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[33] **Switzerland**  
[31] **5387/69;**  
**Feb. 5, 1970, Switzerland, No. 1778/70**

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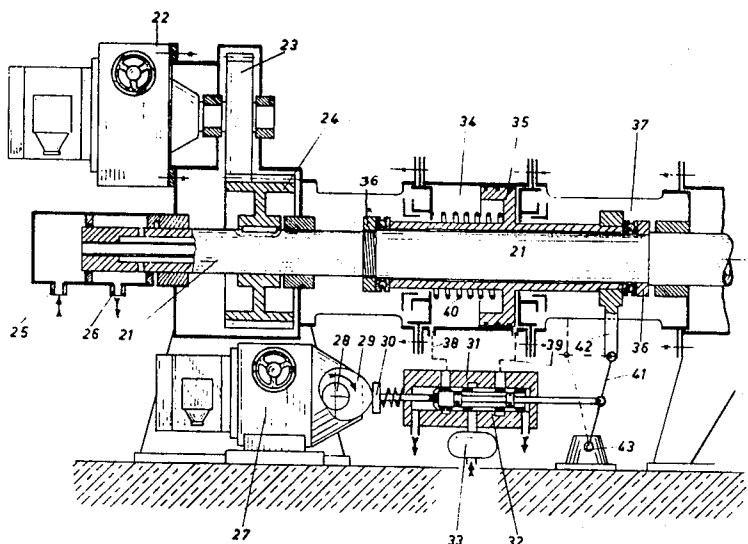
[54] **MIXING AND KNEADING DEVICE**  
**16 Claims, 6 Drawing Figs.**

[52] U.S. Cl. .... **259/102,**  
**259/5, 259/21, 259/40, 15/746.5**  
[51] Int. Cl. .... **B01f 7/00**  
[50] Field of Search .... **259/213,**  
**4-9, 16, 21-26, 102, 32-35, 40-45, 64-70, 17, 27,**  
**47, 52, 59, 79, 93, 112, 123, 111; 15/246.5**

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**ABSTRACT:** A mixing and kneading device comprising a housing and a shaft mounted therein. The shaft carries a conveyor helix and mixing and kneading vanes. The vanes cooperate with stationary elements in the housing to carry out the kneading and mixing functions. The shaft is rotated by a variable speed rotary motor and is also reciprocated to move the vanes toward and away from the stationary elements by a pressure fluid motor having its piston connected to the shaft. The rate of reciprocations of the piston and shaft is cyclically controlled by a valve device which is actuated by a cam driven by a variable speed motor to thereby vary the number of reciprocations during a revolution of the shaft. A second valve device regulates the flow of pressure fluid during a cycle to reduce or stop the flow of fluid to the piston near the end of the shaft's stroke toward the stationary elements.



