May 3, 1955

W. DEPMER ET AL

2,707,712

METHOD OF AND APPARATUS FOR THE EXTRACTION OF SOLID MATERIALS

Filed June 8, 1949

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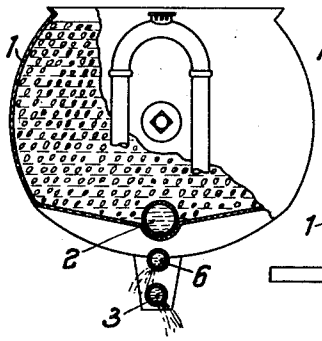
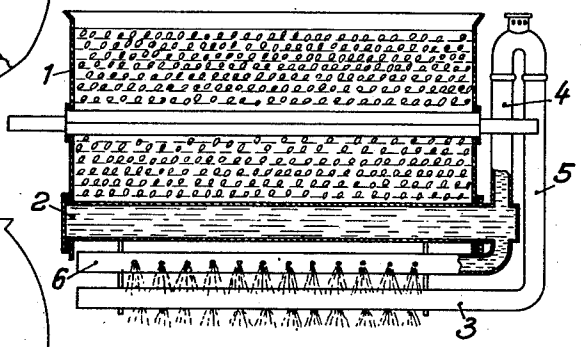


Fig. 2

Fig. 1



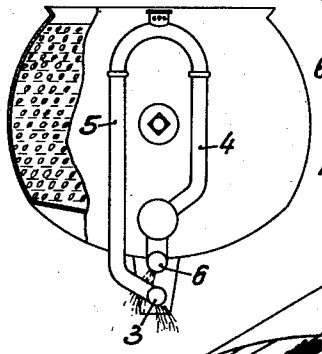


Fig. 3

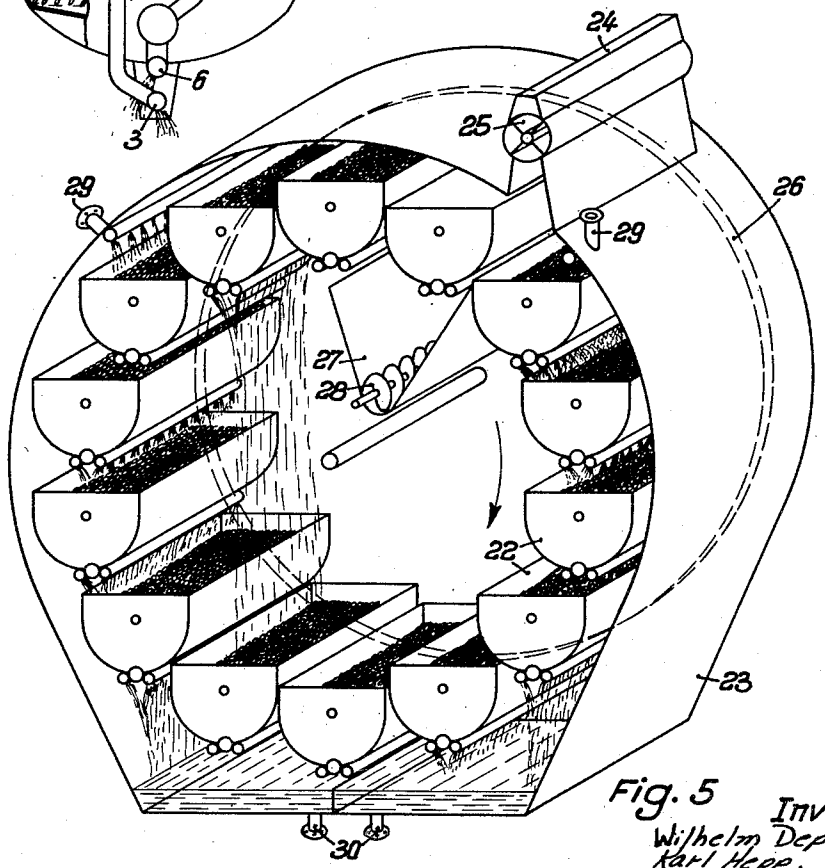


Fig. 5

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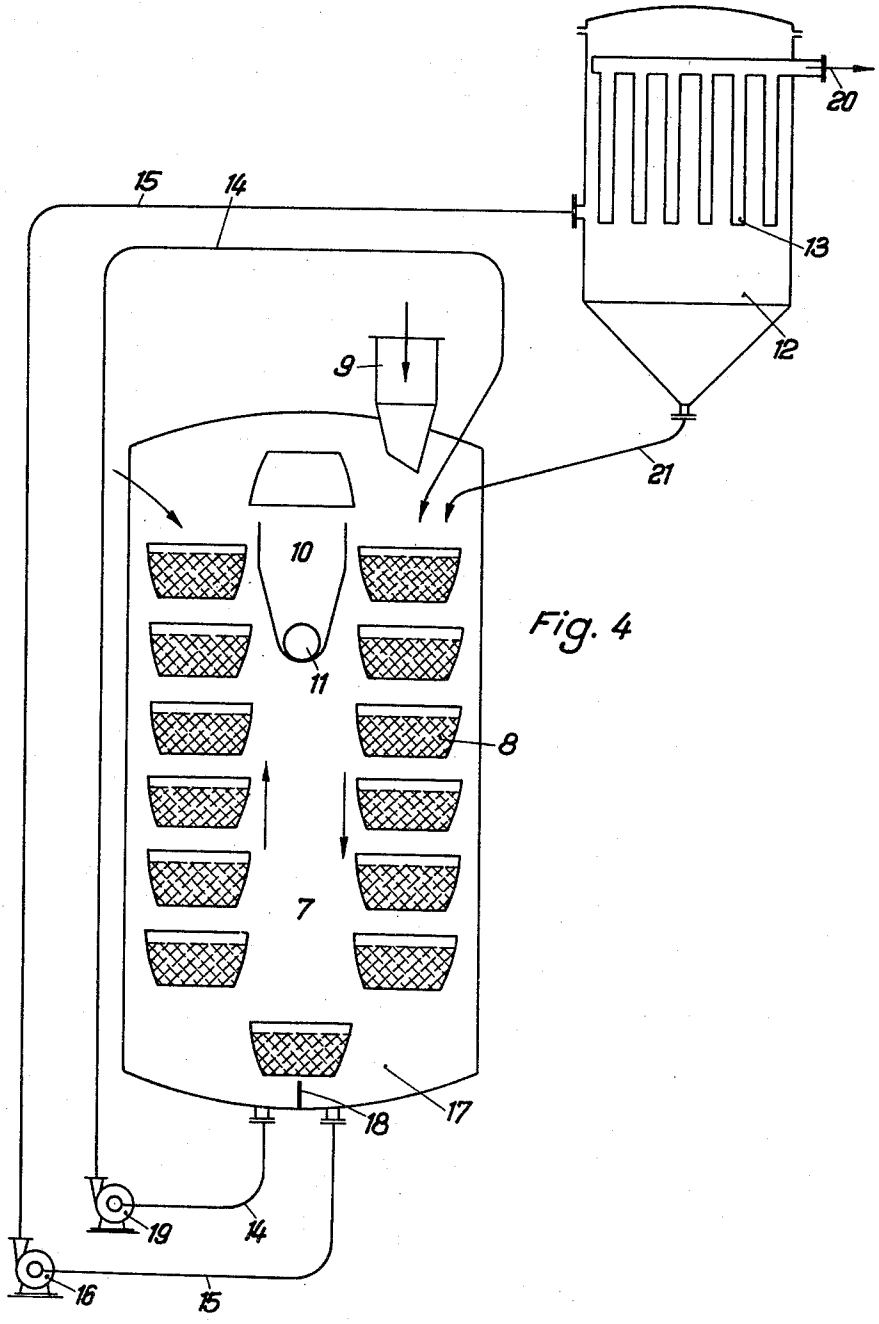


