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C. L. CLARK ET AL

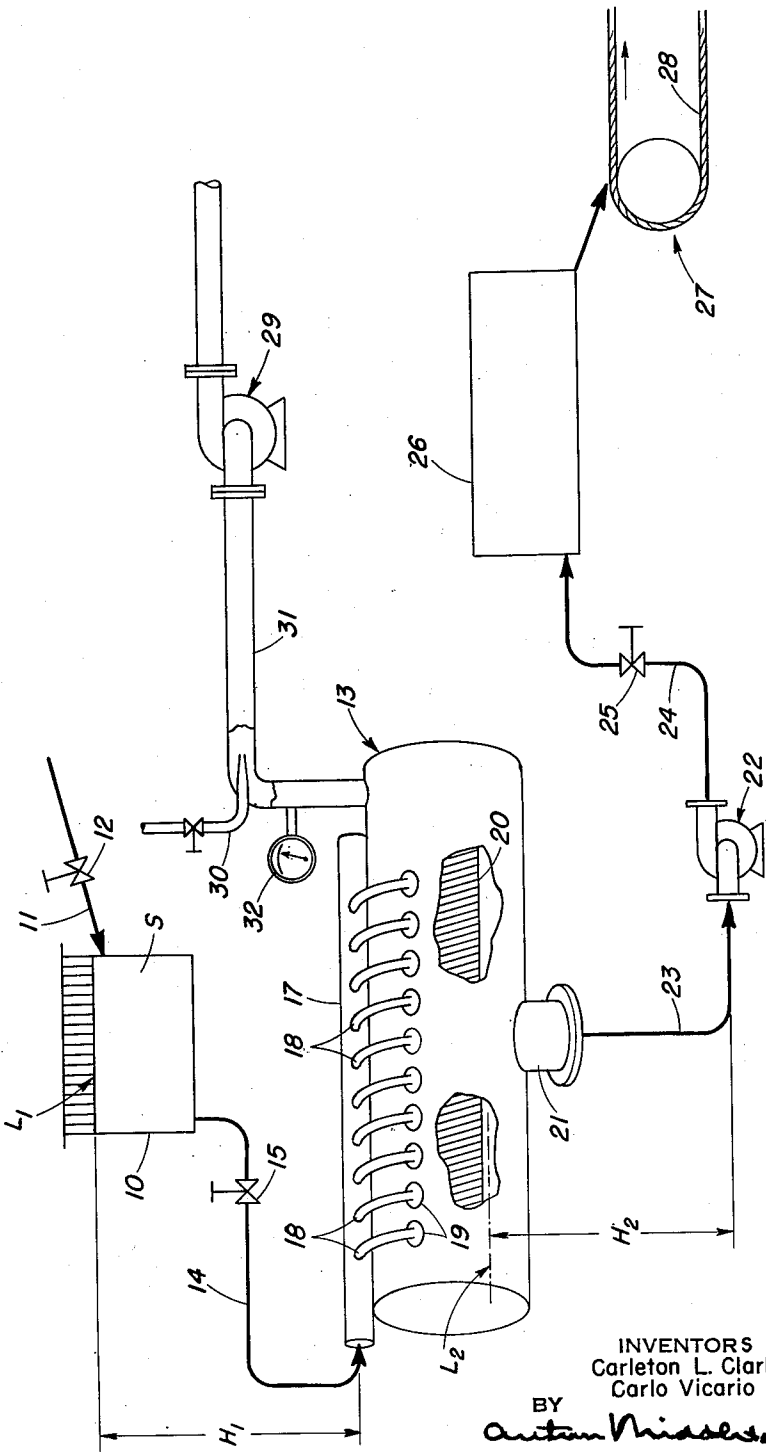
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DEAERATING A SUSPENSION OF PAPERMAKING STOCK

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4 Sheets-Sheet 1

Fig. 1.



