July 11, 1967 H. NISSER 3,330,723

PROCESS AND APPARATUS FOR THE PRODUCTION OF FIBROUS WEBS, ESPECIALLY FOR MAKING PAPER OR CARDBOARD

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Fig. 1

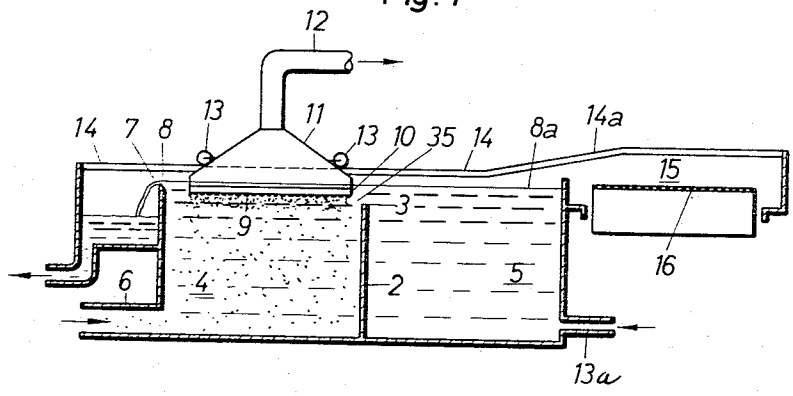
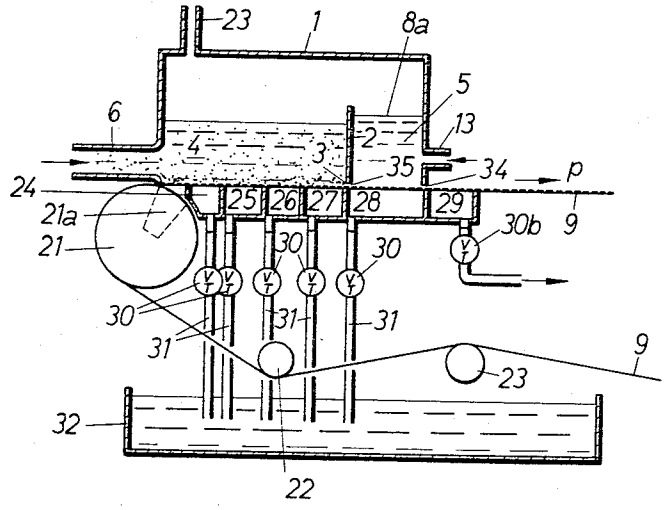


Fig. 2



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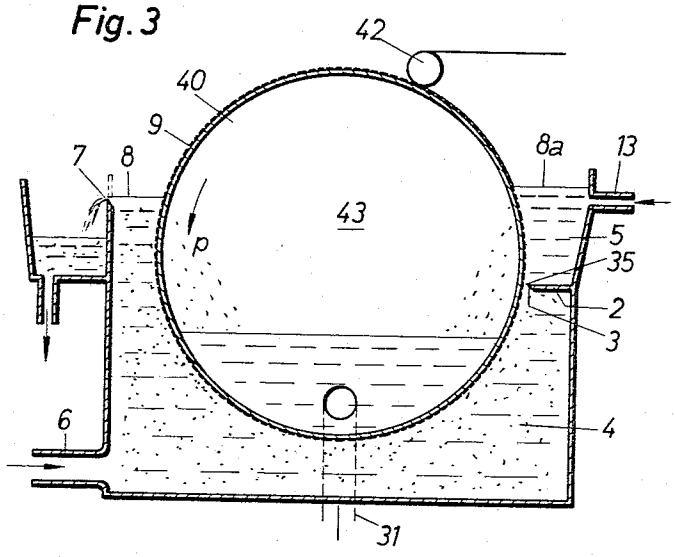
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Fig. 3



