June 14, 1966 G. L. NELSON ETAL 3,255,883

PULP SCREEN WITH DISCHARGE RECEPTACLE

Filed Feb. 18, 1963 4 Sheets-Sheet 1

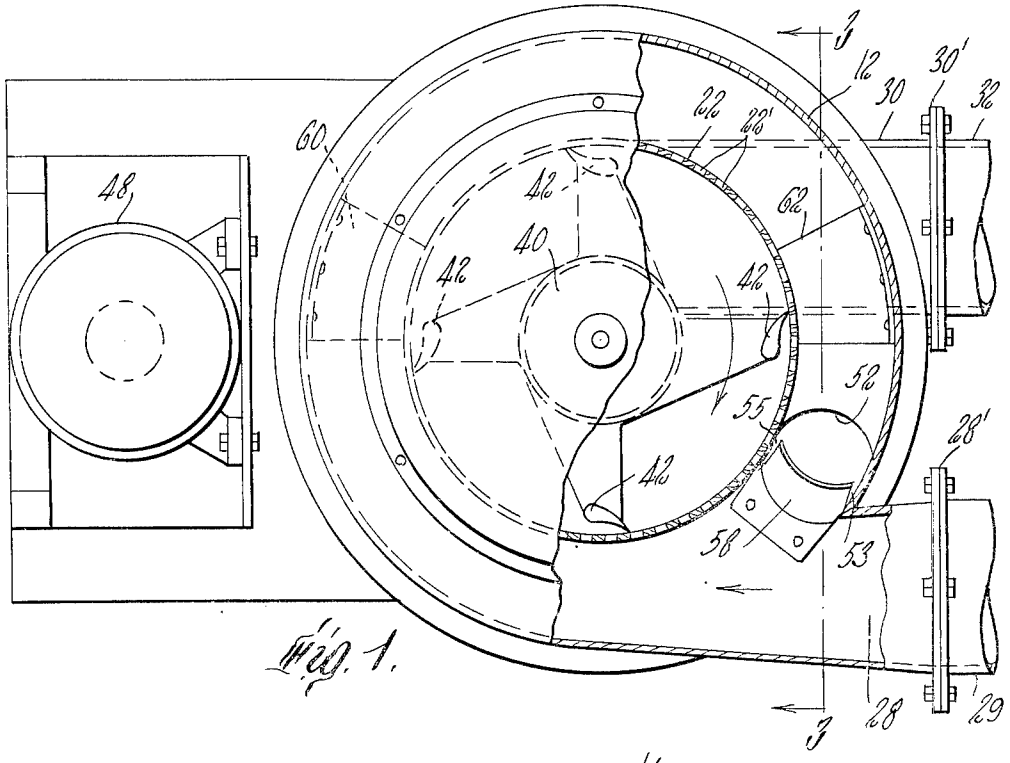

Fig. 1.

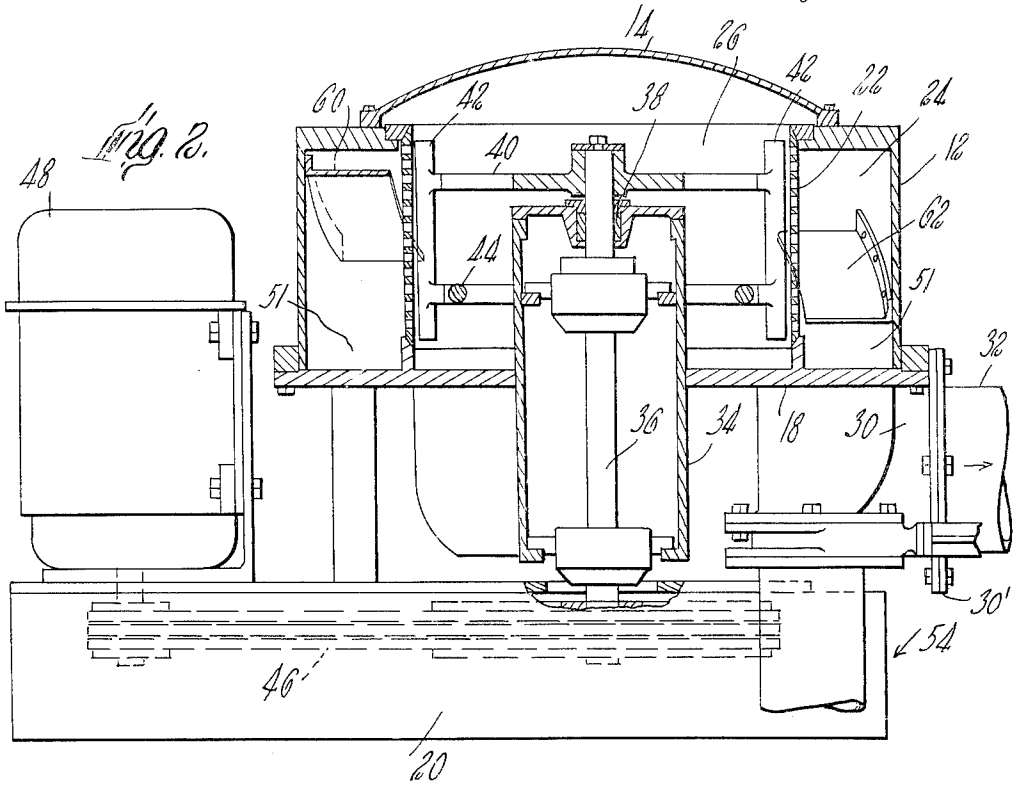

Fig. 2.

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PULP SCREEN WITH DISCHARGE RECEPTACLE

Filed Feb. 18, 1963 4 Sheets-Sheet 2

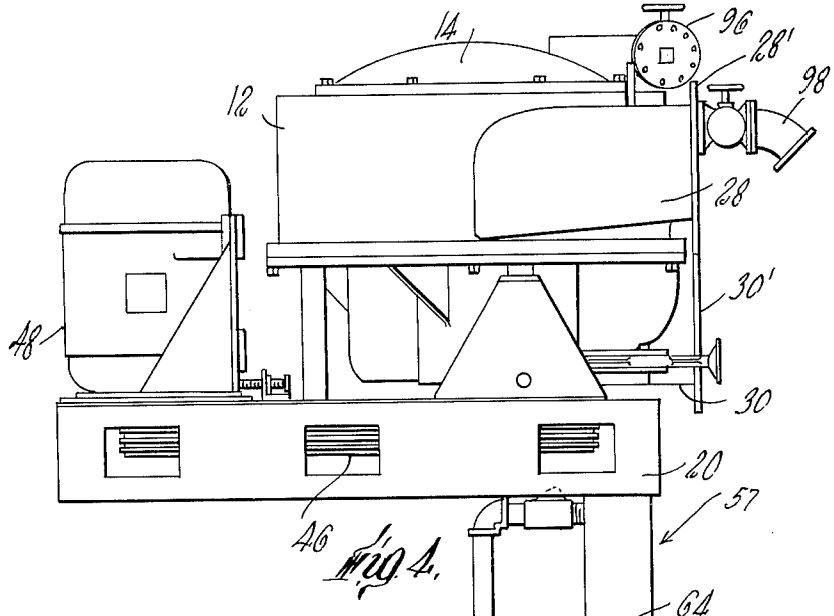


Fig. 4.

