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(54) **Papermaking process and apparatus for use therewith.**

(57) A papermaking process which includes preparing a papermaking stock and delivering that stock to the headbox of a papermachine for deliver onto a machine wire, draining the stock on the wire and processing the backwater or white water thus obtained to generate two fractions one of which fractions has a higher solids content than the other fraction, delivering the fraction having a high solids content for use in preparing papermaking stock and discharging the fraction having a low solids content to waste or for re-use as process water in another part of the process.

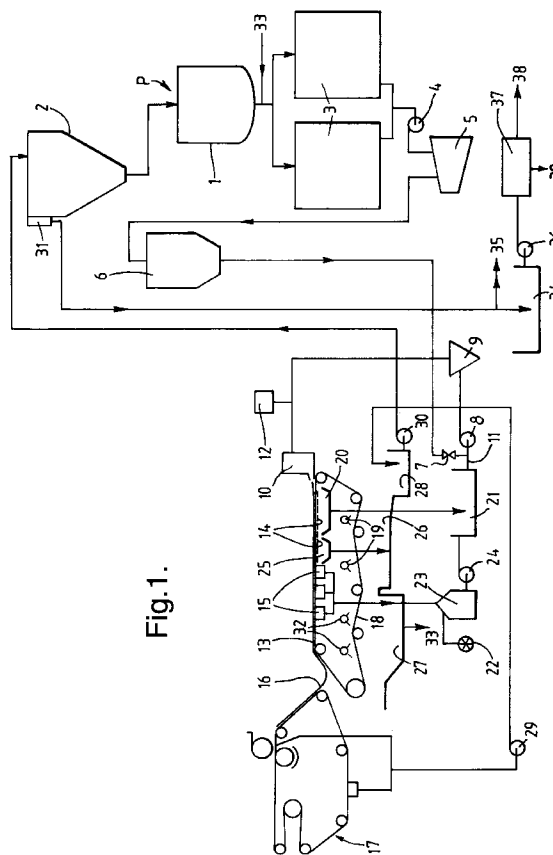


Fig. 1.

This invention relates to a papermaking process and apparatus for use therewith. More particularly, it is concerned with such a process and apparatus having as its purpose to improve the retention of solids materials within the process, thereby reducing both materials wastage and the unacceptable discharge of such materials as effluent into the environment.

Extensive amounts of water are used in the papermaking process. A substantial proportion of this water is continually recycled within the process, but for practical reasons, it is necessary to introduce a quantity of fresh water, thereby necessitating the discharge of a similar amount as waste in order to keep the system in balance. Depending upon the level of water re-usage in the system, the fresh water introduced can be from 10 to 50 m³ per tonne.

The papermaking process involves the slushing together of papermaking fibres and water in a machine such as a hydropulper to form an aqueous slurry. The papermaking fibres may be introduced as sheet woodpulp or (where the papermachine forms part of an integrated pulping and papermaking process) as a pulp slurry fed from the pulp mill. Mineral fillers may also be added at this stage, typically being china clay, calcium carbonate or titanium dioxide.

The slurry from the pulper is held in stock chests and then fed through refiners and stock cleaners to the paper machine after dilution to a suitable consistency. Small quantities of polyelectrolyte may also be added so as to improve retention of the solids materials after the aqueous dispersion has been laid down to form a web on the papermachine wire.

As the web progresses along the papermachine, it progressively drains, assisted by foils and vacuum boxes and a small proportion of the fibrous and mineral components of the stock are lost during the drainage process. At the same time, a substantial amount of fresh water is used in order to clean the papermachine wire after the web has been formed. Fresh water is also used for other purposes in the machine, for example pump gland seals. The added fresh water represents a typical increase of about 30% in the total volume of water drained through the wire. The drained water is commonly referred to as backwater, or sometimes as white water due to the appearance conferred by the entrained fibrous and mineral residues. It is therefore normal practice to recycle the backwater or white water to a backwater tank from which it can be withdrawn to feed the hydropulper during the slushing of pulp newly introduced into the system.