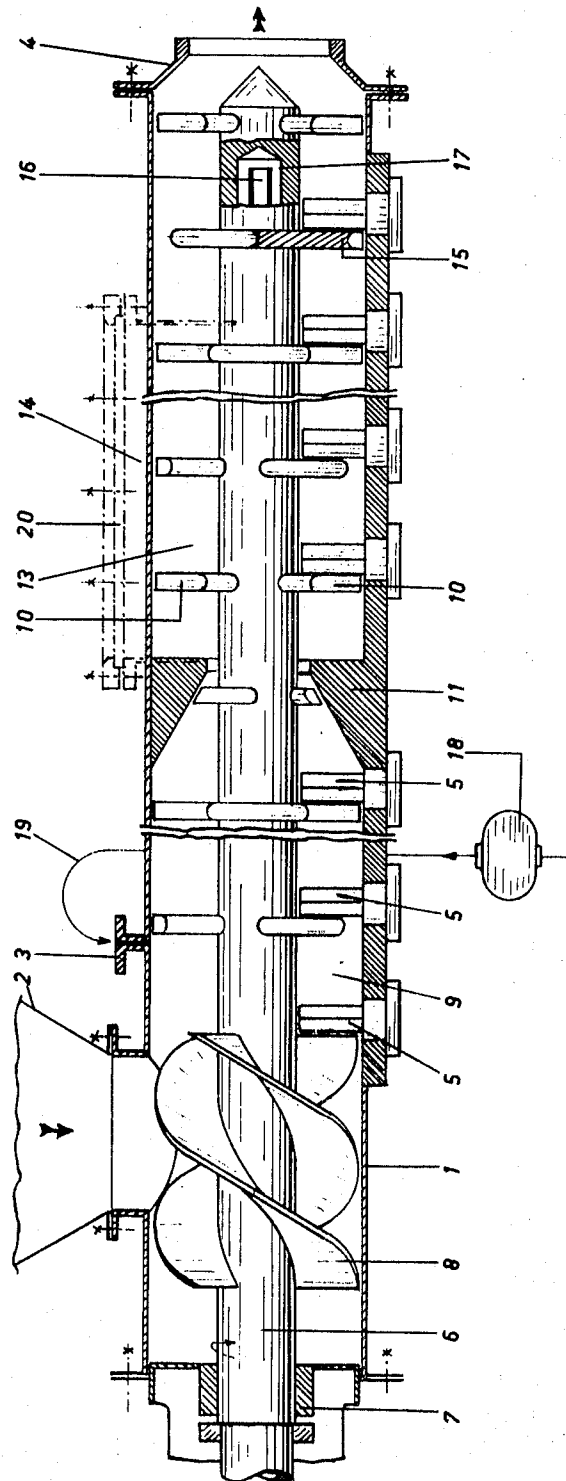


Fig. 1

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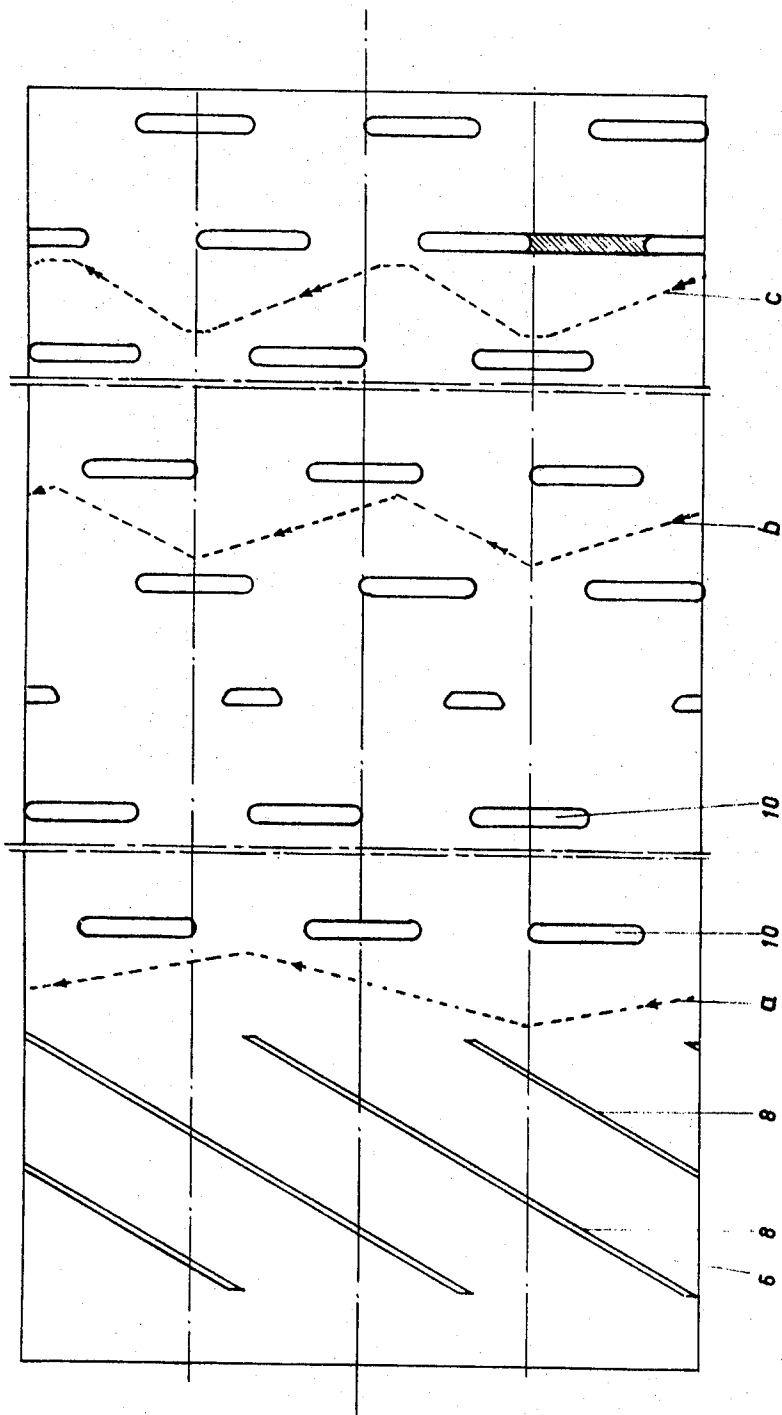


