

May 15, 1962

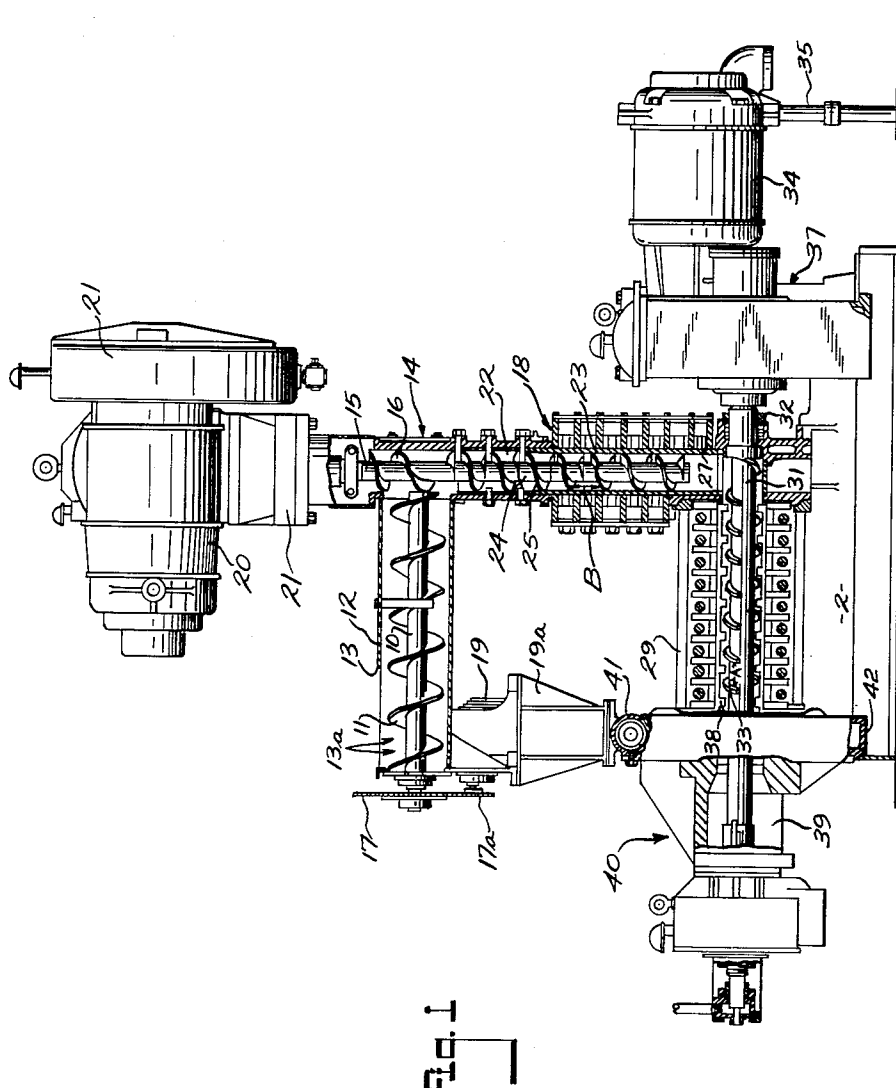
C. W. ZIES

3,034,424

SCREW PRESS WORM DESIGN

Filed Sept. 5, 1958

4 Sheets-Sheet 1



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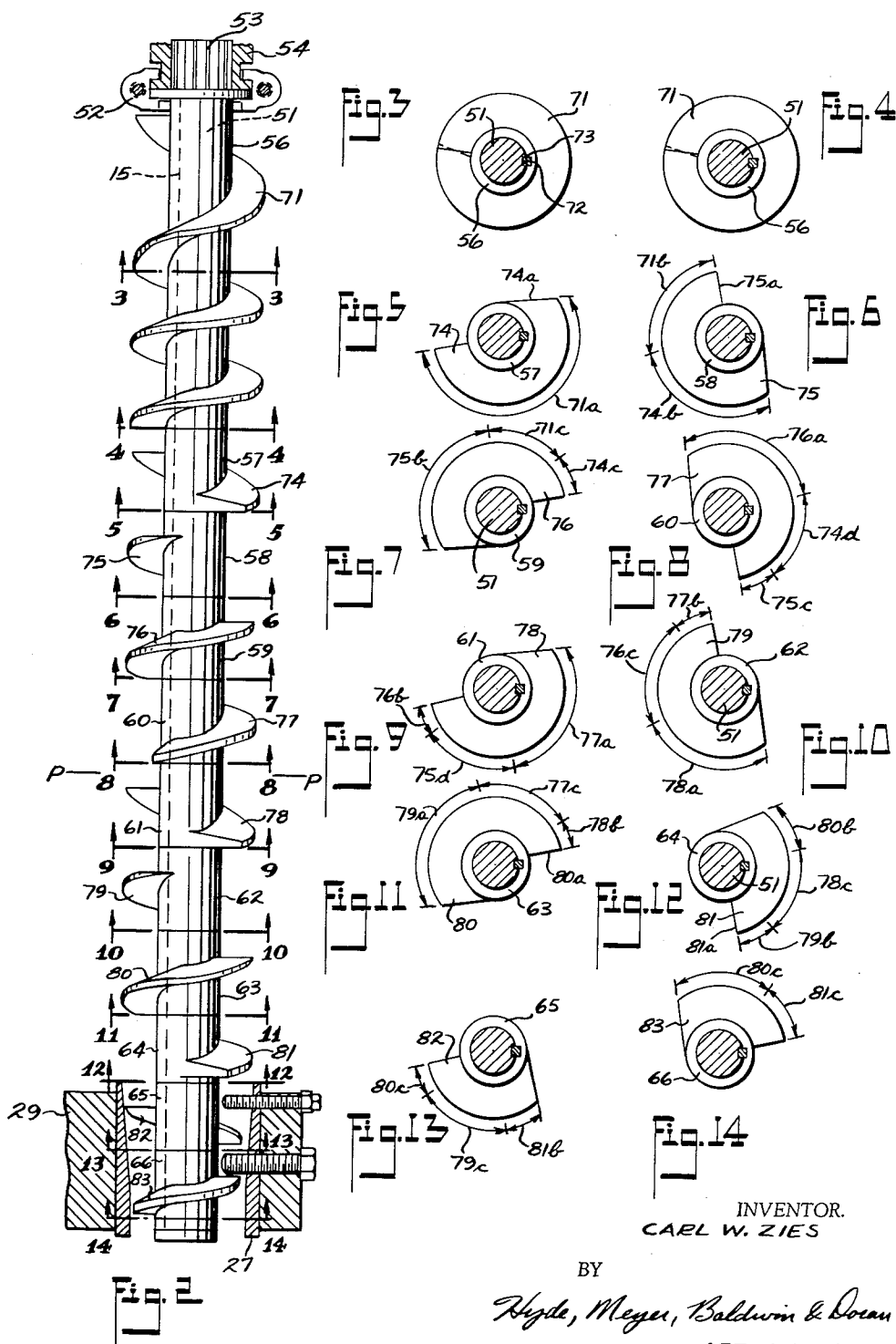
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SCREW PRESS WORM DESIGN

