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3,135,650	6/1964	Robinson et al.	162/343 X
3,272,233	9/1966	Truffitt	162/336 X
2,832,268	4/1958	Boone et al.	162/343

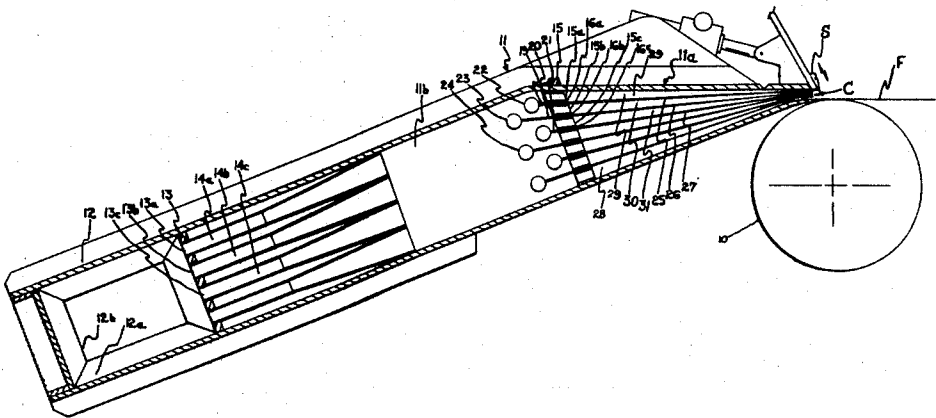
FOREIGN PATENTS

236,864	7/1925	Great Britain	162/343
1,026,276	4/1966	Great Britain	162/343

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[54] **HEADBOX**
14 Claims, 17 Drawing Figs.
[52] U.S. Cl. **162/343**
[51] Int. Cl. **D21f 1/02**
[50] Field of Search **162/336,**
338, 339, 343, 346, 347
[56] **References Cited**
UNITED STATES PATENTS
2,394,509 2/1946 Boettinger **162/343**

ABSTRACT: A headbox construction for a papermaking machine which comprises a slice chamber connected to a preslice flow chamber by means of a perforate member. The slice chamber contains a plurality of plates and/or filaments attached to said perforate member and extend in the direction of stock flow through said slice chamber and define therein a multiplicity of relatively narrow channels of decreasing cross-sectional area in the direction of flow.