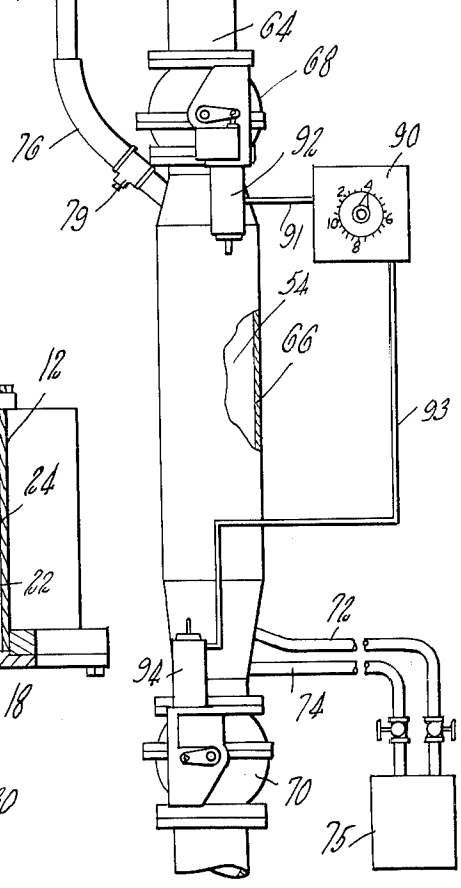
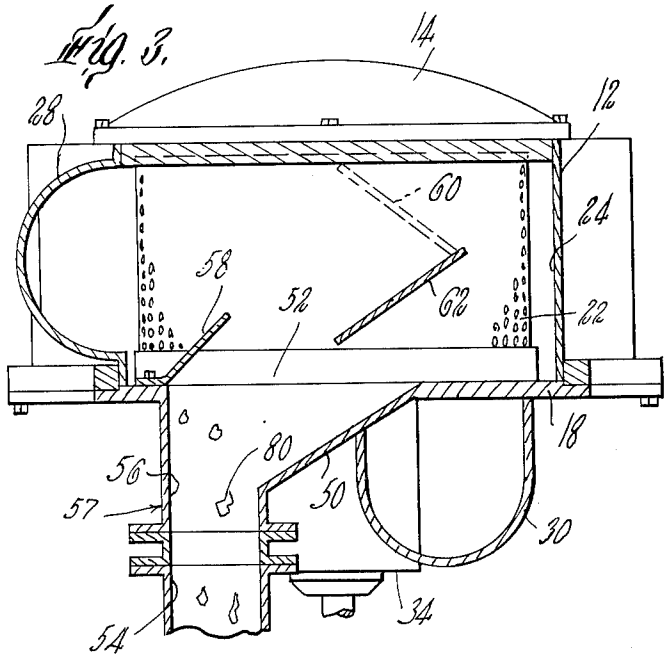


Fig. 3.



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PULP SCREEN WITH DISCHARGE RECEPTACLE

Filed Feb. 18, 1963 4 Sheets-Sheet 3

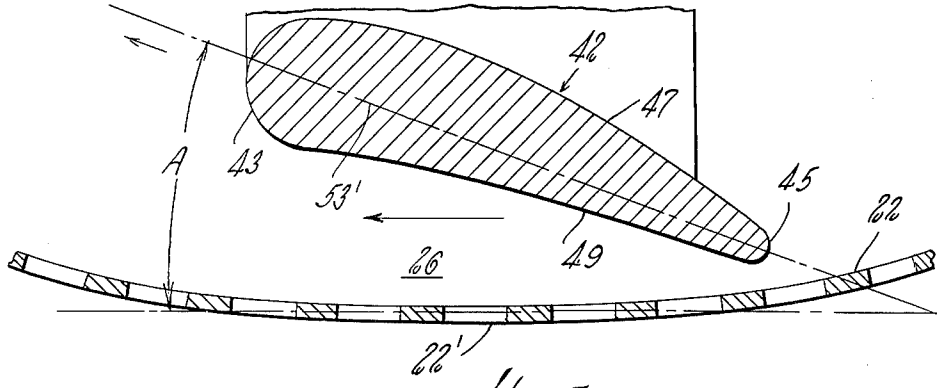

Fig. 5.

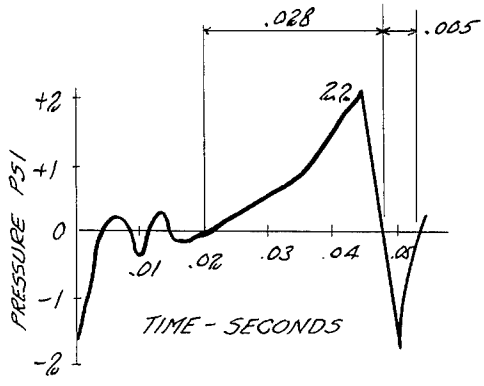

Fig. 6.

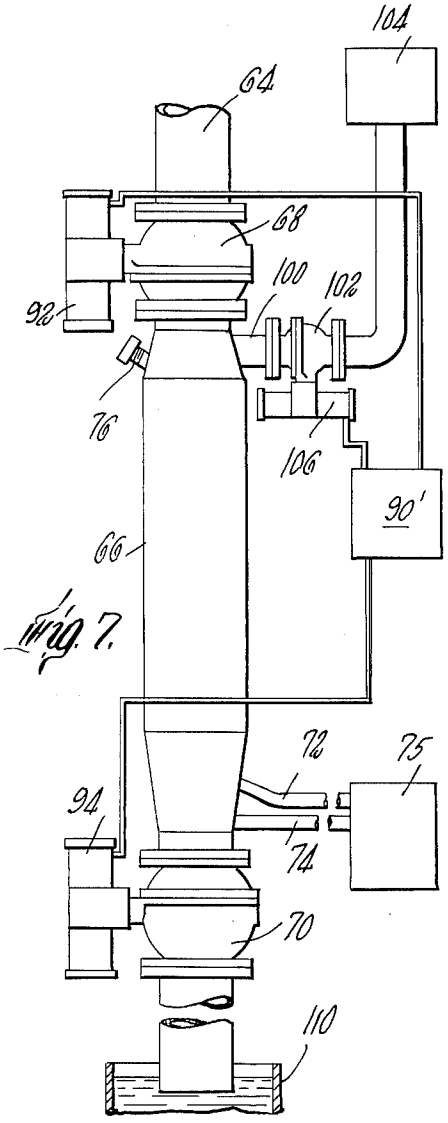

Fig. 7.

