Sept. 20, 1955 H. G. CRAM 2,718,179

MACHINE FOR SEPARATING MATERIALS OF DIFFERENT SPECIFIC GRAVITIES

Filed Dec. 26, 1950 4 Sheets-Sheet 1

Fig. 1.

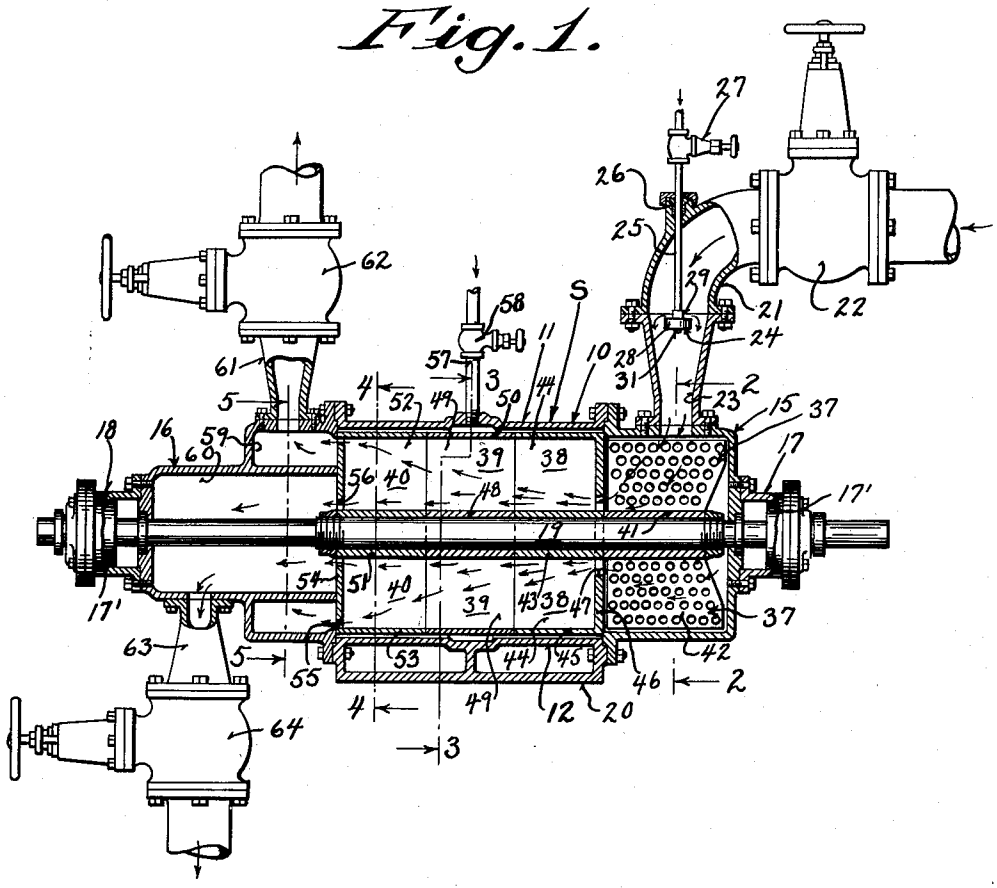
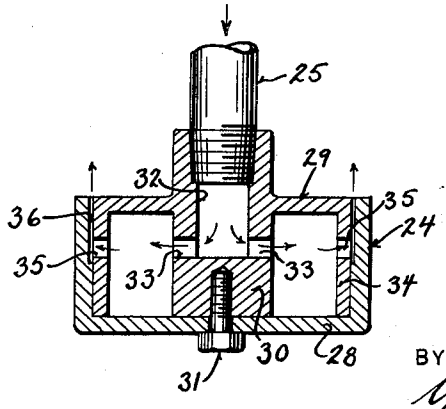


Fig. 6.



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MACHINE FOR SEPARATING MATERIALS OF DIFFERENT SPECIFIC GRAVITIES

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Fig. 2.