Fig. 4

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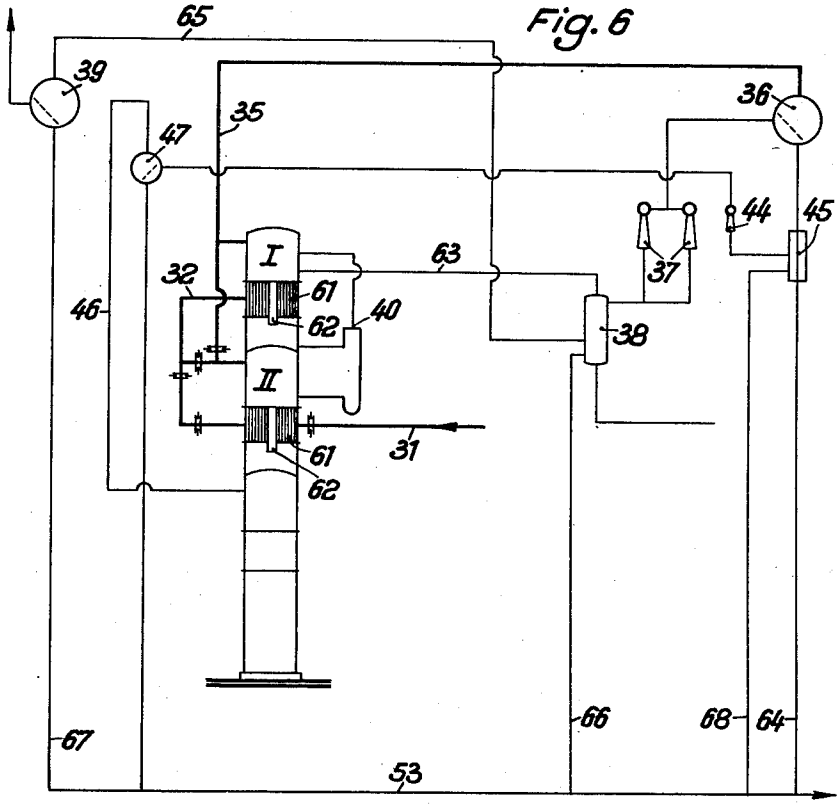
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Fig. 6



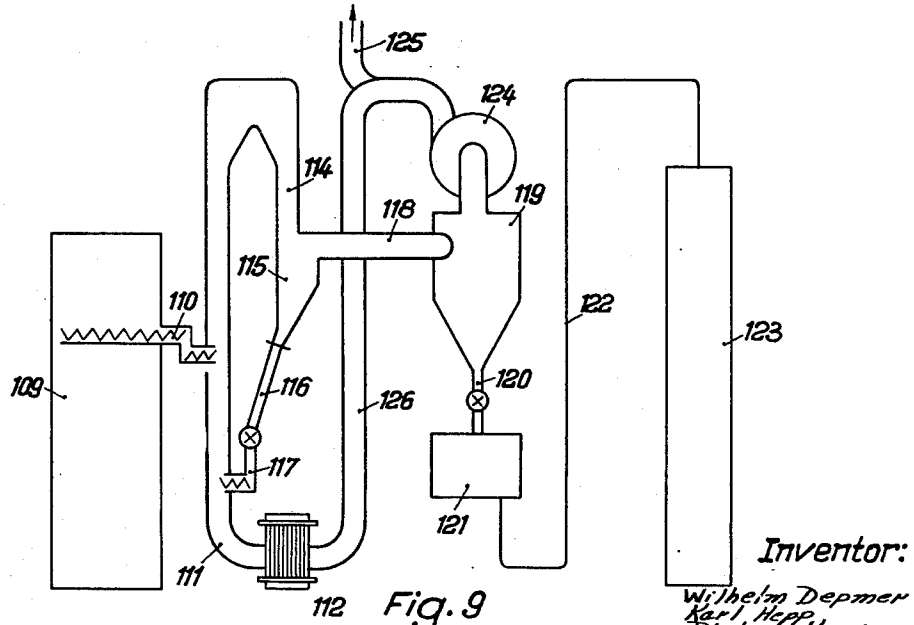


Fig. 9

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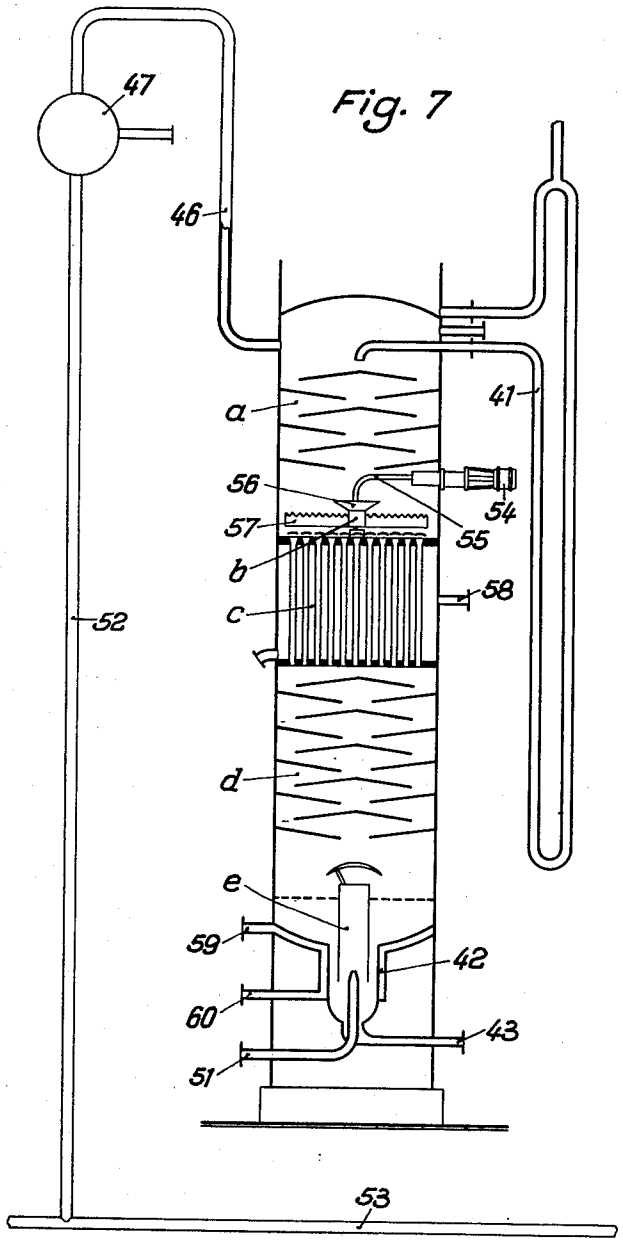
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Fig. 7



