Aug. 8, 1961 R. M. A. T. DE MONTIGNY 2,995,186

APPARATUS FOR MAKING FORMED FIBROUS WEBS

Filed June 6, 1960 2 Sheets-Sheet 1

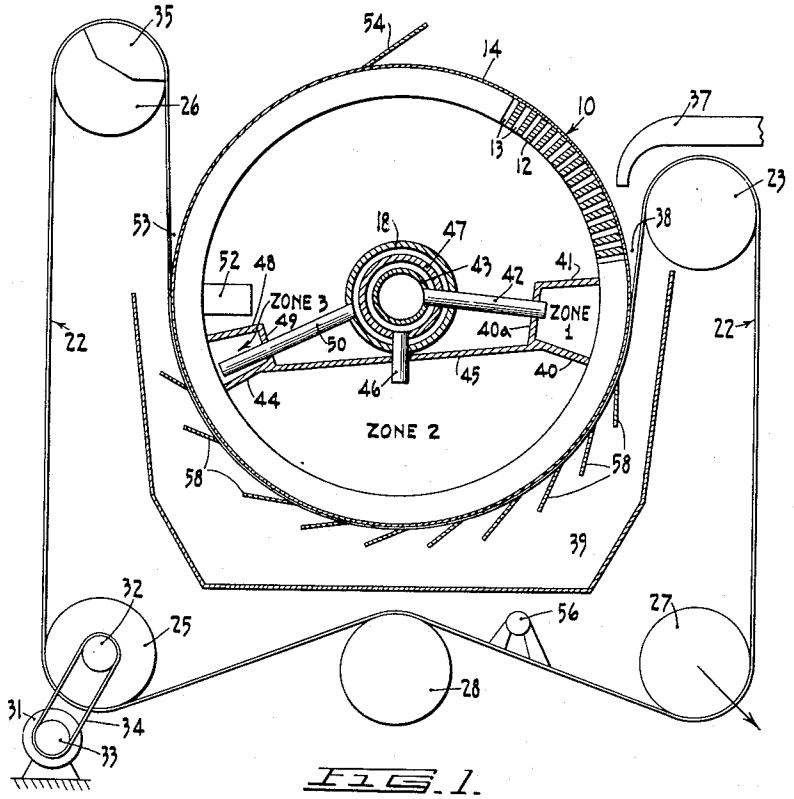

FIG. 1.

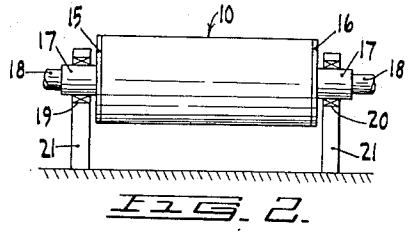

FIG. 2.

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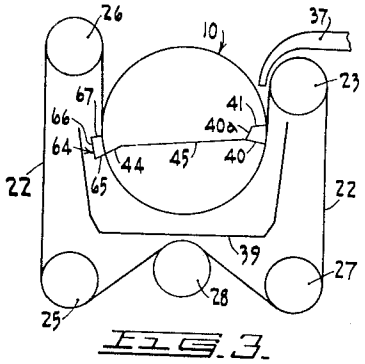

FIG. 3.

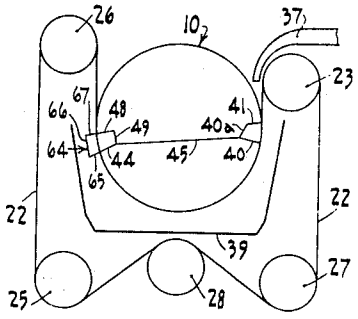

FIG. 4.

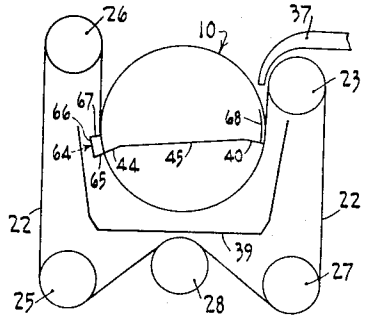

FIG. 5.

