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T. S. LEARY ETAL

3,117,922

RECOVERY OF BITUMEN FROM BITUMINOUS SAND

Filed Aug. 25, 1960

2 Sheets-Sheet 1

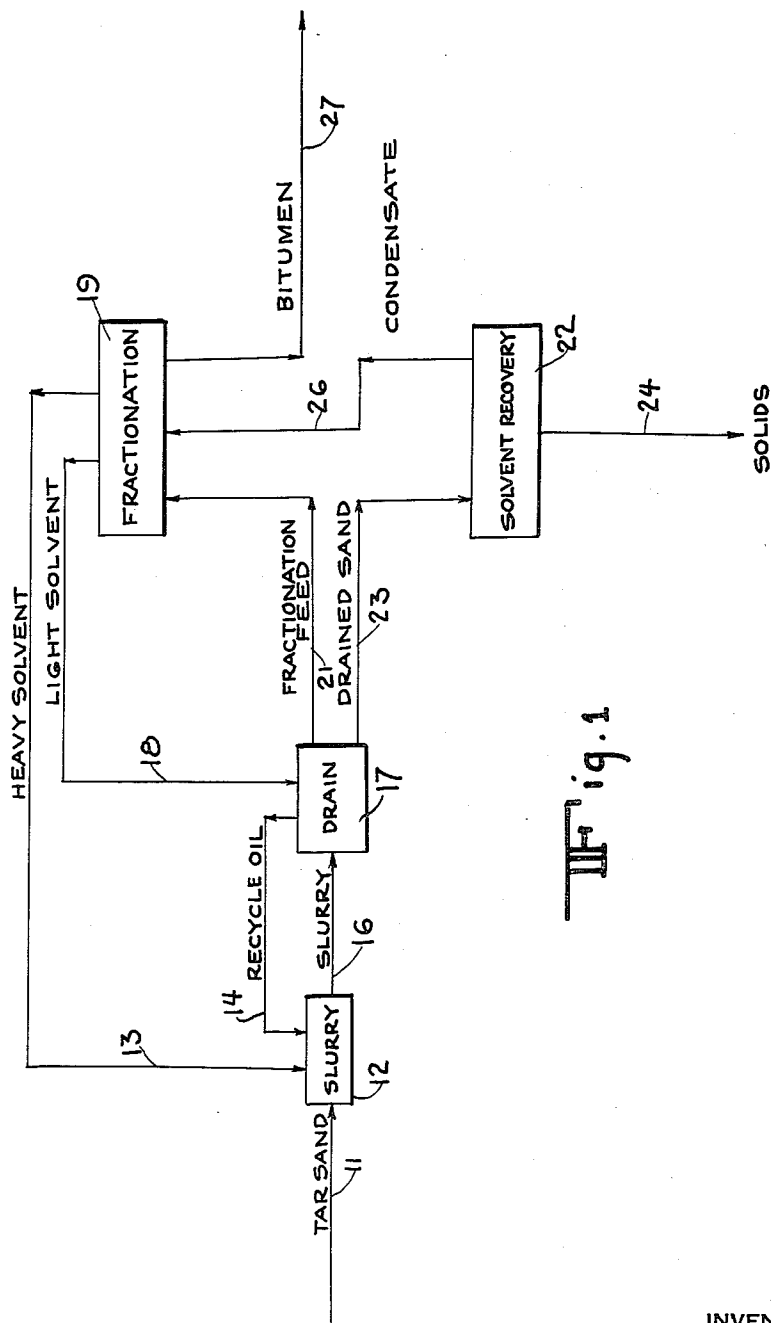


Fig. 1

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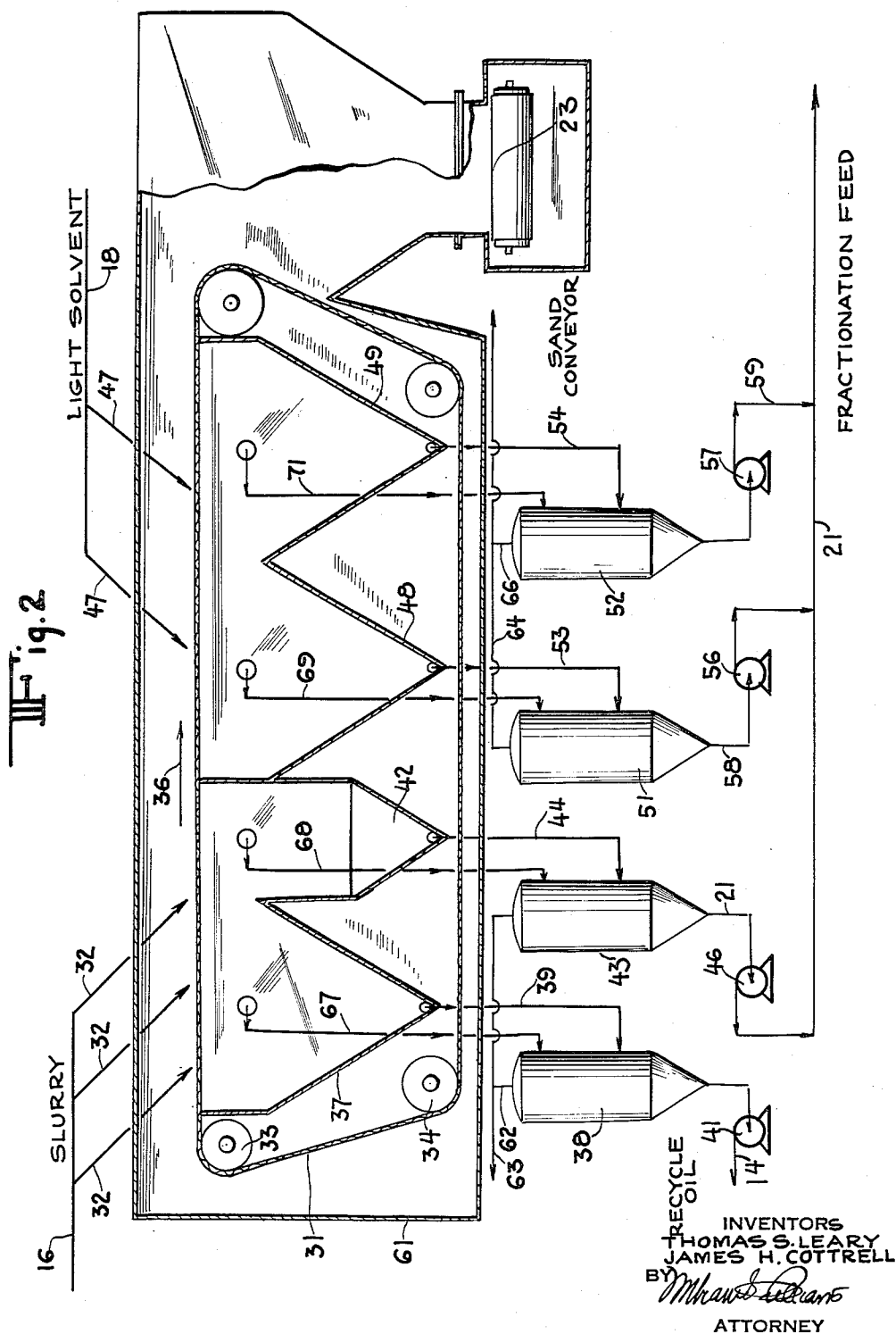
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RECOVERY OF BITUMEN FROM BITUMINOUS SAND

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5 Claims. (Cl. 208—11)

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

Large deposits of bituminous sands are found in various localities throughout the world. The term "bituminous sand" is used herein to include those materials commonly referred to as oil sands, tar sands and the like. One of the most extensive deposits of bituminous sands occurs, for instance, in the Athabasca district of the Province of Alberta, Canada, and extends for many thousands of square miles in thicknesses ranging up to more than 200 feet.

Various methods have been proposed previously for separating bitumen from bituminous sands such as the Alberta tar sands, but none of these methods has met with substantial success. Since the crude oil (or bitumen) obtainable from this type of bituminous sand is relatively viscous material having high tar content and relatively low commercial value in comparison with other crude oils, successful commercial processes must involve relatively little expense in the separation of bitumen from the bituminous sands. Operating costs of previously conceived methods for separating the oil from bituminous sands have been sufficiently high so as to discourage commercial exploitation. In addition, there has been considerable divergence of opinion as to the exact structure of the sands and as to the manner in which the bitumen might best be separated from sand particles.

