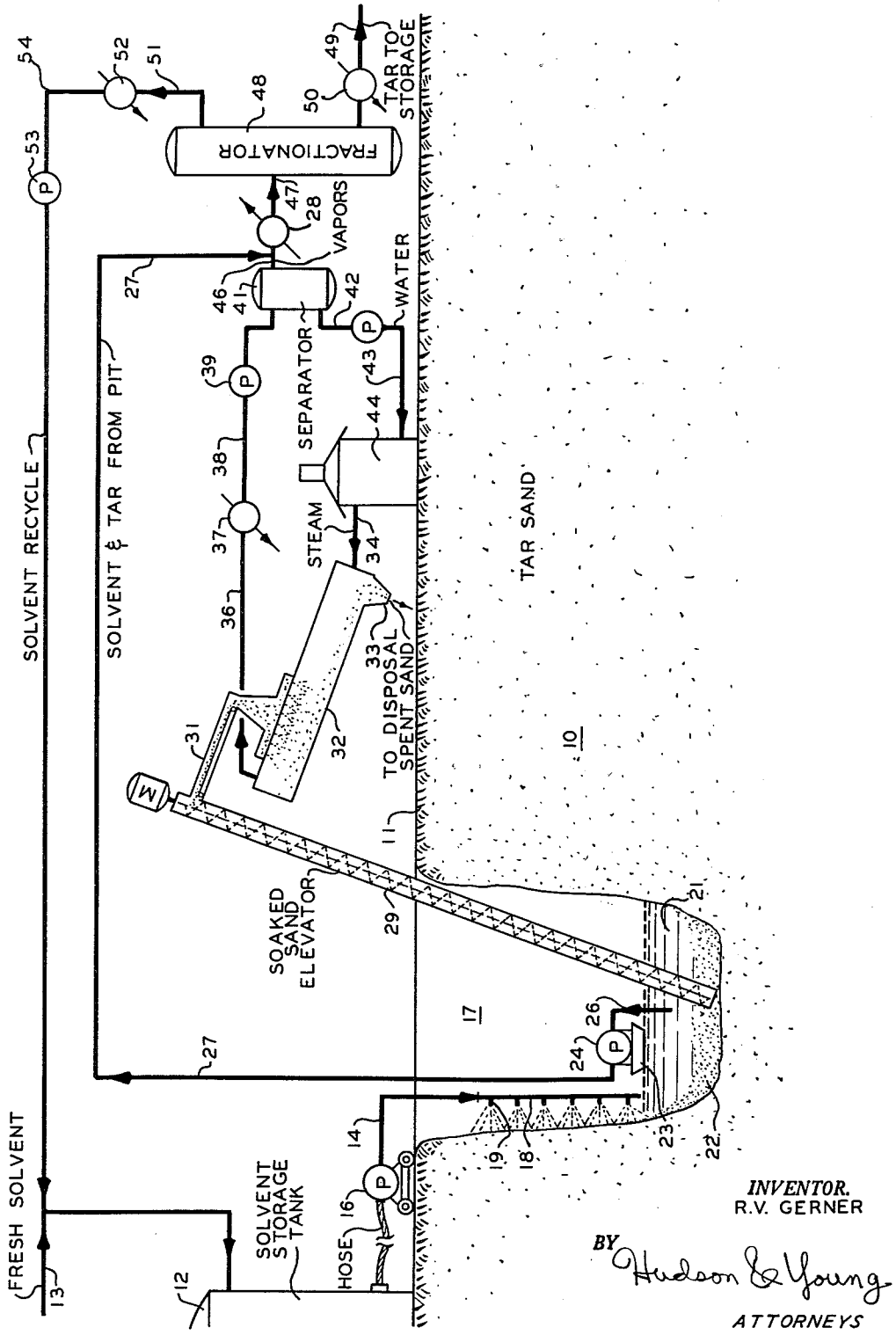
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HEAVY HYDROCARBON RECOVERY FROM PETROLIFEROUS DEPOSITS BY HYDRAULIC WASHING

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HEAVY HYDROCARBON RECOVERY FROM PETROLIFEROUS DEPOSITS BY HYDRAULIC WASHING

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This invention relates to improvements in the mining of petroliferous deposits, such as tar sands, both consolidated and unconsolidated, oil-saturated sands, and oil shale, and the recovery therefrom of useful hydrocarbons.

