My invention relates to the manufacture of pulp, and especially to the production of pulp by cooking or chemical digestion of wood or other fibrous material. The invention is more particularly concerned with the removal from the cooked or digested fiber pulp stock of various chemicals or substances that are present therein after the cooking or digestion process,—whether reagents employed for the purposes of digestion or cooking, or products liberated or produced in that operation. Such removal frees the stock of substances whose presence in the ultimate paper or fiber board might be undesirable, and permits the recovery of the chemicals or substances in question. My invention involves both a novel removal process and a novel system and apparatus for the purpose. The invention is especially useful in connection with the manufacture of fiber pulp for paper, fiber board, or the like.

It is an object of my invention to provide a simple and efficient process for thoroughly removing or extracting from wood or fiber pulp stock the chemicals (such as hereinafter indicated) that are present therein at the termination of the digesting or cooking process, so that such chemicals may be more economically reclaimed or recovered for reuse, or for any use of which they are susceptible. I also aim to obviate the loss or waste of appreciable quantities of chemicals or of pulp stock as an incident of the extraction process, so that large and rapid manufacturing operations may be carried on at minimum expense, and pollution of streams or other natural drains may be avoided. By treating the pulp stock throughout the extraction process at a higher consistency (i.e., with a smaller liquid content relative to fiber) than heretofore, in accordance with my invention, the bulk of material to be handled is greatly reduced, and it becomes practicable to continue extractive treatment after the chemical content has become relatively low.

The treatment of the pulp stock at high consistency avoids extreme attenuation of the stock with liquid as an incident of the extraction, and the handling of large quantities of liquid in this process. My invention also permits of avoiding excessive dilution of chemicals prior to recovery, as well as the enormous consumption of fresh extracting liquid (water) heretofore necessary. The economy in the use of liquid also makes it more practicable to use liquids other than water, if desired, since such liquid(s) may themselves be recovered in the chemical recovery plant, and need not be completely purified to be capable of reuse for extraction purposes. Moreover, the process can be carried out with the pulp and its components substantially as hot as when received from the digester. My invention affords the further advantage that the extraction can be carried out as a continuous process, and under pressure, if desired.

In the cooking or digestion of wood and other fibrous materials into pulp for the manufacture of paper, fiber board, and the like, the wood or other fibrous material is usually cut or crushed into chips or pieces so small that the pieces of the material will be rapidly and thoroughly acted upon in the digesting or cooking process. This process, according to present methods, consists, briefly, in mixing the chips or pieces with a solution of caustic soda or other digesting chemical (if such a chemical is used to assist or augment the cooking effect) in a cooking vessel or tank known as a “digester,” closing this vessel, and then cooking the mass therein by passing steam under pressure into the digester. The particular pressure and temperature of the steam and the period of cooking depend on the nature of the wood or other fibrous raw material being treated, the character of the pulp to be produced, and the particular kind or type of paper, fiber board, or the like that is to be made. When the chips or pieces of fibrous material have been cooked in the solution of soda or other digesting chemical to the extent desired, the contents of the digester are discharged, and are then treated to remove from the digested or cooked fiber stock (as completely as possible) all trace of the digestion liquor, comprising the caustic soda or other digesting chemicals, or such substances as may have been liberated or produced in the digesting or cooking process.

According to the most generally used extraction processes, this is accomplished batch-wise, by discharging each batch of pulp from the digester into a tank or vessel (open or closed) having a filter bottom, either at digester consistency or attenuated with added liquid; allowing the strong liquor to drain out of the stock by gravity, or forcing it out by pressure applied above the stock; and then successively washing the stock with weak liquor and with water, which are successively introduced into the filter tank above the stock and allowed to run through the latter by gravity, or are forced through under pressure. The weak liquor used for such washing of the stock is the water that has been used to wash a previous batch, which, of course, carries some of the chemicals of the pulp in solution. The stronger liquor drained from the filter tank
is delivered to an evaporating plant or other system for the recovery or reclamation of the chemicals in it. The great amount of water required in these processes reduces the strength of the liquor in such a manner that the last phases of the washing to such weakness that it would not pay to attempt to recover the chemical therefrom, so that a large part of such weaker liquor is customarily run to waste. Also, large quantities of the finely comminuted fiber stock are lost in the washing operations, as well as in the running of the water.