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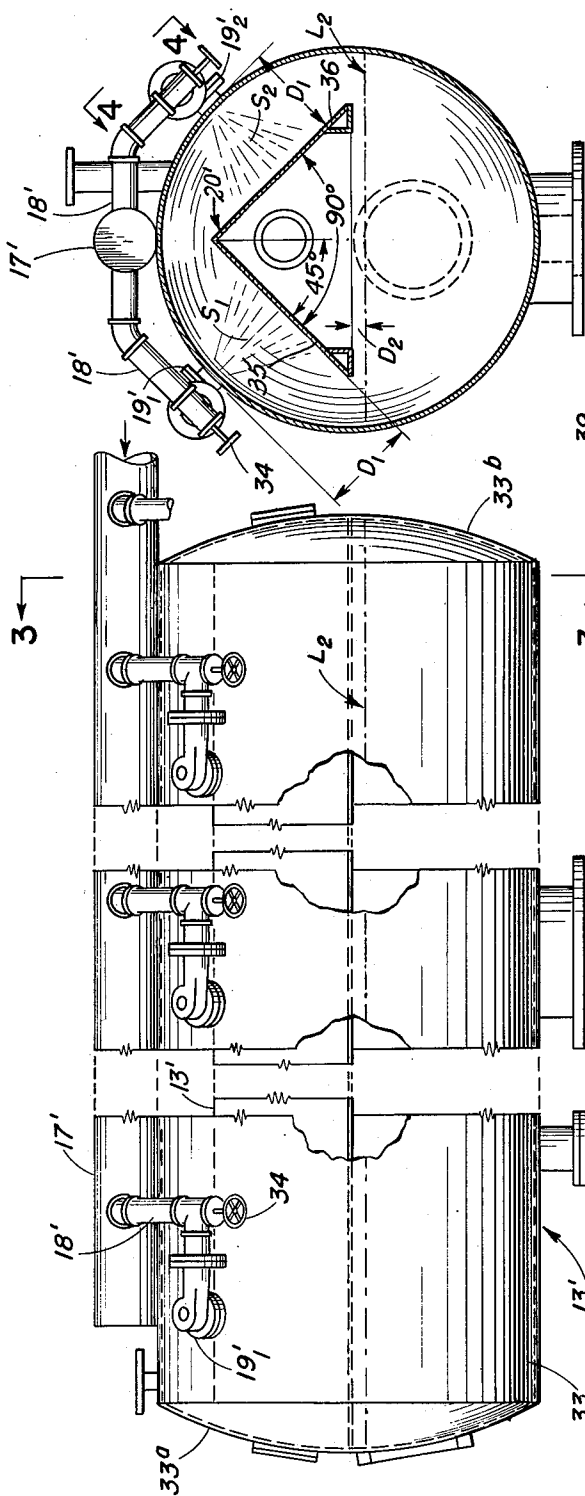


Fig. 2.

Fig. 3.

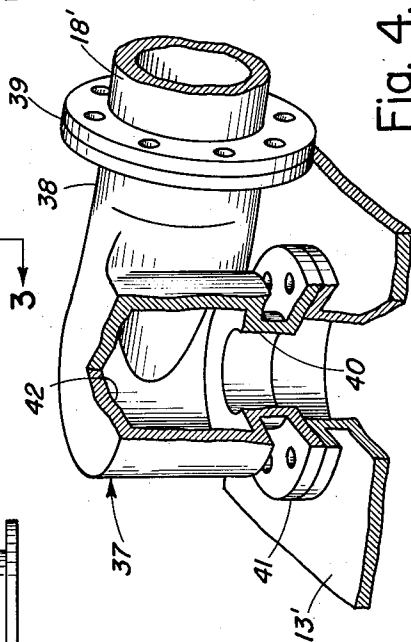


Fig. 4.