The most successful of the previously attempted methods for separating bitumen from tar sands such as the Alberta tar sands have employed the mixing of the bituminous sand with water followed by separation of sand from the mixture by settling. In these processes it has been found that complete separation of the bitumen from the water has presented considerable difficulty due to the formation of oil-water emulsions resulting in the discarding of a significant quantity of crude oil which could not be successfully separated from the water.

In attempting to separate the bitumen from bituminous sands considerable difficulty has also been experienced due to the fact that the solids content of bituminous sands such as Alberta tar sands consists of particles of varying size and includes substantial amounts of silt in the form of clay and other very fine solids particles. In attempting to effect a complete separation of the bitumen from the bituminous sands most previous processes have attempted to retain the silt with the remainder of the solids content of the sands and as a result have usually discarded considerable quantities of crude oil along with the silt and sand. Those processes which have deliberately allowed the silt to remain with the bitumen separated from the sand particles have only led to the necessity for additional processes designed to separate the silt from the oil.

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

It is another object of the invention to provide an anhydrous process by which bitumen substantially free from water and silt may be separated from bituminous sand containing the same with essentially no loss of bitumen with waste sand.

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In accordance with a preferred embodiment of the present invention, bitumen is separated from bituminous sand by forming a slurry of bituminous sand and a first, relatively higher boiling, hydrocarbon solvent and placing the slurry on a moving filter belt to drain hydrocarbon liquid therefrom. A portion of this filtrate is preferably recycled to the slurring step to make the slurry more easily transportable. The bed of sand remaining on the filter belt is washed with a second, relatively lower boiling, hydrocarbon solvent to recover the relatively higher boiling hydrocarbon solvent and remaining bitumen from the sand. This filtrate, together with the remaining filtrate from the first draining, may then be sent to suitable recovery equipment for recovery of bitumen and low boiling and high boiling hydrocarbon solvents. Likewise, the sand may be sent to suitable solvent recovery equipment for recovery of hydrocarbon liquid therefrom.

For a better understanding of the invention reference should be had to the accompanying drawings in which:

FIGURE 1 is a diagrammatic illustration of a suitable process for carrying out a preferred embodiment of the invention; and

FIGURE 2 is a diagrammatic illustration in which equipment is shown in elevation of suitable apparatus for carrying out a portion of the process illustrated in FIGURE 1.

Referring to the drawings, bituminous sand obtained, for instance, by conventional mining techniques, is introduced to the process by suitable means such as a conveyor 11. Bituminous sands treated according to the invention are bituminous sands which contain bitumen (crude oil) and which usually contain silt in addition to the coarser sand particles. For purposes of this application silt may be defined as solids particles which pass through a 200 mesh screen and may include, for instance, extremely fine sand particles as well as clay or other solids present in the form of particles of this size. Bituminous sands of this type may contain widely varying amounts of silt but such silt frequently comprises between about 1 and about 20 weight percent of the total solids content of the bituminous sand. Similarly, the amount of bitumen in the bituminous sand may vary widely. Typical tar sands from which bitumen is obtained in accordance with this invention frequently contain between about 5 and about 20 weight percent bitumen. In addition, such tar sands frequently contain between about 1 and about 15 weight percent water. Compositions of suitable bituminous sands may, of course, vary over even wider ranges and minor amounts of other ingredients may also be present.

It has now been found that in tar sands of the type described above the fines, clays and other silt particles are contained in water envelopes surrounding individual grains of water wet sand particles. Each of these water envelopes containing silt particles is in turn surrounded with a film of bitumen which encases the water envelopes. Further amounts of bitumen partially fill the voids between individual sand particles. The process of the present invention is designed to disperse the sand particles and recover the bitumen surrounding the water envelopes, as well as the bitumen in the interstices of the tar sand, without rupturing the water envelopes. By thus avoiding rupture of the water envelopes, neither water nor silt is permitted to mix with the oil and the problems of water-oil emulsions and silt-oil separation which have been present in previously suggested processes do not occur in the process of the present invention.