Various methods have been employed in the past, and some are still in use at the present time, for the utilization of solid bituminous materials, typically tar sands, which are generally mined from open pits. Hydraulic cutting or washing has proved to be an easy and efficient means for cutting away and dislodging these deposits in situ. In the practice of using a hydrocarbon solvent, such as naphtha, kerosene, or gas-oil, to comminute the deposits and dissolve their hydrocarbon content, it has been noted that the solvent has a greater affinity for the sand than for the previously occluded hydrocarbon values. Consequently, the loss of solvent upon disposal to waste of the spent sand has made this method of recovery prohibitively expensive.

Another difficulty experienced when employing hydraulic washing of tar sands is the tendency of the dislodged sand to settle to the bottom of the mined pit, while still holding a substantial proportion of its adsorbed tar, as well as some of the solvent used to wash the stratified sands from the pit walls. If this dislodged sand is left in the bottom of the pit unprocessed, it will retain as unrecoverable a substantial amount of valuable hydrocarbons. Thus, the value of any tar recovered from the tar solution formed will be nullified by the permanent loss of some of the valuable solvent to the settling sands. Consequently, in order to make the processing of tar sands economically feasible, it is necessary that some means be provided for treating the dislodged tar sands to maximize production of their remaining tar content and to recover adsorbed solvent.

According to the present invention, the heavy hydrocarbons, such as tar, are separated from the tar sands or oil shale in situ by the application of a high pressure jet of solvent to the walls, at a temperature not in excess of 200° F., or lower if necessary, to remain beneath the flash point of the solvent. The direction and position of these jets is readily controllable. When such a jet is directed at deposit walls in a pit, such as tar sands or oil shale, disintegration thereof and comminution of the deposit takes place, which resolves the solid or semi-solid petroliferous deposits into loose grains and a free tar that disperses in the solvent medium. The resulting tar-in-solvent solution is removed from the mining pit by a portable pump which is adapted to float on the solution in the pit. Meanwhile, the dislodged, solvent-soaked sands, which are settling to the pit bottom, are raised therefrom to the surface process equipment by means of any type of solids elevator known to the prior art, preferably by an auger-type of vertical or inclined elevator.

The pumped solution passes to suitable fractionating equipment to separate the product tar oils from the hydrocarbon solvent. The separated solvent may undergo further purification before finally returning to a solvent make-up tank for reinjection into the pit via the hydraulic jets. Concurrently, the hydrocarbon-soaked sand is passing from the elevator directly into a kiln wherein the hydrocarbon-laden sand is steam stripped of its remaining tar and adsorbed solvent.

If the pit mining operation is proceeding in a linear direction, the denuded sands from the separation system

may be conveniently returned to the portion of the mining pit that is no longer being mined, provided a suitable barrier is situated between the two areas of the pit. This procedure permits ready disposal of spent sands without piling up on areas which are to be later mined.

The method and apparatus of the invention are applicable to various materials, such as rich oil shales, assaying more than 35 gallons of oil per ton; medium oil shales, assaying 10 to 15 gallons of oil per ton, such as exists near Fayetteville, Arkansas; low grade oil shales, assaying 1 to 2 gallons of oil per ton such as the Spraberry oil shales; and rich unconsolidated tar sands, such as the "Athabasca" tar sands of Canada, which are estimated to contain upwards of 100 billion barrels of bituminous solid or semi-solid materials.

The position of the deposits which can be treated in accordance with the invention varies widely. Sometimes, the petroleum-bearing formation exists close to the surface with only a thin overburden. In other locations, the formation exists at the surface, while in still other instances subterranean deposits are encountered. The method and apparatus of the invention are applicable to any of these various types of deposits in any of the situations above mentioned.

