Aug. 2, 1960 M. D. WOODRUFF ET AL 2,947,485

DISC REFINER

Filed Feb. 5, 1954 2 Sheets-Sheet 1

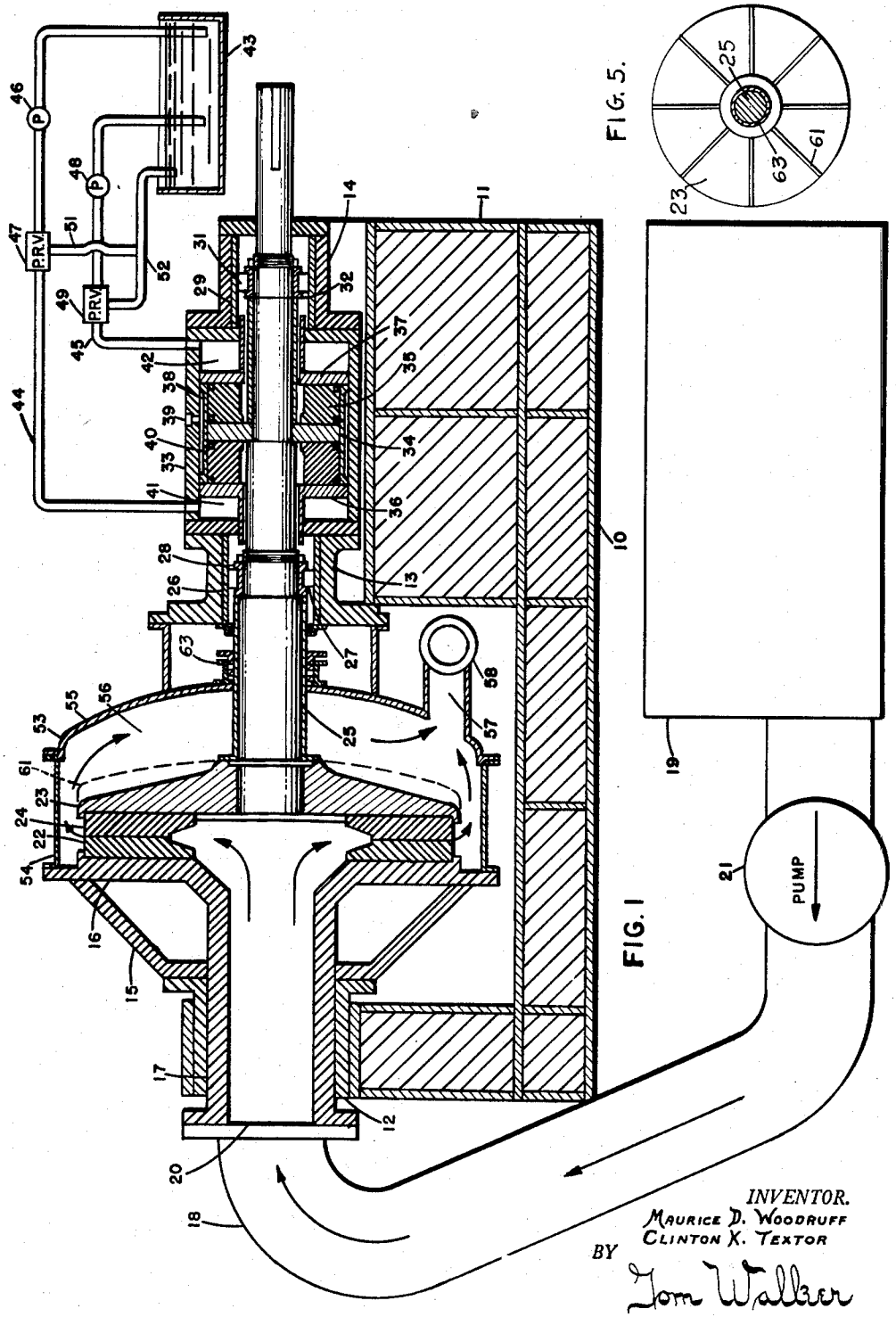



FIG. 1




FIG. 5.