Filed Sept. 5, 1958

4 Sheets-Sheet 2



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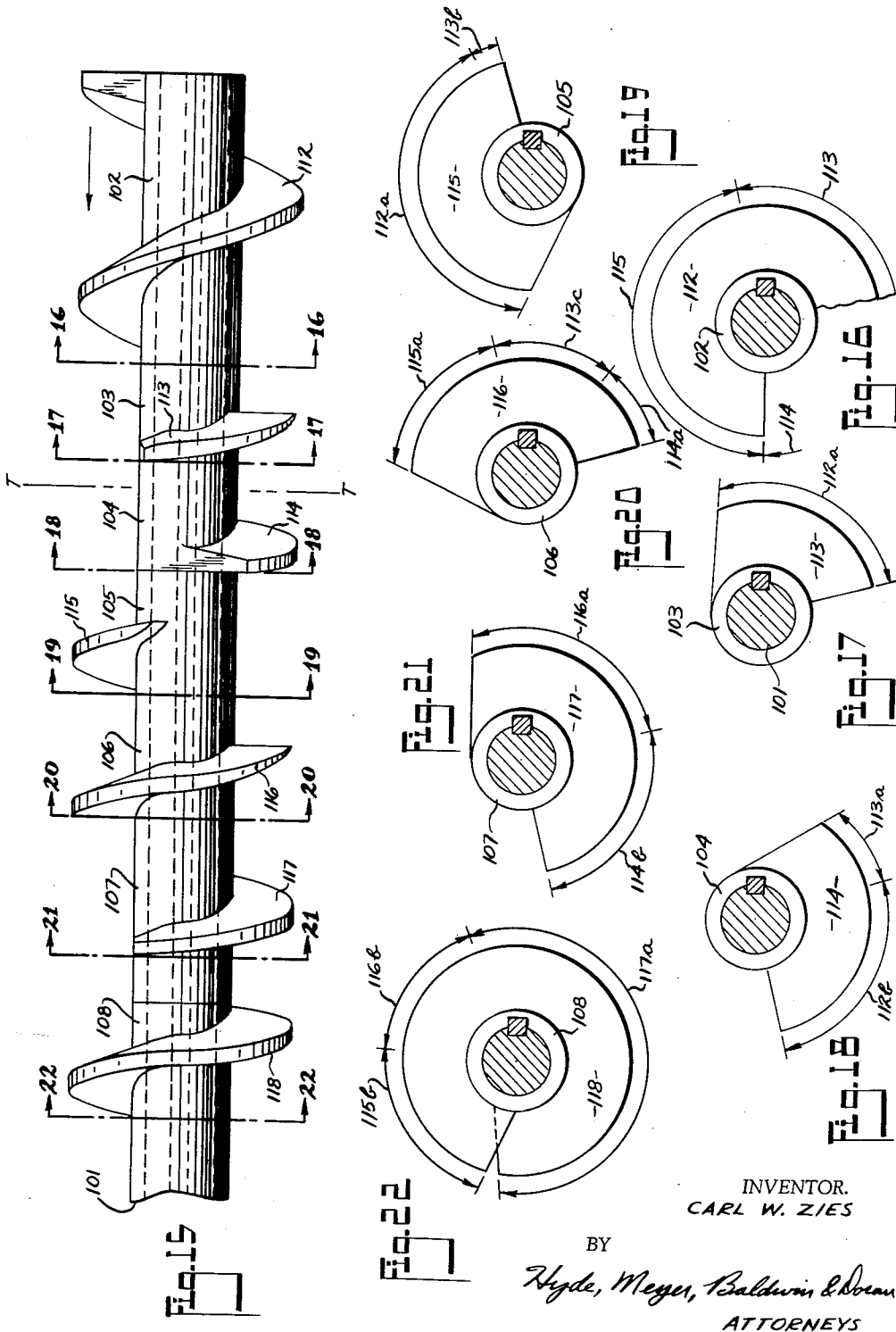
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Filed Sept. 5, 1958

4 Sheets-Sheet 3



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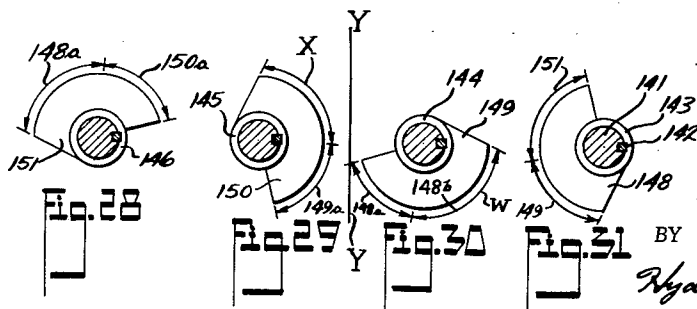
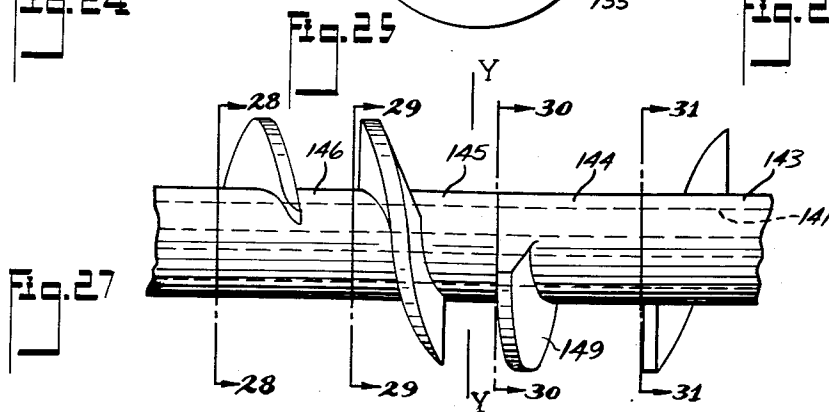
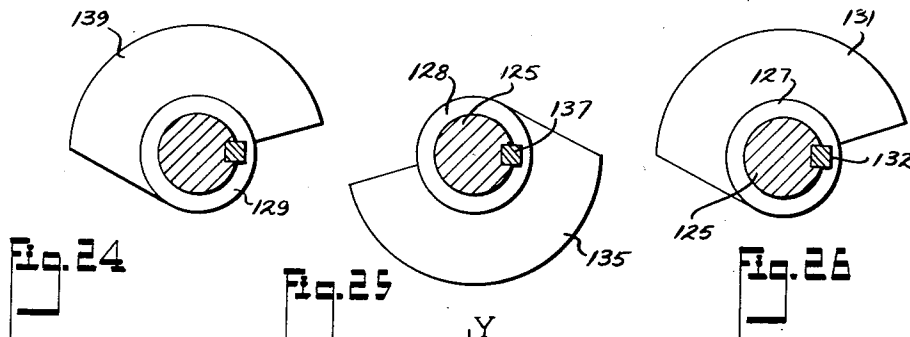
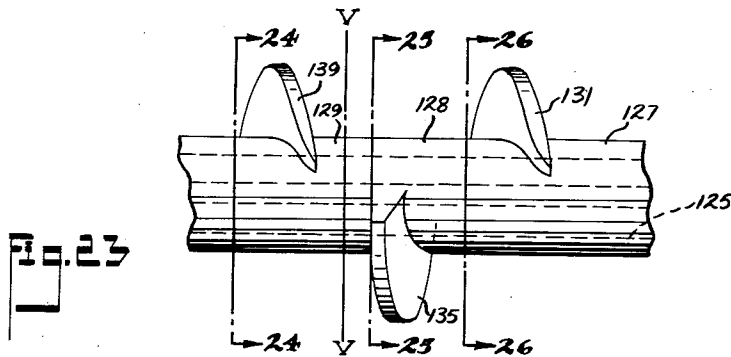
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SCREW PRESS WORM DESIGN

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4 Sheets-Sheet 4



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3,034,424

SCREW PRESS WORM DESIGN

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Filed Sept. 5, 1958, Ser. No. 759,343

3 Claims. (Cl. 100-145)

This invention relates to a mechanical screw press especially designed to process a liquid-bearing material such as oil bearing seeds, wood pulps, or the like for the purpose of extracting the liquid therefrom, and more particularly to a new and improved worm or screw element for use in the same.

In present day mechanically operated screw presses, wherein the liquid bearing material is compressed in a screw press barrel, or in several barrels in tandem, to extract the liquid therefrom, the pressing means in each barrel normally comprises a central shaft having a plurality of worms or helical-shaped flights integral with or attached thereto, each of which has a wrap of approximately 95% or more with respect to the periphery of said shaft.

Each of said elements is usually rotatably mounted on a rotatable shaft disposed axially within a hollow press housing or barrel as aforesaid, and the material to be processed is placed in the latter at its feed end. By rotating said shaft, the worm or helical-shaped flights advance said material through the barrel while at the same time compacting and compressing the same so as to extract the liquid therefrom.

