(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 733 734 A2

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
25.09.1996 Bulletin 1996/39

(51) Int Cl.^{6}: **D21D 5/16**, D21D 5/04

(21) Application number: **96660005.8**

(22) Date of filing: **21.03.1996**

(84) Designated Contracting States:
AT BE DE FR GB SE

(30) Priority: **24.03.1995 FI 951396**

(71) Applicant: **JYLHÄRAISIO OY**
21201 Raisio (FI)

(72) Inventors:
- **Järvensivu, Tapio**
20460 Turku (FI)
- **Roitto, Ilkka**
21250 Masku (FI)
- **Forsten, Esa**
21110 Naantali (FI)
- **Alho, Jouni**
20740 Turku (FI)

(74) Representative: **Hovi, Simo**
Seppo Laine Oy
Lönnrotinkatu 19 A
00120 Helsinki (FI)

(54) **Straining method and screen**

(57) The invention relates to a method and a screen for straining filler and pigment slurries and coating mixtures in paper-making. The screen comprises an infeed chamber (8) incorporating a straining element (3) adapted to pass particulate matter smaller than a predetermined size. The material to be strained is fed to one side of said straining element (3) and the strained material is discharged from the opposite side. The straining is performed under a pressure head over the element and the hole size of the straining element (3) is smaller than 300 um and the flow rate properties of the material being strained are improved by virtue of a rotatable rotor (12) adapted to the ingoing side of the straining element (3).

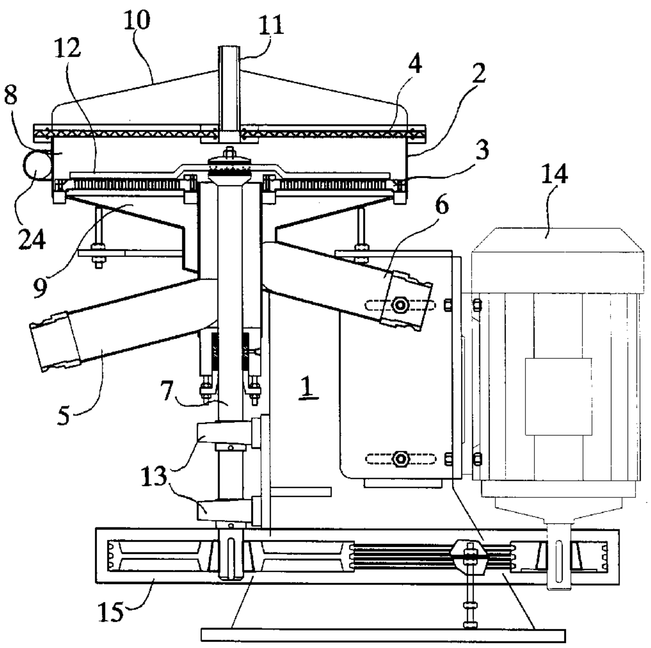


FIG. 1

EP 0 733 734 A2

Description

The present invention relates to a method according to the preamble of claim 1 for straining coating mixtures and slurries used in the paper industry.

The invention also concerns a screen capable of implementing the method.

Different kinds of pigment slurries and coating slip formulas are used in the paper industry for preparing coat mixtures applied to paper and cardboard webs. Such coat mixtures are prepared by mixing various solids with water to a consistency suited for a specific application in the paper mill. To achieve a high quality of the coated web, such coating mixtures must be strained. while primary straining is conventionally made to a freshly prepared slurry or even ready-made coating mixture, additional screens can be arranged to the coat feed circulation of the coater station. The function of the screens is to strain the coating mixture free from solids clumps, fiber detached from the web, felt hair detached from the paper machine and other foreign matter that could cause coating defects. Straining is implemented using two different basic types of screens: pressure screens and open screens of the vibrating flat type. Vibrating flat screens are conventionally used for straining slurries, whereby straining occurs through a flat wire cloth with the help of the hydrostatic pressure imposed by a slurry layer a few centimeters thick. The wire cloth is kept unclogged by means of vibration that simultaneously improves the straining capacity of the screen apparatus by virtue of decreasing the apparent viscosity of the slurry. A benefit of vibrating screens is their good selectivity as compared to pressure screens. Due to the square holes of the wire cloth employed as the straining element, the screen performs particularly efficient in straining of elongated foreign matter particles such as fibers detached from the web. The hole sizes of the wire cloth may be 50 um and up.