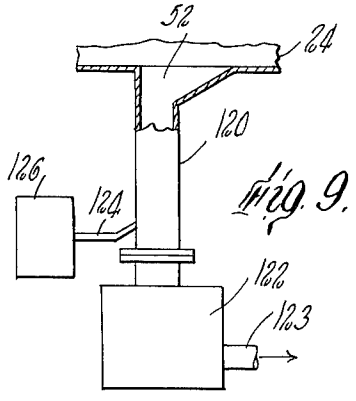

Fig. 9.

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PULP SCREEN WITH DISCHARGE RECEPTACLE

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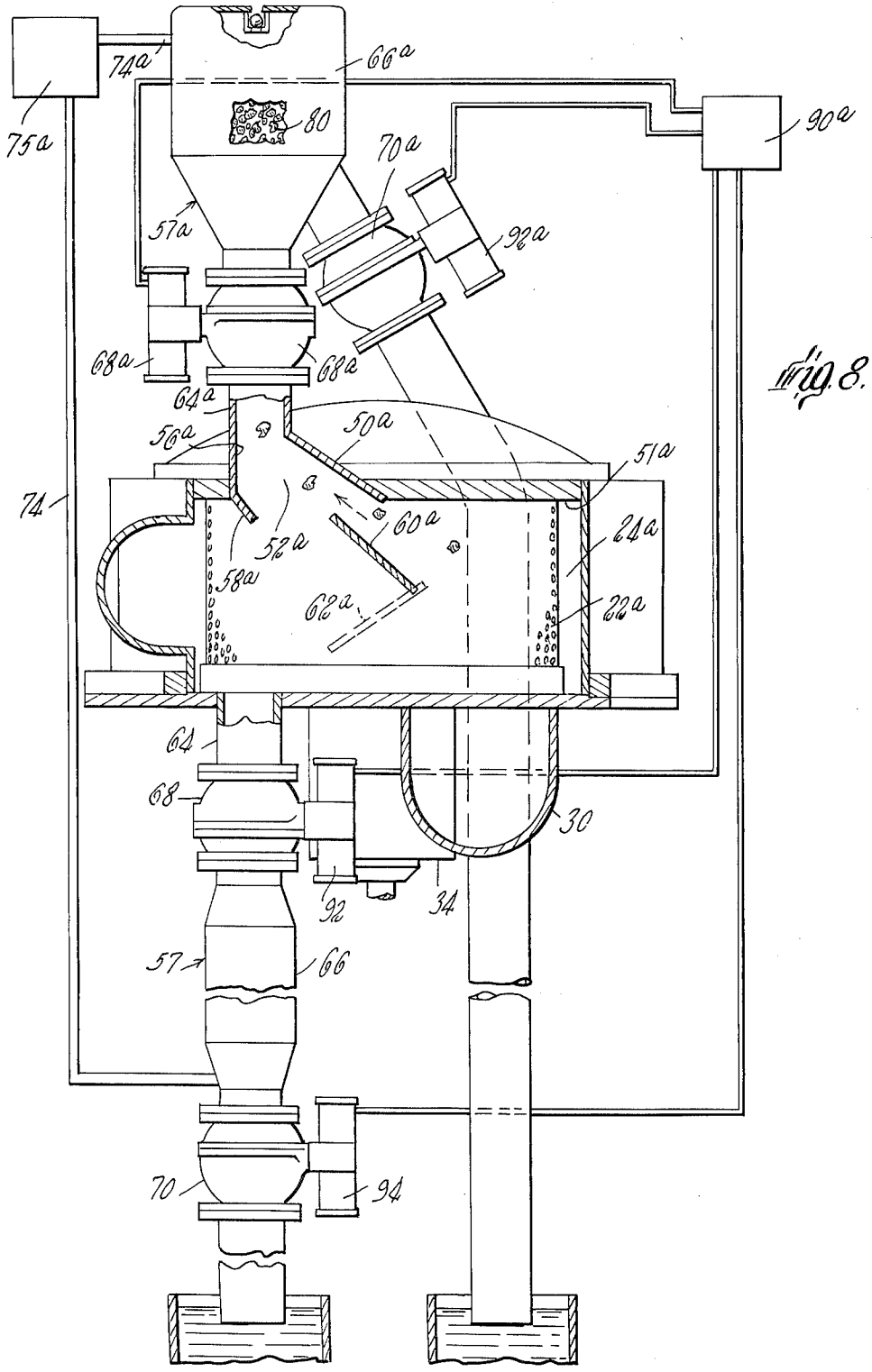

Fig. 8.

United States Patent Office 3,255,883 Patented June 14, 1966

3,255,883

PULP SCREEN WITH DISCHARGE RECEPTACLE

George L. Nelson, Westwood, Mass., and Ian J. Clarke-Pounder, Pierrefonds, Quebec, Canada, assignors to Bird Machine Company, South Walpole, Mass., a corporation of Massachusetts

Filed Feb. 18, 1963, Ser. No. 259,265
7 Claims. (Cl. 209—17)

This invention relates to screening devices for removing knots, e.g. large fibrous bundles and other large impurities and debris, from fibrous pulp and other slurries before they are subjected to fine treatment. One example of knots is undefibered wood chips that occur in chemical wood pulp due to incomplete digestion or the imperfect character of the wood chip; another example is undefibered wood chips in ground wood pulp that have accidentally passed through the defibering mechanism; another example is undefibered clumps of wastepaper held together by metal fasteners that occur in wastepaper pulp. Another example is large nonfibrous impurities which may accidentally be present such as glass, brick chips, metal and plastic material. These knots may have specific gravities greater or less or equal to the supporting fluid.