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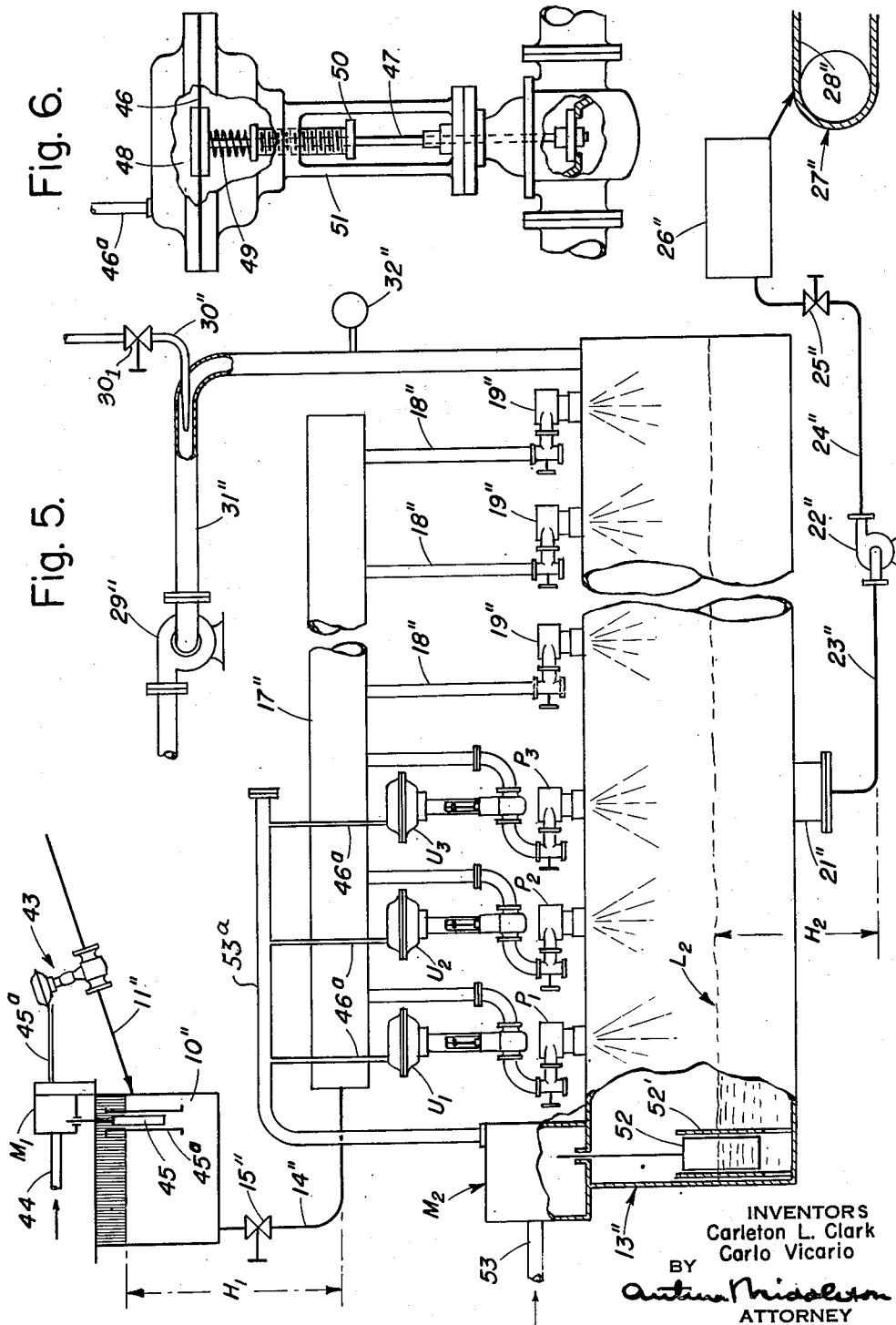
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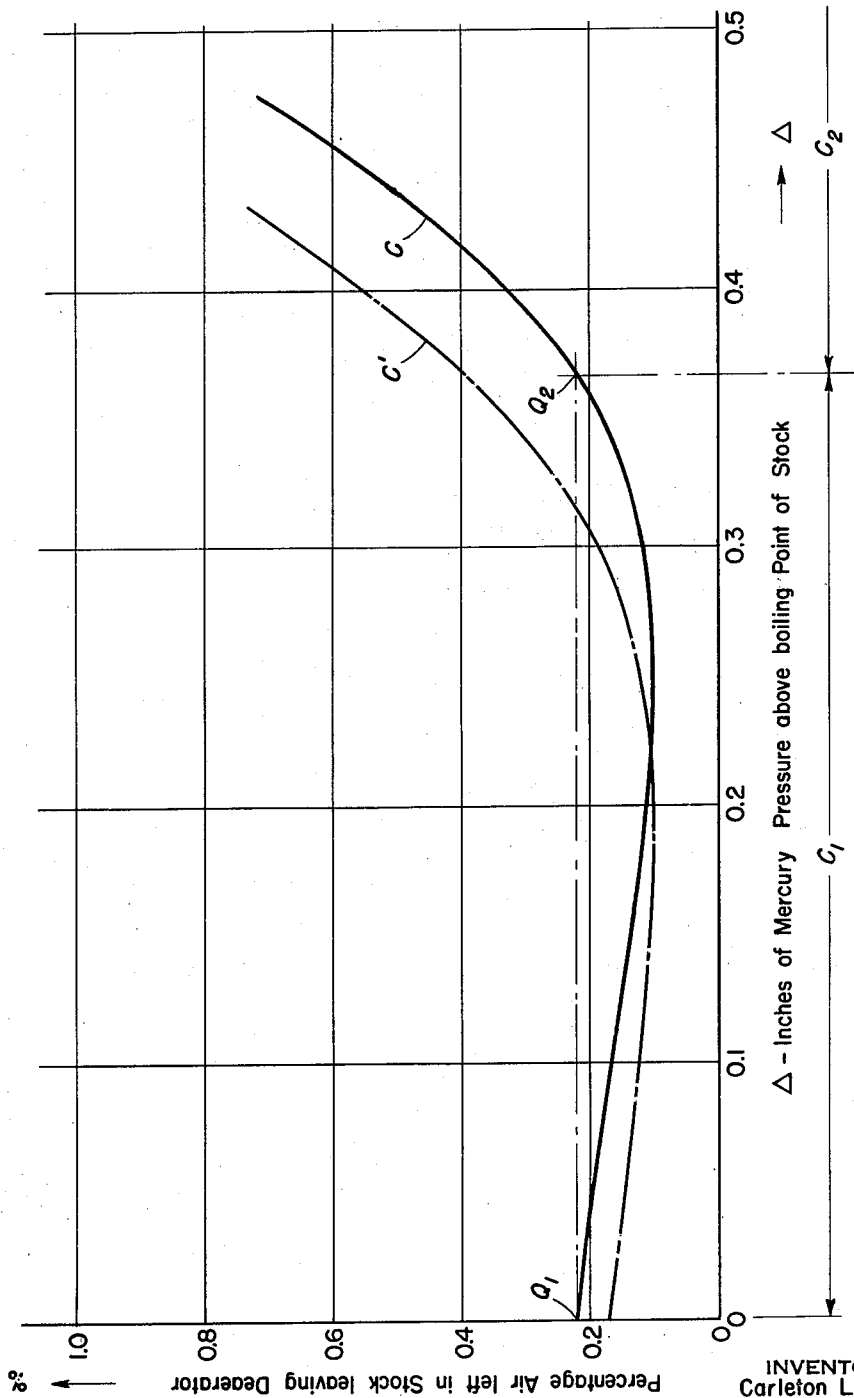


