

March 11, 1969

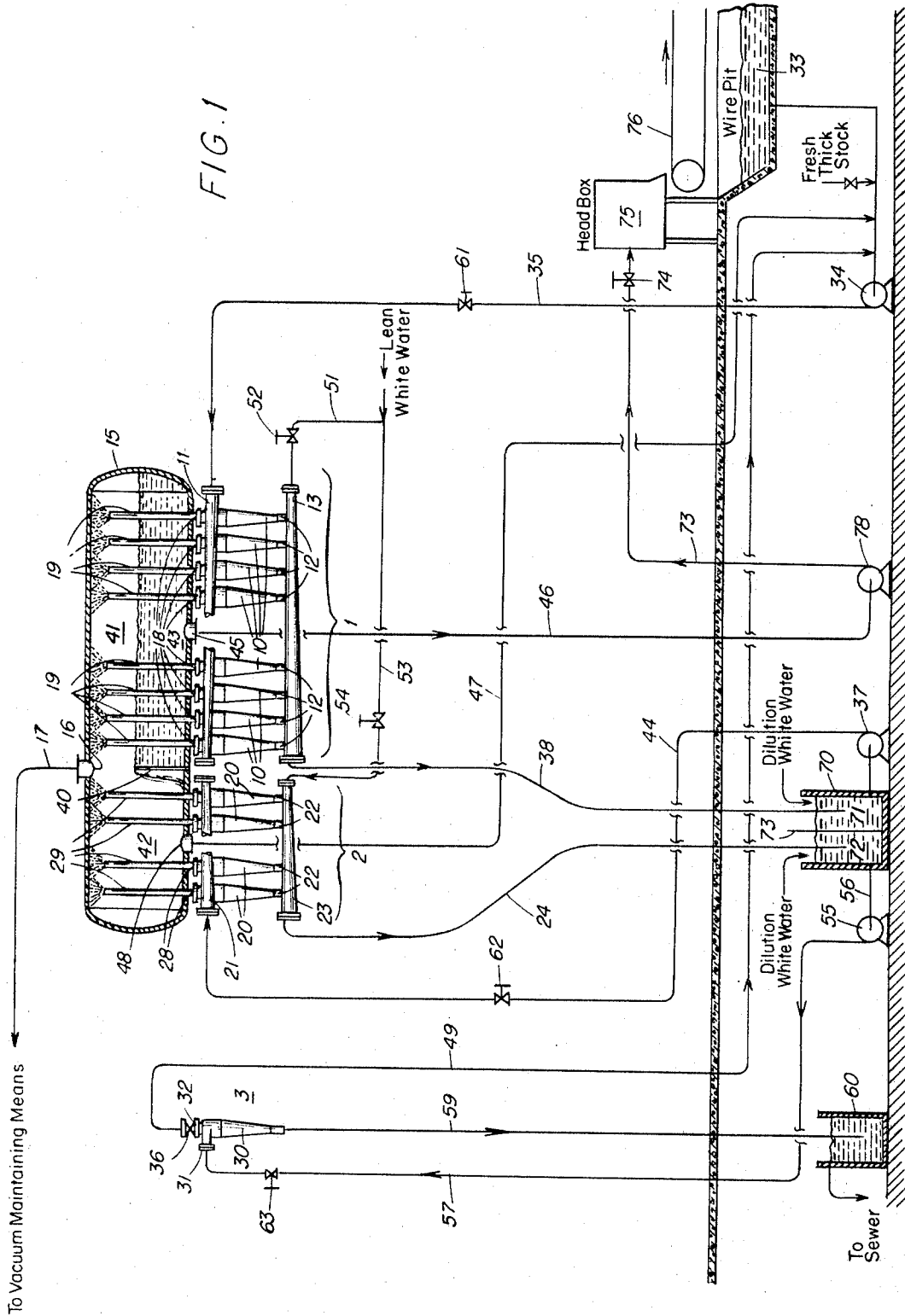
R. G. KAISER

3,432,036

CONDITIONING PAPERMAKING STOCK

Filed Dec. 9, 1964

Sheet / of 4



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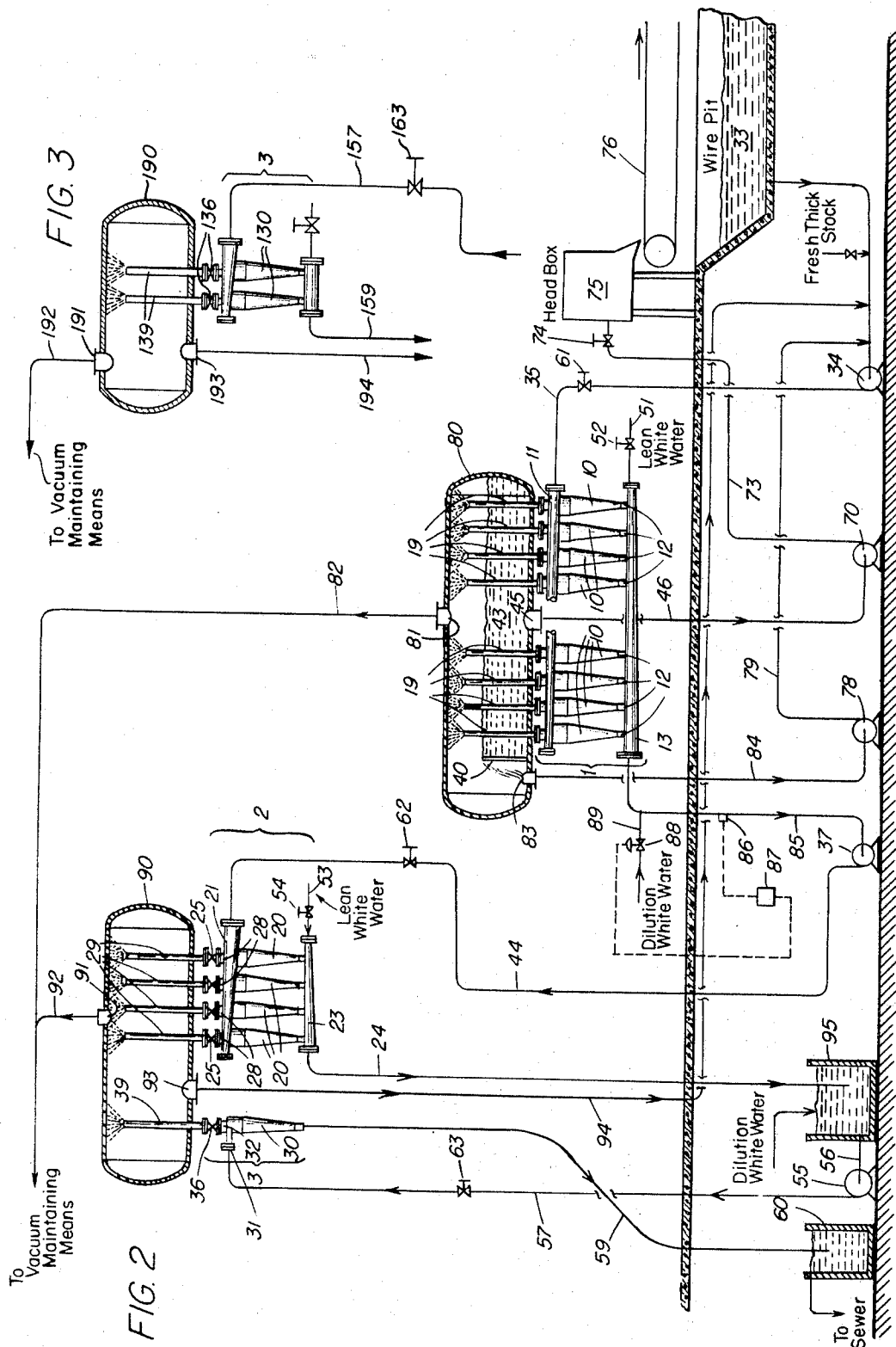
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Sheet 2 of 4



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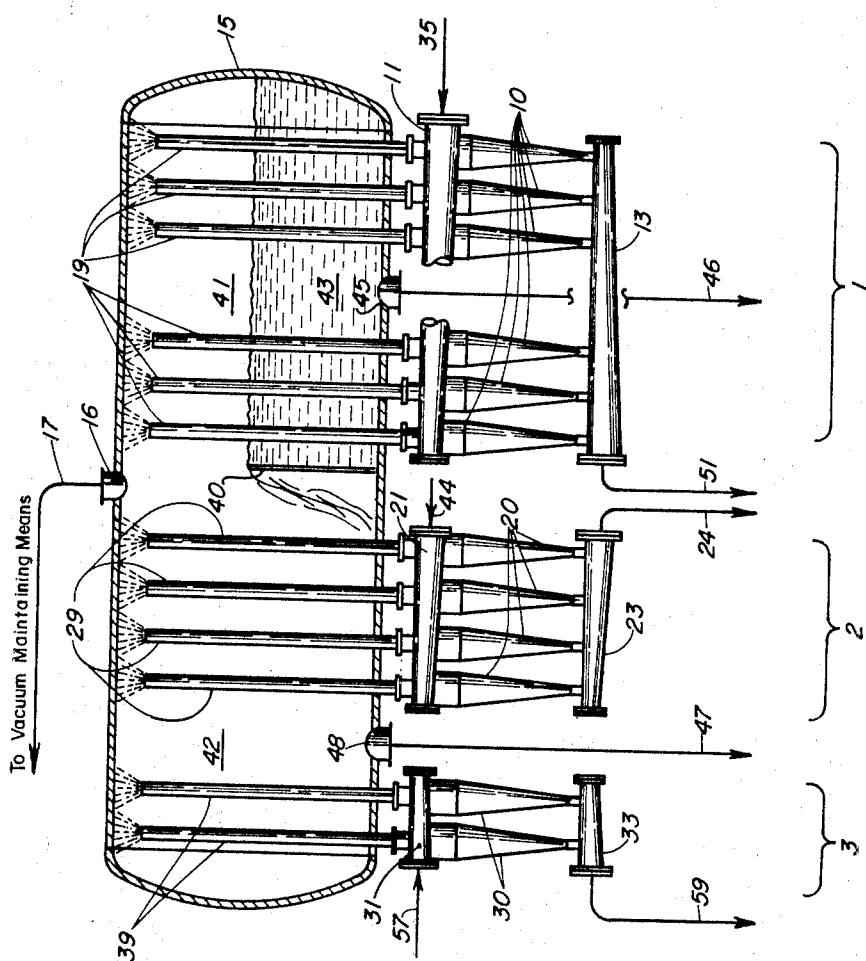
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Filed Dec. 9, 1964