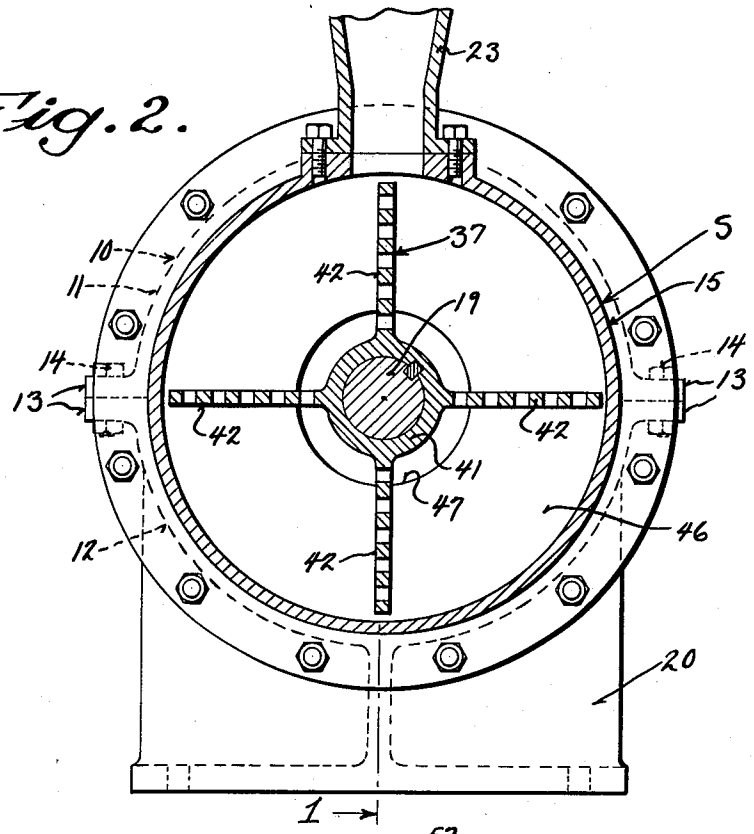
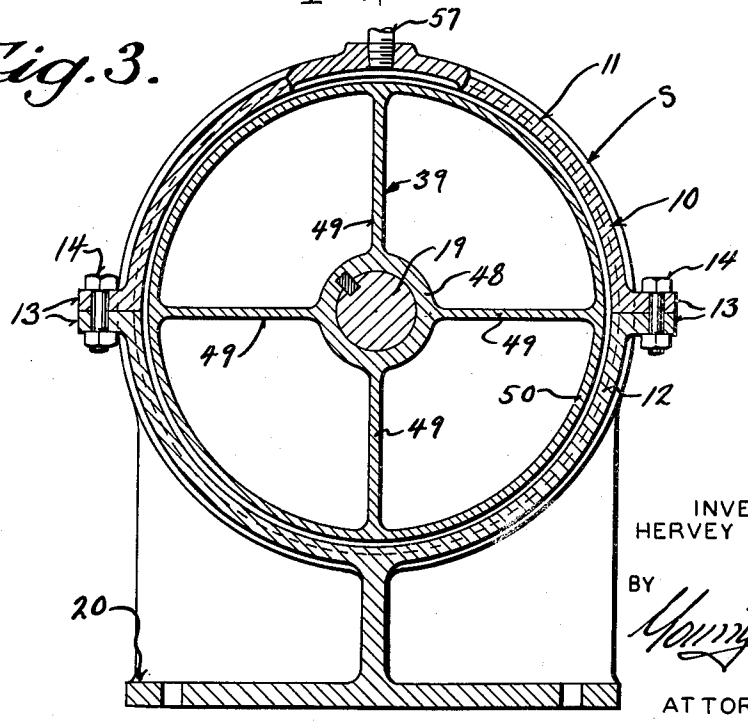


Fig. 3.



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MACHINE FOR SEPARATING MATERIALS OF DIFFERENT SPECIFIC GRAVITIES

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Fig. 4.