Fig. 2

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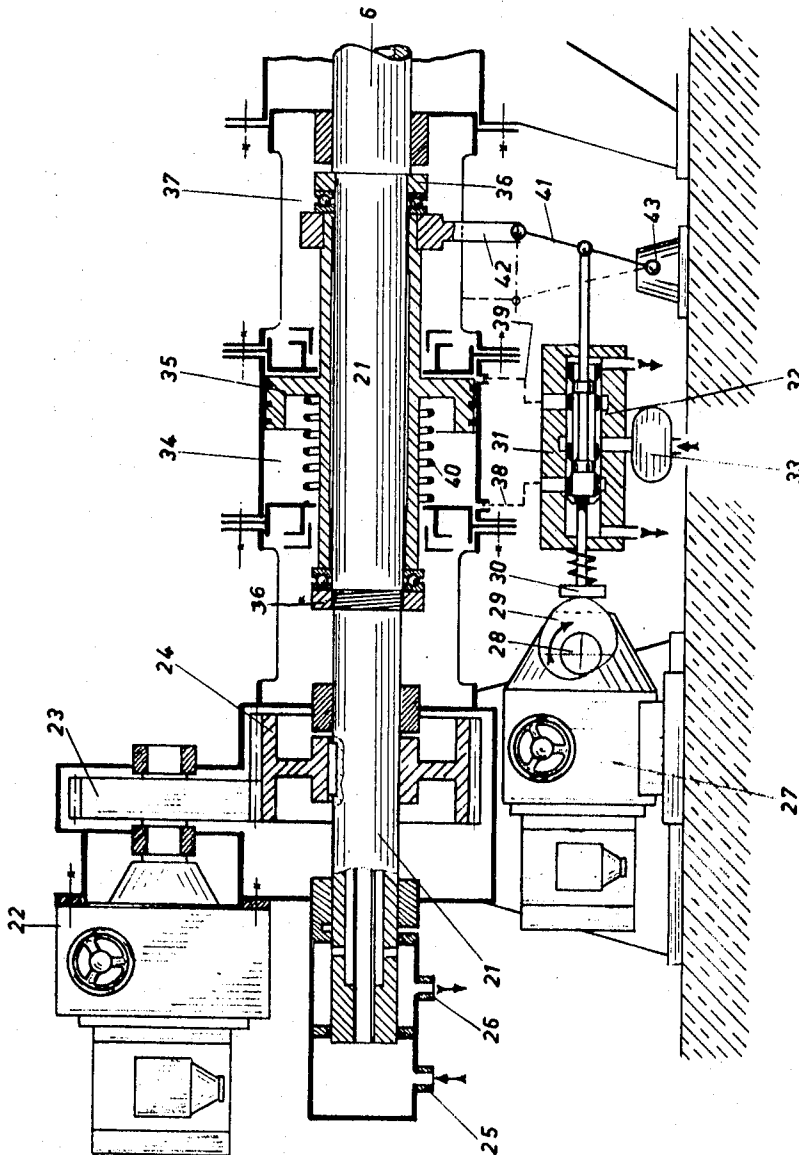