Due to the 30% of fresh water introduced there will be an excess of water available at the backwater tank, and 30% of the backwater is therefore discharged for effluent treatment. Since the water discharged contains a substantial amount of fibrous and mineral solids, it represents a significant wastage of materials. Furthermore, a substantial effluent treatment cost is incurred, and solids recovered at the

treatment plant will need to be dried and burnt or concentrated and sent to landfill.

In order to reduce material losses from the process, and to minimise the costs associated with disposing of the solids from the effluent treatment plant, it has been common practice to install a saveall system such as a disc filter, which separates out suspended solids from the surplus backwater and returns these to the process. However, such systems involve substantial energy usage and are costly to purchase, install and operate.

It is among the objectives of the present invention to substantially improve the retention of solids materials in the papermaking process without substantial increased energy usage and thereby significantly reduce both wastage of those materials and the effluent load which results if they are allowed to pass out of the system.

According to the present invention therefore, a papermaking process includes preparing a papermaking stock and delivering that stock to the headbox of the paper machine for delivery onto the machine wire, draining the stock on the wire and processing the backwater or white water thus obtained to generate two fractions one of which fractions has a higher solids content than the other fraction, delivering the fraction having a high solids content for use in preparing papermaking stock and discharging the fraction having a low solids content to waste or for re-use as process water in another part of the process.

Preferably the process includes using a centrifugal separator to form the said two fractions.

Thus, the centrifugal separator can supply a volume of water containing concentrated solids to each new fill of pulp to be slushed in a hydropulper. The residual clarified water is either allowed to flow to waste, perhaps after more limited effluent treatment, or used for other purposes. Due to the substantial reduction in the solids content of the clarified water, there is a corresponding substantial reduction in the load on the effluent treatment plant.

It will therefore be appreciated that the centrifugal separator combines the normal storage function of a backwater tank with the function of a saveall system so as to reduce material losses.

The separator thus permits storage of an appropriate volume of backwater or white water carrying concentrated solids for re-use in the pulp slushing process whilst leaving a residual low solids concentration in the surplus water flowing to waste. By using this method rather than employing a separate saveall system such a disc filter, both capital and running costs are reduced significantly. In addition, since the separation is generated solely due to the hydro-dynamic effect of the stream of backwater or white water entering the separator, both energy and maintenance costs are minimised since there are no moving parts to the system.

The design of the separator utilised the combined effects of sedimentation and centrifugal action to cause separation and concentration of solids in the water entering the separator. Thus, surplus water overflowing to waste or utilised for other process requirements is much lower in solids concentration than water entering the separator.

Preferably, a centrifugal separator is used comprising an upper cylindrical portion and a lower portion which can be tapered, dish shaped or of any other shape which promotes the concentration of solids. The backwater or white water is introduced tangentially near the outer wall in the upper portion so as to generate a slow peripheral rotation defining a vortex. This rotation causes the solids to be retained and concentrated in the annular region adjacent to the wall of the tank. Due to the slow rotation there is minimal turbulence and the solids sediment to the bottom of the lower portion.

The water separating from the solids migrates inwardly and is then caused to flow upwardly in the centre of the separator as a result of displacement by new incoming backwater. As it is withdrawn this water is discharged directly or through an effluent plant to waste, or alternatively is re-used as appropriate in the papermaking process.

Apparatus for carrying out the process set forth above may comprise a pulp dispersion unit, means for delivering prepared stock to the headbox of a papermachine incorporating a machine wire, means for removing backwater drained through said machine wire during formation of a paper web and for delivering said backwater to a centrifugal separator for generating the first water fraction having a higher solids content and a second water fraction having a lower solid content, the capacity of said separator in respect of the high solids fraction being sufficient to hold enough liquid to supply the requirements of said pulper, and means to deliver the second fraction to waste or to another part of the process.