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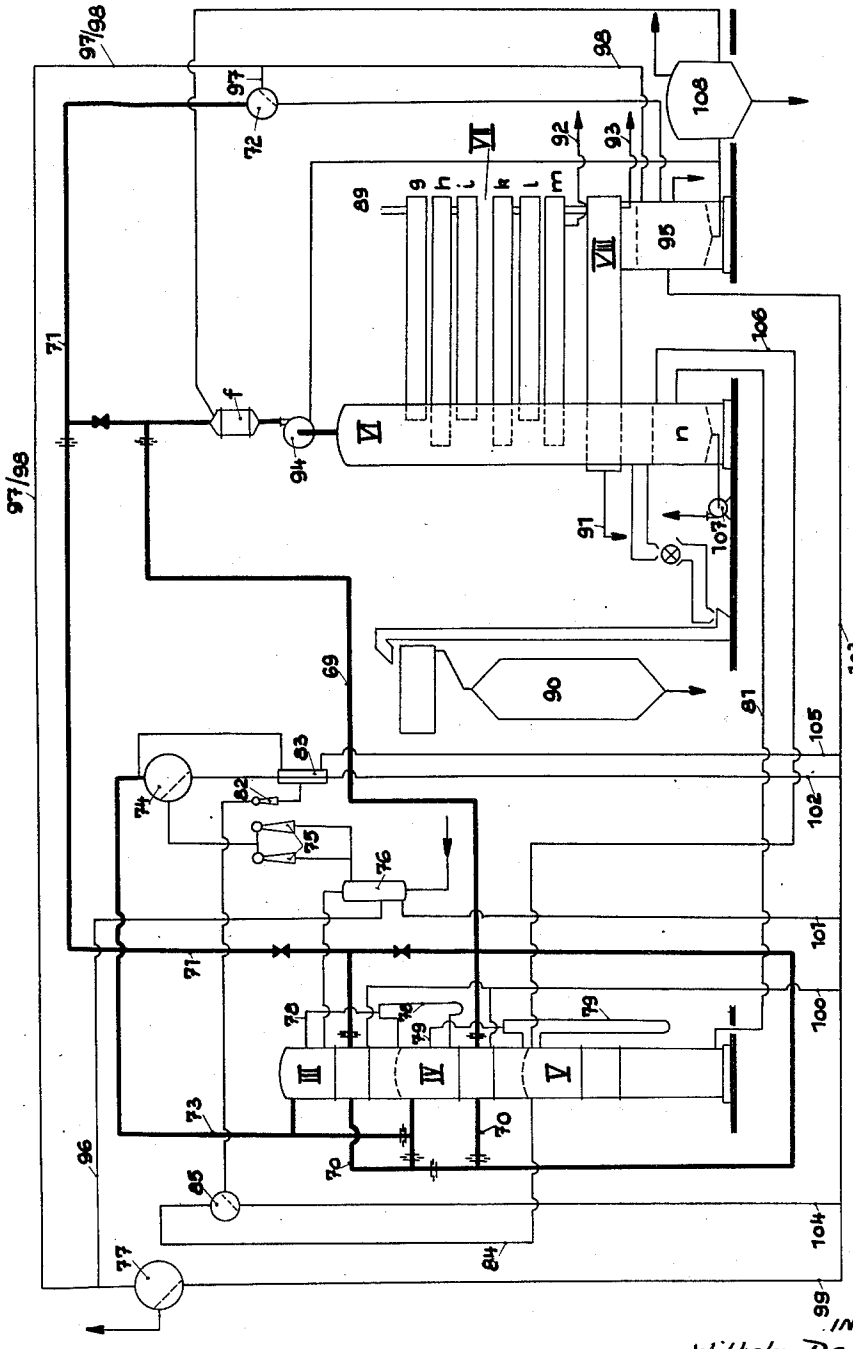


Fig. 8

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METHOD OF AND APPARATUS FOR THE EXTRACTION OF SOLID MATERIALS

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Application June 8, 1949, Serial No. 97,826

Claims priority, application Germany October 1, 1948

20 Claims. (Cl. 260—412.4)

This invention relates to a method of and apparatus for the extraction of solid materials. Continuous extraction of solid materials, especially the extraction of oil from vegetable and animal products, according to conventional processes is carried out in buckets with perforated bottoms being moved in an outwardly closed chamber by means of a paternoster system. The material to be treated enters the bucket at its highest position and is treated with solvent flowing concurrently with the downward moving buckets and countercurrently during their moving upward. The buckets are discharged after one full turn when they have again reached the top position. The solvent is supplied to the surface of the material in the buckets, penetrates the material, and then passes through the perforated bottom onto the surface of the material in the next lower bucket.

The disadvantage of this arrangement is that the velocity of solvent flow has to be controlled by the degree of crushing of the extraction material. In another known method of extraction, which forces the solvent to flow through the material from top to bottom, the material is in a solvent bath during the extraction process. The solvent can be introduced into the buckets from below the perforated bottom. It fills the bucket and leaves it through overflows in the uppermost rim of the bucket-walls. This arrangement, however, failed because the miscella was not subjected to the so-called self-filtration in the buckets or baskets and the fines were washed out of the extraction material. They clogged the pipe lines and got into the final miscella. With still another method the solvent is supplied to the surface of the material in each bucket, the openings in the bucket-bottoms through which the solvent passes out being of such dimensions only that less solvent flows out than is added above, the excess of solvent also flowing off through overflows in the upper rim of the bucket-walls. Part of the solvent thus leaves the extractor at the bottom, and part at the top. Thereby it is unavoidable that a part of the solvent which has just been introduced to the top of the bucket is swept away through the overflows without having come into closer contact with the material in the bucket. Another disadvantage of this arrangement is the fact that any change in the amount of solvent necessary for the extraction also requires an adjustment of the openings in the bucket-bottoms.

The present invention covers an extraction method that is more advantageous than the conventional methods, and also offers advantages in the removal of the extraction agent from the solution and the extracted materials, the better condition of the materials resulting from the extraction by this invention being another asset in the recovery of the extraction agents.

According to this invention, the extraction of solid materials, particularly animal and vegetable materials such as, for example, oil seeds is carried out by maintaining a liquid bath in a number of extraction containers successively passed by the solvent and drawing off the total solution from the bottom of the bucket or basket,

then conducting it through a special overflow arrangement onto the surface of the material in the next bucket. In the new process the velocity of the flow of solvent may be controlled independently of the crushing degree of the extraction material.