Fig. 7.

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DEAERATING A SUSPENSION OF
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3 Claims. (Cl. 183-114)

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This invention relates to the conditioning of cellulose fibers in water-suspension, for use in paper-making, namely either as pulp issuing from a digester that must be washed and screened, or as stock supplied to a paper-making machine. Both such pulp and such stock are intended to be covered herein, but for illustrative purposes, the invention is being described mainly as applied to dilute stock supplied to a paper-making machine wherein entrained and dissolved air causes objectionable foaming in the head-box or cylinder mold of the paper machine. The elimination of such air is desirable inasmuch as even small quantities of it reaching the paper machine are liable to interfere with the proper fiber dispersion during sheet formation and to produce breaks, flaws, or thin spots in the paper.

So it is one of the objects of this invention to devise a method and apparatus for continuously, rapidly, effectively and uniformly effecting de-aeration of the stock to an extent that the foam nuisance is practically eliminated. Another object is to devise ways and means for treating the stock to improve significantly its drainage rate, that being the characteristic of the stock that readily yields up its diluting water while on the traveling foraminous web or wire screen of the paper machine. Thus by increasing the drainage rate, the traveling screen may be run faster, giving a greater rate of production of paper of given quality; or in view of the increased drainage rate the starting stock may be more dilute than normal thus producing a paper of higher quality due to more homogeneous and uniform fiber distribution. Indeed, it is an object of this invention to make paper faster and of better quality.

This invention is based upon the fact that when stock in dilute suspension is to be de-aerated by the use of reduced pressure or vacuum, the cellulose fibers in their water suspension must be injected into the reduced pressure atmosphere of a vacuum tank as an atomized spray or mist, which descends or settles through the atmosphere of the tank and finally collects in a pool in the bottom of the tank. Due to this fine state of subdivision during such descent, a maximum quantity of surface area of the particles is exposed to the vacuum prior to their collection in the pool in the tank. This action is herein referred to generally as disruption of the stock suspension.