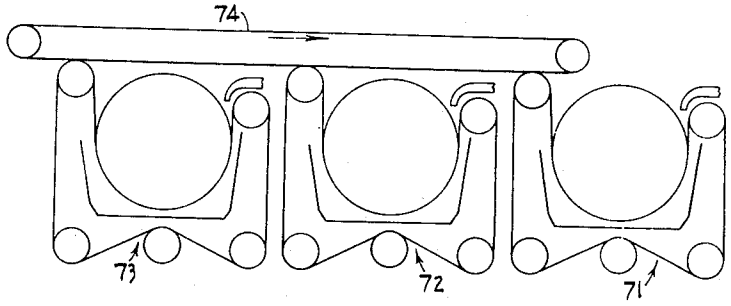

FIG. 6.

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APPARATUS FOR MAKING FORMED FIBROUS WEBS

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14 Claims. (Cl. 162—295)

This invention relates to a method and apparatus for making formed fibrous webs and is particularly applicable to the production of paper.

Existing machines for the production of paper are principally of two types, the Fourdrinier machine and the cylinder machine. Both have serious shortcomings which the present invention is intended to overcome.

In the Fourdrinier machine, an almost negligibly small amount of water removal takes place by gravity flow through the woven wire cloth. A large part of the water removal is effected by the suction action of the table rolls, further water is removed at the vacuum flat boxes and still further dewatering is achieved in the suction zone of the couch roll. Because of this intermittent action involved, a large portion of the wire cloth is ineffective in removing water and this results in a very large machine occupying a great deal of space. Also the frictional drag between the wire cloth and the surface of the vacuum boxes requires high energy input to drive the machine and results in rapid wear of the wire cloth. A further disadvantage is that, particularly at high speeds, considerable disturbance of the structure of the web occurs at each table roll with resulting disturbance of the uniformity of formation and loss of fine material through the openings in the wire cloth.

In the cylinder machine, formation of the web is continuous, resulting in a more compact apparatus. However, the forces causing flow of water through the cylinder are low, being limited to the hydrostatic head resulting from the difference in level between the outside and inside of the cylinder. For this reason, the speed attainable is low as is the maximum weight of web which can be formed on any one cylinder. A further shortcoming is that the differential in speed between the periphery of the cylinder and the slurry of fibres results in strong orientation of the deposited fibres and a highly anisotropic web.

The object of this invention is to provide a machine for making paper or the like in which the disadvantages of the conventional Fourdrinier and cylinder machines are largely overcome.

A further object of the invention is to provide a method and apparatus capable of operation over a wide range of speeds and which is capable of making a formed fibrous web while occupying a relatively small space.

A further object of the invention is to provide a method and apparatus capable of forming a fibrous web rapidly so that flocculation of the fibres is largely avoided.

A still further object of the invention is to provide an apparatus in which the frictional wear of its web forming structure is generally less than that of conventional equipment. It is also an object of this invention to provide a method and apparatus capable of forming a web having a high degree of uniformity of structure.

An apparatus in accordance with the invention utilizes a rotatable cylinder having a foraminous surface and a continuous foraminous band enveloping part of the periphery of the rotatable cylinder. This continuous foraminous band is movable with the cylinder. Means are provided for feeding a stream of fibrous pulp at the ingoing nip between the cylinder and the foraminous band. The foraminous band is tensioned to compress

the pulp between the band and the cylinder. Means are also provided for removing a formed web from the outgoing nip between the cylinder and the foraminous band. First, second and third zones are located in the part of the periphery of the cylinder enveloped by the foraminous band. In the first zone which commences substantially at the ingoing nip, water is expressed from the stream of fibrous pulp due to the convergence of the foraminous band and the foraminous cylinder. The water is expressed predominantly outwardly although, as will be more fully explained below, part of the water may pass into the interstices of the foraminous surface of the cylinder. In the second zone, an air flow at a relatively low pressure differential is established acting outwardly of the cylinder to displace water through the foraminous band. However, the relatively low pressure differential is selected so as to be insufficient to separate the web from the cylinder. In the third zone, an air flow at a relatively high pressure differential is established acting inwardly with respect to the cylinder.

