

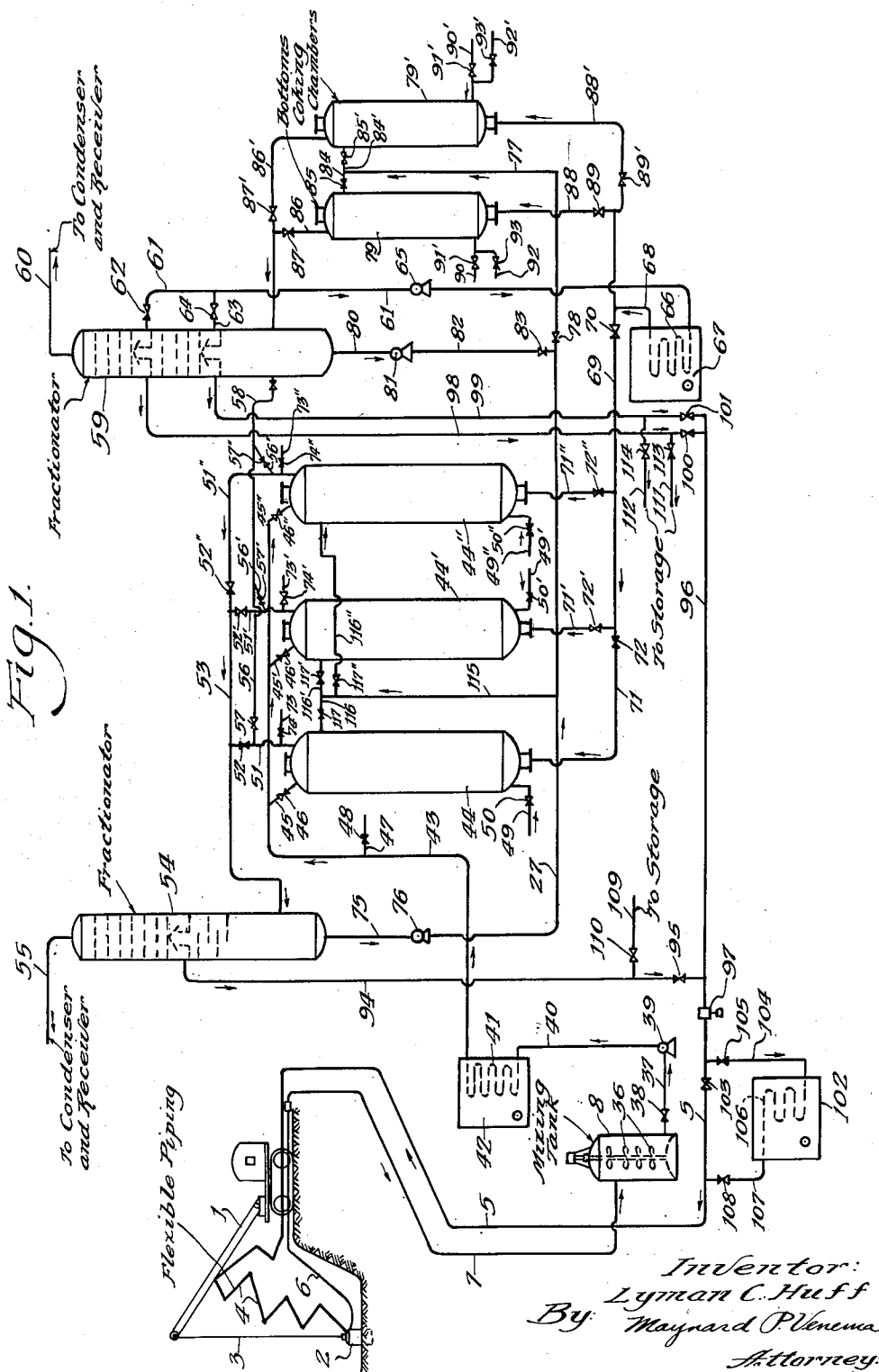
March 4, 1952

L. C. HUFF
PROCESS FOR CONVERSION OF A MIXTURE
OF HYDROCARBONACEOUS SOLIDS
AND LIQUID HYDROCARBONS

2,587,729

Filed May 31, 1946

2 SHEETS--SHEET 1



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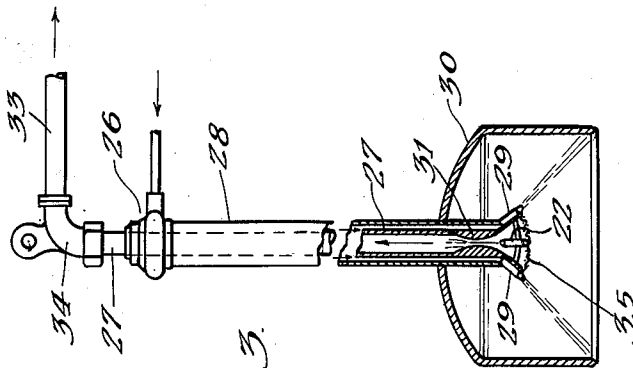


Fig. 3.

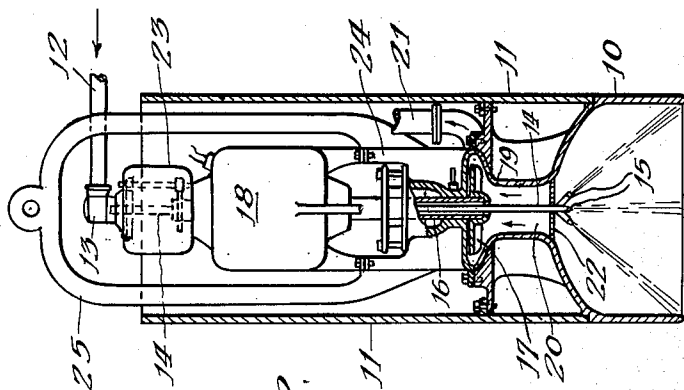


Fig. 2.

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UNITED STATES PATENT OFFICE

2,587,729

PROCESS FOR CONVERSION OF A MIXTURE
OF HYDROCARBONACEOUS SOLIDS AND
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Application May 31, 1946, Serial No. 673,506

1 Claim. (Cl. 196—56)

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This invention relates to improvements in the mining and processing of hydrocarbonaceous solids, such as oil-saturated sands, tar sand, oil-shale, bitumen or asphalt deposits, and the like which may be found in natural beds and deposits. More particularly, the invention relates to improved means for the high pressure hydraulic cutting of the solid material from the bed and for hydraulically transferring the material to an improved processing operation which operates in combination with the hydraulic mining operation. The improved process employs the steps of flash distillation, drying, and coking or asphaltizing, all of which may be carried on simultaneously and continuously by means of alternate chambers.

In the mining and cutting operation, a bell or hood-like chamber, which is open at the bottom, is used to enclose cutting nozzles and pumping means to remove the material cut away and dislodged by the high pressure streams or jets from the nozzles therein. The hood confines the liquid cutting agent and the removed solid material such that the mixture is all removed and sucked away by pumping means which is also within the chamber. A portable crane may be employed to handle the hood and its internal hydraulic cutting and pumping apparatus such that it may be moved from one spot to another over the entire bituminous deposit.

A hot hydrocarbon solvent material is preferably used as the cutting liquid in the mining operation and the solvent is also preferably an oil fraction obtained from the processing of the material being mined, however, steam, hot water or other fluid may be employed under high pressure as the cutting medium and the fluidizing or transporting medium for transferring the solid material to the processing unit.