In present-day pulp and paper mills it is desired to remove knots from pulp in a hydraulically sealed condition without a liquid-air interface. As is well known, this prevents foaming and allows "pump-through" operation from the defibering device which has great advantages with respect to simplifying the pulp piping and machinery and increasing the production rate. Though heavy impurities such as metal and dirt are easy to separate, e.g. by centrifugal action, fibrous knots have been difficult to separate because of their intimate association with the good fibers and their only slight difference in specific gravity, if any, from the good fibers. For this reason all hydraulically sealed screening devices heretofore suggested for the screening out of knots have suffered from either high loss of good fibers or reduction of consistency due to the addition to the pulp of large proportions of liquid for scrubbing the knots before their removal. The prior art screening devices have also suffered in having low capacity per square foot of screen plate area, and a tendency to contaminate the pulp with broken knot particles.

It is the main object of this invention to provide a fluid sealed knot screening device which does not have these drawbacks.

Specifically, objects of this invention are to provide: a knot screening device that removes all knots which either sink or float; a knot screening device that removes virtually no good fibers; a knot screening device that does not dilute the pulp; a knot screening device that does not generate foam even when the flow is soap-like; a knot screening device that can handle extremely high flow rates of pulp at consistencies ranging up to 2 percent; a knot screening device that does not break the good fibers or the knots; a knot screening device that requires little pressure drop in the flow and requires little power; a knot screening device that is compact and simple to enable low-cost manufacture and operation.

A still more specific object of the invention is to provide a compact knot screening device that is capable of handling 300 to 500 tons of pulp, dry weight, per day, that removes all knots and less than 1 percent of good fibers, preferably less than ⅕ of 1 percent.

Besides the main object, other principal objects of the invention are to provide a screen plate and foil combination of general utility, and to provide a unique arresting arrangement for impurities.

According to the invention it has been realized that the prior art apparatus have adopted the wrong approach,

that of maintaining a continuous outflow of knots from the inlet chamber of the screening device. By maintaining such a flow, inherently loss either of good fibers or of consistency of the pulp must occur.

The present invention in one of its important aspects employs a different concept, that of sealing the inlet chamber against such continuous outflow, and employing knot discharge means, such as a sump device having a chamber in which knots can collect. While it is true that the specific gravity of the knots is usually close to that of the pulp, it has been found that if a relatively quiescent condition is maintained at the entry of the sump device, the knots are capable of entering the sump device by gravity movement at a rate that enables the screening device to handle unusually large quantities of high consistency pulp. Particularly with a screen plate cleaning device, most advantageously with such a device mounted at the accepts side of the screen plate that pulses the knots periodically from the screen plate, the knots separate rapidly under gravity movement without damaging the fibers or breaking the knots.

It was discovered that a specially shaped and positioned foil member operating on the accepts side of the screen plate has an extremely high and long positive pressure pulse relative to the negative pulse and keeps the screen plate clean with the knots periodically pushed away from the screen plate, even with extremely high flows through the screen plate. The special shape of the foil member is a concave foil surface disposed toward the screen plate with the trailing edge mounted to sweep closer to the screen plate than the leading edge, the foil member having an elongated cross-section. The special position is with the axis of the foil member set at an angle in the range of between 15° and 30° to the screen plate surface. Particularly when the screen plate openings are in the range of ¼ to ⅞ inch, with at least 30 percent of the screen plate being open, a good effect upon the knots is obtained despite the high rate of pulp flow through the perforations. The special foil member is not limited in its usefulness to knot screen plates, but can be employed to advantage with all types of screen plates, and with all size openings, although the maximum effect is achieved within the limits specified above.

Advantageously, the knot discharge means is operable to discharge knots from the sump chamber through a sump outlet, the sump outlet being isolated, during said discharge, from fluid communication with the inlet chamber. Thereby the screening device is sealed against loss of the good fibers when the knots are removed. Preferably this knot discharge means comprises a dumping valve preventing continual flow from the sump chamber during knot collection, and an isolation valve capable of isolating the sump chamber from the inlet chamber, the dumping valve operable to dump the sump chamber only when the isolation valve is closed. It is advantageous to employ a pulp-free liquid barrier to the entry of pulp to the sump device by introducing a pulp-free liquid having a specific gravity that differs from that of the knots in the direction of the specific gravity of the pulp, and preferably a specific gravity that falls between the specific gravity of the knots and of the pulp. This pulp-free barrier can be maintained by an extremely low flow of liquid from a pressure source due to the sealed condition of the sump device, so that virtually no dilution occurs. Advantageously, this pulp-free liquid is introduced to the knot collection zone or sump chamber of the sump device to act upon the knots.

It is found that the lateral movement of the fluid feed can be employed to carry the separating knots to the sump device for collection, in conjunction with an arresting surface of vertical extent. For example, in a vertical screen plate construction with the screen plate mounted within

the pressure casing to define an annular inlet chamber, a gutter immediately adjacent the end of the screen plate can define the end of the inlet chamber toward which the knots move, the sump opening can be disposed in the gutter, and the movement of the liquid about the screen plate will cause the knots at all points about the inlet chamber to move laterally, circularly to the sump opening. Arresting surfaces on the downstream side of the sump opening arrest the lateral movement of the knots and allow them to enter the sump device with gravity movement. A sloping ramp at the upstream side of the sump opening aids in the arresting of lateral movement of the knots and facilitates their entry into the sump device.

Further, it is found with the screening device as described above that an extremely large tangential inlet extending nearly the same height as the screen plate can be employed, which enables the attainment of very rapid circular movement throughout the inlet chamber. The vertical movement of the knots from the remote end of the inlet chamber to the sump opening is enhanced in this screening device by the use of deflector plates sloping in the direction of lateral movement of the pulp towards the sump opening. Where the arresting surface of the sump device comprises a scoop member, advantageously the closest deflector plate has its closest edge to the sump opening extending closer thereto than the inner edge of the scoop member, whereby, if knots strike the deflector plate and never move opposite from their gravity direction, their entry into the sump opening is assured. When a scoop member is employed, advantageously lateral flow passages on both sides of the scoop member maintain a flow at this level. This insures that knots carried in the flow will arrive at the level of the scoop member and have their lateral movement arrested so that they will enter the sump opening.

According to the invention as applied to chemical pulps and the like, the apparatus takes advantage of the fact that the majority of knots have a specific gravity slightly exceeding that of the supporting liquid, the gravity movement of the knots being of a sinking nature, and a sump opening for knot passage into the sump chamber is disposed in the bottom of the inlet chamber. In combination with the basic screen apparatus, an outlet at the top of the inlet chamber is provided for periodic opening and purging of any floating material that might occur. Where very little floating material occurs, it is possible merely to place a valve at the top and allow the pressure of the inlet chamber to force the floating objects out from time to time.