The tar sand or bituminous sand entering on the conveyor 11 is mixed with relatively high boiling, heavy liquid hydrocarbon solvent in a slurring section 12. This slurring operation may be carried out in any suitable apparatus such as conventional mixing or slurry-

ing tanks, and the heavy liquid hydrocarbon solvent may enter through suitable means, such as conduit 13. The heavy hydrocarbon solvent may be added in any suitable amounts, such as between about 1 and about 5 barrels per barrel of bitumen present in the tar sand, and preferably has a boiling range between about 400 and about 700° F. The use of relatively heavy hydrocarbon solvent in this slurring operation is preferred to the use of relatively lighter hydrocarbon solvent for a number of reasons. Perhaps the most important of these is that the relatively heavy hydrocarbon solvent, being relatively higher boiling and having relatively higher aromatic content, is a better solvent for the bitumen and thus less likely to rupture the water envelopes around the sand particles than a relatively lighter solvent. In addition, lighter solvents have a strong tendency to de-asphalt the bitumen and form an asphalt-containing phase which is incompatible with the remainder of the hydrocarbon liquid present. The presence of such an asphalt-containing phase would complicate the separation process and might well result in clogging of the filter belt when the hydrocarbon liquids are drained from the sand as described below.

In addition to the heavy hydrocarbon solvent described above, additional hydrocarbon liquid is preferably added to the slurry to make the same more readily transportable. This additional liquid preferably takes the form of recycle oil comprising heavy hydrocarbon solvent and bitumen which may be recycled from a subsequent stage of the process as through a conduit 14. This additional liquid may be used in any suitable amounts, such as between about 1 and about 5 barrels per barrel of bitumen. The use of additional liquid in this manner serves not only to make the slurry more transportable, but also to lower the solids to oil ratio of the slurry, thus improving the extraction efficiency due to better dispersion of solids in the liquid phase.

From the slurring section 12, the slurry is transported, as through a conduit 16, to a draining section 17 described in more detail below and shown in more detail in FIGURE 2. As described in greater detail below, the slurry is placed on a filter medium such as a moving filter belt and hydrocarbon liquid is drained therefrom. If desired, a portion of the liquid may be removed from the slurry by conventional decanting methods prior to placing the slurry on the filter medium. A portion of the bitumen and heavy hydrocarbon solvent obtained as filtrate from the draining operation or by decanting prior to the draining operation is preferably recycled to the slurring stage through the conduit 14 as described above. In some instances, it may be desired to form the initial slurry of bituminous sand entirely with such recycle oil rather than with fresh heavy hydrocarbon solvent or a mixture of fresh solvent and recycle oil as described above. In this event, the fresh heavy hydrocarbon solvent may be added to the slurry prior to the draining or decanting operation or may be used to wash the sand on the filter medium during or immediately following the draining of slurry liquid therefrom. Following this initial draining stage, the bed of sand remaining on the filter is washed with a relatively light, low boiling hydrocarbon solvent introduced, for instance, through a conduit 18. This light hydrocarbon solvent preferably has a boiling range between about 100 and about 400° F. and serves to displace the mixture of bitumen and heavy hydrocarbon solvent from the interstices of the sand as well as to dilute the hydrocarbon liquid envelope surrounding each water envelope to the point where very little bitumen remains in the sand bed. The sand may be washed with any suitable quantities of light hydrocarbon solvent, with between about 1 and about 5 barrels of light hydrocarbon solvent per barrel of bitumen originally present in the bituminous sand being preferred. The use of light hydrocarbon solvent for this washing step is preferred to the use of heavier hydro-

carbon solvent in order to insure complete recovery of bitumen and also to insure that the solvent may be easily and completely removed from the sand as described below.

In mixing the tar sand feed with the heavy hydrocarbon solvent to form a slurry as described above, care should be taken to insure that the mixing is sufficiently gentle so that the envelopes of water surrounding the sand particles and containing the silt are not ruptured. In order to avoid premature rupture of the water envelopes, it is necessary that water be substantially excluded from the slurring and draining operations of the present invention since the use of water in the process would free the silt from the water envelopes immediately surrounding the sand particles and lead to the difficulties described above which have been encountered by prior art processes.