The primary purpose for the use of the worm or screw press is that it is capable of developing preselected high pressures within a range of approximately 1,000 to 20,000 p.s.i., applied directly to the material being processed. Usually, the pressure so applied to the material is gradually increased as the latter is advanced through the press toward its discharge end so as to effect a maximum liquid extraction. As is understood in the art, with the worm element or elements rotating, the thrust developed by any one of the flights thereon is applied to the material being processed so as to ultimately force the same through the barrel in a direction substantially parallel to the worm shaft and against the back face of the next succeeding flight. The vectors of force exerted by the lead face of any one worm flight actually go in all directions into the material, but because of the confining wall of the press housing and the back face of said next succeeding worm flight, said force results in compacting the material between said cooperating flights. One might consider such a system as being somewhat like that of a cylindrical housing equipped at the bottom with a wall to seal off the same and with a plunger reciprocally movable in said housing and exerting a force on a compressible material.

With this construction, a maximum extraction of liquid is realized, whereas a highly compressed, relatively dry material is discharged from the press.

Various constructions of screw presses have been utilized in the past in an attempt to obtain substantially high pressures in order to obtain a maximum extraction of liquid from a liquid bearing material. For example, in one construction a constant internal diameter of press barrel as defined above, has been employed, but the shaft, or the screw flight roots, rotatably mounted thereon is substantially conically tapered so that the volume of the material-containing space is progressively less at the discharge end of the barrel than at the feed end. In still another construction, a tapered shaft and a similarly tapered barrel housing is employed with the taper of each converging toward the discharge end of the latter so as to decrease the volume of material-containing space at the said discharge end with respect to the feed end. Still

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other types of press structures have been utilized, for instance on one type of machine the pitch of the worm flight on the screw conveyor shaft and/or shafts has been decreased toward the discharge end.

In each of the prior art machine constructions referred to above, as well as others known in the art, the wrap of the worms or helical-shaped flights has been substantially 95% or more of the circumference of the screw element shaft.

In the compression of materials having a liquid fraction which it is desirable to efficiently extract, I have found that the extraction problem varies with certain physical characteristics of the material, principally the "pressure tolerance" as I may term it, for want of a term at present sufficiently specific. In justification for this let me say that the term comprehends a certain critical pressure at which material will most readily yield up the maximum amount of its liquid in a continuous screw pressing process at a certain rate of material travel. I have found that this critical pressure will vary with the type of material, and that the critical pressure for cotton seed, for example, is quite different from the critical pressure for meat cracklings, and both of these distinctly differ from the critical pressure for eucalyptus chips.

May I further say that one of the best presses in the prior art for the extraction of liquid comprises two pressure barrels in sequence, the first one feeding a partially compressed mass to the second, and for spacial economy the first press barrel has usually been disposed vertically, so that the lower or discharge end of the vertical barrel feeds directly into the receiving or feed end of the horizontal barrel. This arrangement, while conventional, is not necessarily the only possible one since the first barrel might be inclined at an angle, or even horizontally. In any event the material is partially compressed in the first barrel, accompanied preferably by partial liquid expression and the final pressing, under higher unit pressures, takes place in the second barrel, and particularly near the discharge end of the second barrel.

In order for the second barrel to function efficiently, under what might be considered predetermined conditions (depending on the character of the material being compressed) it is desirable that the first barrel deliver to the second barrel a uniform product, but this was not normally possible with the pre-existing worm design in the first barrel, namely the 360° wrap worm. Under such conditions material was rarely delivered in uniform condition because pressure tolerances varied. Some materials arrived in rather loosely packed form and other materials packed so tightly in the first barrel that the resulting plug could not be forced into the second barrel and some part of the moving elements jammed, or the driving motor became overloaded and stalled.

Commenting again on pressure tolerance, it may be regarded as determining the point up to which, at a particular worm rate of rotation, compression may be increased while still efficiently extracting the maximum amount of liquid in the first barrel, and, as above mentioned, this point varies with the material, with its liquid content, and with the rate of application of increasing pressure on the material.

I have devised a worm flight arrangement for a screw press barrel which will automatically accommodate itself to any type of liquid-bearing solid from which the liquid is to be extracted, and which, though usable in any barrel or sequence of barrels, is of particular advantage in the first pressure barrel of a multi-barrel unit. When material is fed to a pressure barrel equipped with my novel screw arrangement, it will be compacted in a continuously delivered uniform condition at the discharge end of the barrel. As heretofore indicated, this barrel may be the only one operating in the process, but more usually, and

preferably, it will be the first barrel of two pressure barrels or housings.

A primary object of the invention, therefore, is the provision of a novel and improved helical worm assembly for use on a rotatable shaft in a continuous press barrel, and wherein the worm flight arrangement is such that the pressure build-up will not exceed the pressure tolerance of the material, having in mind the most efficient compaction and liquid extraction.

Another object of the invention is to provide a screw flight arrangement as defined in the last preceding paragraph, whereby there is afforded a rearward pressure relief path of tortuous character, and whereby pressure build-up beyond a desirable critical point is avoided.

A further object of the invention is to provide a screw flight arrangement as defined in the last two preceding paragraphs which is especially adapted for use in the first pressure barrel of a multi-barrel assembly.

A further object of the present invention is the provision of a new and improved helically shaped worm or screw element especially designed for use with a continuous mechanical press machine or the like and wherein said worm may consume or absorb only a predetermined limited portion of the working effort applied by the prime power source of said machine and hence prevent an overloading of the same.

A further object of the present invention is the provision of a new and improved helically shaped worm or screw element especially designed for use with a continuous mechanical press machine, or the like, and wherein the said worm is capable of applying predetermined increments of pressure upon a compressible material being processed in said machine.

Still another object of the present invention is the provision of a new and improved worm or screw element especially designed for use with a mechanical press machine or the like, and wherein said worm is provided with a plurality of individual discontinuous helically shaped flights, the wrap of each of which with respect to the periphery of its mounting shaft is preferably within the range of 20-80%.

Another object of the present invention is the provision of a new and improved worm or screw element especially designed for use with a mechanical screw press or the like and wherein said worm is provided with a plurality of individual discontinuous helically shaped flights, each of which has a preselected wrap preferably within the range of 20-80% of the periphery of its supporting shaft, and wherein said worm is further characterized by having each of said flights placed in a predetermined location along its shaft length to provide for an increase and/or decrease in the pressure applied thereby, at any predetermined point along said shaft, to a compressible material being processed by said machine.

Still another object of the present invention is the provision of a new and improved worm or screw element for a mechanical press as referred to in the above objects, and further characterized by having the extent of peripheral wrap of the plurality of individual discontinuous flights relatively extensive at the feed end of the conveyor shaft and thence progressively decreasing toward its discharge end.

Yet another object of the present invention is the provision of a new and improved worm or screw element for a mechanical screw press or the like as above referred to, and wherein the extent of wrap of the plurality of individual discontinuous flights is relatively limited at the feed end of the conveyor shaft and thence progressively increases toward its discharge end.

Another object of the present invention is the provision of a new and improved worm or screw element especially designed for use with a mechanical screw press, and wherein the worm is provided with a plurality of individual discontinuous helically shaped flights, the wrap of each of which extends substantially 50% or 180°

around the periphery of the mounting shaft of said worm and further characterized by having each of said flights displaced on said shaft approximately 180° from the next adjacent flights on either side thereof.

Still another object of the present invention is the provision of a new and improved worm or screw element especially designed for use with a mechanical screw press or the like, and wherein the worm is provided with a plurality of individual discontinuous helically shaped flights, the wrap of each of which extends substantially 180° around the periphery of the mounting shaft of said worm, and further characterized by having the leading edge of each of said flights displaced on said shaft approximately 90° from the leading edge of the next adjacent flights on either side thereof.

Additional objects and advantages of the worm or screw arrangement of the present invention will be realized by one skilled in the art to which it pertains upon reference to the following disclosure of several preferred embodiments which are illustrated in the accompanying drawings forming a part of this specification, and wherein:

FIG. 1 is a view of a conventional mechanical screw press with parts thereof in vertical section to show otherwise hidden parts of the several conventional worm or screw elements utilized therein;

FIG. 2 is a longitudinal elevational view of one embodiment of worm or screw element embodying the present invention and which may be adaptable to either one of the barrel elements shown in FIG. 1, but preferably to the vertical barrel.