In another extraction process, the pulp from one or more digesters is accumulated in a reservoir, and is thence run continuously over a series of rotary vacuum filters, on each of which the pulp spreads out in a rather thin mat, which is continuously stripped off. Thus a certain amount of liquor is extracted from the pulp at each filter, and the amount of chemical(s) in the pulp is reduced. In order that a satisfactory pulp mat may be formed on the face of each filter, great dilution or attenuation of the digester pulp is necessary before its introduction to the first filter, and likewise great dilution or reattenuation of the liquor stripped from the face of each filter and introduced to the next succeeding filter. Accordingly, large quantities of extracting liquid (water) are added to the pulp ahead of the filters, and to the pulp mat on each filter, where it serves to attenuate and wash the pulp. The proportion of the chemical in the pulp extracted by each filter is relatively small. The liquor or filtrate extracted from the pulp at the first filter is led off to the chemical recovery plant or other point of reclamation or reuse.

Besides requiring the use and handling of very large quantities of liquid, this process has the drawback that it must be carried out at comparatively low temperatures, to permit of maintaining sufficiently high vacuum at the filters; accordingly, much of the heat in the stock as it comes from the digester is lost. Moreover, air is apt to be entrained with the liquor extracted from the pulp at the filters, tending to create large quantities of foam that is very troublesome, both to handle and to break or dissipate.

In another and somewhat similar extraction process, the pulp from one or more digesters is accumulated in a reservoir, and is thence run continuously (with very great attenuation) through a rotary vacuum filter, where additional extraction liquid is supplied to the pulp mat. After stripping from the filter, the pulp is again attenuated with water, and then undergoes mechanical pressure in a rotary screw press to squeeze out some of the liquid, before going to the usual refinement treatment. The filtrate from the rotary filter goes to the recovery plant, while the liquid from the screw press may be returned to the rotary filter as part of the attenuating and washing liquid there used, if it is not run to waste.

In carrying out my invention as hereinafter described, I extract the chemical(s) from cooked or digested stock by alternately and repeatedly compressing the stock mechanically, while suitably enclosed or confined and in the state of pulp, so as to express or squeeze out part of the chemical-laden liquid or liquor from the pulp, and introducing to the stock other liquid capable of taking up or displacing chemicals remaining in the stock after the previous expressing step,—hereinafter generally referred to as "extractant" or "liquid." Even when kept enclosed through
combination of fiber and liquid dealt with in my process as "stock" simply, without regard to its composition as determined by the quantity of liquid associated with the fiber, or to the presence or absence of chemicals; while for purposes of distinction, I have referred to stock of relatively low consistency (including digester consistency) as "pulp," and to stock of the higher consistency (eventually brought about by compression of the pulp in my process as "magma.")

Mechanical expression of liquor from the pulp is preferably effected by a continuously operating dehydrating press in which the stock is confined and is progressively fed forward through a constrictive permeable-walled passage of progressively reduced cross-section—the wool-channel and press casing of the walled forming the progressively reduced and permeable-walled constrictive passage for the stock, as well as the means for feeding it. The introduction of liquid to the stock, for further recovery of chemical therefrom, takes place at a section of the press passage where the pulp has been compressed and thickened to a caked condition, and at an area of the passage wall suitably removed from its wall area that is permeable,—the pressure on the stock due to the feed being relaxed at the point of introduction of the liquid. The liquid may be introduced between the stock cake and an enclosing wall, at one side of the cake, or in the feed of the material through the passage beyond this point, the liquid so introduced is progressively squeezed, pushed or forced into or through the stock cake in the passage, by the compressive pressure of the enclosing walls on the liquid and cake, and a corresponding amount of liquor is expelled from this stock,—consisting of original liquor of the pulp more or less diluted with the liquid squeezed into the stock as just described.

It is possible to pass liquid through the continuous, unbroken cake of stock in this forcible manner, without disrupting or "channelling through it, because the previously thickened stock is held together in an integral matted, continuous magma cake, sealed with the enclosing walls at its edges. As hereinafter described, this continuous cake is preferably maintained unbroken and sealed at its edges from its formation throughout all the subsequent treatment.

The introduction of liquid and its expression into or through the stock as above described may be repeated as often as necessary in order to bring about the desired freedom of the stock from chemical. Of course the section of the press passage in which the pulp is thickened and cake and the section or sections where liquid is introduced and squeezed into or through the stock may be structurally separate rather than one continuous passage; but it is better that the cake should not be broken in transition from one passage or section to another, since that would result in breaking the continuous cake thus formed, without proper penetration of the liquid throughout the cake. Yet if found desirable for any reason, the cake may be broken up after several compressions and intervening introduction(s) of liquid, and the stock may then be repulped with added liquid before undergoing further compressions and intervening introduction(s) of liquid,—as explained more fully hereinafter.

