

Oct. 16, 1962

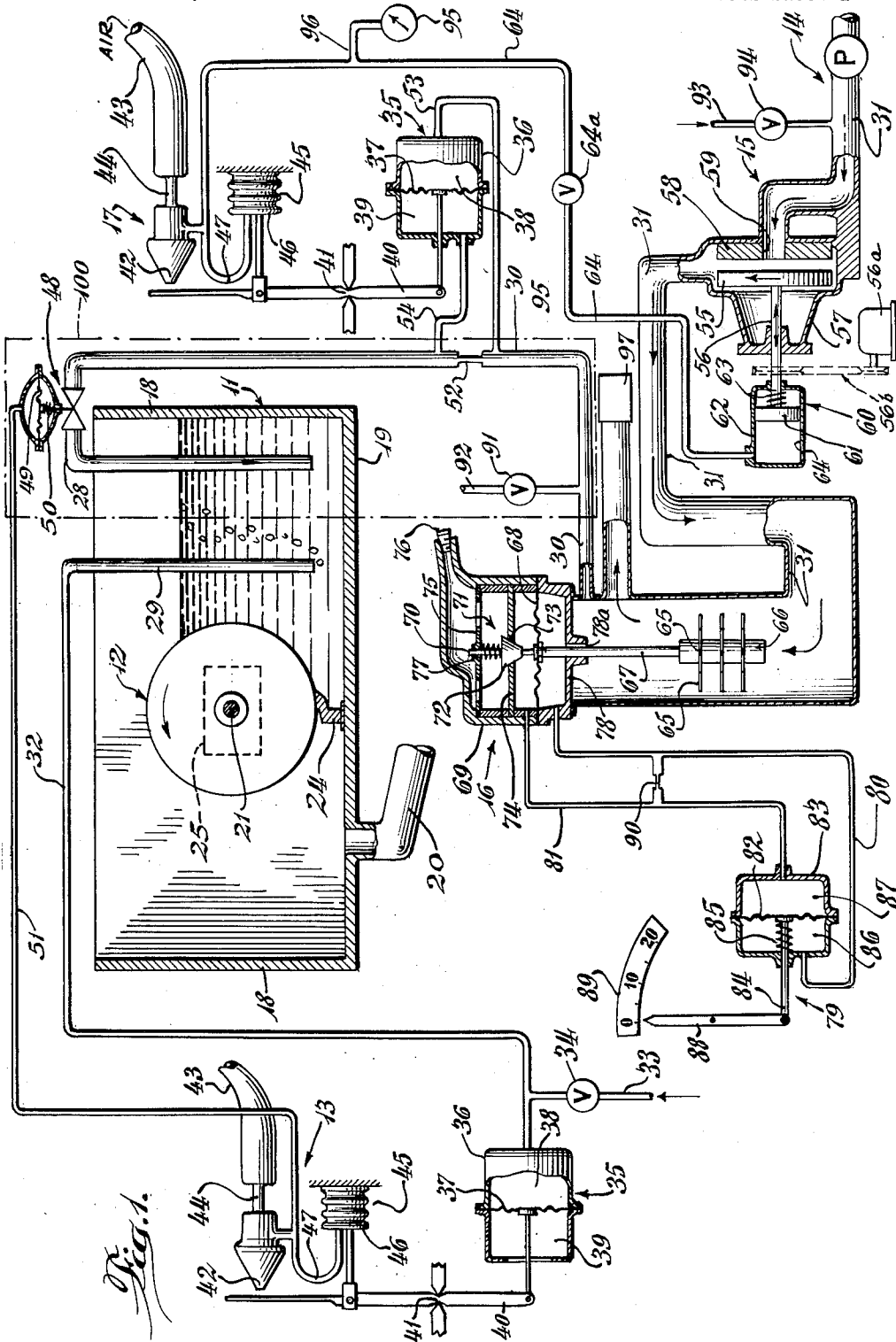
L. W. ZABEL

3,058,672

PAPERMAKING MACHINE

Filed Oct. 19, 1959

3 Sheets-Sheet 1



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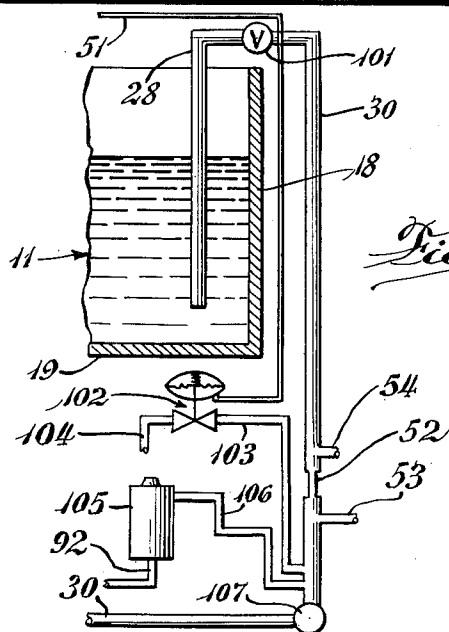
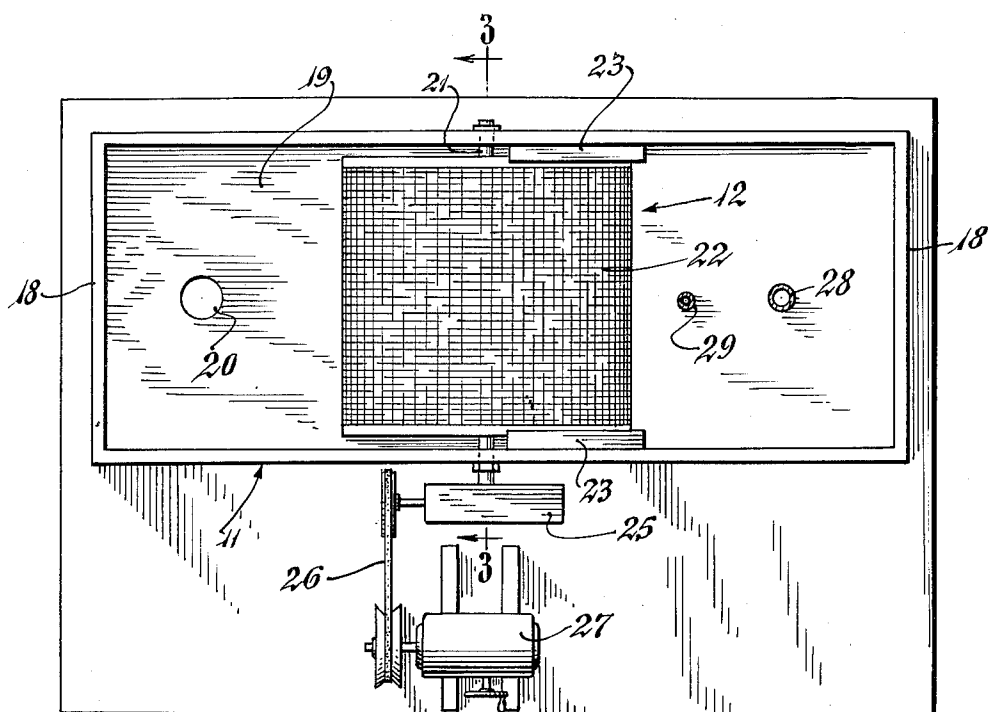
L. W. ZABEL  
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3 Sheets-Sheet 2