FIGS. 3-14 are sectional views taken substantially on the corresponding section lines of FIG. 2 and illustrate the various degrees of wrap and the circumferential angular placement of each of the flights on the worm element;

FIG. 15 is a longitudinal view in side elevation of a second embodiment of worm element arrangement embodying the present invention;

FIGS. 16-22 are sectional views taken substantially on the corresponding section lines of FIG. 15, and illustrate the various degrees of wrap and the positional interrelationship of the flights on the shaft shown therein;

FIG. 23 is a fragmentary view in side elevation of a third embodiment of worm element arrangement embodying the present invention;

FIGS. 24-26 are sectional views taken substantially on the corresponding section lines of FIG. 23, and shows still another form of wrap arrangement for each of the flights thereof;

FIG. 27 is a longitudinal fragmentary view in side elevation of a fourth embodiment of worm element embodying the present invention; and,

FIGS. 28-31 are sectional views taken substantially on the corresponding section lines of FIG. 27 and shows the extent and disposition of wrap for each of the worm flights of FIG. 27.

Before describing in detail the several embodiments of worm or screw elements of the present invention, one common example, which illustrates the practice of this invention, as distinguished from screw presses of the prior art, is the difference in results attainable by using a positive displacement pump versus that of a centrifugal pump in a closed fluid system. If a positive displacement pump, for example a piston pump or a gear pump, is employed to move a liquid from one point to another through a pipe line of a fluid system under pressure, disregarding frictional resistance, the positive displacement pump will continue to force liquid through the pipe. If it is assumed that the pipe line is provided with a terminal valve, and further if it is assumed that the valve is slowly closed, the pressure within the pipe line will slowly increase. By a further closing of the valve, pressures may be attained within the system whereby the pipe line itself may burst, the positive displacement pump may fail, or the power source driving the

pump such as a motor, may become overloaded and stall. Thus it is with the continuous mechanical screw presses presently known and developed in the art which utilize worm or screw elements having helical flights thereon whose wrap extends substantially 95% or more of the circumference of the element supporting shaft. On the other hand, continuing the present analogy, if a centrifugal pump is used in the same system, as described above, in place of the positive displacement pump, and if the valve as referred to is slowly closed, the pressure within the system also increases. The centrifugal pump continues to deliver liquid to the terminal valve until a certain limiting pressure is reached. At that point the amount of liquid furnished by the centrifugal pump to said system begins to decrease with increasing pressures until a pressure is reached at which the pump continues to operate, but does not displace the liquid which is agitated but not advanced. In contradistinction to the screw presses of the prior art, the new and improved worm element of this invention permits a continuous mechanical screw press to be operated or to be designed and controlled more in the fashion of the centrifugal pump, except that the system is designed to stop material movement within the press.

Referring now to the drawings wherein like elements are identified throughout the drawings by the same reference character, the screw press herein shown in FIG. 1, is of conventional construction, and illustrates, merely for purposes of disclosure, one preferred type of machine adapted to utilize the novel and improved worm elements of the present invention in the process of extracting a predetermined amount of liquid from a liquid-bearing material. Other possibilities applicable to the instant form of worm element arrangement will be familiar to those skilled in the art.

The screw press shown in FIG. 1 includes a base 2 supporting feeding means thereabove, which in its present form comprises a horizontal rotatable shaft 10 carrying a helical worm 11, the shaft and worm being enclosed in a tubular housing 12 which has a feed opening 13 at the receiving end thereof. Oil-bearing material dropped through opening 13 as shown by the arrows 13a is carried to the right and discharged into a vertical cylindrical chute 14 communicating with the housing 12 and which has a vertical shaft 15 rotatably mounted therein, having thereon substantially continuous screw flights 16 which are adapted to force the material downwardly therethrough. Conventional drive means is provided for shafts 10 and 15. Shaft 10 is driven from cooperating sprockets 17 and 17a which in turn are operated by a motor as indicated at 19, the latter being supported above the machine base 2 by any suitable structural members as indicated at 19a. The drive of shaft 10 does not require much power since loose material is merely being advanced laterally into chute 14 where incipient pressure begins to be applied. Vertical shaft 15 is driven from motor 20 through a gear reduction train in housing 21, the latter being mounted on top of the aforesaid chute 14 and likewise supporting the motor 20 thereabove. This driving train is of conventional design and therefore is not shown herein in detail.

Forming a downward continuation of chute 14 are two vertical barrel sections 22 and 23 which are coaxial and coextensive with chute 14. The lowermost end of barrel section 23 is rigidly attached to the base 2 of the machine. Shaft 15 continues downwardly through barrel sections 22 and 23, and carries thereon a plurality of screw hubs or collars as identified by the reference character 24, each having its respective helical screw flight 25 thereon, the periphery of which closely approaches the inner face of the barrel wall, in addition, the wrap of each of said flights is seen to extend substantially 95% or more, around its respective hub or collar. Said shaft, hubs and screw flights comprise one form of worm or screw element known in the art. In accordance with

the present invention, the individual worm flights may be inventively modified as hereinafter described.

Adjacent the lower end of the vertical barrel 23 there is here shown an imperforate collar 27 located directly below the end of the lowermost hub on the shaft 15.

From the vertical barrel 23, the partially compacted material is delivered to a horizontal barrel 29, the general construction of which is herein shown to be somewhat similar to the construction of the aforesaid vertical barrel. The barrel 29 connects at its right end or charging end with barrel 23 just below the collar 27, carried within the latter. A shaft 31 is rotatably mounted therein, the same extending centrally longitudinally therethrough, and being suitably journaled at its ends within bearing supports as indicated at 32. The shaft 31 is provided with a plurality of interrupted helically shaped worm flights 33, the pitch of which becomes successively less as the same progresses toward the left end of said supporting shaft. In addition, as is seen in FIG. 1, the wrap of each of said latter flights extends substantially 95% or more around the circumference of the shaft 31. The drive for said shaft includes the motor 34, supported above and upon the base 2 of the machine by means including stanchion 35, the motor being drivingly connected to the right end of shaft 31 by means of a suitable gear train supported in housing 37 on the adjoining end of the machine base.

Having thus far described a conventional construction of screw press as shown in FIG. 1, the liquid-bearing material to be processed, is carried downwardly and initially compressed by the flights 16 on the shaft 15 and then delivered to the flights 25 carried on the lower end of the said shaft. As the material is advanced through the barrel sections 22 and 23, the pressure developed by said flights is gradually increased. As a result, said material is partially compacted at the lowermost end of the shaft 15 whereby some of the liquid is extracted therefrom.

The screw press continues its operation, and the material is advanced and projected into the confines of the collar 27 which is directly below the shaft 15 and which also communicates with the charging end portion of the horizontal shaft 31 in the second barrel. The material, at this stage in the process, may have been compacted sufficiently to be termed a material plug.

With the shaft 31 rotatably driven by its motor 34 clockwise, as viewed from the right end of the machine in FIG. 1, the material, as thus deposited in the collar 27, is scraped off and picked up by the flights 33 on the latter shaft and thence carried by the horizontal screw flights toward the discharge end of the second barrel. As said material is thus moved, and since, in the instant machine the pitch on the aforesaid flights 33 also usually becomes progressively less, said material is further compacted so as to extract additional liquid therefrom. Knife bars as indicated at 38 may also be mounted in the barrel 29 and extend radially inwardly in the spaces between screw flights so as to prevent compacted material from merely rotating with the shaft 31.

The material thus compacted, and from which most of the liquid has been extracted, is discharged through an aperture (not shown) of a choke assembly 40 located on the left end of the shaft 31, said aperture being variably regulated to obtain a predetermined pressure on said material. The structural and operational details of one embodiment of choke assembly similar to that herein shown is fully described in U.S. Patent No. 1,752,054 to Raymond T. Anderson. Briefly this type of choke assembly includes a worm as seen at 41 in FIG. 1 which produces co-acting rotation of a peripheral gear in housing 42, which through the operation of further cooperating parts results in a change in the diameter of the aforesaid escape aperture or opening, somewhat similar to the operation of an iris diaphragm. In this manner, any preselected pressure may be provided in an attempt

to extract the greatest volume of liquid from said liquid-bearing material.