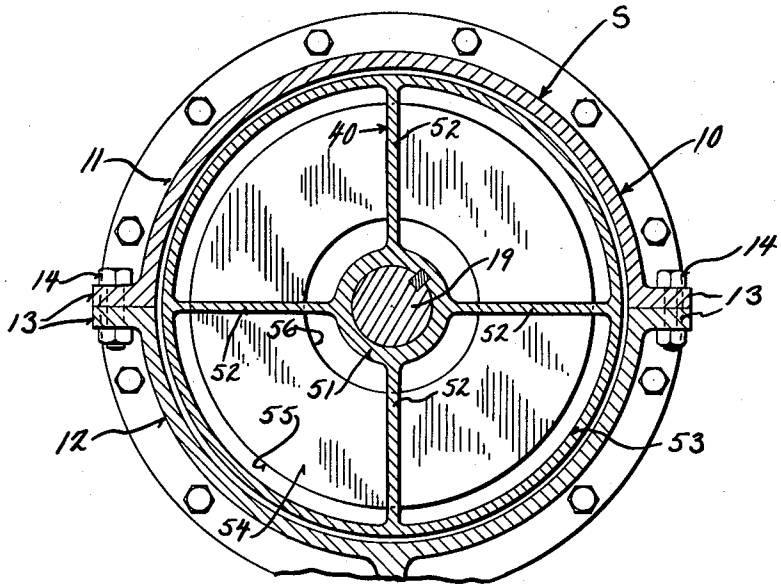
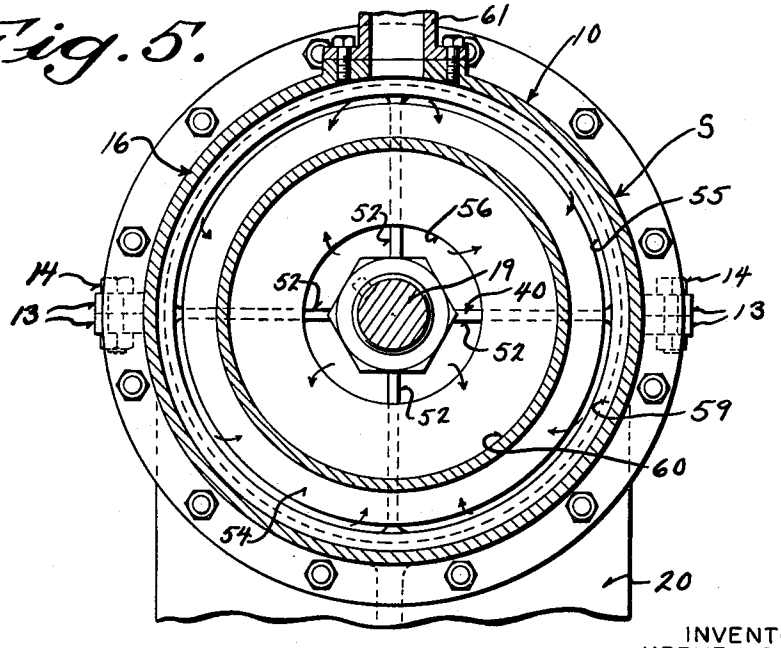


Fig. 5.