The processing of the tar sands, following the aforementioned hydraulic mining operation, in one embodiment comprises briefly the steps of thoroughly mixing the solid material and the cutting liquid or solvent, heating the mixture to a distillation temperature in a suitable heater and passing it to a flashing and drying zone, flashing off the vaporous material in said flashing zone, passing the flashed vapors to a first fractionator and fractionating and condensing said vapors into desired fractions, discontinuing the flashing operation in said flashing and drying zones when the latter is substantially filled with heavy residue and mineral matter, passing a highly heated vapor stream into said zone and subjecting the material therein to further dis-

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tillation and drying, passing the resulting products of the higher temperature distillation and drying operation to a second fractionator and therein fractionating said resulting products into desired light, intermediate and heavy fractions, subjecting a portion of the intermediate fractions to heating and recycling the heated fraction to said flashing and drying zone as the highly heated vapor stream for effecting the higher temperature distillation and drying of residue in said flashing and drying zone, removing heavy bottoms material from the lower end of each said fractionators and coking said material in separate chambers, withdrawing a portion of the intermediate fractions from each of said fractionators and employing these last said fractions under pressure as the solvent material in the high pressure hydraulic mining operation.

One of the important advantages of the processing operation, comprising a portion of this invention, is the fact that the initial distillation of the bituminous material can be carried out at a relatively low temperature and the light fractions thereby separately removed without subjecting them to the destructive temperatures necessary in the second distillation and drying step. The improved process also provides a period of "digestion" for the solid material. This digestion period occurs during the period in which the heavy residual mineral matter is being built up within the flashing and drying chamber, prior to the drying step. It has been found that the oil of the type held within certain types of tar sands and the like, is susceptible to higher yields when there has been a digestion period at a moderate temperature and for a moderate period of time.

In the processing of tar sands, there have been three principal methods which have been employed for the separation of the oil from the sand. One method has been the direct distillation of the solid material. Another has been the use of a solvent, such as naphtha, kerosene, or gas oil, to remove the oil from the sands, however, in practice it has been found that the solvent has had a greater affinity for the sand than had the original crude oil and the consequent loss of the solvent in the spent sand was unduly expensive. A third method for the separation of the oil from the sand is the use of hot water, however, this process has made necessary rather elaborate agitation and separation steps for removing the water from the oil.

Various methods have been tried in the past and are in use at present for the extraction of

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solid bituminous materials, such as tar sands, which are removed from open pits. A shale "planner" has been used to some extent, but in general has been found to be rather unsatisfactory, particularly for the "gummy" types of tar sands. A method which employs dynamiting, picking the material up by steam-shovel, and hauling it by tractor to the processing plant has also been used, but this method has been found to be rather slow and expensive. In comparison, the mining method embodied in this invention is highly efficient and less expensive to carry out. The hydraulic cutting provides easy and efficient means for cutting away and dislodging the material and the solvent is entirely recovered by being pumped away with the dislodged solid material and returned to the processing plant.

The features and advantages of the present invention will be more apparent upon reference to the accompanying drawings and the following description thereof.

Figure 1 illustrates diagrammatically the method of mining or removing the solid bituminous material in combination with an improved method of processing the solid material to obtain valuable hydrocarbon products. Various modifications and alternative methods of operation will be described in connection with the description of the unit.

Figure 2 of the drawing shows a cross-sectional view through one form of the high pressure hydraulic jet cutting and pumping apparatus which is used to remove the solid carbonaceous material.

Figure 3 of the drawing is a cross sectional view through another form of apparatus having liquid jet nozzles, for high pressure cutting of the bituminous material and a Venturi-nozzle and liquid ejection stream to remove the liquid cutting agent and the dislodged solid material from the mining zone.

Referring now to Figure 1 of the drawing, there is shown a movable type of crane 1 which may be used to handle and move about the hydraulic mining apparatus 2 which is supported from a cable 3 at the end of the boom of the crane 1. A liquid or solvent material to be used in the cutting apparatus 2 is supplied under high pressure through flexible piping 4 which in turn connects with a supply line 5. The flexible piping 4 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 dislodged solid material and the cutting liquid, all of which is confined within the hood or shell of the apparatus 2, is removed or pumped away from the apparatus through a flexible hose 6 that connects with a transfer line 7 which in turn communicates with a mixing tank 8.