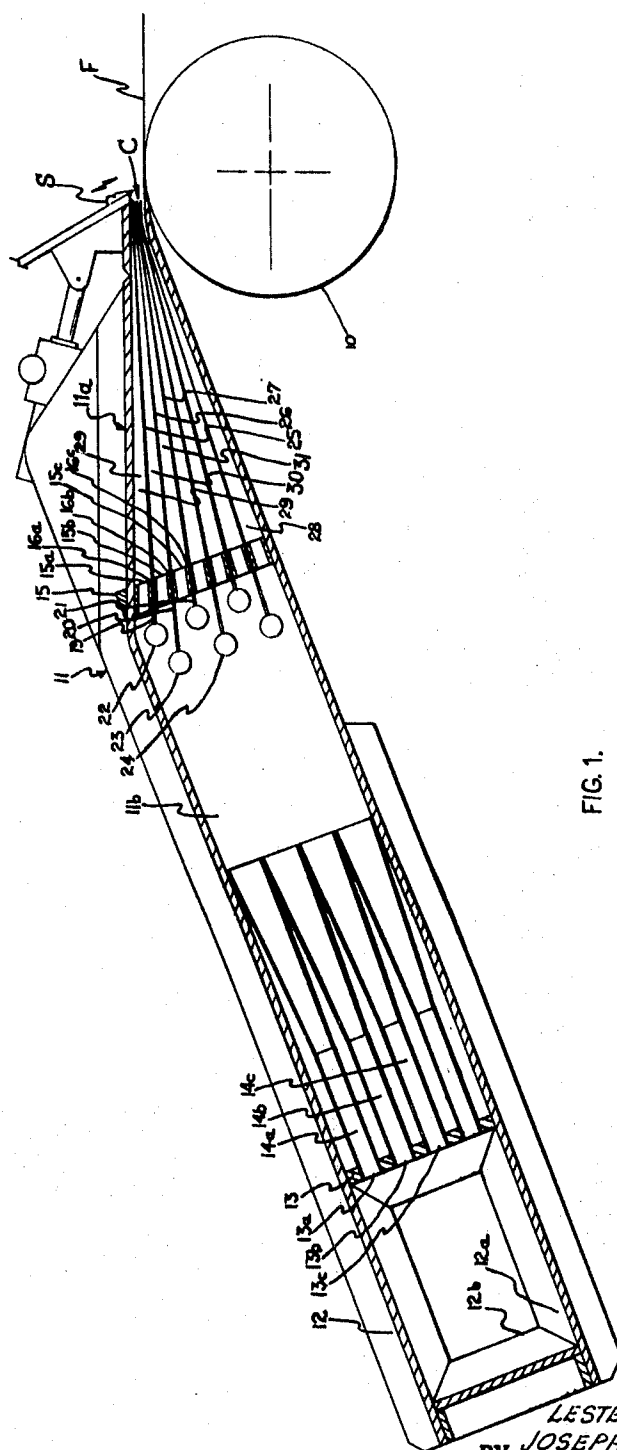
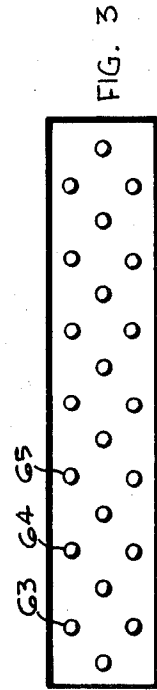
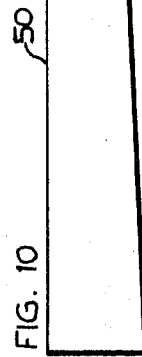
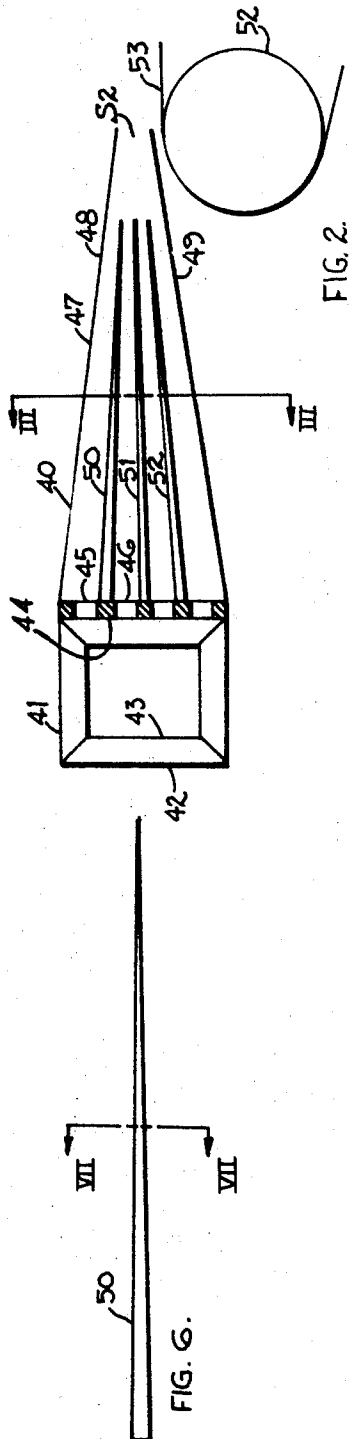


FIG. 1.

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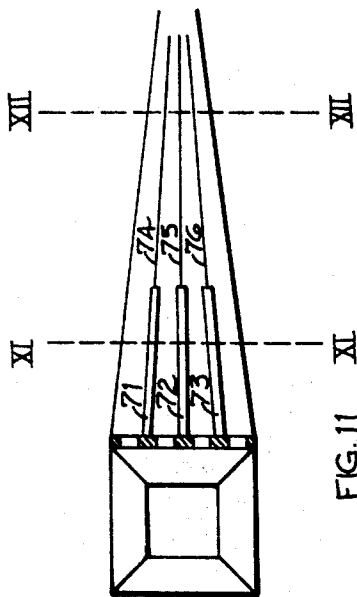


