March 20, 1951 C. W. BILBE 2,545,938

SOLVENT EXTRACTION APPARATUS

Filed May 5, 1945 2 Sheets-Sheet 1

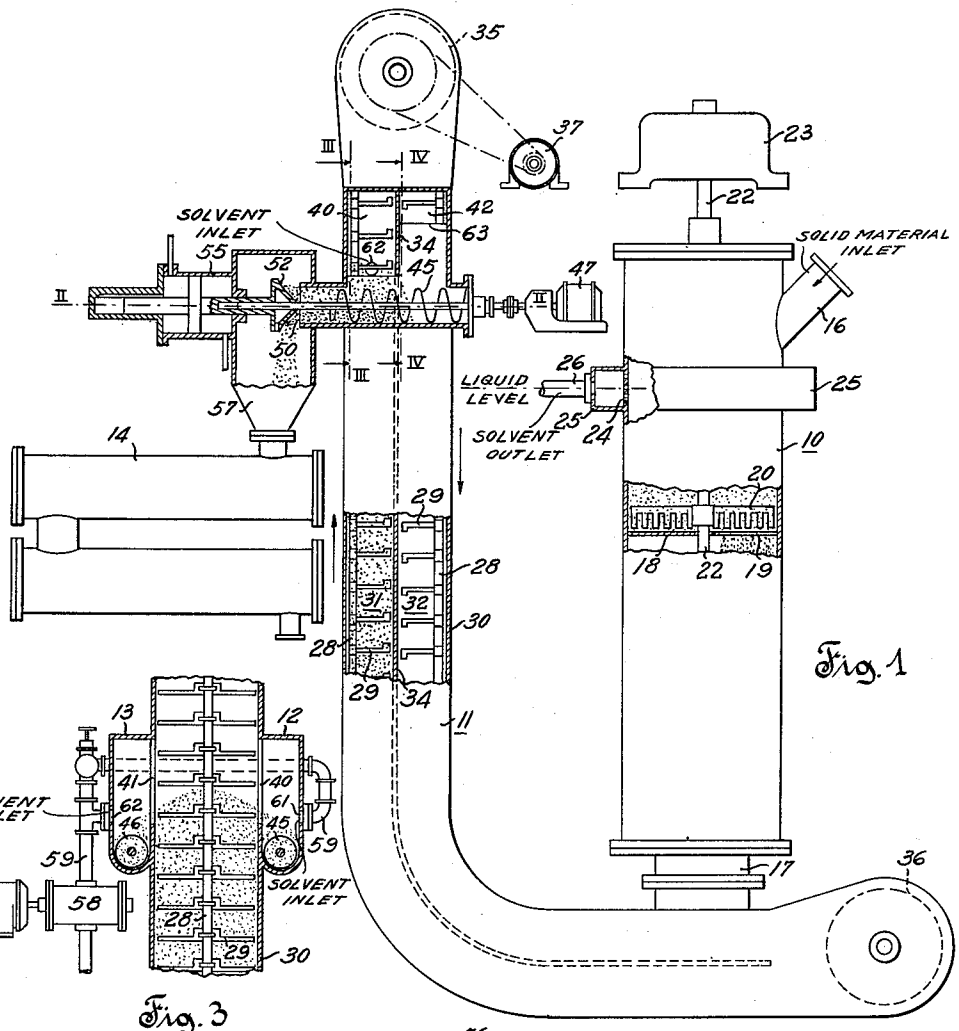

Fig. 1

Fig. 3

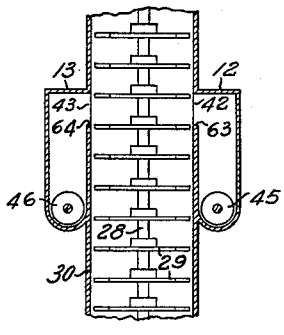

Fig. 4

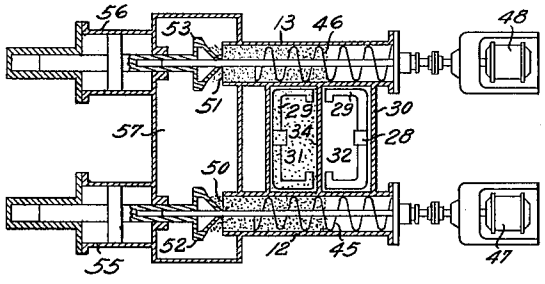

Fig. 2

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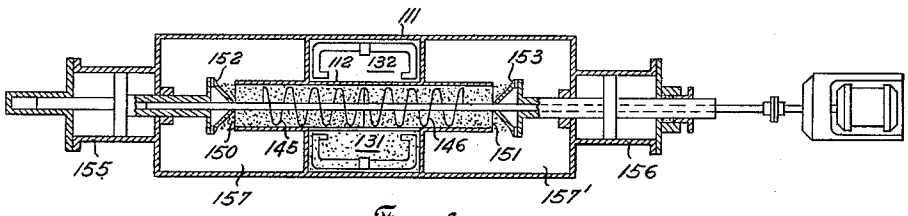

Fig. 6

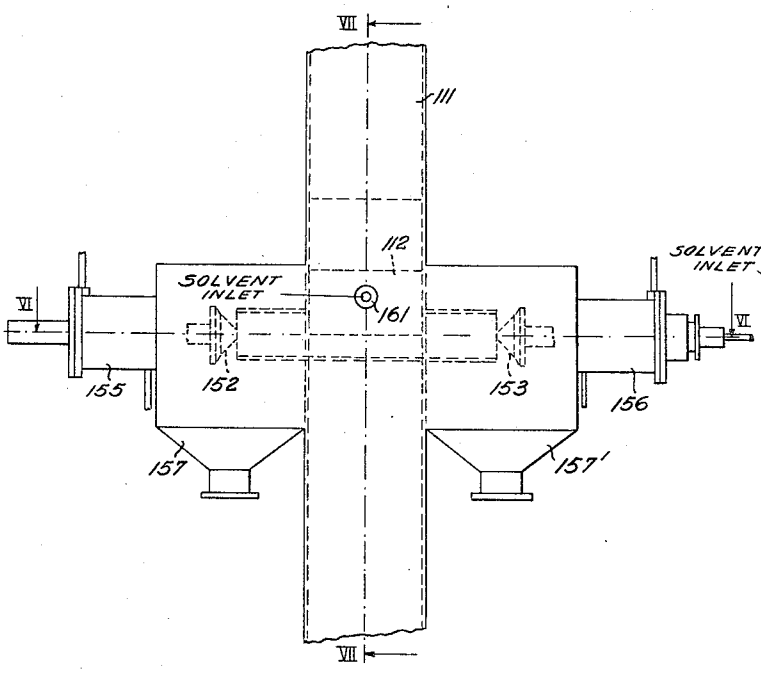

Fig. 5

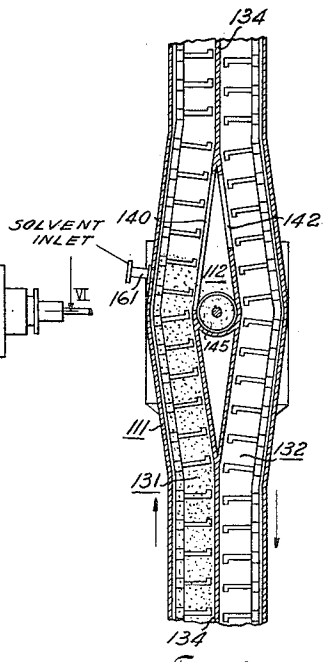

Fig. 7

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UNITED STATES PATENT OFFICE

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SOLVENT EXTRACTION APPARATUS

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2 Claims. (Cl. 23—270)

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The present invention relates generally to improvements in the art of treating materials and relates more particularly to improvements in methods and apparatus for the continuous countercurrent solvent extraction of solid materials.

It has heretofore been proposed to remove fats, oils and like substances from various animal and vegetable materials by the use of suitable solvents. This removal or separation of oily substances or the like from solid materials such as soybean, cottonseed and nut meal may be effected either by the treatment of the material in batches or by the continuous treatment thereof. The present invention is primarily concerned with the provision of an improved method and apparatus whereby solvent extraction may be effectively accomplished in a continuous, uninterrupted and economical manner.