In the case of a rotary screw type of press, the relaxation of feed pressure on the stock is preferably produced by deepening the feed screw channel at a point where the material has been brought to magma of suitably high consistency (say 30-40% fiber, more or less), and the extractant may be introduced through an internal hollow or duct in the screw, with radial outlets therefrom delivering at points distributed along the bottom of a channel convolution. Beyond the portion of the channel into which these outlets open, the channel depth is increased progressively toward the delivery end of the press, very much as in the antecedent portion of the feed screw.

Instead of introducing fresh or other extrinsic extracting liquid to the magma each time (or even using it as the principal extractant), and passing the liquor from each expressing stage or operation directly to the chemical recovery plant, I prefer to introduce into one or more of the earlier stages the liquor expelled from the stock in later expressing stage(s), only using fresh or extrinsic liquid extractant in the last stage(s), and only passing the relatively strong liquor of the first expressing operation(s) or stage(s) directly to the chemical recovery plant. This, of course, means a further economy in the use of liquid (water),—besides that due to working the stock at higher consistency, as above explained. Hence the amount of fresh or extrinsic extracting liquid required is only a fraction of that generally used, and none of the expressed liquid need be run to waste. Loss of fiber stock in the extraction process is obviated, as well as loss of chemicals.

Of course it will be understood that the systems here illustrated and particularly described might be either contracted or expanded, so as to have a smaller or a larger number of reexpressing or dehydrating stages and liquid-reintroducing stages, and that in an extended or amplified system, with a greater number of such stages, the points of introduction of fresh or extrinsic liquid might be varied or multiplied, as well as the points of liquor withdrawal, and the connections for passing expressed liquor from later stages in the sequence of expressing operations to earlier stages in such sequence. More specifically, expressed liquor may be withdrawn from any stage of the process, or extrinsic liquid may be introduced at any stage. It will also be understood that if desired some fresh liquid may be combined with the liquor to provide the extractant introduced to the fiber stock in one or more stages of the process.

The introduction of fresh or other extrinsic liquid into the system affords a means of controlling and regulating its temperature at all points ultimately reached by liquid extractant: e. g., by suitably varying the temperature of this fresh liquid, the temperature in the system can be kept equal to that of the entering pulp, or made either higher or lower, as desired. The amount of liquid so introduced not only affords additional cooling in the latter event, but also affords a means of controlling the concentration of the liquor expressed from the stock in subsequent stages of the process.

Various other features and advantages of the invention will appear from the following description of species or forms of embodiment, and from
the drawings. So far as novel over the prior art, all of the features and combinations shown or described are of my invention.

Fig. I is a schematic and diagrammatic general view of an extraction system for the purpose of my invention, including a diagrammatic vertical mid-section view of a rotary screw press of my invention; and Fig. II shows a cross-section through the screw press, taken as indicated by the line and arrows II—II in Fig. I.

Fig. III is a schematic and diagrammatic general view of an extraction system including a series of rotary screw presses such as shown in Fig. I; and Fig. IV is an end view of the presses shown in Fig. III from the right of that figure,—with parts in front of those shown broken away and removed,—illustrating the interconnection of the presses for the passage of stock from one to another, with provision for repulping the stock between them.

Fig. V is a general schematic and diagrammatic view, similar to Fig. I, illustrating a more elaborate form of extraction system and rotary screw press, for producing more complete purification of fiber pulp.

Fig. I shows diagrammatically a plurality of pressure digesters 10 which may be operated batchwise in such staggered relation to one another that the reservoir or accumulating tank 11 into which they periodically discharge always contains a substantial amount of digested or cooked fiber pulp. From the tank 11, this pulp (preferably at digester consistency) is continuously run or fed into the extraction system, into the housing inlet 12 of the rotary screw press 15. Preferably, the tank 11 and its (valved) connections from the digester 10 and to the screw press inlet 12 may be closed pressure-tight, so as to exclude the atmospheric air from the stock and allow controlled pressure higher than atmospheric (and even more or less approximating that in the digesters) to be maintained in the extraction system, from the inlet 12 clear to the "semi" where the stock is discharged out of the extraction system, as explained hereinafter.