Attainment of at least some of these objects is based upon our discovery that an unexpected

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increase in the rate of de-aeration is realized if the de-aerating vacuum has its degree or value controlled to lie within a narrow critical range. In order to describe that range, it is first necessary to point out that paper-making stock is maintained at an elevated temperature that is established as being appropriate to operations in each particular paper mill. This temperature thus varies with different mills so it must be taken into consideration in defining that critical range of the degree or measure of vacuum to be used, because that degree of vacuum under which the stock suspension will boil at its mill temperature is our beginning point in measuring our critical range of vacuum to be used. This point represents the vapor pressure of the stock to be de-aerated at its established temperature. If the teaching of this invention is followed, there can be removed substantially all of the air from the stock above the 0.1% by volume that is accepted as being unextractable.

More particularly, our discovery is that on the disrupted stock to be de-aerated, there must be maintained as closely as practicable, a vacuum in degree such that the pressure of the vacuum does not exceed 0.3 inch of mercury pressure above the absolute vapor pressure (boiling point) of the supplied stock. As far as practical operation is concerned, deviation from this limit seems to be more critical in an upward direction from the 0.3 value than in a downward direction. This means that it is more critical to deviate away from the vapor pressure than toward that pressure. What has just been stated with regard to this critical range can be visually shown on a graph marked on the ordinate with percentages of air remaining in the stock being de-aerated, and on the abscissa the absolute pressure of the vacuum above the boiling point of the stock at its supplied temperature. The curve on such a graph drawn as a result of tests, presents a low and very shallow or almost horizontal initial portion that merges with a steeply rising portion. The shallow portion comprises a measure of the critical range extending from a beginning point on the ordinate which represents that boiling point. So it is a teaching of this invention that the degree of vacuum to be used on the disrupted stock is indicated by this shallow portion of the curve on such a graph, since that is the range in which can be accomplished maximum de-aeration at the greatest speed.

In the practice of this invention, the stock to be de-aerated is supplied to a constant level chest from whence it flows to a header supplying a plu-

reality of the stock-injecting atomizing nozzles feeding directly into the vacuum tank in which the level of de-aerated stock is kept constant. The vacuum in the tank is adjustably maintained within the critical range of this invention by the joint effect of a steam jet and a vacuum pump. A discharge leg together with a discharge pump removes the de-aerated stock from the pool thereof in the vacuum tank to the head box of the paper machine. An automatic control device maintains constant a desired level of the pool of de-aerated stock in the tank for insuring a constant supply head for the discharge pump so the pump will feed the paper machine at a uniform rate. This control device proposed for the purpose operates in a manner to correct the stock level by throttling automatically, first one and then sequentially others of the spray nozzles or vice versa opening first one and then others.

This invention finds embodiment in a vacuum tank which is in the form of a horizontal drum provided with a double row of stock-injecting atomizing nozzles fed from a header extending longitudinally of the tank. The nozzles discharge into the tank in a downwardly inclined direction and preferably against impingement faces spaced a suitable distance both from the nozzles and from the level of the de-aerated stock in the tank.

The best embodiment of our invention now known to us has been chosen as an example for illustration, but it is to be understood as being illustrative and not limiting because obviously changes can be made therein so long as they do not depart from the requirements of the appended claims or of their equivalents. This embodiment is shown in the accompanying drawings, in which

Fig. 1 shows semi-diagrammatically an apparatus arrangement embodying the invention including the improved vacuum tank for the de-aeration of the stock.

Fig. 2 is an enlarged side view of the vacuum tank showing structural details of the improved vacuum tank including the arrangement of spray nozzles.

Fig. 3 is a cross-sectional view on the line 3—3 of Fig. 2.

Fig. 4 is an enlarged perspective detail view of one of the spray nozzles with wall portions thereof broken away.

Fig. 5 is a diagrammatic view of the apparatus arrangement of Fig. 1 with automatic control means added for maintaining stock levels constant by means of automatically controlled valves.

Fig. 6 is an enlarged although semi-diagrammatic detail view of one of the automatically controlled valves.

Fig. 7 is a graph showing the critical range of high vacuum to be maintained in the vacuum tank in accordance with this invention.

The apparatus arrangement embodying this invention is shown semi-diagrammatically in Fig. 1 and comprises an open supply tank or chest 10 containing suspended stock S currently supplied thereto as is indicated by a connection 11 having a control valve 12. The stock level L_1 in this tank is to be maintained constant at a suitable height by controlling the feed thereto.