To explain further the construction and operation of one specific form of the hydraulic mining apparatus 2, reference may be made to Figure 2 of the drawing. The lower end of the apparatus comprises a circular hood-shaped section 10, which is open at the bottom and is adapted to contact the bed on natural deposit of the bituminous material. Above the hood 10 is a shell section 11 which serves as a shield and supporting frame for the internal mechanical apparatus. The high pressure cutting liquid or solvent material is supplied to the apparatus by way of inlet line 12, at the upper end of the device. The fluid passes through a swivel pipe joint 13 to an internal line or conduit 14 which is centrally positioned and passes downwardly to the lower portion of the apparatus. Conduit 14 terminates in

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a series of nozzles 15 which discharge the medium in jet-like high pressure cutting streams, which in turn are directed angularly downward such that the solid bed will be cut away and dislodged for removal within the area covered by the hood 10. Around the internal line 14, there is positioned a rotatable shaft 16 and an impeller blade 17 suitable for a centrifugal type pump. The shaft 16 and the blade 17 may be driven by a motor 18 which is supported in the upper portion of the apparatus. The housing 19 for the impeller blade 17 is supported from the shell 11 and connects directly with the top of the hood 10 by way of the short connecting conduit 20, as indicated in the drawing. The centrifugal pump, provided by the rotating blade 17 and the housing 19, draws the solid material, that has been cut away, and the cutting liquid upwardly through the conduit 20 and discharges it to the outlet line 21. The outlet 21 may in turn connect with flexible piping or the hose 6, such as indicated in Figure 1 of the drawing. A perforated plate or screen 22 is placed across the entrance of the inlet conduit 20 and serves to keep out any over sized material that would cause damage in being drawn through the centrifugal pump. The screen 22 may be attached to the conduit 14 and thus be made to rotate with the conduit and discharge nozzles. In the apparatus shown, a system of gears is used in the box 23 above the motor 18, in order to rotate the interior line 14 and the jet nozzles 15. However, in an alternate method of construction, the jet nozzles 15 may be placed at a slight angle such that the high pressure stream will cause their rotation, and the gear box 23 may be eliminated. Above the pump housing 19, a supporting frame 24 is provided to carry the motor 18 and to furnish attachment means for a yoke 25. The yoke 25 is provided with a lifting eye at its upper end which makes the apparatus adaptable for handling by any type of hoist or moveable crane such as previously indicated.

In a somewhat simplified form of the cutting and pumping apparatus, as indicated in Figure 3 of the drawing, the centrifugal pump is eliminated and in its place an ejector type of pump is used. High pressure liquid or solvent material enters the upper end of the apparatus through inlet 26 and passes downwardly through the annular channel between an inner conduit 27 and an outer conduit 28. At the lower end of the annular flow channel there are provided a plurality of discharge nozzles 29 which provide high pressure jet streams for cutting away and dislodging the solid bituminous material. An open bottom hood member 30 serves to confine the cutting liquid and the dislodged solid material such that both may be removed by way of the internal pumping means provided. The inner conduit 27 is provided with a Venturi-nozzle 31 at its lower end such that a high pressure jet stream of liquid from a centrally located nozzle 32 will cause a jet pump action to draw the solids and liquid mixture upwardly therethrough into conduit 27 and be discharged therefrom, through outlet line 33. A swivel type of pipe joint 34 is used between the upper end of conduit 27 and the discharge line 33 such that the apparatus may be readily moved about by means of a movable crane or like equipment. The discharge nozzles 29 are preferably placed at an angle which will cause the conduits 27 and 28 to rotate from the pressure of the jet streams and provide a full circular cutting action on the solid material bed. Since it is desirable to rotate the nozzles 29, the

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inlet joint 26 and the outlet joint 34 must be of a swivel type of construction as well as a type that will withstand high pressure service. A perforated plate or screen 35 is positioned across the flared inlet to the ejector or Venturi nozzle 31 in order to prevent its clogging with large pieces of solid matter.