Fig. 3

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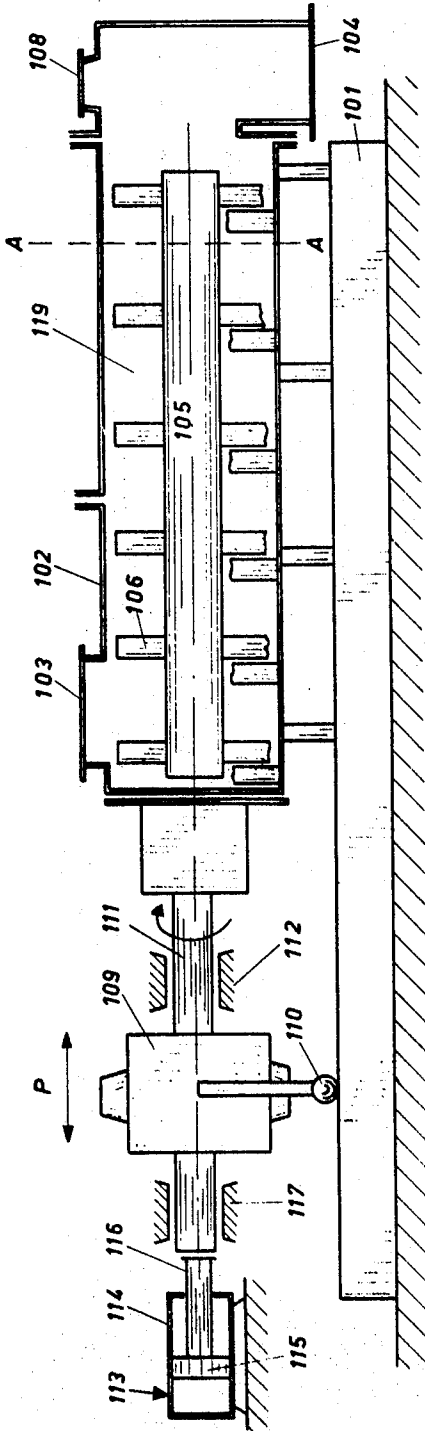


Fig. 5

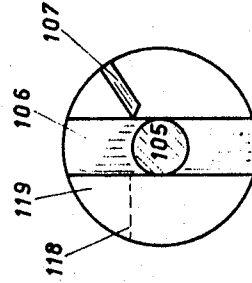


Fig. 6

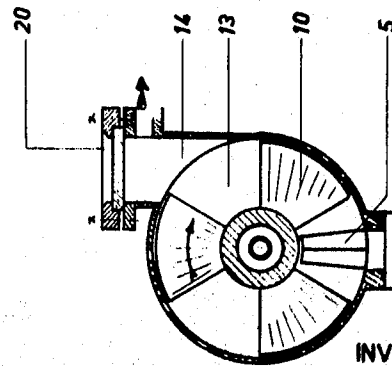


Fig. 4

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## MIXING AND KNEADING DEVICE

Mixing and kneading devices are known in which the kneading member performs a synchronous to and fro movement which is superimposed over the normal rotary movement. Thus, for each revolution, the kneading member moves between the most forward and the rearmost position inside the kneader casing. The inside of the casing is provided with fixed projections or toothlike kneading obstacles which, during each revolution, pass through appropriate interruptions of the flights of the kneading member and strip off the kneaded material.