In the continuous solvent extraction of materials, it is common practice to advance the material through a bath of countercurrently moving solvent and then drain or squeeze the liquid from the more or less exhausted material prior to discharging such material to a drier for subsequent treatment. One type of apparatus heretofore proposed for effecting such continuous countercurrent solvent extraction consists, generally, in the provision of an upright tank having an inlet for solid material at the upper portion and an outlet for such material at the lower portion with a conveyer for removing the material from the outlet to a point of discharge to the drier. The tank in such prior art apparatus is normally provided with a screened outlet in the upper portion for the escape of liquid, including the solvent and extracted oil, and the conveyer is provided with, or is associated with, means for effecting partial separation of the liquid from the solid material.

As to the means for effecting such partial separation, one type of prior art apparatus includes an elevating conveyer of sufficient length as to extend well above the solvent level established by the liquid outlet and provided with perforated conveyer members for permitting partial drainage of the liquid by gravity back to the solvent level within the conveyer. In other instances the conveyer is moved through a perforated casing section above the liquid level to permit partial drainage of the liquid through a wall of the conveyer casing where it is caught and returned to the extraction apparatus. In still other prior art systems, the material is subjected to pressure either within the conveyer or externally thereof and above the liquid level to

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squeeze some of the liquid from the material. Since it is desirable to keep the material in contact with the solvent for as long a period of time as possible and since it is also more effective to subject the material containing less of the substance being extracted therefrom to the fresher and purer solvent, it is common practice in the systems hereinabove described to supply the fresh solvent at a point in the conveyer as near as possible to the point of discharge of the solid material. This supply point is usually located below the place of drainage or squeezing of the material.

Although systems provided with an elevating conveyer in which drainage is permitted either through a perforated portion of the conveyer casing or within the conveyer passage, per se, have enjoyed a certain degree of commercial success, there are nevertheless numerous disadvantages attendant such installations. One of the major objections to this type of apparatus is that the conveyer must be exceedingly long, extending a sufficient distance above the solvent level to permit a satisfactory separation by drainage of the liquid from the solid. Consequently, the original cost of this equipment is great and a large enclosure for the solvent extraction plant is necessary. Likewise, the material must be advanced at an objectionably slow speed, in conveyers of the drainage type, to provide adequate drainage time and consequent separation prior to discharge of the solid material to the driers. Furthermore, apparatus of this type is not generally satisfactory for use with all materials since some materials, such as flaxseed, consist of finely divided particles which either clog the perforations or are carried therethrough with the liquid. Another serious difficulty encountered with this type of equipment is in the constant need for cleaning and maintenance thereof. Since the majority of the materials processed contain a relatively large proportion of fine particles, the perforations provided for the draining of the liquid constantly become clogged, necessitating frequent stoppages in the operation of the unit to clean the perforated portions of the conveyer or its casing for proper functioning of the unit. Therefore, not only is the maintenance cost high but the necessary interruptions in operation are costly.

Similarly, numerous disadvantages are attendant the various mechanical separating means heretofore proposed. One of the principal objections to the use of mechanical separators in solvent extraction systems is in the difficulty

which is encountered in providing and maintaining an operative device. Mechanical separators heretofore proposed have been disposed above the solvent level in the conveyer or externally of both the conveyer and the solvent bath in the conveyer; and such devices have proven ineffective due to the fact that the saturated material, which is in the nature of a plastic mass and extremely difficult to handle after leaving the solvent bath, packs tightly when subjected to pressure, sticking and jamming in the various parts of the mechanical separating device and necessitating almost constant cleaning and maintenance attention. It has also been heretofore proposed to provide mechanical means at the lower outlet of the initial extraction chamber for feeding the material against pressure directly to the drier and eliminating the conveyer. However, the vertical arrangement of the large equipment, including the extraction chamber, separating device and drier, in such systems is highly impractical because of the objectionable resulting height. Furthermore, the pressure head against which such separating devices must operate is extremely great with a correspondingly high packing pressure necessary to effectively squeeze the liquid from the material being discharged; and failure of the separating mechanism, when located below the initial extraction chamber, results in the flooding of the drier. In addition to the foregoing objections to mechanical separators as heretofore proposed, the majority of these devices produce an undesirable and excessive comminution of the solid material being processed.