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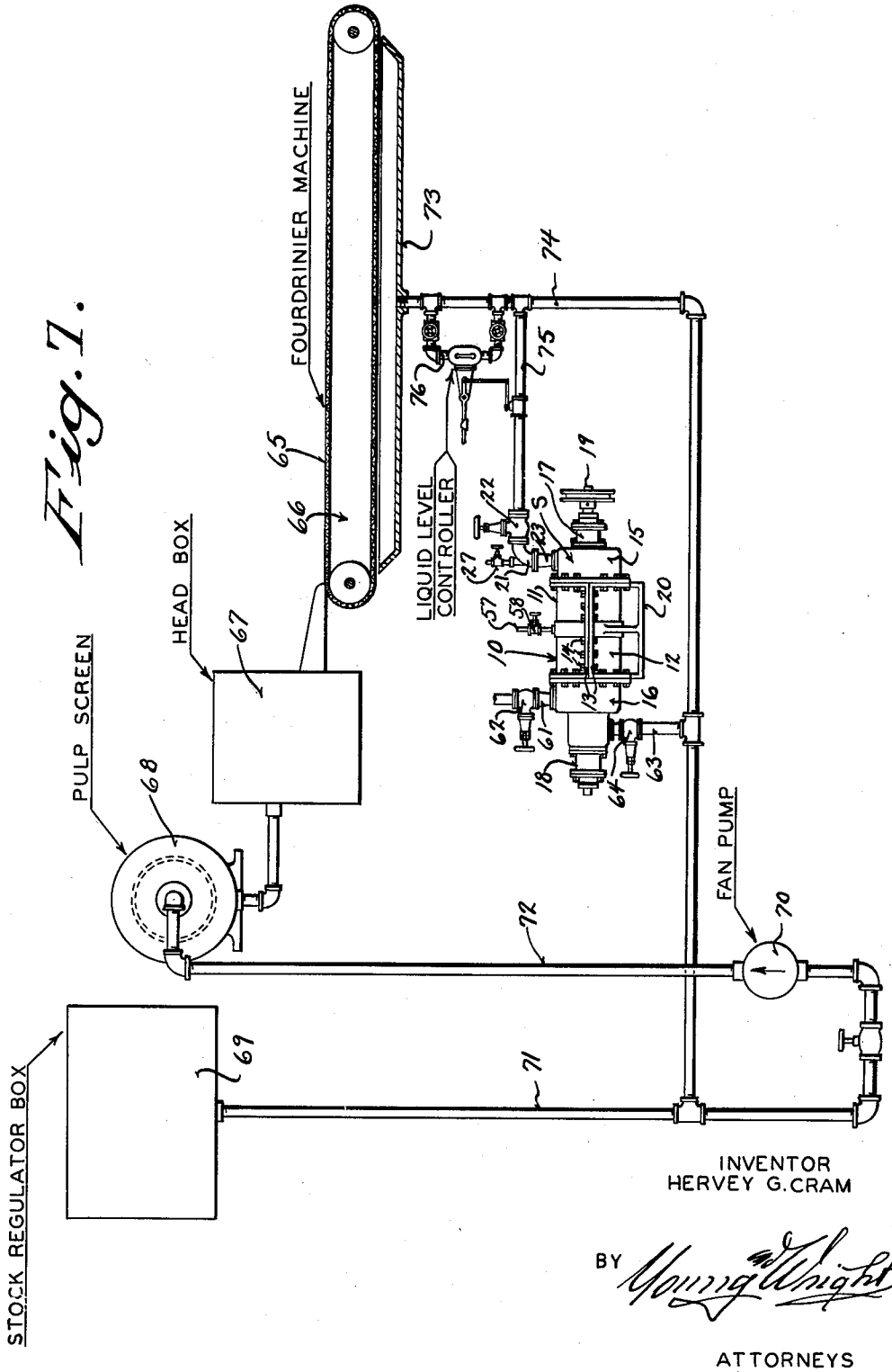
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Sept. 20, 1955 H. G. CRAM 2,718,179

MACHINE FOR SEPARATING MATERIALS OF DIFFERENT SPECIFIC GRAVITIES

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Fig. 1.



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2,718,179

MACHINE FOR SEPARATING MATERIALS OF DIFFERENT SPECIFIC GRAVITIES

Hervey G. Cram, Appleton, Wis.

Application December 26, 1950, Serial No. 202,788
6 Claims. (Cl. 92—28)

This invention appertains to a novel appliance for effecting the separation of materials of slightly different specific gravities when in liquid suspension, and more particularly to a novel machine for recovering usable materials from a waste liquid.

One of the primary objects of my invention is the provision of a machine operating upon the centrifugal principle of separation, embodying a cylindrical body or casing having rotatable runners therein of different characters and having an intake head at one end and a discharge head at the opposite end, certain of the runners functioning to confine the material therein and deliver the same to the discharge head, the material of higher specific gravity being (by centrifugal force) positioned at the periphery of the runners, and the material of lower specific gravity at the hub portions of the runners.

Another salient object of the invention, is the provision of novel means for aerating the material as the same enters the intake head, whereby to cause a flocculation of usable particles being introduced into the machine.

A further important object of the invention is the provision of a novel runner arranged within the intake head to effect a complete mixture of the liquid suspended material, as the same is introduced into the body.

A still further object of the invention is to provide means for introducing water or other desired liquid between the periphery of certain runners and the inner surface of the body or casing, to effect a steadying reaction on such runners and to establish some buoyancy to the said runners.