According to the invention as applied to ground wood pulp and the like, the apparatus takes advantage of the fact that the majority of knots have a specific gravity slightly less than that of the supporting liquid, the gravity movement of the knots being of a floating nature, and a sump opening for knot passage into a top sump chamber is disposed in the top of the inlet chamber. A sump opening at the bottom of the inlet chamber also can then be employed to permit passage of any sinking objects into the bottom sump chamber.

These and numerous other features and advantages of the invention will be explained in more detail with reference to the drawings wherein:

FIG. 1 is a top plan view, partially in cross-section, of a preferred embodiment of the apparatus of the invention;

FIG. 2 is a vertical side view of the embodiment of FIG. 1, partially in cross-section;

FIG. 3 is a vertical cross-sectional view of the apparatus of FIG. 1 taken on lines 3—3 thereof in the direction of the arrows;

FIG. 4 is a side view of the apparatus of FIG. 1 including a bottom sump device;

FIG. 5 is a cross-sectional view of one preferred foil member of the invention and its relation to the screen plate;

FIG. 6 is a graph of time versus pressure at the screen plate that can be generated by the foil member of FIG. 5;

FIG. 7 is a side view of another preferred mechanically sealed sump discharge apparatus for the knot screening device;

FIG. 8 is a side view of another preferred embodiment of the knot screening device for removal of floating objects; and

FIG. 9 is a fragmentary side elevational view of a further alternative embodiment of the sump device.

Referring to FIGS. 1–4, a knot screening device is shown that is particularly suited for removal of knots that sink in a carrier liquid, e.g. black liquor. A pressure casing is defined by vertical cylinder 12 covered with a pressure dome 14 and upstanding from floor 18. The pressure casing is mounted on frame 20 (FIGS. 2 and 4). A vertical, cylindrical, perforate screen plate 22 (FIGS. 1–3) is mounted concentrically with vertical cylinder 12 and is sealed at both top and bottom casing to define two chambers, namely, annular inlet chamber 24 (FIG. 2) and central accept chamber 26. The screen plate openings 22′ are sized not to pass any knots 80 (FIG. 3) but to pass all good fibers, "good fibers" meaning sheaves that are usable after refining as well as single fibers. In this embodiment the openings 22′ in screen plate 22 preferably range between ¼ and ⅞ inch. Each end of the inlet chamber 24 is defined by a gutter 51 (FIG. 2) immediately adjacent the end of the screen plate 22, with no intervening ledge.

A feed passage 28 (FIGS. 1, 3 and 4) at one side of the pressure casing is constructed and arranged to fill the inlet chamber 24 with fluid under pressure, directing fluid tangentially of the pressure casing in the clockwise direction as viewed in FIG. 1 to maintain lateral circular flow at the gutter 51 located at the bottom of the inlet chamber 24. The feed passage 28 (FIGS. 3 and 4) has a substantial height, e.g., nearly that of screen plate 22. The high degree of perforation of the screen plate 22 enables the use of such an unusual relation of feed passage 28 to screen plate 22. Flange 28′ (FIGS. 1 and 4) on the feed passage 28 is for example connected to piping or inlet pipe 29 (FIG. 1) carrying hot black liquor pulp from a blow tank (not shown) in a chemical pulp mill (not shown) at the rate of 4,000 gallons per minute.

At the opposite side of the pressure casing an accept outlet pipe 30 (FIGS. 1–4) extends below floor 18, the upper portion of the accept outlet pipe 30 being cut away and in communication with the accept chamber 26. As can be seen in FIG. 1, the accept outlet pipe 30 is constructed and arranged to tangentially intercept liquid which is carried in the accept chamber 26 and which rotates in the same direction as does the foil members 42 (FIGS. 1 and 2). Accept outlet pipe 30 is provided with flange 30′ (FIGS. 1, 3 and 4) adapted to be connected to pulp accept outlet passage 32 which may discharge directly to fine screening and washing apparatus (not shown) in the pulp mill (not shown).

A drive shaft housing 34 (FIGS. 2 and 3) extends upwardly through floor 18 centrally of the accept chamber 26. A drive shaft 36 (FIG. 2) extends through a seal 38 into the accept chamber 26, from which a spider 40 (FIGS. 1 and 2) extends radially, supporting foil members 42 spaced at regular angular intervals to each other. Each of the foil members 42 has an upright extent corresponding substantially to the vertical height of the screen plate 22. A horizontal ring 44 (FIG. 2) joins the lower parts of the foil members 42 together. The drive shaft 36 is driven by belts 46 (FIGS. 1, 2 and 4) driven by electric motor 48.

A means to intercept spirally sinking knots 80 (FIG. 3) comprising a sump opening 52 (FIGS. 1 and 3) is provided in gutter 51, preferably, as shown, located downstream in the lateral flow path of the pulp from the feed passage 28, most advantageously adjacent the vertical line through the feed passage 28 but out of the direct flow path therefrom. From upstream the floor of the gutter 51

slopes downwardly toward the opening defining ramp **50** (FIG. 3), e.g. extending down 8 inches in 18 inches of lateral extent. A vertically extending sump chamber **54** (FIGS. 2–4) of a sump device **57** is disposed below and in communication with sump opening **52**. A vertical wall or arresting surface **56** (FIG. 3) on the downstream side of sump opening **52**, revealed by ramp **50**, is located to arrest the lateral movement of knots **80** (FIG. 3) to promote their vertical entry into the sump chamber **54**. Preferably, a further arresting surface having a vertical extent, scoop member **58** (FIGS. 1 and 3), is mounted at the top of vertical wall **56** and slopes upwardly into the approaching flow. Lateral openings **53** and **55** (FIG. 1) at the sides of the scoop member **58** maintain a flow of pulp at the level of the scoop member **58** to insure impingement of the knots **80** (FIG. 3) on the scoop member **58**.

Preferably, two downwardly sloping deflector plates, upper plate **60** and lower plate **62** (FIG. 3) are mounted upon the inside surface of vertical cylinder **12**, constructed and arranged to deflect the clockwise moving knots **80** (FIG. 3) downwardly, formed, e.g., of flat plate that is cut to mate with the vertical cylinder **12**. The lower edge of the upper deflector plate **60** is below the level of the upper edge of lower deflector plate **62** and the lower edge of lower deflector plate **62** is below (and hence closer to the sump opening **52** than) the upper or inner edge of scoop member **58** to insure that all knots **80** (FIG. 3) strike the lower deflector plate **62**.