In pressure screens the straining element conventionally comprises a cylindrical slotted drum. The drum is typically made from wire of approx. 1 mm dia. which is first wound into a spiral and then the wire turns are attached in a suitable manner equidistantly spaced from each other. Typically, the slot width is 75 - 300 um. Owing to the screen fabrication method, the slot will have an elongated shape. For instance, the above-described type of screen drum actually has only a single, spiralled slot.

Pressure screens are used for straining both slurries and coating mixtures when installed in the coating circulation. The straining surface is kept clean by mechanical scraping or backwashing. The screen is washed or the accumulating rejects are removed by way of tapping a suitable amount of the fluid being strained away from the screen, generally at intervals of a few hours. The capacity of a pressure screen per unit straining area is multifold as compared to a vibrating screen, because the stiff structure of the screen drum allows use of a several times higher pressure head than in a vibrating screen. Typically, the proportion of holes on the screen drum is smaller than 10 % of the total area of the drum. Because the straining slot has an elongated shape, long and thin fibers can pass through the slots of the screen.

A problem hampering vibrating screens is their low straining capacity per unit area, particularly with regard to their open area which may amount up to 30 - 40 % of the straining element total area. The strength of the wire cloth is a limiting factor of straining capacity and no significant pressure head can be imposed on the screen in order to improve the straining capacity of the wire cloth. Typically, approx. 1 m^2 of wire cloth surface is required to strain 1 liter of slurry per second. Due to the low capacity of vibrating screens per unit area, a large footprint is required for these screens. Typically, up to ten vibrating screens are required for straining pigment slurries. Arranging such a high number of screens in a mill building may be extremely awkward making the use of vibrating screens even impossible.

A major problem hampering both vibrating and pressure screens is the clogging of the screen during use. In spite of vibrating and mechanical scraping, the screen units have to be dismantled for cleaning and maintenance at regular intervals, and moreover, gradual clogging causes degradation of straining capacity.

As to their construction, straining apparatuses disclosed in DE patent application 30 10 952 and EP patent application 0 616 072 resemble vibrating screens. In these apparatuses, the straining element comprises a perforated plate, whereby the plate is kept clean and the straining capacity improved with the help of a blade adapted to rotate close to the plate. As a stiff plate is difficult to perforate so that a sufficiently small size of holes can be attained combined with a high proportion of the open area formed by the perforating holes, and thus, large permeable area with respect to the total area of the plate, these apparatuses are hampered by low selectivity and, due to the small proportion of open area, also by inferior efficiency particularly with regard to their selectivity. Typically, the proportion of the permeable area in the perforated plate is approx. 10 % and, because the flow resistance of the screen increases rapidly with smaller hole sizes, the holes of the perforated plate usually must have a diameter of 0.5 mm or larger. These apparatuses are designed for straining of paper web and cellulosic fibers and removal of foreign matter from pulped wastepaper. As the apparatus disclosed in patent application EP 0 616 072 is basically intended for straining and cleaning of pulped wastepaper, it is obvious that the perforated screen plate used therein must have large holes to provide easy passage for paper web fibers. In fact, equipment intended for straining of suspensions containing paper web fibers are not suitable for highly selective straining applications such as straining of coating mixes or filler slurries. While straining in such apparatuses is not performed under a pressure head, a small pressure difference may develop over the straining element from the pumping of the material to be strained. However, this has no significant effect on the function of the apparatus, because the straining elements provide a low flow resistance due to the large hole size.

Though the capacity of a pressure screen is large with regard to a vibrating screen, its selectivity is poor. Particularly, straining of elongated or planar foreign matter particles away from a suspension being strained is difficult due to the geometry of the straining slot. The straining surface is kept clean by mechanical scraping or frequently repeated backwashing. Scraping causes wear of both the drum and scrapers. Fibrous foreign matter has a tendency to accumulate and thereby clog the screen slots, as well as to form large build-ups in the interior of the screen that cannot be removed along with the reject removal, but instead, require opening and manual washing of the screen. Backwashing causes large losses of strained material and gives rise to a wastewater treatment problem. Moreover, backwashing cannot be implemented so effectively that the need for frequently repeated opening and washing of the screen could be eliminated. A further shortcoming of backwashing is related to transient changes due to backwashing in the composition of the mixture being strained that may result in coating defects.