As shown in Fig. I, the rotary screw press 15 comprises a feed and pressing screw or worm 16 revolving in a double-walled barrel structure or chamber 17 preferably of uniform bore from end to end. The stock to be treated, at the consistency of pulp, enters the press casing 17 through the top inlet 12 at the left-hand end of the casing, and after traversing the worm 16 is discharged out of the extraction system at the right hand end of the casing, through an outlet hood 18, that delivers downward. The mechanical compression of the stock in the press 15 maintains it in a compact mass at the discharge end of the casing 17, thus sealing the extraction system pressure-tight at this point. As shown, the worm shaft 20 extends out through a suitable pressure-tight packing 21 at the left hand end of the casing. The worm 16 may be driven by any suitable means (not shown) connected to the shaft 20, and suitable thrust bearings (not shown) may be provided to take the end thrust of the worm. A suitable speed of revolution for the worm is about 50–60 R. P. M. As here shown, the worm 16 also has a (floating) shaft 22 extending from its right hand end through a packing 23 in the wall of the hood 18,—for a purpose hereinafter described. On this shaft 22 is mounted a four-vane paddle wheel 24, which revolves with the worm and chops and breaks up into small pieces the compressed and caked magma discharging from the right hand of the casing 17. To facilitate the subsequent handling and transportation of the concentrated magma discharging through the hood 18, it may be thinned with water or liquid (such as paper-mill white-water) supplied through a valved pipe 25 delivering downward through the top of the hood 18.

Aside from features hereinbefore or hereinafter described or indicated, the press 15 and its construction and accessories may correspond substantially to ordinary rotary screw press practice.

As shown in Fig. I, the inner casing wall 26 (defining the bore or tubular housing in which the worm 16 revolves) consists of a foraminous plate pierced with a multitude of fine holes 27, preferably tapered outward so as to be self-clearing. These holes may be about 1/4" in diameter at their small inner ends. The perforate plate 26 may preferably be as thin as is consistent with adequate strength, and may be supported at suitable intervals by ribs 28 integral with the casing 17, as is usual in the construction of presses of this character. Preferably, the inner surface of the casing bore (formed by the wall 26) has a number of shallow longitudinal grooves 29 such as indicated in Figs. I and II, to resist rotation of the stock by the rotating worm 16, so that the latter may propel and press the stock more effectively.

As shown in Fig. I, the continuous external screw channel or groove 30 of the worm 16 is progressively reduced in cross-sectional area from the inlet 12 toward the right, substantially to a point corresponding to an annular partition 31 in the interspace between the inner wall 26 and the outer wall of the casing 17. This partition 31 divides the interspace into two separate filtrate chambers 32 and 33. The worm channel 30 diminishes in both axial width and radial depth as far as the last worm channel convolution 34 at the left of the partition 31. Beyond this point, the worm channel 30 remains of substantially the same width (measured axially of the worm); but in the next succeeding convolution 35 (to the right of the partition 31), the depth of the channel 30 is increased rather suddenly, as indicated at 36 in Fig. II. This increase in depth at 36 may preferably be as abrupt as consists with considerations of mechanical strength of the worm 16. Beyond this point, the worm channel 30 is again progressively reduced in depth and constricted (toward the right), until at the end of its last convolution 31 at the extreme right, the cross-sectional area of the channel is substantially the same as shown for its convolution 34.

It will be seen, therefore, that the press 15 and worm or feed-screw 16 may be regarded as comprising two structurally united but functionally distinct sections: a left-hand dehydrating section A and the worm-channel convolution 34 at its delivery end, and a right-hand supplemental section or extension B beginning with the worm-channel convolution 35 at its receiving end. In a way, indeed, the corresponding portions or sections of the worm channel 30 may be regarded as distinct serially interconnected constrictive passages. Nevertheless, the dehydrating and supplemental parts A, B together present a continuous screw channel, in such wise that the deeper receiving end portion 35 of the screw thread in the supplemental screw section or extension B forms a direct
continuation of the screw thread in the main dehydrating screw section A from its shallow dehydrating screw section A, and remains substantially the same width as the latter throughout the section B, though decreasing in depth. As shown in Fig. II, the increase in depth from the delivery end portion 34 of the screw channel of the section A to the receiving end portion 35 of the screw channel of the extension B is made on an offset at 36; or, in other words, the wall portion at 36 which connects the delivery and receiving thread portions at the bottoms thereof is offset relative to the normal continuation of said thread portions. However, notwithstanding the relatively abrupt increase in depth and cross-sectional area at the transition 36 from section A to section B, the worm or screw-channel 30 may be sufficiently even-sided throughout to sustain, transmit, and guide the stock cake formed in the section A (as hereinafter in its transition from section to section without breaking it up,—though temporarily relaxing the mechanical pressure on the stock where the channel ends, as its transition is completed.