The invention achieves a high degree of efficiency in the utilization of the peripheral length of the cylinder in that in the first zone, such of the water as is readily extractable by reason of the pressure between the foraminous band and the foraminous cylinder is extracted within a short peripheral distance. The outwardly acting air flow established in the second zone displaces the water outwardly where it is more readily handled than if collected within the cylinder. Preferably positive pneumatic pressure is used in the second zone to avoid the difficulties arising from handling a substantial volume of water in an inwardly acting vacuum system. In the second zone the maximum pressure which can be utilized is limited by the pressure at which the foraminous band and the web separate from the foraminous cylinder. In the third zone, an inwardly acting air flow at a relatively high pressure differential is established preferably by means of vacuum. The limitation on the pressure differential which can be used in the second zone does not apply in the third zone, with the consequence that the pulp can be dewatered to the desired level. The invention thus achieves the advantage of expelling part of the water in the pulp outwardly and part inwardly so that a large volume of water can be extracted using a cylinder of relatively small diameter. The successive action of the three zones as described above enables the apparatus to achieve high production in comparison with its size.

Considering now the drawings which illustrate embodiments of an apparatus in accordance with this invention:

FIGURE 1 is a sectional view in elevation of an apparatus in accordance with this invention.

FIGURE 2 is a side elevation view of the cylinder shown in FIGURE 1.

FIGURE 3 is similar to FIGURE 1, but shows an alternative construction.

FIGURE 4 is similar to FIGURE 3 but shows another alternative construction.

FIGURE 5 is similar to FIGURE 3 but shows another alternative construction.

FIGURE 6 is a diagrammatic elevation view illustrating the utilization of equipment in accordance with this invention to manufacture a multi-ply web.

Referring now to the embodiments illustrated in FIGURES 1 and 2, a paper making machine is illustrated comprising a cylinder **10** which extends the width of the paper making machine and which has a foraminous surface conveniently provided by a thick metal plate **12** having apertures **13**, on the outside of which is a wire screen **14** or other suitable material. End plates **15** and **16** mount the cylinder on sleeves **17** which encircle station-

ary hollow shaft **18**. Sleeves **17** are journalled in bearings **19** and **29** in framework **21**.

A continuous foraminous belt **22** is mounted so as to envelope part of the periphery of cylinder **10** by rolls **23** and **26**, tension adjusting roll **27**, drive roll **25** and guide roll **28**. Rolls **23** and **26** insure that foraminous belt **22** envelopes a substantial proportion of the periphery of cylinder **10** and preferably at least half of the periphery. Foraminous belt **22** may be a wire screen. Roll **27** serves in a conventional manner to apply and adjust the tension of foraminous belt **22**. Roll **25** is driven by motor **31** through pulleys **32** and **33** and drive belt **34**. Although for convenience of illustration, roll **25** is illustrated as being driven it will be appreciated that one or more of rolls **23**, **25** or **26** may be driven, or both such rolls and cylinder **10** or the drive may be applied solely to cylinder **10**. Roll **26** is preferably provided with a suction chamber **35** to guide the formed web.

The fibrous pulp is introduced through the slice or other feeding device **37** into the ingoing nip **38** between foraminous belt **22** and foraminous cylinder **10**. In a first zone which commences substantially at the ingoing nip **38** and which is defined by radial walls **40** and **41** and by inner wall **40***a*, the pulp is compressed between belt **22** and cylinder **10** causing most of the water extracted in the first zone to be expelled outwardly through the surface of belt **22** and part of the water to be expressed inwardly into the apertures **13** of cylinder **10**. The water which is expelled outwardly through belt **22** is received by a trough **39** from which the water is continuously removed by conventional means (not shown). The first zone is supplied with air under pressure by pressure line **42** which communicates with stationary pipe **43**. Pipe **43** is within and coaxial with shaft **18**. The air supplied through pressure line **42** is preferably controlled so that the water expressed inwardly in the first zone partially or completely fills apertures **13** without entering the chamber defined by walls **40**, **40***a*, and **41**.