During the movement, a wedge-shaped space forms between the obstacles and the flights of the rotating kneading member, and part of the kneaded material is forced through this space. The mixing rate and kneading intensity may be varied, depending upon the selected shape and size of the kneading member and of the obstacles. The dispersion and subdividing of the material in its flow influences the mixing and the ease of passage between kneading member flights and obstacles influences kneading.

The simultaneous rotation and to and fro movement results in a combined movement in a form resembling a sine curve in which the material throughput varies in proportion to the revolutions of the shaft of the kneading member.

With known machines, the simultaneous movements are created in gear units of special construction permitting only limited variations of mixing and kneading intensity in relation to throughput. Walter Gresch U.S. Pat. No. 3,219,320, issued Nov. 23, 1965 and entitled, "Method of Continuous Kneading and Mixing, and an Arrangement for Carrying Out the Method", uses a kneading member where the interruptions in the flights are closed at appropriate positions with gap filling elements and, when the obstacles corresponding to the gaps are removed, the flow of material increases. In Danish Pat. No. 87,566, the arrangement of the interrupted flight vanes provides inclined helicoidal lines which produce an increase in material throughput. This increase is enhanced when the vane edge is chamfered. A reduction of throughput at a given number of revolutions is obtained by increasing the shaft diameter of the kneading member as shown in FIG. 1 of U.S. Pat. No. 3,189,324, issued to Ernst Gubler on June 15, 1965 and entitled, "Kneading and Mixing Arrangement", or by using a baffle ring as disclosed in Walter Gresch U.S. Pat. No. 3,367,635, issued Feb. 6, 1968 and entitled, "Arrangement for the Degasification of Plastic Masses During Their Treatment by Means of a Continuous Mixing and Kneading Worm".

It is noteworthy that the known rotating and oscillating kneading machines using interrupted flights on the kneading member have a ratio of 1:1 between rotational movement and longitudinal reversing movement.

An object of this invention is to provide a simple mixing and kneading device in which the ratio between throughput and mixing and kneading efficiency can be adapted continuously over a wide range to make the process especially useful for chemical reactions.

In accordance with the present invention, there is provided a mixing device having a cylindrical casing forming a mixing chamber, with a shaft arranged therein, which carries out simultaneous rotating and oscillating movement, the shaft provided with vanelike mixing or kneading elements cooperating with obstacles mounted inside the casing. A single motor drive is provided for the rotational movement and an independent driving means is provided for the oscillating movement, so that the ratio of the rotary movement of the shaft to the reciprocating movement of the shaft can be varied in a continuous and advantageous manner.

The chamfering of the edges of flight vanes which is employed in the prior art is of no practical benefit to increase throughput in the present device. With rapid rotary movement of the kneading shaft and slow reciprocating movement, there is created an advantageous type of plug-flow and the plug which is formed of the material mixed within the casing is subjected to a predetermined dwell time and throughput.

By changing the number of reciprocating movements per period and by varying the speeds of the to and fro movements, and by using a different speed for the forward and backward strokes, a stepless adjustment for the desired throughput can be achieved in a new manner. Thus, the mixing and kneading effect can be varied by changing the revolutions and is substantially independent of the reciprocating movement.

A device according to the invention can be used advantageously in many fields where continuous processing is required for simultaneous mixing and kneading; for example, chemical reaction, polymerization, drying, heating or cooling, and countercurrent extractions.

Two embodiments of the present device, one for mixing and kneading and the other for continuous drying, are illustrated in the attached drawings in which:

FIG. 1 shows a section of a mixing and kneading device of the invention in which the driving means is not shown;

FIG. 2 is a showing of the development of the kneading shaft of FIG. 1 which includes in dotted lines with arrows the combined reciprocating and rotational movements;

FIG. 3 is a vertical section illustrating the independent driving arrangements for the rotary movement and for the reciprocating movement of the device of FIG. 1;

FIG. 4 is a vertical section of the mixing chamber of FIG. 1 illustrating the vacuum flange attachment for vacuum mixing and kneading;

FIG. 5 illustrates an embodiment of the invention useful for drying, heating and cooling or for solvent extraction, the driving means being omitted; and,

FIG. 6 is a sectional view on section line A—A of FIG. 5.