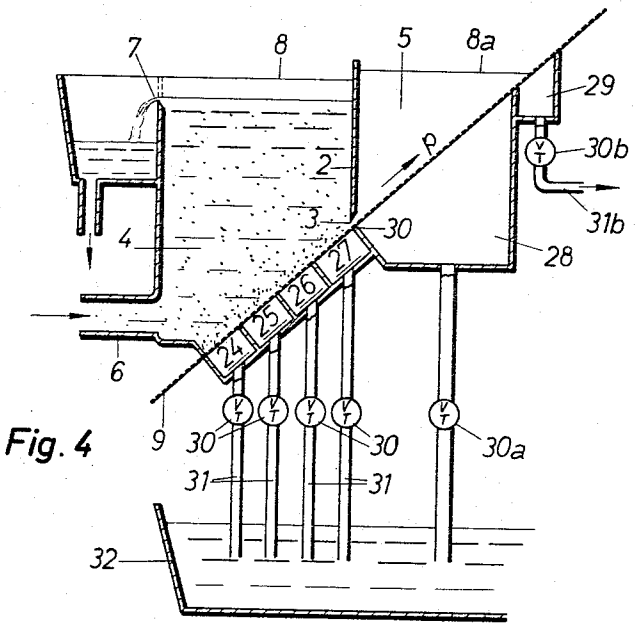


Fig. 4

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PROCESS AND APPARATUS FOR THE PRODUCTION OF FIBROUS WEBS, ESPECIALLY FOR MAKING PAPER OR CARDBOARD

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5 Claims. (Cl. 162—208)

The invention relates to a process for producing flat fibrous layers from fiber suspensions, by permitting the fibers to settle upon a pervious settling surface such as an endless screen or belt. The object of this invention is to prevent the formation of flocs on the side of the layer which faces away from the settling surface, such flocs being caused by the action of fluid currents or surface tensions of the fibrous suspension upon the settling fibers. A solution of this problem is important for the production of paper of uniform quality because the presence of such flocs would cause irregularities in the thickness of the paper.

It is known that greatly diluted suspensions of natural fibers in a liquid such as water, like the fibrous pulps used for paper making, will tend to flocculate as soon as fluid currents are formed in the suspension or as soon as capillary forces or surface tensions are developed at the surface of the newly formed web. This phenomenon occurs in all known paper making process as soon as the velocity of flow of the suspension falls below the limiting value known as the "flocculation velocity," or as soon as the height of the suspension above the pervious deposition surface has subsided to such an extent that the individual fibers in the remaining liquid are no longer able to move about freely and collect on the deposited layer on the side that faces away from the settling surface. In the latter case the fibers under the influence of surface tension clump together to form flocs which settle upon the web that has already been formed on the settling surface. While some portions of the surface of the suspension are covered by the flocs, other portions of the surface are substantially free from fibers and from the latter portions only few fibers will be deposited while from those portions which are covered with flocs there will be a heavy deposition of fibers. The resulting paperlike product will be of uneven thickness, giving the paper an uneven clouded appearance by transmitted light.

The problem of preventing the formation of such fibrous flocs during the production of sheetlike products from fibrous suspensions is solved according to this invention by a process in which the deposition of the fibers is effected in the suspension itself while the latter is kept in motion to prevent flocculation, while at the same time the settling surface is arranged at a distance from the boundary surfaces of the pulp-containing space sufficient to ensure free mobility of the fibers, the deposition of the fibers upon the settling surface being then ended, when the web has acquired the necessary thickness, by moving the settling surface together with fibrous web on it into a liquid that is free or substantially free from fibers while the surface and the web are kept immersed, and finally compacting the still immersed fibrous layer by a difference in pressure between the top of the layer and the bottom of the settling surface. The velocity of flow of the suspension, at least in the neighborhood of the settling surface, must be greater than the "flocculation velocity" of the fibers. The required minimum spacing between the settling surface and the boundary surfaces of the walls of the pulp-containing space is determined by the kind and length of the suspended fibers, the physical properties of the liquid component, and the nature of possible additives, as well as on the concentration of the suspension, and can be ascertained by experiments. The flat fibrous product, e.g. a paper web, has its individual fibers so thoroughly interlaced with one another after the compacting process that surface tensions or capillary forces which occur when the product leaves the liquid, will no longer be able to change the positions of the fibers relative to one another. A fibrous product produced by this method is free from the fibrous flocs that are caused by capillary forces, shearing forces or surface tensions in the known processes, and in comparison with the known products has a more uniform thickness, a more even distribution of fibers and completely uniform translucency.