Sheet 4 of 4

FIG. 5



1

3,432,036

CONDITIONING PAPERMAKING STOCK

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23 Claims

ABSTRACT OF THE DISCLOSURE

In a papermaking stock conditioning system employing sequential stages of cleaners and a vacuum-influenced receiver for deaerating primary cleaned stock, enhanced stability and control of the system are achieved by spraying secondary cleaned stock directly into a zone of vacuum, rather than discharging the secondary cleaned stock into a liquid-filled manifold. The zone of vacuum into which the secondary cleaned stock is sprayed may be the receiver, in which event partitioning means may be employed to segregate the primary stock from the secondary stock, or a zone of vacuum separate from the receiver may be used. Cleaned stock from the stage subsequent to the secondary cleaning stage may be similarly treated.

This invention relates to apparatus and method for conditioning papermaking stock. More specifically, this invention relates to apparatus and method for assuring a substantially constant and readily adjustable flow of cleaned and deaerated papermaking stock to a papermaking machine.

In current papermaking practice, it is desirable that the aqueous suspension of papermaking stock supplied to the papermaking machine be free from contaminants or dirt, including undesirably large particles of papermaking material, in order to produce paper of satisfactory quality. One manner of cleaning papermaking stock to remove such particles involves passing the stock suspension through centrifugal solids separating means which classify the suspension into two fractions, the first being acceptable dirt-free stock and the second being rejected dirt-rich stock.

The dirt-rich fraction so produced commonly contains a substantial amount of reclaimable material and accordingly can be passed through a secondary cleaning stage of such centrifugal solids separating means. Even further stages of cleaning to maximize recovery of acceptable fiber or other material may also be provided. Since each successive cleaning stage handles progressively lesser volumes of suspension, fewer cleaning units need be provided in each successive stage.

The most commonly used centrifugal solids separation means effect separation of one type of suspended solids from another by the influence of centrifugal and centripetal forces. A centrifuge, for example, produces these forces by rapid mechanical rotation. More commonly in this art, however, means are used which create the desired forces by controlling the liquid flow patterns within the separation means.

In cyclonic separation, for example, classification is effected by flow patterns created by forced injection of the feed into the centrifugal solids separation means through a tangential inlet. Such liquid cyclones are commonly referred to as hydrocyclones, and are described in, inter alia, Samson, et al. United States Patent 2,377,524. For convenience, the invention is hereinafter illustrated with reference to hydrocyclones, but it is to be understood that the invention is not limited thereto.

A multistage cleaning process may employ a plurality of hydrocyclones, for example, connected in parallel with

2

in each cleaning stage, the several stages being connected in series. A typical installation may comprise as many as 80 hydrocyclones in the primary cleaning stage, 12 hydrocyclones in the secondary stage and 8 hydrocyclones in the subsequent stages.

More modern methods of papermaking take advantage of the discovery that paper of superior quality is obtained when the aqueous suspension of stock is deaerated as well as cleaned. Deaeration may be accomplished by atomizing the stock suspension into a closed tank or receiver which is maintained under vacuum, suitably about 0.3 inch of mercury above the pressure at which the stock boils. Methods and apparatus for simultaneous deaeration and cleaning have also been developed and are described in United States Patents 2,717,536, 2,876,860, and 2,931,503.

This invention is directed to improved apparatus and method for effecting both stock cleaning and deaeration and which provide enhanced controllability over the processes of the prior art. The method and apparatus of this invention ensure that the stock suspension supplied to the papermaking machine will be of greater uniformity in both flow rate and solids content. Enhanced uniformity in weight and caliper of paper and higher quality results, these advantages being of increased importance at modern rapid machine speeds. An additional advantage of the apparatus and method of this invention is a higher yield of acceptable papermaking stock.

Commercially available centrifugal solids separation means often vary in their operating characteristics. The degree of solids separation effected within each unit at constant feed quality and flow rate may also vary. Thus the proportion of the feed rejected as dirt-rich suspension may vary considerably from hydrocyclone to hydrocyclone within a given stage. Such variations may be tolerated in the primary cleaning stage, in part because rejected fiber is recoverable in subsequent cleaning stages; but such variations are not so readily tolerated in secondary and subsequent cleaning stages for at least two reasons. Firstly, an excessive rejection of acceptable fiber in the secondary stage is not economically correctable in subsequent stages and may cause overloading of the subsequent stage or stages with consequent increase of the rate of rejection in those stages and ultimate increase in the amount of fiber discharged with the final stage of rejects to the sewer. Conversely, insufficient rejection of suspension is accompanied by a greater concentration of dirt in the accepts. Secondly, variations in flow characteristics in the secondary hydrocyclones cause surging, which is reflected ultimately in variations in the flow of cleaned and deaerated stock to the papermaking machine with consequent variations in the weight and caliper of the finished paper. Further, it has been found that variations in operation of the secondary hydrocyclones affect the performance of the entire cleaning and deaeration system. The effect of such variations has been to cause pyramiding upsets within the system and thereby deleteriously to affect paper quality.

To compensate for these flow variations, the prior art has provided means for individually adjusting the flow characteristics of each hydrocyclone, as by the provision of valves connected to one or both of the individual hydrocyclone outlets. These valves permit adjustment of the pressure drop across the hydrocyclones, and thereby compensate in some measure for the variations in flow characteristics. But the provision of such means for adjusting the individual flow characteristics of the hydrocyclones has created many additional problems. Altering the adjustment of one hydrocyclone may well affect the operating characteristics of others in the same bank or stage with consequent need for adjustment and readjustment

of the others, and the individual adjustment of a large number of valves to obtain a balanced and properly operating system is difficult and time-consuming. Even minor changes in the grade or weight of paper desired or in the nature of the feed suspension have required frequent readjustments during which the quality of the finished paper once again varies. Thus, the yield of finished paper of the desired quality from feed stock is lowered. The provision of these valves has also led to higher pressure drops across the cleaning stages and thus to higher pumping costs.

I have discovered that it is possible to eliminate these problems and thereby attain a high yield of clean and deaerated papermaking stock in a readily controlled and easily adjustable system. The apparatus and method of my invention provides papermaking stock of a uniform solids content at a uniform rate. My invention also permits the papermaker rapidly to adjust the grade or weight of paper being manufactured without laboriously readjusting each hydrocyclone. The enhanced uniformity of flow characteristics attained by the use of my invention results in a far reduced tendency to system instability. Thus, the stock conditioning systems of my invention may be placed in operation with far greater ease and rapidity and during operation require far less attention on the part of skilled operators. These advantages result in the obtention of higher yields because a lessened amount of off-grade paper is ultimately produced.

Other advantages and features of the invention will in part be obvious and will in part appear hereinafter.

In accordance with the present invention a stock cleaning system is provided comprising at least a primary cleaning stage and a secondary cleaning stage. Each cleaning stage comprises at least one centrifugal solids separating means, suitably hydrocyclones or other known devices having an inlet and first and second outlets and being adapted to receive aqueous papermaking stock suspension and, when the suspension is introduced into the inlets of the separating means with sufficient force, i.e., at a sufficient inlet pressure, to segregate the suspension into two fractions, and to discharge a dirt-poor fraction from the first or "accepts" outlets and to discharge a dirt-rich fraction from the second or "rejects" outlets of each separating means. The separating means of each cleaning stage are connected in parallel. Additional cleaning stages similar to those described above can also be provided.

A stock deaeration station is also provided comprising an enclosed receiver which is maintained at a pressure substantially less than atmospheric. Suitable vacuum-maintaining means, for example a vacuum pump, steam-jet ejector or combination thereof, are provided to maintain the receiver at the desired sub-atmospheric pressure. The receiver is adapted to receive and deaerate stock suspension and to collect deaerated stock as a pond therein. Means are also provided for withdrawing deaerated stock from the pond and for conveying the stock wherever desired, as to the headbox of a papermaking machine.

Means are provided to introduce papermaking stock suspension into the inlets of the primary centrifugal solids separating means with sufficient force to effect segregation of the feed into primary dirt-poor and primary dirt-rich fractions. Means are also provided to introduce rejected primary dirt-rich suspension into the inlets of the secondary centrifugal solids separating means with sufficient force to effect a similar segregation of that suspension into secondary dirt-poor and secondary dirt-rich fractions. In addition, means are provided for introducing the secondary dirt-poor stock suspension into a zone of vacuum under deaerating conditions.