The mixing and kneading device shown in FIG. 1 has a cylindrical casing 1 provided with a feed hopper inlet 2 for solids and an inlet 3 for liquids, pastes or fluidized powders, the casing being subdivided into a mixing chamber 9 at the feeding section and a kneading section 13 between the inlet and the outlet. An outlet 4 is provided at the opposite end of the casing at the point most remote from the inlets 2 and 3. Stationary kneading elements 5 are provided in the mixing chamber 9 of the casing and serve as obstacles for the material flow. These elements 5 can be inserted into the casing and fixedly secured to the casing from the outside. It is contemplated that the kneading elements may be fashioned with bores which serve as feeding tubes through which additional substances can be introduced into the mixing chamber.

A kneading shaft 6 is provided along the central longitudinal axis of the casing and is supported by main bearing 7 on the end of the shaft attached to the driving means. Additional bearing supports may be provided in the casing.

The shaft 6 is provided with closed screw flights 8 in the feeding section below feed inlet 2 to permit smooth, continuous delivery of material from the hopper to the mixing chamber 9. The screw flights 8 serve the function of a conveyor helix on the shaft near the inlet. The shaft 6 is also provided with mixing and kneading vanes 10 which are spaced longitudinally along the shaft in the feeding and kneading sections. Kneading elements 5 are inserted in a staggered helicoidal pattern within the casing 1 downstream of the conveyor helix near the inlet. The material is mixed and kneaded very intensely within the feeding section of the mixing chamber in advance of baffle ring 11 inserted in the casing 1. The worked material is pushed over this baffle ring into the kneading section 13 of the mixing chamber which is provided with an exhaust opening 14 to permit the withdrawal of volatiles in this zone which is used for degassing. The baffle ring is located within the housing between the mixing and kneading vanes to divide the housing into a mixing section and a degassing section.

The opening 14 is covered by an observation window 20 and has a flange for connection to a vacuum (shown in FIG. 4). Gap closing elements 15 are inserted between consecutive vanes 10 on the kneading shaft 6 near the outlet end of the mixing chamber. These gap closing elements serve as mechanical stops to prevent backflow of the material near the

outlet die 4 from interfering with the material flowing through the degassing zone.

As shown in FIG. 1, the entire kneading shaft 6 is hollow and is provided along its length with concentric heating or cooling tubes which pass in a heating or cooling medium at 16 and withdraw the medium at 17. In addition, liquid inlet 3 is supplied by line 19 with predetermined portions of liquid from proportioning pump 18.

FIG. 2 is a view of the development of the screw flights 8 and the vanes 10 on the kneading shaft 6 and the three different positions, *a*, *b*, *c*, and *c*, of fixed kneading elements 5 are shown in dotted lines and arrows in relation to the rotating kneading shaft. These positions, *a*, and *c*, result from three different ratios of rotation and reciprocating movement. Dotted line *a* results when one longitudinal forward and back stroke is synchronized with one revolution of the shaft 6. Dotted line *b* shows a double stroke per shaft revolution. Dotted line *c* shows a double stroke for each shaft revolution and a stroke interruption occurring at the end points for a duration corresponding to 15° of revolution. The dotted lines illustrate regulation of periodically repeated wiping-off operations at the kneading vanes over their entire width.

FIG. 3 schematically shows the combined drive for the shaft 6 which is connected to hollow driving shaft 21 in line therewith. The driving shaft 21 is guided in slide bearings and is driven through gear train 23, 24 by variable speed motor 22. The end of the hollow driving shaft 21 is provided with inlet 25 and outlet 26 for heating or cooling medium.

