April 26, 1966 C. B. HORSLEY ETAL 3,248,090

FLOW CONTROL MEANS FOR VIBRATORY REFINER

Filed Oct. 31, 1961 2 Sheets-Sheet 1

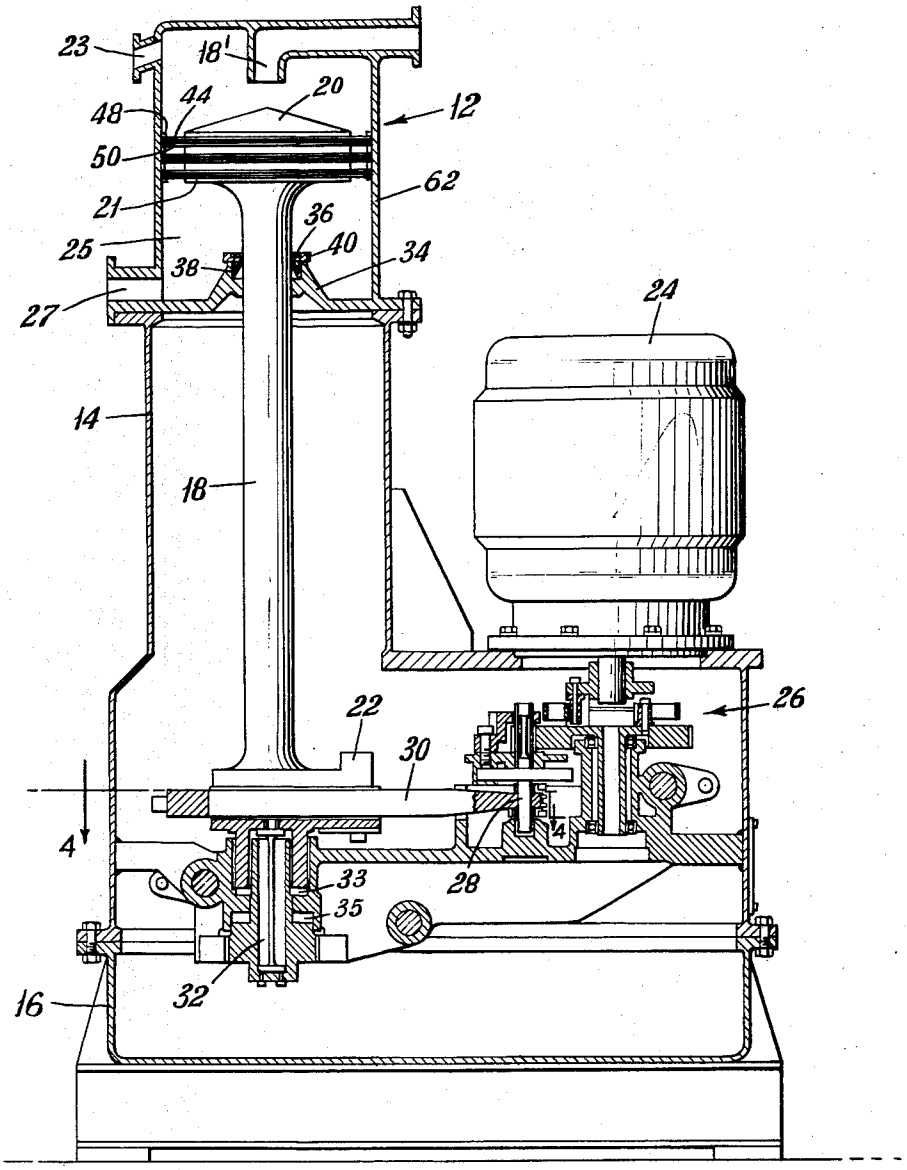


Fig. 1.