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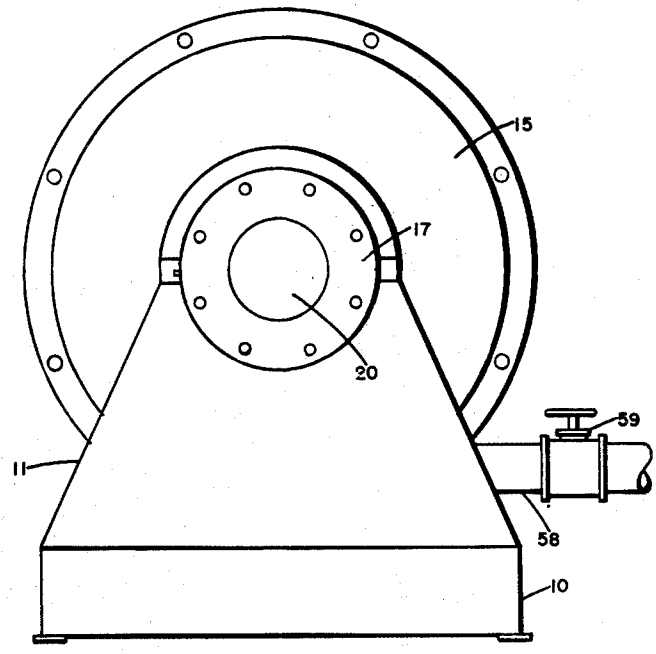



FIG. 2

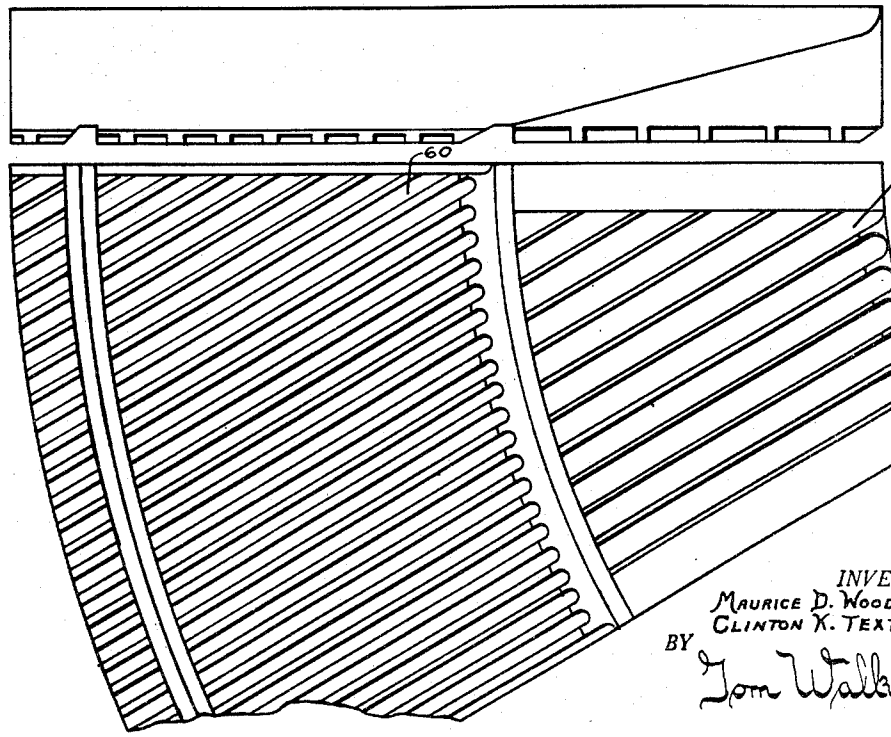



FIG. 4

FIG. 3

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2,947,485

# DISC REFINER

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17 Claims. (Cl. 241—32)

This invention relates to disc mills as used in the refining of fibrous materials, for example wood pulp.

The object of the invention is to simplify the construction as well as the means and method of operation of disc mills, whereby such mills may not only be economically manufactured, but will be more satisfactory in use, of longer life, adaptable to a wide variety of applications, and be unlikely to get out of repair.

An object of the invention is to present a generally new mill structure of simplified construction and operation.

Another object of the invention is to introduce a principle of pressure refining into mill structure of the kind described.

A further object of this invention is to enable the refiner to operate at disc or plate pressures considerably higher than has been feasible heretofore.

A further object of the invention is to make the mill self compensating for variations in the clearance between the working surfaces, as may result from wear or from temperature change or from deformation of thrust bearings.

Still another object of the invention is materially to reduce the thrust on the thrust bearing, whereby this bearing and associated parts may be made relatively small and inexpensive.