In the conventional screw press machine of the type just described, wherein the wrap of each of the flights on the worm element or elements is substantially 95% or more of the circumference of the element shaft, the forces generated thereby are of such magnitude that the processed material oftentimes is compacted to such a degree in one or other of the barrels that it opposes the action of said worm elements in advancing the same toward the discharge end and hence said press becomes inoperative.

In the disclosure now to follow relating to the new and improved worm or screw element of the present invention, the novel phases of which will be described in detail, it will be apparent that the disadvantages of the prior art constructions, as hereinabove described, have been overcome, and that the improved construction is capable of continuously processing substantially large quantities of liquid bearing materials without effecting the overloading and/or stalling of the press.

Referring now particularly to FIGS. 2-14, inclusive, of the drawings, one preferred embodiment of worm element arrangement of the present invention is shown, and is preferably substituted for the vertical elements as the same are seen in the conventional screw press of FIG. 1.

More specifically, the present embodiment of my invention comprises a cylindrical shaft 51 which is adapted to have its upper part rotatably journaled within a bearing carried within the chute 14 of the conventional screw press of FIG. 1 such that its adjoining upper end, as indicated by the splines 53, is operatively connected by means of coupling 54 to the aforesaid gear train in housing 21. A plurality of bored collars or hubs 56-66 inclusive, are threaded over the shaft 51 in tandem fashion, and in end-to-end contact, and are each in turn integrally provided with a helical worm flight. The particular characteristics and configurations of each of said flights and the manner in which the same are located axially on the said collars to effect the desired results will now be described.

As seen in FIGS. 2-4 inclusive, the collar 56 is integrally formed with a continuous helical flight 71. The collar 56 is preferably located on the aforesaid shaft 51 such that the flight 71 is substantially adjacent the delivery end of the helical worm 11 on the shaft 10. As also herein shown, the pitch of the present form of helical flight 71 may decrease as the helix of the same is developed downwardly along its collar 56 whereby to exert an increasing component of thrusting or propelling force on the material being processed. As seen in FIGS. 3 and 4, the shaft 51 and collar 56 are preferably formed with complementary key grooves 72 which define a rectangular keyway adapted to receive a key 73 so that the said collar will rotate with the shaft.

With reference now directed to FIGS. 2 and 5, collar 57 is located on the shaft 51 in vertical juxtaposition to the aforesaid collar 56, and is integrally provided with a partial helically shaped flight 74. As seen particularly in FIG. 5, the wrap of the flight 74 extends approximately 216° about the circumference of the collar 57 or has what is defined in the art as approximately a 60% wrap, the helix of said flight being developed so as to project in a clockwise direction looking downwardly along said shaft. Collar 57 is also suitably keyed to the shaft 51 as is collar 56 so as to be rotatable therewith.

In like manner, collar 58 is located below the aforesaid collar 57, the adjoining ends thereof preferably abutting each other. Collar 58 is also provided with a helically shaped flight 75, the wrap of which is 60% as above defined or extending approximately 216° around the circumference of its supporting collar, the helix of the same being likewise developed in a clockwise direction downwardly along the shaft 51. Collar 58, in addition,

is keyed to the shaft 51 so as to be rotatable therewith.

The remaining collars 59-66 inclusive, each have a helically shaped flight integral therewith, the same being identified in the present instance by the reference characters 76-83, inclusive. As seen in FIGS. 7-11, the flights 76-80 inclusive each have a wrap of approximately 60%, as above defined, whereas, flights 81-83 as seen in FIGS. 12-14, each have a wrap of approximately 30%, or a helical projection of substantially 108° along the circumference of their respective supporting collars 64-66, inclusive.

Beginning with helical flight 75, and thence continuing with every successive flight thereafter, it is seen that the collars or hubs 58-66 are located on the shafts 51 and keyed thereto, in the manner above described, such that any one flight is displaced or advanced approximately 90° circumferentially of said shaft, or in a clockwise direction as viewed in the drawings, FIGS. 3-14 and to thereby locate the leading edge of any one of said partially aligned flights 90° ahead of the last preceding partially aligned flight.

In the structure just described, the fact that a plurality of juxtaposed screw flights have substantially less than a 360° wrap, and that they are staggered or non-aligned with respect to an end view, provides a tortuous passage through which an excess of pressure can be relieved rearwardly toward the entry end. In other words, returning to my terminology as used earlier herein, the flights can be arranged and oriented so that, at the rate of operation of the driving shaft, and bearing in mind the initial liquid content of the material, the pressure will first build up, but will relieve itself rearwardly before the pressure tolerance of the particular material is relieved.

Certain interesting positional and pressure relationships result from the worm flight assembly shown in FIGS. 2 to 14 inclusive.

In the conventional press, as is seen in FIG. 1, the volume of material enclosed between any two adjacent flights, for example the flights 25 in the vertically disposed worm element, partakes the form of substantially a hollow space the contour of which follows the helical projection of the adjacent flights. Hence, with this construction, any liquid bearing material forced into this space between said pairs of adjacent flights is compacted into said spacial configuration. As above mentioned, especially when the pitch between adjoining flights decreases as the discharge end of the flight is approached, and because of the confining nature of the enclosing barrel the material tends to be further compacted, and with no provision for pressure relief, the mass opposes any further action of the worm element. The compacting forces created by any one pair of adjoining flights are actually applied to the material in substantially all directions, but because of the confining walls of the press housing, the forces acting throughout approximately 360° in a direction substantially parallel to the longitudinal axis of the cylindrical volume of said material are applied to compress the same in attempting to extract a maximum quantity of liquid therefrom.

Referring now to the instant embodiment of worm element, it is seen that the first helical flight 71 is substantially continuous for approximately three complete turns about the shaft 51. As above mentioned, this flight is located at the feed end of the element, and its purpose is merely to provide a substantially continuous feeding of the material into the confines of the upper barrel housing 22. The pitch of said flight may therefore be substantially large, as herein shown, so that only incipient low pressures are exerted on the material.

With this in mind, assume that the press is in operation, with the shaft and worm assembly of FIG. 2. Let it be further assumed that FIGS. 2-14, represent the position of the shaft 51 and the various flights supported therein at any one predetermined instant during said

processing period, the relationship between the screw flights being maintained while the shaft remains assembled.

With the above assumed conditions, it will now be seen, with particular reference first to FIGS. 4 and 5, that the cooperating faces of the flights 71 and 74, namely the surfaces of said flights facing each other, which may be referred to hereinafter as the cooperating faces of one compression system will be effective to compress only that volume of material as above defined that lies directly between said surfaces in the axial direction. As seen particularly in FIG. 5, the arrowed segmental line, identified by the reference character 71a, and which extends around the curved edge of the flight 74 also outlines the portion of the flight 71, next above, which, with flight 74, forms the aforesaid compression system. Hence, it is seen that said flights cooperate with each other to compress a column of liquid-bearing material which has substantially a semicylindrical configuration, and one that extends approximately 60% around the circumference of the shaft 51. With the present compression system it is therefore realized that of the total peripheral volume of material which corresponds to the volume that lies between adjoining flight surfaces in the 360° worm element of the conventional screw press, approximately 40 percent in the present embodiment is not compressed by said flights, and is therefore not compacted therebetween. Consequently, the partial wrap of the present operating flights provides a relief for the pressure to a point below the pressure tolerance of the material.

Next, continuing downwardly along the shaft 51, it is seen, with reference being directed to FIG. 6, that flights 75 (which as above defined, is displaced 90° ahead of the flight 74 located thereabove, clockwise about the said shaft) cooperates with both flights 71 and 74 to define two separate compression systems. These two systems are hence effective to process two distinct pressure columns of liquid-bearing material lying in a side-by-side relation, which columns have different lengths measured axially along the shaft 51. The arrowed lead line, identified by the reference character 71b in FIG. 6, denotes the portion of the said flight 71 which cooperates with flight 75 to define one of said compression systems effective to compress a predetermined column of material, the length of which is substantially the same as the distance between said cooperating flights. By a comparison with the aforesaid compression system formed by the flights 71 and 74, it is seen that in the present instance, the column of material compressed between flights 71 and 75 is substantially arcuate in cross sectional configuration and extends approximately 25% around the circumference of the shaft 51. In addition, said column is located next to the previously described material column in a direction that is clockwise about the shaft as viewed in FIGS. 5 and 6.