The reciprocating movement is provided by a separate drive which is powered by a variable speed motor 27. Keyed on the output shaft 28 of motor 27 is cam disc 29. The cam disc can be replaced to provide a different curve. The curve of the cam disc governs the rapidity of the forward stroke and the slowness of the backward stroke. Variations in these rates are achieved by substituting discs. The curved surface of the disc 29 guides the spring loaded head 30 of hydraulic regulating valve 32. The regulating hydraulic valve 32 is a multiple-disc type fitted with cylinder 31, fed with fluid from pressure pump 33, and driven by pump motor 27 whose transmission is not shown. The hydraulic passageways in the regulating valve 32 lead to working cylinder 34 mounted coaxially with hollow driving shaft 21, with working piston 35 interposed therebetween. The piston 35 is clamped to the shaft 21 over ball bearings 37 in such manner that the driving shaft 21 rotates freely, but the piston does not rotate, the ball bearings resting against the face of the tightening nut 36 which is threaded onto the driving shaft 21.

Depending upon the position of disc 29, the hydraulic fluid flows under pressure either through line 38 or line 39 which pushes the piston either to the left or to the right. The movement in the forward direction to the right is assisted and the movement to the left is dampened by spring 40 mounted on nonturning piston 35.

The reciprocating movement to and at the turning point is controlled by a limit sensor having a bar transmission 41, the bar being pivoted on bearing point 43 and connected to the stem of sliding discs inside of the hollow stem of valve 32. These sliding discs provide a superimposed bypass for the hydraulic fluid within the valve 32 and serve to maintain the hydraulic pressure at a desired value once the end position has been reached and until the curve on cam disc 29 causes the stem 30 to reverse. The cam disc is curved to provide a holding position over 15° of arc at the periphery of the disc; and, in this 15° arc, the reciprocating push-pull motion is stopped. the hydraulic drive is assisted by the spring 40 which accumulates force during the backward stroke and expends this force to assist the forward stroke.

FIGS. 5 and 6 show an alternative embodiment for drying, heating or cooling, or solvent extraction in which the mixing and kneading device has a cylindrical casing 102 fed through hopper inlet 103 and exhausted at outlet 104. The casing 102 is provided with shaft 105 mounted for rotating and reciprocating movement, the shaft being provided with pairs

of mixing and kneading blades 106 mounted in diametric opposition. The blades 106 scrape the inside walls of the casing and, in turn, are wiped by fixed scraping elements 107 which are inserted into the casing.

As shown in FIG. 6, the scraping elements 107 are located in the upper right in the casing when the shaft turns clockwise. The vacuum exhaust flange 108 is mounted on the casing near the discharge outlet 104 (FIG. 5). Shaft 105 is rigidly secured to the driving shaft 111, supported on the bearings 112, by a flange connection. The combined rotating and reciprocating drive for shaft 111 is furnished by a variable speed motor in a case 109 which rests on pivotable support 110 on the same base plate 101 which supports the casing. This mounting permits proper alignment of the casing and motor during the reciprocating movement of shaft 111.

The push-pull movements of shaft 111 are controlled by piston 113, the rod 116 for the piston being keyed onto the end of the shaft 111 and the piston sliding in a rigidly mounted cylinder 114. The velocity of the stroke may be regulated in the manner already illustrated and described in connection with FIGS. 1-4. The shafts 111 and 105 are hollow to permit circulation of a heating or cooling medium, and casing 102 is jacketed to permit heating or cooling.

When casing 102 is filled only up to 65 percent volume during operation, to the level shown in dotted line 118 in FIG. 6, the free space 119 can be used for evaporative drying.

Dwell time and throughput can be readily varied by changing the ratio of rotational to reciprocating movement. If the forward stroke is adjusted to occur with both blades in horizontal position, then both blades push the material forward. If the back stroke occurs with one blade in the filled position and one blade in the free space 119 (FIG. 6) in vertical position, then the backstroke will agitate only 50 to 55 percent of the material which was previously pushed forward. This permits a continuous or stepless adjustment between the horizontal and vertical positions, and the velocities of the forward and back strokes and of rotation may all be adjusted independently.

