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Hill

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[54] **PAPERMAKING MACHINE HEADBOX WITH MULTIPLE STIFF, VIBRATIONAL RODS OR PLATES EXTENDING DOWNSTREAM IN THE SLICE CHAMBER**

[75] Inventor: **Lester M. Hill,** Beloit, Wis.

[73] Assignee: **Beloit Corporation,** Beloit, Wis.

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[52] **U.S. Cl.** **162/216,** 162/341, 162/343
[51] **Int. Cl.** **D21f 1/02**
[58] **Field of Search** 162/341, 343, 336, 162/216

[56] **References Cited**

UNITED STATES PATENTS

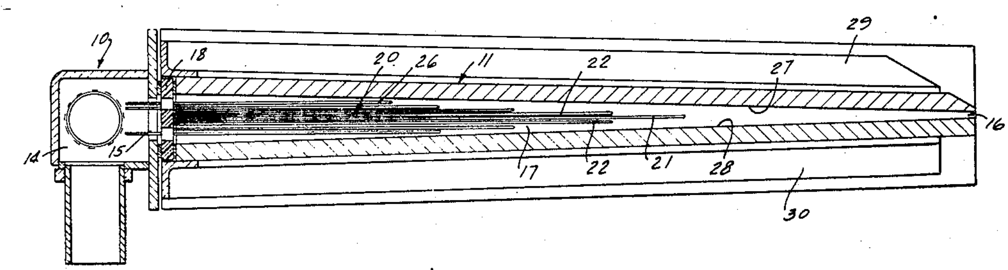
3,607,625	9/1971	Hill et al.	162/343
3,220,919	11/1965	Parker et al.	162/343
3,236,725	2/1966	Goldsmith	162/343 X

Primary Examiner—S. Leon Bashore
Assistant Examiner—Richard H. Tushin
Attorney—Hill, Sherman, Meroni, Gross & Simpson

[57] **ABSTRACT**

A headbox structure for feeding a slurry of stock onto a traveling forming surface for a paper making machine including a tapering slice chamber with cantilever supported self-supporting, self-exciting vibrational rods or plates cantilever supported at their upper end and extending in a downstream direction within the slice immediately ahead of the slice opening and operational to reduce the network strength between the fibers as they are delivered onto the traveling forming surface.