In like manner, the arrowed lead line, identified by the reference 74b in FIG. 6 denotes the arcuate portion of the flight 74 which cooperates with flight 75 to define the second of the compression systems now under consideration, which second system is effective to exert pressure in the second of the aforesaid distinct columns of liquid bearing material. In this instance, the length of the column is substantially the same as the distance between the flights 74 and 75. By a comparison of FIGS. 5 and 6, it is seen that the column of material which is compressed between the flights 74 and 75 is also arcuate in its cross sectional projection and extends approximately 25% around the circumference of the shaft 51, while being located next to, but in a counterclockwise direction from, the material column formed by flights 71 and 75.

Considering next the flight 76 which, as above mentioned, is displaced substantially 90° ahead of the flight 75 in the direction of their rotation, it is seen with particular reference being directed to FIGS. 4-7, that said flight 76 cooperates with each of the flights 71, 74 and

75, to define in the present instance, three separate compression systems which are also capable of exerting axial force on three separate and distinct columns of material, each of which has a different axial length with respect to the shaft 51. Specifically, with reference to FIG. 7, the lead line identified as 71c denotes the portion of the flight 71 which cooperates with the similarly shaped and axially spaced portion of the flight 76 to define one of said three compression systems effective to process a likewise similarly shaped column of material, the length of which is substantially the same as the distance between flights 71 and 76. With the worm element herein shown, said material column, while being compressed between the cooperating portions of the flights 71 and 76, extends longitudinally along the axis of the shaft 51 and through the opening between the interspaced flights 74 and 75, which opening is defined by the end faces 74a and 75a, respectively, of said flights. Said material column is therefore substantially arcuate in cross sectional configuration and extends approximately 15% around the circumference of the shaft 51, while being located in a clockwise direction next to the material column formed by the flights 71 and 75.

The arrowed lead line 74c in FIG. 7, likewise indicates the arcuate portion of the flight 74 which cooperates with flight 76 to define the second of said three compression systems now under consideration, which system is effective to process a separate and distinct material column whose length is substantially the same as the axial distance between flights 74 and 76. The material column while being compressed between the flights 74 and 76 extends past the flight 75, and in addition, extends substantially 15% around the circumference of the shaft 51.

In like manner, the lead line 75b indicates the portion of the flight 75 which cooperates with flight 76 to define the third of the instant three compression systems which is hence effective to process a material column whose length is substantially the same as the distance between flights 75 and 76. As seen particularly in FIG. 7, the material column thus formed by flights 75 and 76 extends substantially 30% around the shaft 51.

Continuing the present analogy, each of the remaining flights 77-80 inclusive in the present arrangement of worm elements will also cooperate with three preceding flights mounted thereabove on the shaft 51, in the manner described hereinabove, so as to compress three distinct and different columns of material, each of which has a cross sectional configuration that is the same as the cooperating axially aligned portions on the respective cooperating flight faces and a length that is substantially the same as the axial distance between said flights. For example, with reference directed to FIG. 8 of the drawings, the arrowed lead lines 74d, 75c, and 76a indicate the respective portions of the flights 74, 75 and 76 which cooperate with flight 77 to compress material therebetween. The identical notation has been followed throughout the drawings to and including FIG. 11, as to the several remaining combinations of said flights as will be understood by one skilled in the art.

The remaining flights 81-83 inclusive as shown respectively in FIGS. 12-14, each have a wrap of approximately 30% and are each displaced radially of the shaft, one from the other by substantially 90° in a clockwise direction as viewed in said latter mentioned drawings. In addition, the leading edge 81a of flight 81 (FIG. 12) is seen to be displaced approximately 90° ahead of the corresponding leading edge 80a (FIG. 11) of the next above flight 80 in such manner that the surfaces of flight 81 are advanced 90° ahead of the latter flight surfaces.

With reference now directed particularly to FIG. 12, it is seen that flight 81 is oriented to combine with predetermined portions of each of the flights 78, 79 and 80 located thereabove as are identified in FIG. 12 to exert pressure on three distinct columns of material, the length and configuration of each being directly related to the

axial distance between said flights and the extent of the matching surface portions thereof, in a manner substantially similar to that as is hereinabove described for the flights 76-80, inclusive.

In much the same manner, flight 82 also cooperates with portions of the flights 79, 80 and 81, as identified in FIG. 13, to exert pressure on still another three distinct and separate columns of material therebetween, the length and configuration of the same being likewise directly related to the axial distance between said flights and the lateral extent of the matching surfaces thereof.

The lowermost flight 83, as viewed in FIG. 14 hence cooperates with portions of flights 80 and 81 to exert pressure on two distinct and separate columns of material therebetween.

It will now be realized that in the just described arrangement of worm elements, the partial wrap flights are effective to provide a plurality of distinct and separate compression systems which, at any one instant, are spaced around the supporting shaft 51 in a spiral fashion, and in addition, are effective to compress columns of material, each of which has a length corresponding to the axial distance between the associated cooperating flights establishing said columns, a cross sectional configuration of each column being directly related to the surface area that is common in axial projection to said cooperating flights.

The total energy that may be developed by any one worm flight, or in other words, the work in terms of horsepower that may be developed by said worm flight, is a function of the area of the operating surfaces of the same. Therefore in the present form of worm element wherein each of the various flights has a preselected partial wrap of approximately 30% or 60%, by a careful selection of the degree of wrap of the individual worm flights, the total input energy that will be built up by the complete shaft assembly can be readily predetermined. In this manner the energy required to be delivered to the shaft assembly by the prime mover or driving source, as, for example, an electric motor or other available power source, may be more closely predetermined.

It will now be realized that with the preselected partial wrap for the various worm flights as in the instant embodiment of worm element, various magnitudes of compression or compaction forces are developed at any one plane taken transversely of its longitudinal axis. For example, consider for a moment the plane as indicated at P-P in FIG. 2 and assume that a cylindrical volume of material is being processed by worm element 78. It will now be apparent that the maximum compression force (which I will term a first magnitude force) occurs in the material columns that the between the portions of flights 77 and 78; the next largest or second magnitude force being in two separate material columns lying between the pairs of flights 76 and 78; and 77 and 79, the latter columns being spaced approximately 90° one from the other radially of the shaft 51 and also spaced from the first defined material column and on opposite sides of the same. The compression forces at said plane P-P which are of the least or third magnitude and lie in three separate material columns between the pairs of flights 75 and 78, 76 and 79, and 77 and 80, said columns being also spaced approximately 90° one from the other, and interspaced between the aforesaid material columns having the first and second magnitudes of compression forces. It will of course be apparent that the aforementioned compression forces of higher magnitudes will tend to be partially dissipated into the adjacent material columns whose compression forces are of a lower magnitude.

FIGS. 15-22 of the instant drawings, illustrates a second embodiment of worm element assembly of the present invention, and, like the previous form, may also be substituted for either and/or both the conventional worm

elements in the press machine of FIG. 1, although preferably in the vertical barrel.

More specifically, the instant form of worm arrangement consists of a plurality of helically shaped flights, some of which have at least a 95% or continuous wrap as herein above defined, while others have various partial wraps, preferably between 30-60%. In addition, the wrap of said flights is seen to increase toward the discharge end of the worm element.

Referring now particularly to FIG. 15, the shaft 101 has a plurality of flight-carrying hubs or collars mounted thereon, the same being herein identified by the reference characters 102-108, inclusive, the numbers increasing in the direction of material movement.

The collar 102 has a continuous helically shaped flight 112, said collar being mounted on the end of the shaft 101 which may be hereinafter referred to as the feed end of the shaft assembly. With this construction the pitch of said flight is preferably coarse so as to carry the material to be processed longitudinally along the shaft without developing any excess compaction or compression forces. The collar 103 next positioned on the shaft carries a partial wrap helical shaped flight 113 which has a wrap of approximately 30%, as is viewed in FIG. 17 whereas the next positioned collar 104 on said shaft carries a partial helical flight 114, whose wrap is approximately 40% as seen in FIG. 18, said flight in addition being advanced clockwise radially of the shaft substantially 90° from the aforesaid flight 113.