From the tank 10, the stock is supplied to a vacuum tank or de-aerator 13 to which stock from chest 10 is supplied gravitationally by conduit 14 through a control valve 15, leading to and into one end of a horizontal header 17 from which in turn lead lateral branch conduits 18 to respective spray nozzles indicated at 19 which are

mounted upon the vacuum tank 13 and through which the stock is injected into the tank. This tank is in the form of a horizontally extending drum while header 17 extends substantially horizontally to the horizontal axis of that drum. The stock being injected into this tank 13 is projected onto an impingement plate 20, hereinafter more fully described for further disrupting the sprayed particles of fiber and water, if they need it.

De-aerated stock collects in a pool thereof below the impingement plate to a certain level L_2 and is withdrawn from the tank bottom through a sump 21 by means of a pump 22. A conduit 23 leads from the sump 21 to the inlet end of the pump, while a conduit 24 provided with a control valve 25 leads to the head box 26 of a paper-making machine 27 indicated by its endless screen band 28.

The level L_1 of the stock in the supply chest 10 is defined by the height H_1 relative to the header 17, while the level L_2 in the vacuum tank is defined by the height H_2 above the inlet end of pump 22. The levels L_1 and L_2 both are to be maintained substantially constant through automatic level control devices hereinafter more fully described in conjunction with Figs. 5 and 6. Such level control devices, however, are well-known and are commercially available.

The degree of vacuum required according to this invention is maintained in the tank as by means of a vacuum pump 29 shown to operate jointly with and to be boosted by a steam jet 30, both the pump and the jet operating in series in an exhaust conduit 31. A vacuum gauge 32 is shown for indicating the degree of reduced pressure thus maintained in tank 13 in terms of inches of mercury.

The de-aerating vacuum tank and its immediate appurtenances, especially the atomizing spray nozzles with their supply conduits, and the impingement structure within the tank are shown in greater detail in Figs. 2, 3, and 4. In these figures the horizontally extending drum-like tank designated as 13' has a horizontally extending cylindrical body portion 33 and outwardly convex end portions 33^a and 33^b. The horizontally extending feed header for the tank is indicated as 17' and its branch conduits as 18'. Especially Fig. 3 shows that there are provided two rows of branch conduits extending from the header in opposite directions to supply accordingly two rows of spray nozzles 19₁' and 19₂'. Each of the branch conduits 18' has a control valve 34 for controlling or throttling the supply of stock to the respective spray nozzles.

The impingement plates extending horizontally within the tank 13' is designated as 20' which is in the nature of a hollow ridge having a cross-section resembling an inverted V. This structure presents a pair of outer inclined plates or faces 35 and 36 extending under about 45° against the vertical or at about 90° with respect to each other, upon which faces impinge sprays S_1 and S_2 of the stock injected into the tank by the correspondingly disposed rows of nozzles 19₁' and 19₂'. The distance of the nozzles from these impingement faces is designated as D_1 , while the distance of the lower horizontal edges of these faces from the stock level L_2 is designated as D_2 .

The structure of the atomizing spray nozzle is exemplified in the nozzle unit 37 shown perspective in Fig. 4 with wall portions thereof broken away to show particularly the internally unobstructed nature thereof. This nozzle unit has an inlet neck 38 having a flange connection 39

with a respective branch conduit 18', and an outlet neck 40' having a flange connection 41' with the tank. The inlet neck 38' leads tangentially into a body portion which represents an internally unobstructed swirl-chamber 42', whereas the outlet neck 40' leads off from the center of the swirl-chamber and in a direction at right angles to the direction of the inlet neck.

Fig. 5 represents in principle the same apparatus arrangement that is shown in Fig. 1, although more diagrammatic, and with emphasis being placed upon the addition of devices for controlling the stock levels L_1 and L_2 . That is to say, there is indicated a stock supply 11'', a stock chest or tank 10'', a header 17'', supplied from tank 10'' through a conduit 14'', and a control valve 15''. The header supplies a vacuum tank 13'' through branch conduits 18'' and nozzles 19''. From this vacuum tank the de-aerated stock is withdrawn by way of a sump 21'' through a conduit 23'' leading to a pump 22'' whence a conduit 24'' through a valve 25'' delivers the stock to a head box 26'' of a paper-making machine 27'' indicated by its endless screen band 28''. The horizontally extending impingement structure although indicated in Fig. 1 and shown in Figs. 2 and 3, has not been shown in Fig. 5.