The apparatus that is suitable for performing this process comprises a first container with a delivery conduit for the fresh suspension and with contrivances to keep the pulp at a constant level and in motion, the boundary surfaces and the settling surface having a minimum spacing that is sufficient to permit free movement of the individual fibers. There is also a second container connected with this first container by a communicating opening at least partly submerged in the liquid, the second container being filled with liquid of little or no fiber content. There is also at least one dewatering chamber with a liquid discharge conduit, the dewatering chamber or chambers being on one side of a pervious settling surface whose other side is in contact with the liquid in the first container, in the communicating opening and/or in the second container, the settling surface being movable from the first container through the communicating opening into the second container and then out of the latter, the settling surface being finally provided with means to maintain a pressure difference on the two sides thereof. The effect of this pressure difference is to draw liquid from the fibrous suspension through the settling surface.

The fibers of the suspension are deposited on the side of the settling surface which faces toward the container and are held to that surface by the pressure difference. As soon as a sufficient quantity of fibers has been deposited on the settling surface, the latter with its layer of fibers is moved through the communicating opening into the second container without the settling surface or its layer of fibers leaving the liquid. Such an emersion of the fibrous layers from the liquid would result in the immediate formation of flocs. Upon entering the second container the deposition of fibers on the pervious surface ceases because the liquid in the second container is practically fiber free. On the other hand, the fibrous layer now becomes more compacted by the pressure difference between the upper side of the fibrous layer and the lower side of the settling surface or by the force of the flowing liquid caused by this difference of pressure so that the individual fibers will no longer get separated from the fibrous layer or shift their positions inside the layer. Since the fibrous layer will now no longer be affected by changes of surface tension, the settling surface with the fibrous layer thereon can now be safely lifted out of the liquid. The fibrous web thus produced will retain exactly the same distribution of fibers that was acquired from the suspension in the first container in which the individual fibers until their moment of deposition were free to move in any direction. The fibrous product thus produced is not only uniformly translucent but has the same strength in all directions.

The drawings show several modifications of the apparatus used in this invention, the same reference characters being used to designate the same or corresponding parts.

FIGURE 1 shows an intermittently operated apparatus for the performance of the process of this invention.

FIGS. 2–4 show applications of the invention to continuously operating paper making machines where:

FIGURE 2 is a Fourdrinier paper making machine;

FIGURE 3 is a cylinder mold paper making machine; and

FIGURE 4 is an inclined-wire paper making machine.

In FIGURE 1 are shown two containers **4** and **5** of about equal size separated by an intermediate wall **2** with a free upper edge **3**. The container **4** at the left contains a fibrous pulp supplied by an inlet conduit **6**, the overflow escaping at **7**. In this manner the pulp in chamber **4** will be kept in sufficiently rapid motion to prevent floccing of the fibers. The container **5** at the right contains fiber free water or clear water supplied by conduit **13**. The container **5** is arranged adjacent to a downwardly opening chamber **15**. The free upper edge **3** of the intermediate wall **2** is below the level of any of the other upper edges of containers **4** and **5**. The liquid level **8** in container **4** is kept higher than the upper edge **3** of the intermediate wall **2**. In that manner a communicating liquid layer will be established in the passageway **35** between the fibrous pulp in container **4** and the fiber free water in container **5**.

A frame **10** which carries on its lower side a screen or pervious model **9** for the formation of the flat fibrous product is provided on its upper side with a hood **11** having an airtight connection therewith. Between the screen or model **9** and the boundary walls of the container **4** with the liquid level **8** therein, at least the minimum spacing is provided that is necessary to permit free movement of the individual fibers. The hood **11** has a conduit **12** connected to it, leading to a vacuum pump (not shown). The frame **10** can be transported from the container **4** to container **5** and from there to the chamber **15** on rollers **13***a* running on rails **14** that are mounted along the upper edges of containers **4** and **5**, and on the sidewalls of chamber **15**. These rails have inclined portions **14***a* for lifting the frame out of the liquid during its passage from container **5** to chamber **15**. Beneath the frame **15** there is a conveying device **16**.