When employing a hydrocarbon solvent for the high pressure cutting fluid, the bituminous material in the tar sands will be substantially dissolved and removed from the mineral material by the time the mixture has been pumped to the processing unit. In the preferable embodiment of the combination process, an intermediate gas oil fraction, which is a product of the distilling process, is heated and passed to the mining apparatus as the hot solvent material.

In an alternate method of carrying out the mining operation, hot water or steam may be used in the high pressure jets in the mining hood to cut away the bituminous deposit and fluidize the particles such that they may be conveyed by pipe line to the processing unit. The passage of the water and solids mixture directly to the distillation chambers, however, means the expenditure of considerable heat and energy in flashing off the large quantity of water present. It is, therefore, advisable to remove the oil from the water by employing conventional settling basins, mixers, and skimming basins which have been used in connection with such types of material.

Referring again to Figure 1 of the drawing, the description of the processing unit, which is used in combination with the high pressure hydraulic mining method, will be continued. The solvent and solids slurry, from the mining apparatus 2, is charged to the mixing tank 8 by way of pipe line 7. The slurry mixed within tank 8 by means of blades 36 so that the liquid solvent and solids material is thoroughly mixed prior to the heating and distillation steps. The mixture leaves the tank 8 by way of line 37, having valve 38, and passes through pump 39 which provides sufficient pressure to force the heavy material through line 40, heating coil 41 in the heater 42, and be carried through line 43 to a series of distillation and drying chambers 44, 44' and 44''. The material is heated to a temperature of about 600 or 700° F. within the heater 42, such that the major portion of the lighter hydrocarbon fractions within the solids material, as well as the hydrocarbon solvent, will be continuously flashed off in a distillation operation within one of the distillation chambers. The material is charged by way of one of the respective lines 45, 45' or 45'', the flow being controlled respectively by valves 46, 46' and 46''.

In order to lower the distillation temperature during this initial distillation step and to further protect the light fractions against excessively high temperatures, super-heated steam may be introduced into the transfer line 43 by way of line 47, having valve 48, or it may be introduced directly to the distillation chambers by way of the respective lines 49, 49' and 49'', the flow being controlled respectively by valves 50, 50' and 50''.

Three distillation and drying chambers, 44, 44' and 44'' are furnished in the preferable processing unit, such as diagrammatically illustrated in order to provide for the continuous and simultaneous operation of all steps. Thus, one of the chambers may be operated as an initial flash distillation chamber, a second as a drying cham-

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ber, while the third is having the coke and dried residual material removed therefrom. One of the advantages of this improved method of operation is the carrying out of the distillation and drying operations in two separate steps, so that a digestion period is obtained during the first step while heavy residual and mineral matter is building up in the distillation chamber. As has been previously noted, with some types of bituminous materials, such as tar sands in particular, it has been found that subjecting the material to heat for a given period of time aids in effecting a higher recovery of oil from the solid material.