In the first zone the stream of fibrous pulp is subjected to compression resulting from the tension of the foraminous band and curvature of cylinder **10**; in addition, it is subjected to a dynamic pressure resulting from the rapid convergence of the band and the cylinder. Water is therefore expressed from the stream of fibrous pulp both outwardly through the foraminous band and inwardly into the apertures of the foraminous cylinder. The factors determining the rate and partition of the outward and inward flow include the characteristics of the pulp fibres, their concentration, the temperature of the water, the speed of rotation of the cylinder, the porosity of the cylinder and the foraminous band and also the pneumatic pressure established in the first zone. The foregoing factors could conceivably be adjusted to result in any one of three conditions, namely water flowing inwardly into the interior of the cylinder, water flowing inwardly merely to an extent such that the apertures in the foraminous cylinder are partially or completely filled without the water entering the interior of the cylinder and, as the third possibility, an outward flow of air. If the water were permitted to flow into the interior of the cylinder, means would have to be provided to remove such water, thus complicating the construction of the apparatus and presenting difficulties when the cylinder is long and when the volume of water to be removed is large. If, on the other hand, an outward flow of air were established in the first zone, there would be a tendency for the formation of the web to be disturbed. Accordingly, the pneumatic pressure in the first zone is established at a value which will permit part of the water removed in the first zone to be expressed inwardly, but under conditions such that the water enters the interstices of the wall of the cylinder but not the interior of the cylinder. The water which enters the interstices of the wall of the cylinder must be passed outwardly through the formed web and the foraminous band in the second zone but it is nevertheless advantageous to have this inward flow in the first zone to give rapid formation. Such rapid formation increases the surface area available for dewatering and inhibits lateral extrusion of the pulp at right angles to the direction of flow, that is, towards the sides of the apparatus. The inward flow has the further advantage that a measure of balance is provided between inward and outward flow of the water during formation which assists in providing uniform formation.

The second zone which is conveniently defined by radially extending walls **40** and **44** and by inner wall **45** is supplied with air under pressure by pressure line **46** which communicates with stationary pipe **47**. Pipe **47** is within and coaxial with shaft **18**. The air supplied through pressure line **46** establishes an outwardly acting pressure differential in the second zone to expel water outwardly through belt **22**. The water extracted in the second zone is collected by trough **39**. In the second zone water is removed which cannot readily be removed in the first zone. However, the pressure differential in the second zone must be maintained at a value below that at which the web which has been formed and belt **22** would be forced away from the surface of cylinder **10**.

The third zone is defined by radial walls **44** and **48** and by inner wall **49**. In the third zone a vacuum line **50** which communicates with the space between shaft **18** and pipe **47** establishes a vacuum which creates a relatively high inwardly acting pressure differential and a resulting large flow of air causing the removal of further water. As the pressure differential acts inwardly the amount of the pressure differential is not limited in the same way as described in connection with the second zone. Due to the previous removal of the bulk of the water in the first and second zones a small proportion of water remains to be extracted under vacuum in the third zone thus overcoming the difficulties consequent upon extracting a large volume of water by vacuum.

A pressure box **52** may conveniently be provided at the outgoing nip **53** to ensure that the formed web is transferred on to belt **22**.

A doctor blade **54** riding on the free-surface of cylinder **10** strips the web or any part of the web to prevent it returning to the ingoing nip in the event of it adhering to cylinder **10**. Cleaning shower **56** cleans band **22**. Other cleaning showers (not shown) may be provided if needed, to clean the meshes of screen **14** and apertures **13**. Doctors **58** or other convenient means may be provided in the first and second zones to facilitate or increase the removal of water in these zones.

Each of the zones referred to above extend at least the width of the web which is being formed.

Referring now to FIGURE 3 of the drawings, the apparatus illustrated is similar to that shown in FIGURES 1 and 2 except that in the third zone an inwardly acting pressure chamber **64** defined by walls **65**, **66** and **67** replaces the vacuum chamber illustrated in FIGURE 1. It will be appreciated that other alternatives may be used such as for example the use of both inwardly acting vacuum and pressure in the third zone as illustrated in FIGURE 4.

Another alternative is shown in FIGURE 5 in which an arcuate backing plate **68** is juxtaposed in sliding contact with the inner surface of the cylinder **10** to control the inward flow of water in the first zone.