The floor **18** of the pressure casing is preferably flanged to vertical cylinder **12** to enable their separation and the insertion of a higher screen and a spool piece and to permit extension of height of the pressure casing. In such an extended pressure casing circular flow to the bottom can be maintained by the deflectors plates **60** and **62**.

Referring to FIG. 4, in the preferred embodiment the sump device **57** is vertical and comprises inlet leg **64**, sump casing **66**, an isolation valve **68** and a dumping valve **70**, operable automatically by pressure lines **91** and **92**. The isolation valve **68** is at the entrance and the dumping valve **70** being at the outlet to the sump casing **66**. The sump device **57** is sized to accommodate the largest knots **80** (FIG. 3) that occur, hence the knot passage through the sump opening **52** and sump device **57** including the valves **68** and **70** (FIGS. 4 and 7) is on the order of 6 inches or more. Two pulp-free liquid pipes **72** and **74** communicate with the bottom of the sump casing **66**, preferably positioned to direct liquid upon collected knots to flow off good fibers and maintain the knot mass in a loosened state. The pipes **72** and **74** are adapted for connection to a source **75** of pulp-free liquid of a pressure greater than that of the inlet chamber **24** and of a specific gravity less than the knots **80** (FIG. 3), but advantageously, greater than that of the fibers. For example, the pulp-free liquid can be black liquor specific gravity 1.08, the same as the carrier liquor for the pulp; the knots **80** (FIG. 3) having a specific gravity of 1.14 and kraft fibers specific gravity of 1.03. Each pipe is sized to transmit a flow in the range of 15–25 gallons per minute. A vent pipe **76** communicates with the upper part of the sump casing **66** and with a point in the system having a general fluid pressure corresponding to that of the apparatus, e.g. as shown, connected to the inlet leg **64** of the sump device **57**.

An adjustable timing mechanism **90** (FIG. 4) energizes pressure lines **91** and **93**, and the pressure lines **91** and **93** are connected to valve actuators **92** and **94** on isolation valve **68** and dumping valve **70**, respectively, the mechanism adjustably timed, as shown, to produce an accumulation and dump cycle corresponding to the type and volume of pulp being handled, for example, a four-minute cycle, the cycle beginning by isolation valve **68** closing and dump valve **70** immediately thereafter opening to dump the knots collected in sump chamber **54** while further knots accumulate in leg **64** and after one minute dumping valve **70** closing, immediately thereafter isolation valve **68** opening, and staying open for 3 minutes for the entry of further knots.

One or two valved floater outlets **96**, **98** (FIG. 4) are provided at the top of the inlet chamber **24** to be opened from time to time to discharge any floating debris.

Referring to FIGS. 1 and 5, the foil members **42** are mounted in the accepts chamber **26** to be moved clockwise by electric motor **48**, in the same circular direction as the outlet flow so any pumping effect of the foil members **42** is utilized. The foil member **42** shown in FIG. 5 in horizontal cross-section is elongated having a rounded leading edge **43**, a smaller rounded trailing edge **45** and curved faired sides **47** and **49**. It has been discovered that to obtain unusually good positive pressure conditions at the screen plate **22** both as regards amplitude and duration, the curved side **49** of the foil member **42** adjacent the screen plate **22** should be concave, as is shown, the opposite side **47** convex, and the foil axis **53'** (extending through the center of the leading and trailing edges) should be set at an angle A to the portion of the screen plate **22** corresponding with the center of the foil member **42** so that the surface near the trailing edge **45** is closest to the screen plate **22**, the best results occuring with angle A in the range of 15° to 30°, the presently preferred angle A being 20°.

A clearnce between the foil member **42** and screen plate **22** in the range of ⅛ to ⅜ inch preferably is provided to prevent shear of fibers or jamming.

With further reference to FIG. 5, the screen plate **22** is highly perforate, with large perforations **22'**, so that the screen offers little resistance to flow of liquid but will bar the entry of knots **80** (FIG. 1) to the accept chamber **26**. Advantageously, the large perforations **22'** (FIG. 5) are in the size range of ¼ to ⅞ inch in diameter.

As the pulp flows inwardly through the screen plate **22**, the knots **80** (FIG. 1) are pressed tightly against the screen plate **22** by the high volume flow. As illustrated in FIG. 6, the specially configured foil member **42** (FIG. 5) with angle A in the range of 15°–30° provides an extremely long duration, high amplitude, positive pressure pulse (and the negative pulse is of short duration and amplitude compared to prior art hydrofoils) in the vicinity of the screen plate **22** to force knots **80** radially outwardly from the screen plate **22** so they can sink in the inlet chamber **24**.

Advantageously, the housing or pressure casing is built to withstand pressures of 50 p.s.i.

OPERATION

In a typical operation, the hot black liquor from the blow tank (not shown) of a chemical pulp mill (not shown) is introduced under pressure through piping **29** and feed passage **28** to the pressure casing. This black liquor constitutes a highly alkaline solution of a consistency of between about ½ and 2 percent pulp to liquor, 3 or 4 percent of the pulp being knots **80** (FIGS. 1 and 3) of a size in the range of ½ to 3 inches, but sometimes considerably larger. The liquid feeds through feed passage **29** (FIG. 1) tangentially of the pressure casing and fills inlet chamber **24**, maintaining a circular motion in the gutter **51**. The screen plate **22** is protected against damage by heavy impurities such as dirt, nails, etc., by the centrifugal force achieved by the tangential inlet of the liquid which causes such dense objects to be thrown to the periphery, down which they slide to the bottom. Because of lower pressure in the accept outlet passage or pulp pipe **32** than in the inlet pipe **29**, the stock flows radially inwardly through the perforate plate **22** thence to accept outlet pipe **30** and to accept outlet passage **32**. The knots **80** (FIG. 1) are drawn to the perforate screen plate **22** by the high flow therethrough. Periodically, for instance, every twentieth of a second, a foil member **42**