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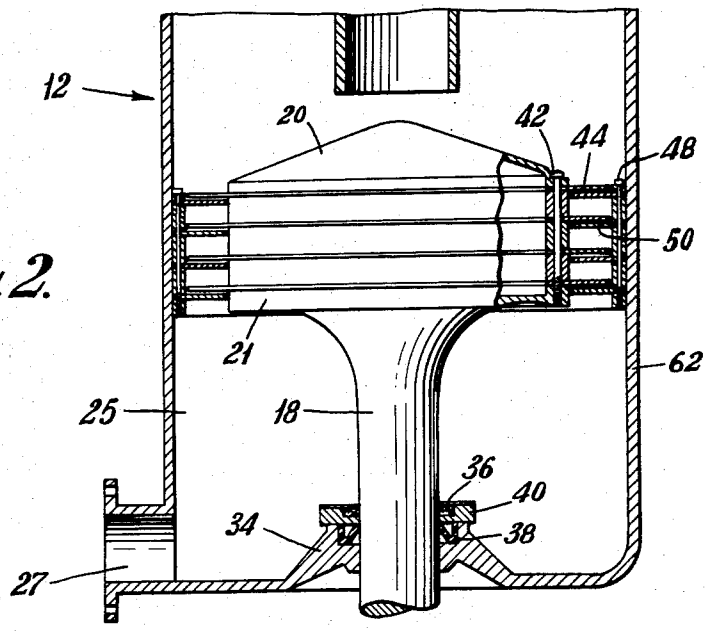


Fig. 2.

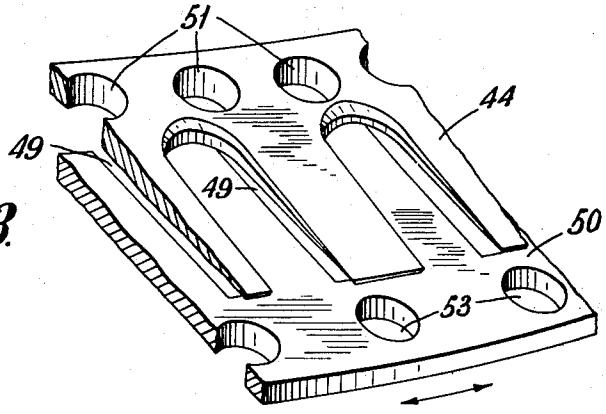


Fig. 3.

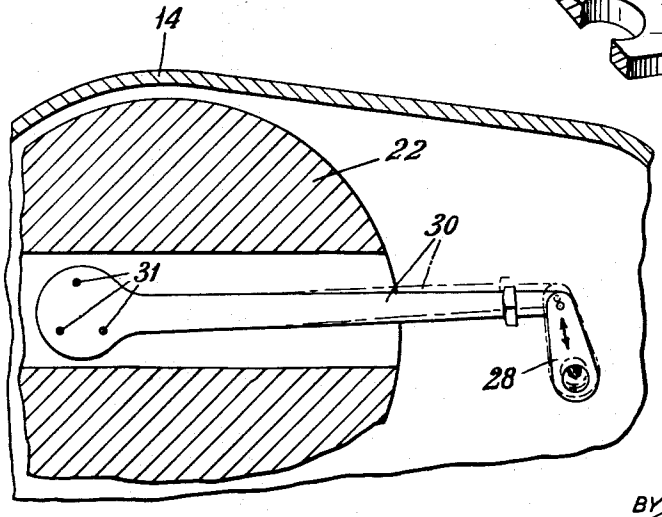


Fig. 4.

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FLOW CONTROL MEANS FOR VIBRATORY REFINER

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2 Claims. (Cl. 259—4)

This invention relates to vibratory refining apparatus and, more particularly, to apparatus for subjecting liquids, emulsions, hydrosols, slurries, and other mixtures to oscillatory or vibrating effects in order to modify the properties or characteristics of the treated substances. For convenience, the term "fluent materials" will be used to refer to the liquids, emulsions, hydrosols, slurries, etc. which are capable of treatment by the inventive apparatus.

Heretofore, it has been found that for many desired results in many classes of fluent materials, alternating pressure and acceleration and/or alternating shear produce especially good results. One example of apparatus for producing such effects is that disclosed in U.S. Patent 2,584,053, entitled "Means for the Application of Alternating Shear at Sonic Frequencies to the Treatment of Material." However, although such apparatus achieves the desired results, it is inoperable for many fluent materials because of packing of the fluent material on one or both sides of the refining assembly. This packing is especially troublesome in the treatment of viscous fluent materials, and often leads to a complete stoppage of the flow through the vibratory assembly.

It is, therefore, the main object of the present invention to provide a flow control means for vibratory refining apparatus whereby packing of the material being refined is substantially eliminated.

It is another object of the invention to provide such flow control means whereby fluent material can be passed through vibratory refining apparatus at commercially practical flow rates.

Other aims and advantages of the invention will be apparent from the following description and appended claims.