It is therefore an object of the present invention to provide an improved method and apparatus for solvent extraction which obviates the objectionable features of the prior methods and devices.

Another object of my invention is to provide an improved solvent extraction method and apparatus which is highly efficient in the removal of oils and like substances from solid materials and wherein separation of the liquid from the solids is speedily and effectively obtained in a continuous manner.

Another object of this invention is to provide an improved solvent extraction apparatus which is of simple construction, which is inexpensive to manufacture and operate, and which occupies a minimum amount of space both as to floor area and height.

Another object of the invention is to provide an improved solvent extraction apparatus wherein all parts are readily accessible for examination, replacement or repair.

Another object of my invention is to provide an improved solvent extraction apparatus wherein separation of the liquid from the solid material is effected by means of an independently operating mechanical separator which may be adjusted independently of its associated apparatus as to both speed and pressure, and with which a maximum degree of separation may be obtained prior to discharge of the solid material to the drier for removal of the remaining solvent by evaporation.

Another object of the present invention is to provide an improved method and apparatus for solvent extraction wherein maximum separation of the liquid from the solid material is effected in a continuous manner by discharging the material against pressure and while under a bath of fresh solvent, without undesirably affecting the characteristics of the final products.

A further object of the present invention is to provide an improved method of solvent extraction comprising, moving a body of material through a body of counterflowing solvent in an initial extraction chamber, removing the material from the initial chamber and elevating it through a column of other solvent, separating the material from the solvent in the column beneath its upper extremity, and utilizing the solvent column height to maintain the initial chamber constantly filled with solvent.

An additional object of my invention is to provide an improved solvent extraction apparatus comprising, a primary extraction chamber having a solid material inlet, an elevating conveyer for removing solid material from the primary chamber, means for constantly maintaining the chamber and the conveyer filled with solvent, and means for removing solids from an upper portion of the conveyer below the level of the solvent therein.

Additional objects and advantages of the present invention will be apparent from the following detailed description.

A clear conception of the present improvement and of the mode of constructing and of utilizing apparatus built in accordance with my invention may be had by referring to the drawing accompanying and forming a part of this specification, wherein like reference characters designate the same or similar parts in the various views.

Fig. 1 is a part sectional side elevation showing an apparatus constructed in accordance with my invention and adapted to perform the several steps of my improved method;

Fig. 2 is a horizontal sectional view taken along the line II—II of Fig. 1;

Fig. 3 is a vertical sectional view taken along the line III—III of Fig. 1;

Fig. 4 is a vertical sectional view taken along the line IV—IV of Fig. 1;

Fig. 5 is a fragmentary front elevation of the discharge portion of a modified form of apparatus;

Fig. 6 is a horizontal sectional view taken along the line VI—VI of Fig. 5; and

Fig. 7 is a vertical sectional view taken along the line VII—VII of Fig. 5.

Referring to the drawings and more particularly Figs. 1 to 4 thereof, the improved apparatus comprises in general an upright member **10** forming the primary extraction chamber, an elevating conveyer **11** associated with the lower portion of the chamber, and a pair of final extraction, washing and separating chambers or chests **12**, **13** disposed on opposite sides of the conveyer and communicating with a drier **14**.

As shown in the drawings, the primary extraction chamber **10** is provided with an upper solid material inlet **16** and a lower solid material outlet **17**. Within the chamber **10** and secured to the side wall thereof, a plurality of vertically spaced nonrotatable plates **18** are provided. The plates **18** are each formed with one or more radial openings **19** disposed in staggered relationship with respect to the openings in the preceding and succeeding plates. One or more radially extending arms **20** are provided immediately above each plate, and these vertically spaced arms are secured to a shaft **22** driven by a motor **23** for rotation therewith. Below the upper solid material inlet **16**, the wall of the chamber **10** is per-

forated as indicated at 24, and this perforated portion of the chamber wall is surrounded by a jacket 25 having a liquid outlet pipe 26 leading therefrom.