For the process according to this invention, there are used, for example, also buckets with perforated bottoms or a number of pipes arranged at the bottom of the buckets, the pipes being provided with openings and surrounded by wire netting. The solution flows from the material through the perforated bottoms or the pipes to one or more headers or the like. The headers are conducted within or without the buckets first upward and then downward terminating in a distributing main through which the solution passes on to the surface of the material in the next bucket. To render the syphon effect of the headers ineffective, they are at their uppermost point provided with one or more openings or interruptions. The invention thus provides for always maintaining a certain liquid level in the bucket, yet forcing the whole of the solution to flow through the material to be extracted before it can pass from one bucket to the next.

The distributing main may have several openings through which the solution is distributed over the next bucket. Part of the openings may also be provided in one or more pipes, through which the solution then passes from the lowest part of the bucket up to overflow level. In this case, however, these openings are of such dimensions as to allow only one part, for example one third to two thirds, of the liquid entering the bucket to flow off, while the remainder rises up to the highest point of the header and flows off through the distribution main provided at the end of the header. Owing to the fact that the extraction agent or the solution of the extracted materials in the extraction agent is conducted in each bucket through the material to be extracted, it is possible to obtain a solution poor in suspended matter and a particularly extensive extraction, especially so if the extraction according to this invention is coupled with a suitable purification of the solution obtained. This is done according to the invention in such a way that the filtration of the miscella or any other solutions obtained by extraction, the object of which being the removal of solid particles, the foots, suspended in the solution, is so conducted as to make the foots accumulate in one part of the solution. This part of the solution is returned to the extraction process in which it is freed of the solid particles by flowing in the extraction baskets through the extraction material as a constantly regenerating filter material.

The filter for the miscella or the like is, for example, arranged in a settling tank into which the miscella or the like is conducted from the extraction by means of, for example, a pump. Through the filter which is covered by the solution, purified miscella is constantly drawn off, while from the lower part of the settling tank another part of the solution in which, owing to the effect of the filter and the settling, foots have accumulated, is returned to the extraction process. In the well-known continuous extraction already mentioned, in which the material to be extracted is carried through the extraction in baskets, the said stream branched-off from the settling tank gets, for example, on the surface of a suitable basket filled with the extraction material. As a result of this method, the foots contained in the said branched-off stream separate in the material to be extracted, the latter thus operating as a filter and contributing essentially to the removal of the solid constituents from the solution.

It may in many cases be of advantage to arrange the settling and filter apparatus above the extraction apparatus, in order to allow the solution containing solid par-

ticles to flow back into the extraction without the aid of conveyors. Moreover, an improvement in the extraction is obtained by the invention, especially if the returned solution is added to the material to be extracted at the point it enters the extraction apparatus in continuous extraction.

The continuous extraction may, for example, be carried out in the well-known manner by moving buckets or baskets through a closed chamber by means of a paternoster system. The buckets may, however, also be moved on a circle, this being achieved by arranging the buckets movable in a wheel similar to a giant wheel as seen at village fairs and in its simple form consisting of a circular disc rotating around its center axis.

The result is a compendious construction without complicated devices effecting, notwithstanding this simplicity, a careful extraction with the material to be extracted abundantly accumulating in the solvent.

It is expedient to operate on the side of the concurrent flow with quantities of solvent larger than on the countercurrent side of the continuous extraction. For special purposes, detergents may be added for a further purification of the miscella, these being then together with the foots also returned to the extraction material in the extraction baskets. The extraction agent may be removed by well-known methods from the extraction solution and the residue of the extraction. However, the advantages gained by an extraction according to the present invention cause an essential improvement also of these stages of the process. In particular, it is possible to completely remove the extraction agent from the solution and to perform the distilling off of the solvent from the extract most preservatively, rapidly and at a low temperature, thereby avoiding the damaging and destroying of substances sensitive to higher temperature, such as for instance phosphatides, vitamins, or other active components and the like, which may be contained in the solution.

For this purpose, the temperature in all the sections of the column in which the extraction agent or a remnant of same is distilled off from the solution is kept, if possible, at a uniform height and expediently below the permissible maximum.

This is especially accomplished by the construction of a heating plant, for example in the form of a falling film evaporator provided with vertical heating tubes and arranged between two consecutive sections of a distilling column provided in the generally known way with appropriate installations, for example plates. In the said heating plant the temperature drop which the oil solution has suffered by the evaporation of solvent in the upper section of the column is quickly compensated in the film evaporator thus enabling the distillation to be carried out without any essential fluctuations in temperature, at the most advantageous temperature, in the shortest time, and with high efficiency.

Accordingly, the qualities of the obtained oils, fats, or the like, are particularly good.

To avoid local superheatings in the heating system of the film evaporator, the latter is advantageously heated with warm water, which is kept at constant temperature by, for example, introduction of steam, or the heating may be effected by steam or solvent vapors which are vented to a vacuum step and kept at constant temperature by a control valve.

After a certain, for example the major part, of the solvent has evaporated from the miscella in an evaporator of the vertical steam type system, or in two or more evaporators of the same or a similar type, the remaining solvent is, according to this invention, expelled in the distilling column. The temperature of the column is maintained at, for example, 50 to 75° C., preferably 70° C., the operations being carried out under a vacuum of about .1 to .25 atmospheres, for example .15 atmospheres. To ensure a sufficiently strict observance of these conditions, the column has an upper section in which the oil or the

like flows downward over incorporated plates countercurrently to the gas-vapor mixture. In the film evaporator adjacent to this section of the column the temperature of the oil is maintained at 70° C. by heating with, for example, warm water. The oil or the like is delivered by, for example, a rotating overflow distributor to the pipes of the evaporator in quantities as uniform as possible. Thence it enters another section of the column which may be constructed like the first but suitably is fitted with an agitator operating advantageously by the principle of the mammoth pump and being heated in its lower part and/or the conduit pipe of the mammoth pump with, for example, steam. By this arrangement, the rapid and preservative removal of the solvent is accomplished.

Furthermore, the process covered by this invention has the advantage of a very low steam consumption, which may be even more reduced by utilizing the evolving vapors for heating purposes, especially to heat the evaporators in which the solution is treated before it enters the column.

The removal of the extraction agent from the extracted material, too, can be further improved by this invention.

To utilize the vapors evolving during the distillation of the solvent from the extracted material for heating purposes, dust and other solid particles are removed from the vapors according to the invention by washing the solvent-bearing vapors with warm water having preferably a temperature that is above the dew-point of the vapors. In this case, the separation of the suspended solid substances from the vapors is especially advantageous. The recovery of the solvent from the condensate or the washing agent can then also be rendered more favorable.