Means are provided for introducing the primary dirt-poor suspension into the receiver under deaerating conditions, suitably by introducing the stock suspension therein in the form of a spray or mist. Means are also provided for excluding air from the rejects outlets of both the primary and secondary separating means, and for conveying secondary dirt-rich suspension from the sec-

ondary rejects outlets under air-excluding conditions. The secondary dirt-rich suspension can be conveyed to subsequent cleaning stages or can be discarded. Subsequent cleaning stages can advantageously be similar to the secondary cleaning stage above described, although subsequent stages may require a lesser number of separating means by reason of the lesser volume of suspension to be treated.

Unexpectedly, it has been found that by discharging the secondary dirt-poor fraction to a zone of vacuum under deaerating conditions, rather than to a conventional liquid-filled manifold, for example, significant advantages are attained. Variations in the flow characteristics of the secondary centrifugal solids separating means are reduced to the point where they are no longer of major significance and their effect upon the operation of the system as a whole is largely mitigated or for practical purposes eliminated. The need for individual adjusting means on each separation means to regulate flow characteristics is obviated in most instances and, if employed, the necessity for adjustment of such means is drastically reduced. As known in the art and as shown, for example, in United States Patents Nos. 2,717,536 and 2,876,860 above referred to, the dirt-poor fraction of suspension emitted from the accepts or dirt-poor suspension outlet of separating means such as a hydrocyclone is an upwardly spiraling liquid mass surrounding an axial liquid-free core. As shown in the patents, means may be provided connecting the dirt-poor suspension outlets of each separating means by an open-ended inlet pipe to the evacuated space within an enclosed zone above the level of any liquid accumulated therein. Suspension is supplied to the cleaners with sufficient force to classify the suspension and to expel a dirt-poor fraction of suspension from each open-ended pipe as a spray. The inlet pipes are not liquid-filled, as the spiraling liquid surrounds an axial liquid-free core. In each of the patents, the dirt-poor stock expulsively sprayed into the evacuated zone is collected as a pond and conveyed to a papermaking machine or other point of use, and is thus primary dirt-poor suspension. The primary dirt-rich suspension of Patent No. 2,876,860 is disclosed to go to discard or to retreatment in hydrocyclones, while that of Patent No. 3,717,536 is disclosed to be treated in a secondary cleaning stage, the secondary dirt-poor suspension being recycled to the primary cleaning stage through a pipe or manifold connected to the primary feed pump. Such a pipe is necessarily filled with liquid in operation.

The advantages of this invention are realized to a large extent in those installations having a third cleaning stage even if the third stage is conventional, i.e., if the tertiary dirt-poor fraction does not discharge into a zone of vacuum. Further advantages may be realized, however, if the tertiary accepts also discharge into a zone of vacuum. Similarly, it is preferred, although not essential, that cleaning stages subsequent to the third stage likewise are arranged to discharge acceptable dirt-poor suspensions into a zone of vacuum.

Advantageously, but not necessarily, the receiver into which primary acceptable stock suspension discharges may also serve as the zone of vacuum into which the secondary dirt-poor stock is introduced. In many instances the secondary dirt-poor suspension is sufficiently clean to be acceptable papermaking stock.

In other instances, particularly where very low paper-making stock dirt contents are required, it may be desirable to reprocess the secondary dirt-poor stock, suitably by returning it to the primary cleaning stage, to ensure more complete dirt removal.

In one embodiment of this invention, the receiver is divided into two portions by suitable partitioning means and primary dirt-poor stock is admitted to one portion and secondary dirt-poor stock is admitted to the other portion, both portions being maintained under vacuum. A weir is advantageously positioned within the receiver as a parti-

tioning means to isolate the pond of primary dirt-poor stock from the secondary dirt-poor stock while permitting free intercommunication between the evacuated spaces on either side of the weir. Suitable outlets and conduit means are provided to permit secondary dirt-poor stock, together with primary dirt-poor stock overflowing the weir, to be recycled to the primary cleaning stage. Similarly, in this embodiment, the dirt-poor fraction from the tertiary and subsequent cleaning stages may, if desired, be discharged into the evacuated space of the receiver. The tertiary accepts may discharge on the same side of the weir as the secondary accepts, or if the secondary accepts are sufficiently clean the primary and secondary accepts may discharge into the receiver on one side of the weir and the tertiary (and subsequent stage) accepts may discharge into the receiver on the other side of the weir.

The zone of vacuum into which the secondary and, if desired, subsequent dirt-poor fraction discharges need not be the receiver and can be a separate chamber or a plurality of separate chambers provided for this purpose. Such chambers are provided with suitable vacuum-producing means and means for conveying deaerated secondary suspension therefrom. Deaerated secondary dirt-poor suspension may be conveyed from the secondary chamber to the papermaking machine, or it may be recycled to the input of the primary cleaning stage. The accepts fraction from subsequent cleaning stages is normally not sufficiently clean for papermaking purposes and is accordingly recycled to the primary cleaning stage from the respective accepts vacuum chambers, if such are employed.

Various illustrative embodiment of the invention are shown in the accompanying drawings, in which:

FIGURE 1 is a schematic representation of one embodiment of the invention wherein the receiver serves as a common zone of vacuum for the dirt-poor suspension from both the primary and secondary cleaning stages, and

FIGURE 2 is a schematic representation of another embodiment of the invention wherein the dirt-poor stock suspension from the secondary cleaning stage discharges into a zone of vacuum separate from that into which the dirt-poor stock suspension from the primary cleaning stages discharges. Also schematically illustrated in the embodiment of FIGURE 2 is apparatus wherein the dirt-poor stock suspension from a tertiary cleaning stage also discharges into a zone of vacuum.

FIGURE 3 is a schematic representation showing the tertiary cleaners discharging into a zone of vacuum apart from the zone or zones of vacuum into which the primary and secondary cleaners discharge.

FIGURE 4 is a schematic representation showing dirt-poor stock from the primary and secondary cleaning stages discharging into a common zone of vacuum, with primary and secondary dirt-poor suspension commingling within the common zone.

FIGURE 5 is a schematic representation showing dirt-poor stock from the primary, secondary and tertiary cleaning stages discharging into a common zone vacuum.

In FIGURE 1 a three-stage cleaning and deaeration system is shown. The primary cleaning stage 1 and the secondary cleaning stage 2 each comprises a plurality of centrifugal solids separating means generally indicated as hydrocyclones. Those centrifugal solids separating means in the primary stage are indicated by the numeral 10 and those in the secondary stage are indicated by the numeral 20. For simplicity, the tertiary cleaning stage 3 is shown as a single hydrocyclone 30 although a plurality of such devices can be employed.

The primary cleaning stage 1 and the secondary cleaning stage 2 are associated with a receiver 15. The receiver 15 is divided into two zones 41 and 42 by weir 40. The hydrocyclones 10 of the primary cleaning stage 1 communicate with zone 41 on one side of the weir and the hydrocyclones 20 of the secondary cleaning stage 2 communicate with zone 42 on the other side of the weir.

Receiver 15 is connected through port 16 and conduit 17 to suitable means (not shown) for establishing and maintaining a vacuum within the receiver.

A pond or reservoir 43 of primary cleaned and deaerated stock is collected within zone 41 of receiver 15. Pond 43 is in part bounded by weir 40, which also defines the maximum height which the top of the pond may attain. The weir 40 therefore serves two purposes: it divides the receiver into two zones, thereby isolating primary dirt-poor stock suspension from secondary dirt-poor stock suspension, and it also prevents pond 43 from rising above a predetermined level.

A similar pond of secondary dirt-poor stock suspension (and primary dirt-poor stock suspension from pond 43 overflowing weir 40) can be maintained within zone 42 of receiver 15, or alternatively receiver 15 may be adapted to allow suspension entering zone 42 to drain therefrom as fast as it enters. If such a pond is maintained within zone 42, its level is also desirably controlled by any suitable means, such as a level control system of any type known in the art operable mechanically, electrically or pneumatically, or by the provision of further weir means.

The hydrocyclones 10 of the primary cleaning stage 1 are connected in parallel, their inlets being interconnected by manifold 11 and their lower or "reject" outlets 12 being interconnected by means of manifold 13. The hydrocyclones 20 of the secondary cleaning stage 2 are similarly arranged in parallel, their inlets being interconnected by manifold 21 and their lower or "reject" outlets 22 being interconnected by means of manifold 23.

The hydrocyclones 10 and 20 deliver de-dirted stock suspension from their accepts outlets, indicated by numeral 18 for the primary hydrocyclones 10 and by numeral 28 for the secondary hydrocyclones 20. The accepts outlets 18 of the primary hydrocyclones 10 communicate with zone 41 within receiver 15 through inlet pipes 19. The inlet pipes 19 are arranged to project above the level of pond 43 maintained within receiver 15 by weir 40 so that the stock suspension enters the receiver under deaerating conditions above the level of the pond. The accepts outlets 28 of the secondary hydrocyclones 20 communicate with zone 42 within receiver 15 through inlet pipes 29.

Pump 34 draws dilution white water from wire pit 33 together with fresh thick stock from a stock preparation chest (not shown) or other source. The proportion of white water and thick stock may be controlled to any desired proportion by suitable regulation devices (not shown) according to known practice. The inlet side of pump 34 is also connected to zone 42 in receiver 15 through conduit 47 and port 48 and to the accepts outlets 32 of the tertiary cleaning stage hydrocyclones 30 through conduit 49. The discharge side of pump 34 is connected through conduit 35 to the primary cleaning stage inlet manifold 11.