11 Claims, 4 Drawing Figures



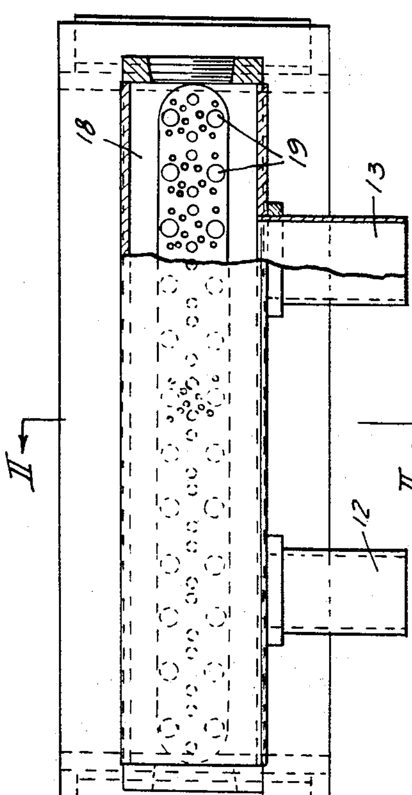


Fig-1

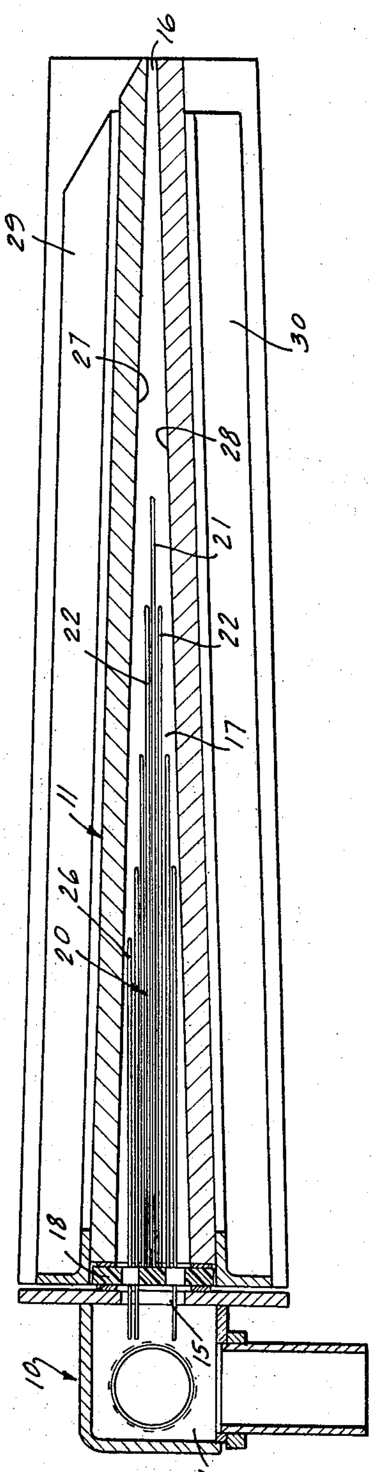


Fig-2

INVENTOR.
LESTER M. HILL

BY Hill, Sherman, Meroni, Gross & Simpson ATTORNEYS

Fig. 3

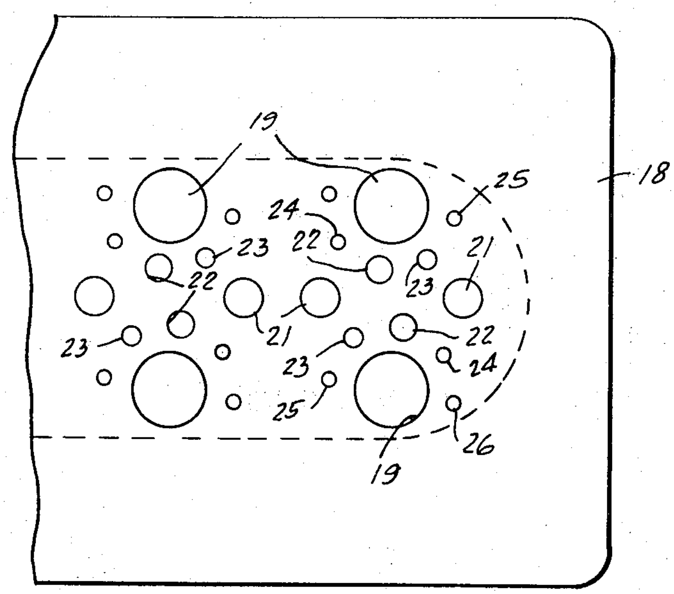
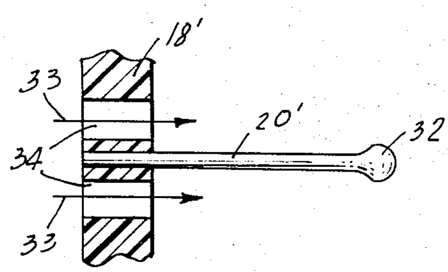


Fig. 4



INVENTOR.
LESTER M. HILL

BY Hill, Sherman, Meroni, Gross & Simpson ATTORNEYS

PAPERMAKING MACHINE HEADBOX WITH MULTIPLE STIFF, VIBRATIONAL RODS OR PLATES EXTENDING DOWNSTREAM IN THE SLICE CHAMBER

BACKGROUND OF THE INVENTION

The invention relates generally to an improved structure and method for improving the uniform dispersion of fibers on a paper web formed on the traveling forming surface by assuring stability of the dispersion of the fibers as they flow through the slice opening.

In commercial paper making processes involving delivery of flowing stock from a headbox through a slice opening onto a traveling forming surface, such as, a fourdrinier wire, the principal objective in achieving uniform formation of a paper web is the prevention of the natural tendency of the fibers to flocculate. Flocculation obviously causes nonuniformity with its inherent disadvantages including nonuniform appearance, nonuniform thickness, nonuniform increaseptivity and so forth. In all commercial paper making machines such as of the fourdrinier type, means are provided to insure dispersion of the fiber networks throughout travel of the stock through the headbox. This dispersion is generally effected by generating turbulence in the fiber suspension both in the headbox and on the fourdrinier surface. Uniform dispersion of the fibers is achieved through turbulence in the headbox and the continued uniform dispersion must be maintained to avoid this natural tendency toward flocculation. On the fourdrinier surface the drainage is deliberately retarded to allow sufficient treatment of the undrained suspension to obtain uniform formation. On a fourdrinier machine in which the table rolls have been replaced by suction boxes, the fiber suspension is drained comparatively much more rapidly with considerably less activity generated in the undrained stock suspension which forms the web. Thus, the formation of the sheet formed on the suction box or flat box fourdrinier is much more sensitive to the condition of the stock as it is discharged from the headbox than with a conventionally formed sheet. It is essential and of importance that when delivery of the stock is occurring uniformly and without flocculation through the headbox, that flocculation not be permitted to occur at any point during delivery particularly when the large scale turbulence generated in the headbox degenerates as the stock flows through the slice chamber and the slice opening onto the wire.