*Fig. 2.*



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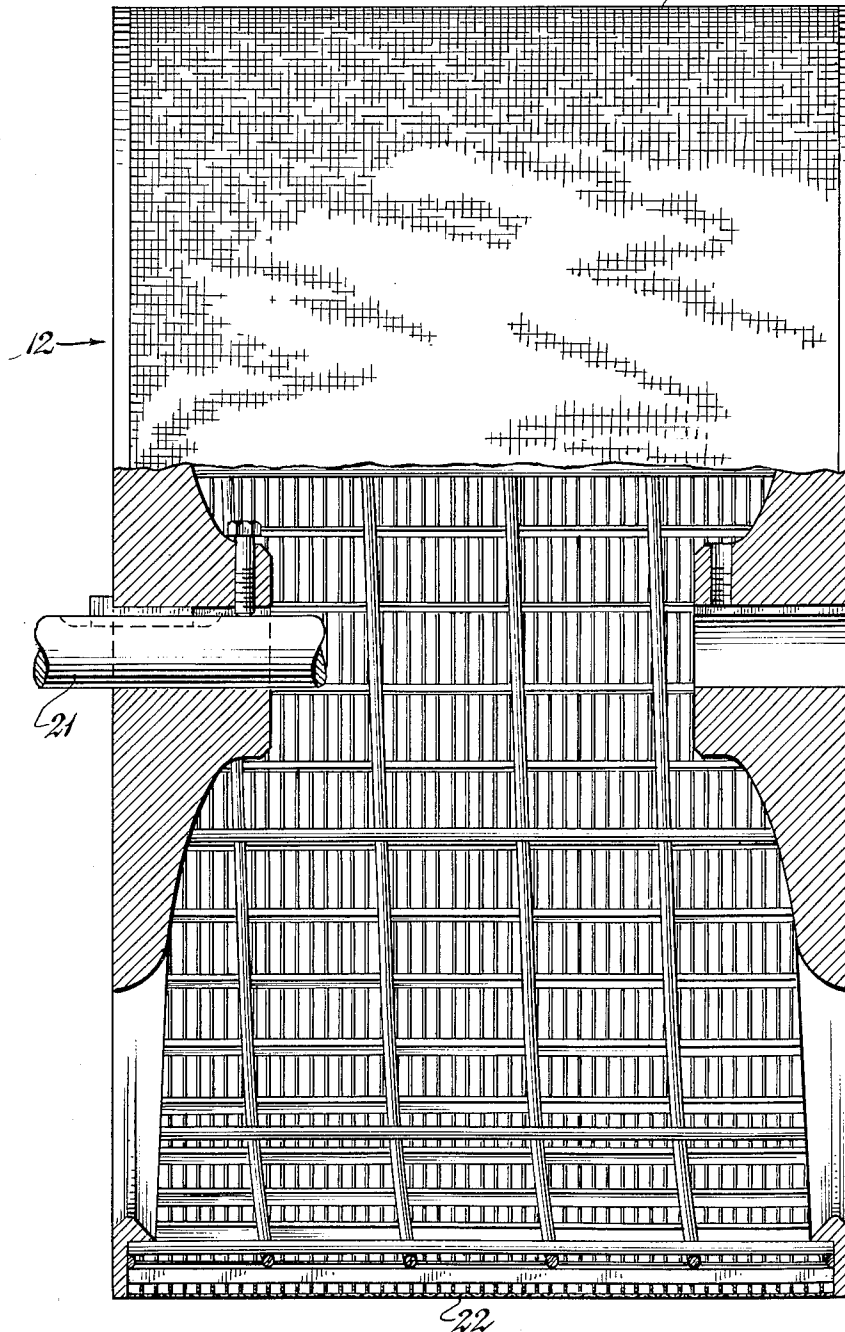
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*Fig. 3.*

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## PAPERMAKING MACHINE

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19 Claims. (Cl. 241—37)

My invention relates to papermaking machines and more particularly to instruments for analyzing paper stock. Still more particularly, the invention relates to instrumentalities for measuring the so-called "freeness" of paper stock and for controlling the "freeness" of stock that is supplied to a papermaking machine.

"Freeness" and "consistency" are two distinct, but interrelated, important factors in the quality of paper stock supplied to paper machines. Consistency is synonymous with density and means the percentage by weight of air-dry pulp in any combination of stock and water. Consistency is regulated by changing the amount of water in the stock, and this may be done either manually or automatically.

Freeness is a measure of the drainage of water from the stock, as it would actually take place on a paper machine, and designates the rate at which water drains through and from a suspension of pulp and water when a wire or perforated plate is used as a strainer. A relatively free stock is usually composed of coarse, relatively long, fibers while a relatively slow stock consists of short, fine, well fibrillated fibers. Relatively slow stock has the quality of tending to form a dense mat from which water drains slowly, while the water from relatively free stock drains from it relatively fast. The degree of freeness of stock may thus be determined by the rate of water drainage from it, and in order that measurement of the freeness only is indicated, exclusive of consistency and other variable factors, it is essential that variations of the latter factors be eliminated or else taken into account.

The testing of the freeness of stock supplied to a paper machine is generally done on a sampling basis. A tester for testing a sample may be of the so called Canadian Standard type consisting essentially of two main parts, a container and a funnel. The container has a wire bottom on which pulp collects as soon as drainage starts, forming a mat, which contains pulp in proportion to the amount of drainage that has taken place. The flow of water through the wire, which at first is rapid, is slowed down by resistance of the pulp mat. The water strained through the pulp mat passes into the funnel which has two outlets, a first one on the bottom of the funnel, and the second one slightly above the bottom. The outlet at the bottom is not large enough to pass a large volume of water under a low head; consequently, there is an overflow through the second outlet which is caught by a graduate; and the overflow is a measure of the relative freeness of the stock, a free stock causing a large overflow and a slow stock a smaller one.

Although such a freeness tester is quite consistent and accurate, nevertheless, obtaining readings of freeness on a sampling basis obviously has limited usefulness; and it is accordingly an object of the present invention to provide an improved freeness or drainage rate tester which is of a continuous type, continuously providing an accurate reading of freeness of stock being supplied to a paper machine. It is also an object of the invention to provide mechanism for changing the freeness of stock being supplied to a paper machine suitably connected to such a freeness tester, so that the freeness is automatically and continuously maintained at a constant value.