As shown in Fig. I, the worm 16 has a central longitudinal internal chamber or duct 38 extending inward from its right-hand or “discharge” end, and coextensive with the section B. This is connected through a series of some dozen radial orifices 30 of the screw channel B with this offset wall portion 36 and with the bottom portion X of the screw channel of section B at its deep receiving end 35, and thus serves (along with the adjacent ports 42) to introduce or deliver treating fluid or liquid from said passage-way 35 to the pressed material in its travel from the pressing screw A to the extension B. The chamber 38 is also connected through the interior of the hollow right-hand shaft or duct 22 to a stationary box 35 whereeto is connected a valved liquid supply pipe 40. A pressure-tight joint may be made between the stationary box 35 and the receiving shaft 22 in any suitable way,—diagrammatically indicated in Fig. I by a washer 41 attached to the shaft, with its margin held fluid-tight against the interior of the box 35 by the hydraulic pressure in the box.

As shown in Fig. I, the filtrate chamber 32 has multiple outlets which unite in a discharge pipe 43, and the filtrate chamber 33 has a discharge outlet pipe 44. These liquor discharge pipes 43 and 44 are connected through multeway valves 45, 48 to a liquor pipe line 47, which connects at one end into the pulp inlet 12 of the press 15, and leads off at its other end to any desired point of disposal, such as a storage tank or the usual chemical recovery plant of a paper mill. Another pipe line 48 leading to any desired point is shown connected to the valve 46. The valves 45, 46 allow the liquor from either or both the press chambers 32 and 33 to be passed either to the recovery plant or to the pipe line 48, and the valve 48 also permits of passing the liquor from the chamber next to the press inlet 12 of the press 15. Suitable liquor-handling pumps may be provided in the pipe line 47, as shown.

In the initial dehydrating press section A, the stock (entering at pulp consistency) is progressively compressed and fed along toward the right, and its chemical-laden liquid or liquor is progressively expressed or squeezed out, through the holes in the perforated housing plate 26, into the surrounding liquid chamber 32, until in the channel convolution 34 the stock is brought to a magma of a consistency that is determined by the particular design of the worm 16 and the consistency of the pulp entering at 12. In cases where a press designed for relatively thin pulp is used to treat a much thicker pulp, such thick pulp may be thinned with liquid supplied to the press inlet 12 through the pipe 47, so that the stock shall not reach an excessive consistency in the press 15. The liquid thus introduced to the pulp at 12 controls or influences the temperature throughout the process, as well as the consistency of the stock and the concentration and temperature of the liquor expressed at various stages of the process. As the stock becomes sufficiently thickened in the press section A, it forms a cake of sufficient consistency and cohesion to engage effectively in the grooves 26 of the housing bore 25, Fig. I, which thus restrains the stock to turn with the worm 16 in its further travel to the right. In the press section B, the mechanical pressure hitherto maintained on the stock by the worm 16 is relaxed, owing to the increase in depth and area of the channel 30 at 35, leaving (more or less) in the X (shown with dash lines) in the bottom of the convolution 35 and perhaps a subsequent convolution, which is filled and kept filled by extraction liquid introduced thereto through the holes 42. Illustratively, assuming a pulp of 13% consistency at the inlet 12, and that in the convolution 34 it is brought to a consistency of about 35%, the space at X may correspond in volume to a stock consistency of about 17%—supposing (contrary to fact) that the liquid introduced into this space were fully and uniformly combined with the pulp in the corresponding length of the worm channel 30. This liquid can be introduced into the space at X under a very slight pressure head, just sufficient to induce the right rate of flow through the various pipes and passages. In the worm channel convolution 35 and the succeeding convolution(s), liquid is taken up or absorbed by the stock cake through its inner side; at any rate,—whether the foregoing is exactly the correct explanation or not,—the liquid introduced through the openings 42 is very quickly sealed in; so that as the contents of the screw channel 30 are progressively compressed during further travel to the right in the progressively diminishing channel 30, the liquid does not flow back into the channel convolution 35 where it entered, nor create any back pressure there, but is forced or squeezed into and through the cake of stock. Thus further amounts of chemical-laden liquid or liquor are forced out and expressed through the holes of the perforated plate 26 into the chamber 33. This further recovery of liquor results, as I believe, from displacement of the original liquor of the pulp (entering at 12) by the liquid supplied at X as above described, with some dilution of such liquor in the cake by the liquor at X. The relaxation of pressure on the stock cake just beyond the point 36 and the opportunity for the cake to expand are very brief,—only as pulp inlet 12, seen in the press shown in Figs. I and II operates at some 50–60 R. P. M., as above mentioned,—before pressure on the stock (and liquid) is renewed in the succeeding constriction of the screw channel section B,
which favors displacement of the liquor in the pulp by the liquid introduced at X, rather than dilution. The liquor discharging from the chamber 32 through the pipe 43 is of the same concentration as in the pulp entering the screw 16 from the inlet 12, and may be at substantially the same temperature: i.e., this liquor is at the full digester concentration, if the pulp received at 12 is the undiluted digester liquor. The liquor discharging from the chamber 33 through the pipe 44 is generally of somewhat lower concentration, as explained above; while its temperature depends on the amount and temperature of the liquid supplied through the pipe 46 and introduced at X, as well as on the initial temperature of the entering pulp. Accordingly, the temperature of this liquor may be controlled and regulated by suitably varying the temperature of the liquid supplied at 46, and may be kept equal to that of the entering pulp, or made higher or lower, as desired from time to time. When the liquor discharged at 44 is introduced into the pulp intake 12 through the pipe 47, the temperature of the pulp and of the liquor discharged at 43 are also controlled or influenced, as already mentioned.