It is an object of the present invention to provide an effective straining method offering improved selectivity as compared to conventional pressure screens.

The goal of the invention is achieved by performing straining under a pressure head through a straining element having a hole size smaller than 300 um and improving the flow the material passed through the element by virtue of arranging a turbulent flow on the ingoing side of the straining element.

Advantageously, a turbulent flow is arranged on the ingoing side of the straining element and the surface of the wire cloth is kept clean by means of a rotary blade adapted to the ingoing side of the element.

More specifically, the method according to the invention is characterized by what is stated in the characterizing part of claim 1.

Furthermore, the screen according to the invention is characterized by what is stated in the characterizing part of claim 6.

The invention offers significant benefits.

The screen according to the present invention acts as a pressure screen combining the advantages of a vibrating screen and a conventional pressure screen. High selectivity is attained, because the straining element can be a similar wire cloth as is used in a vibrating screen. The wire cloth is supported by a grooved polymer plate and a support wire or fabric, whereby the pressure head rating of the screen is widely improved over a conventional vibrating screen. While the straining element may also be a perforated plate, the fabrication of a small-hole plate with a sufficiently large proportion of open area using concurrent manufacturing methods is expensive as compared to the costs of a wire cloth straining element. Slurries such as coating mixes and filler slurries used in papermaking are thixotropic and pseudoplastic as to their flow properties, whereby such materials are characterized by significant increase of fluidity under mixing of such materials. This property is utilized in the invention by generating a turbulent flow on the ingoing side of the straining element of the screen by means of an agitating rotor. The agitation of the material to be strained decreases essentially the viscosity of the material and simultaneously the agitation increases the straining capacity of the small-hole screen. Additionally, because the cleaning of the wire cloth is accomplished by means of an agitating rotor instead of vibration, the wire cloth will not be subjected to stress by vibration. With no need for vibration, the stresses imposed by vibration on the straining element are also eliminated. Owing to the support structures of the wire cloth, the screen can be operated with a pressure head as high as that used in conventional pressure screens.

Because the wire cloth used has 4 to 5 times as much open area on the straining surface as compared to spiralled wire drums of pressure screens, the straining capacity of the screen according to the invention per unit area of the straining element is larger than in conventional pressure screens operated at equal pressure head. Additionally, as the present screen can be operated at an essentially higher pressure head than is possible with a conventional vibrating screen, the straining capacity at a constant open area can be increased in linear proportion to the elevated pressure head. Since the straining capacity of a screen is proportional to the pressure difference over it, the capacity of the present screen may be easily elevated tenfold over that of a conventional vibrating screen, whereby a single screen apparatus will be is sufficient for applications conventionally requiring the use of several screens in parallel. A particularly effective contribution to straining capacity of the present screen is imparted by the agitation of the material being strained, thus permitting a screen according to the present invention to bestow essential reduction of straining costs due to the smaller number and size of screens required.

The wire cloth is kept unclogged and clean by means of a rotor invoking a turbulence that elevates the foreign matter away from the wire cloth surface. The movement of the rotor parallel to the wire cloth surface improves the separation of elongated foreign matter particles such as fibers. Also the separation of other shapes of foreign matter is enhanced, because the rotor generates a flow vector orthogonal to the accept material flow via the holes of the screen, whereby the passage through the wire cloth will be impeded for particles to be classified as reject. Additionally, the turbulence serves to prevent build-up of the material being strained onto the interior surfaces of the screen.

In the following the invention will be examined by making reference to the appended drawings in which

Figure 1 shows longitudinally sectional view of a screen apparatus according to the invention;

Figure 2 shows a straining element suited for use in the apparatus illustrated in Fig. 1;

Figure 3 shows a partial enlargement of the diagram of Fig. 2 and

Figure 4 shows an assembly diagram of the element illustrated in Fig. 2.

An essential variable which is characteristic of the present invention is the hole size of the straining element that in this context refers to the largest diagonal dimension of the hole, e.g., its diameter. In practice, the shape of the holes can be varied depending on the manufacturing method of the straining element. To achieve sufficient selectivity, the hole size may maximally be 300 um, but conventionally the hole size seldom exceeds 200 um. While the hole size is advantageously in the range 50 - 120 um, the actual design value of hole size is among other factors dependent on the shape of the holes.