From the draining section 17 the filtrate is preferably passed to suitable recovery equipment such as a fractionation section 19, as through a conduit 21, while the drained and washed sand is preferably passed to a solvent recovery section 22 as by a conveyor 23. The solvent recovery section may take any suitable form such as conventional evaporation equipment designed to recover liquid from solids. Solids may be removed for disposal, as through a conduit 24, while hydrocarbon solvent recovered from the solvent recovery section may be passed to the fractionation section as through a conduit 26. Water separated from sand and hydrocarbon solvent in the solvent recovery section may be slurried with the solids being disposed of through conduit 24.

The fractionation section may comprise any suitable apparatus, such as conventional fractionating equipment, and is preferably designed to recover bitumen, light hydrocarbon solvent and heavy hydrocarbon solvent. The bitumen may then be withdrawn, as through a conduit 27, for storage or further processing while the heavy hydrocarbon solvent is preferably passed to the slurring section 12 through conduit 13 as described above and the light hydrocarbon solvent is preferably passed to the washing stage of the draining section 17 through conduit 18 as described above.

FIGURE 2 shows in somewhat greater detail an arrangement of apparatus suitable for use in operating the draining section 17 referred to and shown generally in FIGURE 1. Referring now to FIGURE 2, the slurry entering the draining section through conduit 16 is preferably distributed onto a suitable filter medium, such as a moving filter belt 31, by suitable means such as a plurality of conduits 32 designed to spread the slurry uniformly over the filter belt. The filter belt 31 may be constructed of any suitable material, such as standard filter belt screening and may be supported and driven in a conventional manner. The belt 31 is shown in FIGURE 2 as being supported about idlers such as 33 and 34. The openings in the filter material should, of course, be sufficiently large to permit free flow of liquid while being sufficiently small to retain the sand particles. Since, in the separation of bitumen in accordance with the present invention, the silt remains trapped in the water envelopes surrounding the sand particles, clogging of the filter belt with silt is not a problem. In order to allow free drainage of fluid through the filter belt, it is, however, necessary to insure that the water envelopes do not become ruptured. If, for instance, the bituminous sand is mixed with water or the slurry of bituminous sand and hydrocarbon solvent is mixed too violently so that the water envelopes are ruptured, the filter belt almost immediately becomes clogged with silt which co-operates with the sand particles to prevent free passage of fluid and it becomes impossible to maintain proper drainage through the belt.

As the filter belt 31 moves in the direction indicated by an arrow 36, a first portion of the liquid draining from the slurry may be collected in a hopper 37 and passed

to a collecting tank 38, as by a conduit 39. This portion of the filtrate is preferably recycled to the slurring section 12 through conduit 14 as described above by suitable means such as a pump 41. Additional filtrate is drained from the slurry through the filter belt 31 and may be collected in a second hopper 42 and thence passed to a collecting tank 43 through a conduit 44. From the vessel 43 this filtrate may be passed via a pump 46 through the conduit 21 to the fractionation section 19 as described above. The sand bed remaining on the filter belt 31 is then washed with light hydrocarbon solvent as described above in order to remove the heavy hydrocarbon solvent and remaining bitumen and further dilute the films of liquid hydrocarbon surrounding the water envelopes of the individual sand particles to the point where very little, usually less than about 5 percent, of the original bitumen remains in the sand. This light hydrocarbon solvent may be introduced through the conduit 18 as described above and is preferably distributed on the filter belt by suitable means such as distribution conduits 47. The liquid draining through the sand bed and filter belt 31 may be collected by suitable means, such as hoppers 48 and 49, and passed to suitable collecting tanks, such as 51 and 52, by conduits such as 53 and 54. From the collecting tanks 51 and 52 the filtrate from the washing operation may be passed by suitable means, such as pumps 56 and 57, through conduits 58 and 59 to the conduit 21 for passage to the fractionation section 19 as described above.

The solvent wet sand, containing essentially light hydrocarbon solvent and with the water envelopes surrounding the individual sand particles still unruptured and thus still trapping the silt, may be discharged from the filter belt 31 onto the sand conveyor 23 for transportation to the solvent recovery section 22 as described above in connection with FIGURE 1.