While the device is capable of serving to advantage in many types of industry, the principal purpose of the device as illustrated and described in the present case, is in the manufacture of pulp and paper, and a few of these operations within the paper industry to which the device is applicable, are as follows:

(1) The separation of valuable paper-making material from the excess liquid of suspension in the filtrate from the Paper-Machine Wire as effected by the addition of shower water at the screens, head-box etc., so that, the paper-making material may be returned to the fan pump for recirculation of the same to the Paper-Machine Wire, and, provide for the required continuous discharge of the clear liquid of suspension (water) to waste or for re-use.

(2) The separation of the pulp from the liquid of suspension, as in the thickening of the accepted pulp from the screens from a low consistency of around 0.5% to a consistency of 3% or higher, as required for delivery to the beaters or paper-machine, which means, the elimination of Deckers on many grades of pulp, and the assurance of a clear liquid for discharge to waste, or, for re-use.

(3) The separation of objectionable foreign matter from the pulp or paper stock in liquid suspension, such foreign matter, usually being of a higher specific, gravity than the acceptable pulp or paper stock.

With these and other objects in view, the invention consists in the novel construction, arrangement and formation of parts, as will be hereinafter more specifically described and claimed, and illustrated in the accompanying drawings, in which drawings:

Figure 1 is a longitudinal sectional view through the separating machine, taken on the line 1—1 of Figure 2, looking in the direction of the arrows.

Figure 2 is a transverse sectional view through the intake head of the machine, taken on the line 2—2 of Figure 1, looking in the direction of the arrows.

Figure 3 is a transverse sectional view, through the machine taken on the line 3—3 of Figure 1, looking in the direction of the arrows and illustrating one of the enclosed runners.

Figure 4 is a transverse sectional view through the machine, taken on the line 4—4 of Figure 1, looking in the direction of the arrows and illustrating the inner and outer discharge openings of the outermost enclosed runner.

Figure 5 is a transverse sectional view through the discharge head of the machine, taken on the line 5—5 of Figure 1, looking in the direction of the arrows.

Figure 6 is an enlarged fragmentary detail vertical sectional view through the aerating head.

Figure 7 is a diagrammatic view showing one use of my improved separating machine in the paper industry.

Referring to the drawings in detail, wherein similar reference characters designate corresponding parts throughout the several views, the letter S, generally indicates my separating machine, and the same includes a cylindrical body or casing **10**, preferably formed in an upper semi-cylindrical section **11**, and a lower semi-cylindrical section **12**. These sections are provided with abutting flanges **13**, which can be connected together in any preferred way, such as by bolts **14**. Secured to the opposite terminals of the body **10**, is an intake head **15** and a discharge head **16**. These heads **15** and **16** terminate in bearing casings **17** and **18**, respectively, and these bearing casings support bearings **17'** for a main shaft **19**, which extends axially through the body **10** and the heads **15** and **16**. This shaft **19** can be directly driven from a suitable motor, not shown. The lower section **12** of the body **10** can have cast thereon any preferred type of base **20**, whereby the separating machine can be rigidly secured to a floor, or other desired base. However, it is to be understood that the separating machine S can function either in a horizontal plane, as shown, or in a vertical plane.

Communicating with the intake head **15**, is a pipe **21** for the delivery of material (in liquid suspension) into the intake head and the body **10**. The rate of volume flow through the pipe **21** is controlled by a valve **22**. By referring to Figure 1, it can be seen that the pipe **21**, at its point of connection with the intake head **15**, is slightly restricted, as at **23**, and that the pipe gradually tapers toward said restricted portion. Positioned in the pipe **21**, directly above the restricted portion **23** of the pipe, is an aerating jet **24**, for a purpose which will be later set forth. It is to be noted that air under pressure is fed to the jet **24** by means of a tube **25**, which extends into the pipe **21** through a packing gland **26**, and the rate of flow of compressed air through the tube **25** is controlled by a hand operated valve **27**.

