July 17, 1951 J. T. COGHILL ET AL 2,561,013

APPARATUS FOR THICKENING PULP

Filed Sept. 6, 1947 4 Sheets-Sheet 1

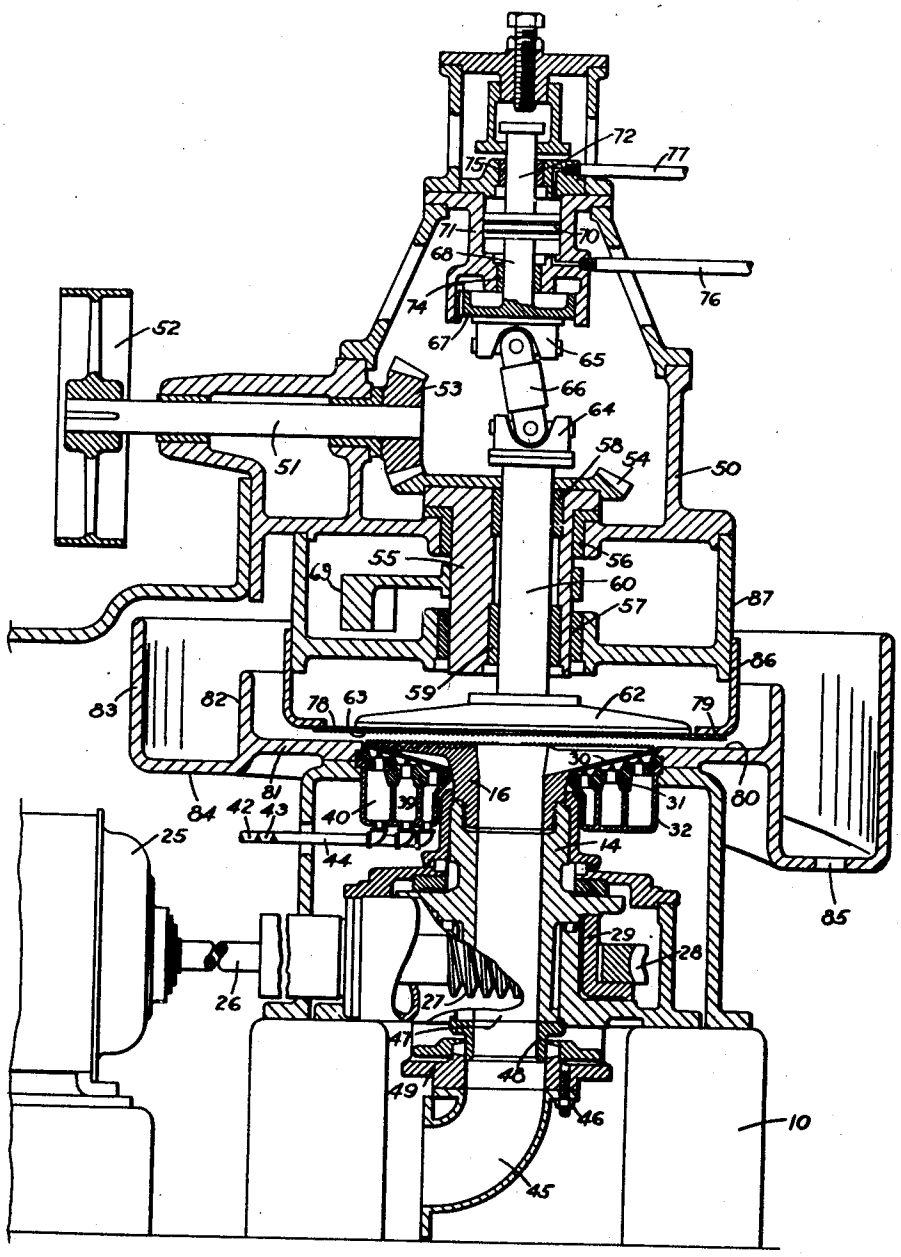


FIG. 1.

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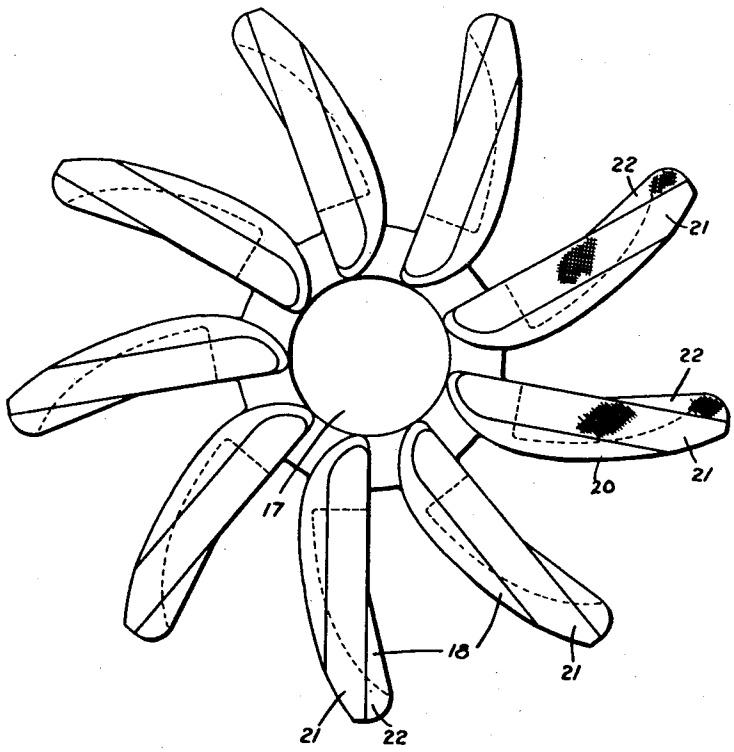


FIG. 2.

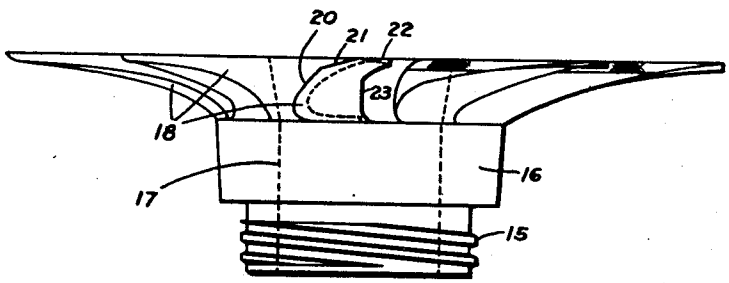


FIG. 3.