By this invention it is, moreover, possible to utilize the heat contained in the vapors as by spraying them with hot water, they are so extensively freed of solid substances that it is now possible to employ them as heating medium. They may serve for heating the evaporators, or some of them, in which the extraction agent is distilled off from the solution, for example from the miscella. If, for instance, the distillation is performed in several evaporators through which the solution passes successively, the evaporator reached last by the solution may be heated with the vapors, and the preconnected evaporators may be heated with the vapors of the one or more afterconnected evaporators. In many cases it may, however, be advisable to accomplish the separation of the extraction agent from the extracted solid substances by intimately contacting them with a heat carrier in so short a time, for example a few seconds, that no undesirable changes can occur. Hot gases or vapors are then used according to the invention as heat carriers, the separation of the solvent being performed while the substances to be freed of solvent are carried in a gas stream. In special cases, the operations may be carried out in such a way that the materials are kept in bubbling agitation by the injected gases as, for example, according to the principle of the Winkler gas producer. The performance of the evaporation of the solvent during the conveyance of the materials by means of a gas or vapor stream is especially advantageous. The temperature of the vapor stream is preferentially maintained above the boiling point of the solvent to be evaporated at the respective operating conditions and the vapor stream is advantageously employed at a speed high enough to prevent a settling down of the solid substances in the evaporating chamber. The separation from the gases or vapors of the solid substances largely freed of the solvents may be effected in well-known arrangements, such as, for example, cyclones, multiclones, combined disintegrators and scrubbers, and the like. The gases or vapors evolving from the expelling of the solvent may, if necessary after an appropriate purification and reheating, be employed for the same purpose or for the

heating of evaporators, for the evaporation of the solvent from the oil-solvent mixtures resulting from the extraction, or the like. According to this invention, the process may be carried out under vacuum, especially so if the extracted solid materials are to be used as food. Operations may, however, also be performed under normal or higher pressure. For expelling the solvent contained in the solid materials it is of advantage to employ superheated vapors of the solvent used for the extraction.

If the particles of the solvent-bearing solid materials are not of a uniform size, the separation of the solvent may happen to take an irregular course. The solvent is expelled from solid materials of a fine particle size more quickly than from such of a coarser particle size. In order to extend the separation so far as to largely free the coarser particles, too, from the solvent, it may in many cases be suitable to largely expel the solvent from but one part of the solid materials passing through the expelling apparatus and to separate the other part still containing solvent from the first to treat it once more in the same or another apparatus.

To accomplish the expelling of the solvent as extensively as possible, it may be advisable to have the treatment according to this invention followed by the steaming and deodorizing operation.

The distilling off of the solvent and the deodorizing, or the latter alone or combined with a treatment of the solvent-bearing solid materials in the conventional worm driers may, according to this invention, also be performed under vacuum, advantageously by use of suitable arrangements for charging and discharging the vacuum apparatus.

Other and farther objects of the invention will be apparent from the following description taken in connection with the accompanying drawings which show diagrammatically and by way of example typical installations in which the principles of the invention may be applied.

Fig. 1 illustrates a vertical section of a bucket carrying the material to be extracted.

Figs. 2 and 3 show this bucket partly in side view and partly in section.

Fig. 4 is a diagrammatic illustration of an installation for the continuous extraction fitted with the buckets according to this invention.

Fig. 5 shows another type of this installation.

Fig. 6 illustrates a plant for the recovery of the solvent from extracts,

Fig. 7 is a vertical section through a distillation column used in this plant.

Fig. 8 illustrates a plant for the recovery of the solvent from extracted materials and from the solution obtained from the materials.

Fig. 9 shows another installation for the recovery of solvent from extracted oilseeds and from the miscella.

In Figs. 1 to 3, numeral 1 is the bucket carrying the material to be extracted. A pipe 2 or several pipes are arranged in the lower part of the bucket. The pipe 2 is perforated and surrounded by permeable wire nettings, allowing mainly only the solution but not the extraction material to flow off through the pipe. It terminates in a pipe system consisting of an ascending line 4, a descending line 5, and a horizontal perforated line 3. In the connection between 4 and 5 or in pipe 5, an opening or an interruption is provided. Besides the pipelines 3, 4, and 5, another line 6 may be provided, also having several outlet openings and being connected with the pipe 2. The number and the cross-sections of the openings in pipe 6 are so dimensioned as to allow the passage of only part of the solution flowing through the pipe of the pipes 2, while a remaining part must travel through the pipes 4 and 5 to the opening in pipe 3. After completion of the extraction, the liquid can completely flow out of the bucket 1 through the openings in pipe 6.

By the pipe system 2, 4, 5, 3, and, if required, 6, the maintenance of a certain easily adjustable liquid level in each container is accomplished, on the one hand. On the other hand, the total quantity of solvent introduced from above into the receptacles is actually moved through the contents of the receptacles and uniformly delivered into the next container through the outlet openings in pipes 3 or 6.

In Fig. 4, 7 is an extraction chamber in which extraction baskets 8 are moving in the way of a paternoster. The feeding device 9 charges the material to be extracted into the baskets which move downward from the feeding point to the lowest point of the extraction chamber and then upward again to above the discharging device 10. There the material to be extracted is tipped out of the baskets into the device of conventional type 11 through which it leaves the extractor. 12 is a closed settling tank with the filter 13 in its upper part.

The extraction of crushed oil seeds is, for example, carried out in such a manner that an oil solution is introduced through the pipe-line 14 into the uppermost of the downward moving baskets charged with the material to be extracted. The oil solution is separately collected in the lower part of the extraction chamber and conducted through a pipe-line 15 by means of the pump 16 into the settling tank 12. Solvent is introduced into the uppermost of the baskets moving upward. The solvent flows successively through the material in the baskets, and the oil solution resulting therefrom is collected separately in the extraction chamber. To avoid a mixing of this solution with the richer one collected on the other side of the extraction chamber, the settling tank 17 of the extraction chamber is divided by, for example, a partition wall 18. The oil solution obtained on the left side of the extraction chamber is conducted through the pipe-line 14 by means of the pump 19 onto the material in the uppermost basket on the right side.

From the settling tank 12, part of the miscella is drawn off through the filter and line 20 in a purified condition. A second stream of the miscella is drawn off at the bottom of the settling tank 12 through line 21 and returned into the extraction chamber being expediently conducted onto the uppermost of the downward moving baskets. Particularly suitable for this method are basket type constructions provided with arrangements for the maintenance of a liquid level which renders it possible to operate on the concurrent flow side with quantities of solvent larger than those on the counter-current-flow side. By this measure the effect of the extraction can be farther improved.

According to Fig. 5, a number of extraction baskets 22 may be arranged in an air tight closed casing 23. 24 is the feeding device into which the material is fed through a feed hopper 25. From the feeding device the material falls into the containers 22 passing by underneath the feeder. The containers or baskets are arranged in a wheel 26. 27 is the discharging device which can be discharged by the screw conveyor 28. 29 are the supply lines for the solvent, 30 the outlets of the extraction agent from the casing 23. When the containers in their orbit have arrived over the discharge arrangement, the extraction is completed. They can then be discharged by tipping. The arrangement illustrated in Fig. 5 for moving the baskets on a circle during the continuous extraction has in operation proved so reliable and advantageous that it may also be employed with advantage when the overflowing of the solution from one receptacle into the other is performed by other known arrangements.

The top section *a* of the column according to Fig. 7 is equipped with built-in plates. The oil solution is delivered to, for example, the top plate through line 41 and flows downward over the plates in counter-current to steam entering the column below at 51. Through line 46, a mixture of solvent vapor and steam is withdrawn from the column and condensed in the condenser 47. The condensate is conveyed through the downpipe

52 into a header 53 which terminates, for example, in a solvent-water separator.