A still further object of the invention is to obviate the use of dams and the like on the grinding plates.

A further object of the invention is to provide for variation in or correction of the quality of the discharged pulp material through adjustment of a discharge valve, adjustment of plate spacing, or both, one in conjunction with the other.

A still further object of the invention is to present a new method of pulp refining, involving a principle of pump-through under pressure.

A further object of the invention is to provide a disc mill possessing the advantageous structural features, the inherent meritorious characteristics and the method of operation herein mentioned.

With the above primary and other incidental objects in view as will more fully appear in the specification, the invention intended to be protected by Letters Patent consists of the features of construction, the parts and combinations thereof, and the mode of operation, as hereinafter described or illustrated in the accompanying drawings, or their equivalents.

Referring to the accompanying drawings, wherein is shown one but obviously not necessarily the only form of embodiment of the invention,

Fig. 1 is a view partly diagrammatic and partly in longitudinal section of a mill in accordance with the illustrative embodiment of the invention, certain hydraulic controls and a part of the pulp flowing system being indicated in diagram.

Fig. 2 is a view of the mill of Fig. 1 in end elevation.

Fig. 3 is a fragmentary view of a plate suitable for use in the present mill.



Fig. 4 is an end view of the plate shown in Fig. 3.

Fig. 5 is a modification of the revolving plate showing vanes thereon.

Like parts are indicated by similar characters of reference throughout the several views.

Referring to the drawings, a disc mill or pulp refiner in accordance with the illustrated embodiment of the invention comprises a base **10** from which rises a support **11**. The latter provides a pedestal mount for spaced apart, relatively stationary housing elements **12**, **13** and **14**. The element **12** is rigidly connected, through an adapter **15**, to the back of a stationary plate-disc **16**. The plate **16** has an axial, reversely extending tubular projection **17** having a bearing in the housing element **12** and projecting through and beyond such element. The tubular projection **17** is open throughout its length. The outer or left hand end thereof in the present instance defines the inlet **20** of the machine, there being connected thereto a supply conduit **18** as diagrammatically indicated in Fig. 1 hereof. Also as diagrammatically indicated in Fig. 1, the conduit **18** leads from a raw pulp chest **19** and has interposed therein a pump **21** whereby pulp material in liquid suspension may be drawn from the chest **19** and delivered under pressure to the inlet **20**.

The front of the plate **16** has installed thereon a circular series of grinding plates **22**. In concentric opposing relation to the plate **16** is a disc **23** carrying grinding plates **24** in aligned spaced relation to the plate **22**. The disc **23** is mounted on a shaft **25** for rotation relative to the plate **16**. In response to such motion the grinding plates **24** move relatively to the plates **22**. It will be understood, in this connection, that the plates **22** and **24** are formed with grooved or toothed surfaces which cooperate in a grinding reduction of the pulp material, such material passing through the space between the respective grinding plates radially from the center to the periphery, the path of flow being as indicated by the arrows in Fig. 1.

The shaft **25** is supported for rotary motion in the housing elements **13** and **14**. Its outer or right hand end extends through and beyond the housing element **14** and is constructed and arranged for connection to a source of rotary power as for example an electric motor. Within housing element **13** is an elongated race **26**. Rolling bearings **27** are received in the race **26** and these are mounted in a grooved bearing sleeve **28** made fast on the shaft **25**. Within the housing element **14** is a similar bearing structure, including a race **29**, bearings **31** and sleeve **32**.

The shaft **25** is thus supported within the housing elements **13** and **14** for axial as well as rotary motion. Interposed between the housing elements **13** and **14** is a hydraulic cylinder **33**. Within the cylinder **33** is a thrust bearing **34** of the "Kingsbury" type. Such a bearing includes shoe elements **35**, and, in accordance with the instant invention, further comprises end plates **36** and **37** having a sliding fit in the bore of the cylinder **33**. The plates **36** and **37** are separated by, and the shoes **35** are surrounded by, a sleeve **38** connected as by a key **39** to the cylinder **33** for relative longitudinal motion but not relative rotary motion. The assembly of parts including the shoes **35**, the plates **36** and **37** and the sleeve **38** make up a piston assembly **40** reciprocable in the cylinder **33** and defining at the opposite ends thereof chambers **41** and **42**.