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APPARATUS FOR THICKENING PULP

Filed Sept. 6, 1947 4 Sheets-Sheet 3

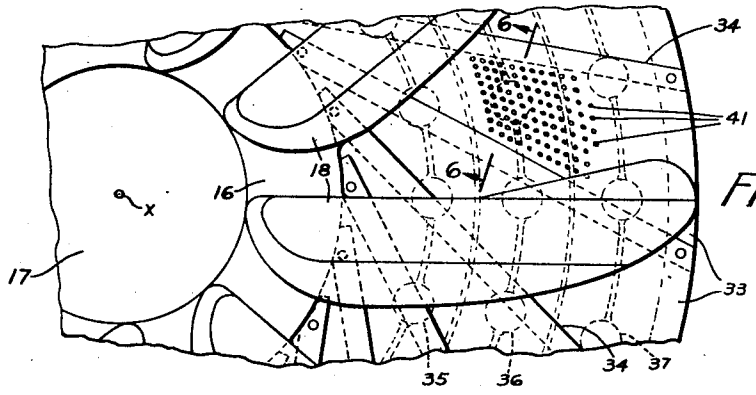


FIG. 4.

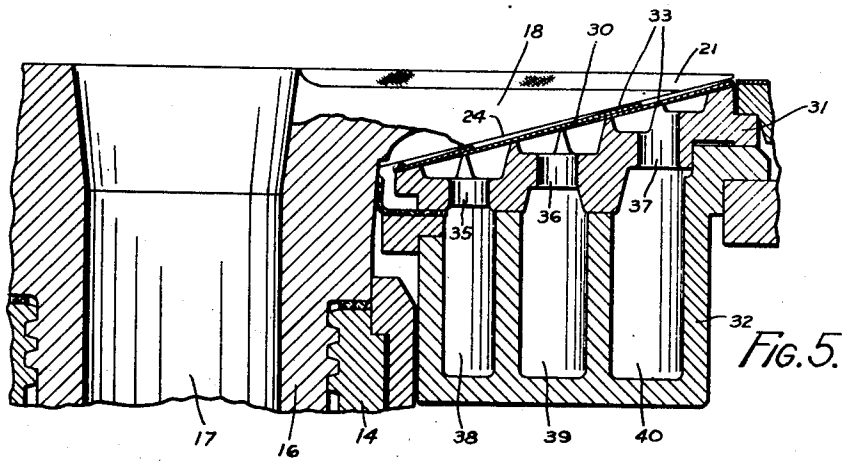


FIG. 5.

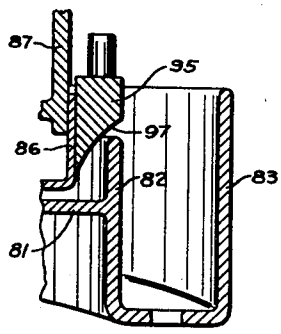


FIG. 12.

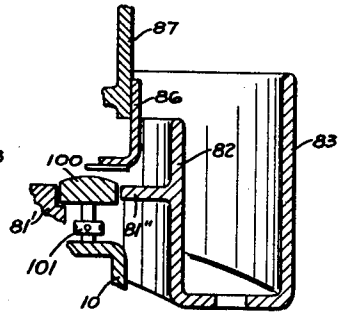


FIG. 13.

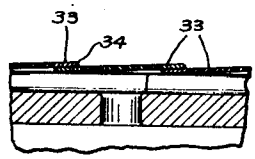


FIG. 6.

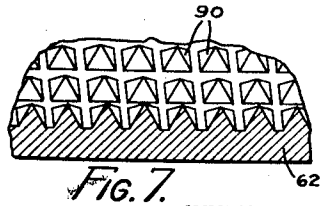


FIG. 7.

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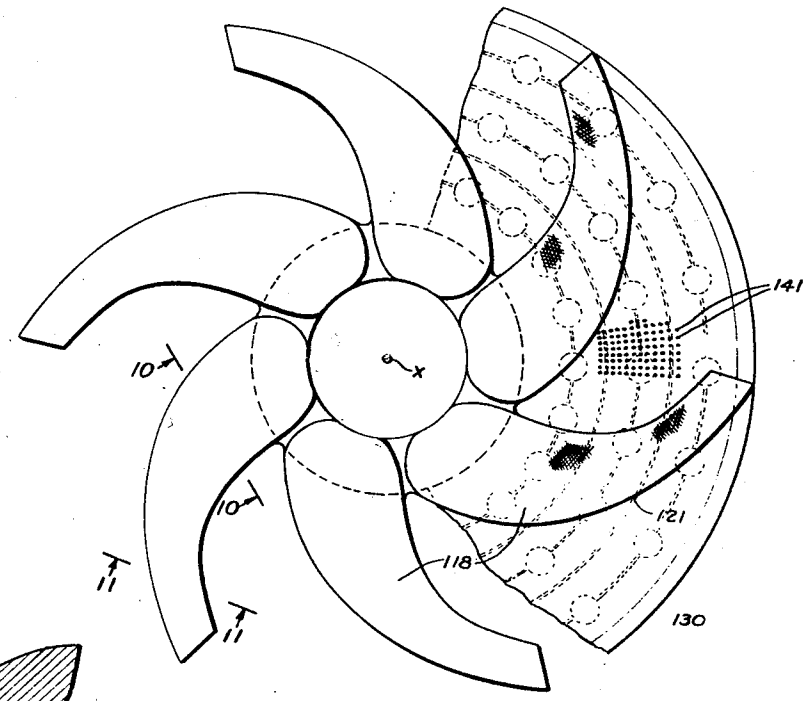


FIG. 8.

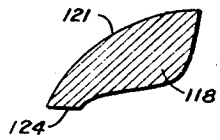


FIG. 10.