Below the top section *a* of the column there is the distributor *b* which has two or more arms and can be rotated in known way, for example by means of a motor 54 with a flexible shaft 55. The distributor may, for example, be driven also by a steam jet apparatus or by the treated miscella itself, employing therefore, for example, a bladed wheel or the like.

The oil solution drops from the section *a* into a receiving hopper 56 provided at the distributor *b*, from where it is delivered into the trough-shaped arms 57 of the distributor. The troughs forming the arms of the distributor have notched rims. Through the notches or teeth of the trough-rims, the oil solution flows over in a very uniform distribution and is, therefore, also very evenly distributed over the pipes of the film evaporator *c* into which the oil solution now advances. In the film evaporator, over the heating pipes caps are put which in their turn warrant, even within each heating pipe, a uniform distribution of the oil solution distributed by the distributing arrangement *b*. The film evaporator *c* is advantageously heated with warm water kept at a constant temperature by steam introduced at 58, or with vapor or solvent vapors which are vented to a vacuum step and can be kept at constant temperature by a control valve. Adjacent to the film evaporator is the section *d* which is also equipped with well-known installations as, for example, plates. In this section, the miscella or the like is strongly agitated by means of, for example, a device *e* formed in the way of a mammoth pump and receiving driving steam through line 51. This arrangement is advantageously provided with a heating system 42. 59 is the heating-steam supply line, 60 the condensate outlet line. The oil freed of solvent leaves the column through the line 43.

The oil solution, which advantageously has before been freed of part, for example the main part, of the solvent, is in the column according to the invention practically kept at constant temperature. The heat withdrawn from it by the evaporation of the solvent is constantly compensated for by the film evaporator *c* and the heating in the agitator or stirrer *e*, so that a favorable temperature in all the sections of the column can be maintained with certainty. The evaporation evolving from thin layers, the vacuum can undisturbedly exert its effect in the column. Superheating of the oil is impossible, because no heated parts are employed besides the film evaporator and the agitator, and because a rise in the temperature of the oil or the like above the intended maximum is with certainty prevented by the way the film evaporator is heated and by the strong agitation of the liquid in the agitator.

The final evaporation of the solvent is thus accomplished rapidly and in a preservative way.

Should part of the solvent have previously been evaporated in a pre-connected apparatus, the performance of this evaporation under similarly favorable conditions is a prerequisite to the preservative treatment of the oil or the like in the column. It is, therefore, advantageous in the process according to the invention to effect the preceding partial evaporation in two or more evaporators operated in a well-known way under vacuum. It may be expedient to combine the evaporators through which the oil solution passes successively, for example evaporators I and II, and the column Fig. 6 to one towerlike arrangement. Both evaporators have a high vapor chamber for the purpose of dealing with an excessive formation of froth. They are equipped with vertical heating systems 61 and overflow pipes 62. The evaporator II may advantageously be subdivided into three or more evaporating chambers arranged one after the other with regard to the passage of the oil solution.

The oil solution is advantageously supplied to the evaporator I by a preheater 38 through the line 63. Through the conduit 40 it may, for example, pass continuously from the evaporator I via an adjustable overflow into the evaporator II.

To ensure a preservative treatment of the oil solution in the evaporators equal to that in the column, the said evaporators are operated under vacuum and at temperatures possibly not exceeding those prevailing in the column. The evaporator II is, for example, heated with steam of 100° C. supplied by the pipe-line 31. At an absolute pressure of .4 kilograms per square meter, this would correspond to a vapor temperature of 70° C. of the vapors evolved from the solution to be treated. These vapors may be employed for the heating of the evaporator I, to the heating system of which they are supplied through the line 32. At the same absolute pressure of .4 kilograms per square meter, the vapors evolved in the evaporator I then have a temperature of, for example, 50° C. They pass through the line 35 into the condenser 36, the resulting condensate passing through the downpipe 64 also to, for example, the header 53.

The venting of the condenser 36 is effected by means of the steam jet apparatus 37. The exhaust steam of the said steam jet apparatus may, for example, serve for the heating of the pre-heater 38. It may, however, also be employed for heating the evaporator II or both evaporators or the like.

For the venting of the pre-heater 38 serves the condenser 39, which is connected with the pre-heater by the line 65. The vacuum in the condenser 47 is maintained by the steam jet apparatus 44. From the pre-heater 38 and the condenser 39 the condensates are conveyed to the header 53 through the downpipes 66 and 67.

The exhaust steam of the steam jet apparatus 44 is condensed in the condenser 45 which may be operated with, for example, the condensate of the condenser 36 as a cooling medium and the condensate of which passes through the downpipe 68 into, for example, the header 53.

It is, however, also possible to employ the exhaust steam of the steam jet apparatus 44 for heating the evaporator I or II.

For regulating the operations of the evaporators, the provision of connecting lines may often be advisable enabling the transfer of vapors from the heating system of the evaporator II to that of the evaporator I and/or of vapors from the vapor chamber of the evaporator II to that of the evaporator I or immediately to the condenser 36.

The distilling off of the solvent from the miscella in the plant illustrated in Fig. 8, is effected in the evaporators III and IV and in the column V successively passed through by the oil solution. The pipe-lines 78 and 79 are provided for this purpose. The column and the evaporators are mounted one upon another in a towerlike arrangement and may be of conventional design.

According to this example, two evaporators with a vertical heating pipe system and an overflow pipe as illustrated in Figs. 6 and 7 are used. The vapor chamber of the two evaporators is designed very high, e. g., 1.5 to 2 meters, with a view to dealing with the excessive formation of froth. The second evaporator is expediently subdivided into three or more evaporating chambers connected in series through which the oil solution is conducted successively.

The distilling of the solvent from the meal of the extracted oil seed is effected in the steam-jacketed screw conveyors *g, h, i, k, l, m* of the plant VII and in the steaming drum VIII. The meal enters the conveyor *g* at 89. It is conveyed to the other end of the conveyor where it falls into the next lower conveyor *h*. After having passed through this conveyor and the following ones, the last remnant of solvent is removed from the meal in the steaming drum by the use of direct steam. The meal is conveyed by well-known means through the steaming drum and then conducted to the meal-cooling plant 90. The drum is fitted with jacket-heating and

heating coils. From the steam-jacketed conveyors the solvent vapors escape into the tower VI. The vapors of the steaming drum are first conducted into one of the conveyors, for example *m*, through which they then also escape into the tower VI. The condensates resulting in the plant are removed at **91**, **92**, and **93**.

From the tower VI, the vapors consisting mainly of solvent vapors and steam are by means of the blowers **94** delivered to the purifier *f* when they are sprayed with warm water having a temperature above the dew point of the vapors. If, for example, the dew point is 90° C., water of about 100° C. is used. By the spraying, dust and other solid substances are removed from the vapors. These vapors may forthwith be supplied, for example through line 71, to the condenser 72 and the condensate resulting therein separated, for example in a separator **95**, into benzine and water.