The invention can be performed in various ways, but one embodiment thereof and an example of a centrifugal separator for use therein will now be described by way of example and with reference to the accompanying drawings in which:

Figure 1 is a diagram showing a stock flow system for a papermachine incorporating the invention;

Figure 2 is a diagrammatic cross-sectional view on the lines II-II of Figure 3 of a centrifugal separator for use in the process; and,

Figure 3 is a diagrammatic plan view of the separator shown in Figure 2;

Referring first to Figure 1, this shows a hydropulper 1 into which raw pulp is fed as indicated at P to be slushed with water from a combined backwater tank and centrifugal separator 2 (which is described in more detail below with reference to Figures 2 and

3). The pulp P fed to the hydropulper 1 may be in the form of bales of dry papermaking pulp, or when the system is embodied in an integrated pulp and papermaking system, a pulp slurry fed from the pulping plant. Slushed pulp from the pulping plant is stored into stock chests 3 from which it is then withdrawn as required by a pump 4 and fed through refiners 5 to a small header chest 6.

The slurry is withdrawn from the chest 6 by pump 8 through a valve 7 and fed to cyclone cleaners 9 to the headbox 10 of the papermachine. Slurry entering the pump 8 is reduced to an acceptable consistency for paper formation by the addition of high solids backwater, the source of which is described below, through the connection 11. Before the papermaking stock enters the headbox 10, a polyelectrolyte may be added from a supply 12 thereof as to improve retention of papermaking materials on the papermachine.

Papermaking stock from the headbox 10 is laid down on a papermachine wire 13 and drained with the assistance of underwire foils 14 and vacuum boxes 15. The formed web 16 is then lifted from the wire and fed into the press section of the papermachine, the first press of which is shown at 17.

During the return run 18 of the papermachine wire beneath the foils and vacuum boxes, sprays 19, utilising clean water, are used to wash solids residues from the wire.

Water withdrawn by drainage through the first set 20 of the foils 14 is drained directly into a high solids backwater tank 21. Vacuum is applied to the vacuum box 15 by a vacuum pump or exhauster 22 which applies vacuum through a vacuum separator 23. Water collected in the holding tank 23 is withdrawn by a pump 24 and fed into the backwater tank 21.

Water drained from the set of foils 20 and from the vacuum boxes 15 has a relatively high solids content and is fed through the line 11 in order to adjust the consistency of the aqueous slurry being withdrawn from the header chest 6 by the pumps.

Water from the second set 25 of foils 14 has a lower solids content and is allowed to drain directly into the machine pit 26. This water together with the wash water from the sprays 19 which collects in the machine pit 26 is passed to a medium solids backwater tank 28. Further water extracted from the sheet or derived from the felt washing sprays (not shown) in the first press 17 is withdrawn by a pump 29 and also fed to the medium solids backwater tank 28. Water collected in the hogpit 27 is derived from the sprays 32 immediately thereabove and has a high fibre content. This water is returned directly to the stock chests 3 through connection 33.

The medium solids backwater collected in the tank 28 is withdrawn by a pump 30 and fed to the separator 2, the operation of which is described below with reference to Figures 2 and 3.

Clarified water withdrawn from outlet 31 of the

separator 2 is fed either to an effluent pit 34 or for re-use in the cleaner sprays 19, pump seals etc. in the process as indicated at 35. Water flowing to the effluent pit 34 is withdrawn by a pump 36 and fed to an effluent plant 37 of known kind. Clean water from the effluent plant may then be discharged to the environment through line 38 whilst residual solids are retained at 39 for disposal. The volume of residual solids is substantially less than in the same process in which a conventional backwater tank is used in place of the separator 2.

Turning now to Figures 2 and 3, these show the detailed construction of the backwater separator 2.

The separator comprises a stainless steel circular tank 40 with a conical lower portion 41. In one paper-machine stock flow system the tank had a diameter of 4 metres and a capacity of the order of 30 m³. Incoming backwater was pumped from the medium solids backwater tank 28 into the outer zone of the separator through a pipe 42, the water discharge being tangential so as to produce a vortex with a slow liquid rotation at a minimum velocity of approximately 0.3 m/sec. as indicated by arrows 43 in Figure 3. To achieve efficient separation the minimum velocity should be calculated according to the formula.

$$V = \sqrt{0.03D}$$

where:

V = velocity of incoming backwater in metres/sec.

D = diameter of the tank in metres.