In like manner, the collar 105 carries a similarly shaped flight 115, whose wrap is approximately 50% and which is advanced substantially 180° clockwise about the shaft 101 relative to the previously described flight 114.

The collar 106 next positioned on the shaft 101 likewise carries helical flight 116 whose wrap is approximately 50%, said latter flight being advanced substantially 90° clockwise about the shaft with respect to flight 115.

Continuing along the shaft 101 to the left as viewed in FIG. 15, collar 107 also carries a partial helically shaped flight 117 which, in its present form preferably has a wrap of 60%, being likewise advanced substantially 90° clockwise about said shaft with respect to the aforementioned flight 116.

To complete the characterization of the present form of worm element arrangement, the collar 108 mounted on the left or discharge end of the shaft 101, carries a flight 118 which has substantially a continuous wrap, as is seen more clearly in FIG. 22.

This particular construction of worm element is especially adapted to process materials, such as wet paper pulp or the like, wherein pressures between 100 and 1000 p.s.i. are required to dewater the same to a desired degree.

In the present form of worm element arrangement it is also intended that the pitch of the various flights may be of any predetermined value so as to provide any preselected thrust for the same. For instance, the pitch of the flight 112 at the feed end of the element may be twice that of the pitch of any one of the partial helical flights 113-117. In like manner, the final flight 118 at the discharge end may be reduced in pitch as compared with the preceding partial wrap flights, such that the thrust of flight 118 is a maximum for said element at its discharge end.

Referring now particularly to FIGS. 16-22, wherein I show the relative positions of the various flights on the present form of worm element, it will be realized that flight 113 cooperates with a like portion of the continuous flight 112, as identified by the lead line 112a, to define one compression system which is capable of processing a column of material which is approximately 30% of the particular cylindrical volume lying between the respective planes of said flights.

Continuing toward the discharge or left hand end of the shaft, the next disposed flight 114, as seen in FIG. 18, combines with flights 112 and 113, at the zones iden-

tified by the respective lead lines 112b and 113a, to define two separate compression systems, each of which is effective to process a column of material having a cross sectional configuration corresponding to the cooperating projected surfaces of the associated flights and a length that is substantially the same as the axial distance between said flights.

The next flight 115 which is advanced 180° clockwise around the shaft 101 relative to the flight 114, as viewed in FIGS. 18 and 19, hence cooperates directly with flight 112, at the zone indicated by reference character 112c and less directly with flight 113 at the zone identified by reference character 113b to define still another two distinct compression systems each of which is effective to process a material column of corresponding configuration and length.

The flight 116 next disposed on the shaft 101, cooperates with corresponding portions of each of the flights 113, 114 and 115 at the zones indicated at 113c, 114a, and 115a respectively to define three distinct compression systems, each of which is likewise effective to process a material column of corresponding configuration and length.

Flight 117 and the next disposed continuous flight 118 are each positioned to cooperate as herein shown with the combination of flights 114 and 116, and 115, 116 and 117, as seen at 114b and 116a, and 115b, 116b and 117a, respectively to define in each instance a group of two and a group of three separate compression systems which likewise process columns of material whose shape corresponds to the configuration and distance between the individual associated flights.

The discharge surface of the continuous wrap flight 118 will hence cooperate with the choke device, as above referred to, to provide a maximum thrust on the material therebetween.

With this particular assembly of worm elements, it is now apparent to those skilled in the art, that the flights 113 and 114 which have a 30% and a 40% wrap, respectively, are able to develop less total thrust on the material being processed than the flights 115 and 116 which have a 50% wrap and flight 117 which has a 60% wrap.

If a material, such as a paper pulp, is being dewatered in the vertical barrel of the apparatus such as is shown in FIG. 1 using the novel press assembly of the present embodiment, the 30% and 40% wrap flights 113 and 114 which are located adjacent the feed end of the element hence exert less compacting action on the pulp at a stage of the dewatering operation where the pulp requires low pressures to attain effective dewatering, or, as I have chosen to say, within the pressure tolerance of the material. As the material is advanced by the worm element the dewatering increases along the length of the shaft since the wrap of the flights is increased to 50% and 60% and is effective to exert a greater total thrust on the pulp and, therefore, greater dewatering results. In the dewatering process, by the time the pulp has reached the final worm flight 118, much higher pressures are required to be applied to the pulp for final dewatering.

As is now apparent, the present form of worm arrangement is also capable of developing various magnitudes of compression and compaction forces at any one transverse plane taken along its axis. For example, at the plane indicated by the line T—T in FIG. 15, the flights 112 and 113 are hence capable of compressing a material column of approximately 30% of the cylindrical volume of material extending therebetween by forces of first magnitude, as above defined, whereas flights 112 and 114 are capable of compressing an adjoining material column, extending approximately 15% around the shaft, with a force of the second magnitude while flights 112 and 115 compress a material column of approximately 45% of said cylindrical volume with a force of the third magnitude. It is therefore apparent that the aforesaid forces of higher magnitude will tend to extend into the

material columns acted upon by forces of a lesser magnitude, and hence provide for the continual operation of the worm element. Also, if the composite or sum total pressure begins to exceed the pressure tolerance of the material, said pressure begins to relieve itself rearwardly through the tortuous path represented by the wrap interruptions of each flight.

FIGS. 23–26 illustrate another preferred form of worm contour and assembly encompassed by the present invention, wherein a plurality of partial wrap flights are carried on a supporting shaft such that any one adjacent flight is displaced circumferentially about said shaft substantially 180° from the flight and/or flights adjoining thereto.

Specifically, with reference directed particularly to FIG. 23, the worm element herein shown includes a central shaft 125 mounting a plurality of cylindrical collars, only three of which are shown and identified by the reference characters 127–129 inclusive. Each of said collars is preferably integrally formed with a helical shaped flight, the wrap of which extends approximately 50% or 180° around the circumference of the shaft 125.

With reference directed particularly to FIGS. 24–26, inclusive, it is seen that collar 127, carrying flight 131, is keyed at 132 to the shaft 125 such that said flight is displaced approximately 180° circumferentially about the said shaft from the flight 135 carried on the next disposed collar 128, the latter also being similarly keyed to the shaft, as seen at 137. In like manner, collar 129 mounted next to the aforesaid collar 128, and which carries flight 139, is suitably keyed to the shaft 125 as seen at 140 in FIG. 24, so as to position said flight 180° from the flight 135. Hence, in this manner flights 131 and 139 are each located on substantially the same side of the shaft 125, since they are each displaced 180° circumferentially about said shaft from flight 135 located therebetween. Consequently, flights 131 and 139 are each in substantial alignment longitudinally of the aforesaid shaft 125.

Although not shown, it is intended that the construction of the remaining portion of the shaft assembly be developed in the identical manner to that as just described whereby every flight is displaced approximately 180° circumferentially around the supporting shaft 125 from the next adjoining flight and/or flights. And, if desired, the pitch of the flights, as the worm element is developed toward its discharge end, may be reduced so that the thrust of the same may be increased in the same manner as above described.

With this particular construction the instant embodiment is also capable of developing predetermined finite magnitudes of compression and compaction forces to effect the most efficient extraction of a liquid from a liquid bearing material without creating undue stress upon or overloading the driving mechanism for the same, and without exceeding the pressure tolerance of the material. And, as will also be realized, with the flights being located in the manner just described, the instant worm element is capable, at any one instant, of directly compressing distinct columns of material within the semi-cylindrical volume between adjoining flights, and whose cross sectional configuration is substantially the same as the arcuate shape of the aforesaid flights.

In FIGS. 27–31, I have shown another embodiment of worm element, taking still another structural form, which partakes of the same inventive concepts of this invention as are hereinabove defined.

Specifically, this form of worm element assembly comprises a central supporting shaft 141 which supports a plurality of cylindrical collars, only four of which are indicated in FIG. 27 by the reference numerals 143–146, inclusive. Each of said collars is integrally formed with a helically shaped flight, the wrap of which also extends approximately 5% around the circumference of the supporting shaft 141 in substantially the same manner as in

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the next previous embodiment. However, in the present construction the aforesaid collars are keyed to said shaft as is indicated at 142, such that any one flight is displaced approximately 90° circumferentially around the shaft from any adjoining flight and/or flights.