The conveyer 11, as shown, is preferably of the endless drag type comprising a chain 28 or the like carrying a plurality of blades or drag links 29. The conveyer is housed within a casing 30 forming a conduit which is divided into an elevating passage 31 and a return passage 32 by an intermediate partition 34. At opposite ends of the conveyer the chain 28 is guided by pulleys 35 and 36, the upper pulley 35 being driven by a motor 37 in a clockwise direction so that the chain moves upwardly in passage 31 and downwardly in passage 32 as indicated by the arrows. The conveyer is shown as operative in a horizontal and vertical plane but this may be modified as desired in particular instances.

The upper portion of the conveyer passage 31 is in open communication by way of ports 40, 41 with the chambers or chests 12, 13, respectively, associated with the opposite sides of the conveyer casing. The chests 12, 13 may either be formed integral with the conveyer casing, as shown, or they may be formed as separate members, communicating with the conveyer casing by suitable piping. The conveyer passage 32, at its upper portion, is likewise in open communication with the chests 12, 13 by way of ports 42, 43, respectively. It should, however, be noted that the ports 40, 41 are of considerably greater vertical length than the ports 42, 43, opening into the chests 12, 13 at a point below the lower extremities of the ports 42, 43 as will be hereinafter more fully described. The chests 12, 13, respectively, are provided, adjacent the lower portions thereof, with spiral conveyers or feeders 45, 46 operated by suitable motors 47, 48, respectively, in a direction such as to feed the material toward the respective discharge openings 50, 51 and plug valves 52, 53 or the like. The valves 52, 53 are yieldingly movable axially of their respective spiral feeders 45, 46 and may be adjusted as to the pressure to be applied against material fed thereto by varying the pressure in the cylinders of the servomotors 55, 56, respectively, in an obvious manner. Communicating with the discharge openings 50, 51 of the chests 12, 13 through a spout 57 are one or more driers 14 of a conventional type which form no part of the present invention and therefore need not be further described. Solvent is supplied to the chests 12, 13 of the apparatus from a suitable source of supply by way of a pump 58 and piping 59 communicating with the chests 12, 13 through inlet ports 61, 62, respectively. The solvent supply ports 61, 62 are preferably located above the spiral feeders 45, 46 but below the lower lips 63, 64 of the ports 42, 43, respectively, for reasons as will hereinafter become apparent.

The spiral conveyers 45, 46, operating in conjunction with the suitable known internal formation of chests 12, 13 and restricted discharge openings 50, 51, form a mechanism of known character which may be referred to hereinafter for convenience as: fluid expressing, compressed solids ejecting means. This term (fluid expressing, compressed solids ejecting means) defines any suitable known mechanism, or its substantial equivalent, for expressing fluids from a mass of fluid containing solids and ejecting the solids, in compressed, relatively fluid free state, from the space within which it operates.

In operation of the device, solvent is supplied

through the solvent inlets 61, 62 to the chests 12, 13, respectively, and raw solid material containing the substance to be extracted is fed to the chamber 10 by suitable means through the upper inlet 16. With valves 52, 53 closing the respective discharge openings 50, 51, both passages of the conveyer as well as the chamber 10 are flooded with solvent up to the level of the outlet 26 communicating with the chamber 10. Since the solvent escapes through the perforated portion 24 of the extraction chamber and is conducted away from the unit through the outlet 26, it is apparent that a continuous flow of solvent from the upper portion of the conveyer to the lower portion thereof and then through the lower outlet 17 and upwardly within the chamber 10 to the liquid outlet is established, with a liquid level in both the conveyer and the initial extraction chamber being maintained approximately at the point of discharge of the liquid, as indicated.

The solid material being fed to the upper portion of the chamber 10 falls by gravity to the uppermost of the plates 18 where it is carried to the opening 19 by the arm 20, falling by gravity to the next succeeding plate for similar handling. Thus, it is seen that the material is advanced downwardly in the chamber 10 from the upper inlet 16 to the lower outlet 17 in a retarded manner and through a bath of countercurrently moving solvent. Since the first contact between the solid material and the solvent occurs in this chamber, the greatest amount of oil is removed by the solvent during this initial treatment.