In accordance with the present invention, there is provided apparatus for controlling the flow of fluent material through a vibratory refining head having an annular refining assembly comprising: a conical member positioned on the feed side of the refining head and within the inner edge of the annular refining assembly; feed means for presenting unrefined fluent material to the apex of the conical member; and a cylindrical casing surrounding the refining assembly and extending both above and below the refining assembly, the cylindrical casing having a first outlet above the exit of the feed means and a second outlet below the refining assembly.

Fluent material is deposited on the apex of the conical member by the feed means and flows down over the conical member toward the annular refining assembly. As the fluent material reaches the annular refining assembly, part of the material passes directly into the refining assembly and the remainder of the material swirls upward into the cylindrical casing. Part of the material which swirls upward passes out of the apparatus through the upper outlet in the cylindrical casing, and is then recycled into the feed means. Thus the material directly above the refining assembly is constantly agitated by the incoming material sliding down over the conical member, and packing of the material is thereby substantially eliminated.

The apparatus of the present invention will now be described in more detail by referring to the drawing.

One form of the novel apparatus is shown in FIG. 1. The refining head is indicated generally by the numeral 12. This head is mounted upon a vertically arranged cylindrical casing 14, which in turn is held by a supporting casing 16 enclosing the driving mechanism. Within the head 12 and casings 14 and 16 is mounted a balanced spring-mass torsionally vibratory system comprising a main torsion bar 18 having attached to its upper end a drum 21 and to its lower end a massive inertia counterweight 22. The dimensions and elastic characteristics of the main torsion bar 18 are chosen in relation to the masses of the bodies 21 and 22 so that, taking into account the additional masses of the parts attached to these masses, such as the refining members described below, and the damping forces exerted by the material being refined, the system will have a predetermined natural frequency of torsional oscillation with the mass 21 oscillating in opposite phase from the mass 22 and at a predetermined amplitude.

One optional form of vibratory drive is hereinafter disclosed and described, but the details thereof do not constitute any novel part of the present invention. Referring again to FIG. 1, an electric motor 24 is connected through a speed increaser 26 to an eccentric 28. A flexible driving connection 30 of somewhat greater elasticity than the main torsion bar 18 connects the eccentric 28 to the counterweight 22, inducing rotational oscillation of the latter. As indicated by the double-ended arrow in FIG. 4, the movement of the eccentric drive 28 causes transverse oscillatory motion of the end of the flexible rod 30 to which it is linked. Since this flexible driving member is rigidly affixed to the counterweight 22 by three bolts 31, it is clear that continued oscillatory motion of the flexible arm 30 will quickly induce rotational oscillation of the counterweight 22. The oscillations of the counterweight are transmitted through the main torsion bar 18 to the drum 21. It will be evident that by operating the motor 24 at the proper speed with reference to the gearing, the system can be excited through the resilient exciter connection 30 to vibrate at the predetermined natural operating frequency. The inertia forces are balanced since the masses 21 and 22 oscillate in opposite phase, and substantially the only forces on the bearing of the driving mechanism are due to the refining work done.

The spring-mass assembly comprising the torsion bar 18, the upper mass 21, and the lower mass 22 is preferably supported on the casing 16 by oil pressure in cavities 33 and 35. The oil pressure in the upper cavity 33 acts directly on the lower annular surface of mass 22, while the oil pressure in the lower cavity 35 is transmitted to the spring-mass assembly through a torsionally flexible but axially rigid thrust absorbing connector 32. It is preferable to use a flexible connector of this type to obviate the difficulties of lubrication inherent in a vibratory system wherein the parts do not move in one direction a sufficient distance to carry lubricant to all the surfaces, as in a rotating bearing. The details of this thrust absorbing connection are fully disclosed and described in U.S. Patent No. 2,625,380, issued January 13, 1953, and entitled "Thrust Absorbing Device for Rotationally Oscillating Systems." Consequently, further details thereof will not be set forth in the present specification, since reference may be had to such patent for additional information.

It can be seen in FIG. 1 that the main torsion bar 18 protrudes through a sealing collar 34. The enlarged cross-sectional view of FIG. 2 illustrates the various sealing components which are held within the collar 34 surrounding the bar 18. These comprise a sealing ring 36 of leather or fibrous material and a second sealing ring 38, of rubber or the like, separated from the ring 36 by

the inturned portion of a flange **40** on the sealing collar **34**. The purpose of the sealing collar **34** is to prevent the escape downwardly into the casing **14** of any of the refined material where it might interfere with the driving mechanism mounted in the lower portion of the machine, and any other sealing means which accomplishes this purpose may be used.