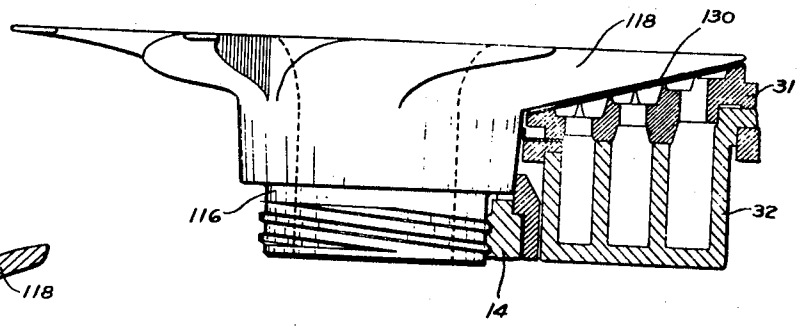


FIG. 9.

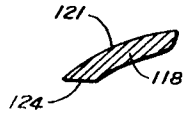


FIG. 11.

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Patented July 17, 1951

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UNITED STATES PATENT OFFICE

2,561,013

APPARATUS FOR THICKENING PULP

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Application September 6, 1947, Serial No. 772,488

20 Claims. (Cl. 92—26)

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The present invention relates to a machine for dewatering or thickening paper-making or other fibrous pulp.

There have been several different types of machines employed or built heretofore for de-watering or thickening pulp. In one type of such machine, a cylinder covered with a wire netting is revolved in a vat of stock; the top of the cylinder extends above the contents of the vat; as the cylinder revolves water passes through to the inside; a layer of pulp is formed on the outside; and a couch roll and so-called doctor, placed above the cylinder, remove this layer of dewatered pulp. In another very similar type machine the pulp is drawn against the cylinder screen by vacuum as the cylinder revolves in the vat; and a valve arrangement shuts off the vacuum and applies air pressure to blow the deposit of pulp off the cylinder as the cylinder surface emerges from the vat. This latter form of machine has increased production and greater efficiency in water extraction, but the cost of operation is increased. In another type machine, the aqueous slurry of pulp is pumped over a screen so that the water runs through the screen and a mat of pulp is deposited on the screen which is scraped off by a traveling sweep arm or blade. In still another type machine, the pulp is pressed against a perforated surface by a worm or screw, which moves the pulp across the surface into a constantly restricting space, thereby forcing the water out through the perforations.

Various other types of de-watering or pulp thickening machines have been built, also. In most prior machines, however, a mat of pulp is allowed to form before the thickened stock is removed from the screen. This mat tends to clog the screen, therefore, during most of the time of the de-watering operation, hindering drainage and lowering the water-removal rate. Moreover, because of their principle of operation, all prior machines are massive and require a very considerable floor area to provide any practical rate and volume of water extraction.

The primary purpose of the present invention is to provide a pulp de-watering machine which will be faster and more efficient in operation than any such machine previously built.

Another object of the invention is to provide a machine which will be able to thicken pulp rapidly and efficiently from consistencies in the order of 2% to 4% to consistencies in the order of 10% to 35%.

Another object of the invention is to provide a

2

dewatering machine in which the pulp is so handled as to be self-clearing and self-cleaning as regards the drainage surface.

Another object of the invention is to provide a dewatering machine which will, simultaneously with the thickening of the pulp, separate and classify the expressed water, which contains small quantities of fibre, according to its contents so that the portion of the expressed water, containing the best fibre, is separated from the portion of the expressed water that contains more dirt and fibre debris, whereby the desirable fibre contents of the expressed water can subsequently be reclaimed.

A further object of the invention is to provide a pulp de-watering machine which will be much more compact and require much less space than any pulp thickening machine heretofore built, which at the same time will handle a much greater volume of slurry than previous de-watering machines, and which nevertheless will be simple in construction and in operation.

Still another object of the invention is to provide a machine which will satisfy a need in the industry for a thickener which will deliver uniform heavy consistency pulp when the supply consistency varies, uncontrolled, in the range of 2% to 4%, and without requiring dilution of the supply to a mat-forming consistency, which is in the order of 1%.

Other objects of the invention will be apparent hereinafter from the specification and from the recital of the appended claims.

In the drawings:

Fig. 1 is a part elevation, part vertical sectional view of a machine built according to one embodiment of this invention;

Figs. 2 and 3 are a plan view and an elevational view, respectively, on an enlarged scale of one form of sweep head that may be employed in this machine;

Figs. 4 and 5 are a fragmentary plan view and a fragmentary vertical sectional view, respectively, of the sweep head, de-watering plate, and drainage chambers of this machine;

Fig. 6 is a fragmentary sectional view of the line 6—6 of Fig. 4;

Fig. 7 is a perspective view on a greatly enlarged scale showing fragmentarily the structure of the knurled working surface provided on the gyratory upper plate of the machine;

Figs. 8 and 9 are a fragmentary plan view and a fragmentary vertical sectional view, respectively, corresponding to Figs. 4 and 5, and showing the sweep head and de-watering plate of a

machine constructed according to a modification of the invention;

Figs. 10 and 11 are sections through one of the sweep arms taken on the lines 10—10 and 11—11, respectively, of Fig. 8; and

Figs. 12 and 13 are fragmentary sectional views showing modifications in the machine structure to provide different forms of dams for the de-watered stock at the discharge zone of the machine.

In the machine illustrated, the slurry of stock, which is to be thickened, is pumped from below through a hollow shaft to which a rotary sweep head is secured. The sweep head has a plurality of outwardly extending arms. The slurry of stock fans out between these arms over a generally conical de-watering surface which lies just beneath the arms and surrounds the shaft. The de-watering surface is perforated so that water can quickly drain through it from the stock into a chambered member that lies just below the de-watering surface. Above the sweep head is a plate which is formed with a knurled or roughened working surface on its under side and which is given continuously a gyratory or orbital motion. The sweep arms extend across the width of the de-watering surface and as the sweep head rotates, the thickening stock deposited on the de-watering surface is continuously displaced by the arms and squeezed between them and the gyrating plate. The gyratory motion of the plate and the rotary motion of the arms tends to roll the stock transversingly under compression between and in tractive contact with the opposed surfaces of the sweep arms and upper plate. This not only squeezes more water out of the pulp but also causes the thickening stock to be formed into nodules so that as the pulp drops over the back of a sweep arm, after having been rolled between that arm and the gyrating upper surface, it is in nodulated condition. In this condition it does not mat, and will leave the water free to run out through the holes of the de-watering surface. Thus faster drainage and consequently faster de-watering per unit of drainage area can be obtained.