As flow conditions change as the stock flows from the headbox through the slice and out through the slice openings, the effect of the turbulence in the box changes and flocculation tends to occur. If uniform dispersion within the headbox can be maintained, the tendency to flocculate will be defeated. It is proposed in the present invention to defeat this tendency to flocculate. It is believed that this flocculation tendency is caused by various phenomenon including the fiber-to-fiber friction between the fibers. This friction may be referred to as network strength and if the network strenght can be reduced, uniform dispersion without flocculation and maintenance of uniform dispersion can be accomplished.

It is accordingly a general and overall objective of the present invention to provide a method and apparatus for reduce the network strength between fibers as they flow through the slice chamber immediately before flowing out of the slice opening so that uniform dispersion is maintained and the tendency to flocculate is reduced.

A further object of the invention is to provide an arrangement for reducing the network strength between fibers just as the stock is delivered onto the traveling fourdrinier surface so that the generation of large scale turbulence within the headbox which was heretofore thought necessary in order to maintain turbulence in the stock as it was delivered onto the wire becomes unnecessary.

In further explanation of the last objective above recited, a limitation in headbox has been that the means for generating turbulence in fiber suspension in order to disperse them has generally been by comparatively large scale devices. With such devices it is possible to develop small scale turbulence by increasing the intensity of the turbulence generated. The turbulent energy is transferred from large to small scale, and the higher the intensity, the greater the rate of energy transfer and the smaller the scale of turbulence sustained. However, a detrimental effect results from the high intensity of large scale turbulence in that large waves and free surface disturbances developed on the fourdrinier surface. It has been felt that in headbox performance that the degree of dispersion and level of turbulence are closely relate, i.e., the higher the turbulence the better the dispersion. In selecting a headbox design in accordance with the foregoing, the paper machine designer chose a design which he felt obtained maximum turbulence and dispersion without entering the area of the disadvantageous effects of disturbance of the formation of the web on the fourdrinier surface. That is, an objective of headbox design has been to generate a level of turbulence that was high enough for dispersion, but low enough to avoid free surface defects during the formation period.

In attempting to achieve the headbox design between the limiting criteria of obtaining sufficient turbulence to avoid flocculation and yet not obtain excessive turbulence which would disturb paper formation, it is necessary to arrive at a compromise design and one which may not achieve optimum paper formation under all roll conditions and under all stock consistencies. The defects in sheet formation as a result of the extremes in headbox design, i.e., very high or very low turbulence are even more marked where a fourdrinier is used with all table rolls and foils replaced by suction boxes. Thus, when the turbulence is very low, as for example in the discharge from a conventional rectifier roll type headbox, the formation of the sheet formed by the rapid drainage over the suction boxes in the absence of table roll activity directly reflects the poor dispersion in the discharge jet. On the other hand, when the turbulence is very high, a wave pattern is generated in the free surface of the flow on the wire as a consequence of the turbulence. With the rapid drainage of the suspension in this case, the formation of the sheet reflects the mass distribution pattern of these waves. In addition to the free surface wave patterns, excessive turbulence may also entrain air and disrupt the thickened fiber mat which have been deposited, and cause formation defects.

Thus, by reducing the network strength between fibers in the slice chamber in accordance with the present invention, the production of excessive large scale turbulence that is sufficiently large to prevent complete degeneration of turbulence to flow all the way through the slice chamber and the slice opening onto the wire is avoided and the minimum requirement is that the turbulence be sufficient so that dispersion is maintained and flocculation does not occur by the time the stock gets to the slice chamber. It will be apparent that the analysis and study of the exact characteristics and behavior of the individual stock fibers as they flow at relatively high speed from the headbox onto the wire is very difficult so that some theorizing must be done, but the beneficial results of the practice of the instant invention are consistent with the foregoing theoretical explanation and the advantages are present and obtained.

It is, therefore, a further object of the present invention to provide a device for generating self-vibration or spontaneous vibration within the stock immediately as it exits from the slice opening so that fiber-to-fiber friction is reduced and network strength is reduced maintaining dispersion of the fibers as they exit from the slice opening and maintaining their dispersion on the fourdrinier forming surface.