The vaporized stream from the flash distillation operation is passed from the particular distillation chamber being used, 44, 44' or 44'', by way of line 51, 51' or 51'', having respectively control valves 52, 52' and 52'', to line 53 which in turn passes the vapors to the fractionator 54. The fractionator 54 operates to fractionate the vapors into desired fractions or products, with the lighter fractions being taken off overhead by way of line 55, which will in turn carry the vapors to suitable condensing and receiving apparatus. The heated stream of solids and solvent is continuously passed to one of the distillation chambers until it is substantially filled with heavy residual and mineral matter, the stream is then switched to a second distillation chamber which has been cleaned and readied for use, and the filled chamber is then subjected to a drying out operation. During the drying operation, the resulting vapors are passed from the drying chamber by way of line 56, 56' or 56'', the flow being controlled respectively by valves 57, 57' and 57'', to line 58 which in turn passes the material to the fractionator 59. In the fractionator 59 the vapors are fractionated into desired light, intermediate and heavy fractions, with the light overhead fractions being carried by way of line 60 to suitable condensing and receiving apparatus. All, or a portion of the intermediate fractions which may be collected in centerwells within the fractionator 59, may be recycled to the distillation and drying chambers 44, 44' and 44'' with added heat, to effect the desired drying out operation. A kerosene fraction is withdrawn from the fractionator 59 by way of line 61 having valve 62, or alternately a gas oil fraction withdrawn through line 63, having valve 64 or a mixture of the two and the withdrawn fraction or fractions charged by means of the pump 65, to a heating coil 66, in a heater 67. The recycle fraction is heated to a temperature of the order of 900 to 1000° F. in the heating coil 66 prior to its introduction into the particular chamber 44, 44' or 44'' which is effecting the drying out operation. The hot stream passes from the heater 67 by way of lines 68 and 69, through control valve 70, to line 71, 71' or 71'', having respectively control valves 72, 72' and 72'', which in turn communicate with the lower ends of each of the distillation and drying out chambers. The residual matter is thus stripped of all its volatile fractions and is substantially dried out to a coke-like material which may be subsequently removed, in a third step, by internally placed cables, or by other common methods of coke removal. When the residue has been sufficiently dried out, the hot drying out recycle stream is then switched to the chamber which has been effecting a flash distillation and is filling with residue. The drying out chamber may then be subjected to action of steam in order that the coke-like material may be more easily removed. During this steam-

ing out operation, the exhaust steam and entrained volatiles may be removed from the upper portion of the chamber by means of line 73, 73' or 73'', having respectively control valves 74, 74' and 74''. This steam may be vented to the atmosphere or passed through a steam recovery and wash column, wherein some hydrocarbon oil may be separated from the water.

The heavy bottoms fractions from each of the fractionators 54 and 59 is passed to suitable coking or asphalt producing chambers. The heavy material from fractionator 54 passes by way of line 75, pump 76, line 77, having valve 78, and lines 84 and 84', to the coking chambers 79 and 79'. The heavy residual material from fractionator 59 passes by way of line 80, pump 81, and line 82, having valve 83, to line 77, in order that it may also be charged to coke chambers 79 and 79'. The material is charged to the coking chambers alternately however, such that one may be cleaned while the other is in operation. The flow from line 77 to the coke chambers 79 and 79' is by way of respective lines 84 and 84', which are respectively controlled by valves 85 and 85'. The vapors from the coke chambers pass by way of lines 86 and 86', having the respective valves 87 and 87', to the fractionator 59 wherein they are fractionated together with the vapors from the drying out step. A heated recycle oil fraction is also used within the coking chamber 79 and 79', to aid in the drying out and coking operation therein. Thus, a portion of the recycled stream or heater 67 may pass by way of lines 88 and 88 or 88', to the lower end of the coking chambers, the flow being controlled by the respective valves 89 and 89'.

If it is found desirable, asphalt products may be made from the fractionator bottoms within the chambers 79 and 79'. This may be accomplished by providing steam and hot air for blowing the material within the chambers. The steam may be supplied to the chambers 79 and 79' by way of lines 90 and 90', having the respective valves 91 and 91', and heated air may be supplied by way of lines 92 and 92', having adjustment valves 93 and 93'.

In another modification of the processing operation and apparatus, the coking chambers 79 and 79' may be eliminated, in which case the fractionator bottoms will be passed to the distillation and drying out chambers 44, 44' and 44''. The bottoms from fractionator 54 will pass by way of line 75, pump 76, line 77, line 115 and line 116, 116' or 116'', to the particular chamber effecting the drying out and coking step, the flow being controlled respectively by valves 117, 117', and 117''. The bottoms from fractionator 59 will pass by way of line 80, pump 81, line 82, line 77, having valve 78, and line 115, becoming mixed with the bottoms from fractionator 54 in line 115, prior to reaching the drying out chambers. In this operation the bottoms material is reduced to coke at the same time the heavy residual and mineral matter is dried out. The drying out operation, as before, is carried out following the initial flash distillation step and the building up of the residual material in the chamber.