Referring to Fig. 1, the screen shown therein is assembled onto a planar base 1. Straining occurs in a screen chamber 2 formed by rotation-symmetrical, relatively flat chamber that is divided into two subchambers by means of a straining element 3. The top part of the chamber is closed by a lid 4. To the lower part of the screen chamber 2, about its center shaft, is formed an infeed channel 5 and a discharge channel 6 surrounding said infeed channel 5. The infeed channel 5 exits into the upper subchamber of the screen chamber 2, that is, to an infeed chamber 8 enclosed from above by the lid 4 and from below by the straining element 3. Beneath the straining element 3, delimited by said straining element and the bottom of the screen chamber 2 is located a discharge chamber 9, wherefrom a discharge channel 6 exits. Additionally, to the center axis of the screen chamber 2 is arranged a gas vent channel 11 exiting into the infeed chamber 8. The gas vent channel 11 is connected to a lattice 10 supporting the lid. To the circumference of the screen chamber 2 is adapted a reject discharge nozzle 24. In the center of the infeed channel 5 is adapted a shaft 7 extending up to the infeed chamber 8. To the end of the shaft 7 is mounted an agitating rotor 12 arranged at a distance from the upper surface of the straining element 3. The shaft 7 is mounted to the planar base 1 of the screen apparatus on bearings 13 and is rotated by means of an electric motor 14 driving a V-belt and pulley transmission chain mounted on the planar base 1.

Referring to Figs. 2, 3 and 4, the straining element 2 is shown therein in more detail. The element comprises five members. The frame of the element is formed by a perforated support plate 17. The support plate 17 is a circular, essentially flat plate having a round hole 21 at its center. The circumference of the round hole 21 and the outer rim of the plate 17 are provided with holes 22 and 23 to accommodate fixing screws, and the holes perforating the support plate 17 are made to the bottoms of annular grooves machined to the support plate. Onto the support plate 17 is adapted a support wire fabric 19 having relatively large mesh holes, and onto the support wire fabric 19 is placed the straining wire cloth 20 proper made from a woven material similar to that of the wire of a vibrating screen, in which interwoven wires form holes through which the material to be strained can pass through the wire fabric. The support wire fabric 19 and the straining wire cloth 20 are attached to the support plate 17 at their outer rims and at the inner rim about the center hole 21 with the help of clamp rings 16 and 18, whereby the support wire fabric 19 serves to prevent the straining wire cloth from sagging into the grooves of the support plate 17.

The function of the screen apparatus described above is as follows. The material to be strained is fed into the screen via the infeed channel 5 under a pressure head, whereby the material first enters the infeed chamber 8, wherefrom it passes via the straining element 3 into the discharge chamber 9 and therefrom further via the discharge channel 6 into, e.g., the coating mix circulation of a coater station. The major portion of the material entering the infeed chamber 8 can pass through the straining wire cloth 20, whereupon the actual reject separation of oversize particulate matter as well as clumps and fibers from accepts takes place. The accept portion passed through the wire cloth 20 can subsequently flow through the coarse-mesh support fabric 19 and the holes of the support plate 17 into the discharge chamber.

As a substantial amount of material to be strained is passed through the screen apparatus, the straining wire cloth 20 would easily become clogged unless actively kept clean. The screen according to the present invention is basically a pressure screen in which the fluid being strained is passed through the wire cloth with the help of a pressure head. Such a pressure head can be readily accomplished with the help of a feed pump by controlling the volume flow rate to a sufficiently high value. The material to be strained is fed into infeed chamber forming the upper space above the wire cloth so that the infeed flow exits into the chamber at the center of the straining element about the rotor shaft, whereby the material flow takes place radially toward the perimeter of the chamber. Actual cleaning of the wire cloth is performed by means of the driven rotor 12. When rotated at a tangential speed of approx. 5 - 20 m/s, the driven rotor 12 causes turbulence which detaches oversize particulate matter from the surface of the wire cloth 20. By virtue of the feed flow arrangement and the centrifugal pumping effect imparted by the rotor 12, the detached rejects are driven toward the perimeter of the chamber having the rejects discharge nozzle 24 mounted thereto, whereby the rejects can be removed either as a continuous flow, or alternatively, at controlled intervals. The reject fraction can be strained in a secondary screen such as a vibrating screen. Since the rejects fraction with respect to the total volume of material strained usually is relatively small, cyclic discharge of the rejects from the screen chamber will often suffice.