In a preferred form, the invention may comprise a tank to which paper stock is supplied through a conduit. A rotatable drum is disposed in the tank, sealed with

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respect to the bottom and sides of the tank, and the stock in the tank is maintained at a level below the drum. The outer surface of the drum is composed of screen similar to that used on a Fourdrinier paper machine; and, as the drum rotates, the stock tends to flow through the perforate surface of the drum. At the lower side of the drum, the stock flows quite rapidly through the drum; but, on portions of the drum closer to the upper surface of the stock in the tank, the paper fibers mat on the drum, so that less water from the stock passes through the drum. The drum thus acts similarly to a Fourdrinier wire in a paper machine, at first allowing the water to drain quite rapidly from the web and subsequently reducing the drainage as the stock fibers mat to a greater extent. The rate at which the stock flows into the tank is thus a measure of the freeness of the stock.

The invention consists of the novel constructions, arrangements and devices to be hereinafter described and claimed for carrying out the above stated objects, and such other objects, as will be apparent from the following description of preferred forms of the invention, illustrated with reference to the accompanying drawings, wherein:

FIG. 1 is an elevational sectional view of the tank and drum of a freeness tester, according to the principles of the invention, together with a diagrammatic illustration of control elements for measuring and controlling freeness or drainage rate of paper stock;

FIG. 2 is a top view of the drum and tank taken on an enlarged scale;

FIG. 3 is a sectional view taken on line 3—3 of FIG. 2; and

FIG. 4 is a partial schematic illustration of a control system for measuring and controlling freeness, according to the invention, which may be substituted for a part of the FIG. 1 diagram.

Like characters of reference designate like parts in the several views.

Referring now to FIGS. 1, 2 and 3, the illustrated continuous freeness or drainage rate measuring and control system may be seen to comprise, in general, a tank 11, a rotatable drum 12 within the tank, a flow level control system 13, a stock supply 14, a stock refiner 15, a stock consistency measuring device 16, and a refiner control system 17.

The tank 11 comprises sides 18 and a bottom 19 having a stock outlet 20 which drains into a stock supply container (not shown) from which the stock supply 14 is provided with stock. The drum 12 is provided with end shafts 21 by means of which the drum is rotatably mounted between opposite sides 18 of the tank, and the outer surface of the drum is formed of a screen 22, which is that type generally used as a Fourdrinier wire in a papermaking machine. Such a screen may be of 50 x 60 mesh or 70 x 80 mesh, for example, in which 50, 60, 70 and 80 wires respectively are provided to the inch. The diameters of these wires are such that generally there is about 40 percent open area in the wire, although it will be understood that this can be quite variable. The openings through such a wire then have an area on the order of .00013 square inch. The diameter of the drum 12 is not critical. In an actual embodiment of the invention, the drum had a diameter of 2 feet; but it may be either larger or smaller.

Shields 23 are provided between opposite tank sides 18 and the ends of the drum, and a shield 24 is provided between the bottom 19 and the lower surface of the drum 12 for the purpose of preventing any flow of stock around the sides and underneath the drum. The drum is rotated by any suitable driving mechanism, such as a gear box 25 driven through a belt 26 from a motor 27.

A stock supply conduit 28 extends down into the tank

11, and a bubbler tube 29 also extends into the tank between the conduit 28 and the drum 12. The conduit 28 is connected by means of conduits 30 and 31 to the paper stock supply 14. The bubbler tube 29 is connected by means of a pipe 32 to an air pressure conduit 33 having a valve 34 therein.

The flow level control system 13 comprises a differential pressure responsive motor 35. The motor 35 is formed by a housing 36 having a flexible diaphragm 37 fixed therein so as to extend between opposite sides of the housing and define cavities 38 and 39. The cavity 38 is connected to the conduit 32, and the cavity 39 is connected to atmosphere. A control arm 40 is pivoted at 41 and is connected by any suitable connecting mechanism at one end of the arm to the diaphragm 37 substantially at the center of the diaphragm. The upper end of the arm 40 is in close proximity to a jet or nozzle 42 provided in an end of a conduit 43 connected to a source of air under pressure. The conduit 43 is provided with a restriction 44 therein. An expansive bellows 45 has one of its ends 46 connected to the arm 40 above the pivot 41, and the other end of the bellows 45 is held fixed. The bellows 45 is connected by means of a conduit 47 to the conduit 43 at a point between the restriction 44 and the jet 42.

An air pressure actuated control valve 48 is provided between the conduits 30 and 28 for metering stock supplied into the tank 11 in accordance with the air pressure applied on to the valve 48. The valve comprises a diaphragm 49 and a compression spring 50 which tends to move the diaphragm in such manner as to open the valve 48. The valve 48 is connected by means of an air pressure conduit 51 with the conduit 47.

The refiner control system 17 is, in some respects, similar to the flow level control system 13 and includes the same parts 35 to 47. A restriction 52 is provided in the conduit 30, and the cavities 38 and 39 of the motor 35 are respectively connected by means of conduits 53 and 54 to the conduit 30 on opposite sides of the restriction 52.

The refiner 15 comprises a rotatable disc 55 fixed on a drive shaft 56 which is rotatably mounted in a fixed part 57. The plate 55 is positioned opposite a fixed disc 58 having a central opening 59 therein. The refiner 15 is effectively positioned in the conduit 31 with the part of the conduit 31 connected to the stock supply 14 connected also to the central opening 59, and the refiner is connected with the remainder of the conduit 31 so that stock flows between the plates 55 and 58 into the latter part of the conduit 31.

A motor 60 is provided for applying axial force on the rotatable plate 55. The motor 60 comprises a piston 61 slidably disposed in a cylinder 62, and a spring 63 is positioned between the piston 61 and an end of the cylinder. A conduit 64 connects the other end of the cylinder with the conduit 47 of the refiner control system 17. The shaft 56 and thereby the plate 55 are rotatably driven by any suitable driving mechanism such as a motor 56a and a pulley and belt arrangement 56b.

The consistency measuring device 16 includes a so called "war club" comprising a plurality of outwardly extending shafts 65 fixed in an enlarged part 66 of a rod 67. The rod suspends the war club in a portion of the conduit 31 with the ends of the shafts 65 being in close proximity to the sides of the conduit 31. The shaft 67 is fixed in any suitable manner to the center of a diaphragm 68 that is fixed at its outer periphery to the sides of a housing 69. A plunger 70 of a valve 71 rests on the upper end of the rod 67 and has an enlarged conical portion 72 adapted to cooperate and seal with a conical opening 73 provided in a plate portion 74 fixed within the housing 69. The plunger 70 extends through a perforated housing portion 75, and the housing 69 is connected to a conduit 76 having water under pressure therein, the arrangement being such that water under pressure

may pass through the housing portion 75 and through the valve 71. A spring 77 is provided between the housing portion 75 and the enlarged conical portion 72 for urging the latter in a valve closing direction. The housing 69 includes a partition 78 between the diaphragm 68 and the conduit 31; and the shaft 67 extends through the partition, the partition being formed with a fluid conducting opening 78a therethrough along the rod as shown.