For example the flight 148 carried on collar 143 is advanced substantially 90° ahead of the next disposed flight 149 on collar 144 in a clockwise direction as seen in FIGS. 30 and 31. In like manner, the last mentioned flight 149 is advanced 90° ahead of the next succeeding flight 150 carried on the collar 145, also viewing the same in a clockwise direction as seen in FIGS. 29 and 30. In similar fashion the latter flight 150 is advanced 90° ahead of the next succeeding flight 151, the relation therebetween being seen in FIGS. 28 and 29. The remaining partial wrap flights not shown in the fragmentary illustration of worm element as seen in FIG. 28, are developed in the same manner as herein described such that each flight has a partial wrap of substantially 50% and is also displaced 90° circumferentially around its supporting shaft 141 from any one of its adjoining flight and/or flights.

It is also intended in the present form of shaft assembly that the pitch of the flights, as the said assembly is developed toward its discharge end, may be suitably reduced such that predetermined quantities of thrust are applied to the material being processed at preselected positions along the axis of the supporting shaft.

With this particular construction, it will now be apparent upon referring to FIGS. 28-31 inclusive, that at any one predetermined instant during the processing cycle of said element, a predetermined part of the flight 148 combines with a part of the next disposed flight 149, as is identified by the reference numeral 148a in FIG. 30, to define a compression system capable of developing compression and compaction forces of first magnitude which is effective to process a column of material of approximately 25% of a cylindrical volume extending longitudinally along the shaft 141 between said flights. At the same time, the remaining part of the aforesaid flight 148 as seen at 148b cooperates with a corresponding part of the flights 151 to define a second compression system which is operative to process a material column of approximately 25% of said cylindrical volume, and which adjoins the previously described material column while having a length longitudinally of the barrel which is substantially the same as the distance between said flights.

Considering next the flights 149 in FIG. 30 a part thereof cooperates with the adjoining flight 150 toward the discharge end of the element, the corresponding portion of which is identified by the lead line 149a in FIG. 29, to define another system capable of developing first magnitude forces of compression which are likewise operative upon a material column disposed therebetween and which extends approximately 25% around the circumference of the shaft.

The remaining part of flight 150 cooperates with a corresponding surface portion of flight 151, the same being identified by the lead line 150a in FIG. 28, to develop compression forces of first magnitude, likewise operable on a material column of approximately 25%, as above defined.

It is now realized that in the present construction of worm element, any one flight that has a flight adjoining thereto on both of its sides longitudinally of the supporting shaft 141, for instance flight 149, cooperates with both of said adjoining flights, in the present instance with flights 148 and 150 respectively, to develop compression forces therebetween which are of the first magnitude, the respective material columns processed thereby being longitudinally spaced along the shaft 141. Said material columns are also seen to be spaced approximately 90° one from the other circumferentially of the said shaft, and to have a cross sectional disposition also extending approximately 25% around the said shaft.

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It will be also apparent that any one flight, for instance flight 148, will cooperate with the third flight spaced therefrom on the shaft 141 toward the discharge end of the element, such as flight 151, to develop compression forces of the third magnitude, as previously defined. Each of the adjoining flights 149 and 150 also combines with a part of the third flight (not shown) spaced therefrom, being identified by the reference letter W and X respectively, to develop third magnitude forces.

Hence, it is realized that the instant form of worm element is capable of developing various magnitudes of compression and compaction forces at any one transverse plane, such as the plane indicated by the line Y-Y in FIG. 27. Assuming that a cylindrical volume of material is being processed by the present element, it will be seen that at said transverse plane, a material column of approximately 25% of said volume will be acted upon by first magnitude forces created by flights 149 and 150, while a similar shaped column of said material volume which is disposed alongside the last mentioned column will be acted upon by forces of third magnitude which are created by flight 149 and a flight (not shown) which is carried on the shaft 141 next to the flight 151 on the side thereof toward the discharge end of the shaft.

It will also be realized that a material column of approximately 25% of said volume, which is located on the opposite side of the first mentioned column of material, is acted upon by forces of third magnitude created by cooperating portions of flights 148 and 151. Finally, a material column of approximately 25%, which peripherally completes the cylindrical volume of material, is acted upon by corresponding parts of the flight 150 and a flight (not shown) located on the shaft 141 next to the flight 148 on the side thereof toward the feed end of the element, which develop forces of third magnitude therebetween.

Therefore, it is now apparent that the forces of higher magnitude will tend to be dissipated into the material columns being processed by forces of a lesser magnitude and hence prevent the material from being compacted to a degree whereby the same might oppose the continual operation of the element.

It will also be apparent that if the pressure tolerance of the material is exceeded, the pressure can relieve itself rearwardly through the tortuous path afforded by the less-than-60° wrap of the individual worm flights.

It is understood that this invention is not to be restricted to the specific embodiments described herein, nor to any specific combination of partial wrap worm flights and full wrap worm flights, nor to the specific degree of wrap of worm flight as is herein shown, it being here emphasized that various degrees of wrap and combinations of worm flights may be required under different circumstances of operation, with different materials or moisture contents. Likewise, this invention is not intended to be limited to any special disposition of partial wrap worm flights on a shaft, nor is it intended to limit the invention to the embodiment of any specific range of pressures herein disclosed, it being obvious that operating pressures may vary over a wide range, depending upon the specific raw material being processed, the rate of operation, the moisture content, and other operating factors.

What is claimed is:

1. In a mechanical screw press of the class described having at least one housing in which a liquid bearing material is processed and choke means in communication with the discharge end of said housing effective to provide a predetermined outlet pressure on said liquid bearing material within the pressure tolerance of said material, a worm flight assembly mounted in said housing and operable to forcibly compress and propel said material through said housing, comprising a shaft rotatably mounted in said housing and extending longitudinally therethrough, a plurality of individual screw flights dis-

posed in tandem on said shaft and cooperating with said housing being operative in response to the rotation of said shaft to advance said material longitudinally through said housing, the pitch of said flights being progressively decreased along said shaft in the direction of material movement, at least several of said screw flights being partially in and partially out of longitudinal alignment with each other and each extending helically approximately 200 degrees around said shaft, the leading edge of any one partially aligned flight being advanced 90 degrees around said shaft ahead of the next preceding flight, to define a through passage between any one of said partially aligned flights and the third flight spaced therefrom along said shaft in the direction of material movement whereby the compacting pressure on said material may be rearwardly relieved therebetween, thereby maintaining said outlet pressure within said pressure tolerance of said material.

2. A mechanical screw assembly as defined in claim 1 and wherein at least some of the screw flights each extend helically approximately 100 degrees around said shaft and are spaced one from the other peripherally about the latter at least 90 degrees.

3. In a mechanical screw press of the class described having at least one barrel housing in which a liquid bearing material is processed and choke means in communication with the discharge end of said housing effective to provide a predetermined outlet pressure on said liquid bearing material within the pressure tolerance of said material, a worm flight assembly mounted in said housing and operable in cooperation therewith to forcibly compress and propel said material through said housing comprising a shaft rotatably mounted in said housing and extending longitudinally therethrough, a series of indi-

vidual screw flights disposed in tandem on said shaft and operative in response to the rotation of the same to advance said material longitudinally through said housing, the pitch of said flights being progressively decreased along said shaft in the direction of material movement, a first group of successive flights of said series extending helically approximately 200 degrees around said shaft and a second group of successive flights located juxtaposed on said shaft from said first group extending helically approximately 100 degrees around shaft, the leading edge of any one partially aligned flight being advanced 90 degrees around said shaft ahead of the next preceding flight, to define a through passage between any one of said partially aligned flights and the third flight spaced therefrom along said shaft in the direction of material movement whereby the compacting pressure on said material may be rearwardly relieved therebetween, thereby maintaining said outlet pressure within said pressure tolerance of said material.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,034,424

May 15, 1962

Carl W. Zies

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

Column 11, line 53, for "the", second occurrence, read -- lie --; column 14, line 74, for "5%" read -- 50% --.

Signed and sealed this 25th day of September 1962.

(SEAL)

Attest:

ERNEST W. SWIDER
Attesting Officer

DAVID L. LADD
Commissioner of Patents