The apparatus of FIGURE 1 operates in the following manner: The frame **10** with the screen **9** attached thereto is first positioned in the container **4**, dipping into the pulp which is kept in motion to prevent floccing of the fibers. The vacuum in the hood causes the liquid to pass through the screen **9** while a layer of fibers is formed on the bottom of the screen. The fibers are freely movable in the liquid until their deposition on the screen, since adequate space is provided between the screen and the boundaries of the container. This ensures a uniform deposition of the fibers.

As soon as a sufficiently thick layer of fibers has been deposited on the screen, the frame **10** is transported from container **4** to container **5** without being lifted from the liquid and while the hood is being kept under vacuum, while in container **5** the fibrous layer is compacted by the vacuum in the hood **11** while no additional fibers are being deposited because the liquid in container **5** is free or practically free from fibers and also because the fibrous layer on the screen is sufficiently dense to offer great resistance to the passage of liquid therethrough. Only very little water will therefore need to be introduced by the conduit **13**.

As soon as the fibrous layer on the screen **9** is sufficiently compact, the frame **10** is moved further along the rails **14** and along the upwardly inclined portion **14***a* into the chamber **15**. The fibrous layer is then separated from the screen **9** in a known manner, being allowed to drop upon the conveying device **16** for delivering the completed sheet to a drier (not shown).

In the modification of FIGURE 2 showing the head box and the wire part of a Fourdrinier paper making machine of this invention, the screen **9** is passed around a breast roller **21** and over other rollers, the drawing showing a deflecting roller **22** and a tensioning roller **23**.

The screen **9** is moved in the direction of the arrow *p* by a power driven roller (not shown). Above the screen is positioned a head box **1** which is closed except for its inlet and outlet conduits and which is divided by a separating wall **2** into two containers **4** and **5**. The screen **9** provides in relation to the boundary walls of the container **4** the required minimum free space that is necessary to permit free movement of the fibers. The lower edge **3** of the separating wall **2** is only slightly above the screen **9** and extends over its entire width so as to leave a communicating passageway **35** between containers **4** and **5**. The container **4** is supplied with fresh pulp by conduit **6** while the container **5** is supplied with water by conduit **13**. Care is taken to keep the pulp in container **4** in sufficiently rapid motion to prevent the fibers from flocculation. The liquid level **8***a* in container **5** is kept somewhat higher than the liquid level **8** in container **4** so that a small amount of fiber free water can flow from the container **5** into the container **4** in a direction opposite to the movement of the screen **9**. The heights of the liquid levels **8** and **8***a* in the containers **4** and **5** can be kept constant in a known manner by water level regulators or overflows, not shown in detail on the drawings. If necessary, the air space in head box **1** above the liquid levels **8**, **8***a* can be kept at above or below atmospheric pressure, depending on whether the conduit **23** is connected to a source of compressed air or to a vacuum.

Fitted closely to the underside of head box **1** are several dewatering chambers **24–28**, each discharging into a drain pipe **31** in series with a throttle valve **30**. The lower end of each drain pipe dips into the drained liquid in the tank **32** below the liquid level **33**. If necessary, a suction box **21***a* can also be positioned inside the breast roller **21**. By means of the throttle valves **30** the pressure in every drain pipe above its throttle valve and in its associated dewatering chamber can be regulated independently of the pressures in the other chambers, for example, by having the pressure become gradually less from the chamber **24** to the chamber **28**. The dimensions of the containers **4** and **5** in the direction of movement *p* of the screen **9** is determined by the nature of the pulp, the pressure conditions in the head box **1** and in the chambers **24–28** and also on the operating speed of the machine. With a given density of the pulp and a given velocity of the screen, the pressure differences between head box **1** and the individual chambers **24–28** are established in such a manner that by passage of the screen **9** under the lower edge **3** of the intermediate wall **2** the desired basic weight of the paper will be obtained.