Accordingly, it is an object of the invention to provide an improved method and apparatus for recovering heavy hydrocarbons from petroliferous deposits.

It is a further object to provide a system where the petroliferous materials are recovered in situ with readily portable hydraulic washing apparatus and recovery systems.

It is a still further object to provide a method and apparatus for efficiently recovering heavy hydrocarbons from low grade petroliferous deposits.

Yet another object is to provide a method of processing tar sands by hydraulic washing with hydrocarbon solvents and achieving maximum recovery of the solvents employed.

Various other objects, modifications and alterations of this invention will become apparent to those skilled in the art without departing from the scope and spirit of this invention, and it should be understood that the latter is not necessarily limited to the aforementioned discussion and accompanying drawing.

Referring now to the drawing, I have illustrated a system for mining a petroliferous deposit 10 and the recovery of hydrocarbon values therefrom. Deposit 10, which is adjacent to the surface of the earth, is covered by a thin layer 11 of overburden, upon which is disposed a solvent storage tank 12 provided with a conduit 13 for supplying fresh solvent thereto, as needed. Storage tank 12 is provided with an outlet conduit 14, preferably of a flexible type such as a hose, and a pump 16 is disposed therein. Conduit 14 leads down into an open pit 17 and terminates near the bottom thereof in a head 18 comprising a plurality of adjustable nozzles, such as 19. Flexible conduit 14 may comprise a number of short lengths of piping, with swivel-type joints between each section, which are of a type particularly designed for high pressure service. The depth of head 18 can, of course, be adjusted by adding or removing pipe lengths as desired. Jets 19 are arranged so as to discharge the cutting liquid, preferably a solvent for the hydrocarbon values in the petroliferous deposit, against the face of the deposit itself. Material dislodged and comminuted by the hydraulic washing action of the hydrocarbon solvent falls in the form of a slurry to the bottom of the pit 17. Resulting slurry quickly separates into liquid and solid phases, with a solution 21 of tar in hydrocarbon solvent floating above the washed down, comminuted deposit 22, for example, a tar sand.

The solvent used in the hydraulic cutting action may be any desired solvent such as kerosene or gas-oil or

some other cut of petroleum which would dissolve essentially all of the bitumen in the dislodged sand. But as the process proceeds, however, the solvent will be preferably made from the tar itself. In this manner, a suitable solvent can be made at low cost by a mild cracking or vis-breaking operation. Regarding the temperature at which the solvent may be jetted against the deposit face, almost any desired temperature will be acceptable, but for safety reasons the temperature should be substantially below the flash point of the solvent. Probably this temperature will never run higher than about 200° F.

Solvent will be required in volume sufficient to permit hydraulic mining operation and to adequately dissolve the occluded tars. In some instances, the ratio of solvent used to tar recovered may be as low as 2:1 but, depending upon the difficulty of mining and the solubility of the tar in the particular solvent used, it may range upward to as high as 10:1.

For a type of liquid jet nozzle suitable for high pressure cutting according to this invention, see U.S. Patent 2,587,729, issued March 4, 1952, to L. C. Huff. A small floatable platform **23**, with a pump **24** mounted thereon, floats on the tar solution **21**. The inlet conduit **26** of said pump **24** is disposed below the surface of the tar solution and pumps said solution, comprising heavy hydrocarbon values dispersed in said hydrocarbon solvent, via conduit **27** to a heating zone **28**. Heating zone **28** may be any standard type of preheater which may be controlled so as to cause only partial thermal decomposition of the tar-in-hydrocarbon solvent solution. An elevator **29** is also disposed within pit **17** with its lower terminus in communication with the accumulated comminuted deposit in the bottom of pit **17**. An auger-type of vertical elevator has been found to be particularly suitable for lifting the hydrocarbon-laden comminuted deposit from the bottom of said pit and conducting it to a conveyor belt **31** which feeds into the upper end of a horizontally inclined rotatable kiln **32**. However, almost any type of mechanical elevator is acceptable.

Kiln **32** serves as a stripping zone for said hydrocarbon values. The comminuted deposit is allowed to descend by gravity through the rotating kiln to the lower end thereof.