sweeps by the inner surface of the perforate screen plate 22 and generates a positive pressure pulse in accordance with the graph of FIG. 6. This locally exceeds the velocity head of the stock flowing through the screen plate 22, and the knots 80 (FIG. 1) are forced to move radially outwardly from the screen plate 22 (FIG. 1). The knots 80 (FIGS. 1, 3) being heavier than the liquid sink slowly and since the screen plate 22 protects the knots 80 from contact with the foil member 42, the knots 80 are not broken up. The downward gravity movement can be aided by the downwardly sloped deflectors 60 and 62 (FIG. 3) upon which the knots 80 can impinge and deflect. The ratio of the radially measured cross-section of the annular inlet chamber 24 to the flow rate therethrough increases considerably proceeding from feed passage 28 around the screen plate 22 because while the cross-section is constant (the screen plate 22 and vertical casing cylinder 12 being concentric, FIG. 1) the flow rate decreases because much of the flow enters the screen plate 22. This has the desirable effect of slowing the lateral circular movement of the knots 80 as they approach the sump opening 52 (FIG. 3), giving them time to sink. The spiraling knots 80 (FIG. 3) at the bottom of the inlet chamber 24 move downwardly over the ramp 50 (FIG. 3) and strike the opposite vertical wall 56, which wall 56 arrests their lateral, circular motion, and allows them to sink through the sump opening 52. The ramp 50 has the combined effects of exposing a considerable area of arresting or vertical wall surface 56 to the knots 80, and helping direct long knots 80 (FIG. 3) and sticks endwise into the sump chamber 54 without clogging. The scoop member 58 aids in intercepting and arresting the laterally moving knots 80. Normally isolation valve 68 (FIG. 4) is open and the knots 80 (FIG. 3) proceed from inlet leg 64 into sump casing 66 and accumulate. The fibers have a specific gravity (e.g. 1.02) slightly less than the black liquor (e.g. 1.08) and tend to float out of the sump casing 66 (FIGS. 2, 4) if they are carried therein by the sinking knots 80 (specific gravity e.g. 1.14).

A marked decrease of good fibers in the sump chamber 54 (FIGS. 2–4) is achieved with the pulp-free liquid barrier that is maintained to prevent entry of fibers into the sump chamber 54. Since eddying action of the pulp in the inlet chamber 24 (FIGS. 2, 4) tends to contaminate the liquid barrier, the liquid barrier is replaced by a slight flow of pulp-free liquid, e.g. 15–25 gallons per minute through liquid inlet pipes 72 or 74. This has virtually no diluting effect upon the pulp that flows at rates of thousands of gallons per minute.

By introducing the fiber-free liquid to the bottom of the sump chamber 54, the accumulating knots 80 (FIGS. 1 and 3) continually receive a loosening force that allows any good fibers present to be carried upwardly and prevents clogging of the knots.

Periodically, the sump chamber 54 is discharged while maintaining the inlet chamber 24 (FIGS, 2, 4) mechanically sealed against the loss of good fibers. The control or timing mechanism 90 (FIG. 4) first causes isolation valve 68 to close and then dumping valve 70 to open discharging the contents of the sump chamber 54 to the atmosphere. The pulp-free liquid entering through liquid inlet pipes 72 and 74 serves to disturb the knots 80 and aid their downward movement. During the period of dumping, the inlet leg 64 accumulates further sinking knots 80. After dumping valve 70 is closed by control mechanism 90, the sump chamber 54 fills with pulp-free liquid, the air displaced therefrom escaping through check-valved vent pipe 76. Then isolation valve 68 is opened and the accumulated knots 80 in the inlet leg 64 fall into the sump chamber 54 and knots 80 accumulate 3 more minutes before the dumping procedure occurs again. Tests have shown that less than 1/7 of 1 percent of the good fibers are removed through the sump by this above described procedure.

ALTERNATIVE EMBODIMENTS

Numerous alternative provisions can be employed in the sump casing 66. For instance, vent line 76 can be equipped with a ball float valve (not shown) that connects to the atmosphere and seats in the up position in place of the connection to inlet leg 64. On opening of dumping valve 70, the ball float (not shown) would drop to allow air into the sump casing 66, to aid in dumping, and would remain in that position until the pulp-free black liquor fills the sump chamber 54.

However, according to the invention, instead of breaking the hydraulic leg, which risks the escape of liquor, the provision of FIG. 7 is preferably employed. Referring to FIG. 7, a pulp-free liquor inlet line 100 is connected to the top of sump chamber 66, below isolation valve 68. Liquor inlet line 100 is connected through supply valve 102 to a source 104 of pressurized liquor, the line size and pressure capable of introducing liquor at the same volumetric rate as that of the knots 80 (FIG. 3) and fluid leaving the sump casing 66 through dumping valve 70. Timing mechanism 90′ is adapted to open valve 102 simultaneously with dump valve 70, whereby hydraulic continuity is maintained and the knots 80 (FIG. 3) are forced from the sump casing 66 into knot collection tank 110 by the pressure of pressurized liquor source 104. Following this purging action, dumping valve 70 and valve 102 are closed then isolation valve 68 is opened by the timing mechanism 90. The vent line 76 is shown capped in this embodiment, being unneeded.

As indicated previously, the invention applies to floating knots 80 which may occur.

Referring to FIG. 8 (which shows a sump device 57*a* for floating knots 80 and a sump device 57 for sinking objects), the annular inlet chamber 24*a* has an upper gutter 41*a* adjacent the top end of screen plate 22*a* in which is located sump opening 52*a*, preceded upstream by a ramp 50*a*, and followed downstream by arresting surfaces, wall 56*a* and scoop member 58*a*. Deflector plates 60*a* and 62*a* are disposed to deflect knots 80 upwardly. Isolation valve 68*a* connects the inlet leg 64*a* with sump casing 66*a*, and dump valve 70*a* is adapted to dump the contents of the sump device 57*a* when valve 68*a* is closed, controlled by timing mechanism 90*a*, which timing mechanism 90*a* can also control the cycle of the bottom sump 66*b*, if provided. A single source of fiber-free pressurized liquid 75*a* can introduce fiber-free liquid to the top of sump casing 66*a* along liquor pipe 74*a* and to the bottom of the lower sump casing 66, along the liquor pipe 74, in each case for the purpose of preventing good fibers from entering the sump devices 57*a* and 57 and for maintaining the knots 80 in a loosened condition.

The knot discharge means shown, incorporating an isolation valve 68 (FIGS. 4, 7 and 8) or 68*a* (FIG. 8) and a dumping valve 70 (FIGS. 4, 7 and 8) or 70*a* (FIG. 8), spaced along a sump casing and actuated by a timing mechanism, offers important advantages. Its cycle is easily adjustable to handle a wide range of knot loadings without the need of variable speed motors; it is not subject to damage by metal objects that occur in pulp; it does not break up the knots, a particular advantage advantage in chemical pulp mills; it can handle knots of extreme size without jamming; and it is reliable and relatively immune from wear. However, under some circumstances other discharge means might be employed.