The primary rejects outlets 12 of the primary hydrocyclones 10 are connected via outlet manifold 13 and barometric drop leg 38 to section 71 of seal tank 70, seal tank 70 being divided into two sections, 71 and 72, by partition 73. Suitable facilities (not shown) are also provided for independently adding dilution white water to sections 71 and 72 in order to maintain a generally constant (but not necessarily identical) liquid level in each section. The consistencies of the stock in sections 71 and 72 need not be the same. These facilities may be of any type known to those skilled in the art, eg, a constant speed pump delivering a volume of white water slightly greater than the expected demand therefor coupled with overflow means or other level maintaining means at suitable locations within each section of seal tank 70 or, alternatively, a pump coupled with an automatic control system responsive to the liquid level within each section of the seal tank can be used.

The white water added to each of the sections of the

seal tank 70 reduces the solids content of the feed to the subsequent cleaning stages and thereby increases the efficiency of such stages. Maintenance of a constant level within the seal tank also ensures that a sufficient liquid head is available to prevent cavitation within pump 37. The dilution white water used for this purpose preferably is relatively low in solids content and may be drawn from the wire pit or other suitable source at a point well removed from the head box 75.

Diluted primary rejects are conveyed by pump 37 from section 71 of seal box 70 to the intake manifold 21 of secondary hydrocyclones 20, the suspension being supplied to the hydrocyclones with sufficient force to accomplish classification of the suspension into dirt-poor and dirt-rich fractions as heretofore described. The rejects outlets 22 of the secondary hydrocyclones 20 are connected via manifold 23 and barometric drop leg 24 to section 72 of seal tank 70. Additional dilution white water is desirably added to section 72 for the purposes and in the manner described above.

The diluted secondary rejects are drawn from section 72 of seal tank 70 by pump 55 through conduit 56 and forced through conduit 57 to inlet 31 of tertiary hydrocyclone 30. The accepts outlet 32 of the tertiary hydrocyclone 30 is connected by conduit 49 to the intake of feed pump 34 whereby tertiary dirt-poor stock is recycled to the primary cleaning stage 1. The tertiary dirt-rich concentrate is discarded via barometric drop leg 59 and a suitable seal tank 60 to the sewer. Valves 61, 62 and 63 are provided to adjust the flow rates to the primary, secondary and tertiary cleaning stages, respectively, if desired.

Cleaned and deaerated stock is withdrawn from pond 43 in zone 41 of receiver 15 by pump 78 through port 45 and conduit 46. The stock is pumped through conduit 73 to the headbox 75 of a papermaking machine and thence to the wire 76 of the machine. Papermaker's valve 74 in conduit 73 permits regulation of the rate of flow of stock by the papermaker.

Facilities are provided to inject dilution white water into rejects manifold 13 of the primary cleaning stage 1 through conduit 51. The rate of injection is controlled by valve 52 in conduit 51. Similarly, dilution white water can be injected into rejects manifold 23 of the secondary cleaning stage 2 through conduit 53 at a rate controlled by valve 54. The injection of dilution white water into the rejects manifolds in this manner prevents the build-up of solid materials therein to the extent necessary or desired.

Since conduits 24 and 38 function as barometric drop legs, manifolds 13 and 23 must be elevated above the surface of the liquid in the respective sections of seal tank 70 with which they communicate by at least about 34 feet. Similarly, the rejects outlet of tertiary hydrocyclone 30 must be elevated by about 34 feet above the surface of the liquid in seal box 60 if conduit 59 is to function as a barometric drop leg, as shown. Each of the conduits functioning as a barometric drop leg is affixed to the rejects outlet or manifold in air-excluding relationship at its upper end and its lower end projects below the surface of the liquid in the seal box.

In operation of the embodiment of FIGURE 1, fresh thick stock, white water from wire pit 33 and recycle secondary and tertiary dirt-poor stock are forced by pump 34 through conduit 35 and thence to the primary cleaning stage 1. The stock enters the primary cleaning stage through manifold 11 and thence passes to the inlets of the hydrocyclones 10. The discharge pressure of pump 34 is adjusted to be sufficient to cause classification of suspension entering the hydrocyclones into two fractions, a dirt-poor fraction being discharged from accepts outlets 18 and a dirt-rich fraction being discharged from rejects outlets 12. The acceptable dirt-poor fraction passes through pipes 19 into the evacuated space above the pond 43 within zone 41 of receiver 15 where it is emitted in the form of a spray, thereby effecting deaeration of the sus-

pension. Optionally, the upper ends of pipes 19 may be fitted with nozzles (not shown) to promote atomization of the suspension. The cleaned and deaerated stock collects in pond 43 within the receiver whence it can be withdrawn as required.

Desirably, pond 43 is maintained at a constant level during operation to further enhance controllability of the papermaking operation. This can be accomplished by adjusting the flow of stock suspension to and from pond 43 within receiver 15 so that stock continuously overflows the weir 40. Accordingly, it is preferred that the flow rate of stock suspension supplied to the primary cleaning stage 1 by pump 34 be adjusted so that the flow of primary dirt-poor stock suspension into receiver 15 somewhat exceeds the rate of withdrawal from pond 43. Thereby, the level of pond 43 is caused to rise within the receiver until it reaches a point defined by the weir, but it cannot rise significantly above this level since excess primary dirt-poor stock entering the receiver thereafter would overflow weir 40 into zone 42 of the receiver where it would be admixed with secondary dirt-poor stock. Nor can it fall below the level of the weir so long as the flow rates retain the relationship discussed above.

The primary dirt-rich fraction discharged from the rejects outlets 12 is collected in manifold 13 and thence passes through the barometric drop leg 38 into section 71 of the seal tank 70. Dilution white water, preferably of low solids content, is added to section 71 of seal tank 70 in order to dilute the primary dirt-rich stock for more efficient processing in the secondary cleaning stage 2. In a typical operation, for example, the solids content of the primary dirt-rich stock might be as high as 1% or more and sufficient dilution white water may be added to reduce the solids content to approximately 0.4% or less. The diluted primary dirt-rich stock is drawn off from section 71 of seal tank 70 by pump 37 which forces it through conduit 44 to the secondary cleaning stage 2. The feed to the secondary cleaning stage 2 is distributed to hydrocyclones 20 through manifold 21, the suspension being supplied to the hydrocyclones with sufficient force to effect classification. The secondary hydrocyclones, operating as described above, separate the primary dirt-rich fraction into a secondary dirt-poor fraction and a secondary dirt-rich fraction. The secondary dirt-poor fraction is discharged through the secondary accepts outlets 28 and thence through inlet pipes 29 into zone 42 of receiver 15, which is also maintained under vacuum by the vacuum maintaining means. It is by the discharge of this stream into a substantially liquid-free zone under sub-atmospheric pressure that the effects of the different flow characteristics of hydrocyclones 20 are minimized or eliminated and the controllability of the process is enhanced. The secondary dirt-poor stock drains from zone 42 of the receiver 15 through conduit 47 to the inlet of pump 34 and is thereby recycled to the primary cleaning stage 1.

The secondary dirt-rich fraction is discharged through rejects outlets 22, flows through outlet manifold 23 and barometric drop leg 24 and is collected in section 72 of seal tank 70. Dilution white water is added at this point to reduce the solids content of the stock which is to be fed to the tertiary cleaning stage 3. The collected and diluted secondary dirt-rich fraction is drawn from section 71 of seal tank 70 through conduit 56 by pump 55 and forced through conduit 57 to the tertiary cleaning stage 3. The suspension enters hydrocyclone 30 through a tangential inlet 31 with sufficient force to effect segregation into dirt-rich and dirt-poor fractions. The tertiary dirt-rich fraction is discarded through barometric drop leg 59 and seal tank 60. The tertiary dirt-poor fraction is recycled to the primary cleaning stage through outlet 32, conduit 49 and pump 34.

Cleaned and deaerated papermaking stock is drawn from pond 43 in receiver 15 as required through port 45 and conduit 46 by pump 78. Pump 78 forces the stock

through conduit 73 to, for example, the headbox 75 of a papermaking machine. The flow rate of stock to the headbox is controlled in the conventional manner by papermaker's valve 74 in conduit 73.

The quantity of feed to each of the three cleaning stages can be regulated, if desired, by suitable adjustment of valves 61, 62 and 63. In a typical papermaking operation requiring about 15,000 g.p.m. of finished stock, the flow rates within the system may suitably be 16,000 g.p.m. to the primary cleaning stage, 3,000 g.p.m. to the secondary cleaning stage and 1,000 g.p.m. to the tertiary cleaning stage. If the feed stock contains a relatively larger concentration of dirt, the flow rates to the secondary and tertiary cleaning stages may be proportionately increased.

In FIGURE 2 is illustrated schematically another embodiment of the invention. Here, for simplicity, like elements have been given the same numbers as in FIGURE 1 and will not be again described. In this embodiment, the primary cleaning stage 1 is associated with the receiver 80, while the secondary and tertiary cleaning stages are associated with a separate tank 90. The receiver 80 and tank 90 are both connected to suitable vacuum maintaining means (not shown) through port 81 and conduit 82 and port 91 and conduit 92, respectively. The hydrocyclones 10 of the primary cleaning stage 1 communicate with the interior of receiver 80 through inlet pipes 19 which project above the level of the pond 43 containing the cleaned and deaerated stock.

As in the embodiment of FIGURE 1, the level of pond 43 is desirably maintained at a constant and predetermined level, suitably by provision of weir means 40 and by supplying primary dirt-poor stock to receiver 80 at a rate at least slightly greater than the rate at which product deaerated stock is drawn therefrom. Overflowed primary acceptable stock from pond 43 is recycled to the primary cleaning stage 1 by pumps 78 and 34 via conduits 84, 79 and 35. Provision other than that shown and described may be made for maintenance of a constant head in pond 43, or no such provision may be made.