It will be appreciated that modifications can be made with structures shown. For example, the roll **23** shown in FIGURE 1 can be located close enough to cylinder **10**, having regard to the quantity of pulp in nip **38** for there to be a suction effect from roll **23** coincident with nip **38** to assist in the outward expulsion of water from the web. Another modification would be to eliminate the third zone from the interior of the cylinder **10** and include such zone in a separate roll such as roll **26**.

In FIGURE 6 of the drawings, separate units **71**, **72**

and **73** are each similar to the apparatus illustrated in FIGURE 1, except that it may be desirable to eliminate the third zone from each unit. However, the formed web from each of units **71**, **72** and **73** is transferred to the surface of belt **74** to provide a laminated web. With the construction shown in FIGURE 5 it will be necessary to adjust the conditions, so that the webs are not dried beyond the point at which they will adhere together to provide the desired laminate.

With this invention it is possible to obtain satisfactory web formation with a cylinder of a diameter of about 30 inches. The length of the cylinder may vary from about 4 to about 30 feet. A typical thickness of the periphery of the cylinder is 1½ inches. The linear speed of the periphery of the cylinder may vary over a wide range but will usually be of the order of 500 to 3000 feet per minute. Tension in the foraminous band may vary in the range of about 20 to 100 pounds per inch width. A typical pressure differential in the first and second zones is within the range of one tenth to one half of an atmosphere, the preferred value being about a quarter of an atmosphere. Although the ranges indicated are the same for the first and second zones, the actual values of the pressure differentials in the two zones usually will not be identical. In the third zone, the pressure differential range will be about one quarter of an atmosphere to one atmosphere with the construction shown in FIGURE 1 but may be as high as about 5 atmospheres with the constructions shown in FIGURES 3, 4 and 5. The preferred value is about ¾ of an atmosphere. When the pressure differential in the second zone is at the top portion of the range referred to above, the pressure differential in the third zone will be in the upper part of its range. It is preferred that the difference between the pressure differentials in the second and third zones be of the order of one half atmosphere. It will be appreciated that while these figures are given for guidance, they may vary considerably depending upon the nature of the pulp and the degree to which it is desired to dry the resultant web.

I claim:

1. An apparatus for making formed fibrous webs comprising a rotatable cylinder having a foraminous surface, a continuous foraminous band enveloping part of the periphery of said cylinder, and being movable with said cylinder, means for feeding a stream of fibrous pulp at the ingoing nip between said cylinder and said foraminous band, means for tensioning said band to compress the pulp between the band and the cylinder, means for removing a formed web from the outgoing nip between said cylinder and said foraminous band, means defining first, second and third zones in the portion of said cylinder enveloped by said band, said first zone commencing substantially at the ingoing nip and constituting a peripheral area of said cylinder in which water is expressed by the convergence of said cylinder and foraminous band at said ingoing nip from the stream of fibrous pulp both outwardly through the foraminous band and inwardly in the direction of the interior of the cylinder at least part of the water displaced in the direction of the interior of the cylinder being contained within the interstices of the foraminous surface of the cylinder while such foraminous surface is within said first zone, means for applying an air flow at a low pressure differential at said second zone acting outwardly of said cylinder to displace water through said foraminous web, said low pressure differential being insufficient to separate the partially formed web in the second zone from said cylinder and means for applying an air flow at a high pressure differential in said third zone acting inwardly with respect to said cylinder for the extraction of additional moisture from said web.

2. An apparatus for making formed fibrous webs as in claim 1, in which the means for establishing an air flow at a low pressure differential in the second zone comprises a pressure chamber within said cylinder for applying pneumatic pressure to said web.

3. An apparatus for making formed fibrous webs as in claim 1 in which the means for establishing an air flow at a high pressure differential in the third zone comprises a vacuum chamber within said cylinder.

4. An apparatus as in claim 1 in which the foraminous surface of said cylinder is adapted to contain within its interstices the water displaced in the direction of the interior of the cylinder in the first zone while such foraminous surface is within said first zone.

5. An apparatus as in claim 1 in which said machine is a paper making machine.

6. An apparatus as in claim 1 in which said third zone comprises both an inwardly acting pressure chamber and an inwardly acting vacuum chamber.

7. An apparatus for making formed fibrous webs as in claim 1 in which said first zone comprises a pressure chamber within said cylinder.