Referring to FIG. 9, the mechanically sealed knot discharge means may comprise a sump pipe or casing 120 extending from the sump opening 52 to a mechanical knot removal device 122 that isolates the outlet 123 from communication with the inlet chamber 24, such as rotatable or reciprocal pressure locks, an example being a screw conveyer with a pressure-sealing plug of knot material. These can carry the knots out of the system

without dropping the screen chamber pressure. In addition, the sump pipe **120** is provided with an inlet pipe **124** leading from a pressurized source **126** of a fiber-free liquid to provide a fiber-free liquid barrier to preclude entry of good fibers into sump opening **52**.

The screen plate **22** of this invention produces an exceedingly small pressure drop in the flowing stock so that no special booster pump is required nor is much power required. Actually, the high-attack angle foil member **42** not only keeps the screen plate **22** clear but also contributes some pumping due to the special relation of foil movement and outlet piping.

While the invention is directed to removing knot impurities, it will be obvious that heavy impurities will also be removed.

The screen apparatus meets a real need in the pulp industry for a compact, economical screening device that removes knots **80** from large quantities of pulp without removing good fibers or diluting the pulp.

What is claimed is:

1. A hydraulically sealed apparatus for removing knots from pulp fluid without removing the pulp, the knots having a specific gravity different from the pulp, the apparatus comprising, in combination, a pressure casing, a screening means positioned within said pressure casing and defining therewith an inlet chamber, the screening means having openings sized to pass all of the pulp without passing the knots, a feed passage constructed and arranged to introduce pulp fluid into said inlet chamber, the apparatus constructed to cause said knots, due to their specific gravity, to move toward one end of the inlet chmaber, said screening means arranged to pass said pulp, means to keep said screening means clean, an accepts outlet passage constructed and arranged to discharge said pulp passing through said screening means, a sump opening in the inlet chamber located adjacent the end of the inlet chamber toward which the knots move, the sump opening sized and positioned to receive said knots, and a sump device provided with a sump chamber normally communicating with said sump opening and having a volume in which knots can collect, knot discharge means operable periodically to discharge said collected knots through a sump outlet while said sump chamber is isolated from fluid communication with the inlet chamber, the sump opening from said inlet chamber comprising the only discharge opening in the respective end of said inlet chamber, and said apparatus including back flow means including liquid inlet means adjacent the point of periodic discharge from said sump device to introduce a back flow of substantially pulp-free liquid having a specific gravity different from that of said knots in the direction of said pulp, said sump device and said back flow means cooperatively constructed and arranged to introduce said pulp-free liquid into the path of movement of substantially all of said knots.

2. The apparatus of claim **1** wherein said means to keep said screening means clean comprises at least one foil mounted on the accepts side of said screening means and adapted to sweep over it, said foil having a concave surface disposed toward said screening means, and the trailing edge mounted closer to said screening means than said leading edge, the foil adapted to transmit a long duration positive pressure pulse through the screen opening to act upon said large objects.

3. The apparatus of claim **2** wherein the openings of said screening means have a flow-cross-section width generally of the order of ¼ to ⅞ inch, said screening means being at least 30 percent open and said foil has a rounded leading edge and faired sides, and the foil axis extending through the center of its leading and trailing edges is set at an angle of between 15° and 30° to the portion of said screening means corresponding with the mid-portion of said foil.

4. A screen separating means for knots and fibrous pulp which employs a specific gravity difference between the knots and pulp to concentrate the knots in one region of said screen separating means comprising an intermittently operable sump means, said sump means having an opening into said region of said separating means, said sump means having a substantial extent away from said opening in the direction said knots move relative to the pulp, whereby said knots can proceed into said sump means and collect therein, and back flow means including means for supplying substantially pulp-free liquid having a specific gravity different from said knots in the direction of said pulp, said back flow means operating when said sump means is in communication with said region of said separating means, said back flow means constructed and arranged to introduce said liquid into the path of movement of substantially all of said knots in a part of said sump means normally closed to discharge, whereby under relatively quiescent conditions said knots can move away from said opening and collect in said sump means, and said liquid can move toward said opening and into said separating means in counter flow to said knots to act upon substantially all of said knots removing good fibers intimately associated with said knots, said sump means adapted to be periodically opened to discharge, wherein said sump means includes two pressure valves spaced apart along the path of said knots in said sump means, each adapted to prevent loss of pressure while said separating device operates under substantial positive pressure, the valve closer to said opening serving as an isolation valve, the valve further from said opening serving as a knot discharge valve adapted to be opened when said isolation valve is closed, said back flow means including means adjacent said discharge valve to introduce said substantially pulp-free liquid whereby said knots are subjected to said back flow substantially throughout the extent of said sump means.

5. The apparatus of claim **4** wherein said sump means comprises an elongated chamber having a substantial vertical extent.

6. The apparatus of claim **5** wherein said sump means is a vertically arranged, circular cross-sectioned chamber.

7. A screen separating means for knots and fibrous pulp which employs a specific gravity difference between the knots and pulp to concentrate the knots in one region of said screen separating means comprising an intermittently operable sump means, said sump means having an opening into said region of said separating means, said sump means having a substantial extent away from said opening in the direction said knots move realtive to the pulp, whereby said knots can proceed into said sump means and collect therein, and back flow means including means for supplying substantially pulp-free liquid having a specific gravity different from said knots in the direction of said pulp, said back flow means operating when said sump means is in communication with said region of said separating means, said back flow means constructed and arranged to introduce said liquid into the path of movement of substantially all of said knots in a part of said sump means normally closed to discharge, whereby under relatively quiescent conditions said knots can move away from said opening and collect in said sump means, and said liquid can move toward said opening and into said separating means in counter flow to said knots to act upon substantially all of said knots, removing good fibers intimately associated with said knots, said sump means adapted to be periodically opened to discharge, wherein said sump means includes two pressure valves spaced apart along the path of said knots in said sump means, each adapted to prevent loss of pressure while said separating device operates under positive pressure, the valve closer to said opening serving as an isolation valve, the valve further from said opening serving as a knot discharge valve adapted to be opened when said isolation valve is closed, a normally liquid-filled conduit means ar-

ranged to receive knots from said discharge valve, and a purge liquid means adapted to introduce substantially pulp-free pressurized liquid into said sump means in the general vicinity of said isolation valve when said valve is closed, to force said knots through said discharge valve into said conduit means.

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