The hydrocyclones 20 of the secondary cleaning stage 2 communicate with the evacuated interior of tank 90 through inlet pipes 29. Valves 25 are optionally provided between the accepts outlets 28 of the hydrocyclones 20 and the inlet pipes 29 and are provided to permit the flow characteristics of each of the secondary hydrocyclones 20 to be individually adjusted, but such valves are by no means essential.

In the embodiment shown, the tertiary hydrocyclone 30 also communicates with the evacuated interior of tank 90 through inlet pipe 39, and thus also discharges dirt-poor stock suspension into a zone of vacuum. If desired, the tertiary hydrocyclone may discharge dirt-poor accepts into a separate zone of vacuum, for example, a third vessel also maintained under vacuum. Alternatively, tank 90 can be divided into two zones in order to isolate tertiary dirt-poor stock from secondary dirt-poor stock by, for example, providing a weir within the tank, making it similar in configuration to the receiver illustrated in FIGURE 1. As presently illustrated however, the secondary dirt-poor stock and the tertiary dirt-poor stock are commingled within tank 90 and are drained therefrom through port 93 and conduit 94. Conduit 94 interconnects tank 90 with the inlet of pump 34 thereby permitting recycling of secondary and tertiary dirt-poor stock to the primary cleaning stage 1.

The embodiment illustrated in FIGURE 1 employs a barometric drop leg to withdraw dirt-rich stock from the primary cleaning stage outlet manifold 13, while in FIGURE 2 the primary cleaning stage is shown at a lower elevation which precludes conduit 85 from functioning in that manner. To prevent cavitation within pump 37 and to avoid a fluctuating back-pressure in manifold 13 which could lead to corresponding fluctuations within the primary hydrocyclones 10 and resulting erratic operation, it is desirable to maintain a constant

liquid level within conduit 85. Any of a number of means may be employed to accomplish this end. As shown in FIGURE 2, sensing means responsive to the liquid level in conduit 85 are provided in operative connection with means admitting dilution water to the conduit in response to the sensed level of the liquid therein. Greater or lesser amounts of dilution white water are thereby added to conduit 85, thus maintaining the liquid level essentially constant or within predetermined limits. The dilution white water added in this manner also serves to dilute the primary dirt-rich stock, thereby desirably reducing its solids content before it is fed to the secondary cleaning stage 2. The dilution white water used for this purpose is preferably of low solids content.

In operation, fresh stock, dilution white water from the wire pit 33, and recycled secondary and tertiary dirt-poor stock, together with any primary acceptable stock overflowing the weir 40 within the receiver 80, are forced by pump 34 through conduit 35 into the primary inlet manifold 11 which distributes the stock to the inlets of the primary hydrocyclones 10. The flow rate to the primary cleaning stage 1 may be controlled by appropriately adjusting valve 61 in conduit 35. The stock enters the hydrocyclones with sufficient force to effect classification. A primary dirt-poor fraction is discharged through the primary accepts outlets 18 and a primary dirt-rich fraction is discharged through primary rejects outlets 12. The primary dirt-rich fraction from the individual hydrocyclones collects in manifold 13 and thence flows through conduit 85 to the inlet of pump 37.

Dilution white water is added through conduit 89 at a rate controlled by adjustment of valve 88 in response to a signal received from the level sensing element 86 and the controller 87. The dilution white water added in this manner reduces the solids content of the primary dirt-rich stock to a level which permits more efficient operation of the secondary cleaning stage 2. Control of the liquid level in conduit 85 within predetermined limits also avoids extremes which would either flood the hydrocyclones 10 or cause cavitation within pump 37.

The diluted primary dirt-rich suspension is forced by pump 37 through conduit 44 at a rate controlled by valve 62 and thence to the secondary inlet manifold 21 from whence it is introduced to the secondary hydrocyclone 20. The secondary hydrocyclones segregate the primary dirt-rich stock into a secondary dirt-poor fraction which is discharged through the secondary accepts outlets 28 and a secondary dirt-rich fraction. The secondary dirt-poor stock then flows through inlet pipe 29 into tank 90, exiting from inlet pipes 29 as a spray or mist which is readily deaerated as a consequence of the vacuum maintained within the tank. The secondary dirt-poor stock then falls to the bottom of tank 90 and is returned to the intake of pump 34 through port 93 and conduit 94 whereby it is recycled to the primary cleaning stage 1. If desired, means can be provided to maintain a pool of collected secondary dirt-poor stock within the tank 90, although this is not required since the stock can be withdrawn as fast as it enters.

The secondary dirt-rich portion is discharged from the secondary rejects outlets 22 into the secondary outlet manifold 23 and thence flows through barometric drop leg 24 to seal tank 95 where it is diluted with additional dilution white water to adjust its solids content. The diluted secondary dirt-rich stock is drawn off from seal tank 95 through conduit 56 by pump 55 which forces it through conduit 57 at a rate controlled by valve 63 and thence to the tertiary cleaning stage 3. The diluted secondary dirt-rich stock enters the tertiary hydrocyclones 30 through inlet 31 and is classified therewithin to form a tertiary dirt-poor stock and a tertiary dirt-rich concentrate.

The tertiary dirt-poor stock is discharged from hydrocyclone 30 through accepts outlet 32 and thence flows through inlet pipe 39 to the interior of tank 90 whence

11

it exits as a spray or mist which intermingles with the secondary dirt-poor stock. This commingled stock is drained from tank 90 through port 93 in the manner described previously. The tertiary dirt-rich stock exits from the lower or rejects outlet of the tertiary hydrocyclones 30, falls through the barometric drop leg 59 and is collected in seal tank 60 whence it can be discarded.

The primary dirt-poor suspension is discharged from the primary accepts outlets 18 and passes through pipes 19 from whence it is discharged within receiver 80 as a spray or mist and is deaerated. The spray then falls and is collected as a pond 43 in the base of the receiver from which it can be withdrawn as required for use in the papermaking operation in the manner described above.

The rate of flow of stock suspension to the primary cleaning stage is desirably adjusted so that primary acceptable suspension enters the receiver at a rate somewhat greater than the rate at which it is withdrawn through conduit 46 and supplied to the papermaking machine. In consequence, primary acceptable dirt-poor stock exceeding the capacity of pond 43 as defined by weir 40 will overflow the weir and be recycled, together with secondary and tertiary acceptable dirt-poor stock, to the primary stock cleaning stage.

FIGURE 3 shows a portion of an embodiment according to the invention in which tertiary cleaners 130 discharge tertiary dirt-poor stock through inlet pipes 139 into a zone of vacuum defined by tank 190, which is connected through port 191 and line 192 with vacuum-maintaining means of the type previously indicated. Tertiary dirt-poor stock exits tank 190 through port 193 and conduit 194 for return to a prior cleaning stage. The arrangement of tertiary cleaners shown in FIGURE 3 may be employed in lieu of that shown in FIGURE 1 or FIGURE 2. Thus, the arrangement of FIGURE 3 may be employed in place of tertiary hydrocyclone 30 of FIGURE 1. Similarly, the arrangement of FIGURE 3 may be employed in the embodiment of FIGURE 2 by removing the tertiary cleaning stage 3, including hydrocyclone 30 and associated inlet pipe 39 from tank 90 of FIGURE 2 and substituting instead the arrangement shown in FIGURE 3.

FIGURE 4 shows a portion of an embodiment according to the invention in which primary cleaners 10 and secondary cleaners 20 discharge primary and secondary dirt-poor stock through inlet pipes 19 and 29, respectively, into a common zone of vacuum defined by receiver 15, which is connected through port 16 and line 17 with vacuum maintaining means of the type previously indicated. Primary and secondary dirt-poor stock commingle in pond 43 within receiver 15, and the deaerated commingled mixture is drawn through port 45 and line 46 under air-excluding conditions for delivery to the papermaking machine or other point of use. Weir 40 within receiver 15 defines the maximum height of pond 43, deaerated stock which may overflow the weir being conveyed from the receiver through port 48 and conduit 47, and may thence be recycled to the primary cleaning stage 1. Weir 40 may be omitted, and other level-maintaining means may be substituted if it be desired to maintain a pond of deaerated stock of essentially constant level within receiver 15. The supply of stock to the primary cleaning stage 1 through conduit 35 and header 11, as well as the supply of suspension to the secondary cleaning stage 2 through conduit 44 and header 21, may be as previously described and depicted in connection with FIGURES 1 and 2. Similarly, the primary dirt-rich suspension from header 13 and conduit 51, as well as the secondary dirt-rich suspension from header 23 and conduit 24 may be conveyed as herein above described.

FIGURE 5 similarly shows a portion of another em-

12

bodiment according to the invention in which primary, secondary and tertiary dirt-poor suspension is discharged into a common zone of vacuum defined by receiver 15, which is maintained under vacuum as previously described. Suspension is supplied to the primary cleaning stage through conduit 35 and header 11 and is classified in cleaners 10 of primary cleaning stage 1, with primary dirt-poor suspension being discharged into the evacuated receiver through inlet pipes 19, the deaerated stock collecting as pond 43 and being withdrawn therefrom through port 45 and conduit 46 for delivery to the paper-making machine or other point of use. Partitioning means, shown as weir 40 defining the maximum height of pond 43, are provided within the receiver, and serve to segregate the pond 43 of deaerated primary dirt-poor stock from the secondary and tertiary dirt-poor stock introduced into zone 42 within evacuated receiver 15. Secondary dirt-poor suspension is discharged through inlet pipes 29 extending from secondary cleaners 20, while tertiary dirt-poor stock is discharged through inlet pipes 39 extending from tertiary cleaners 30. The supply of suspension to secondary cleaners 20 and tertiary cleaners 30 may be as previously described, and the routing of secondary dirt-poor suspension and tertiary dirt-poor suspension can similarly be as described and depicted herein above. Secondary and tertiary dirt-poor suspension, together with primary dirt-poor suspension overflowing weir 40, are withdrawn from the receiver through port 48 and conduit 47 and may suitably be recycled to the primary cleaning stage.