Besides cleaning the straining element 3, the rotor 12 serves to improve flow through the screen. Because the hole size of the straining element must be relatively small, the flow resistance of the straining element to high-viscosity materials such as coating and filler slurries will be high. While a pressure head imposed on the straining element can increase the flow through the screen apparatus, the application of the straining method according to the invention to such high-viscosity materials is essentially based on vigorous agitation with the help of a rotor. Such agitation can significantly reduce the viscosity of slurried materials thus aiding their through the straining element, whereby a screen apparatus with a high straining capacity is achieved without compromising its selectivity against foreign matter. Hence, while agitation in the present straining method has partially the same function as the vibration of a vibrating screen, such agitation combined with an appreciably higher pressure head than that used in a vibrating screen results in a significantly greater straining capacity than what can be attained using vibration alone.

In addition to those described above, the present invention may have alternative embodiments. Although the straining cloth or wire can be selected from a number of different fabric types, it is advantageous to use a fabric made from interwoven wires, whereby a wire cloth is provided characterized by large proportion of open area combined with good selectivity against foreign matter. while the fabrics and wires employed in the method typically have a hole size of approx. 50 - 120 um, the actual size of mesh holes will be selected according to the application. The support plate and the support fabric must have a design permitting minimum resistance to the flow of the strained material and simultaneously provide support for the straining wire cloth against the stress imposed by the pressure head. While straining under a pressure head without a wire cloth support would be detrimental to the cloth, the present supported screen construction can be operated at the same pressure head, typically approx. 1 bar, as is imposed in conventional pressure screens over the straining element. While the straining element may also comprise a perforated plate made from sheet steel or other suitable material, it will be rather costly by virtue of concurrent manufacturing techniques to manufacture a small-hole perforated plate with an open area of 20 - 30 %. However, such a plate can be fabricated by means of laser machining, whereby it is possible to achieve a straining element of higher mechanical strength than that of a conventional wire cloth. However, as the straining capacity of a screen is ultimately determined by the open area of the straining element, it is entirely suitable to use a low-cost straining element of smaller open area as long as the straining capacity requirements of the specific application are fulfilled.

The operation of the screen apparatus may be controlled by altering the profile and rotational speed of the agitating rotor as well as the pressure head over the straining element. The rotor shape can be varied widely provided that the rotor design preserves its agitating properties to generate a turbulent flow which elevates foreign matter aggregates away from the surface of the straining element. The drive motor of the rotor can be placed so that the shaft 7 need not extend through the straining element, whereby the alternative location of the drive motor in the illustrated embodiment would be above the screen. Owing to the use of a rotatable rotor in the screen apparatus, the optimal shape of the screen chamber obviously is rotation-symmetrical. With alternative arrangements of agitation, cleaning of the straining element and infeed of material to be strained, different designs of the screen apparatus are possible. The infeed of the material to be strained can be arranged from the side of the screen chamber, whereby any clumpy and hard aggregates possibly carried over with the infeed cannot land in the gap between the rotor and the straining element thereby causing damage to the rotor. For instance, in a screen apparatus with a rectangular cross section of the screen chamber, the infeed nozzle could be place on the short side of the rectangular chamber and the turbulent flow could be accomplished using high infeed velocity or different kinds of rotor wing or propeller agitator designs. Further, the planar shape of the straining element could be replaced by a slightly curved straining plate, or alternatively, a curved support plate on which the wire cloth or other straining fabric is placed. While the latter arrangement offers improved ejection of rejects toward the perimeter of the screen chamber, a more complicated construction results.

Claims

1. A method of straining filler and pigment slurries and coating mixtures in papermaking, in which method

   - feeding the material to be strained into a chamber (8) having at least a portion of its walls formed by a straining element (3) perforated with holes, said element being capable of passing particulate matter smaller than a predetermined size,

   - routing the fraction of the infed material passed through the straining element (3) to further use and removing the retained fraction as rejects, and

- elevating the pressure head on the ingoing side of the straining element (3) above the pressure on the outgoing side of element,

characterized in that

- using as the straining element (3) a perforated member with a hole size smaller than 300 um, and
- agitating the material to be strained on the ingoing side of the straining element (3) in order to decrease its viscosity.