FIG. 11

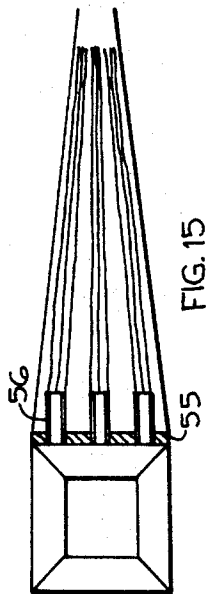


FIG. 15



FIG. 12

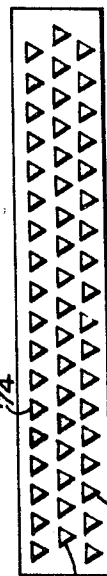


FIG. 13

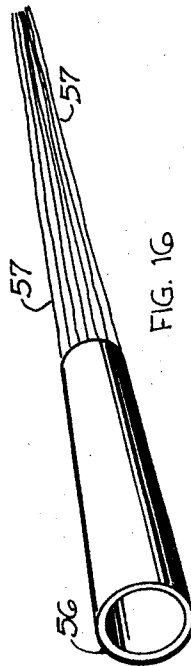


FIG. 16

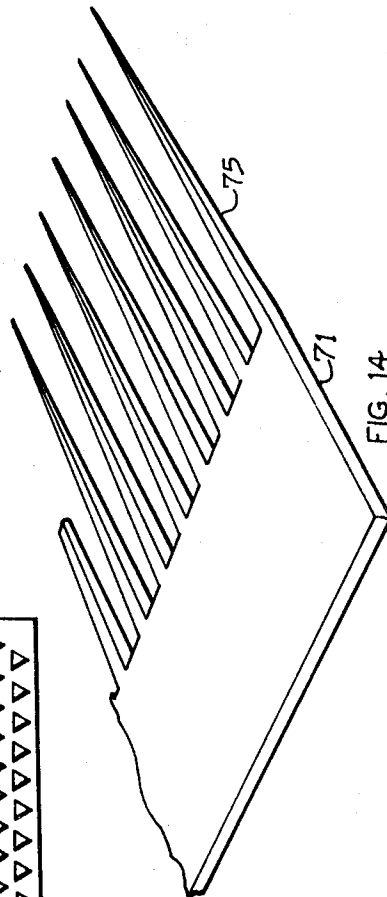


FIG. 14

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HEADBOX

This invention relates generally to a headbox for a paper-making machine, and more particularly to a headbox construction in which the slice chamber includes a plurality of passages formed by elements in the direction of stock flow to uniformly direct stock towards the slice opening at the downstream of said slice chamber.

In the Fourdrinier papermaking process, the principal difficulty in achieving uniform formation of a paper web is the natural tendency of the fibers to flocculate. An important feature of all Fourdrinier machine designs therefore is a means to disperse the fiber networks during the period of sheet formation. At the present time, dispersion of the fiber network is effected by generating turbulence, used in the broad sense, in the fiber suspension both in the headbox, frequently through the use of rectifier rolls, and on the Fourdrinier table as a consequence of the reaction of the free surface of the stock to the variable acceleration over table rolls and foils. The dispersing activity that occurs on the Fourdrinier table is an important supplement to the turbulence generated in the headbox and as a rule, the drainage on a Fourdrinier table is deliberately retarded to allow sufficient treatment of the undrained suspension to obtain uniform formation. On a Fourdrinier in which the table rolls have been replaced by suction boxes, on the other hand, the fiber suspension is drained comparatively much more rapidly with considerably less activity generated in the undrained suspension. It follows that the formation of the sheet formed on a suction box or flat box Fourdrinier is much more sensitive to the characteristics of the headbox discharge than that of a conventionally formed sheet.

A basic limitation in headbox design has been that the means for generating turbulence in fiber suspensions in order to disperse them have been comparatively large-scale devices only. With such devices, it is possible to develop small scale turbulence by increasing the intensity of turbulence generated. Thus the turbulence energy is transferred naturally from large to small scales and the higher the intensity, the greater the rate of energy transfer and hence, the smaller the scales of turbulence sustained. However, a detrimental effect also ensued from this high-intensity large-scale turbulence namely the large waves and free surface disturbance developed on the Fourdrinier table. Thus a general rule of headbox performance has been that the degree of dispersion and level of turbulence in the headbox discharge were closely correlated; the higher the turbulence, the better the dispersion.