The combined effect of the vortex and the tendency of the solids to sediment results in the solids being drawn outwardly and downwardly, as indicated by reference numeral 44. The residual clarified water, indicated by arrows 45 in Figure 2, passes upwardly in towards the centre of the vessel. The construction of the vessel and the vortex effect together ensure that water with a high concentration of suspended solids moves downwardly in the vessel, whilst the residual clarified water flows upwardly.

In order to prevent mingling of incoming backwater and the upwardly flowing clarified water, a cylindrical baffle 46 extends downwards into the water in the tank and a weir 47 is provided in the form of an annular trough 48. The trough 48 has a lower wall 49, an outer side wall 50 and an inner annular wall 51, the upper edge 52 of which is below the upper level 53 of the liquid in the tank when it is full. Liquid escaping over the weir is indicated by arrows 54 and the clarified water is removed from the trough 48 by a pipe 55 which exists from the lower wall 49 of the trough.

In the construction described above the lower portion 41 is conical but it could be dish-shaped or any other convenient shape which promotes the collection of solids.

Operation of such apparatus was typically as follows. For a backwater separator of 30 m³ capacity, the rate of flow of backwater from the papermachine

to the separator was 80 m³/hour. The concentration of solids in the incoming backwater was measured at 165 mg/l with the solids comprising cellulose fibre, kaolin and titanium dioxide. During a period of one hour, the pulper was filled twice with a total of 60 m³ of backwater. Clarified water overflowed from the separator for 15 minutes flowing to waste and then to Effluent Treatment. The suspended solids present in the clarified water was measured and was found to be 40 mg/l. The backwater separator therefore functioned to reduce the solids in the waste water from 165 mg/l to 40 mg/l. This represents a typical saving.

It has been found that even with backwater having a concentration of solids ranging between 120 - 400 mg/l the suspended solids in the clarified water did not exceed 40 mg/l. Polyelectrolyte additions may be made to the incoming backwater if desired to increase flocculation of the solids, but a substantial economic benefit results even without the use of such a flocculant.

In order to improve retention of cellulose fibre, it may under certain circumstances be advantageous, as mentioned above, to add a flocculant before the backwater enters the separator. If a heavy floc is formed, the backwater will be less mobile and this will in turn reduce the tendency for fibre to be lost with the upwardly flowing waste water. An alternative means of improving fibre retention is to add both a flocculant and air to the incoming backwater. This will cause the fibre to both flocculate and float. The fibre will then be held in the outer part of the vessel while the clarified water continues to flow upwardly in the central portion as before. This results in very clear waste water. The accumulation of solids from both the outer portion and the conical part of the vessel are then fed to the hydropulper as described above, thereby providing good overall solids retention in the system.

A problem which can arise in a closed circuit system in which a high proportion of the water is recycled. Such water tends to rise in temperature as it is continually recycled through the system due to the fact that work is done on it by means of pumps etc., part of which becomes converted into heat and this is undesirable. To hold the temperature down therefore it may sometimes be necessary to increase the addition of cold fresh water to the system. To keep the system in balance therefore an increased amount of water recovered from the separator has to be discharged from the system. Because this additional water being discharged contains a small amount of solids which is removed in the effluent plant, these solids are lost to the system and the system as a whole is marginally less efficient in retaining the solids materials. However, this does not seriously detract from the benefits of the present invention.

Some papermaking machines employ a backwater silo. In such machines the separator of the present invention will be operated in place of this silo.

In earlier papermaking processes, no separation is made between high and medium solids backwater. All backwater is collected and returned to the backwater tank or used for consistency adjustment. The separator system of the invention is also applicable to such a process and, indeed, greater benefits in terms of material savings and reductions in effluent load may sometimes be achieved.