A meter 79 is connected to the housing 69 by means of conduits 80 and 81. The meter 79 comprises a diaphragm 82 fixed at its periphery within a housing 83. A rod 84 is fixed to the center of the diaphragm, and a spring 85 is provided between the diaphragm 82 and an end of the housing 83. The diaphragm 82 divides the housing 83 into cavities 86 and 87 which are respectively connected to the conduits 80 and 81. The shaft 84 is connected to an indicator needle 88 pivoted at approximately its center, and a scale 89 is provided to register the positions of the pointed end of the needle. A restricted conduit 90 is provided connecting the conduits 80 and 81. For additional details of the consistency measuring device 16, the copending application of Fred D. Perkins, Serial No. 826,352, filed June 10, 1959, may be referred to.

A consistency reducing valve 91 is provided in a water supply conduit 92 connected to the conduit 30. A water supply conduit 93 is connected to the conduit 31 between the refiner 15 and the stock supply 14, and a valve 94 is provided in the conduit 93.

A meter 95 may be connected by means of a branch conduit 96 to the conduit 64 for measuring changes in stock freeness when the refiner is fixed in its refining action. In this case, the conduit 64 is closed between the conduit 96 and the motor 60 as by means of a valve 64a in the conduit 64, so that the motor 60 is inoperable.

The conduit 31 beyond the consistency measuring device 16 is connected to a conventional Fourdrinier type paper machine shown diagrammatically at 97.

The modified control system partially illustrated in FIG. 4 is the same as that illustrated in FIG. 1 with the exception that the portion of the FIG. 1 system in a dotted line enclosure 100 has been replaced by the portion of the system illustrated in FIG. 4.

In the modified control system, the pressure actuated valve 48 has been replaced by a manually operated valve 101 between the conduits 30 and 28. An air pressure operated valve 102, which is similar to the valve 48 except that air pressure opens the valve rather than closes it, is connected to the air pressure conduit 51. The valve 102 is adapted to open and close communication between a conduit 103, connected to the conduit 30 adjacent the conduit 53, and a conduit 104 arranged to discharge into the stock supply container (not shown) connected to the stock supply 14.

A constant flow regulator 105 is connected to the water supply conduit 92 and is connected by means of a conduit 106 with the conduit 30 at a point adjacent to the point of connection of the conduit 103 with the conduit 30. The flow regulator 105 may be of any suitable type and is preferably adjustable so as to provide a constant flow output through the conduit 106, such as of 15 gallons per minute, for example.

A pump 107 is provided in the conduit 30 between its point of connection with the conduit 31 and the points of connection with the conduits 103 and 106. This pump may be of any constant displacement type, that is, one that provides a constant output with the pump impeller being driven at a constant speed; in particular, it may, for example, be one having a rubber bladed impeller for providing the constant output. The pump may be of such capacity as to discharge at a constant output of 5 gallons per minute, for example.

In operation, paper stock is supplied from the stock supply 14 to the paper machine 97, flowing through the refiner 15 and the conduit 31. The disc 55 of the refiner

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is rotatably driven by a suitable motor (not shown) in close proximity to the fixed disc 58, and the stock in flowing through the refiner passes between the discs 55 and 58 and from thence into the after part of the conduit 31. The stock in travelling between the discs 55 and 58 is rubbed and brushed en route, and the refiner performs two functions, namely fiber separation and work on individual fibers. Depending on the distance the rotatable disc 55 is moved toward the fixed disc 58, the brushing and fraying action on the fibers is increased, so as to thereby decrease the freeness of the stock passing through the subsequent portion of the conduit 31.

A small portion of the paper stock flowing through the conduit 31 passes into the conduit 30, which acts as a sampling conduit. The stock in the conduit 30 passes through the restriction 52 and the valve 48 into the conduit 28 and into the tank 11 to form a pond of stock in the tank. The drum 12 is rotated by the motor 27 which drives the drum by means of the gear box 25 and the belt 26. The drive mechanism for the drum is so arranged that the drum is driven at quite a slow speed, such as from 3 to  $7\frac{1}{2}$  r.p.m. With a drum having a diameter of two feet as before mentioned, the peripheral speeds of the drum would thus be between 18.84 and 47.10 feet per minute.

The stock within the tank is maintained at a predetermined level, such as that level shown in FIG. 1, about three-fourths of the way to the top of the drum 12. The flow level control system 13 functions to accomplish this result.

Compressed air is supplied to the bubbler tube 29 from the air supply conduit 33, through the valve 34 and the pipe 32. The air pressure within the pipe 32 is applied on to the diaphragm 37 of the motor 35 in the system 13, inasmuch as the pipe 32 is connected to the cavity 38 in this motor 35.

The conduit 43 is connected to a source of air under pressure, and air discharges through the restriction 44 and the nozzle 42. If the stock level within the tank 18 falls, the air pressure within the pipe 32 and applied to the right side of the diaphragm 38 of the motor 35 in the system 13 decreases, and the arm 40 moves counter-clockwise about its pivot 41 due to the atmospheric pressure applied to the left side of the diaphragm 37 and the air jet from the nozzle 42 effective on the arm 40. The nozzle 42 is thus opened, so that there is a greater air pressure drop across the restriction 44 with a consequent reduction in air pressure in the conduits 47 and 51. The air pressure in the pipe 51 is applied to one side of the diaphragm 49 of the valve 48 and when it is so reduced, the spring 50 of the valve 48 becomes increasingly effective so as to open valve 48. The flow of paper stock through the conduits 30 and 28 thus increases, tending to return the level of stock in the tank 11 to its former level.

The reduction in air pressure within the conduits 47 and 51 is effective, due to the bellows 45, on the arm 40. A reduction in air pressure in the bellows 45, occasioned by the reduction in pressure in the conduit 47, causes the bellows 45 to draw the arm 41 in a clockwise direction, tending to return the arm 40 to its original position, blocking the nozzle 42 to a greater extent. Thus, for a predetermined drop in air pressure in the bubbler tube 29 and pipe 32, there is a predetermined drop of air pressure in the conduits 47 and 51 and a consequent predetermined opening of the valve 48. Any greater drop in air pressure in the conduits 47 and 51 and any greater opening of the valve 48 are prevented due to the functioning of the bellows 45, acting as a follow up device, in closing the nozzle 42 by means of the arm 40.

Conversely, when the level of stock in the tank 11 increases above its predetermined desired level, the air pressure in the conduit 32 and applied on the right side of the diaphragm 37 of the motor 35 in the system 13 causes the diaphragm 37 to be moved to the left as seen

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in FIG. 1 pivoting the arm 40 in a clockwise direction about its pivot 41. Such movement of the arm 40 closes the nozzle 42 to a greater extent and reduces the air pressure drop across the restriction 44 so as to raise the air pressure within the conduits 47 and 51. The increased pressure in the conduit 51 is applied on to the valve diaphragm 49, causing the spring 50 of the valve 48 to be less effective, so that the valve 48 is closed to a greater extent. This increase in pressure in the conduit 51 is applied through the conduit 47 to the bellows 45, moving the end 46 of the diaphragm to the left as seen in the figure so as to return the arm 40 to a position opening the nozzle 42 to the original extent. Thus, under these conditions, the valve 48 is closed to a greater extent than previously, the closing being variable with the increase in pressure in the pipe 32 and the distance the stock level has risen above the predetermined level.