In selecting a headbox design under this limiting condition then, one could choose at the extremes, either a design that produces a highly turbulent, well-dispersed discharge, or one that produces a low-turbulent, poorly dispersed discharge. Since either a very high level of turbulence or a very low level (and consequent poor dispersion) produces defects in sheet formation on the Fourdrinier machine, the art of headbox design has consisted of making a suitable compromise between these two extremes. That is, a primary objective of headbox design up to this time has been to generate a level of turbulence which was high enough for dispersion, but low enough to avoid free surface defects during the formation period. It will be appreciated that the best compromise would be different for different types of papermaking furnishes, consistencies, Fourdrinier table design, machine speed, etc. Thus a universal headbox design with presently available devices and techniques would be difficult, if not impossible to establish. Furthermore, because these compromises always sacrifice the best possible dispersion and/or the best possible flow pattern on the Fourdrinier wire, it is deemed that there is a great potential for improvement in headbox design today.

The defects in sheet formation as a result of these extremes in headbox design, i.e., very high or very low turbulence, are even more marked when an a Fourdrinier is used wherein all table rolls and foils are 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 suction boxes

in the absence of the 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 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 had been deposited earlier and cause formation defects.

Thus not only are the present extremes of headbox characteristics unsuitable, but it is also difficult to find a suitable compromise for a suction box Fourdrinier application.

The unique and novel combination of elements of the present invention provide for delivery of the stock slurry to a forming surface of a papermaking machine having a high degree of fiber dispersion with a low level of turbulence in the discharge jet. Under these conditions, a fine scale dispersion of the fibers is produced which will not deteriorate as the turbulence decays away; at least it will not deteriorate to the extent that occurs in the turbulent dispersions which are produced by conventional headbox designs. It has been found that it is the absence of large-scale turbulence which precludes the gross reflocculation of the fibers since flocculation is predominately a consequence of small scale turbulence decay and the persistence of the large scales. Sustaining the dispersion in the flow on the Fourdrinier wire then, leads directly to improved formation.

The method by which the above is accomplished, that is, to produce fine scale turbulence without large scale eddies, is to pass the fiber suspension through a system of parallel channels of uniform small size but large in percentage open area. Both of these conditions, uniform small channel size and large exit percentage open area, are necessary. Thus the largest scales of turbulence developed in the channel flow have the same order of size as the depth of the individual channels and by maintaining the individual channel depth small, the resulting scale of turbulence will be small. It is necessary to have a large exit percentage open area to prevent the development of large scales of turbulence in the zone of discharge. That is, large solid areas between the channel's exits, would result in large-scale turbulence in the wake of these areas.

In concept then, the flow channel must change from a large entrance to a small exit size. This change should occur over a substantial distance to allow time for the large-scale coarse flow disturbances generated in the wake of the entrance structure to be degraded to the small-scale turbulence desired. The walls defining the channels immediately following the entrance structure should be stiff enough to resist distortion and fluctuation by these coarse flow disturbances and consequent dynamic pressure variations. For this reason, it is important for the entrance to have a reasonably large open area to avoid unreasonably large downstream pressure fluctuations. Thus the more the coarse turbulence in the flow channel is degraded toward a fine scale, the less stiff the channel walls need be to resist distortion. A simple way of achieving stiffness is by increasing the thickness of the channel wall and this is the type of construction used at present as will be hereinafter described in detail. Since it is therefore desirable for the channel walls to progress from stiff thick members at their upstream ends to thin members at their downstream ends, the structure for conditioning the flow should consist of gradually converging channels defined by walls which simultaneously slowly converge and gradually decreases in stiffness. Thus the simultaneous convergence of the channel size and the walls defining the channels are complementary effects. Because of the diminishing channel depth, the pressure fluctuations are reduced to smaller scale and hence lower intensities which allows thinner walls to be used to define the channel. Because of the diminishing wall thickness, the area between channels approaches the small dimension that it must have at the exit end. This concept of simultaneous convergence is deemed to be an important concept of design of this invention. While the

preceding the slice opening S should be in the order one eighth inch or smaller and the size of the solid areas between the channels at their exits should be much smaller than the size of the channels themselves. The exit open area should therefore be preferably in the order of at least 80-95 percent. However, open areas in the order of 50 percent and larger are conceivable. In order to prevent plugging of the entrance portion of the slice chamber it is desirable to maintain the vertical dimension of each of the channels 29, 30 and 31, etc. at the upstream end in the order of 1 inch and the overall open area of the perforated plate 15 should preferably be greater than 30 percent. However, as a general rule the openings in the distributor should be as small as possible for maintaining the flow pattern small but large enough to avoid plugging. These criteria will vary with the particular application and stock characteristics.