It will be seen that in the operation of the press as above described, the cake of stock in the worm channel 30 is everywhere maintained, guided, transmitted, and sustained at its edges by the worm side walls, and need never be broken, or disturbed in its edge sealing contact with the sides of the channel, from its formation somewhere in the press section A, clear up to the last worm convolution 37—whence it discharges into the hood 18. This is, of course, important for the best efficiency of the liquor recovery in the press section B, since the cake were broken in transition from the press section A to the press section B, or its contact with the worm channel sides were disturbed, the liquor supplied at X would pass out through the cracks or openings thus formed, instead of penetrating properly throughout the cake itself. The bottom of the barrel or casing 17 being even throughout its length, without any abrupt change in size, and the feed screw 16 being conformable to the bore, this bore guides and sustains the cake in transition from section A into section B. Thus by the even casing bore and the supply lips or edges of the screw channel 30, the cake is continuously and adequately guided and sustained (during the transition as well as in the rest of its travel) against all disruptive influences, including the outward pressure of the liquid introduced at 42, as well as the centrifugal force due to rotation of the feed screw 16, and the friction with all engaging surfaces. Experience has shown that with proper operation of a press 15 such as shown in Fig. I, as high a recovery of chemical can be obtained as is achieved in the ordinary practice of many paper mills. Where a greater recovery of chemical is desired, or a greater purification of the stock—or both,—a plurality of presses may be arranged in Figs. III and IV, where various parts and features are marked with the same reference characters as in Figs. I and II (with the addition of a letter where distinction appears necessary), as a means of dispensing with repetitive description. As in Fig. I, the pulp from the digesters or storage tank (not shown in Fig. III), enters the first press 15 through the top inlet 12, and discharges downward from outlet hood 18, which delivers through a closed connection, preferably pressure-tight, into the top inlet 12a of the second press 15a, which in turn delivers downward through its outlet hood 18a out of the extraction system. As it may not be convenient to arrange the pulp inlet 12a of the second press 15a directly under the discharge hood 18 of the first press 15, a lateral connection is shown between them, consisting of an upper liquor-discharging connection 50 equipped with a suitably driven rotary feed screw 51, to lift the stock into the inlet 12a of the second press 15a without any back pressure on the first press 15. To facilitate the transfer or feed of the stock by the conveyor 50, it is desirable to thin it with liquid, which may be supplied through a valve and pipe 55 with a valve branch 55a, the former delivering, like the connection 25 in Fig. I, into the top of the outlet hood 18, and the latter shown as delivering through the lower end of the conduit or conveyor casing 58. The conveyor screw 51 acts to remix the liquid supplied as just described with the fiber cake, and prevents repulping. This repulping may bring the stock substantially to the consistency of the original pulp entering at 12, or to a somewhat lower or higher consistency, (e.g., 17%) if preferred. The action in the second press 15a is substantially like that in the press 15 in Fig. I, resulting in further purification of the stock, and further recovery of chemical therewith. In cases where extremely high purification of the stock is desired, either or both the presses 15, 15a in Figs. III and IV may be like that shown in Fig. V and described hereinafter.