2. A method as defined in claim 1, **characterized** in using a straining element (3) having perforations formed by holes remaining between interwoven wires crossing each other.

3. A method as defined in claim 2, **characterized** in supporting the straining element (3) from the side of lower pressure.

4. A method as defined in any of claims 1 - 3, **characterized** in keeping the surface of the straining element (3) clean by arranging a turbulent flow of said material close to said surface.

5. A method as defined in claim 4, **characterized** in keeping the surface of the straining element (3) clean and decreasing the viscosity of the material to be strained with the help of an agitating rotor (12).

6. A method as defined in any of foregoing claims, **characterized** in feeding the material to be strained into the screen infeed chamber (8) via an infeed channel (5) adapted about the drive shaft (7) of the rotor (12) and removing the rejects at the perimeter of the screen infeed chamber (8).

7. A method as defined in any of foregoing claims, **characterized** in that the pressure head over the straining element is approx. 1 bar.

8. A screen for straining filler and pigment slurries and coating mixtures in papermaking, said screen comprising

- an infeed chamber (8) having at least a portion of its walls formed by a straining element (3) perforated with holes,
- elements (5) for feeding the material to be strained into said infeed chamber (8),
- elements (6) for routing the fraction of the material passed through said straining element (3) to further use and elements (24) for discharging the nonpassed fraction out from the screen as rejects, and
- elements for feeding the material to be strained into said infeed chamber (8) so that the pressure in said infeed chamber (8) is higher than the pressure in the discharge chamber (9) after said straining element (3),

characterized in that

- the straining element (3) employed is a perforated member with a hole size smaller than 300 um, and
- in conjunction with the infeed chamber (8) are adapted means (12) for agitating the material to be strained and for forming a flow pattern in the vicinity of said straining element (3).

9. A screen as defined in claim 8, **characterized** in that said straining element (3) is a mesh-like member having its penetrating holes formed by holes remaining between interwoven wires crossing each other.

10. A screen as defined in claim 9, **characterized by** means (17, 19) for supporting said straining element (3) from the side of lower pressure.

11. A screen as defined in claim 8, **characterized** in that said straining element (3) is a stiff, perforated plate.

12. A screen as defined in any of foregoing claims 8 - 11, **characterized** in that said means for agitating the material to be strained comprise a rotatable rotor (12).

13. A screen as defined in claim 12, **characterized** by an infeed channel (5) adapted about the drive shaft (7) of said rotor (12) and by a discharge channel (24) for removing rejects from the perimeter of said screen infeed chamber (8).

14. A screen as defined in claim 9, **characterized** in that said straining element (3) comprises a wire cloth (20) or other similar mesh-like element, a circular and planar perforated support plate (17) adapted to back said wire cloth and a support fabric (19) adapted between said wire cloth (20) and said support plate (17).

15. A screen as defined in any of foregoing claims 8 - 14, **characterized** in that the hole size of said straining member (3) is smaller than 200 um.

16. A screen as defined in any of foregoing claims 8 -

14, **characterized** in that the hole size of said straining member (3) is in the range 50 - 120 um.

17. A screen as defined in any of foregoing claims 8 - 16, **characterized** in that the open area of said straining member (3) is over 20 % of the total area of the element.