The aerating jet **24** consists of a lower housing shell **28**, having fitted therein a closure cap **29**. The cap is provided with a central hub portion **30**, and the shell **28** and the cap **29** are connected by means of a machine screw **31**, which extends through the shell **28** axially into the hub **30**. The upper portion of the hub **30** is provided with an axially disposed opening **32**, with which the tube **25** communicates, and the hub is provided with outlet orifices **33**, which connect the opening **32** with the interior of the shell. The side wall **34** of the cap is provided with orifices **35**, which communicate with an annular cavity **36** formed in the inner face of the shell and this cavity opens out through the upper face, at the rim, of the jet. At this time, it can be seen that, as material flows through the pipe **21** toward the head **15** that compressed air meets the material so as to effectively aerate the same. The purpose

of this aerating action will be later brought out, as stated above.

Keyed or otherwise rigidly fastened to the shaft **19**, is a series of abutting runners **37**, **38**, **39** and **40**. The runner **37** is disposed directly within the intake head **15**, and is of a different character than the runners **38**, **39** and **40**, which are arranged within the body **10**. The function of the runner **37** is also different than the runners **38**, **39** and **40**.

The runner **37**, includes a hub **41**, and radially extending apertured blades **42**, which function in the nature of beaters, and the runner **37** effects a complete mixture of the liquid suspended material, as delivered through pipe **21**. The runner **37** also functions to effect a partial rotation of the material at the lateral entry into the range of the runner **38**.

The runners **38**, **39** and **40**, are of similar construction and have similar functions. The runner **38**, includes a hub **43** and radially extending imperforate blades **44**. The blades **44** are connected by a circular rim **45**. The runner **38**, also includes an outer, disc shaped wall **46**, which is connected to the blades **44**. The wall **46** adjacent to the hub **43**, is provided with an annular opening **47**, through which the aerated and mixed material flows into the runners **38**, **39** and **40**. The runner **39**, includes a hub **48**, carrying a plurality of radially extending blades **49**, and the outer ends of the blades **49** are connected by a cylindrical rim **50**. It is to be noted that this runner **39** has both ends open for the free flow of material therethrough. The runner **40** includes a hub **51** and a plurality of radially extending blades **52**, the outer ends of which are connected by a cylindrical rim **53**. This runner **40**, is also provided with an outer disc shaped end wall **54** which is rigidly connected with the sides of the blades **52**. This end wall **54** is provided with a peripheral circular opening **55**, and an inner circular axial opening **56**. The opening **55** is provided for the discharge of material of higher specific gravity and the circular opening **56** for the discharge of material of lower specific gravity. At this time, it is to be noted that the rims **45**, **50** and **53** of the runners **38**, **39** and **40**, are slightly spaced from the inner surface of the body **10** and function to confine the material within the runners.

As the shaft **19** is driven at a relatively high rate of speed, I preferably introduce water, or other desired liquid, between the inner surface of the body **10** and the rims of the runners. This can be accomplished through the medium of a water delivery pipe **57**, which communicates with the interior of the body. Flow of water through the pipe **57** is controlled by a hand valve **58**. A required pressure on the water may be retained between the body **10** and the rims of the runners **38**, **39** and **40**, to establish some buoyancy for the cylindrically enclosed runners, and to effect a steadying reaction thereon.

Attention is now directed to the discharge head **16** and the same is formed with a cylindrical outer chamber **59** for the reception of the heavier material discharged through the peripheral opening **55** and an inner chamber **60** for the reception of the lighter aerated material discharged through the axial opening **56**. The heavier material from chamber **59** flows into a pipe **61**, which leads to a waste sewer or other desired point, as will be later brought out. The rate of volume flow of the heavier material through pipe **61**, is controlled by a valve **62**. The lighter material in chamber **60** is discharged into a pipe **63** and the rate of volume flow through this pipe is controlled by a valve **64**, and this pipe can lead to a desired delivery point, as will also be later brought out.