It has further been found desirable to impart some flexibility to the downstream end of the trailing members 25, 26, 27, etc. This flexibility provides a convenient way to achieve the small uniform spacing of the members across the width of the slice chamber at the downstream end since this uniform spacing is a hydrodynamically stable condition for this particular structure as indicated by experiments. Thus, flexibility allows the trailing members to be positioned by the dynamic forces of flow; that is, to conform to the streamlines. Alternatively, it would be difficult to achieve uniformly spaced rigid trailing members without mounting the members to the sides of the slice chamber and even then it would be difficult.

It is also desirable to impart some flexibility to the trailing members to allow the passage of large particles which are inevitably present in a commercial stock-flow system. It is therefore a feature of the present invention not to have the trailing members attached to the sides of the slice chamber since this simplifies the construction and avoids a thin rigid channel which would be conducive to plugging by fibers and foreign matter.

In operation, papermaking stock is introduced into the tapered inlet 12 through entrance opening 12a. A portion of the stock enters orifices 13a, 13b, 13c, etc. while the remaining portion exits the tapered inlet 12 through opening 12b for recirculation. From the orifices 13a, 13b, 13c, etc. the stock enters the diffusers 14a, 14b, 14c, etc. by means of which the stock is uniformly distributed across the full width of the preslice chamber 11b. The distribution of stock across the width of the preslice chamber is of a coarse nature having a scale of turbulence or variations in the order of a few inches. The coarsely distributed stock is then forced through the perforations in plate 15 by means of which the scale of turbulence is somewhat reduced but remains far above the desired level for formation of a web. The stock then enters the channels 29, 30, 31, etc. under conditions of relatively coarse and intense turbulence. The upstream ends of the trailing members are supported by the plate 15 and they are strong enough to accommodate the relatively large scale and intensity of the turbulence in the stock. As the stock progresses through the channels, the cross section of which decreases gradually, the intensity and degree of turbulence is likewise decreased. At the downstream end and near the slice portion S the channels are narrow and bounded by flexible walls. At this end the scale of turbulence has been diminished to acceptable papermaking standards. This diminishing turbulence is accomplished by reducing the channel size while still allowing coarse particles to pass by reason of the flexibility of the trailing members defining the channels. The turbulence of the stock, therefore, in the channels is continually degraded from a coarse intense condition to a fine-scale low level. The walls of the channels are graduated in thickness and stiffness accordingly. The ultimate scale of turbulence in the flow from the channels is governed by the size of the channels near the downstream end, and the intensity is determined by the velocity of flow through the channels which in turn is determined by the number of channels. In this manner the scale and intensity of the discharge flow can be independently controlled.

FIGS. 2 through 12 show additional details and other forms of the present invention.

As shown in FIG. 2 a headbox 40 of a somewhat simplified design comprises a tapered inlet header 41 having an inlet opening 42 and an overflow opening 43. The front wall of the header 40 comprises a perforated plate 44 having a multiplicity of perforations 45, 46, etc. therein. These perforations are preferably in the form of orifices and provide for open communication between the inlet header and a slice chamber generally designated by the numeral 47. The slice chamber 47 comprises top 48 and bottom 49 walls converging in the longitudinal or machine direction and terminating at a slice portion S2. Appropriate transversely spaced sidewalls are provided at the front and rear end of the slice chamber. Extending longitudinally within the slice chamber 47 are a plurality of trailing elements 50, 51, 52, etc. One end of each of these trailing elements is attached to the perforated plate 44 at the upstream end of the slice chamber 47. The trailing elements extend for approximately the full length of the slice chamber and are not attached to any other part of the chamber other than at the perforated plate 44.