The purity of the vapors obtained in *f* is now so good as to allow the use of these vapors also for heating purposes. The vapors, or part of them, are, for example, sent through the lines **69** into the heating system of the evaporator IV where the greater part of the steam contained in the vapors condenses. The not condensed remainder of the vapors streams through line **70** on to the heating system of the evaporator III where besides the steam also part of the solvent vapors condenses. The remaining vapors pass on through line **71** to the condenser **72**, into which also any excess of vapors may be conveyed immediately from the purifier *f*. The vapors in the units VI, VII, and VIII, in the heating systems of the evaporators and in the condenser **72** may be kept approximately under normal pressure. Their initial temperature is, for example, about 90° C. and their final temperature about 70 to 75° C. The absolute pressure under which the solvent is expelled from the oil solution in the evaporators III and IV is, for example, .4 kilogram per square cm. The pertinent temperatures of evaporation are then in III about 50° C. and in IV about 70° C.

If the vapors are supplied to the condenser **72** immediately from the purifier *f*, the evaporator IV may, for example, be heated with steam and the evaporator III with the vapors of the evaporator IV, or vice versa.

If the evaporators III and IV are heated with the vapors resulting from the meal distillation, the solvent vapors evolved from the oil solution in the evaporators pass through the lines **73** to the condenser **74**. The latter is vented by means of the steam jet apparatus **75**. The exhaust steam of the jet apparatus may be utilized advantageously, for example, for the preheating of the miscella in the heat exchanger **76** or in any other way. For venting this heat exchanger, the condenser **77** is provided, which is connected with the condensing chamber of the heat exchanger **76** through a line **96**. The condenser **77** may, if required, also serve for the venting of the condenser **72**. In this case, suitable venting lines **97** and, if required, **98** are provided leading from the solvent-water separator **95** to the condenser **77**. Downpipes **99**, **100**, **101**, and **102** convey the condensates from the condenser **77**, the heating system of the evaporator III, the heat exchanger **76**, and the condenser **74** to a common header **103** terminating in the solvent-water separator **95**.

The exhaust steam of the jet apparatus **75** may, if required, likewise be employed for the heating of the evaporator IV or III, or both.

The mixture of solvent vapor and steam resulting in column V may be conducted through the line **84** to the condenser **85** which is vented by means of, for example, the steam jet apparatus **82**. For the condensation of the vapors delivered by this steam jet apparatus there serves the surface condenser **83** which is advantageously operated with the condensate resultant from **74**. The condensates from **83** and **84** are advantageously conveyed through the downpipes **104** and **105** also to header **103** and from there into the solvent-water separator **95**.

From the lower part of column V, the oil freed of solvent flows through line **81** into the oil receiver *n* which may be vented through the line **106**. Pump **107** serves for the discharge of the oil from the receiver *n*.

The water from the separator **95** and the purifier *f* is conducted to an evaporator **108** where the solvent entrained in the water is evaporated. The result is, on the one hand, a mixture of solvent vapor and steam which is handled in the conventional manner, and, on the other hand, hot water. According to the invention, part of the water is now recycled for the operation of the purifier *f* whereby the expenses for the operation of the latter are substantially reduced.

In the apparatus for drying the extracted oil seed meal, the meal coming from the extraction **109** is by means of the feeding device **110** fed to the drier **111** which may consist of a system of ascending and descending ducts. Solvent vapors, having been brought up to the required drying temperature in the heater **112**, are used as a drying agent. The material entering through the feeder **110** is by the solvent vapors taken upwards in the drier and then carried along with the stream of solvent vapors into the descending part **114** of the drier and further into the separator **115**. There the specifically heavier, still solvent-bearing, parts of the material are separated and through the pipe **116** and the feeder **117** returned to the drier. From the separator **115**, the gases carrying the already dried part of the material, stream through the duct **118** into the separator **119** which in this case is built as a cyclone. The solid substances separated in the cyclone fall through the pipe **120** into the apparatus **121** where the evaporation of the last traces of solvent is effected by steam or the like. After the evaporation, the meal is, for example through the pipeline **122**, conveyed to the cooler **123**.

The solvent vapors are sucked off the cyclone **119** by the blower or fan **124** and, if necessary, freed of any remnant of meal particles still contained therein in a fine purification plant (not shown). Any excess of solvent vapors is carried off through the line **125**, the other part returning through the line **126** to the heater **112** and into the drying process.

What we claim is:

1. A process for the continuous solvent extraction of solid material containing extractable material which comprises providing a series of moving confined individual batches of such solid material in an enclosed extraction space, said individual batches of solid material being maintained at rest in moving individual containers provided with perforated bottoms, leading a solvent through said series of batches to produce an extract containing extractable material from said solid material dissolved therein, the solvent being supplied to the individual batches from above and being withdrawn from the individual batches only from the lower portions of the individual batches through the perforated bottoms of said containers and then being supplied to the next batch in such series from above, maintaining said individual batches in separate confined baths of predetermined height in said containers of the solvent supplied to the individual batches, separating from the extract at least a portion of any of the solid material contained therein, removing the extract from the extraction space, removing the solid material which has been subjected to the solvent extraction from said extraction space and distilling solvent off from said extract and said solid material after their removal from the extraction space.

2. A process for the continuous solvent extraction of oils and fats from solid material containing the same which comprises providing a series of moving confined individual batches of such solid material in an enclosed extraction space, said individual batches of solid material being maintained at rest in moving individual containers provided with perforated bottoms, leading a solvent through said series of batches to produce an extract containing oils and fats from said solid material dissolved

therein, the solvent being supplied to the individual batches from above and being withdrawn from the individual batches only from the lower portions of the individual batches through the perforated bottoms of said containers and then being supplied to the next batch in such series from above, maintaining said individual batches in separate confined baths of predetermined height in said containers of the solvent supplied to the individual batches, separating from the extract at least a portion of any of the solid material contained therein, removing the extract from the extraction space, removing the solid material which has been subjected to the solvent extraction from said extraction space and distilling solvent off from said extract and said solid material after their removal from the extraction space.

3. A process in accordance with claim 2 wherein the solvent is distilled off from said solid material after its removal from the extraction space while such solid material is suspended in a stream of a gaseous medium.

4. A process in accordance with claim 2 wherein the solvent is distilled off from said solid material after its removal from the extraction space while such solid material is suspended in a stream of a vaporized solvent.

5. A process in accordance with claim 2 wherein the solvent is distilled off from said solid material under a superatmospheric pressure after its removal from the extraction space while such solid material is suspended in a stream of a gaseous medium.

6. A process in accordance with claim 2, in which the solvent vapors distilled off from said solid material after its removal from the extraction space are blown through a space in which they are countercurrently scrubbed with hot water at a temperature higher than the dew point of said vapors and the resulting scrubbed vapors are then employed for heating purposes in the process.