In Fig. 5 there is included the showing of a diaphragm-actuated valve unit 43' controlled by fluctuations of the level L_1 and through auxiliary air pressure, to regulate the supply of stock to the tank 10'' for automatically maintaining the level L_1 therein constant. There is indicated relay mechanism M_1 which is supplied with auxiliary air 44' at a constant pressure and has operative connection with a float 45' having a vertical guide 45^a. The movements of this float through mechanism M_1 control air pressure admitted through pipe 45^a to the diaphragm chamber of the valve unit 43' and thereby actuate the valve in a manner to compensate for fluctuation of the level L_1 . Such level control devices need not be described in any greater detail, inasmuch as they are well-known per se and commercially obtainable.

In order to effect the automatic control of level L_2 of the pool of de-aerated fibers and de-aerated water in the vacuum tank 13'' one or more of the spray nozzles are each provided with an automatically controlled valve unit similar to that provided for the tank 10'' and shown more fully in Fig. 6. In this instance three such valve units U_1 , U_2 , and U_3 are provided for respective spray nozzles P_1 , P_2 , and P_3 to throttle them individually while all other nozzles may be allowed to operate unchanged at their full capacity. Such diaphragm-controlled valve units are well-known and commercially obtainable and the valve unit exemplified in Fig. 6 is therefore substantially self-explanatory. In such a valve unit a diaphragm 46' is connected to a valve stem 47', and controlled air pressure 46^a is admitted to a diaphragm chamber 48' and will actuate the valve stem to open or close the valve through the deflection of this diaphragm. The air pressure above the diaphragm is opposed by the pressure of a compression coil spring 49' herein termed the diaphragm spring which surrounds the valve stem and is confined between the diaphragm and a bushing 50' which in turn is threaded into the frame or yoke 51' of the valve unit. By screwing this bushing up or down the pressure of the spring upon the underside of the diaphragm can be adjusted, so that the response of the valve unit is thereby adjusted to meet the level control requirements.

As applied to the apparatus embodying this invention, each of the valve units U_1 , U_2 , and U_3 has its diaphragm spring adjusted so that these valve units will respond sequentially to respectively stepped-up auxiliary air pressures to meet the demand as dictated by the up or down movements of a float 52' with the fluctuations of the pulp level L_2 . That is, the movements of the float 52' having a vertical guide 52' influence a relay mechanism indicated at M_2 which receives auxiliary air 53' at a constant pressure. The mechanism then acts to admit consecutively higher actuating air pressures through a header 53^a and branch conduits 46^a to the diaphragm chambers of the respective valve units U_1 , U_2 , and U_3 so that they will function sequentially.

For instance, if the demand requires throttling down the supply of stock passing to the vacuum tank within narrow limits when all three nozzles P_1 , P_2 , and P_3 are running at full capacity, then as a result of movements of the float only the first valve unit U_1 will respond within the range of its own capacity. If the demand for maintaining a constant level L_2 requires a further reduction of stock supply after the first valve unit U_1 has fully closed, then the second valve unit U_2 will begin to close in response to the movements or position of the float, and so on. Vice versa, if all three valve units U_1 , U_2 , and U_3 should be assumed to have been closed, and the demand is for increased stock supply, then the valves will sequentially open in accordance with that demand. In this way, a maximum number of spray nozzles is always kept running at their full capacity and therefore at maximum efficiency, that is with a maximum force of impingement upon the impingement faces 35 and 36.

The desired vacuum is maintained in the tank 13'' by a vacuum pump 29'' operating jointly with or boosted by a steam jet 30'' having a control valve 30¹'' in an exhaust conduit 31'' and is indicated by a vacuum pressure gauge 32''. By means of the vacuum pump and the steam jet there is jointly maintained in the tank 13 or 13'' a vacuum which according to the requirements of this invention should be maintained (as closely as practicable) at 0.3 inch of mercury pressure above the vapor pressure corresponding to the temperature of the supplied stock, the reasons for this limitation being presented by the graph in Fig. 7. That graph shows a concave curve C taken under stock de-aerating conditions with the stock being injected and projected into the vacuum tank against the impingement faces therein. This curve has a shallow initial portion C_1 extending substantially from point Q_1 to point Q_2 of that curve, and a steep portion C_2 extending from point Q_2 , points Q_1 and Q_2 being points upon a parallel to the abscissa.

By maintaining the vacuum substantially within a range of pressures corresponding to the range C_1 or shallow portion of the curve a surprisingly high degree of de-aeration of the stock is attainable at a rapid rate and with a minimum of volumetric space required for the vacuum tank.