In order to prevent unnecessary loss of hydrocarbon solvents and especially of the more volatile light hydrocarbon solvent used to wash the sand bed following the initial draining operation, the filter belt 31 and collection hoppers 37, 42, 48 and 49, as well as the discharge from the filter belt 31 onto the sand conveyor 23, are preferably enclosed within a substantially vapor tight housing such as 61. Openings in the housing 61 necessary for passage of the sand conveyor 23 and the various conduits are preferably minimized and sealed where possible in order to prevent unnecessary loss of valuable solvent vapors.

In order to assist in draining liquids through the filter belt 31 and to minimize the size and number of such filter belts required, it is preferred that the drainage through the filter belt be augmented by maintaining the area under the filter belt under a suitable vacuum. This makes possible higher drainage rates for given bed thicknesses and thereby reduces the amount of equipment necessary to achieve the desired draining and washing of the sand. Any suitable vacuum pressures may be employed for this purpose, with vacuums of up to about 10 inches of mercury being preferred for the filtrate from the washing step which is collected in the collection hoppers 48 and 49 and vacuums of between about 10 and about 20 inches of mercury being preferred for the initial draining operation from which the filtrate is collected in the collection hoppers 37 and 42. Where such vacuums are used, drain rates of up to about 10 or more gallons per minute per square foot of draining surface are obtainable with average sand bed thicknesses of about 6 inches. Such vacuums may be applied in any suitable manner. For instance, as shown in FIGURE 2, vacuum lines, such as conduits 62 and 63 from conventional vacuum producing equipment, may apply suitable vacuum to the collecting tanks 38 and 43 respectively while similar conduits 64 and 66 may be used to apply vacuum to the collecting tanks 51 and 52 respectively. Suitable means such as conduits 67, 68, 69 and 71 may be used to apply the

vacuum from the collecting tanks to the collection hoppers as shown in FIGURE 2.

The slurring of bituminous sand with relatively heavy, high boiling hydrocarbon solvent and the draining operation in which this solvent is drained from the sand are preferably carried out at temperatures between about 100 and about 200° F. The subsequent washing step in which the sand bed is washed with relatively light, low boiling hydrocarbon solvent is preferably carried out at lower temperatures, such as between about 60 and about 120° F. The following specific example illustrates a practical application of the present invention using the process described and shown in the drawings.

Example

Referring to FIGURE 1, tar sand enters the slurry section 12 through the conduit 11 at the rate of 10,305 tons per hour. This tar sand, which has been mined by any conventional method, has the following composition.

Ingredients:	Weight percent
Bitumen	10.0
Water	4.5
Sand	78.5
Silt	7.0

Heavy hydrocarbon solvent enters the slurry section through the conduit 13 at the rate of 8,101 gallons per minute (g.p.m.). This heavy solvent has the following properties.

Gravity, ° API	30.4
Viscosity (centistokes):	
At 100° F	3.7
At 210° F	1.4
ASTM distillation (° F.):	
IBP	490
10%	520
30%	535
50%	550
70%	568
90%	600
EP	640

Recycle oil from the drain section 17 is passed to the slurry section 12 through the conduit 14 at the rate of 12,218 g.p.m. and has the following composition.

Ingredients:	Volume percent
Bitumen	33.2
Heavy solvent	66.3
Water	0.3
Solids	0.2

From the slurring operation, slurry is passed to the draining section 17 through the conduit 16 at the rate of 40,384 g.p.m. This slurry has the following composition.

Ingredients:	Volume percent
Bitumen	20.0
Heavy solvent	40.1
Water	4.7
Solids	35.2

The light hydrocarbon solvent introduced to the draining operation through the conduit 18 as described above to wash the drained sand on the filter belt is introduced at the rate of 8,101 gallons per minute and has the following properties.

Gravity, ° API	61.7
Viscosity (centistokes):	
@ 50° F	0.81
@ 100° F	0.62
ASTM distillation (° F.):	
IBP	139
10%	173
30%	213
50%	262

ASTM distillation (° F.):—Continued

70% -----	307
90% -----	351
EP -----	394

To assist in draining hydrocarbon liquid from the slurry and sand bed on the filter belt 31, collection hoppers 48 and 49 and the collection tanks 51 and 52 are maintained under a vacuum of 5 inches of mercury while the collection hoppers 37 and 42 and the collection tanks 38 and 43 are maintained under a vacuum of 15 inches of mercury. Under these conditions a draining rate of 9 gallons per minute per square foot of filter surface is maintained with an average sand bed depth of 6 inches.