The material being continuously advanced through the chamber 10 finally falls through the lower outlet 17 into the horizontal portion of the conveyer 11. Since the chain 28 and links 29 of the conveyer are being continuously advanced in a direction as indicated by the arrows, the material is moved through the passage 31, being carried upwardly therethrough by the links 29. As the material reaches the upper portion of the passage 31 adjacent the ports 40, 41, it is discharged through these ports to the respective chests 12, 13, falling by gravity into the continuously operating spiral feeders 45, 46 which advance the material to the respective openings 50, 51 for discharge therethrough to the drier against the pressure of the valves 52, 53, respectively.

Obviously, as the operations are being carried out with the solid material being advanced upwardly through the closed passage 31 of the conveyer, the fresh solvent being supplied at 61, 62 is prevented from flowing freely downwardly within the passage 31 which is filled with solid material and solvent throughout its length, and the solvent therefore rises in the chests 12, 13, submerging the spiral feeders and the material being handled thereby and overflowing through the ports 42, 43 into the empty passage 32 of the conveyer. It is therefore apparent that, during the operation of the device, the lower lips 63, 64 of the ports 42, 43, respectively, act as dams over which the overflow liquid from the chests 12, 13 is conducted to the empty return passage of the conveyer. From the passage 32 the liquid flows downwardly within the conveyer and thence upwardly within the initial extraction chamber to the liquid outlet 26 as hereinabove described.

Referring now to Figs. 5 to 7 of the drawings, a modified form of apparatus (fluid expressing, compressed solids ejecting means) which may be used at the upper portion of the conveyer for separating the liquid from the solid material

during discharge to the drier is illustrated. In the modified arrangement, the material moving passage 131 and the return passage 132 of an elevating conveyer 111 are separated by an intermediate partition 134 as in the apparatus hereinabove described with reference to Figs. 1 to 4 of the drawings. However, in the modification shown in Figs. 5 to 7, a single final extraction and separation chest 112 is provided, such chest being disposed between the passages 131 and 132 at the upper portion of the conveyer and forming a part of the intermediate partition 134. The chest or chamber 112 is in open communication with the passage 131 by way of a port 140 and the chest 112 is likewise in communication with the passage 132 through a port 142. The port 140 is larger than port 142 which has its lower extremity located somewhat above the lower extremity of port 140. Within the chest 112 and adjacent the bottom thereof are provided a pair of spiral conveyers or feeders 145, 146 disposed in a common plane and driven from a common shaft but with the spiral flights thereof formed for delivery in opposite directions. The spiral feeders 145, 146 are adapted to feed material toward discharge openings 150, 151 and plug valves 152, 153, respectively, into spouts 157, 157' communicating with a drier, not shown. The valves 152, 153 may be adjusted by supplying more or less pressure to the cylinders of the respective servomotors 155, 156. Fresh solvent is supplied from a suitable source to the conveyer passage 131 adjacent the chest 112 through the inlet port 161.

In operation, the modified device functions substantially like the preferred arrangement. The solid material is advanced through a body of countercurrently moving solvent in the initial extraction chamber and is conveyed upwardly in the elevating passage 131 of the conveyer. The material being moved through the passage 131 is discharged into the chest 112 through the port 140 and settles by gravity in the spiral feeders 145, 146 submerged in a bath of fresh solvent being continuously supplied through the supply port 161. The spiral feeders 145, 146 discharge the solid material into the spouts 157, 157' through the openings 150, 151 against the pressure of the valves 152, 153, respectively. The liquid from within the chest 112 overflows the lower edge or discharge lip of the port 142 into the return passage 132 of the conveyer and circulates through the passage 132 and the initial extraction chamber to the liquid outlet provided therein.