Superheated steam is passed upwardly through said stripping zone in intimate countercurrent contact with the descending comminuted deposit. This stripping action will remove substantially all of the adsorbed hydrocarbons on the deposit particles, with the hydrocarbon-denuded, comminuted deposit being removed from the lower end via conduit **33** and being passed to disposal. The kiln will generally operate at substantially atmospheric pressure although a slight positive pressure can be provided. Steam entering the kiln through line **34** may have almost any desired degree of superheat, but probably will not be operated much above 700° F.

The steam stripping forms a vapor phase, consisting essentially of vaporized hydrocarbons and spent steam, which is removed from the upper end of kiln **32** via conduit **36**. The mixture in conduit **36** passes first to a cooling means **37**, such as a standard heat exchanger, which sufficiently reduces the temperature of the mixture to condense the mixed vapors; the resulting liquefied mixture passes through conduit **38**, having pump **39** disposed therein, to an oil-water separator **41**. Condensed water vapor is withdrawn from the bottom of settling zone **41** via conduit **42** and may preferably be passed to the make-up water line **43** for steam boiler **44**. The liquefied hydrocarbons pass from separator **41** via conduit **46** to the said heating zone **28**, wherein they also further partially crack. The combined, partially cracked, hydrocarbon values pass from preheater **28** via conduit **47** to a primary fractionation zone **48**. In fractionator **48**, the heavier hydrocarbon values are separated as product and passed via lower conduit **49** having cooling means **50** therein, to storage. The remaining lighter hydrocarbon values are withdrawn from the top of fractionator **48** via conduit **51**, passing through cooling means **52**, and the resulting liquefied lighter hydrocarbons are pumped via pump **53** in line **54** back to solvent storage tank **12**, for further use as the hydraulic cutting fluid. If the lighter hydrocarbon output exceeds its requirement for use as cutting fluid, the excess may have other conventional uses.

While the invention has been described in connection with present, preferred embodiments thereof, it is to be understood that this description is illustrative only and is not intended to limit the invention.

I claim:

1. The process for recovering adsorbed hydrocarbon values from a naturally-occurring petroliferous deposit which comprises directing a jet of fluid hydrocarbon solvent against said deposit to comminute the same, separately collecting the resulting solution and the resulting comminuted deposit, recovering said adsorbed hydrocarbon values and said hydrocarbon solvent from said collected deposit by passing said collected deposit to a stripping zone, and stripping said adsorbed hydrocarbons from said collected deposit by passing superheated steam countercurrently through said stripping zone.

2. The method of claim 1 wherein the said petroliferous deposit is a tar sand.

3. The method of claim 1 wherein the said petroliferous deposit is an oil shale.

4. The method of claim 1 wherein said hydrocarbon solvent is selected from the group consisting of naphtha, kerosene, and gas oil.

5. The method of claim 1 wherein said hydraulic washing action takes place at a temperature below 200° F.

6. The method of claim 1 wherein the volume ratio of said hydrocarbon solvent used to said heavy hydrocarbon values produced is in the range of 2:1 to 10:1.

7. The method of claim 1 wherein said stripping zone is maintained at a temperature between 400 and 700° F.

8. The process for recovering adsorbed hydrocarbon values from a naturally-occurring petroliferous deposit which comprises directing a jet of fluid hydrocarbon solvent at a temperature below the flash point of said solvent against said deposit to comminute the same, separately collecting the resulting solution and the resulting comminuted deposit, recovering said adsorbed hydrocarbon values and said hydrocarbon solvent therefrom by passing said collected deposit to a stripping zone, stripping said adsorbed hydrocarbons from said collected deposit by passing superheated steam countercurrently through said stripping zone, collecting the resulting vaporized hydrocarbon from said stripping zone and passing said collected solution to a fractionation zone, fractionating said vaporized hydrocarbon into heavier and lighter hydrocarbon fractions, recovering said heavier hydrocarbon fraction as product, and recycling said lighter hydrocarbon fraction as said hydrocarbon solvent.