The chambers **41** and **42** are supplied with hydraulic fluid, as from a reservoir **43**, for the purpose of making longitudinal adjustments of the piston assembly **40** and for dampening such motions. Further, the piston assembly **40** is connected with the shaft **25** in such a way that the piston assembly **40** and shaft **25** are intercon-

nected for unison axial adjustment. Thus, axial adjustment of the piston assembly **40** effects a corresponding axial adjustment of the shaft **25**.

The chamber **41** in cylinder **33** is connected by a line **44** with the reservoir **43**. The chamber **42** in cylinder **33** is connected by a line **45** with the reservoir **43**. The line **44** includes a pump **46** and a pressure regulating valve **47**. Similarly the line **45** includes a pump **48** and a pressure regulating valve **49**. The valves **47** and **49** have return and excess flow connections **51** and **52** to the reservoir **43**.

In its illustrated form the hydraulic circuit has been reduced to relatively simple terms. It will be understood that such circuit may further include other valves and controls aiding in the attainment of the desired objective. In general, however, the system may operate to supply hydraulic fluid to chamber **41** at one pressure and to supply hydraulic fluid to the chamber **42** at the same or another pressure to the end that the piston assembly **40** may be balanced in one position or may be over balanced in one direction or another, that is, the piston may be urged in a right hand or a left hand direction depending upon whether the over balancing pressure is in the chamber **41** or the chamber **42**. Further, it will be understood that return flow from the chamber **41** or **42** to the reservoir **43**, resulting from motion of the piston assembly, is permitted through the pressure regulating valves **47** and **49** and passages **51** and **52**, or through other means. Further, it will be understood that such return flow is relatively restricted so that the motion of the piston assembly **40** in either direction is damped.

The stationary grinding plates **22** and the rotary disc **23**, together with the plates **24** thereon, are surrounded by a casing **53** made up of a ring shaped member **54** fastened to the plate **16** and a closure member **55** connected to the member **54**. The members **54** and **55** are connected to one another and to the plate **16** in a liquid tight manner, the casing defined by such members being in spaced relation to the periphery of the disc **23** and the back thereof in a manner to form a chamber **56**. The casing **53** further is formed with an outlet opening **57** terminating in a discharge pipe **58** in which is positioned a regulating valve **59** (see Fig. 2).

The pulp material after passing between the grinding plates **22** and **24** flows into the chamber **56** and is discharged to another point in the refining system by way of outlet **57** and pipe **58**. The outlet control valve **59** represents a restriction by which the chamber **56** may be maintained filled with pulp material, and it will be understood that the valve is adjustable, making the outlet restriction variable.

In the operation of the mill pulp material is drawn from the chest **19** and fed to the inlet **20**, it being understood that in using the term "pulp material" herein there is meant a suspension comprised primarily of a liquid in which a certain amount of wood pulp or other fibers is carried in suspension. Passing through inlet **20**, the pulp material is directed to the space between the grinding plates **22** and **24**, is carried radially outward between such plates and discharged peripherally into the chamber **56**. From the chamber **56** the pulp material leaves the machine, as before mentioned, by way of outlet **57**, pipe **58** and valve **59**.

Since the pulp material is delivered to the machine under pressure, and since its discharge from the machine is restricted by the valve **59**, the chamber **56** becomes a pressure chamber, the pressure in such chamber being a function of several variables, including the speed of rotation of the shaft **25** and the setting of valve **59**. Thus, rotation of the disc **23** in the chamber **56** tends to create a pressure in the chamber which is related to the speed of rotation of the disc. Also, by moving the valve **59** to positions of greater and lesser restriction the rate of flow of pulp material out of the chamber **56** is varied and the pressure in such chamber correspondingly varied.

Still further, the pressure in chamber **56** may vary in correspondence with variations in inlet pressure. Thus, a rising pressure at inlet **20** is reflected in a rising pressure on the front face of the disc **23** resulting in an increased flow rate into the chamber **56** and a corresponding rise in pressure in such chamber. This pressure, applied to the back of the disc **23** opposes and largely balances the pressure applied to the front of the disc **23** so that these pressures largely offset one another insofar as axial thrust on the shaft **25** is concerned. In the operation of the refiner, therefore, it is necessary to contend with only slight axial thrust on the main rotating shaft so that the need for heavy thrust bearings and massive supports is in large extent eliminated.