7. A process for the continuous solvent extraction of oils and fats from solid material containing the same which comprises providing a series of moving confined individual batches of such solid material in an enclosed extraction space, said individual batches of solid material being maintained at rest in moving individual containers provided with perforated bottoms, leading a solvent through said series of batches to produce an extract containing oils and fats from said solid material dissolved therein and fines of the solid material, the solvent being supplied to the individual batches from above and being withdrawn from the individual batches only from the lower portions of the individual batches through the perforated bottoms of said containers and then being supplied to the next batch in such series from above, maintaining said individual batches in separate confined baths of predetermined height in said containers of the solvent supplied to the individual batches, removing extract from said extraction space, filtering a portion of the extract to remove fines therefrom, enriching the fines in another portion of the extract, recycling the latter portion to the extraction space and returning it to at least one of said batches of solid material in said series from above and distilling solvent off from said filtered extract and solid material after removal from the extraction space.

8. A process in accordance with claim 7 in which the extract enriched with fines is returned to a batch in the beginning of said series of batches.

9. A process for the continuous solvent extraction of oils and fats from solid material containing the same which comprises providing a series of moving confined individual batches of such solid material in an enclosed extraction space, said individual batches of solid material being maintained at rest in moving individual containers provided with perforated bottoms, leading a solvent through said series of batches to produce an extract containing oils and fats from said solid material dissolved therein and fines of the solid material, the solvent being supplied to the individual batches from above and being withdrawn from the individual batches only from the lower portions of the individual batches through the perforated bottoms of said containers and then being supplied to the next batch in such series from above, maintaining said individual batches in separate confined baths of predetermined height in said containers of the solvent supplied to the individual batches, removing the solid material which has been subjected to the extraction from the extraction space, removing extract from said extraction space, permitting fines to settle in a body of said extract to provide a lower portion enriched with fines, withdrawing and filtering a portion of the extract from the upper portion of said body, withdrawing extract enriched with fines from said lower portion, recycling it to the extraction space and returning it to at least one of said batches of solid material in said series from above and distilling solvent off from said filtered extract and solid material after removal from the extraction space.

10. An extraction apparatus comprising a series of buckets, means for moving said buckets in a vertical cycle in an extraction chamber, means for charging said buckets with material to be extracted, means for discharging the solid material after its extraction from said buckets, means for introducing solvent into said buckets from above, said buckets having perforated bottoms through which the solvent introduced into the buckets and material extracted thereby which is dissolved therein may leave such buckets, means associated with each of said buckets for receiving solvent leaving such buckets through its perforated bottom and for maintaining a solvent bath of predetermined height within each bucket while preventing overflow of solvent from its upper portion.

11. An extraction apparatus comprising a series of buckets, means for moving said buckets in a vertical cycle in an extraction chamber, means for charging said buckets with material to be extracted, means for discharging the solid material after its extraction from said buckets, means for introducing solvent into said buckets from above, said buckets having perforated bottoms through which the solvent introduced into the buckets and material extracted thereby which is dissolved therein may leave such buckets, conduit means associated with each of said buckets for receiving solvent leaving such buckets through its perforated bottom, said conduit means rising to an overflow above the level of the perforated bottom of such bucket to maintain a solvent bath of predetermined level therein.

12. An apparatus in accordance with claim 11 comprising in addition conduit means associated with the overflow for carrying solvent from the overflow downwardly towards the top of a lower bucket in the series during at least one portion of the cycle.

13. An apparatus in accordance with claim 11 comprising in addition conduit means associated with the overflow for carrying solvent from the overflow downwardly to a horizontal perforated pipe arranged beneath the bottom of the bucket associated with such overflow.

14. An apparatus in accordance with claim 11 comprising in addition a settling tank outside of said extraction chamber, means for supplying the solution of the extracted material in the solvent leaving the buckets to said settling tank, filter means in said settling tank through which such solution may be withdrawn, conduit means in the lower portion of said tank for withdrawing solution therefrom and any fines contained therein and returning such solution to a bucket in the extraction chamber.

15. An apparatus in accordance with claim 11 comprising in addition at least one evaporator and a distilling column disposed in series, and means for filtering and supplying the solution of extracted materials in the solvent leaving the buckets to said evaporator and distilling column series.

16. An apparatus in accordance with claim 11 comprising in addition at least one evaporator and a distilling column disposed in series, means for filtering and supplying the solution of extracted material in the solvent leaving

the buckets to said evaporator and distilling column series, and a film evaporator arranged within said distilling column between two sections thereof through which the solution passes in passing from one section to the other.

17. An apparatus in accordance with claim 11 comprising in addition at least one evaporator, means for filtering and supplying the solution of extracted materials in the solvent leaving the buckets to said evaporator, an upright distilling column having two vertically disposed sections, a film evaporator arranged between and connecting such sections, means for supplying solution from such evaporator to the upper portion of said distilling column and an agitator arranged in the lower portion of said column.

18. An apparatus in accordance with claim 11 comprising in addition at least one evaporator, means for filtering and supplying the solution of extracted material in the solvent leaving the buckets to said evaporator, an upright distilling column having two vertically disposed sections, a film evaporator arranged between and connecting such sections, means for supplying solution from such evaporator to the upper portion of said distilling column, means for introducing steam into the lower portion of the distilling column and an agitator arranged in the lower portion of said column.

19. An extraction apparatus comprising a series of buckets, means for moving said buckets in a vertical cycle in an extraction chamber, means for charging said buckets with material to be extracted, means for discharging the solid material after its extraction from said buckets, means for introducing solvent into said buckets from above, said buckets having perforated bottoms through which the solvent introduced into the buckets and material extracted thereby which is dissolved therein may leave such buckets, a compartment associated with each bucket below its perforated bottom to receive solvent leaving such bucket through its perforated bottom, conduit means connected with such compartment rising to an overflow above the level of the perforated bottom of such bucket to maintain a solvent bath of predetermined level therein, conduit means for carrying solvent from the overflow downwardly to a horizontal perforated pipe arranged beneath the bottom of the bucket associated with such overflow and outlet means associated with such compartment permitting discharge of only a portion of the solvent received by such compartment through the perforated bottom of the bucket associated therewith, whereby the remaining portion of such solvent received by the compartment is caused to flow to said overflow.

20. A process for the continuous solvent extraction of solid material containing extractable material which comprises supplying solid material to be extracted to an enclosed extraction space, moving said solid material in said enclosed extraction space in the form of a series of confined individual batches in a vertical cycle which in its first portion moves downwardly and in its remaining portion moves upwardly, said individual batches of solid material being maintained at rest in moving individual containers provided with perforated bottoms, supplying solvent to the solid material in such cycle from above to a batch near the beginning of said cycle and leading such solvent successively through the series of batches in said cycle which are moving downwardly to produce an extract containing extractable material from said solid material, separately supplying solvent to the solid material in such cycle from above to a batch near the end of said cycle and leading such solvent successively through the series of batches in said cycle to produce an extract containing extractable material from said solid material, the solvent being supplied to the individual batches from above and being withdrawn only from the lower portions of the individual batches through the perforated bottoms of said container and then being supplied to the next batch in the series below the batch from which it is withdrawn from above, maintaining said individual batches in separate confined baths of predetermined height in said containers of the solvent supplied to the individual batches, removing the extract from the extraction space, removing the solid material which has been subjected to the solvent extraction from the extraction space and recovering the solvent contained in the extract and the solid material after their removal from the extraction space.

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