As the stock thickens and its consistency increases it is moved continuously outward toward a discharge area surrounding the working zone of the machine. Where the sweep arms are generally radial of the sweep head, radial traverse of the stock may be improved by making the de-watering surface in the form of a multiplicity of separate plates which are stepped with reference to one another and arranged so that their leading edges are skew or oblique, that is, tangent to a circle circumscribed about the axis of the sweep head. The steps prevent the stock from sliding around between the de-watering surface and gyrating plate with the sweep arms embedded therein; and they force the stock to progress outwardly with some radial compression as the sweep arms pass over them. If a sweep head is used having spirally shaped arms, a stepped de-watering surface may not be required. The spiral of the sweep arms will effect the desired radial traverse and compression of the thickened stock.

The upper surfaces of the sweep arms are preferably slightly roughened to grip the stock better as it is rolled between them and the gyrating upper plate. A degree of back pressure or restraint on the stock flow at the discharge zone is advantageous for efficient de-watering, and this may be achieved in various ways.

With the machine of the present invention it has been demonstrated in commercial scale operation that water may be removed from 3% sulphite pulp at the rate of 33 gallons per square foot of perforated plate while increasing the consistency to 25%. This represents a capacity of 7.5 tons per day per square foot of de-watering area which is several times the performance of de-watering machines heretofore used.

Referring now to the drawings by numerals of reference and particularly to Figs. 1 to 6 inclusive, 10 denotes the base or frame of the machine. Journaled in this base or frame in any suitable manner, is a hollow shaft 14. The shaft is internally threaded adjacent its upper end to receive and engage the externally threaded portion 15 (Fig. 3) of a rotary sweep head 16 which is adapted to rotate with the shaft.

The sweep head is bored at 17 (Figs. 2 and 3) to have an opening aligning with the bore of the shaft 14. It has a plurality of arms 18 which extend approximately radially of the axis of the head, and which, in the embodiment shown, are integral with the head. These arms are all alike. They have generally convex leading surfaces 20 which are smooth and which join inclined roughened surfaces 21, that, in turn, join flat roughened upper surfaces 22. In the embodiment shown the upper surface 22 of each arm extends from the outer end of the arm radially inwardly only about half the length of the arm. The under surface 24 of each arm is inclined downwardly from the tip to the hub of the arm and is a generally conical surface. The rear surfaces 23 of the sweep arms may be of any desirable shape. As shown they are concave and relieved.

The shaft 14 is adapted to be driven from a motor 25, which is mounted in the base of the machine, through a shaft 26 which has a worm 27 integral with it that meshes with and drives a worm wheel 28. The worm wheel 28 is keyed to a sleeve 29 that is fastened in any suitable manner to the shaft 14. Thus, the sweep head 16 may be rotated.

As the sweep arms rotate, they travel over a generally conical de-watering surface 30 (Figs. 4, 5 and 6) made up of a plurality of overlapping perforated plates 33. These plates are riveted or otherwise fastened to a casting 31 in such wise that their leading edges 34 are oblique or skew to the axis x of shaft 14, that is, are tangent to a circle circumscribed about axis x. The front edge 34 of each plate overlies the rear edge of the next preceding plate around the de-watering surface as clearly shown in Figs. 4 and 6, and the plates slant downwardly from front to rear as shown in Fig. 6 so that their leading edges 34 are tangent to an imaginary cone coaxial with axis x. Each plate has a plurality of perforations or holes 41 through which the expressed water may drain. For clearness in illustration, only a part of one surface is shown perforated in Fig. 4.

The undersurface 24 of each sweep arm 18 is shaped to closely conform to the shape of the generally conical de-watering surface so that as the arms rotate they may readily disclose the thickening stock off of the de-watering surface. The clearance between the bottom surfaces of the sweep arms and the de-watering surface may be determined by adjustment of sweep member 16 in shaft 14. The length of the sweep arms is such as to cover the full radial width of the de-watering surface.

The casting 31, to which the de-watering plates 33 are secured, is provided with three concentric

series of angularly spaced holes, the holes of the three series being designated 35, 36 and 37, respectively. These three series of holes communicate, respectively, with the three concentric annular chambers or channels 38, 39 and 40 formed in a member 32 to which casting 31 is secured in any suitable manner. Member 32 is fastened in the base 10 of the machine. The chambers 38, 39 and 40 are drained by pipes 42, 43 and 44, respectively (Fig. 1), which are connected to holes in the bottoms of the chambers and which may lead to suitable water containers (not shown).

The aqueous slurry of pulp, which is to be dewatered or thickened, is supplied to the machine through a pipe 45, (Fig. 1) which is secured to the frame of the machine by bolts 46 and which communicates and registers with the bore 47 of shaft 14. The shaft has a nose or sleeve 48 secured to its lower end that is surrounded by a packing member 49. The pipe 45 is secured to this packing member which, in turn, is secured in any suitable manner to the frame 10.

Mounted upon the base 10 and secured thereto in any suitable manner is an upright or column 50. Journaled in this upright or column is a shaft 51 to which is keyed a pulley 52, which may be driven in any suitable manner either from the motor 25 or from a separate motor (not shown). Secured to the inner end of the shaft 51 is a bevel pinion 53 which meshes with and drives a bevel gear 54. This bevel gear 54 is fastened in any suitable manner to a cylindrical barrel 55 which is journaled on suitable bearings 56 and 57 in the upright 50. The barrel is provided with an eccentric bore which is fitted with bearings 58 and 59 to receive the reciprocating rod or plunger 60. The bushings 58 and 59 permit rotation of the barrel 55 on the plunger 60 and reciprocation of the plunger 60 in the barrel 55 during rotation of the barrel.

Secured to the lower end of the plunger 60 is a head or plate 62, which is preferably circular, and whose undersurface 63 is knurled. The upper end of the plunger is connected by means of a pair of universal joints 64 and 65, and a connecting link 66 to the flanged head 67 of a piston rod 68 which projects from one side of a piston 70.

This piston 70 is reciprocable in a cylinder 71 which is rigidly secured to the upright 50. The piston has a piston rod 72 projecting from its upper side. The opposite ends of the cylinder 71 are closed by the packing glands 74 and 75, which provide suitable guide bearings for the piston rods 68 and 72. The rim of the flanged head 67 is keyed to the cylinder 71 so that the piston 70 is prevented from rotating as it moves vertically in the cylinder. The piston is adapted to be reciprocated by fluid pressure which may be applied selectively to opposite sides of the piston through the pipes 76 and 77.