In conventional disc refiners of the present class it is usual to provide the grinding plates **22** and **24** with dams inhibiting a too rapid flow of the pulp material between the plates. The present invention obviates the need for such formation in the grinding plates, as shown for example in Fig. 3. The passages intermediate the ribs **60** through which the pulp material flows are open to the periphery of the plates with no obstruction whatsoever. The rate of flow of the pulp material between the plates **22** and **24**, and therefore the degree of reduction of the pulp material, is determined by the adjustment of valve **59**. The valve **59** thus becomes the primary control means for the machine.

When it becomes necessary or desirable to change the freeness of the pulp material being discharged by way of pipe **58**, it can be accomplished by adjusting valve **59**. If it is desired to achieve a slower pulp material the valve **59** is turned to increase the amount of restriction exercised on outlet **57**. The result, since the inlet pressure is relatively constant, is to increase the pressure in chamber **56** and thereby to retard the rate of flow of the pulp material between the plates **22** and **24**, increasing the dwell or length of time the material is held between these plates and increasing the refining action.

Moreover, the disc **23** is essentially floating and is free to adjust itself axially under pressure differences between the inlet **20** and chamber **56** to compensate for variations in the clearance between the plates **22** and **24**. In this connection, in the operation of the machine the disc **23** normally is urged in a left hand direction or toward the stationary plate **16** by a pressure in hydraulic chamber **42** in over balancing relation to the pressure in chamber **41**. The pressure at inlet **20** and in chamber **56** normally are substantially balanced so that only a relatively small over balancing pressure in chamber **42** is required, even though the machine operates at plate pressure considerably higher than those at which disc refiners have operated in the past.

According to a concept of pressure conditions in the chamber **56**, the pressure values therein vary from a minimum adjacent to the axis of the disc **23**, or shaft **25**, to a maximum at or near the periphery of the disc **23**, it being assumed that pressure within the chamber **56** is generated, or in part results, from the agitation of the pulp material in the chamber caused by rotation of the disc **23**. This agitation may be increased by the use of vanes on the back of the disc **23**, as is suggested at **61** in Fig. 5.

Also, it may be desirable to locate the outlet from the chamber **56** at or near the shaft **25**. This has the advantage of avoiding discharge at high pressure and of enabling the pressure in the chamber **56** to be increased, without materially changing the discharge pressure which controls the rate of movement of the pulp.

The shaft **25** is, of course, axially disposed with respect to the disc **22**. It extends through the casing **53**, and, between the casing and the housing element **13**, is surrounded by sealing assembly **63**.

With further regard to the floating characteristic of

the disc 23, it will be understood that it is unnecessary to initially set the disc for a particular clearance between the plates 22 and 24, nor is it necessary periodically to adjust such clearance to compensate for wear, temperature variation or deforming of thrust bearings. According to the present concept of milling, the pump 21 is turned on to fill the system, including chamber 56, with pulp in suspension. Then the valve 59 is adjusted to a selected position of restriction and the electric motor is started to rotate the shaft 25 and disc 23. Finally, the hydraulic circuit is adjusted to create an overbalancing pressure in the chamber 42 with the result that the shaft 25 moves axially to cause the disc 23 to approach plate 16. The power input to the motor gradually is increased, and, as the plates 22 and 24 achieve a working relation the power consumption reaches a predetermined rate indicating the operating load has reached a desired value. The power input is stabilized at this point and the operation of the machine thereafter proceeds automatically except for occasional adjustments of the valve 59 to correct or change the quality of the work.

At the selected speed of operation, and the selected position of adjustment of the valve 59, the pressure on the front face of the disc 23 and the pressure on the back thereof, plus the overbalancing hydraulic pressure in chamber 42, are substantially in equilibrium. As the surfaces on the grinding plates wear, the gap between them is slightly increased which decreases resistance to flow of the pulp material through the gap, resulting in an increase in pressure on the back of disc 23. The disc 23 moves slightly under this pressure differential, closing any developed gap between the plates and restoring the pressure balance on opposite sides of the disc. This adjustment imposes no change in the rate of flow through outlet 59 and results in no change in work quality, this remaining a function of the position of adjustment of the valve 59.

As the grinding plates 22 and 24 continue to wear, however, the edges of the grooves 60 become dull and the grooves decrease materially in depth. Either or both of these occurrences representing an extreme condition of wear, necessitate an increase in the pressure on the pulp material between the plates 22 and 24 to produce pulp of the same characteristics. This increase in plate pressure is provided by raising the pressure in chamber 42 through manual adjustment of pressure regulating valve.