The foregoing description illustrates methods and apparatus by which the advantages of this invention can be attained, but these descriptions are merely illustrative and should not be construed as limiting since modifications thereof will be readily apparent to those skilled in the art. For example, it is not necessary that the secondary and tertiary dirt-rich stocks be withdrawn by means of barometric drop legs. As in the case of the primary cleaning stage, the secondary and/or tertiary cleaning stage may be at a lowered elevation so long as facilities are provided to ensure that the dirt-rich stocks are withdrawn under air-excluding conditions which also permit an even back-pressure on the secondary and tertiary hydrocyclones to be maintained. Thus, the means illustrated in the embodiment of FIGURE 2 for withdrawing the primary dirt-rich stock are equally applicable to the secondary and/or tertiary cleaning stages as well.

In other embodiments, the primary hydrocyclones could be replaced by centrifuges and/or the tertiary cleaning stage could be omitted or more than three cleaning stages could be provided. These are but a few of the possible modifications within the scope of the invention.

I claim:

1. In apparatus for cleaning and deaerating a suspension which includes primary and secondary cleaning stages each comprising centrifugal solids separating means adapted to classify suspension into dirt-rich and dirt-poor fractions and to discharge such fractions from individual outlets of each separating means, means for supplying suspension to the primary cleaning stage with sufficient force to classify and expel the suspension from the separating means of the primary cleaning stage as primary dirt-poor and primary dirt-rich suspension, an enclosed receiver adapted to collect deaerated suspension as a pond therewithin, evacuating means connected to the receiver for maintaining the interior of the receiver under vacuum, means for discharging primary dirt-poor suspension from the primary cleaning stage into said receiver under deaerating conditions above the pond therewithin, means for withdrawing deaerated suspension from the pond in the receiver, and means for supplying the dirt-rich fraction of suspension from the primary cleaning

stage to the secondary cleaning stage with sufficient force to classify and expel said fraction from the separating means of the secondary cleaning stage as secondary dirt-poor and secondary dirt-rich suspension; the improvement which comprises

enclosing means and associated vacuum maintaining means connected therewith defining an enclosed evacuated space,

individual pipe means connecting the dirt-poor suspension outlet of each separating means of the secondary cleaning stage to said enclosing means, each such pipe means terminating in an open end within the evacuated space defined by said enclosing means for discharge of secondary dirt-poor suspension as a spray from each such open-ended terminus into the evacuated space under deaerating conditions above the level of any liquid that may accumulate therein, means for conveying secondary dirt-poor suspension under air-excluding conditions from said means enclosing the evacuated space, and

means for conveying secondary dirt-rich suspension from the secondary cleaning stage under air-excluding conditions.

2. Apparatus according to claim 1, in which the separating means of the secondary cleaning stage comprise hydrocyclones.

3. In apparatus for cleaning and deaerating a suspension which includes primary and secondary cleaning stages each comprising centrifugal solids separating means adapted to classify suspension into dirt-rich and dirt-poor fractions and to discharge such fractions from individual outlets of each separating means, means for supplying suspension to the primary cleaning stage with sufficient force to classify and expel the suspension from the separating means of the primary cleaning stage as primary dirt-poor and primary dirt-rich suspension, an enclosed receiver adapted to collect deaerated suspension as a pond therewith, evacuating means connected to the receiver for maintaining the interior of the receiver under vacuum, means for discharging primary dirt-poor suspension from the primary cleaning stage into said receiver under deaerating conditions above the pond therewithin, and means for supplying the dirt-rich fraction of suspension from the primary cleaning stage to the secondary cleaning stage with sufficient force to classify and expel said fraction from the separating means of the secondary cleaning stage as secondary dirt-poor and secondary dirt-rich suspension; the improvement which comprises

individual pipe means connecting the dirt-poor suspension outlet of each separating means of the secondary cleaning stage to said receiver, each such pipe means terminating in an open end within the evacuated space within said receiver for discharge of secondary dirt-poor suspension as a spray from each such open-ended terminus into the evacuated space under deaerating conditions above the pond therewithin,

means for conveying primary and secondary dirt-poor suspension under air-excluding conditions from said receiver, and

means for conveying secondary dirt-rich suspension from the secondary cleaning stage under air-excluding conditions.

4. In apparatus for cleaning and deaerating a suspension which includes primary and secondary cleaning stages each comprising centrifugal solids separating means adapted to classify suspension into dirt-rich and dirt-poor fractions and to discharge such fractions from individual outlets of each separating means, means for supplying suspension to the primary cleaning stage with sufficient force to classify and expel the suspension from the separating means of the primary cleaning stage as primary dirt-poor and primary dirt-rich suspension, an enclosed receiver having partitioning means dividing the interior of the receiver into a first portion adapted to collect

deaerated suspension as a pond therewithin and a second portion, evacuating means connected to the receiver for maintaining the interior of the receiver under vacuum, means for discharging primary dirt-poor suspension from the primary cleaning stage into the first portion of said receiver under deaerating conditions above the pond therewithin, means for withdrawing deaerated suspension from the pond in the receiver, and means for supplying the dirt-rich fraction of suspension from the primary cleaning stage to the secondary cleaning stage with sufficient force to classify and expel said fraction from the separating means of the secondary cleaning stage as secondary dirt-poor and secondary dirt-rich suspension; the improvement which comprises

individual pipe means connecting the dirt-poor suspension outlet of each separating means of the secondary cleaning stage to the second portion of said receiver, each such pipe means terminating in an open end within the evacuated space within the second portion of said receiver for discharge of secondary dirt-poor suspension as a spray from each such open-ended terminus into the evacuated space under deaerating conditions above the level of any liquid that may accumulate therein,

means for conveying secondary dirt-poor suspension under air-excluding conditions from the second portion of said receiver, and

means for conveying secondary dirt-rich suspension from the secondary cleaning stage under air-excluding conditions.

5. Apparatus according to claim 4, having means conveying secondary dirt-poor suspension to the primary cleaning stage.

6. In apparatus for cleaning and deaerating a suspension which includes primary and secondary cleaning stages each comprising centrifugal solids separating means adapted to classify suspension into dirt-rich and dirt-poor fractions and to discharge such fractions from individual outlets of each separating means, means for supplying suspension to the primary cleaning stage with sufficient force to classify and expel the suspension from the separating means of the primary cleaning stage as primary dirt-poor and primary dirt-rich suspension, an enclosed receiver having weir means defining the maximum height of a pond of deaerated primary dirt-poor suspension collected therewithin, evacuating means connected to the receiver for maintaining the interior of the receiver under vacuum, means for discharging primary dirt-poor suspension from the primary cleaning stage into said receiver under deaerating conditions above the pond therewithin, means for withdrawing deaerated suspension from the pond in the receiver, and means for supplying the dirt-rich fraction of suspension from the primary cleaning stage to the secondary cleaning stage with sufficient force to classify and expel said fraction from the separating means of the secondary cleaning stage as secondary dirt-poor and secondary dirt-rich suspension; the improvement which comprises

individual pipe means connecting the dirt-poor suspension outlet of each separating means of the secondary cleaning stages to the receiver on the side of the weir opposite the pond, each such pipe means terminating in an open end within the evacuated space within the receiver on the side of the weir opposite the pond for discharge of secondary dirt-poor suspension as a spray from each such open-ended terminus into the evacuated space under deaerating conditions above the level of any liquid that may accumulate therein,

means for conveying suspension which may overflow the weir from the pond and secondary dirt-poor suspension from the receiver under air-excluding conditions, and

means for conveying secondary dirt-rich suspension

15

from the secondary cleaning stage under air-excluding conditions.

7. Apparatus according to claim 6, having means conveying suspension which may overflow the weir from the pond and secondary dirt-poor suspension to the primary cleaning stage.