From the foregoing detailed description, it is apparent that the solid material, in both forms of apparatus, continuously remains completely immersed in a bath of solvent from the time it reaches the liquid level in the chamber 10 until it is discharged from the chests 12, 13 or the chest 112 to the drier. In addition, it should be noted that the solvent bath is of increasing freshness as the material is advanced to its final discharge point, with the fresh solvent being supplied adjacent the point of discharge of the exhausted solids. By immersing the material in a final solvent bath at the point of discharge thereof, a final extraction and displacement of oil is effected. Furthermore, by keeping the material completely immersed in a bath of liquid during all of the operations, the material is readily handled by all parts of the apparatus, and the difficulties heretofore encountered with prior devices are obviated. By the mechanical squeezing means herein provided, the length of the conveyer may be reduced to a minimum; and because of the effective separation obtained by such squeezing device, the size and number of final driers for evaporating the comparatively small amount of solvent remaining with the treated solids may also be substantially reduced. The compression mechanism is continuously operating while submerged, but the amount of pressure necessary for efficient separation of liquid from the solid material is exceptionally small because of the low head under which such device is operating. Because of the minimum pressure against which the material is discharged in the present device, the desired characteristics of the material remain unaffected during the process. It is furthermore apparent that the mechanical separator may be controlled independently of the other apparatus both as to speed and pressure, and it is located in an accessible position for any necessary repair or the like. While the liquid level in the return passage 32 of the conveyer has, as a matter of convenience, been shown and described as being the same as that in the chamber 10, this will obviously vary somewhat dependent upon various circumstances, such as the amount of solid material in the chamber 10 and the rate at which it is advanced therethrough against the countercurrently moving liquid. The level of liquid in the passage 32 will, however, normally be located somewhere between the level of the liquid outlet 26 and the lower lips of the ports 42, 43 during operation of the apparatus. The various parts of the apparatus may obviously be altered somewhat without departing from the scope of the invention; and although two final extraction and separation chests have been shown and described in the preferred embodiment, the device may be modified by eliminating one of these chests or chambers and its attendant parts, if desired. It is apparent that in both forms of the device herein illustrated and described, the solid material is removed from the initial extraction chamber and elevated through a column of solvent from which the solids are discharged by pressure beneath the upper extremity of the liquid column. Likewise, in both forms of apparatus the height of the column of liquid is utilized for maintaining the initial extraction chamber constantly filled with liquid.

Although the invention has been shown and described in conjunction with a particular type of initial extraction chamber and apparatus and a continuous conveyer of the drag link type, it may obviously be utilized with similar equipment in like manner and with equal success; and it should therefore be understood that it is not desired to limit this invention to the precise steps in the method or the exact details of construction of the apparatus or the application and mode of operation herein shown and described for various modifications within the scope of the claims may occur to persons skilled in the art.

It is claimed and desired to secure by Letters Patent:

1. In a device for treating solids with liquid, an upwardly extending conduit having an inlet for solids and an outlet for liquids at a lower portion thereof, an elevating conveyer in said conduit for moving solids upwardly from said solids inlet, a fluid supply connection opening into an upper portion of said conduit, a pair of chests disposed on opposite sides of said conduit at an upper portion thereof, each said chest being connected with the interior of said conduit

through a port for receiving solids and fluid from said conveyer, a restricted solids outlet opening through a wall of each said chest below the level of said ports, and fluid expressing compressed solids ejecting means in each said chest and below the level of said ports for ejecting compressed solids through said restricted solids outlet openings.

2. In a device for treatment of solids with liquids, an elevating conveyer confined within a conduit having a fluid outlet and solids inlet at its foot, said conduit having separate elevating and return passages, a fluid feed connection opening into an upper portion of said elevating passage, a chamber formed within said conduit and extending transversely thereof between said elevating and return passages at an upper portion thereof, a port connecting said chamber with the interior of said elevating passage for receiving solids and fluid therefrom, restricted openings in opposite ends of said chamber and penetrating opposite side walls of said conduit

below the level of said port, fluid expressing compressed solids ejecting means within said chamber and below the level of said port and constructed and arranged to simultaneously eject compressed solids in opposite directions through said restricted openings and a second port connecting an upper portion of said chamber with the interior of said return passage above the level of said first port for conducting fluids from said chamber into said return passage.

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