From the above description it will be apparent that there is thus provided a device of the character described possessing the particular features of advantage before enumerated as desirable, but which obviously is susceptible of modification in its form, proportions, detail construction and arrangement of parts without departing from the principle involved or sacrificing any of its advantages.

While in order to comply with the statute the invention has been described in language more or less specific as to structural features, it is to be understood that the invention is not limited to the specific features shown, but that the means and construction herein disclosed comprise but one of several modes of putting the invention into effect.

Having thus described our invention, we claim:

1. A pressure refiner for pulp material, including a rotatable shaft, a disc on said shaft, having front and back sides, relatively stationary means in opposing facing relation to the front of said disc, means mounting said shaft providing a continuous floating bias of said disc to said stationary means a substantially liquid tight casing in surrounding spaced apart relation to the periphery and back of said disc forming a pressure chamber, a liquid suspension of pulp material under pressure being supplied to a space between said disc and said stationary means centrally thereof and flowing radially in said space for peripheral discharge into said chamber, and a relatively restricted outlet from said chamber maintaining said chamber filled with the liquid pulp suspension, rotation of said disc therein producing a pressure on the back of said disc within said pressure chamber exerted in opposition to thrust pressures on the front of said disc the sum of the bias and the back pressure produced on the back of said disc by the rotation of said disc being constantly in balance with the pressure produced on the front of said disc to establish a predetermined clearance between said disc and said stationary means at all times.



2. A pressure refiner according to claim 1, characterized in that said restricted outlet includes valve means adjustable to vary the rate of flow out of said chamber.

3. A pressure refiner for pulp material, including a rotatable shaft, a disc on said shaft having front and back sides, relatively stationary means in opposing facing relation to the front of said disc means defining radial passages between said stationary means and said disc, a substantially liquid tight casing in surrounding spaced apart relation to the periphery and back of said disc forming a pressure chamber, said shaft extending axially through said chamber, a liquid suspension of pulp material being supplied under pressure to the passages between said disc and said stationary means centrally thereof and flowing radially outward into said chamber, producing a thrust on the front of said disc, an outlet from said chamber spaced radially outward of said shaft and restricted to maintain said chamber filled with the liquid pulp suspension, rotation of said disc in said chamber producing a pressure exerted in opposition to thrust pressures on the front of said disc and pressure means of a compensating nature continuously supplementing said opposition pressure to maintain a balance relative the thrust on the front of the disc and a predetermined operating clearance between said disc and said stationary means.

4. A pressure refiner according to claim 3, characterized in that said outlet is located relatively distant to said shaft.

5. A pressure refiner according to claim 3, characterized by vanes formed on the back of said disc aiding in the development of back pressure in said chamber.

6. A pressure refiner for pulp material, including a support, a shaft mounted on said support for freedom of rotary and axial motions, a piston on said shaft, a hydraulic cylinder receiving said piston, means for supplying hydraulic fluid to the opposite ends of said cylinder for axial adjustment of said shaft and for dampening such motions of adjustment, a disc on said shaft in spaced relation to said piston stationary means immediately opposite said disc, pulp material in liquid suspension being supplied through said stationary means to the front of said disc and moving radially outward past the periphery thereof, a substantially liquid tight casing in surrounding spaced apart relation to the periphery and back of said disc into which said pulp material flows, and an outlet from said casing restricted to maintain said casing filled with the pulp material, said material substantially absorbing end thrusts on said disc produced during the operation thereof, the rotation of said disc producing back pressure thereon due to the configuration of said housing and means normally providing a floating bias of said piston and thereby said disc automatically complementing said back pressure to maintain a predetermined position of the disc in said housing.

7. A refiner for pulp material, including a support, a shaft mounted on said support for relative rotary and axial motions, a piston on said shaft, a hydraulic cylinder receiving said piston, means for supplying hydraulic fluid to the opposite ends of said cylinder for axially adjusting said shaft and for dampening such motions of adjustment, means providing for normal unbalance of said piston to induce a continuous floating bias of said shaft, disc means on said shaft, and a pressure chamber

receiving said disc means and dampening axial thrusts delivered through said disc means to said shaft the floating bias of said shaft complementing the dampening effect of said pressure chamber to balance axial thrust delivered through said disc means and maintain a predetermined position of said disc means.