As previously noted, in the preferred embodiment of the combination process, an intermediate oil fraction from fractionator 54 is withdrawn from a center-well therein, and passed by way of line 94 having control valve 95, to line 96, 97 and to line 5, which in turn carries the hot fraction to the mining apparatus 2 wherein it is

used as a hot solvent and cutting fluid under high pressure, for effecting the removal of a solid bituminous material. In alternate operations, fractions from the fractionator 59 may be used alone as the hot solvent, or used in combination with the intermediate fraction from fractionator 54. Intermediate oil fractions may be withdrawn from fractionator 59 through lines 98 and 99 having valves 100 and 101 respectively, to transfer lines 96, which will in turn carry the material to pump 97 and line 5. A heater 102 is provided for heating up the solvent material when the unit is being started, so that a hot solvent may be available for the mining apparatus, or of course, the heater may be used to provide additional heat to the fractions withdrawn from the fractionators, where a higher temperature solvent is desired than that which is obtained directly. The flow through the heater 102 may be obtained by closing valve 103 in line 5 and switching the material through line 104, having valve 105, to heating coil 106 and thence to line 107, having valve 108, the latter line in turn connects with the transfer line 5. When solvent material is not required in connection with the mining operation, it may be passed to a suitable place of storage. The material from fractionator 54 may be transferred to storage by way of line 94 and line 109, having shut-off valve 110, while the material in fractionator 59 may be passed to storage by way of lines 98 and 99 and the respective branch lines 111 and 112, having respectively shut-off valves 113 and 114.

It may be seen from the above description of the mining and processing operations and the efficient combination of the two, that a means is provided for recovering and transporting solid hydrocarbonaceous material from their natural deposits, such as tar sands and like materials. Further, that the processing operation effects the removal of the lighter hydrocarbon fractions without subjecting them to high destructive distillation temperatures, while continuously converting such types of hydrocarbonaceous materials into desired products, such as gasoline, kerosene, diesel fuel, gas oil and coke or asphalt.

It should also be understood, that the invention is not limited to the exact forms of apparatus illustrated nor to the specific flow which has been described.

The heaters and chambers of this processing unit may be operated at substantially atmospheric pressure or at a superatmospheric pressure, from about 100 to 600 pounds per square inch, in which case, the action of the solvent would be increased and the bituminous solids would be subjected to considerable decomposition and cracking, to thereby result in the production of more valuable light products.

I claim as my invention:

A process for the pyrolytic conversion of a mixture of hydrocarbonaceous solid material and a fluid medium which comprises subjecting said mixture to an elevated temperature under non-coking conditions, introducing the heated mixture into a flashing and drying chamber, flashing off lower boiling fractions from said mixture and passing them to a first fractionator for fractionation and recovery of desired fractions therefrom, discontinuing said flashing operation and the passing of said mixture to said chamber when it is substantially filled with a heavy residual material, subsequently passing a heated vapor stream through said residual material in said chamber and effecting a coking

and a higher temperature distillation thereof, passing vaporous products resulting from said higher temperature distillation and coking step to a second fractionator and fractionating the same therein to produce desired light, intermediate and heavy fractions, heating a portion of the intermediate fractions from said second fractionator and recycling them to said drying chamber as the said heated vapor stream for effecting said higher temperature distillation and coking step, passing heavy fractions from both of said fractionators to a separate coking zone, passing a portion of said heated vapor stream through said heavy fractions in said separate coking zone, effecting coking of said heavy fractions and the removal of vaporous products from said coking zone, passing the last said vaporous products to said second fractionator together with vaporous products from said drying chamber.

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