8. In apparatus for cleaning and deaerating a suspension which includes primary, secondary and tertiary cleaning stages each comprising centrifugal solids separating means adapted to classify suspension into dirt-rich and dirt-poor fractions and to discharge such fractions from individual outlets of each separating means, means for supplying suspension to the primary cleaning stage with sufficient force to classify and expel the suspension from the separating means of the primary cleaning stage as primary dirt-poor and primary dirt-rich suspension, an enclosed receiver adapted to collect deaerated suspension as a pond therewithin, evacuating means connected to the receiver for maintaining the interior of the receiver under vacuum, means for discharging primary dirt-poor suspension from the primary cleaning stage into said receiver under deaerating conditions above the pond therewithin, means for withdrawing deaerated suspension from the pond in the receiver, means for supplying the dirt-rich fraction of suspension from the primary cleaning stage to the secondary cleaning stage with sufficient force to classify and expel said fraction from the separating means of the secondary cleaning stage as secondary dirt-poor and secondary dirt-rich suspension, and means for supplying the dirt-rich fraction of suspension from the secondary cleaning stage to the tertiary cleaning stage with sufficient force to classify and expel said secondary dirt-rich fraction from the separating means of the tertiary cleaning stage as tertiary dirt-poor and tertiary dirt-rich suspension; the improvement which comprises

enclosing means and associated vacuum maintaining means connected therewith defining an enclosed evacuated space,

individual pipe means connecting the dirt-poor suspension outlet of each separating means of the secondary cleaning stage to said enclosing means, each such pipe means terminating in an open end within the evacuated space defined by said enclosing means for discharge of secondary dirt-poor suspension as a spray from each such open-ended terminus into the evacuated space under deaerating conditions above the level of any liquid that may accumulate therein,

means for conveying secondary dirt-poor suspension under air-excluding conditions from said means enclosing the evacuated space,

zone-enclosing means and associated vacuum-maintaining means connected therewith defining an enclosed evacuated zone,

additional individual pipe means connecting the dirt-poor suspension outlet of each separating means of the tertiary cleaning stage to said zone-enclosing means, each said additional pipe means terminating in an open end within said zone-enclosing means for discharge of tertiary dirt-poor suspension as a spray from each such open-ended terminus of said additional pipe means into the evacuated zone under deaerating conditions above the level of any liquid which may accumulate therein,

means for conveying tertiary dirt-poor suspension under air-excluding conditions from said zone-enclosing means, and

means for conveying tertiary dirt-rich suspension from the tertiary cleaning stage under air-excluding conditions.

9. Apparatus according to claim 8, in which the separating means of the secondary and tertiary cleaning stages comprise hydrocyclones.

10. In apparatus for cleaning and deaerating a sus-

16

pension which includes primary, secondary and tertiary cleaning stages each comprising centrifugal solids separating means adapted to classify suspension into dirt-rich and dirt-poor fractions and to discharge such fractions from individual outlets of each separating means, means for supplying suspension to the primary cleaning stage with sufficient force to classify and expel the suspension from the separating means of the primary cleaning stage as primary dirt-poor and primary dirt-rich suspension, an enclosed receiver adapted to collect deaerated suspension as a pond therewithin, evacuating means connected to the receiver for maintaining the interior of the receiver under vacuum, means for discharging primary dirt-poor suspension from the primary cleaning stage into said receiver under deaerating conditions above the pond therewithin, means for withdrawing deaerated suspension from the pond in the receiver, means for supplying the dirt-rich fraction of suspension from the primary cleaning stage to the secondary cleaning stage with sufficient force to classify and expel said fraction from the separating means of the secondary cleaning stage as secondary dirt-poor and secondary dirt-rich suspension, and means for supplying the dirt-rich fraction of suspension from the secondary cleaning stage to the tertiary cleaning stage with sufficient force to classify and expel said secondary dirt-rich fraction from the separating means of the tertiary cleaning stage as tertiary dirt-poor and tertiary dirt-rich suspension; the improvement which comprises

enclosing means and associated vacuum maintaining means connected therewith defining an enclosed evacuated space,

individual pipe means connecting the dirt-poor suspension outlet of each separating means of the secondary cleaning stage to said enclosing means, each such pipe means terminating in an open end within the evacuated space defined by said enclosing means for discharge of secondary dirt-poor suspension as a spray from each such open-ended terminus into the evacuated space under deaerating conditions above the level of any liquid that may accumulate therein,

additional individual pipe means connecting the dirt-poor suspension outlet of each separating means of the tertiary cleaning stage to said enclosing means, each such additional pipe means terminating in an open end within the evacuated space defined by said enclosing means for discharge of tertiary dirt-poor suspension as a spray from each such open-ended terminus of said additional pipe means into the evacuated space under deaerating conditions above the level of any liquid that may accumulate therein,

means for conveying secondary and tertiary dirt-poor suspension under air-excluding conditions from said means enclosing the evacuated space, and

means for conveying tertiary dirt-rich suspension from the tertiary cleaning stage under air-excluding conditions.

11. In apparatus for cleaning and deaerating a suspension which includes primary, secondary and tertiary cleaning stages each comprising centrifugal solids separating means adapted to classify suspension into dirt-rich and dirt-poor fractions and to discharge such fractions from individual outlets of each separating means, means for supplying suspension to the primary cleaning stage with sufficient force to classify and expel the suspension from the separating means of the primary cleaning stage as primary dirt-poor and primary dirt-rich suspension, an enclosed receiver having partitioning means dividing the interior of the receiver into a portion adapted to collect deaerated suspension as a pond therewithin and a remaining space, evacuating means connected to the receiver for maintaining the interior of the receiver under vacuum, means for discharging primary dirt-poor suspension from the primary cleaning stage into said portion of the receiver under deaerating conditions above

the pond therewithin, means for withdrawing deaerated suspension from the pond in the receiver, means for supplying the dirt-rich fraction of suspension from the primary cleaning stage to the secondary cleaning stage with sufficient force to classify and expel said fraction from the separating means of the secondary cleaning stage as secondary dirt-poor and secondary dirt-rich suspension, and means for supplying the dirt-rich fraction of suspension from the secondary cleaning stage to the tertiary cleaning stage with sufficient force to classify and expel said secondary dirt-rich fraction from the separating means of the tertiary cleaning stage as tertiary dirt-poor and tertiary dirt-rich suspension; the improvement which comprises

individual pipe means connecting the dirt-poor suspension outlet of each separating means of the secondary cleaning stage to the remaining evacuated space in said receiver, each such pipe means terminating in an open end within said evacuated space for discharge of secondary dirt-poor suspension as a spray from each such open-ended terminus into the evacuated space under deaerating conditions above the level of any liquid that may accumulate therein,

additional individual pipe means connecting the dirt-poor suspension outlet of each separating means of the tertiary cleaning stage to the remaining evacuated space in said receiver, each such additional pipe means terminating in an open end within said evacuated space for discharge of tertiary dirt-poor suspension as a spray from each such open-ended terminus of said additional pipe means into the evacuated space under deaerating conditions above the level of any liquid that may accumulate therein,

means for conveying secondary and tertiary dirt-poor suspension under air-excluding conditions from said receiver, and

means for conveying tertiary dirt-rich suspension from the tertiary cleaning stage under air-excluding conditions.

12. Apparatus according to claim 11, having means conveying secondary and tertiary dirt-poor suspension to the primary cleaning stage.

13. In apparatus for cleaning and deaerating a suspension which includes primary, secondary and tertiary cleaning stages each comprising centrifugal solids separating means adapted to classify suspension into dirt-rich and dirt-poor fractions and to discharge such fractions from individual outlets of each separating means, means for supplying suspension to the primary cleaning stage with sufficient force to classify and expel the suspension from the separating means of the primary cleaning stage as primary dirt-poor and primary dirt-rich suspension, an enclosed receiver having weir means defining the maximum height of a pond of deaerated primary dirt-poor suspension collected therewithin, evacuating means connected to the receiver for maintaining the interior of the receiver under vacuum, means for discharging primary dirt-poor suspension from the primary cleaning stage into said receiver under deaerating conditions above the pond therewithin, means for withdrawing deaerating suspension from the pond in the receiver, means for supplying the dirt-rich fraction of suspension from the primary cleaning stage to the secondary cleaning stage with sufficient force to classify and expel said fraction from the separating means of the secondary cleaning stage as secondary dirt-poor and secondary dirt-rich suspension, and means for supplying the dirt-rich fraction of suspension from the secondary cleaning stage to the tertiary cleaning stage with sufficient force to classify and expel said secondary dirt-rich fraction from the separating means of the tertiary cleaning stage as tertiary dirt-poor and tertiary dirt-rich suspension; the improvement which comprises

individual pipe means connecting the dirt-poor suspension outlet of each separating means of the second-

ary cleaning stage to the receiver on the side of the weir opposite the pond, each such pipe means terminating in an open end within the evacuated space within the receiver on the side of the weir opposite the pond for discharge of secondary dirt-poor suspension as a spray from each such open-ended terminus into the evacuated space under deaerating conditions above the level of any liquid that may accumulate therein,

additional individual pipe means connecting the dirt-poor suspension outlet of each separating means of the tertiary cleaning stage to the receiver on the side of the weir opposite the pond for discharge of tertiary dirt-poor suspension as a spray from each such open-ended terminus into the evacuated space under deaerating conditions above the level of any liquid that may accumulate therein,

means for conveying suspension which may overflow the weir from the pond and secondary and tertiary dirt-poor suspension from the receiver under air-excluding conditions, and

means for conveying tertiary dirt-rich suspension from the tertiary cleaning stage under air-excluding conditions.

14. In a process for cleaning and deaerating paper-making stock in which the stock is classified in cleaner means comprising a primary cleaning stage into primary dirt-poor and primary dirt-rich fractions, primary dirt-poor stock is sprayed under deaerating conditions into an evacuated receiver and deaerated primary dirt-poor stock is withdrawn from the receiver, and the dirt-rich fraction of stock from the primary cleaning stage is classified in cleaner means comprising a secondary cleaning stage into secondary dirt-poor and secondary dirt-rich fractions which are expelled from separate outlets of each secondary cleaner; the improvement which comprises conveying the secondary dirt-poor stock under air-excluding conditions from the dirt-poor suspension outlet of each secondary cleaner through an individual inlet pipe to an enclosed space maintained under vacuum for discharge of secondary dirt-poor stock from an open-ended terminus of each such pipe within the evacuated space as a spray above the level of any liquid that may accumulate within the evacuated space,

conveying secondary dirt-poor stock from the enclosed evacuated space under air-excluding conditions, and

conveying secondary dirt-rich stock from the secondary cleaning stage under air-excluding conditions.