8. A disc refiner according to claim 7, characterized in that said pressure chamber is formed by a substantially liquid tight casing in enclosing relation to said disc means and maintained filled with pulp material discharged from said disc means.

9. A refiner for pulp material, including a support, a shaft mounted on said support for relative axial and rotary motions, means for applying a pressure urging said shaft axially in one direction and accommodating an automatical floating adjustment thereof, disc means on said shaft, said disc means acting on pulp material supplied thereto and delivering an axial thrust to said shaft in the opposite direction, and a pressure chamber receiving said disc means and maintained filled with pulp material discharged from said disc means for automatically counter-balancing, in conjunction with said pressure applying means, said last mentioned axial thrust.

10. A pulp refiner, including a relatively stationary grinding plate, a rotatable grinding disc in opposing relation to said plate, said disc being freely adjustable toward and from said plate, and means defining a closed circuit for flow of pulp material under pressure to the front of said disc, between said disc and said plate and to the back of said disc, the said pressures at the front and back of said disc becoming unbalanced by change in spacing of grinding surfaces and means applying a continuous bias to said disc which automatically accommodates adjustment of said disc to maintain the original spacing thereof relative said stationary plate to restore the equilibrium of such pressures.

11. A pulp refiner, including a disc supported for freedom of rotary and axial motions, means for supplying pulp material under pressure to the front of said disc, said material flowing peripherally over the said disc to the back thereof, means defining a pressure chamber at the back of said disc in which a pressure is developed acting on said disc in opposition to the pressures at the front thereof, and a grinding plate in opposing relation to the front of said disc, the clearance between said disc and said plate being automatically adjusted in response to variations in the pressure difference at the front and back of said disc and means for inducing floating bias of said disc applied to the back thereof and supplementing said opposition pressure for effecting an equilibrium of said disc at a predetermined position.

12. A pulp refiner, including a shaft supported for axial and rotary motions, relatively movable pulp grinding means including a disc on said shaft and a relatively stationary plate mounted in opposing relation to said disc, means defining a substantially liquid tight chamber receiving said disc, a restricted outlet from said chamber, and means for pumping pulp material under pressure between said disc and said plate and radially outwardly thereof into said chamber and out said restricted outlet, the rotation of said disc in said chamber producing in conjunction with said restricted outlet a pressure controlling the rate of flow of pulp material between said disc and said plate as well as automatically adjusting the clearance between said disc and plate and means applying a floating bias to said shaft insuring an equilibrium of pressures on said disc and a predetermined clearance between said disc and plate.

13. A pulp refiner according to claim 12, characterized by means for varying the restriction imposed by said outlet to vary the period of dwell of pulp material between said disc and said plate.

14. A pulp refiner, including a relatively stationary grinding plate, a rotatable disc in opposing relation to said plate, an inlet area to which pulp material under pressure is supplied, such material passing radially between said disc and said plate, a discharge area into which the material flows after passing between said disc and said plate, and means for maintaining the material in said discharge area under pressure the pressures of said discharge area and of said inlet area being applied to said disc in opposition to one another, and means providing automatic axial adjustment of said disc relative said plate under influence of said pressures.

15. A refiner for pulp material including a housing, means defining an input channel into said housing for supplying a liquid suspension of pulp material, including a stationary refiner means fixed in said housing, a shaft in said housing having a refining disc fixed thereto disposed in facing relation to said stationary means, a restricted outlet from said housing and means for effecting a continuous floating bias of said disc and shaft towards said stationary means, the housing being so formed that on rotation of said disc and delivery of said suspension radially between said disc and stationary means and into said housing a back pressure will be automatically developed on said disc slightly less than the thrust on the front by said suspension said back pressure plus said floating bias being additive to automatically maintain a predetermined clearance between said disc and stationary means.

16. A refiner according to claim 15 characterized by vanes formed on the back of said disc aiding in the development of back pressure in said housing.

17. A method of pulp refining in a disc mill including the steps of supplying a suspension of pulp material intermediate relatively rotatable disc refiner means, radially dispersing said suspension peripherally of said discs creating a thrust against one of said discs, containing the radially dispersed suspension to create a back pressure on said one of said discs in opposition to and slightly less than said thrust, and applying a continuous floating bias on said disc additive to said back pressure to continuously maintain said one disc in predetermined relation to the other at all times.

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