Claims

1. A papermaking process which includes preparing a papermaking stock and delivering that stock to the headbox of a papermachine for deliver onto a machine wire, draining the stock on the wire and processing the backwater or white water thus obtained to generate two fractions one of which fraction has a higher solids content than the other fraction, delivering the fraction having a high solids content for use in preparing papermaking stock and discharging the fraction having a low solids content to waste or for re-use as process water in another part of the process.
2. A papermaking process as claimed in claim 1 which includes using a centrifugal separator to form the said two fractions.
3. A papermaking process as claimed in claim 2 which includes using a centrifugal separator which is self-operated by the hydrodynamic effect of the stream of backwater or white water fed into it.
4. A papermaking process as claimed in claim 3 in which said centrifugal separator comprises an upper cylindrical portion and a lower portion which is tapered or dish-shaped and which includes introducing the liquid tangentially near an outer wall in the upper portion so as to generate a slow peripheral rotation defining a vortex with low turbulence, thus causing the solids in the liquid to be retained and concentrated in the annular region adjacent said wall and to sediment to the bottom of the lower portion.
5. A papermaking process as claimed in claim 3 which includes introducing water into the separator at a minimum velocity calculated according to the formula $V = \sqrt{0.3D}$, where V = the velocity of incoming water in metres/sec and D = the diameter of the separator in metres.
6. A papermaking process as claimed in claim 5 which includes introducing water into the centrifugal separator to cause a vortex with a slow liq-

uid rotation at a minimum velocity of 0.3 m/sec.

7. A papermaking process as claimed in claim 4, claim 5 or claim 6 which includes causing the liquid separated from the solids to migrate inwardly and upwardly where it is withdrawn and discharged directly or through an effluent plant to waste, or for re-use in the papermaking process.
8. A papermaking process as claimed in claims 1 to 7 which includes delivering the fraction having a higher solids content to a hydropulper.
9. A papermaking process as claimed in claim 8 which includes using said centrifugal separator as a backwater tank and delivering said fraction having a higher solids content to each new fill of pulp to be slushed in said hydropulper.
10. A papermaking process as claimed in claims 2 to 9 which includes adding polyelectrolyte to the backwater delivered to the centrifugal separator to increase flocculation of the solids.
11. A papermaking process as claimed in claims 2 to 9 which includes adding a flocculant and air to the incoming backwater or white water delivered to the centrifugal separator.
12. Apparatus for carrying out the process set forth in claim 1 comprising a pulp dispersion unit, means for delivering prepared stock to the headbox of a papermachine incorporating a machine wire, means for removing backwater drained through said machine wire during formation of a paper web and for delivering said backwater to a centrifugal separator for generating the first water fraction having a higher solids content than a second water fraction having a lower solids content than that of the first water fraction, the capacity of said separator in respect of the higher solids fraction being sufficient to hold enough liquid to supply the requirements of said pulper, and means to deliver the second fraction to waste or to another part of the process.
13. Apparatus as claimed in claim 12 in which said centrifugal separator is self-operated by the hydrodynamic effect of the stream of backwater or white water fed into it.
14. Apparatus as claimed in claim 13 in which said centrifugal separator comprises an upper cylindrical portion and a lower portion which is tapered or dish-shaped and means for introducing the liquid tangentially near an outer wall in the upper portion to generate a slow peripheral rotation defining a vortex with low turbulence, thus causing

solids in the liquid to be retained and concentrated in the annular region adjacent said wall and to sediment to the bottom of the lower portion.

15. Apparatus as claimed in claim 14 in which means are provided to cause the liquid separated from the solids to migrate inwardly and upwardly and means for withdrawing and discharging said liquid directly to an effluent plant to waste, as for re-use in the papermaking process.