In Figure 7, of the drawings, one use of the improved separating device S is shown, and the same is used to receive water drained from the paper stock flowing over a wire **65**, of a Fourdrinier machine **66**. Pulp, or paper stock, is supplied to the wire by means of a head box **67**, which in turn is supplied from a pulp screen **68**. As is ordinary practice, the pulp or stock is initially received within a stock regulator box **69**, and is pumped to the screen by a pump **70**. A pipe **71** connects the head box with the pump and the pump is in turn connected to the screen by a pipe **72**. The water draining from the wire **65** is caught in a pan **73** and leading from the pan is a drain pipe **74**, which can be connected to the head box pipe **71**. This pipe **74** is connected to the intake pipe **21** of the machine by a length of pipe **75**. The flow of material from the pipe **74** to the separating machine S is governed by a liquid level controller **76**.

In operation of the separating machine S, the dilute mixture of pulp or paper stock, and water, is introduced into the machine from the pan **73** to the pipe **21**, wherein the mixture is thoroughly aerated by the aerating jet **24**. The dilute mixture is first introduced into the machine at the intake head **15**, and then into contact with the mixing runner **37**. This runner thoroughly agitates the mixture and transmits a rotation thereto previous to the lateral entry of the mixture at or near the axis to and through the cylindrically enclosed runners **38**, **39** and **40**. The cylindrical rims of these runners confine the mixture and at the same time, the rapid rotation thereof (through centrifugal force) moves the material of higher specific gravity toward the cylindrical rims. The material of lower specific gravity, i. e., aerated pulp, or paper stock, is discharged at the axial opening **56** to the chamber **60** and to and through pipe **63**, as controlled by the valve **64**, and this material is returned to the head box or to the pump **70**. The heavier liquid, i. e., water plus particles of foreign matter may not have been effected by aeration or, which may be of a higher specific gravity than the pulp or paper stock, is confined in the periphery of the cylindrical enclosure of the runners **38**, **39** and **40**, as stated, by centrifugal force, and ejected through the peripheral opening **55** to chamber **59** and discharged therefrom through the pipe **61** with the rate of flow controlled by the valve **62**.

It will be apparent that the rate of flow through the pipes **61** and **63**, as controlled by the position of the valves **62** and **64**, will determine the consistency of the segregated pulp or paper stock.

In the separation of pulp or paper stock from its liquid of suspension (water), that water will not be aerated by ordinary means, such as is provided by this device. This is of advantage, in that, it is essential that the specific gravity of the liquid should not be reduced.

Aeration, as herein referred to, means air adherence to, or air absorbence by, a particle of material, such as pulp or paper stock, with the result that its specific gravity is reduced, thus bringing about some differentiation between the material and the liquid suspension.

It should be noted, that aerated pulp or paper stock may become unaerated, partially or as a whole, if allowed to stand for any length of time in a settling tank, or the like, and, it will be apparent that any pulp or paper-stock which does become unaerated under this condition would result in the pollution of the water of dilution as separated off by means of settling tanks, etc.

In connection with the above, it is well to note, that with the machine S, the total elapsed time from the point of aeration through the field of centrifugal separation to segregation of the pulp or paper-making material and the liquid of dilution, is less than five seconds.

Referring to the separation of objectionable foreign matter from the pulp or paper stock in liquid suspension, it will be observed that as the thickened pulp is discharged from the axis of the body that foreign matter or dirt will be extracted from the pulp and discharged with the liquid of suspension with great efficiency.

Theory

The design and the operation of the separating machine S is based on the following:

That the time of separation of a material of a lower specific gravity from its liquid of suspension in a still

pool such as a tank is not affected by the depth, in that, while the rate of settling, in the case of material heavier than the liquid of suspension, or the rate at which material lighter than the liquid of suspension will rise increases with the hydrostatic pressure which is relative to the depth of the pool; however, this is off-set by the relatively increased distance which the material must travel to the top, or bottom of the pool as the case may be.

The design of the separating machine S as shown in Figure 1 of the drawings, and with the shaft and runners rotating at 1200 R. P. M., provides for a pressure range of zero at the axis to 94 feet (static pressure head) at the confining cylindrical (peripheral) section of the runners, and at the same time, the distance of travel of the material for separation is restricted to 6¼" or .553 feet.