The fibrous layer that has been deposited on the screen **9** is covered in container **5** with practically fiber free water and is compacted by a sufficient difference of pressure. In that manner a solidly compacted web is produced whose structure is able to resist the effect of surface tension. This compacted web leaves the head box **1** at the place **34** and is then passed over the suction box **29** which is provided with a conduit **31***b* in series with a throttle valve **30***b* and connected to a suction pump (not shown). The clear water which is carried out by the compacted web is drawn off by the suction box **29**. The compacted web is then further dewatered as in the known paper making machines, either by means of additional suction chambers or by table rolls or other suction devices, is then brought to a press section and finally to a drier section to obtain the desired dryness. These devices, however, are not shown on FIGURE 2 as they do not differ from those generally used for such purposes.

In the cylinder mold paper making machine shown in FIGURE 3, a cylinder **40** on which is stretched a screen **9** is rotated by a motor (not shown) while dipping into a container **4** with fresh fibrous pulp delivered to this container by conduit **6**. The liquid level **8** in the container **4** is kept constant by an overflow **7** where excess pulp is allowed to escape, the pulp in container **4** being kept in

motion thereby to prevent flocculation of the fibers. Between the screen 9 and the boundary walls of the container 4 there is sufficient space to permit the fibers to move about freely. Since the fluid pressure inside the cylindrical screen 9 is lower than the fluid pressure outside, liquid from the pulp will pass into the inside 43 of the cylinder mold 40 from where it will be removed by the discharge conduit 31 while the fibers will be deposited on the outside of the screen 9. During rotation of the cylinder mold 40 the passage of the screen 9 through the pulp in the container 4 will cause an endless layer of fibers to be deposited on the screen and will adhere tightly to the latter until it is removed by the take-off roller 42 near the top of the screen.

Between the container 4 and take-off roller 42 at the ascending side of the cylinder mold 40, a portion of the periphery of the screen is covered by a second container 5 which is filled with clear or fiber free water and which is separated from the first container 4 by a separating wall 2. The edge 3 of the wall which is adjacent the cylinder mold 40 is spaced only slightly from the screen 9, leaving a communicating passageway 35 between containers 4 and 5 through which a small amount of clear or fiber free water can pass from the the container 5 into the container 4. For this purpose the liquid level 8*a* in container 5 is kept higher than the liquid level 8 in container 4. The clear or fiber free water is supplied to container 5 by conduit 13. In consequence of the relatively greater pressure acting upon outside of the fibrous layer than from the inside of the cylinder mold 40, the fibrous layer will be compressed and compacted and will emerge from the clear or fiber free water in container 5 in that condition on its way to the take-off roller 42.

In the machine of FIGURE 4 with the inclined screen, the containers 4 and 5 are arranged in the same manner as in FIGURE 3. The endless screen 9 in FIGURE 4 is moved in an inclined upward direction *p* under the pulp filled container 4 which is open toward the screen. Fresh pulp is supplied to the container 4 by conduit 6 while the excess escapes across the overflow 7. In that manner the pulp in container 4 is kept in motion sufficiently to prevent flocculation while the liquid level 8 in container 4 is kept at a constant height. Between the screen 9 and the boundary walls of container 4 sufficient free space is provided to permit free movement of the fibers.