The filtrate from the draining step which is not recycled through the conduit 14 as described above is passed to the fractionation section 19 through the conduit 21 at a total rate of 17,057 g.p.m. and has the following composition.

Ingredients:	Volume percent
Bitumen -----	22.7
Heavy solvent -----	46.1
Light solvent -----	30.9
Water -----	0.2
Solids -----	0.1

The drained sand from the draining operation is passed to the solvent recovery section 22 by the conveyor 23 at the rate of 9,913 tons per hour and has the following composition.

Ingredients:	Weight percent
Bitumen -----	0.5
Heavy solvent -----	0.5
Light solvent -----	5.0
Water -----	4.6
Solids -----	89.4

From the solvent recovery section 22 solids are sent to disposal through the conduit 24 at the rate of 8,889 tons per hour, of which approximately 0.6 weight percent is bitumen and the remainder sand and silt. For ease of transportation, these solids are preferably slurried with the 456 tons per hour (1,824 g.p.m.) of water separated from the sand and hydrocarbon solvent in the solvent recovery section.

From the solvent recovery section condensate is passed to the fractionation section 19 through the conduit 26 at the rate of 3,060 gallons per minute. This stream has the following composition.

Ingredients:	Volume percent
Heavy solvent -----	7.7
Light solvent -----	92.3

In the fractionation section, heavy solvent, light solvent and bitumen is recovered, with the heavy solvent and light solvent being recycled through conduits 13 and 18 respectively as described above and the bitumen being recovered for further processing or storage through the conduit 27 at the rate of 3,489 gallons per minute. This bitumen, which is the product of the process, has the following properties.

Gravity, ° API -----	6.8
Viscosity (centistokes):	
@ 100° F -----	27,000
@ 210° F -----	420

ASTM distillation (° F.):

IBP -----	545
10% -----	680
30% -----	880
EP @ 46% -----	1,005

While the invention has been described above with respect to certain preferred embodiments thereof, it will be understood by those skilled in the art that various changes and modifications may be made without departing from the spirit and scope of the invention and it

is intended to cover all such changes and modifications in the appended claims.

We claim:

1. The process for recovering bitumen from bituminous sand containing the same which comprises forming a slurry of said bituminous sand and between about 1 and about 5 barrels per barrel of bitumen of a relatively heavy liquid hydrocarbon solvent boiling between about 400 and about 700° F., draining hydrocarbon liquid from said slurry on a two dimensional filter zone and then washing the resulting sand bed remaining on said filter zone with between about 1 and about 5 barrels per barrel of bitumen originally present in said bituminous sand of a relatively light hydrocarbon solvent boiling between about 100 and about 400° F. to displace said heavy hydrocarbon solvent and recover additional hydrocarbon oil from said sand while maintaining the physical relationship between the filter zone and the sand bed substantially undisturbed during such washing.

2. The process for recovering bitumen from bituminous sand in which sand grains are surrounded by water envelopes containing silt particles and in which bitumen encases such water envelopes which comprises forming a slurry of said bituminous sand and between about 1 and about 5 barrels per barrel of bitumen of a relatively heavy liquid hydrocarbon solvent boiling between about 400 and about 700° F. under mixing conditions sufficiently gentle so that said water envelopes are not ruptured to thereby dilute the films of bitumen surrounding the water envelopes with said solvent and release bitumen therefrom, placing said slurry on a two dimensional filter zone, draining a first portion of hydrocarbon liquid filtrate from the slurry on said filter zone, and washing the resulting bed of sand on said filter zone with between about 1 and about 5 barrels per barrel of bitumen originally present in said bituminous sand of a relatively light liquid hydrocarbon solvent boiling between about 100 and about 400° F. to thereby further dilute the films of hydrocarbon liquid surrounding the water envelopes of the sand particles and release bitumen and heavy hydrocarbon solvent therefrom while maintaining the physical relationship between the filter zone and the sand bed substantially undisturbed during such washing.