There is shown in Fig. III a unified system of extractant and liquor connections for the presses 15, 15a, intended to apply the purest extractant always to the purest stock, upon the countercurrent principle. For this purpose, (hot) water is supplied to the second press 15a at 40a, just as in Fig. I, and the discharge pipe 44a from the second section B of this press 15a is connected through the valve 45a to the supply pipe 46a that supplies the liquor extractant to the second section B of the first press 15, this pipe line 25 being shown as provided with a liquor pump. The liquor discharge pipe 43a from the section A of the second press 15a is connected through the valve 46a to the supply pipe 44a that supplies the liquor extractant to the second section B of the first press 15, this pipe being shown as provided with a liquor pump. It will be seen that the extractant introduced to the stock at all stages of the process—except the very last—is the (hot) liquor expresser therefrom in the second-ensuing compression of the stock. As shown, the valved liquor discharge pipes 43, 44 for both the sections A and B of the first press 15 are connected to the valve line 47 leading to any desired point of liquor disposal, such as a storage tank or the usual chemical recovery plant of a paper mill, and this pipe also extends and is connected into the pulp inlet 12 of this press.

With an extractor system such as illustrated in Figs. III and IV, including a couple of presses 15, 15a operating in series, the fiber can be brought to satisfactory purity for paper making, and may be transferred from the outlet 18 of the second press 15a directly to the refiner. To secure the mutual division of work between two such presses 15, 15a that are just alike, it may be desirable to operate the second press 15a at somewhat lower speed than the first press.
As will readily be seen from Fig. III, the recovery of extracting chemical with such a system is complete, since the only discharge of liquid from the system is through the pipe line 41, leading to storage or directly to the chemical recovery plant. The use of separate presses in series as just described in connection with Figs. III and IV results, of course, in breaking the stock or magma cake formed in the first press 15, which necessitates repulping the stock to lower consistency and rethickening and recaking it in the second press 15a. While the liquid extractant used for repulping the stock serves a useful purpose in recovering chemical from the stock in the first stage A of the second press 15a, this procedure is obviously more complicated and inefficient than to effect the purification without breaking and having to reform the cake. The drawback can be avoided by performing the complete purification operation in a single longer press 15b, such as illustrated in Fig. V, having sections A and B like those shown in Figs. I and II, and also sections C and D which are duplicated of section B. The action of these sections C and D is to express still further amounts of chemical-laden liquid from the stock with the aid of extractant introduced thereto just as in the section B. As shown in Fig. V, the screw sections A, B, C, D all together present a continuous channel which decreases in cross-sectional area in the dehydrating section A, just as in Fig. I, and in the several supplemental sections or extensions B, C, D decreases in depth (and cross-sectional area) while remaining throughout of substantially the same width as at the delivery end of the section A, like the screw channel of the section B in Fig. I, but increases abruptly in depth (and cross-sectional area) at the transition from screw section to screw section, again as in Fig. I. The cake, therefore, remains unbroken from its formation in the section A all the way through the succession of supplemental dehydrating sections B, C, and D to its discharge from the last convolution 31b of section D into the hood 16b. Of course such a press may have a greater or less number of sections than the four shown in Fig. V.

As shown in Fig. V, the supply of liquid to the supplemental press sections B, C, D is similar to that through the interior of the hollow discharge-end of the worm or feed-screw 16b at its right, and into the bottom portion X of the screw channel in each supplemental section, at its deep receiving end, just as in the case of the supplemental section B in Fig. I. Accordingly, the worm 16b has internal longitudinal chambers or ducts 58 and 59 corresponding to the sections B, C, and D, and separated by transverse partitions or septa 60. Liquid is supplied to the chamber 30b of the section B through a central axial pipe-duct 62 corresponding essentially to the hollow shaft 22 in Fig. I. Liquid is supplied to the chamber 58 of the section C through a larger concentric pipe-duct 63. Liquid is supplied to the section D through a still larger concentric hollow shaft or duct 64, substantially similar to the hollow shaft 22 in Fig. I. The ends of the shaft 64 and of the pipes 63 and 62 are connected to the pipes of the liquid extractant system through stationary boxes 39b, 39c, and 39d, that make suitable fluid-tight joints with the rotating parts to which they connect, and around the parts which extend through them. Of course other arrangements might be made for conveying liquid to the cavities 39b, 58, 59, if preferred. The liquid extractant piping is arranged and connected substantially like that shown in Fig. III, and its corresponding parts are marked with the same reference characters, as a means of dispensing with repetitive description,—a distinctive letter being added where such distinction appears necessary.