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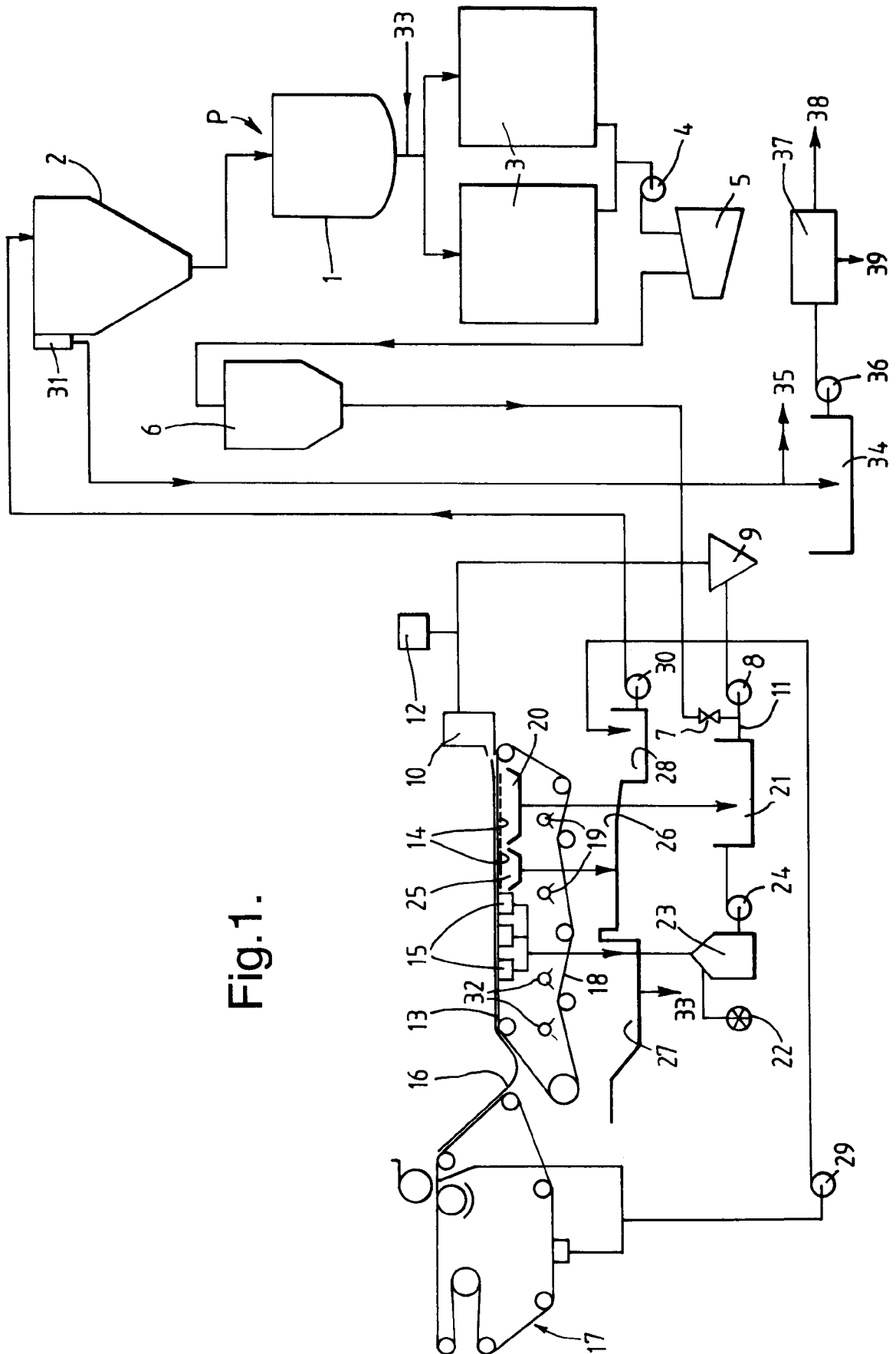
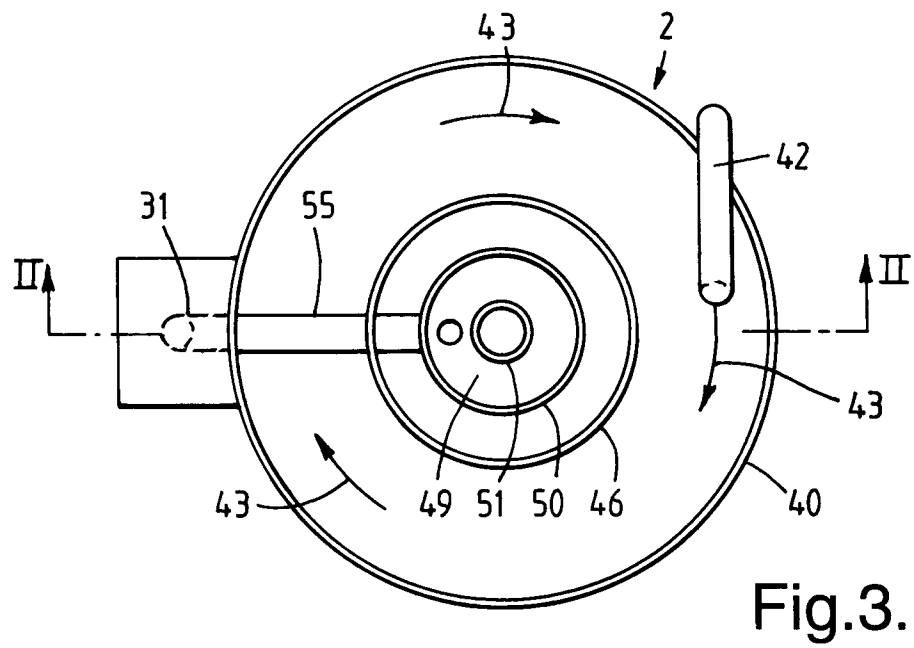
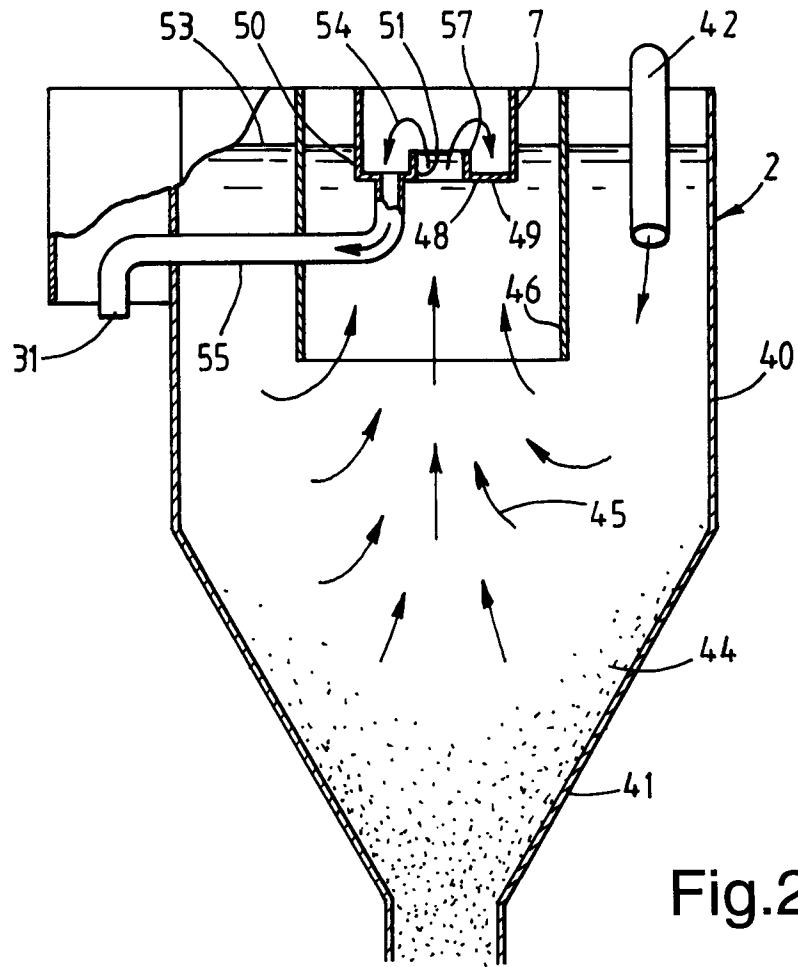


Fig.1.





European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 94 30 5938

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	DATABASE WPI,n 91-079108, Derwent Publications Ltd, London, GB; & SE-A-8902087 (ABB ATOM) *The entire abstract*	1	D21C11/00 D21C9/18
P, X	--- DATABASE WPI,n 94-239403, Derwent Publications Ltd, London, GB; & JP-A-6173183 (MITSUBISHI PAPER MILLS) *The entire abstract*	1, 2	
A	--- WO-A-87 03023 (SUNDS DEFIBRATOR) * claims 1-3 *	1-14	
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)
			D21C
The present search report has been drawn up for all claims			
Place of search		Date of completion of the search	Examiner
THE HAGUE		20 December 1994	Fouquier, J-P
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