When the barrel 55 is rotated, the plunger 60 and plate 62 are caused to travel, relative to the bearings 56 and 57, in a circular path having a radius equal to the eccentricity of the bearings 58 and 59. This provides the desired gyratory or orbital motion of plate 62 and its working surface 63.

The bore of the cylinder 71 is coaxial with the bearings 56 and 57 and also with the bore of shaft 14. During the rotation of the barrel 55, the plunger 60, and the head or plate 62 are prevented from rotating relative to the frame of the machine by reason of the connection of the plunger through the universal joints 64 and 65 with the flange 67 of piston rod 68 which, as already stated, is held against rotation by its keyed connection with the cylinder 71. To prevent vibration of the machine, due to the weight of the gyrating parts, a counterweight 69 is secured to barrel 55. This counterbalances the gyrating movement.

Through axial movement of the piston 70, the working surface 63 of the plate 62 can be adjusted to the desired distance above the plane surfaces 22 of the sweep arms 18 to provide a thin working space between the knurled surface 63 of plate 62 and the upper surfaces 21 and 22 of the sweep arms. Through movement of piston 70, also, the distance between upper surface 63 and the sweep arms can be varied cyclically, if desired, to aid the de-watering action.

Surrounding the sweep arms 18 is a trough member 81. This member has a smooth flat surface 80 adjacent the outer ends of the sweep arms and of the de-watering surface 30 which acts as a discharge area on which the nodulated de-watered stock is discharged by the rotating sweep arms 18 and gyrating upper plate 62. A circular wall 82 integral with member 81 surrounds its discharge area 80. The wall 82 acts as a dam restraining flow of the thickened pulp at the outlet zone, and putting a back pressure on the pulp to insure that water is extracted from the pulp to the desired degree.

Integral with the member 81 is an outer wall 83 which is spaced from and concentric with inner wall 82. The two walls 82 and 83 define a trough whose bottom 84 is arranged on a slant so that the stock which discharges over dam 82 may be carried downwardly by suitable means to one point where an opening 85 is provided in bottom wall 84 through which the thickened stock may pass to a receptacle or onto a conveyer for further processing.

This machine is particularly adapted for delivering thickened stock at consistencies ranging from 10% to 40% and therefore one of its advantageous uses is in washing operations where the thickened pulp will be immediately reslushed to around 3% to 4% consistency. The collection trough illustrated in Fig. 1 is suitable for use in such cases for the dilution water may be added to the stock in the trough. It will be understood, however, that in cases where the pulp is desired for further treatment at the high consistencies at which it may be delivered by the present machine, a simple trough would not be used but some more positive means of collecting and delivering the pulp to a central discharge point may be employed.

The stock is prevented from riding up over the plate 62 by a ring 78 which is fastened to the plate 62 and which overlaps at all points the flange 79 of an annular guard 86 that is adapted to slide axially on the outside surface 87 of upright 50.

The surfaces 21 and 22 of the sweep arms are preferably somewhat roughened to grip the pulp tractively and resist slippage on the pulp as they rotate relative to the pulp pressed between them and the knurled working surface 63 of the gyrating upper plate 62. It is this tractive contact plus the relative motion of the opposed surfaces of sweep arms and plate, plus the compression exerted on the pulp by the surfaces which causes the pulp to be formed into nodules, permitting efficient extraction of water from the pulp and preventing it from matting.

The surfaces 21 and 22 of the sweep arms need only be slightly roughened as by a file, but the

surface 63 of the gyrating plate is preferably regularly knurled. We have found that the surface most suitable and most productive for plate 62 consists of a basically flat or smooth surface upon which are superimposed a multiplicity of tiny protrusions.

One form of suitable knurled surface is shown in Fig. 7. This working surface is comprised of a symmetrical pattern of pointed protrusions 90 in the form of closely spaced regular quadrilateral pyramids which project from the basic surface 62. The knurled surface of plate 62, however, may take any desired form and may, for instance, have any of the forms of knurled surfaces described specifically in the copending application of James T. Coghill and Harold S. Hill Serial No. 705,540, filed October 25, 1946.

The surfaces 21 of the sweep arms are preferably basically plane surfaces inclined to the axis of the sweep head and to surfaces 22, whereas surfaces 22 are preferably basically plane surfaces perpendicular to the axis of the sweep head and parallel to the basically plane surface 63 of plate 62. Because of the inclination of the surfaces 21, the stock is subject to progressively increasing compression as it is rolled traversingly between surfaces 21 and 63; and it remains under maximum compression when it is between surfaces 22 and 63. The compression exerted by transition of the stock from inclined surface 21 to parallel surface 22 is caused not only by the rotary movement of the arms 18 but also by the gyratory movement of plate 62, for surfaces 22 do not extend for the full length of the arms 18 but are arranged only at the outer ends of the arms tapering off midway the lengths of the arms as clearly shown in Fig. 2. Thus, as the sweep head rotates and the plate 62 gyrates, the stock is rolled upwardly between surfaces 21 and 63, upwardly from surface 21 onto surface 22 and radially outwardly, also, from surface 21 to surface 22 where it is compressed between surfaces 22 and 63. In Figs. 2 and 3 the roughened surfaces are indicated only on two of the sweep arms and only on parts of the surfaces 21 and 22 of those arms. It is to be understood, however, that preferably the whole of the surfaces 21 and 22 of all the arms are roughened.

In operation, the stock enters the working area of the machine through the pipe 45, the bore 47 of shaft 14, the bore 17 of sweep head 16, and the spaces between the sweep arms 18. It fans out over the de-watering surface 30 and up against the working surface 63 of gyratory plate 62. As it spreads out over the de-watering surface 30, water drains from the pulp through the holes in the plates 33 and holes 35, 36 and 37 in casting 31 into the several channels 38, 39 and 40. The sweep head rotates clockwise as viewed in Fig. 4; and the sweep arms 18 continuously clear the thickening stock from the de-watering surface 30 while at the same time squeezing portions of the stock between the inclined surfaces 21 and plane surfaces 22 of the sweep arms and the opposed surface 63 of the upper plate 62.