The trailing elements are thus permitted to float freely within the slice chamber with the exception of their restriction at the point of attachment to the perforated plate 44. With papermaking stock flowing through the slice chamber the trailing elements will form a multiplicity of longitudinally extending flexible channels through which the papermaking stock will flow thereby gradually reducing large-scale turbulence in the papermaking stock while maintaining a high degree of fiber dispersion. The thus-conditioned papermaking stock exits through the slice opening S2 and is deposited on the Fourdrinier wire 53 or on any other appropriate web-forming surface. The Fourdrinier wire 53 is supported immediately beneath the slice by a roll 54, commonly referred to as a breast roll.

As shown in FIGS. 3 through 10, the trailing members may have different forms each of which can be readily adapted to suit a particular operating condition. For example, as will be readily apparent to those skilled in the art it may be more convenient to have the flexible members 50, 51, and 52, etc. extend transversely of the slice chamber in the form of a full-width sheet, as described in connection with FIG. 1, where the transverse dimension of the preslice flow chamber is relatively narrow. On the other hand, it will be apparent that in extremely wide headboxes it may be more practical to have a plurality of relatively narrow sheets extending in the transverse direction of the slice chamber. Accordingly, FIG. 4 shows the flexible trailing elements extending transversely of the slice chamber with the flexible elements having approximately the same transverse dimension as the slice chamber.

As shown in FIG. 5 the transverse dimension of the individual trailing elements 60, 61, 62, etc. is reduced to a fraction of the transverse dimension of the preslice flow chamber which may be a more practical approach for headboxes having a relatively large transverse dimension.

FIG. 3 shows a further embodiment of the present invention and it will be noted that the trailing elements herein consist of a plurality of flexible rods or wires 63, 64, 65, etc. having a generally circular cross-sectional area. This embodiment is particularly useful where stock characteristics require the use of channels of extremely small cross-sectional area.

As shown in FIG. 6, the longitudinal cross-sectional area of the trailing elements 50, 51, 52, etc. is preferably made so as to have its cross-sectional area decrease longitudinally in the direction of flow. The decrease in cross-sectional area is commensurate with the decrease in cross-sectional area of the slice chamber 11a of FIG. 1 and 47 of FIG. 2. In this manner the complementary effects of simultaneous convergence of the channel size and the flexible elements are obtained. In the embodiment of FIG. 6 the transverse cross-sectional area remains substantially rectangular as shown in FIG. 7.

FIG. 8 shows the cross-sectional area of the trailing elements 50, 51, 52, etc. of FIG. 3 and while this cross-sectional

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The whole was passed into an oven at 150° C., and kept there for 1-2 minutes. Thereafter, onto the previous layer a second layer (foamed) was spread, which consisted of:

PVC, paste making resin, having a K-value of 72	100 parts (by weight)
dioctyl phthalate	80 parts (by weight)
azodicarbonamide	2 parts (by weight)
dibasic lead phthalate (stabilizing kicker)	2 parts (by weight)
TiO ₂	5 parts (by weight)
polypropylene flakes	5 parts (by weight)

The initial thickness of this layer was 200 microns.

The whole was then passed into an oven at 200° C. and kept there for 1-2 minutes. The release paper was then removed. The system was then subjected to a slight tension in order to facilitate the separation of those components that were incompatible with each other; then the system was coupled to a cotton jersey fabric (with the second layer adjacent to the fabric), after preliminarily having spread on the fabric some plastisol of the first layer which served as a binder. Said coupling occurred in about 1 minute in an oven heated to 150-170° C.

The poromeric material thus obtained showed the following air transpiration rates:

Pressure (mm. Hg)	cm. ³ of air Hr. cm. ²
20	2.0
40	80
60	121
100	205
150	270

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The release paper was then removed and the system was subjected to a slight tension and subsequently was coupled to a jersey fabric made of polyamide fibers, the second layer being adjacent to the fabric after preliminary having spread on the fabric some plastisol of the first layer which serves as a binder.

The poromeric material thus obtained shows the following air transpiration rates:

Pressure (mm.Hg)	cm. ³ of air hr. cm. ²
20	2.0
40	80
60	121
100	205
150	270

Example 3

On a device for the preparation of artificial leather substrate of release paper was spread coated with a plastisol consisting of (layer 1, compact):

PVC, paste making resin with a K-value = 70	100 parts (by weight)
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