What is claimed is:

1. a mixing and kneading device comprising a housing having an inlet and discharge, a shaft mounted for rotation and reciprocation in said housing, spaced mixing and kneading vanes secured to said shaft, stationary kneading elements secured to the casing wall and cooperating with said vanes in the mixing and kneading functions, rotary means to rotate said shaft, reciprocating means to cyclically reciprocate said shaft to move said vanes toward and away from their cooperating stationary elements, means to control the speed of rotation and means to control the reciprocating means to vary the to and fro movement of said reciprocating means using different speeds for the forward and backward stroke.

2. A mixing and kneading device as set forth in claim 1, wherein the shaft is provided with a conveyor helix thereon near the inlet, said mixing and kneading vanes being helically arranged on said shaft downstream of the helix, and wherein a baffle is located within the housing intermediate the vanes to divide said housing into a mixing section and a degassing section.

3. A mixing and kneading device as set forth in claim 2, wherein said shaft carries a baffle member to define the end of the degassing section, said baffle member being secured to the shaft between vane members near the discharge.

4. A mixing and kneading device as set forth in claim 2, wherein the rotary means is a variable speed motor and a gear train operatively connecting said motor to said shaft.

5. A mixing and kneading device as set forth in claim 4, wherein said reciprocating means is a pressure fluid motor comprising a relatively movable piston, a hollow piston rod, a valve stem and a cylinder, said rod being operatively connected to said shaft.

6. A mixing and kneading device as set forth in claim 5, wherein said hollow piston rod is connected to said piston, said shaft passing through said hollow piston rod for free ro-

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tary movement therein, and cam disc connecting means for securing said piston to said shaft in abutting relation therewith to transmit the reciprocating movement of the piston to the rotating shaft.

7. A mixing and kneading device as set forth in claim 6, wherein a biasing spring is provided on said valve stem to act upon the piston to bias it into the final position of a stroke in one direction.

8. A mixing and kneading device as set forth in claim 5, wherein the reciprocations of the pressure fluid motor are controlled by a fluid distributing valve device connected thereto and wherein said valve device is cyclically actuated by a variable speed motor driven means.

9. A mixing and kneading device as set forth in claim 8, wherein said variable speed motor driven means comprises a variable speed motor, cam means rotated by said motor, and means operatively connecting said cam means to said valve device.

10. A mixing and kneading device as set forth in claim 9, wherein said valve device comprises a valve casing, supply, exhaust and motor ports in said valve casing, a slidable, hollow piston type valve member having flow passages therein in said casing for selectively interconnecting said supply and exhaust ports to said motor ports to supply and exhaust pressure fluid to and from said cylinder.

11. A mixing and kneading device as set forth in claim 10, a flow regulating valve member located within said hollow valve member to cooperate with said flow passages to control the

flow of fluid therethrough, and means responsive to the reciprocatory movements of said shaft to actuate said regulating valve to a position wherein it cooperates with said flow passages to regulate the flow of pressure fluid therethrough, said means responsive to the reciprocatory movements positioning said regulating valve in its flow regulating positions at the end positions of the shaft strokes.

12. A mixing and kneading device as set forth in claim 1, wherein the vanes are secured to the shaft in diametrically opposed pairs for an additional wall scraping function, and cooperate with their corresponding stationary elements.

13. A mixing and kneading device as set forth in claim 1, wherein said housing is provided with a connection adapted to be connected to a vacuum means.

14. A mixing and kneading device as set forth in claim 1, wherein the reciprocating means is a stationary pressure fluid motor comprising relatively movable piston and cylinder elements with one of the elements connected to said shaft, and wherein the rotary means comprises a variable speed motor mounted upon said shaft for movement therewith.

15. A mixing and kneading device as set forth in claim 14, wherein said rotary means is housed in a case, said case being mounted on a pivotable support.

16. A mixing and kneading device as claimed in claim 15, wherein said pressure fluid motor is in axial alignment with the end of said shaft and said variable speed rotary motor is connected to said shaft by gear means concentric with said shaft.

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