The upper plate 62 is, of course, traveling in an orbital path through rotation of the barrel 55 in a clockwise direction with reference to Fig. 4. Hence, as the sweep arms displace the stock from the de-watering plate it is carried between the roughened surfaces 21 and 22 of the sweep arms and the knurled surface 63 of the plate 62 and has tractive contact with these opposed surfaces so that it is rolled traversingly in different tangential directions with reference to the opposed surfaces by reason of the orbital motion of plate 62. Thus, it is formed into small discrete nodules of pulp in which the fibres are curled and twisted upon one another. These nodules of fibres roll over the backs 23 of the sweep arms and either join fresh fibre gathered by the next sweep arm or are carried by the gyratory motion of the plate 62 radially outwardly beyond the sweep arms onto the smooth upper discharge surface 80 of well member 81, depending upon the relative position of each sweep arm and the gyratory plate at any instant. The pulp on the de-watering surface is continuously urged outwardly as well as upwardly by the rotating sweep arms, for it is traversed radially along the leading edges 34 of the plates 33 by the rotation of the sweep arms. The steps in the de-watering surface, which are formed by the leading edges 34 of the plates 33, moreover, prevent the pulp from sliding around between the surfaces 30 and 63 without being worked.

The pulp then follows an interrupted path radially or spirally outward with periods of tight compression between tractive surfaces having relative motion which causes it to form into nodules, alternating with periods of relief from such rolling compression, when the thickened nodules thus formed may mix with fresh incoming pulp and are permitted to drain under the influence of more moderate pressure. Under these circumstances the pulp remains relatively loose and does not mat up or jam between the relatively converging surfaces 30 and 63 (Fig. 1). This relative looseness of the pulp between the sweep arms is desirable for proper functioning of the apparatus and is encouraged by the fact that whereas the rotation of the sweep arms is relatively slow, in the order of 100 ft. per minute at their tips, the surface speed of the gyrating upper plate is much faster, in the order of 240 ft. per minute. The pulp is therefore compressed between the tops of the sweep arms and the gyrating plate under constantly changing pressures and directions.

As the thickened pulp piles up it falls over wall 82 into the trough between walls 82 and 83 and is carried down spiral bottom 84 and out of opening 85. In continuous operation, an increasing compression of pulp, over and above that obtained between surfaces 21 and 22 and surface 63 is obtained by means of the dam 82 and the pulp feed pressure, using the pulp feed pressure to force pulp into the entry zone of the working space between the opposed surfaces of the sweep arms and upper plate, and using the dam 82 to provide a suitable restraint on the flow of the pulp at the outlet zone.

The gyratory motion of the plate 62 plus the rotary motion of the sweep arms is sufficient to nodulate the pulp, but, under certain conditions it may be desirable to vary cyclically the distance between the sweep arms and pulp to alternately increase and decrease the amount of pressure on the pulp. This cyclical variation in the depth of the working space may be effected by reciprocation of piston 70 under control of a suitable valve mechanism such as illustrated, for instance, in the copending application of James T. Coghill and Harold S. Hill, above mentioned.

Instead of using the annular wall 82 as the sole means of damming the stock, auxiliary means may be employed. Thus, as shown in Fig. 12 an auxiliary weighted ring 95 may be used. This ring is mounted to slide on the outer surface of

the guard 86. It is made light enough to be lifted by the pressure of the de-watered pulp, but has its lower surface 97 shaped to provide a more restricted opening than is provided with the wall 82 alone, thereby to put a greater head of pressure against the pulp to insure more complete extraction of the water from the pulp.

Another means for securing a head of back pressure against the pulp is shown in Fig. 13. Here the discharge surface is made in two parts 81' and 81'' and between the two parts there is interposed a damming ring 100. This ring is made adjustable by a turn buckle 101 which is connected at one end to the under side of the ring and at its opposite end is mounted upon a rigid part of the frame 10. By adjustment of this ring, the amount of the discharge opening around the sweep arms can be restricted at will.

Instead of using a sweep member having approximately radial arms and a de-watering surface made of overlapped plates as shown in Figs. 4 and 5, the machine may be equipped with a smooth de-watering surface and with a sweep member having arms spirally curved longitudinally, as illustrated in Figs. 8 and 9. The sweep member in the latter case has a hub portion 116, which threads into shaft 14, and a plurality of arms 118, which are spirally curved longitudinally. The front surfaces 121 of these arms are convex to lift the pulp off the de-watering surface, and to squeeze the pulp between the arms and the upper working surface 63 of the machine. These surfaces 121 are preferably roughened to have tractive contact with the pulp. The under surfaces 124 of the arms are inclined downwardly from the tips of the arms to the head 116 and lie in an approximately conical surface coaxial with axis x, so that as the arms rotate their undersurfaces closely hug the de-watering surface 130. This surface is here a truly conical surface. It may be formed of separate plates, but the upper surfaces of these plates all lie in the same cone coaxial of axis x.

The surface 130 is perforated as before and fastened to casting 31. In fact, surface 130 and sweep head 116 can be directly substituted for surface 30 and sweep head 16 of the embodiment first described. The machine then operates generally in the same way as first described. When the sweep head 116 rotates, its spiral sweep arms displace the thickening stock, press it upwardly and outwardly against the upper gyrating surface 63.

One of the features of the machine is the fractionation of the water expressed from the pulp. It has been found in practice that the water which first flows out of the aqueous slurry is richest in fibre while that which is expressed last is richest in dirt. Through provision of channels 38, 39 and 40 at different radial positions beneath de-watering plate 30, the different grades of white water can readily be separated. The white water flowing into channel 38 which is nearest the entry zone of the slurry is richest in good fibre and can be reclaimed, while that collected in channel 40 is full of dirt and fibre debris with a much smaller proportion of good fibre and may be discarded. The water collected in channel 39 is intermediate in quality and under some conditions can be reclaimed like that collected in channel 38.

While the apparatus of the present invention has been described as a machine complete in itself and may be so constructed and sold, it may also form part of a machine for treating thickened pulp such as the machine described in the pending application of James T. Coghill, Serial No. 773,012, filed September 9, 1947. In this latter case, the apparatus of the present invention serves to thicken the pulp prior to further treatment of the pulp in another part of the machine of application Serial No. 773,012.

While the invention has been described in connection with different specific embodiments thereof, it is capable of further modification, and this application is intended to cover any variations, uses, or adaptations of the invention following, in general, the principles of the invention and including such departures from the present disclosure as come within known or customary practice in the art to which the invention pertains and as may be applied to the essential features hereinbefore set forth and as fall within the scope of the invention or the limits of the appended claims.