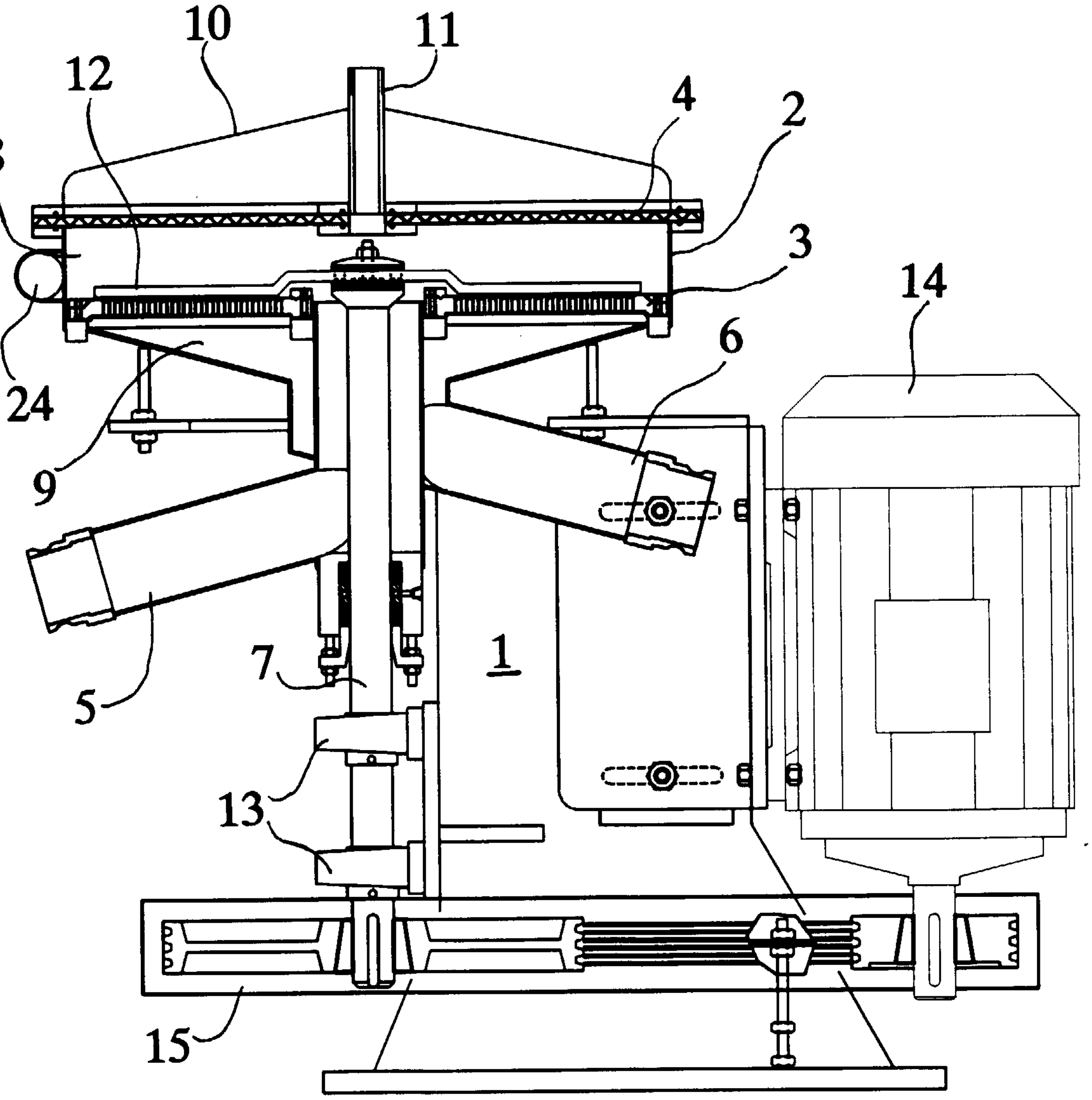


FIG. 1

FIG. 3

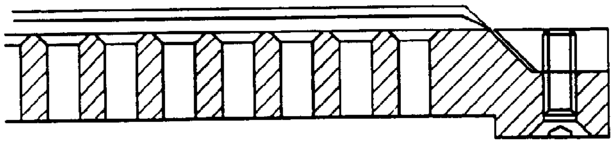