Based on the above, the rate of travel of separation in the separating machine S would be equivalent to that within a still pool having a depth of 94 feet; however, the distance of travel separation in the machine S being actually 0.553 feet, the rate of separation in the machine would have to be:

$\frac{94'}{0.553'}$ or 170 times that of tank (still pool) separation

and, based on a lateral flow through the machine of 900 G. P. M. the actual time of positive rotation would be:

0.825 Sec. per foot of cylinder length

and as an example, based on an aerated white water test, it was determined that separation by gravity (as in still pool) was accomplished in three minutes, or, 180 seconds, therefore,

$$\frac{180 \text{ Sec.} \times 0.553 \text{ feet (Depth of Pool)}}{0.825 \text{ Sec. (per ft. of cylinder)} \times 94 \text{ ft.}}$$

or (Equivalent head in machine)

1.28 feet is the length of cylinder required for this particular material in liquid suspension for machine S separation, based on passage through at the rate of 900 G. P. M. The purpose of the above is to indicate the basis for design, in that, with a sample of a proposed material to be treated at hand, a simple laboratory test can be made, which, plus the capacity required, is not only the information for design, but it also predetermines the success to be expected from the machine S operation on any liquid suspended material.

It is well to note that some materials are sufficiently heavy, with relation to the liquid of suspension as to permit separation without aeration, in fact, may not be affected by aeration, in which case, separation is reversed in the machine S, in that, the material will be discharged through the peripheral slot (**55**) and the liquid of suspension through the axial opening (**56**).

It is well to note that there are some materials which present very stable liquid suspension, and which cannot be aerated. These materials are not subject to separation either by the machine or still pool settling, however, most pulp and paper stocks and all white water are within the range of machine separation.

Changes in details may be made without departing from the spirit or the scope of this invention, but what I claim as new is:

1. A device for continuously separating materials of different specific gravities in liquid suspension comprising a cylindrical body, an intake head at one end of the body communicating therewith, a discharge head at the opposite end of said body, said discharge head having an inner chamber and an outer chamber, a pipe for continuously supplying liquid carrying solids to the intake head, end and intermediate rotatable runners in the body extending substantially the full length thereof for rapidly rotating the liquid in the body, all of said runners including axial hubs, cylindrical rims and blades connecting the hubs and rims, the end runners having outer walls facing the intake and discharge heads, the outer wall of one end runner having an axial opening communicating with the inlet head, the outer wall of the other end runner having an axial opening communicating with the inner chamber of the discharge head, and a peripheral opening communicating with the outer chamber of the discharge head.

2. A device for continuously separating materials of different specific gravities in liquid suspension as defined in claim 1, and an aerating jet in said supply pipe disposed adjacent to the inlet head.

3. A device for continuously separating materials of different specific gravities in liquid suspension as defined in claim 1, an aerating jet in said supply pipe disposed adjacent to the inlet head, and a rotatable agitating and mixing runner in the intake head.

4. A device for separating continuously materials of different specific gravities in liquid suspension, comprising a cylindrical body, an intake head at one end of the body communicating therewith, a discharge head at the opposite end of the body, said discharge head having an inner chamber and an outer chamber, means for continuously supplying liquid containing solids to the intake head, and rotatable runners in the body extending substantially the full length thereof for rapidly rotating the liquid in the body, said runners having rotatable rims for confining material at the periphery of the runners, said body and discharge head having communication adjacent to their axis for delivery of material of light specific gravity from the runners to the inner chamber, and said body and discharge head having communication adjacent to their peripheries for discharge of material of higher specific gravity from the runners to the outer chamber, an aerating head disposed in the means for continuously supplying liquid containing solids to the intake head, and means for supplying compressed air to the aerating jet, said aerating jet including a shell, a cap closing the shell having an axial hub, said hub being provided with an axial chamber for receiving compressed air from said supply means, said hub having ports connecting the chamber with the interior of the shell, and said shell having a peripheral outlet cavity at its upper end communicating with the interior of the shell.

5. A device for continuously separating materials of different specific gravities in liquid suspension as defined in claim 4, and a mixing runner rotatably mounted in the intake head including perforated blades.

6. A device for continuously separating materials of different specific gravities in liquid suspension as defined in claim 4, an aerating head disposed in the means for continuously supplying liquid containing solids to the intake head, and means for supplying compressed air to the aerating jet, and a rotatable agitating and mixing runner in said intake head having perforated blades.

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