Having thus described our invention, what we claim is:

1. In a machine for extracting liquid from a fibrous material, a perforated drainage plate, an inlet through which a slurry of the material may be fed over said drainage plate, a sweep arm having an under face arranged in operative relation with the drainage plate and movable to gather the thickening material up off of the plate, a second plate having a working surface opposed to the upper surface of the sweep arm and so disposed relative to said upper surface that the material displaced by the sweep arm is compressed between the upper face of the sweep arm and said second plate on movement of the sweep arm, and means for actuating the sweep arm.

2. In a machine for extracting liquid from a fibrous material, a perforated drainage plate, an inlet through which a slurry of the material may be fed over said drainage plate, a sweep arm arranged to scrape from the drainage plate the thickening material deposited on the drainage plate on relative movement between the sweep arm and plate, said sweep arm having its upper face inclined upwardly and rearwardly with reference to the path of relative movement of the arm and drainage plate, an upper working plate having a working surface spaced a slight distance above the upper face of the sweep arm and so disposed to the said upper face that the two surfaces converge rearwardly of the sweep arm, and means for effecting relative movement between the sweep arm and the two plates to cause thickened material to be displaced from the drainage plate and to be compressed between the sweep arm and the upper plate.

3. In a machine for extracting liquid from a papermaking pulp, a perforated drainage plate, an inlet through which a slurry of the pulp may be fed over said drainage plate, a sweep arm arranged in operative relation with the drainage plate and adapted on relative movement forwardly of the drainage plate to pick up thickening pulp deposited on the drainage plate, a second plate mounted above the sweep arm and adapted to be positioned close enough thereto to engage thickened pulp picked up by the sweep arm and to compress said pulp between itself and the sweep arm, means for imparting forward movement of the sweep arm relative to the drainage plate, and means for imparting relative movement in a different direction between the sweep arm and the second plate.

4. In a machine for extracting liquid from a fibrous material, a perforated drainage plate, an

inlet through which a slurry of the material may be fed over said drainage plate, a sweep arm arranged in operative relation with the drainage plate and adapted on relative movement forwardly of the drainage plate to pick up thickening material deposited on the drainage plate, a second plate mounted above the sweep arm and adapted to be positioned close enough thereto to engage thickened material picked up by the sweep arm and to compress said material between itself and the sweep arm, both the second plate and the sweep arm having opposed roughened working surfaces to engage the thickened material tractively, means for imparting forward movement of the sweep arm relative to the drainage plate, and means for imparting movement to the second plate in different directions tangentially of the sweep arm.

5. In a machine for extracting liquid from a fibrous material, a perforated drainage plate, an inlet through which a slurry of the material may be fed over said drainage plate, a sweep arm arranged in operative relation with the drainage plate and adapted on reltive movement between the drainage plate and the sweep arm to pick up thickened material deposited on the drainage plate, a second plate mounted above the sweep arm and having a roughened working surface opposed to the upper surface of the sweep arm and adapted to be positioned close enough thereto to engage thickened material picked up by the sweep arm and compress said material between itself and the sweep arm, means for effecting relative movement between the drainage plate and the sweep arm, and means for imparting a gyratory orbital motion to the second plate tangentially with reference to the opposed working surfaces of the sweep arm and second plate.

6. In a machine for extracting liquid from a fibrous material, a perforated drainage plate, an inlet through which a slurry of the material may be fed over the drainage plate, a rotary sweep arm arranged in operative relation to the drainage plate and having an upper face inclined upwardly and rearwardly with reference to the direction of movement of the arm over the drainage plate, a second plate mounted above the sweep arm and having a working surface inclined to the axis of the sweep arm and having converging relation to the inclined upper face of the sweep arm, means for rotating the sweep arm, and means for imparting a gyratory oribtal motion to the second plate about an axis extending in the direction of the axis of the sweep arm.

7. In a machine for extracting liquid from a fibrous material, a perforated drainage plate, an inlet through which a slurry of the material may be fed over the drainage plate, a rotary sweep arm arranged in operative relation to the drainage plate and having a forward face inclined upwardly and rearwardly and terminating in a plane upper surface, a second plate mounted above the sweep arm and having a substantially plane working surface generally parallel to the plane of the upper surface of the sweep arm, both the inclined and plane surfaces of the sweep arm being roughened and the plane working surface of the second plate being roughened, means for rotating the sweep arm, and means for imparting orbital motion to the second plate about an axis extending in the direction of the axis of the sweep arm.

8. In a machine for extracting liquid from a papermaking pulp, a conical perforated drainage plate, an inlet disposed centrally of the drainage plate through which a slurry of the pulp may be fed over said plate, a sweep arm rotatable about the axis of said plate for sweeping up off of the plate thickening pulp deposited thereon, and separate concentric annular channels positioned under the plate at different radial distances from the axis of the plate for collecting separately the liquid which passes through the perforations in the plate at different radial distances from the axis of the plate.

9. In a machine for extracting liquid from a papermaking pulp, a centrally disposed inlet through which a slurry of pulp may be fed, a drainage surface surrounding said inlet and comprising a plurality of circularly arranged overlapping plates, each of which has its leading edge projecting above the rear of the preceding plate and arranged tangentially of a circle about the axis of said inlet and lying in a surface of revolution coaxial of said inlet, a rotary head mounted coaxial with said inlet and having a sweep arm which projects generally radially therefrom, and which overlies said drainage surface, and means for continuously rotating said head.

10. In a machine for extracting liquid from a papermaking pulp, an inlet through which a slurry of pulp may be fed, a drainage surface surrounding said inlet and comprising a plurality of circularly arranged overlapping plates, each of which has its leading edge projecting above the rear of the preceding plate and arranged tangentially of a circle circumscribed about the axis of said inlet, the leading edges of said plates lying in a common surface, a rotary head coaxial with said inlet and having a sweep arm which projects generally radially therefrom and which overlies said drainage surface, the lower surface of said sweep arm closely fitting the surface in which the leading edges of said plates lie, and a working plate mounted above said sweep arm and adapted to cooperate therewith, means for continuously rotating the sweep head and means for continuously moving the working plate in different directions substantially perpendicular to the axis of the sweep head.