The annular space between the drum **21** and the cylindrical casing **62** is occupied by a series of dual blade refining assemblies comprising an upper ring of blades **44** (see FIG. 2) attached to the periphery of the drum **21** and a lower ring of blades **50** attached to the inner surface of the casing **62**. The rings of blades **44** are secured to the drum **21** by means of a series of mounting bolts **42** which fit mounting apertures **51** near the inner circumferential portion of each ring, and the rings of blades **50** are secured to the casing **62** by means of a series of bolts **48** which fit apertures **53** near the outer circumferential portion of each ring. Both the drum **21** and the casing **62** are provided with a series of flanges for holding the rings of blades in closely spaced vertical relation.

A vertical space between the oscillating blades **44** and the stationary blades **50** is determined by the force with which the oscillating blades are pressed toward the stationary blades, the type of fluent material being treated, the consistency of the fluent material, and, to some extent, the rate of flow of the fluent material. The force with which the oscillating blades are pressed toward the stationary blades may be adjusted to provide the vertical spacing required for the desired degree of refining and flow rate and the desired refiner loading (which determines the percentage of full load operation of the driving motor). In most cases, it is preferred to have a vertical spacing between about 0.001 and 0.020 inch. One means for varying the vertical space between the oscillating and stationary blades is shown in FIG. 1. Annular cavities **33** and **35** below the lower mass **22** are filled with oil; by varying the pressure of the oil in these cavities by means of a pump (not shown), the vertical position of the mass **22**, the torsion bar **18**, the mass **21**, and the oscillating blades **44** can be varied to provide the desired vertical spacing between the oscillating blade rings and the stationary blade rings.

As best seen in FIG. 3, the oscillatory blades **44** are wider than the intervals **49** between the stationary blades **50** and are positioned directly over the intervals **49** so as to overlap the edges of blades **50**. The lengths of the blades are such that blades **50** closely fit the outer surface of the drum **21** and that blades **44** closely fit the inner surface of the outer casing **62** leaving space for bolts **48**. The lower edges of the oscillatory blades **44** are preferably slightly beveled to retain fibers between the two sets of blades and to prevent the oscillating blades from scraping the stationary blades clean. Each refining opening is of accurately predetermined size and is normal to the direction of vibration. The refining blades may be formed from relatively thin stainless steel plates or other suitably rugged material.

Returning to FIG. 1, a feed pipe **18'** is disposed concentrically within the cylindrical casing **12**, so that the exit of the pipe is directly over the apex of conical member **20** which is secured to the top of the drum **21**. Thus, as the fluent material to be refined is fed into the cylindrical casing **62** through the feed pipe **18'**, the fluent material flows down over the conical member **20** toward the refining assemblies. The flow rate of the feed material is maintained at a rate greater than that which can be passed through the refining assemblies so that part of the fluent material swirls upward as it leaves the conical member **20**, thus continuously agitating the material directly above the refining assemblies. As the material is swirled upward into the annular space between the feed pipe **18'** and the cylindrical casing **62**, part of the fluent material is discharged through outlet **23** in the casing, which is preferably located above the exit of the feed pipe. The discharged material is eventually recycled back to the feed pipe **18'**. Similarly, any foreign objects, such as nails, in the fluent material which are too large to pass through the refining assemblies are carried upward by the material and are eventually discharged through the outlet **23**. Since the fluent material above the refining assemblies is constantly being agitated, packing of the material in that space is substantially eliminated. After the material has been refined, it drops into the annular space **25** between the torsion bar **18** and the cylindrical casing **62** and is discharged through outlet **27**. In the case of some fluent materials, such as extremely viscous materials, the space **25** is made large enough that a head space of air is constantly maintained directly below the refining assemblies. However, in other cases it is desirable to maintain space **25** completely filled with the refined material, i.e., with no head space of air. The size of the space **25** is determined mainly by the flow rate of material through the refining assemblies, and the size of outlet **27**.