Thus the control system 13 functions to maintain the stock in the tank 11 at a predetermined level within close limits, the system acting to close the valve 48 when the pond rises above this level and functioning to open the valve 48 to a greater extent when the pond falls below this level.

As will be observed from FIG. 1, the stock in the tank 19 is maintained below the top of the drum 12, such as at a level about three-fourths of the height of the drum. As the drum is rotated by the motor 27, the shields 23 and 24, contacting respectively the sides and bottom of the drum 12, seal the drum sides and bottom with respect to the tank and thus maintain the pond of stock within the tank 11 at one side of the drum with little leakage around the drum.

The drum 12 in its rotation allows water from the stock to drain through the drum and particularly through the exterior screen of the drum. The fibers of the stock adjacent the bottom shield 24 collect rapidly on the drum adjacent the shield 24 and there is considerable water flow through the drum adjacent the shield 24. As the periphery of the drum rises in the pond of stock, the screen of the drum collects less and less of the stock fibers and there is a decreased drainage of water from the stock through the drum and there is a greater matting of the stock fibers on the drum periphery. As the screen of the drum rises above the pond of stock, the stock fibers remain on the drum and the fibers eventually are washed off the surface of the drum on the left side of the drum as seen in FIG. 1 by the water that flows through the drum from the pond of stock.

Since the exterior surface of the drum 12 is a Fourdrinier type screen, few of the stock fibers pass through the screen surface, similar to the operation of such a screen in a papermaking machine. The screen on the drum 12 functions similarly to such a screen on a paper machine also in initially passing a considerable amount of water with little matting of the stock fibers and subsequently, as the wire moves, providing a decreased water draining through it with an increasing matting of the stock fibers. The rate of water flow through the screen periphery of the drum is substantially the same as the rate of the stock flow through the conduits 30 and 31 if the pond is to be kept to the same level. Both of these factors correspond to the rate of drainage through a Fourdrinier wire on a paper machine and are proportional to the freeness of the stock and to its rate of drainage on a paper machine and may thus be measured for an indication of stock freeness. The rate of stock flow through the conduits 30 and 31 is utilized in the freeness tester as illustrated for indication of stock freeness, and particularly accurate results, corresponding to those obtainable from a Canadian Standard freeness tester, are obtainable with the herein disclosed freeness tester, in which a Fourdrinier wire is used for the exterior surface of the drum 12 and with the drum slowly rotating at 3 to  $7\frac{1}{2}$  r.p.m.

The air forced through the conduit 32 and bubbler

tube 29 not only constitutes a means for maintaining the level of stock constant, but this air also functions to agitate the stock in the stock pond within the tank 11 so as to keep the stock fibers evenly dispersed. The stock within the pond thus is maintained suitable for application on to the drum 12 as it rotates for an indication of freeness, without clumps of fibers that could otherwise disturb the operation and upset the freeness measurements.

In order to utilize the illustrated system as a measuring device rather than a device for maintaining freeness constant, the conduit 64 is blocked between the motor 60 and its point of connection to the meter 95 by closing the valve 64a. Under these conditions, the refiner 15 has its discs a constant distance apart and its refining action does not change. The meter 95 under these conditions indicates the variations in freeness of the stock within the tank 11 and thus within the conduit 31 and that which is supplied to the paper machine 97, as will be described.

The system 17 functions basically similarly to the system 13. In the system 17, the cavity 38 of the motor is connected through the conduit 53 with one side of the restriction 52, and the cavity 39 is connected through a conduit 54 with the other side of the restriction 52. The system 17 thus is responsive to the fluid pressure drop across the restriction 52 and thus indirectly measures the volume of flow through the conduit 30, which is an indication of the freeness of the stock as previously mentioned.

As the volume of stock flow through the conduit 30 increases, there is a greater pressure drop across the restriction 52 in the conduit 30, the pressure in the conduit 54 dropping with respect to the pressure within the conduit 53. The diaphragm 37 thus moves to the left as seen in the figure, moving the arm 40 in a clockwise direction so as to block the nozzle 42 to a greater extent. This causes a rise in the air pressure within the conduits 47 and 64, with a corresponding indication on the meter 95, the rise of air pressure in the conduits 47 and 64 being held to an amount proportional to the increased flow through the conduit 30 by means of the bellows 45 acting to return the arm 40 to its original position. Conversely, a decreased flow through the conduit 30 and restriction 52 causes a relatively high pressure to exist in the conduit 54, moving the diaphragm 37 to the right as seen in the figure. The arm 40 is moved counterclockwise by this movement of the diaphragm, so that the parts act in the opposite manner, producing a drop in the air pressure in the conduit 64 which is registered on the meter 95.

The system 17 may also be utilized for controlling the freeness of stock so as to maintain the freeness substantially constant. In this case, the conduit 64 is in its complete state, being connected with the motor 60 of the refiner 15 with the valve 64a open. Under these conditions, as the freeness of the stock tends to increase, the flow of stock through the conduit 30 increases, and the drop across the restriction 52 increases. The increased pressure drop across the restriction causes the pressure in the conduit 64 to rise, and this increased pressure is applied on the piston 61, moving the piston against the spring 63 so as to move the refiner plate 55 toward the plate 58. This increases the refining effect of the refiner 15 and reduces the freeness of the stock, so that the stock remains at substantially the same freeness value. Conversely, as the freeness of the stock tends to decrease, the flow of stock through the conduit 30 decreases, and the drop across the restriction 52 decreases. The decreased pressure drop across the restriction causes the pressure in the conduit 64 to decrease, so that the spring 63 is effective to move the movable refiner plate 55 farther away from the fixed plate 58 to decrease the stock refining effect of the unit 15. The freeness is thus increased so as to maintain the freeness substantially at its predetermined desired value.

In order that the reading of freeness on the meter 95 or the control of the refiner 15 shall be reliable, both the temperature and consistency of the stock as it is supplied to the tank 11 must remain uniform. In ordinary Fourdrinier papermaking operations, it is not difficult to maintain the temperature of the stock uniform with appropriate heating and cooling mechanisms (not shown) if such are needed. In general, the amount of water in use with a paper machine is so large that little temperature variation takes place without the use of such heating and cooling mechanisms.