Additional objects, advantages and features will become more apparent with the description of the preferred embodiments of the invention in connection with the specification, claims and drawings, in which:

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a rear elevational view of a headbox structure constructed and operating in accordance with the present invention with a portion broken away for purposes of description:

FIG. 2 is a vertical sectional view taken substantially along the line II—II of FIG. 1;

FIG. 3 is an enlarged fragmentary elevational view of a portion of the structure of FIG. 1; and

FIG. 4 is an enlarged fragmentary sectional view showing a form of vibrating member.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In the structure illustrated, the stock is first delivered to a headbox chamber **14** through stock inlet lines **12** and **13** from a suitable stock delivery source. The source will be provided by the usual structure including fan pumps which provide the stock under sufficient controllable flow volumes and pressure to deliver to a traveling fourdrinier surface at the required velocity. The headbox chamber **14** is small relative to the usual chamber, and it will be understood that the size illustrated is not to be limiting, but any size may be provided which provides stock flow at sufficient turbulence so that dispersion will be maintained as the stock enters the slice unit **11.**

The slice unit has a slice chamber **17** with an inlet end **15** and a slice opening **16.** The chamber is defined by an upper wall **27** and a lower wall **28** and the structure is suitably supported and reinforced such as by members **29** and **30.**

As will be apparent, stock is furnished through the inlet lines **12** and **13** into the headbox **14** whereupon it flows into the slice chamber **17** and out through the slice opening **16** onto a traveling fourdrinier. The slice chamber **17** is tapered from its entry end **15** to the slice opening **16,** and as the stock exits through the opening, it flows at the desired velocity relative to the travel of the fourdrinier wire. Means, not shown, may be provided to relatively move the walls **27** and **28** to control the size of the slice opening **16.**

Within the slice chamber **17** are a plurality of separate vibrational self-exciting thin elongate rod members **20.** These members are cantilever supported at their upper ends and extend downstream in the general direction of stock flow, preferably parallel to each other. They have sufficient stiffness to be sulf-supporting. It has been discovered that cantilever elongate rods constructed in this fashion will be self-exciting due to the flow of stock along their surface in an elongate slice as illustrated. This self-excitation occurs as soon as the stock beings to flow and the excitation is transmitted to the stock and the fibers reducing the fiber-to-fiber friction, which in turn reduces the network strength and attains dispersion throughout travel through the slice and continues its effect onto the wire. This self-excitation will occur at the natural frequency of the rod members, and they are surrounded by the water which is the carrier for the fibers of the stock. The self-excitation will be uniformly felt throughout the slice chamber and will not materially effect the small scale turbulence which remains in the stock flow due to its turbulence within the headbox and will not cause secondary flow patterns to deteriorate the flow stream. The excitation will occur at the natural frequency of the rods which can be expressed by the conventional formula $f = \sqrt{k/m}$ where k is the spring constant and m is the mass of the rod members. While the preferred form embodies individual rods self-supporting sheets or plates will also work. These plates can be of substantially narrow width, which is preferred, or can be of increasing wider width to the degree where they extend completely across the slice.

The structure for providing the cantilever support for the rod members **20** is shown as a plate **18** having openings **19** therethrough for admitting the flow of stock. The openings are shown in the form of circular holes which are generally uniformly distributed across the plate. In the arrangement shown the holes are arranged in upper and lower rows, and while the rod members are substantially randomly distributed across the slice this random distribution is achieved by an organized arrangement of the rods relative to the holes.

Although the rods **20** may be each of uniform size, in a preferred arrangement as shown, the rods centrally spaced between the upper and lower walls **27** and **28,** are larger and the successive rods spaced outwardly toward the walls are of increasing size.

The central rods **21** are also longer than the joining rods proceeding towards the upper and lower walls of the slice chamber **17.** The length of the rods is chosen so that they do not engage the surfaces of the walls **27** or **28,** and there is an increasing space between the ends of the rods and the walls in a downstream direction. The rods are preferably of uniform thickness throughout each of their lengths. However, they may also be shaped and may be round, flat, curved or spiralled. However, a preferred shape is shown in FIG. **4.**

The central rods **21,** FIG. **2,** are arranged in a row extending horizontally across the center of the plate **18.** The remainder of the rods are arranged with their centers positioned on circles swung from the centers of each of the holes **19.** The largest rods of the groups surrounding each of the holes **19** are positioned closest to the center of the slice chamber **17.** Thus, as illustrated in FIG. **3,** the rods **22** are the largest of each of the groups positioned around the holes **19** and are placed slidably above and below the center row of rods **21.** The next largest group of rods is shown at **23** positioned outwardly from the rods **22.** The next largest is **24,** and these are positioned outwardly from the rods **23.** The remaining rods **25** and **26** are for convenience of the same size as the rods **24.**

FIG. 4 illustrates a preferred form of rod **20'** which is cantileverally supported on the wall **18'.** Flow holes **34** surround the rod with the direction of flow being shown by the arrows **33.** The rod functions in operation as a vibrating member, and for enhancing this motion, it is provided with an enlarged or bulbous end **32.** A pressure wave or sonic field is generated in the liquid paper stock by the rod **20'** whose vibration is excited by the flow of the suspension passing them. The vibration of the element is excited by the separation of the flow by the flared tip **32.** The vibratory movement of the members **20'** enhance dispersion as above stated.