A dot-and-dash line curve C' also shown in the Fig. 7 graph shows similar or only slightly deviating conditions as a result of plotting these conditions when no impingement plate was used.

Naturally, the higher the established temperature of the stock to be de-aerated, the less vacuum in terms of total absolute pressure is needed to reach the critical range thereof and vice versa. Actual boiling of the stock will produce some refrigerating effect which is to be minimized.

Referring to Fig. 5, the operation is as follows:

Stock from tank 10" flows to the header 17" under a head H₁, maintained by the level-control device M₁. The header distributes the stock to the various spray nozzles 19" as well as to spray nozzles P₁, P₂, P₃. The supply of stock to nozzles 19" is set for their maximum capacity and maximum stock disrupting efficiency, while nozzles P₁, P₂, P₃ are automatically controlled in sequential order by the level control device M₂ so as to maintain the level L₂ of de-aerated stock constant. The automatic control of nozzles P₁, P₂, P₃ by the device M₂ and valves U₁, U₂, U₃ is such that as many of these nozzles as possible operate at their full capacity, while only one of them is being correctively regulated. For example, if a condition exists where all nozzles P₁, P₂, P₃ run at their full capacity, and a rise of level L₂ requires throttling down the stock supply to the tank, then the control device will automatically effect such throttling, say, upon nozzle P₁. If the degree of throttling required exceeds the corrective capacity of nozzle P₁, then the control device will automatically start throttling down the stock supply to nozzle P₂, and then similarly the supply to nozzle P₃.

Vice versa, if a condition exists where the supply to all nozzles P₁, P₂, P₃ is closed, then if a dropping of level L₂ requires correction, the control device M₁ through valves U₁, U₂, U₃ will sequentially open up the supply to these nozzles depending upon the amount of correction required.

Thus the de-aerated stock which continuously collects in a pool in the tank, is delivered under a head H₂ to pump 22" which in turn delivers it to head box 26" of paper machine 27".

All the while the vacuum in tank 13" is being maintained as by the joint suction effect of pump 29" and ejector 30" at a value corresponding to a pressure of about 0.3 inches of mercury (indicated by gauge 32") above the absolute vapor pressure of the stock at the established temperature, in order to attain a maximum of de-aeration at a maximum speed.

Such treatment gives the de-aerated stock a "frozen" appearance in which a thin layer of water covers the entire surface of the stock in the head box without any bubbles appearing. This results in a distinct grouping of the fibers, which when dispersed give a uniform de-flocked dispersion and thus an extremely good formation on the paper machine.

Whereas in the foregoing, reference has been made to ways and means for treating paper-making fibers in dilute suspension, called stock in the foregoing description, this invention is also applicable to such fibers that are used earlier in the paper-making process, namely when they are called pulp after issuance from a digester. Such pulp requires washing and screening. Such pulp can be de-aerated to advantage by the use of this invention since effective de-aeration improves the drainage rate of the pulp which in turn increases the capacity of the screen or washer.

Whereas in the foregoing, dilute paper-making stock has been described as the material to be treated for de-aeration thereof, it is to be understood that by the word "dilute" is meant liquid-suspended solids in any proportion that is fluid enough to be pumpable, and the paper-making stock can comprise any liquid-suspended solids that are used in the making of paper, the de-aeration of which solids by this invention, is advantageous.

What we claim is:

1. The process of treating paper-making solids in suspension to effect de-aeration thereof, which comprises subjecting such suspension while at an established temperature to a degree of vacuum that lies within a range indicated on a curve on a graph representing on the ordinate the proportions of air left in the suspension after de-aeration and on the abscissa the pressure above the absolute pressure of the boiling point of the suspension at said temperature, which curve exhibits an initial shallow portion merging into a steeply ascending portion whereon the range is indicated by the shallow portion that extends from a beginning point corresponding to the boiling point of the suspension at said temperature, whereupon maximum de-aeration will be accomplished.

2. The process of treating paper-making solids in suspension to effect de-aeration thereof, which comprises subjecting such suspension while at an established temperature to a degree of vacuum that lies in a critical range extending from the absolute pressure corresponding to the boiling point to an absolute pressure of about 0.3 inch of mercury above that point.

3. The process of treating paper-making solids in suspension to effect de-aeration thereof, which comprises subjecting such suspension while at an established temperature to a degree of vacuum maintained to correspond substantially to an absolute pressure of 0.3 inch of mercury above the boiling point of the suspension at that temperature.

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