15. In a process for cleaning and deaerating paper-making stock in which the stock is classified in cleaner means comprising a primary cleaning stage into primary dirt-poor and primary dirt-rich fractions, primary dirt-poor stock is sprayed under deaerating conditions into an evacuated receiver, and the dirt-rich fraction of stock from the primary cleaning stage is classified in cleaner means comprising a secondary cleaning stage into secondary dirt-poor and secondary dirt-rich fractions which are expelled from separate outlets of each secondary cleaner; the improvement which comprises

conveying the secondary dirt-poor stock under air-excluding conditions from the dirt-poor suspension outlet of each secondary cleaner through an individual inlet pipe to said evacuated receiver for discharge of secondary dirt-poor stock from an open-ended terminus of each such pipe within the evacuated space as a spray above the level of the pond therewithin,

conveying primary and secondary dirt-poor stock from the receiver under air-excluding conditions, and conveying secondary dirt-rich stock from the secondary cleaning stage under air-excluding conditions.

16. In a process for cleaning and deaerating paper-making stock in which the stock is classified in cleaner

means comprising a primary cleaning stage into primary dirt-poor and primary dirt-rich fractions, primary dirt-poor stock is sprayed under deaerating conditions into an evacuated receiver and deaerated primary dirt-poor stock is withdrawn from the receiver, and the dirt-rich fraction of stock from the primary cleaning stage is classified in cleaner means comprising a secondary cleaning stage into secondary dirt-poor and secondary dirt-rich fractions which are expelled from separate outlets of each secondary cleaner; the improvement which comprises

conveying the secondary dirt-poor stock under air-excluding conditions from the dirt-poor suspension outlet of each secondary cleaner through an individual inlet pipe to said evacuated receiver for discharge of secondary dirt-poor stock from an open-ended terminus of each such pipe within the evacuated space as a spray above the level of any liquid that may accumulate therebelow, while segregating primary dirt-poor stock from secondary dirt-poor stock within the evacuated receiver,

conveying secondary dirt-poor stock from the enclosed evacuated space under air-excluding conditions, and conveying secondary dirt-rich stock from the secondary cleaning stage under air-excluding conditions.

17. Process according to claim 16, in which secondary dirt-poor stock is conveyed from the evacuated space to the primary cleaning stage.

18. In a process for cleaning and deaerating paper-making stock in which the stock is classified in cleaner means comprising a primary cleaning stage into primary dirt-poor and primary dirt-rich fractions, the primary dirt-poor stock is sprayed under deaerating conditions into an evacuated receiver and deaerated primary dirt-poor stock is withdrawn from the receiver, primary dirt-poor stock is discharged into the evacuated space at a rate greater than that at which it is withdrawn therefrom and primary dirt-poor stock overflows a weir within the enclosed space, and the dirt-rich fraction of stock from the primary cleaning stage is classified in cleaner means comprising a secondary cleaning stage into secondary dirt-poor and secondary dirt-rich fractions which are expelled from separate outlets of each secondary cleaner; the improvement which comprises

conveying the secondary dirt-poor stock under air-excluding conditions from the dirt-poor suspension outlet of each secondary cleaner through an individual inlet pipe to the evacuated space within the receiver on the side of the weir opposite that on which primary dirt-poor stock is sprayed, for discharge of secondary dirt-poor stock from an open-ended terminus of each such pipe within the evacuated space as a spray above the level of any liquid that may accumulate therebelow,

withdrawing overflowed primary dirt-poor stock and secondary dirt-poor stock together from the evacuated space, and

conveying secondary dirt-rich stock from the secondary cleaning stage under air-excluding conditions.

19. In a process for cleaning and deaerating paper-making stock in which the stock is classified in cleaner means comprising a primary cleaning stage into primary dirt-poor and primary dirt-rich fractions, the primary dirt-poor stock is sprayed under deaerating conditions into an evacuated receiver and deaerated primary dirt-poor stock is withdrawn from the receiver, the dirt-rich fraction of stock from the primary cleaning stage is classified in cleaner means comprising a secondary cleaning stage into secondary dirt-poor and secondary dirt-rich fractions which are expelled from separate outlets of each secondary cleaner, and the dirt-rich fraction of stock from the secondary cleaning stage is classified in cleaner means comprising a tertiary cleaning stage into tertiary dirt-poor and tertiary dirt-rich fractions which are expelled from separate outlets of each tertiary cleaner; the improvement which comprises

conveying the secondary dirt-poor stock under air-excluding conditions from the dirt-poor suspension outlet of each secondary cleaner through an individual inlet pipe to an enclosed space maintained under vacuum for discharge of secondary dirt-poor stock from an open-ended terminus of each such pipe within the evacuated space as a spray above the level of any liquid that may accumulate within the evacuated space,

conveying the tertiary dirt-poor stock under air-excluding conditions from the dirt-poor suspension outlet of each tertiary cleaner through an individual inlet pipe to an enclosed zone maintained under vacuum for discharge of tertiary dirt-poor stock from an open-ended terminus of each such pipe as a spray above the level of any liquid that may accumulate within said zone,

conveying secondary dirt-poor stock from the enclosed evacuated space under air-excluding conditions,

conveying tertiary dirt-poor stock from said zone under air-excluding conditions, and

conveying tertiary dirt-rich stock from the tertiary cleaning stage under air-excluding conditions.

20. In a process for cleaning and deaerating paper-making stock in which the stock is classified in cleaner means comprising a primary cleaning stage into primary dirt-poor and primary dirt-rich fractions, primary dirt-poor stock is sprayed under deaerating conditions into an evacuated receiver and deaerated primary dirt-poor stock is withdrawn from the receiver, the dirt-rich fraction of stock from the primary cleaning stage is classified in cleaner means comprising a secondary cleaning stage into secondary dirt-poor and secondary dirt-rich fractions which are expelled from separate outlets of each secondary cleaner, and the dirt-rich fraction of stock from the secondary cleaning stage is classified in cleaner means comprising a tertiary cleaning stage into tertiary dirt-poor and tertiary dirt-rich fractions which are expelled from separate outlets of each tertiary cleaner; the improvement which comprises

conveying the secondary dirt-poor stock under air-excluding conditions from the dirt-poor suspension outlet of each secondary cleaner through an individual inlet pipe to an enclosed space maintained under vacuum for discharge of secondary dirt-poor stock from an open-ended terminus of each such pipe within the evacuated space as a spray above the level of any liquid that may accumulate within the evacuated space,

conveying the tertiary dirt-poor stock under air-excluding conditions from the dirt-poor suspension outlet of each tertiary cleaner through an individual inlet pipe to said enclosed space maintained under vacuum into which secondary dirt-poor suspension is discharged, for discharge of tertiary dirt-poor stock from an open-ended terminus of each such pipe as a spray above the level of any liquid that may accumulate within said enclosed space,

conveying secondary and tertiary dirt-poor stock from said enclosed space under air-excluding conditions, and

conveying tertiary dirt-rich stock from the tertiary cleaning stage under air-excluding conditions.

21. Process according to claim 20, in which the secondary dirt-poor stock is segregated from the tertiary dirt-poor stock within the evacuated space.

22. In a process for cleaning and deaerating paper-making stock in which the stock is classified in cleaner means comprising a primary cleaning stage into primary dirt-poor and primary dirt-rich fractions, primary dirt-poor stock is sprayed under deaerating conditions into an evacuated receiver and deaerated primary dirt-poor stock is withdrawn from the receiver, the dirt-rich fraction of stock from the primary cleaning stage is classified in cleaner means comprising a secondary cleaning stage into secondary dirt-poor and secondary dirt-rich fractions

21

which are expelled from separate outlets of each secondary cleaner, and the dirt-rich fraction of stock from the secondary cleaning stage is classified in cleaner means comprising a tertiary cleaning stage into tertiary dirt-poor and tertiary dirt-rich fractions which are expelled from separate outlets of each tertiary cleaner; the improvement which comprises

conveying the secondary dirt-poor stock under air-excluding conditions from the dirt-poor suspension outlet of each secondary cleaner through an individual inlet pipe to said evacuated receiver for discharge of secondary dirt-poor stock from an open-ended terminus of each such pipe within the evacuated space as a spray above the level of any liquid that may accumulate therebelow, while segregating primary dirt-poor stock from secondary dirt-poor stock within the evacuated receiver,

conveying the tertiary dirt-poor stock under air-excluding conditions from the dirt-poor suspension outlet of each tertiary cleaner through an individual inlet pipe to said evacuated receiver for discharge of tertiary dirt-poor stock from an open-ended terminus of each such pipe within the evacuated space as a spray above the level of any liquid that may accumulate therebelow, while segregating primary dirt-poor stock from tertiary dirt-poor stock within the evacuated receiver.

conveying secondary and tertiary dirt-poor stock from said receiver under air-excluding conditions, and

22

conveying tertiary dirt-rich stock from the tertiary cleaning stage under air-excluding conditions.

23. Process according to claim 22, in which primary dirt-poor stock is sprayed into the evacuated space at a rate greater than that at which it is withdrawn therefrom and deaerated primary dirt-poor stock overflows a weir within the enclosed space, secondary and tertiary dirt-poor stock is sprayed into the evacuated space on the side of the weir opposite that on which the primary dirt-poor stock is sprayed into the evacuated space, and overflowed primary dirt-poor stock and secondary and tertiary dirt-poor stock are withdrawn together from the evacuated space.

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FRANK W. LUTTER, *Primary Examiner*.

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