilled in the art without departing from the scope of the following claims.

We claim:

1. Apparatus for treating bituminous sands which comprises, in combination: a rotary pulper and sand conditioner provided with means for introducing tar sands therein, means for introducing hot water and steam, means for introducing conditioning agents, means for pulverizing and agitating the bituminous sands, and means for segregating conditioned pulp from foreign material; a secondary sand conditioner provided with means for introducing pulp therein, means for introducing an oil agglomeration medium, and means for agitating the pulp and agglomerating medium; a flotation cell provided with means for introducing sand particles and agglomerated oil, means for introducing water, means for controlling water level, means for removing sand particles, and means for removing agglomerated oil; a tertiary sand conditioner provided with means for introducing sand particles containing oil, and means for agitating the sand and oil particles; a secondary flotation cell provided with means for introducing the agitated sand and oil particles, means for removing the clean sand particles, means for removing the clean oil particles; and means for mixing a light petroleum fraction with the oil removed from the two flotation cells; means for mixing the light petroleum fraction and the recovered oil; and means for removing the light petroleum fraction and recovered oil from the fine sand tailings.

2. A process for treating bituminous sands to separately recover the bitumen and the bitumen-free sand therefrom which comprises introducing bituminous sands, conditioning reagent, hot water and steam into a rotary pulper and sand conditioner having means for agitating and pulverizing said bituminous sands, disintegrating said bituminous sands therein and thereby forming a pulp comprising disintegrated bituminous sands and water; segregating foreign matter from said pulp and cascading said pulp into a secondary sand conditioner having means for agitating said pulp, introducing into said secondary sand conditioner a solvent adapted to dissolve bitumen, agitating and aerating the mixture of pulp and solvent; cascading the agitated and aerated mixture of pulp and solvent into a primary flotation cell containing water; skimming a froth comprising bitumen and solvent from the surface of the water in said primary flotation cell; cascading bitu-

minous sand slurry from the bottom of said primary flotation cell into a tertiary sand conditioner, and agitating and aerating said sand slurry; cascading the aerated bituminous sand slurry into a secondary flotation cell containing water; skimming a froth comprising bitumen and solvent from the surface of the water in said secondary flotation cell and removing clean sand particles from the bottom of said secondary flotation cell.

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