9. The process for recovering adsorbed hydrocarbon values from a naturally-occurring petroliferous deposit which comprises directing a jet of fluid hydrocarbon solvent against said deposit to comminute the same, separately collecting the resulting solution and the resulting comminuted deposit, recovering said adsorbed hydrocarbon values and said hydrocarbon solvent from said collected deposit by passing said collected deposit to a stripping zone, stripping said adsorbed hydrocarbons from said collected deposit by passing superheated steam countercurrently through said stripping zone, collecting the resulting vaporized hydrocarbon from said stripping zone and passing said collected solution to a fractionation zone, fractionating said vaporized hydrocarbon into heavier and lighter hydrocarbon fractions, recovering said heavier hydrocarbon fraction as product, and recycling said lighter hydrocarbon fraction as said hydrocarbon solvent.

10. The process for the partial thermal decomposition and recovery of heavy hydrocarbon values found in a naturally-occurring petroliferous deposit which comprises subjecting said deposit to the hydraulic washing action of a hydrocarbon solvent, permitting the resulting slurry to separate into a liquid and solids phase, removing said liquid phase comprising said heavy hydrocarbon values dispersed in said solvent to a heating zone wherein partial thermal decomposition thereof takes place, concurrently removing said solids phase consisting essentially of hydrocarbon-laden comminuted deposit from the areas of said washing action and introducing the same into a horizontally inclined rotatable stripping zone, allowing said comminuted deposit to descend by gravity through said stripping zone to the lower end thereof, passing superheated steam upwardly through said stripping zone in intimate countercurrent contact with the said descending comminuted deposits therein, removing the substantially hydrocarbon-denuded comminuted deposit from the lower end of said stripping zone and passing to disposal, withdrawing a vapor phase consisting essentially of vaporized hydrocarbons and water from the upper end of said stripping zone, first condensing said vapor phase by passing through a first cooling means before pumping to a settling zone, withdrawing condensed water vapor from the bottom of said settling zone and passing the same to a make-up water tank for a steam generation means, passing the liquid hydrocarbons from said settling zone through said heating zone for further partial cracking of said hydrocarbon values, passing the combined partially-cracked hydrocarbon values from said heating zone to a primary fractionation zone for separation of heavier hydrocarbon values as product from said lighter hydrocarbon values, passing said lighter hydrocarbon values first to second cooling means before returning them to a solvent make-up tank which supplies a hydraulic washing means.

11. In a process for the recovery of heavy hydrocarbon values from a naturally-occurring subterranean petroliferous deposit wherein said deposit is comminuted by the hydraulic washing action of a hydrocarbon solvent with the resulting slurry separating into a liquid and solids phase, removing said liquid phase comprising said heavy hydrocarbon values dispersed in said solvent to a heating zone wherein partial thermal decomposition of said heavy hydrocarbon values takes place, and then passing said partially thermally decomposed liquid phase to a primary fractionation zone for separating the product comprising heavier hydrocarbon values from the lighter hydrocarbon values, the improvement which comprises concurrently removing said solids phase consisting essentially of hydrocarbon-laden comminuted deposit from the area of said washing action and introducing said comminuted deposit into a vertically inclined rotatable stripping zone, allowing said comminuted deposit to descend by gravity through said stripping zone to the lower end thereof, passing superheated steam upwardly through said stripping zone in intimate countercurrent contact with the said descending comminuted deposits therein, removing the resulting substantially hydrocarbon-denuded comminuted deposit from the lower end of said stripping zone and passing to disposal, withdrawing a vapor phase comprising hydrocarbons and water from the upper end of said stripping zone, condensing said vapor phase by passing the same through a first cooling means before pumping to a settling zone, withdrawing condensed water vapor from the bottom of said settling zone, passing the liquefied hydrocarbons from said settling zone through said heating zone for further partial cracking of said hydrocarbon values, and therefrom to said primary fractionation zone for separation of heavier hydrocarbon values as product from said vaporized lighter hydrocarbon values, and passing said lighter hydrocarobn values to a second cooling means before returning them to a solvent make-up tank which supplies a hydraulic washing means.

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