It will be seen that the process is substantially continuous, and may be made a substantially closed cycle of operation as regards liquid extractant. The use of air pressure or vacuum is entirely avoided, as well as foaming and all difficulties or losses incident thereto. Substantially all the chemical(s) employed, liberated, or produced in the digesting or cooking process and present in the stock at the conclusion of that process are extracted and discharged from the system in relatively concentrated state; while the fiber stock is discharged in a relatively pure state, suitable for the manufacture of paper, fiber board, or the like, and at high consistency. The process can be run very economically, since there is no need of allowing the fiber stock or the extracted liquor to cool; the amount of liquid that must be handled is minimized; the consumption of fresh water is relatively very low; the loss of fiber is minimized; and only the small amount of chemical allowed to remain in the fiber stock as it leaves the extraction system is lost. The process is simple and efficient, requires minimum handling of the material and minimum expenditure of power, as well as a minimum of manual labor, and is particularly well adapted to large scale manufacturing operations. Furthermore, the rotary screw presses here shown have a certain refinement on the fiber of the stock, thus reducing the amount of work to be done on the stock afterward in the refiner.

Having thus described my invention, I claim:

1. In a device of the class described, the combination of a tubular perforate housing, a pressing screw rotatable therein for providing and pressing material fed into said housing, said screw having an extension on its delivery end provided with a continuation of the thread of said screw, the receiving portion of the thread on the extension being deeper than the delivery portion of the thread on the presser, said delivery and receiving thread portions being connected by a wall portion at the bottoms thereof which is offset relative to the normal continuation of said thread portions, said extension being provided with an internal passageway and a port connecting said passageway with said offset wall portion for delivering fluid from said passageway to pressed material in its travel from said pressing screw to said extension.

2. In a rotary screw press of the character described, the combination with a permeable-walled barrel presenting an even bore, without abrupt change in size, of coating rotary sectional feed-screw means conformable to said bore and presenting an even-lipped cutting screw channel which is progressively reduced in cross-sectional area in the several screw sections, but is increased in depth and cross-sectional area at the transition from section to section, said feed screw means cooperating with said barrel to progressively feed wet material being forced through said screw channel and to progressively express liquid or liquor from the material, thickening and caking the material in the first screw
section, and also cooperating with said barrel to
guide and sustain the cake against all disruptive
influences in transition from section to section,
thus maintaining the cake unbroken; and means
for introducing treating liquid for the material
into the screw channel where the cross-sectional
area is increased as aforesaid, at the opposite
side of the unbroken cake from the permeable
barrel wall; so that in the feed of the material
beyond where the liquid is thus introduced, this
liquid is mechanically forced into and through
the cake, expelling further amounts of liquor
therefrom by displacement.

3. The combination of claim 2, wherein the
rotary sectional feed screw embodies a continu-
ous external screw-channel having substantially
even lips or edges throughout and is also of sub-
stantially uniform width beyond the first screw
section, said screw being progressively reduced in
cross-sectional area in the several sections and
relatively abruptly increased in depth at its bot-
tom, and said feed-screw also embodying means
defining internal flow passage for treating liquid
into the screw-channel where the latter is of
maximum depth.

4. The combination of claim 2, wherein the
bore of the permeable-walled barrel is provided
with shallow longitudinal grooves, effective to
resist rotation of the material progressed by the
rotary sectional feed-screw means.

5. In the treatment of digested or cooked fiber
stock, for the removal of chemicals present there-
in, as it comes from the digester to caked
magma; means for confining the stock pulp in a
constrictive permeable passage substantially as it
comes from the digester; means for compressing
the stock pulp and expressing chemical-laden
liquid or liquor therefrom by pressure; means
for thickening and caking the stock into a
magma; means for introducing liquid extractant
for chemical into the stock pulp as the latter
passes from the feed-in portion of the constric-
tive passage into the succeeding portion; means
for maintaining the stock cake formed in said
feed-in portion continuous throughout the rest
of the treatment without breaking it up; and
said means for introducing the liquid extractant,
as aforesaid, to the unbroken cake being so ar-
ranged in relation to said cake and to the con-
strictive permeable passage that said liquid is
mechanically forced outwardly into and through
said cake in the succeeding portion of said pas-
sage, thus expelling liquid in the cake by dis-
placement, rather than merely by dilution and
squeezing out as when a formed cake is broken,
repulped, and recompressed.

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