Although four dual blade assemblies are shown in the drawings, any desired number of blade sets may be employed. The precise number and size of the blade arrangements depend on the type of material to be treated and the desired capacity. It has been found that the average mean velocity of the centers of the blades (i.e., four times the maximum displacement of the blade center from its mean position multiplied by the frequency) should not be less than about 100 feet per minute. At a frequency of 220 c.p.s. and a blade-tip amplitude of ± 0.225 inch, a blade-center velocity of about 985 feet per minute or more is usually desirable. A blade speed of less than 100 feet per minute has very low efficiency, the efficiency increases very sharply from 100 feet per minute to 985 feet per minute, and above about 985 feet per minute the efficiency increases at a slower rate. In the case of most pulps, speeds of 650 to 1000 feet per minute seem to produce excellent results and efficiency. The fluent material to be refined is fed through the inlet pipe **18'** onto the conical member **20** and starts to pass through the narrow refining openings defined by the oscillatory blades **44** and the stationary blades **50**. Partially refined material emerges from the bottom of the first dual blade assembly and passes through the next assembly, and so on until the refined product emerges into the annular space **25** between the torsion bar **18** and the cylindrical casing **62** and is discharged through outlet **27**. Escape of refined material in a downward direction is prevented by sealing rings **36** and **38**.

The axial distance between the oscillating and stationary blades is preferably between about one thousandth and twenty thousandths of an inch, depending on the force with which the oscillating blades are pressed toward the stationary blades, the consistency of the pulp slurry, the nature of the pulp, and the desired flow rate. By varying the force with which the oscillating blades are pressed toward the stationary blades and the pulp consistency, almost any desired peak stress on the fibers can be obtained. Moreover, it appears that when fibers have passed through one pair of the oscillating and stationary blade arrangements, each fiber has been subjected to substantially the same treatment as every other fiber.

In an example of the inventive apparatus, unbleached Chesapeake kraft pulp was processed in a refiner head having seven pairs of oscillating and stationary blades. The differential oil pressure in the bottom cavities was about 280 p.s.i., the frequency was about 220 c.p.s., the blade-tip amplitude was ± 0.225 inch, and the average mean velocity of the centers of the oscillating blades was about 985 feet per minute. Each annular arrangement of blades contained 72 equally spaced blades about 0.312 inch in width. The outside diameter of the oscillatory blade arrangements was about 15 inches. The head above the blades was about 18 inches, and the refined pulp was allowed to fall freely from the last pair of blade arrangements. The refined pulp was withdrawn from the machine at a rate of about 95 gallons per minute and was

uniformly refined. The best flow rate previously obtainable from sonic refining apparatus under similar conditions with fluent material of the same consistency was between 40 and 60 gallons per minute.

While a presently preferred embodiment of the invention has been herein disclosed and described, it is to be understood that this apparatus is susceptible of numerous modifications and changes within the scope of the appended claims. For example, the stationary arrangements of blades could be replaced with solid annular rings, or annular rings with holes therein.

What is claimed is:

1. Apparatus for controlling the flow of fluent material through a vibratory refining head having an annular refining assembly comprising: a conical member positioned on the feed side of said refining head and within the inner edge of said annular refining assembly; feed means for presenting unrefined fluent material to the apex of said conical member to flow down over the conical member toward said annular refining assembly; and a cylindrical casing surrounding said annular refining assembly and extending both above and below said assembly means for causing part of said fluent material to pass directly into the refining assembly and the remainder of the material to swirl upward into said cylindrical casing extending above said assembly, said cylindrical casing having a first outlet positioned above the exit of said feed means and through which part of the material which swirls upward passes out of the apparatus, whereby the material directly above the refining assembly is constantly agitated by the incoming material sliding down over the conical member to avoid packing of the material, and a second outlet positioned below said refining assembly through which the refined material is discharged.

2. Apparatus for controlling the flow of fluent material through a vibratory refining head having an annular refining assembly comprising: a conical member affixed to the feed side of said refining head such that the circumference of the base of said conical member is in closely spaced relation to the inner circumference of said annular refining assembly; feed means having an exit directly above the apex of said conical member to flow down over the conical member toward said annular refining assembly; and a cylindrical casing affixed to said annular refining assembly and extending both above and below said assembly means for causing part of said fluent material to pass directly into the refining assembly and the remainder of the material to swirl upward into said cylindrical casing extending above said assembly, said cylindrical casing having a first outlet above said exit of said feed means and through which part of the material which swirls upward passes out of the apparatus, whereby the material directly above the refining assembly is constantly agitated by the incoming material sliding down over the conical member to avoid packing of the material, and a second outlet below said refining assembly through which the refined material is discharged.

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