The rods must be sufficiently long with respect to their diameter to obtain the self-excitation and must not be so long as to be self-supporting. An example of a small slice arrangement constructed in accordance with the invention is as follows:

Slice chamber length:	2' 9"
Slice chamber width:	19½"
Slice opening:	¼"
Slice depth at entry end:	3⅞"
Diameter of entry openings **19**:	½"
Distance from center of entry openings **19** to center of rods **22, 23, 24** and **25**:	⅞"
Rods **21**:	¼" diameter
Rods **22**:	3/16" diameter
Rods **23**:	⅛" diameter
Rods **24** thru **26**:	3/16" diameter
Angular spacing between rods **22** thru **26**:	45°
Distance between rods **21**:	1"
Distance between openings **18**:	1½"
Length of rods **21**:	21"
Length of rods **22**	18"
Length of rods **23**:	14"
Length of rods **24**:	11"
Length of rods **25** and **26**:	9"

Thus, I have provided a structure ane method which greatly aids uniformity of web formation. As turbulence decays in the slice chamber, small flocks leading to the formation of large flocks will be prevented and will not occur.

I claim:

1. In a headbox structure for feeding a slurry of stock onto a traveling forming surface, the combination comprising, means defining a slice chamber having an entry end leading to the chamber and a discharge slice opening for conducting a stock formed of a dispersion of fibers in a liquid carrier onto a traveling forming surface, a stock headbox supply connected to the entry under the slice for delivering the stock uniformly across the width of the slice chamber, a plurality of separate self-exciting thin elongate vibrational members extending downstream in the slice chamber in the direction of flow and cantilever supported at their upper ends having sufficient rigidity so that their general position is independent of stock flow to be self-supporting along their entire length so that the members vibrate with the flow of stock through the slice chamber and reduce the network strength between the stock fibers, and support means in the slice chamber forming a cantilever support for the upstream ends of each of said members.

2. In a headbox structure for feeding a slurry of stock onto a traveling forming surface constructed in accordance with claim **1** wherein said self-exciting members are of different lengths.

3. In a headbox structure for feeding a slurry of stock onto a traveling forming surface constructed in accordance with claim **1** wherein certain of said self-exciting members are of a different thickness than others.

4. In a headbox structure for feeding a slurry of stock onto a traveling forming surface constructed in accordance with claim **1,** the combination wherein said support means is in the form of a plate extending across the entry end of the slice chamber and a plurality of flow openings are provided through said plate for the flow of stock from the headbox to the slice chamber.

5. In a headbox structure for feeding a slurry of stock onto a traveling forming surface constructed in accordance with claim **4,** the combination wherein certain of said members are arranged in an annular pattern each around said openings on the plate and the openings are substantially circular.

6. In a headbox structure for feeding a slurry of stock onto a traveling forming surface constructed in accordance with claim **1,** the combination wherein said members comprise rods which are substantially circular in cross-section and are of uniform thickness along their length.

7. In a headbox structure for feeding a slurry of stock onto a traveling forming surface constructed in accordance with claim **1,** the combination wherein said slice chamber is uniformly tapered to be of maximum height at the entry end and of minimum height at the slice opening.

8. In a headbox structure for feeding a slurry of stock onto a traveling forming surface constructed in accordance with claim **7,** the combination wherein certain of said members are of different length and the members adjacent the upper and lower walls of the slice chamber are of less length than the members therebetween.

9. In a headbox structure for feeding a slurry of stock onto a traveling forming surface constructed in accordance with claim **8,** the combination wherein the length of the members is such that the distance from the tips of different members to the upper and lower walls of the slice decreases in a downstream direction.

10. In a headbox structure for feeding a slurry of stock onto a traveling forming surface constructed in accordance with claim **1** wherein said vibrational members have an enlarged bulbous end.

11. The method of reducing the network strength between fibers in a stock slurry of dispersed fibers in a liquid carrier being fed from a headbox onto a traveling forming surface through a slice chamber which comprises positioning a plurality of thin self-supporting, self-exciting vibrational members having sufficient rigidity so that their general position is independent of stock flow and being self-supporting along their entire length in the slice chamber immediately ahead of the slice opening, and supporting them cantileverly at their upstream ends to extend substantially parallel to the flow in a downstream direction so that they vibrate and reduce said network strength.

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