At the lower side of that portion of the screen 9 which is covered by container 4, dewatering chambers 24–27 are arranged, each being provided with a discharge conduit 31 in series with a throttle valve 30. The lower ends of these conduits dip into the container 32 for receiving the screened water. Because of the pressure differences between the fibrous layer on the upper surface of the screen and the suction chambers 24–27, the liquid will pass from the pulp container 4 through the screen and into the dewatering chambers 24–27. The fibers that are contained in this liquid will thereby be deposited on the upper side of the screen 9. The fibrous web which is formed during the passage of the screen 9 between the container 4 and the dewatering chambers 24–27, while kept covered with liquid, is moved under the lower edge 3 of the separating wall 2 between the containers 4 and 5 and into the container 5 that is filled with clear or fiber free water where the fibrous web will be under a greater pressure difference resulting on the one hand from the height of the liquid level in container 5 above the screen and on the other hand from the vacuum in the suction chamber 28 beneath the container 5. This vacuum is maintained for example by a throttle valve 30*a* in the liquid discharge pipe 31*a*. The fibrous web which has been compacted in the container 5 and has been rendered insensitive to capillary forces and surface tensions is carried away by the screen 9 across a suction chamber 29 whose portion adjacent the open upper side of the dewatering chamber 28 is covered by the clear or fiber free water in the container 5. The suction chamber 29 is connected to a suction air pump (not shown) through a conduit 31*b* containing a throttle valve 30*b* and serves to draw off the water that is carried along from the container 5 by the fibrous web and the screen 9. The fibrous web is then carried by the screen 9 to the subsequent dewatering devices (not shown).

It will be understood that this invention is susceptible to modification in order to adapt it to different usages and conditions and, accordingly, it is desired to comprehend such modifications within this invention as may fall within the scope of the appended claims.

What is claimed is:

1. A method of producing fibrous webs such as paper and cardboard and the like from flowable fibrous pulp by causing fibers to settle from the pulp on a pervious settling surface which comprises; placing the settling surface in a pulp container with ample distance between the settling surface and the boundary wall of the container to permit free movement of the pulp and fibers relative to said settling surface, continuously supplying pulp to said container near the bottom thereof and continuously overflowing pulp from said container near the top thereof to keep the pulp in motion in the container and prevent flocculation of fibers therein, maintaining a pressure differential between the pulp side of said settling surface and the opposite side thereof to cause liquid of the pulp to pass through said surface and fibers of the pulp to settle on said surface, continuing the deposition of fibers on said settling surface in said pulp container until the desired thickness of fibrous layer has been built up on said surface, maintaining fiber poor liquid in a second container communicating with said pulp container at one region thereof so there is a continuous liquid path between said containers, moving the said surface when the required thickness of fibrous layer is built up thereon from said pulp container to said second container along said liquid path and while keeping the fibrous layer bearing side of said surface immersed in said liquid, maintaining a pressure differential between the liquid side of said surface and the opposite side thereof in said second container to cause said liquid in said second container to compact the fibrous layer on said surface, moving the surface out of said second container and out of said liquid, and removing the compacted fibrous layer from said surface while said surface is removed from both containers.

2. The method according to claim 1 in which said pervious settling surface is in the form of an endless member and is moved continuously in the direction from said pulp container to said second container and then out of said second container and then back into said pulp container.

3. An apparatus for making fibrous webs such as paper and cardboard and the like by the deposition of fibers from a flowable fibrous pulp on a pervious settling surface comprising; a pulp container having boundary walls, a pervious member in said container having means defining said pervious surface, said member being spaced from said boundary walls a sufficient distance to permit free circulation of the pulp in said container to prevent flocculation of fibers in said container, means for continuously supplying pulp to said container near the bottom thereof, and overflowing pulp from said container near the top thereof to keep the pulp in motion in the container, means to maintain a pressure drop across said member from the pulp side thereof to the opposite side to cause liquid flow through said member and deposition of fibers thereon, a second container immediately adjacent said first container and containing fiber poor liquid at a level at least equal to the level of the pulp in said pulp container, means for moving said member along a predetermined path from said pulp container to said second container, means providing liquid communication between said containers along said path so the fibrous layer side of said member will remain immersed in liquid during its travel from said pulp container to said second container, means for main-

taining a pressure drop from the fibrous layer side of said member to the opposite side thereof in said second container to cause the liquid in said second container to compact the fibrous layer on said surface, and means for moving said member out of said second container and out of said liquid to a region of separation of the compacted fibrous layer from said surface.

4. An apparatus according to claim 3 in which said member is endless and is adapted to move continuously from said pulp container to said second container and then out of said second container to said region of separation and finally back into said pulp container.

5. An apparatus according to claim 4 in which the liquid level in said second container is maintained at a higher level than the level of the pulp in said pulp container.

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