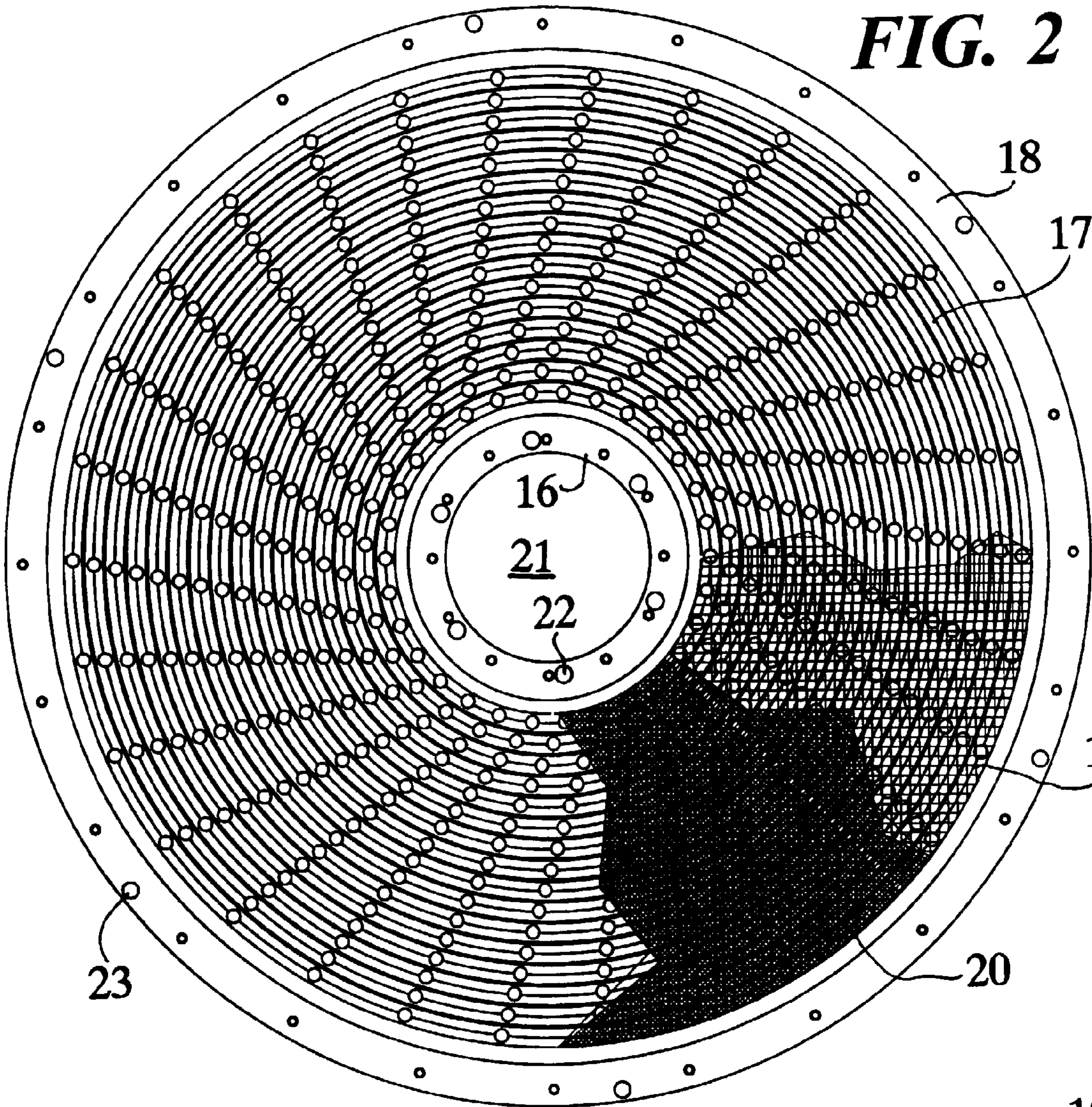


FIG. 2



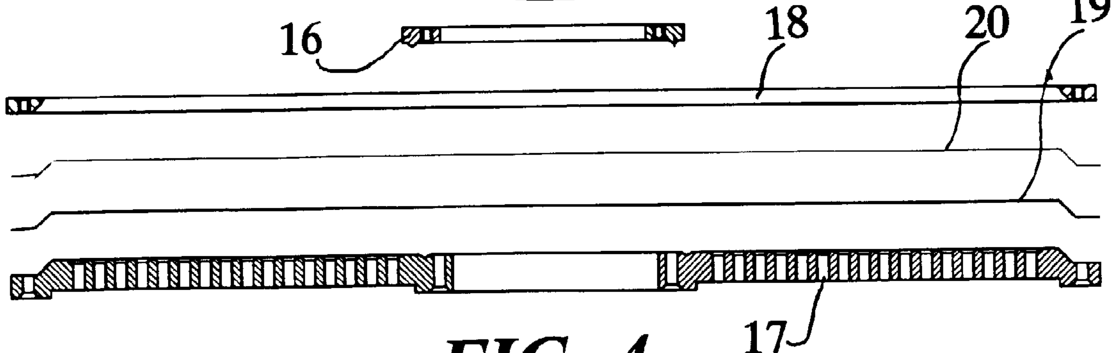


FIG. 4