The consistency of the stock may be maintained uniform with use of the consistency measuring device 16. As has been described, this includes a so-called war club 66 around which the stock flows as it is supplied to the machine 97. The stock in flowing upwardly in the conduit 31, as it is illustrated in FIG. 1, produces an upward force on the war club 66, holding the valve core 72 slightly off its seat 73. Water flows from the water supply conduit 76 through the plate 75, the valve 71, the conduit 81, the restricted conduit 90, and the conduit 80, into the cavity below the diaphragm 68 and around the rod 67 into the conduit 31. Due to the restricted conduit 90, there is a difference in pressure of the water above and below the diaphragm 68, the pressure being higher above the diaphragm and opposing the upward force on the war club caused by the stock flowing upwardly past the war club. There is a balance between the downward force on the diaphragm 68 and the upward force on the war club 66, so that the valve 71 is maintained slightly open. The difference in pressure across the restricted conduit 90 is measured by movement of the needle 88 traversing the scale 89. The water under pressure in the conduit 81 is supplied to the cavity 87, and the water under pressure in the conduit 80 is supplied to the cavity 86, on opposite sides of the diaphragm 82. The water pressure in the cavity 87 is higher than in the cavity 86, to an extent depending on the drop across the restricted conduit 90 and moves the diaphragm 82 to the left as seen in FIG. 1, causing corresponding movement of the needle 88 across the scale 89. The needle indicates the magnitude of pressure drop across the restricted conduit 90 and thus the force on the war club and the consistency of the stock, which causes a greater upward force on the war club 66 with increased consistency and a less force with decreased consistency.

An increase in the consistency of the stock flowing through the conduit 31 upsets the equilibrium just mentioned between the downward force on the diaphragm 68 and the upward force on the war club 66, since the stock now provides an increased upward force on the war club. The rod 67 transmits this upward force and opens the valve 71 to a greater extent, so that there is increased water flow from the conduit 76 and through the conduits 81, 90 and 80. The resultant increased water pressure differential on the diaphragm 68 opposes this increased force on the war club and holds the valve 72 in a slightly more open position in which the increased pressure drop in the restricted conduit 90 corresponds to the increased consistency, the pressure drop being measured by the needle 88 on the scale 89 to indicate the increased consistency. Conversely, when the consistency decreases, the upward force on the war club 66 is less so that the valve core 72 tends to close the valve 71 to a greater extent. The water flow through the conduits 81, 90 and 80 is then less with a decreased pressure drop across the restricted conduit 90. This decreased pressure drop is measured by the needle 88 which indicates on the scale 89 the decreased consistency.

The stock consistency is maintained uniform by manual adjustment of the valve 94 connected to the water supply conduit 93. If the consistency is too great, an increased amount of water is added through the valve 94 and into the stock supply pipe 31; and, on the other hand, if the consistency is low, the valve 94 is closed to a

greater extent to reduce the water supplied from the water supply conduit 93 to the stock conduit 31.

It has been found that the freeness tester including the drum 12 rotating in the tank 11 is more accurate if the stock consistency is relatively low. The consistency of stock supplied to a Fourdrinier paper machine is quite usually on the order of 3 percent. The freeness tester of the invention, on the other hand, is most accurate if the consistency of stock supplied to it is on the order of  $\frac{3}{10}$  percent or up to 1 percent. I, therefore, have provided a water supply conduit 92 connected by means of a valve 91 with the conduit 30. The valve 91 is adjusted so that the consistency of the stock passing through the conduit 30 to the tank 11 is reduced to approximately  $\frac{3}{10}$  percent from its consistency of 3 percent as it is supplied to the machine 97. Conventional consistency measuring devices or systems may be used in connection with the valve 91 for assuring that the consistency of the stock remains at a predetermined reduced uniform value within the conduit 30.

The tester as modified by the showing of FIG. 4 assures that the consistency of the stock supplied to the tank 11 remains at a predetermined low value. The refiner control system 17 functions as before to measure the pressure drop across the restriction 52 in accordance with changes in freeness, for the purpose of either simply indicating the freeness on the meter 95 or controlling the refiner 15 so that the freeness remains constant.

The pump 107 is operated at a uniform speed and is of such construction, as above mentioned, that at uniform speeds it produces a constant output, such as 5 gallons per minute. The constant flow regulator 105 is preferably adjustable, supplying a certain volume of output through the conduit 106 from the water supply conduit 92 into the conduit 30 between the pump 107 and the conduit 53. The rate of output of both the constant flow regulator 105 and the pump 107 are so adjusted that the appropriate reduction of consistency is in effect in the conduit 30 prior to the restriction 52.

The valve 102 is controlled in accordance with the air pressure in the pipe 51 for the purpose of so relieving and bypassing the diluted stock from the conduit 30, just prior to the restriction 52, that the level of stock within the tank 11 remains the same. The flow through the restriction 52, therefore, is the same as the flow of stock through and over the drum 12. The valve 102 is similar to the valve 48 but operates oppositely—the spring closes the valve rather than opens it and the air pressure operates to open the valve rather than close it. Therefore, as the air pressure in the pipe 51 increases, the valve 102 is further opened, while if the air pressure in the pipe 51 decreases, the valve spring further closes the valve. As has been previously described, as the level of the stock pond in the tank 11 falls, the air pressure in the pipe 32 decreases, decreasing the pressure in the pipe 51. The latter pressure decrease tends to close the valve 102 as that the stock being bypassed by the conduit 103 is decreased and the stock level is restored. The air pressures in the pipes 32 and 51, conversely, for a stock pond level that is too high, increase, so as to open the valve 102 and increase the stock bypassed by the conduit 103.

The manually operated valve 101 is for the purpose of assuring that the air control valve 102 is operative within the correct range for maintaining the level of stock in the tank 11 constant. If the valve 102, for example, were wide open with the stock level still increasing, the valve 101 would be closed a certain extent, so that the valve 48 under these conditions could reduce the stock level in the tank.

The illustrated freeness tester automatically gives a continuous accurate reading of stock freeness on the meter 95 or, if connected to the motor 60 of the refiner 15, accurately maintains the freeness of the stock flowing to the paper machine 97 at the same value. In view of the fact that a Fourdrinier type wire is used for

the exterior surface of the drum 12, the rate of drainage through the wire is accurately proportional to the drainage of white water from the stock deposited on a Fourdrinier wire in a papermaking machine. The bubbler tube 29 advantageously functions to assure that the stock fibers remain evenly dispersed throughout the stock pond in the tank 11 in addition to acting as a pond level determining mechanism.

I wish it to be understood that the invention is not to be limited to the specific constructions and arrangements shown and described, except only insofar as the claims may be so limited, as it will be understood to those skilled in the art that changes may be made without departing from the principles of the invention.

What is claimed is:

1. In a stock freeness tester, the combination of a drum having a perforated peripheral surface, means for holding stock in a pond on one side of said drum, means for supplying a flow of stock to the pond, means for maintaining the level of the pond below the top of said drum, means for rotating said drum so that water from the stock drains through the drum and fibers from the stock collect on the perforated surface of the drum, and means to measure the flow of stock thus passing through and carried by the drum as an indication of the freeness of the stock.

2. In a stock freeness tester, the combination of a tank, a perforate drum rotatably disposed in said tank, means for sealing the drum with respect to the adjacent surfaces of the tank for holding stock in a pond in said tank on one side of said drum, means for supplying a flow of stock to the pond, means for maintaining the level of the pond below the top of said drum, means for rotating said drum so that water from said stock drains through said drum and fibers of the stock collect on the drum and are drawn from said pond on to the other side of the drum, and means to measure the flow of stock from said pond as an indication of the freeness of the stock.

3. In a stock freeness tester, the combination of a tank, a perforate drum in said tank, means for sealing opposite sides and the bottom of said tank with respect to said drum for holding stock in a pond on one side of the drum, means for supplying a flow of stock to the pond, means for maintaining the pond at a predetermined level below the top of said drum, means for rotating said drum in a direction so that water from the stock in the pond drains through the drum and fibers of the stock collect on the drum and are moved on the top surface of the drum to the other side of the drum, and means to measure the flow of stock passing through and carried by the drum and supplied to said pond as an indication of the freeness of the stock.

4. In a freeness tester for stock for Fourdrinier type paper machines, the combination of a drum, a Fourdrinier type wire on said drum forming the exterior peripheral surface of the drum, means for holding stock in a pond on one side of said drum, means for supplying a flow of stock to the pond, means for maintaining the level of the pond below the top of said drum, means for rotating said drum so that water from the stock drains through the wire of the drum and fibers from the stock collect on the wire, and means to measure the flow of stock thus passing through and collecting on the drum as an indication of the freeness of the stock.

5. In a freeness tester for stock for a paper machine, the combination of a tank, a drum in said tank having its exterior peripheral surface formed by a Fourdrinier type wire, means for sealing the peripheral surface and the sides of said drum with respect to adjacent sides and bottom of said tank for holding stock in a pond in the tank on one side of the drum, means for supplying a flow of stock to the pond, means for maintaining the level of the pond below the top of said drum, means for rotating said drum in a direction so that fibers from the

stock collect on the periphery of the drum and pass over the top of the drum to the other side of the drum and water from the stock drains through the drum, and means to measure the flow of stock thus passing through and over the drum from the pond as an indication of the freeness of the stock.

6. In a stock freeness tester, the combination of a tank, a perforate drum within said tank, means for sealing said drum with respect to adjacent sides and the bottom of the tank for holding stock in a pond on one side of said drum, means for supplying stock to said pond, means for rotating said drum so that water from the stock drains through the drum and fibers of the stock collect on the periphery of the drum, means for maintaining a predetermined level of stock in said pond below the top of said drum and including a bubbler tube extending into said pond and a source of air under pressure connected to said bubbler tube, bubbles from said tube passing through the stock of the pond functioning to maintain the fibers within the stock pond substantially uniformly dispersed, and means to measure the flow of stock passing into said pond as an indication of the freeness of the stock.

7. In a stock freeness tester, the combination of a tank, a drum within said tank, said drum comprising a screen forming the external surface of the drum and being approximately 2 feet in diameter, means for sealing said drum with respect to adjacent sides and the bottom of said tank for holding stock in a pond on one side of said drum, means for rotating said drum at a speed between 3 and  $7\frac{1}{2}$  revolutions per minute in a direction so that fibers from the stock collect on the external surface of the drum and pass over the top of the drum and water from the stock drains through the drum, means for maintaining said pond of stock at substantially a predetermined level below the top of said drum and including means for supplying stock to said pond, and means to measure the flow of stock supplied to said pond as an indication of the freeness of the stock.

8. In a stock freeness tester, the combination of a tank, a drum within said tank and having a perforate peripheral surface, means for sealing said drum with respect to adjacent sides and the bottom of the tank for holding stock in a pond on one side of said drum, means for maintaining said pond at a predetermined level below the top of said drum and including a bubbler tube extending into the pond and connected to a source of air under pressure whereby the bubbles from said tube function to maintain the fibers of the stock in the pond substantially uniformly dispersed, a conduit for supplying stock to said pond, said level maintaining means including a motor responsive to the pressure in said bubbler tube and a valve connected to said motor for increasing the flow of stock into the pond when the pressure in said bubbler tube drops and decreasing the flow of stock into the pond when the pressure in said bubbler tube increases, and means for measuring the flow of stock flowing into the pond from said conduit as an indication of the freeness of the stock.

9. In a stock freeness tester, the combination of a tank, a drum within said tank and having a perforate peripheral surface, means for sealing said drum with respect to adjacent sides and the bottom of the tank for holding stock in a pond on one side of the drum, means for maintaining the pond at a predetermined level below the top of said drum and including a bubbler tube extending into the pond and connected to a source of air under pressure whereby the bubbles from said tube function to maintain the fibers of the stock in the pond substantially uniformly dispersed, a conduit for supplying stock to said pond, said level maintaining means including a motor responsive to the pressure in said bubbler tube and a valve connected to said motor for increasing the flow of stock through said conduit into the pond when the pressure in said bubbler tube drops and

decreasing the flow of stock through said conduit into the pond when the pressure in the bubbler tube increases, and means for measuring the flow of stock flowing into said pond from said conduit as an indication of the freeness of the stock, said flow measuring means including a restriction in said conduit, a pressure differential motor connected to said conduit on opposite sides of said restriction, and indicating means responsive to the pressure differential applied on said motor.

10. In a stock control device, the combination of a tank, a drum in said tank having an external perforated surface, means for sealing said drum with respect to opposite sides and the bottom of said tank for holding stock in a pond on one side of said drum, a source of stock supply for the pond including a stock supply conduit connected to said tank and a stock refiner having a pair of parts rotatably movable with respect to each other and adjustably movable together for increasing the refining effect of the refiner, means for rotating said drum so that water from the stock drains through the drum and fibers from the stock collect on the periphery of the drum and move over the drum, means for measuring the flow of stock through said conduit as an indication of the freeness of the stock, and means for operatively connecting said measuring means with said refiner so as to move said parts closer together to increase the refining effect of the refiner when the stock flow through said conduit and the freeness increase and to move the said parts away from each other to decrease the refining effect when the stock flow and freeness decrease.

11. In a stock freeness control device, the combination of a tank, a drum within said tank having a perforated external surface, means for sealing said drum with respect to adjacent sides and the bottom of the tank for holding stock in a pond on one side of said drum, means for maintaining the stock in the pond at a predetermined level below the top of said drum, means for supplying stock to said pond and including a stock supply conduit and a refiner connected to said conduit and having a pair of relatively rotatable parts adjustable toward and away from each other, means for rotating said drum so that water from the stock drains through the drum and fibers from the stock collect on the periphery of the drum and pass over the top of the drum, means for measuring the flow of stock passing through said conduit to the stock pond for thus indicating the flow of stock passing through and over the drum as an indication of the freeness of the stock, said measuring means including a restriction in said conduit, a pressure differential motor responsive to the pressures on opposite sides of said restriction and a source of fluid pressure variable by said motor, and a second motor actuable by said variable fluid pressure for the purpose of adjusting the relatively rotatable refiner parts respectively closer together and farther apart as the stock flow through the conduit and the freeness increase and decrease for maintaining the freeness of the stock passing into the pond substantially uniform.

12. In a freeness tester for stock for a Fourdrinier paper machine, the combination of a tank, a drum in said tank having a peripheral surface formed by a screen of the Fourdrinier type, means for sealing said drum with respect to adjacent sides and the bottom of the tank for holding stock in a pond on one side of said drum, means for maintaining the pond at a predetermined level in the tank below the top of said drum, a stock supply conduit for the paper machine, a stock conduit for said pond and connected to said first named conduit, means for rotating said drum so that water from the stock pond drains through the drum and fibers of the stock collect on the periphery of the drum and pass over the top of the drum, means to measure the flow of stock passing to the pond conduit and thus passing through and over the drum as an indication of the freeness of the stock, and means for maintaining uniform

and reducing the consistency of the stock flowing through said second named conduit from said first named conduit and including a pump supplying stock from said first named conduit through said second named conduit at a predetermined rate of output, a water regulator mechanism regulating the supply of water from a water source directed into said second named conduit at a predetermined rate for thereby diluting the stock, said pond level controlling mechanism including a bubbler tube in said pond and a source of air pressure connected to the bubbler tube and a valve under the control of the pressure in the bubbler tube for draining off a portion of the reduced consistency stock in said second named conduit for maintaining the pond level uniform.

13. In a device for controlling the freeness of a semi-fluid stock containing suspended fibrous material, a source of stock supply including a stock refiner having a pair of parts rotatably movable with respect to each other, means for driving one of said parts with respect to the other part, means for changing the refining effect of said refiner, means for measuring the freeness of the stock of said stock supply, and means for operatively connecting said measuring means with said means for changing the refining effect so as to increase the refining effect of the refiner when the stock freeness increases and to decrease the refining effect when the stock freeness decreases.

14. In a device for controlling the freeness of a semi-fluid stock containing suspended fibers, the combination of a drum having a perforated peripheral surface, means for holding stock in a pond on one side of said drum, means for maintaining the level of the pond below the top of said drum, a source of stock supply for the pond, means for rotating said drum so that liquid from the stock drains through the drum and fibers from the stock collect on the perforated surface of the drum, means to measure the flow of stock out of said pond and passing through and carried by the drum as an indication of the freeness of the stock, a stock refiner for the stock from said supply and having a pair of parts rotatably movable with respect to each other and adjustably movable together for increasing the refining effect of the refiner, means for rotatably driving one of said parts with respect to the other, motor means for moving said parts relatively apart and together, and means operatively connecting said stock flow measuring means and said motor means so as to move said parts closer together to increase the refining effect of the refiner when the stock flow and the freeness increase and to move said parts away from each other to decrease the refining effect when the stock flow and freeness decrease.

15. In a device for controlling the freeness of a semi-fluid stock containing suspended fibrous material, a source of stock supply including a stock refiner having a pair of parts rotatably movable with respect to each other, means for driving one of said parts with respect to the other part, means for changing the refining effect of said refiner, a tank, a drum within said tank and having a foraminous outer surface, means for sealing said drum with respect to the adjacent surfaces of said tank, means connecting said source of stock supply with said tank so as to provide a pond of stock on one side of said drum having a level lower than the top of the drum, means for rotating said drum so that liquid from the stock in the pond drains through the drum and fibers from the stock collect on the foraminous surface of the drum, means variable with changes in the rate of transferral of stock by said drum from said pond for measuring the freeness of the stock, and means for operatively connecting said freeness measuring means and said refining effect changing means so as to increase the refining effect of the refiner when the stock is transferred at a greater rate by the drum with a freeness increase and to decrease the refining effect when the stock is transferred at a lower rate by the drum with a freeness decrease.

16. In a device for determining the freeness of a semi-fluid stock containing suspended fibrous material, the combination of a drum having a foraminous outer surface, means for holding stock in a pond on one side of said drum, means for supplying a flow of stock to the pond, means for maintaining the pond at a predetermined level below the top of said drum, means for rotating said drum so that liquid from the stock drains through the drum and fibrous material from the stock collects on the foraminous surface of the drum and moves toward the top of the drum, and means to measure the flow of stock from said stock supplying means to said pond as an indication of the freeness of the stock.

17. In a stock freeness tester, the combination of a tank, a drum within said tank, said drum comprising a screen forming the external surface of the drum, means for sealing said drum with respect to the adjacent sides and bottom of said tank for holding stock in a pond on one side of said drum, means for rotating said drum so that it has a peripheral speed between 19 and 47 feet per minute in such a direction that fibers from the stock collect on the external surface of the drum and move toward the top of the drum and water from the stock drains through the drum, means for maintaining said pond of stock at substantially a predetermined level below the top of said drum and including means for supplying stock to said pond, and means to measure the flow of stock supplied to said pond as an indication of the freeness of the stock.

18. In a device for determining the freeness of a semi-fluid stock containing suspended fibrous material, the combination of a drum comprising a screen forming the external surface of the drum, said screen being made up of sets of strands extending at angles with respect to each other with 50 to 80 strands to the inch and with the diameters of the strands being such that there is about 40 percent open area in the screen, means for holding stock in a pond on one side of said drum, means for maintaining the pond at a pre-determined level below the top of said drum, means for supplying a flow of stock to the pond, means for rotating said drum so that it has a peripheral speed between 19 and 47 feet per minute in a direction so that fibers from the stock collect on said screen and move toward the top of the drum and water from the stock drains through the drum, and means to measure the flow of stock from said stock supplying means to said pond as an indication of the freeness of the stock.

19. In a device for determining the freeness of stock which is supplied to a papermaking machine from a stock source, the combination of a drum having a foraminous outer surface, means for holding stock in a pond on one side of said drum, means for supplying a flow of stock to the pond from the stock source for the papermaking machine, means for maintaining the pond at a predetermined level below the top of said drum, means for diluting the stock supplied from said source to said pond to a predetermined fraction of its consistency as supplied to the papermaking machine, means for rotating said drum so that liquid from the stock in said pond drains through the drum and fibrous material from the stock collects on the foraminous surface of the drum and rotates toward the top of the drum, and means to measure the flow of stock into said pond as an indication of the freeness of the stock supplied to the papermaking machine.

#### References Cited in the file of this patent

##### UNITED STATES PATENTS

|           |           |               |
|-----------|-----------|---------------|
| 1,641,196 | Roucka    | Sept. 6, 1927 |
| 1,840,101 | Jespersen | Jan. 5, 1932  |
| 2,379,835 | Sisler    | July 3, 1945  |
| 2,442,888 | Cram      | June 8, 1948  |
| 2,615,329 | Witham    | Oct. 28, 1952 |
| 2,854,894 | Kline     | Oct. 7, 1958  |