3. The process for recovering bitumen from bituminous sand containing the same which comprises forming a slurry of said bituminous sand and between about 1 and about 5 barrels per barrel of bitumen of a relatively heavy liquid hydrocarbon solvent boiling between about 100 and about 400° F., placing said slurry on a two-dimensional filter zone, draining a first portion of liquid hydrocarbon filtrate from the slurry on said filter zone and recycling said first portion of filtrate to the mixing step described above, draining a second portion of liquid hydrocarbon filtrate from the slurry on said filter zone, washing the resulting bed of sand on said filter zone with between about 1 and about 5 barrels per barrel of bitumen originally present in said bituminous sand of a relatively light liquid hydrocarbon solvent boiling between about 100 and about 400° F. while maintaining the physical relationship between the filter zone and the sand bed substantially undisturbed during such washing, recovering a third portion of liquid hydrocarbon filtrate from the above described washing step, passing said third portion of filtrate together with said second portion of filtrate to a fractionation zone for recovery of bitumen and heavy and light hydrocarbon solvents, passing sand from said filter zone to a solvent recovery zone for recovery of hydrocarbon liquid from sand, water and silt and passing thus recovered hydrocarbon liquid to said fractionation zone.

4. The process for recovering bitumen from bituminous sand containing the same which comprises forming a slurry of said bituminous sand and between about 1 and about 5 barrels per barrel of bitumen of a relatively heavy liquid hydrocarbon solvent boiling between about

400 and about 700° F., placing said slurry on a two dimensional filter zone, draining a first portion of hydrocarbon liquid filtrate from the slurry on said filter zone, washing the resulting bed of sand on said filter zone with between about 1 and about 5 barrels per barrel of bitumen originally present in said bituminous sand of a relatively light liquid hydrocarbon solvent boiling between about 100 and about 400° F. while maintaining the physical relationship between the filter zone and the sand bed substantially undisturbed during such washing, recovering a second portion of hydrocarbon liquid filtrate from the above described washing step, passing said second portion of filtrate together with said first portion of filtrate to a fractionation zone for recovery of bitumen and said heavy and light hydrocarbon solvents, passing sand from said filter zone to a solvent recovery zone for recovery of hydrocarbon liquid from sand, water and silt and passing thus recovered hydrocarbon liquid to said fractionation zone.

5. The process for recovering bitumen from bituminous sand in which sand grains are surrounded by water envelopes containing silt particles and in which bitumen encases such water envelopes which comprises forming a slurry of said bituminous sand and between about 1 and about 5 barrels of heavy liquid hydrocarbon solvent boiling between about 400 and about 700° F. per barrel of bitumen present in said sand under mixing conditions sufficiently gentle so that said water envelopes are not ruptured to thereby dilute the films of bitumen surrounding the water envelopes with said solvent and release bitumen therefrom, placing said slurry on a two dimensional filter zone, draining a first portion of liquid hydrocarbon filtrate from the slurry on said zone and recycling said first portion of filtrate to the

slurrying step described above, draining a second portion of liquid hydrocarbon filtrate from the slurry on said filter zone, washing the resulting bed of sand on said filter zone with between about 1 and about 5 barrels of light liquid hydrocarbon solvent boiling between about 100 and about 400° F. per barrel of bitumen originally present in said bituminous sand to thereby further dilute the films of hydrocarbon material surrounding the water envelopes of the sand particles and release bitumen and heavy hydrocarbon solvent therefrom while maintaining the physical relationship between the filter zone and the sand bed substantially undisturbed during such washing, recovering a third portion of liquid hydrocarbon filtrate from the above described washing step, passing said third portion of filtrate together with said second portion of filtrate to a fractionation zone for recovery of bitumen and heavy and light hydrocarbon solvents, passing sand from said filter zone to a solvent recovery zone for recovery of hydrocarbon liquid from sand, water and silt and passing thus recovered hydrocarbon liquid to said fractionation zone.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,117,922

January 14, 1964

Thomas S. Leary et al.

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 7, line 58, for "3,489" read -- 3,849 --.

Signed and sealed this 9th day of June 1964.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents