Jan. 12, 1971 C. J. WYNSTRA 3,554,866

CYLINDER PAPERMAKING APPARATUS

Filed Jan. 30, 1968

Fig.1

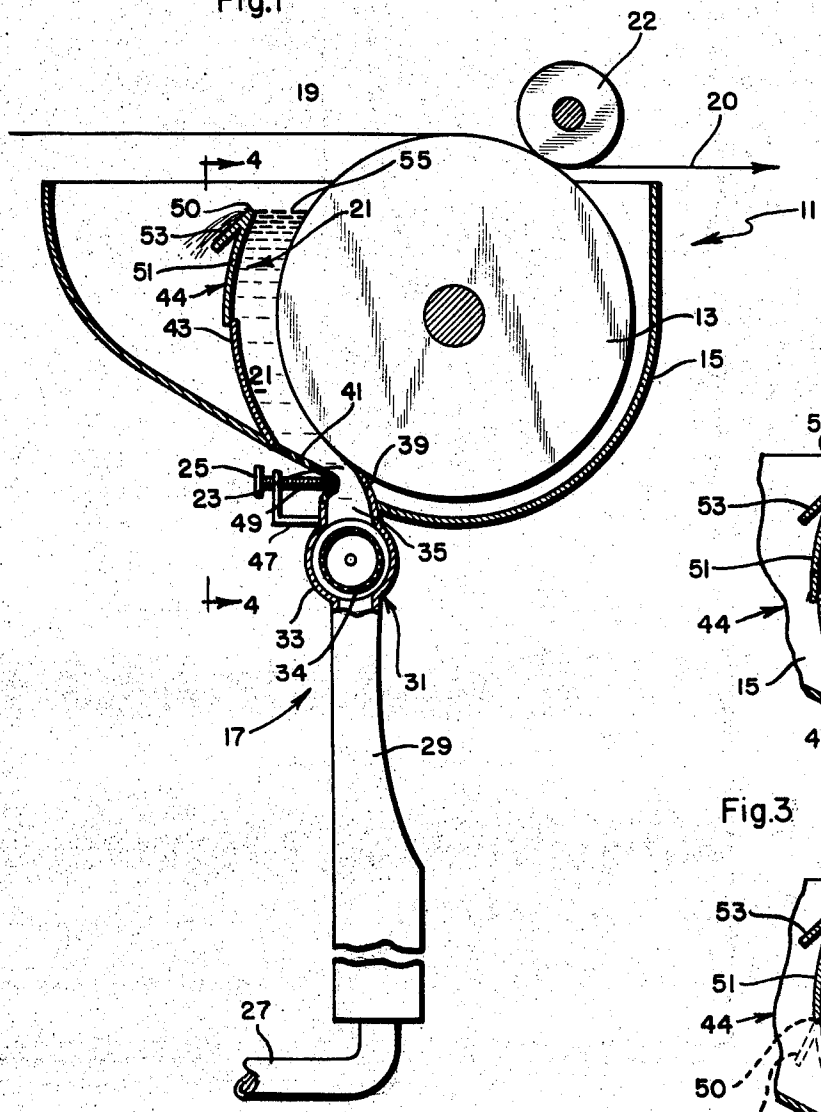


Fig.2

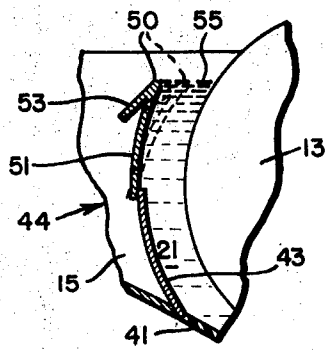


Fig.3

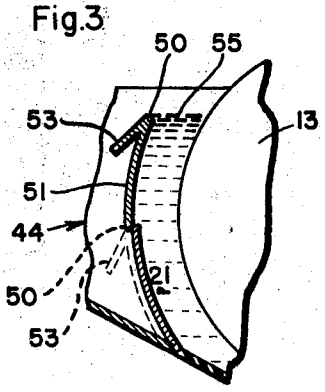
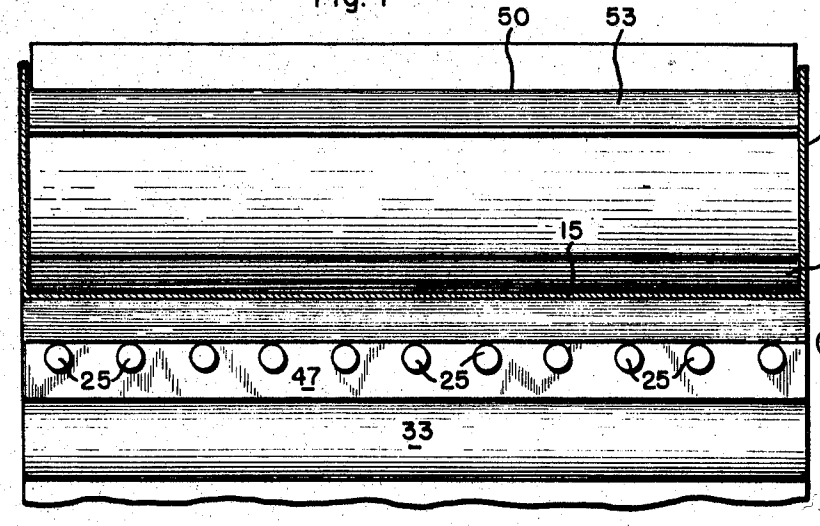


Fig.4



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United States Patent Office 3,554,866 Patented Jan. 12, 1971

3,554,866

CYLINDER PAPERMAKING APPARATUS

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Filed Jan. 30, 1968, Ser. No. 701,758
Int. Cl. D21f 1/04
U.S. Cl. 162—321 6 Claims

ABSTRACT OF THE DISCLOSURE

To provide an improved ratio of strength properties in the machine direction to the strength properties in the cross machine direction, a cylinder papermaking apparatus is provided with means to control the linear velocity of the paper stock relative to the tangential velocity of the rotating cylinder. The volume of stock available at the area of web formation may be controlled, and in a cylinder machine of the overflow kind, the position at which the stock overflows can be adjusted.

This invention relates to a papermaking apparatus and more particularly to the forming of a paper web upon a surface of a rotating cylinder.

In cylinder machines, a dilute paper stock having a suspension of fibers is brought to the surface of the rotating cylinder and the fibers are deposited on the cylinder as a portion of the stock stream enters into the interior of the cylinder. The cylinder is partially immersed in stock and the white water level in the cyninder is below the level of stock outside the cylinder, thereby causing the deposit of fibers. A vacuum may or may not be established within the cylinder.

The present invention is directed to the distribution of the paper fibers on the cylinder and the control of stock flow rate through the cylinder which play a large role in the ultimate physical characteristics of the paper web, such as its quality of formation, its uniformity of basis weight and the ratio of strength properties in the machine direction to the strength properties in the cross machine direction.

One physical characteristic of particular importance is the ratio of strength properties of the paper in the longitudinal direction of the web, called the machine direction, to the strength properties transversely across the web, called the cross machine direction. To achieve a relatively equal ratio of these strength properties, hereinafter called a "grain ratio," it is desirable that the papermaking fibers be distributed uniformly in a generally homogeneous suspension and be generally randomly oriented when applied to the cylinder. To achieve a uniform thickness and density for the sheet, the velocity and direction of the paper stock flow through the cylinder must be carefully controlled so that velocity profiles across the width of the stock stream are essentially uniform and all parts of the stream are flowing essentially parallel, that is, unidirectional.

Additionally, the velocity of the stream flow relative to the tangential velocity of the rotating cylinder also has significant effect on the quality of the paper web, particularly during the initial forming of the web which takes place quickly upon contact of the stock stream and cylinder. Also affecting the quality of the sheet is consistency of the stock during the formation of the web on the cylinder and this is effected not only by the original consistency of the stock but also by the amount of flow into the cylinder and by the amount of stock overflowing at the end of the web formation area. Heretofore, in cylinder machines, the control of the stock consistency

and web formation was usually by changing the rate of stock flow to cylinder, that is, the amount of stock being circulated.

Accordingly, an object of the invention is to provide an improved control for the stock in a papermaking apparatus having a rotating forming cylinder.

A more specific object of the invention is to provide in a cylinder type paper machine control of the velocity of the stock stream, particularly at the time of initial web formation and control of the volume of stock in the area of web formation.

Other objects and advantages of the invention will become apparent from the detailed description taken in connection with the accompanying drawings in which:

FIG. 1 is a diagrammatic end view of a cylinder papermaking apparatus embodying the present invention;

FIG. 2 is a diagrammatic illustration of adjusting the gap between forming passageway and cylinder at the overflow end of the passageway, an adjustment being shown by dotted lines;

FIG. 3 is a diagrammatic illustration of adjusting the gap between forming passageway and cylinder by lowering the overflow end of the passageway, an alternate position being shown by dotted lines; and

FIG. 4 is an illustration, taken along line **4—4** in FIG. 1, of adjusting elements to vary the size of an orifice for the stock stream.

As shown in the drawings for purposes of illustration, the invention is, very generally, embodied in a papermaking apparatus **11** having a rotatable forming cylinder **13** which is mounted in a vat **15**. The vat receives from a distribution system **17** a dilute papermaking stock which compresses a suspension of paper fibers. The surface of the cylinder comprises a fine mesh screen or wire which filters the papermaking fibers from the stock and a filtrate, known as white water, flows from the stream into the drum by a negative pressure which may be caused by a negative pressure within the cylinder or by the level of white water being below the stock level in the vat. In the illustrated embodiment, the apparatus is a so-called overflow system in which the stock stream exits the web formation area at an outlet **19** and overflows this outlet to return to the distribution system with the incoming stock. The paper web formed on the cylinder **13** travels upwardly on the cylinder **13** to the underside of a continuously moving felt **20** to which it is transferred at a couch roll **22**.

In the illustrated apparatus, there is a need to provide better defloccing and a more random orientation of the fibers for web formation. Also, there is need to control closely the velocity of the stock stream as it engages the forming cylinder since, as is well known, it is desirable that the velocity of the stock substantially equal the tangential velocity of the cylinder, particularly in the area of initial and greatest deposition of fibers. Also, it is desirable in such an apparatus that the cross flow components in the stock stream be limited and relatively uniform velocity profiles for the stream be obtained across the width of the cylinder.

In accordance with the present invention, there is provided an extremely simple and inexpensive distribution system with a novel forming passageway or chamber **21** in which the volume of stock in the area of web formation may be controlled and the velocity of the stock stream may be closely adjusted, both as to velocity profiles across the forming cylinder **13** and relative to the tangential speed of the cylinder. More particularly, and as will be explained in detail, a machine operator may accomplish this by control of the pressure head on the stock in the area of web formation and may control the velocity of the stock. The latter is controlled by adjust-

ing a constraining orifice **23** with operation of adjusting elements in the form of adjusting screws **25**.

Referring now in detail to the apparatus for practicing the invention, the stock stream is pumped to the papermaking apparatus **11** through an inlet pipe **27** (FIG. 1) which is usually of circular cross section. From the inlet pipe **27**, the stream enters a tapered passageway **29** in which it then is converted into a wide, thin stream extending generally transversely across the full length of the forming cylinder **13**. During this divergence from the inlet pipe **27** to a wide thin stream, irregularities and lateral components of flow may occur. Also, due to pumping or other operation upstream of the pipe **27**, the stock stream occasionally experiences pressure surges or fluctuations which could effect the uniformity of flow of stock into the passageway **21** and onto the forming cylinder **13**.

To dampen these lateral flow components and to mix the fibers into a homogeneous suspension with the stream, the stream flows from the tapered passageway **29** into a controlled turbulence means **31** for the stream. In the illustrated embodiment of the invention, the means **31** for providing the controlled turbulence includes an elongated explosion chamber **33**, which is approximately 6 inches in diameter and which extends the length of the cylinder. A rotatable mixing roll **34**, which is 4 inches in diameter, is disposed in the explosion chamber **33**. Preferably, the mixing roll **34** is of cylindrical hollow construction with a plurality of perforations in its surface and is sometimes called a holey roll. The mixing roll is journaled for rotation on an axis which extends longitudinally of the explosion chamber and the roll is driven at a predetermined speed, which in one operation is 72 r.p.m. The stock flows into the controlled turbulence means and is agitated as it splits and flows about and through the mixing roll. This causes turbulence, mixes and deflocs the fibers and forms a relatively homogeneous mixture in the stream. This deflocculation and homogenizing assists in developing a more random orientation of the papermaking fibers as they exit from an outlet **35** of the controlled turbulence means **31**.

The flow of homogeneous stock issuing from the controlled turbulence means moves across a relatively short and straight line path to the forming area at the rotating cylinder **13**. In the illustrated embodiment of the invention, the outlet **35** is only about six inches from the cylinder, although the present invention is not to be construed as to be limited to any particular distance.

In accordance with a most important aspect of the invention, the velocity of the stream of stock is controlled immediately prior to deposition of the fibers by means of the constraining orifice **23** through which the stream flows prior to coming into substantially tangential engagement with the cylinder **13**. In this instance, the orifice **23** is defined on one side by a wall **39** fixed at one end to the controlled turbulence means **31** and extends to the periphery of the forming cylinder. A spaced wall **41** for the orifice **23** is formed of a flexible material, such as a multi-ply piece of rubber belting, which can be moved toward or away from the fixed wall **39** with the turning of adjustment screws **25**. The wall **41** is fixed at its lower end to the controlled turbulence means **31** and at its upper end to a plate **43** of means **44** defining the forming passageway **21**. The adjusting screws **25** are turned to cause the wall **41** to extend inwardly or move outwardly and form a constricted throat defining the orifice **23**. As will be explained in connection with some specific examples of operation of the illustrated apparatus, the constraining orifice **23** is capable of relatively wide adjustment to accommodate various flow rates and to adjust the stock velocity relative to speed of cylinder operation. By way of example only, the constraining orifice **23** has been varied between 1.5 and .625 inches. Additionally, it is believed that the constraining orifice **23** not only controls the flow velocity of the stock but it does so without creating any cross flow components. The constraining of

the stream and then its expansion as it moves from the orifice **23** into the forming area causes dampening of any cross flow components and turbulences so that the stream is approaching an unidirectional flow condition at the time of greatest fiber deposition which is within the first few inches of flow across the surface of the cylinder **13**.

The control of velocity profiles across the width of the cylinder to eliminate streaks on the web being formed is provided by turning individual, spaced adjusting screws **25**, as shown in FIG. 4. As illustrated in the embodiment, adjusting screws **25** were provided at intervals across the width of the cylinder. Each adjusting screw is threaded in a bracket **47** with its inner end resting on a flexible metal sheet **49** fastened to the outside of the flexible wall **41**. The rubber belting is flexed inwardly by the ends of the screws **25** to form a relatively smooth curved surface which does not have any sharp corners or edges to which fibers might attach or accumulate. It is contemplated that the adjustable orifice **23** may be constructed in different manners and be within the purview of the invention.

If a streak occurs in the web due to insufficient fiber deposition, the machine operator may turn an adjusting screw **25** to control a local area associated with the streak to provide an opening which is wider than adjacent openings at adjacent screws whereby decreased velocity at the restricted area will result and cause more fibers to deposit on the cylinder at the area of the streak. By suitable adjustment of the adjusting screws, a relatively uniform velocity profile can be maintained across the full width of the machine.

In accordance with an important aspect of the invention, the velocity of the stream through the constraining orifice **23** may be also adjusted and controlled by varying the presure head of the stock within the forming passageway **21**. To change the head, the vertical height of the stock in the forming pasageway may be controlled by vertically adjusting the outlet end **19** of the forming chamber **21** to set the position of stock overflow relative to the orifice **23**. In the disclosed embodiment, the outlet end of the passageway **21** is defined by lip **50** on a movable wall **51** which is a part of the pasageway defining means **44** and which is located above the plate **43**. The movable wall **51** is spaced from the rotating cylinder. Preferably, this wall **51** is movable vertically, from an upper position shown by solid lines in FIG. 3 with the lip **50** above a horizontal plane through the axis of the cylinder to lower position shown by dotted lines in FIG. 3 which lower position is below the horizontal plane. At the lip **50** of the wall **51** is located an outwardly and downwardly turned flange **53** across which the overflowing stock returns to the vat **15**.

The quality of the web is also controlled by the amount of drainage of white water into the cylinder during the formation of the web in the passageway **21**. In this instance, the amount of drainage may be varied by controlling the volumetric capacity of the forming passageway **21** with or without a change in the length of the passageway. More specifically, to provide additional control over the volume of fluid in the passageway **21** and also the velocity of the fluid as it leaves the passageway, the lip **50** of the wall **51** may be moved toward or away from the cylinder to change the size of a gap **55** (FIG. 2) therebetween. For example, as seen in FIG. 2, the lip of the wall **51** may be moved from a position shown by solid lines in FIG. 2 which defines a relatively wide gap to a position closer to the cylinder shown by dotted lines. In this illustrated apparatus the gap has been varied between 2 and 11 inches.

The above described apparatus has been operated at speeds from 200 to 400 feet per minute to produce webs having a basis weight of 10 to 20 pounds per thousand square feet with best results being obtained with lighter weight webs. The height of the overflow lip **50** above the horizontal plane through the axis of the cylinder has been varied between 11 inches above this plane to 4.5 inches below the plane. The gap **55** at the overflow lip **50** was varied within a range of 11 inches to 2 inches and the

width of the constricted orifice **23** was varied between 1.5 and .625 inches. Good results have been obtained with a stock comprising a waste furnish having a freeness of 300. Kraft and tissue furnish with a freeness of 290 also was used as the stock. Exceptionally good results have been obtained with the kraft and tissue furnish with an overflow gap **55** of 2 inches, a restrictive orifice **23** of ⅝ inch, and the overflow lip **50** disposed at 5 inches above the horizontal plane. Operator speeds were varied between 200 and 500 feet per minute with a negative pressure of about ¼ inch of water within the cylinder. The furnish was pumped with a pump having a rated capacity of 3000 g.p.m.

The stiffness grain ratio for the runs, as measured by a Taber stiffness test, which is defined in TAPPI T489m—60, were generally quite low with an average figure of 1.43 which is considerably better than other known conventional counterflow or dry vat formers. This ratio indicates a sheet having a more uniform stiffness and is a most important achievement and is thought to be the result of good fiber mixing and depositing of the fibers from the stock having a velocity controlled to substantially equal the tangential velocity of the cylinder. Ring crush ratios, which are defined in TAPPI T472m—51, were approximately 1.4 as compared to a conventional ratio of 1.88 for other known counterflow or dry vat forming apparatus. The basic weight profiles were relatively uniform and usually with 5%, and with more operating experience in throat adjustment can be improved.

The present invention is of particular importance in that it provides an inexpensive and easy manner of converting existing apparatus to provide improved control over stock distribution, its velocity and fiber mixing. The resulting improvement in the ratio of stiffness in the machine direction to the cross machine direction as well as improved ring crush ratios make the present invention particularly applicable to producing sheets having basis weights of 10–20 pounds per thousand square feet. It will be appreciated that the present invention is not limited to the kind of machine illustrated nor to the particular size, dimension and materials described, which are given merely by way of illustration and not limitation.

While a preferred embodiment has been shown and described, it will be understood that there is no intent to limit the invention by such disclosure but, rather, it is intended to cover all modifications and alternate constructions falling within the spirit and scope of the invention as defined in the appended claims.

What is claimed is:

1. In a papermaking apparatus for controlling the flow of a stream of suspended fibers and forming a paper web therefrom, said papermaking apparatus comprising a rotatable cylinder having a cylindrical surface on a portion of which is to be formed a paper web, means defining with said cylinder a passageway to direct said stream to flow along a portion of said cylindrical surface and to deposit said fibers on said cylindrical surface, means providing an orifice of adjustable dimension in said passageway means located upstream from said cylinder whereby the velocity of said stream relative to the tangential velocity of said cylinder may be adjusted, said means for adjusting the dimensions of said orifice including a plurality of control elements disposed transversely across the width of the cylinder and separately movable to adjust the dimension of a portion of said orifice associated therewith thereby adjusting velocity profiles for portions of said stream.

2. An apparatus in accordance with claim **1** in which means are provided to create turbulence in said stream prior to said stream moving through said orifice.

3. In a papermaking apparatus for controlling the flow of a stream of suspended fibers and forming a paper web therefrom, said papermaking apparatus comprising a rotatable cylinder having a cylindrical surface on a portion of which is to be formed a paper web, means defining a passageway for said stream and for directing said stream to a position substantially tangential to the cylindrical surface of said rotating cylinder, means defining an adjustable orifice adjacent the end of said passageway to adjust the velocity of the stream relative to the tangential velocity of said cylinder, means defining with said cylinder an overflow passageway through which said stream flows and rises to overflow at an outlet end of said passageway, said overflow passageway means being adjustable to various positions to change the volume of said stream available for forming said web, said adjustable orifice means including a plurality of control elements disposed transversely across the width of the orifice and separately movable to vary a portion of the orifice associated therewith thereby providing a changed velocity profile for said stream.

4. An apparatus according to claim **3** in which means are provided for creating a turbulence to mix said fibers upstream of said adjustable orifice means.

5. An apparatus according to claim **4** in which said turbulence means includes a chamber and a rotatable mixing roll in said chamber.

6. In a papermaking apparatus for forming a web of paper from a suspension of fibers in a stream, said apparatus comprising a cylinder mounted for rotation about a substantially horizontal axis, said cylinder having a peripheral surface with openings therein through which passes a filtrate as said fibers are deposited on said cylindrical surface, means defining a conduit for carrying said stream to a position adjacent said cylinder, a chamber having an inlet connected to said conduit means, a rotatable mixing roll disposed in said chamber for defloccing said fibers in said stream, means connected from an outlet from said chamber and extending to the peripheral surface of said rotating cylinder to discharge said stream against said cylinder through an orifice, means for varying the size of said orifice whereby the velocity of said stream is adjusted relative to the tangential speed of said rotating cylinder, said orifice being located at a position below a plane through the horizontal axis of said cylinder, and means defining with said cylinder a passageway by which a portion of said stream flows upwardly along the rising side of said cylinder to overflow said passageway at an outlet end thereof, means for adjusting said passageway whereby the volume of the stream therein is changed, individual control elements extending transversely across the width of said cylinder and being separately movable toward or from said cylinder to control the size of the portion of the orifice associated therewith and thereby an associated velocity profile.

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U.S. Cl. X.R.

162—329, 330