8. An apparatus as in claim 1 in which said first zone comprises a backing plate in sliding contact with the interior of the surface of the cylinder to retain within the interstices of said surface, the water displaced in the direction of the interior of the cylinder in the first zone while such foraminous surface is within said first zone.

9. An apparatus for making formed fibrous webs as in claim 1 in which the means for establishing an air flow at a high pressure differential in the third zone comprises a pressure chamber in sliding contact with the exterior surface of the foraminous band.

10. An apparatus for making formed fibrous webs comprising a rotatable cylinder having a foraminous surface, a continuous foraminous band enveloping part of the periphery of said cylinder, and being movable with said cylinder, means for feeding a stream of fibrous pulp at the ingoing nip between said cylinder and said foraminous band, means for tensioning said band to compress the pulp between the band and the cylinder, means for removing a formed web from the outgoing nip between said cylinder and said foraminous band, means defining first, second and third zones in the portion of said cylinder enveloped by said band, said first zone commencing substantially at the ingoing nip and comprising an outwardly acting pressure chamber, exerting pneumatic pressure on part of the peripheral area of said cylinder so that water is expressed outwardly through the foraminous band and inwardly in the direction of the interior of the cylinder, the water expressed inwardly being contained within the interstices of the foraminous surface of the cylinder while such foraminous surface is within said first zone, means for applying an air flow at a low pressure differential at said second zone acting outwardly of said cylinder to displace water through said foraminous web, said low pressure differential being insufficient to separate the partially formed web in the second zone from said cylinder and means for applying an air flow at a high pressure differential in said third zone acting inwardly with respect to said cylinder for the extraction of additional moisture from said web.

11. An apparatus for making formed fibrous webs comprising a rotatable cylinder having a foraminous surface, a continuous foraminous band enveloping part of the periphery of said cylinder, and being movable with said cylinder, means for feeding a stream of fibrous pulp at the ingoing nip between said cylinder and said foraminous band, means for tensioning said band to compress the pulp between the band and the cylinder, means for removing a formed web from the outgoing nip between said cylinder and said foraminous band, means defining at least two zones in the portion of said cylinder enveloped by said band, the first of said zones commencing substanitally at the ingoing nip and comprising an outwardly acting pressure chamber exerting pneumatic pressure on part of the peripheral area of said cylinder so that water is expressed outwardly through the foraminous

band and inwardly in the direction of the cylinder, the water expressed inwardly being retained within the interstices of the foraminous surface of the cylinder while such foraminous surface is within said first zone and means for applying an air flow at a low pressure differential at said second zone acting outwardly of said cylinder to displace water through said foraminous web, said low pressure differential being insufficient to separate the partially formed web in the second zone from said cylinder.

12. An apparatus for making formed fibrous webs comprising a rotatable cylinder having a foraminous surface, a continuous foraminous band enveloping part of the periphery of said cylinder, and being movable with said cylinder, means for feeding a stream of fibrous pulp at the ingoing nip between said cylinder and said foraminous band, means for tensioning said band to compress the pulp between the band and the cylinder, means for removing a formed web from the outgoing nip between said cylinder and said foraminous band, means defining at least two zones in the portion of said cylinder enveloped by said band, said first zone commencing substantially at the ingoing nip and constituting a peripheral area of said cylinder in which water is expressed from the stream of fibrous pulp both outwardly through the foraminous band and inwardly in the direction of the interior of the cylinder, the water expressed inwardly in the direction of the

interior of the cylinder being retained within the interstices of the foraminous surface of the cylinder while the foraminous surface is within said first zone, and means for applying an air flow at a low pressure differential at said second zone acting outwardly of said cylinder to displace water through said foraminous web, said low pressure differential being insufficient to separate the partially formed web in the second zone from said cylinder.

13. An apparatus as in claim 12 in which the water expressed inwardly in the direction of the interior of the cylinder is maintained within the interstices of the foraminous surface of the cylinder by a backing plate in sliding contact with the interior of the surface of the cylinder.

14. An apparatus as in claim 12 in which the means for establishing an air flow at a low pressure differential in the second zone comprises a pressure chamber within said cylinder for applying pneumatic pressure to said web.

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