11. In a machine for extracting liquid from a papermaking pulp, a centrally disposed inlet through which a slurry of pulp may be fed, an internal conical drainage plate surrounding said inlet, a rotary sweep arm mounted coaxial with said inlet, said sweep arm having an external conical undersurface overlying said drainage plate and being spirally curved longitudinally, and means for continuously rotating said sweep arm.

12. In a machine for extracting liquid from a papermaking pulp, a centrally disposed inlet through which a slurry of pulp may be fed, a drainage plate surrounding said inlet, a rotary sweep arm mounted coaxial with said inlet and overlying said plate, said sweep arm having an upper surface inclined upwardly and rearwardly of its direction of rotation, means for continuously rotating the sweep arm to gather thickening stock up off the drainage plate, and a plate mounted above said sweep arm to cooperate with the sweep arm to compress between itself and the sweep arm pulp gathered up by the sweep arm.

13. In a machine for extracting liquid from a papermaking pulp, a centrally disposed inlet through which a slurry of pulp may be fed, a drainage plate surrounding said inlet, a rotary sweep arm mounted coaxial with said inlet and overlying said plate, said sweep arm having an upper surface inclined upwardly and rearwardly

with reference to its direction of rotation, means for continuously rotating the sweep arm to gather thickening pulp up off the drainage plate, a second plate mounted above the sweep arm and in operative relation therewith, and means for imparting an orbital motion continuously to said second plate about an axis extending in the direction of the axis of the sweep arm.

14. In a machine for extracting liquid from a papermaking pulp, a centrally disposed inlet through which a slurry of pulp may be fed, a generally conical drainage plate surrounding said inlet and coaxial therewith and inclined upwardly from said inlet outwardly, a rotary sweep head mounted coaxial with said inlet and having a plurality of sweep arms which project outwardly therefrom and which overlie said drainage plate, said sweep arms being curved spirally from end to end and having undersurfaces which closely fit said drainage plate and upper surfaces which are inclined upwardly and rearwardly of the direction of rotation of the arms, means for rotating the sweep head continuously, a second plate mounted above the sweep arms in operative relation therewith, and means for imparting a continuous orbital motion to said second plate about an axis extending in the direction of the axis of the head.

15. In a machine for extracting liquid from a papermaking pulp, a generally conical perforated drainage plate, an inlet disposed centrally of the drainage plate through which a slurry of the pulp may be fed over said drainage plate, a discharge zone around the periphery of the drainage plate, a rotary head journaled centrally of the drainage plate and having a plurality of angularly spaced outwardly projecting arms overlying the drainage plate, each of said arms having a roughened working surface inclined upwardly and rearwardly from the front face of the arm, a second plate mounted above the arms and having a roughened working surface opposed to the working surfaces of the arms and extending in a plane perpendicular to the axis of the head, and means for rotating the head to cause the arms to gather thickening pulp off of the drainage plate and pass it between the arms and said second plate.

16. In a machine for extracting liquid from a papermaking pulp, a generally conical perforated drainage plate, an inlet disposed centrally of the drainage plate through which a slurry of the pulp may be fed over said drainage plate, a rotary head journaled centrally of the plate and having a plurality of angularly spaced outwardly projecting arms over-lying said drainage plate, each of said arms having a roughened surface inclined upwardly and rearwardly from the front of the arm, a second plate mounted above the arms and having a roughened working surface opposed to the roughened surfaces of the arms and extending in a plane perpendicular to the axis of the head, means for rotating the head to cause the arms to sweep thickening pulp up off of the drainage plate and pass it between the arms and said second plate, and means for cyclically varying the distance between the opposed surfaces of the arms and the second plate.

17. In a machine for extracting liquid from a papermaking pulp, a generally conical perforated drainage plate, an inlet disposed centrally of the drainage plate through which a slurry of the pulp may be fed over said drainage plate, a discharge zone around the periphery of the plate, a rotary head journaled centrally of the plate and having a plurality of angularly spaced outwardly projecting arms overlying said drainage plate, each of said arms having a roughened upper surface, a second plate mounted above said arms and having a roughened working surface opposed to the roughened surfaces of the arms and extending in a direction substantially perpendicular to the axis of the head, means for rotating the head to cause the arms to sweep thickening pulp up off the drainage plate, and means for imparting orbital movement to the second plate about an axis eccentric of the axis of the head.

18. In a machine for extracting liquid from a papermaking pulp, a generally conical perforated drainage plate, an inlet disposed centrally of the drainage plate through which a slurry of the pulp may be fed over said drainage plate, a discharge zone around the periphery of the plate, a rotary head journaled centrally of the plate and having a plurality of angularly spaced outwardly projecting arms overlying said drainage plate, each of said arms having a roughened surface inclined upwardly and rearwardly from the front of the arm, a second plate mounted above the arms and having a roughened working surface opposed to the roughened surfaces of the arms and extending in a plane substantially perpendicular to the axis of the head, means for rotating the head to cause the arms to sweep thickening pulp up off the drainage plate, means for imparting orbital movement to the second plate about an axis eccentric of the axis of the head, and means for restricting flow of thickened pulp into the discharge zone.

19. In a machine for extracting liquid from papermaking pulp, a generally conical perforated drainage plate, a hollow shaft journaled centrally of said plate, a sweep head mounted on said shaft to rotate therewith but to be adjustable axially relative thereto and having a bore aligned with the bore of said shaft, said sweep head having a plurality of sweep arms which are spirally curved longitudinally and which overlie said drainage plate and which have front faces that are inclined rearwardly with reference to the direction of rotation of the sweep arms, a second plate mounted about the arms and having a working surface opposed to the front faces of the arms, means for feeding a slurry of pulp through the bores of the shaft and sweep head over the drainage plate, means for rotating the shaft, and means for simultaneously moving the second plate in changing directions perpendicular to the axis of the shaft.

20. In a machine for extracting liquid from papermaking pulp, a perforated drainage plate, an inlet through which a slurry of pulp may be fed over said drainage plate, a sweep member operable on relative movement between the sweep member and the drainage plate, to sweep up thickened pulp deposited on the drainage plate, a second member mounted in opposed relation to the sweep member and positioned close enough to the sweep member to engage thickened pulp picked up by the sweep member and to compress said thickened pulp between itself and the sweep member, and means for effecting relative movement between the sweep member and both the drainage plate and the second member.

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