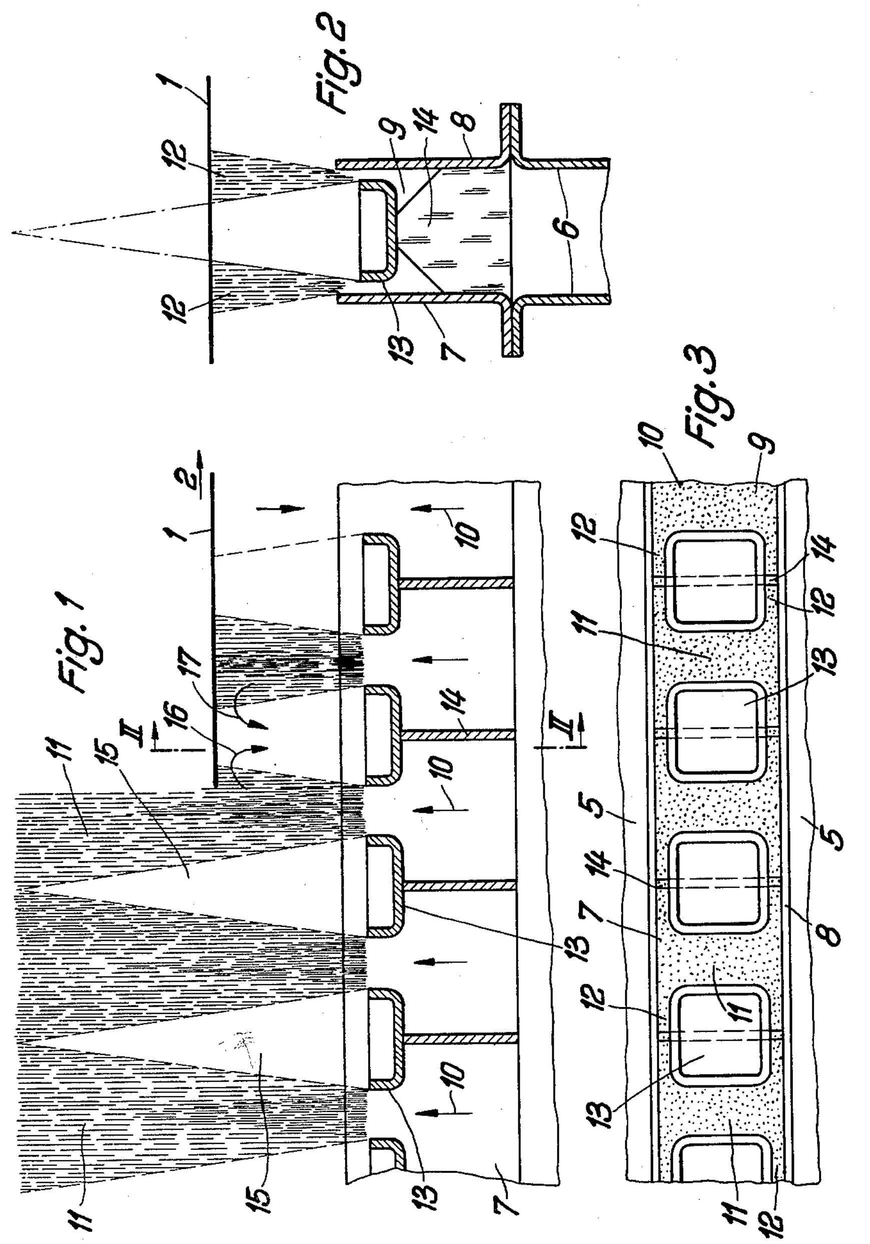
May 4, 1965 H. VITS 3,181,250

APPARATUS AND METHOD OF DRYING WEB MATERIAL BY DIRECTING HOLLOW GAS JET STREAMS AGAINST OPPOSITE FACES OF THE WEB

Filed Sept. 21, 1961 9 Sheets-Sheet 1



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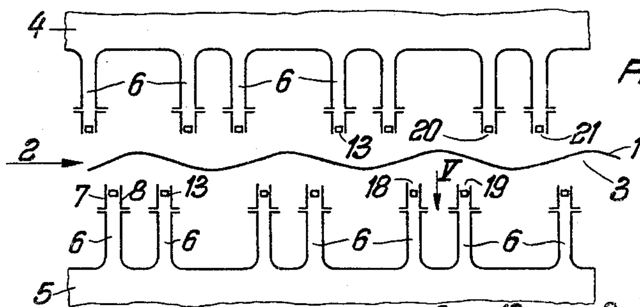

Fig. 4

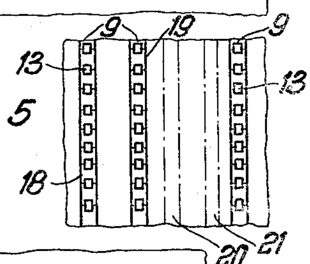

Fig. 5

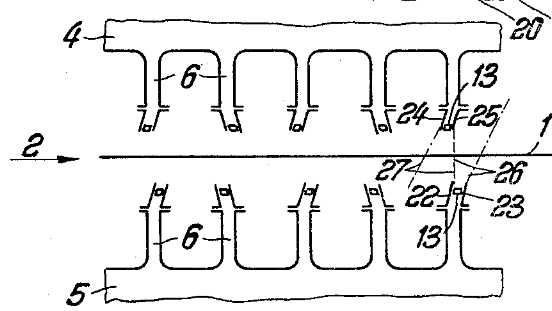

Fig. 6

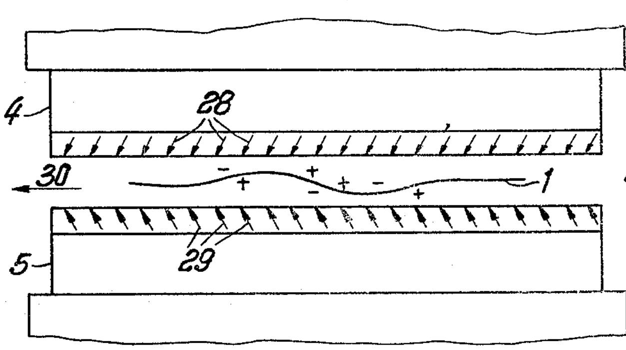

Fig. 7

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Fig. 8

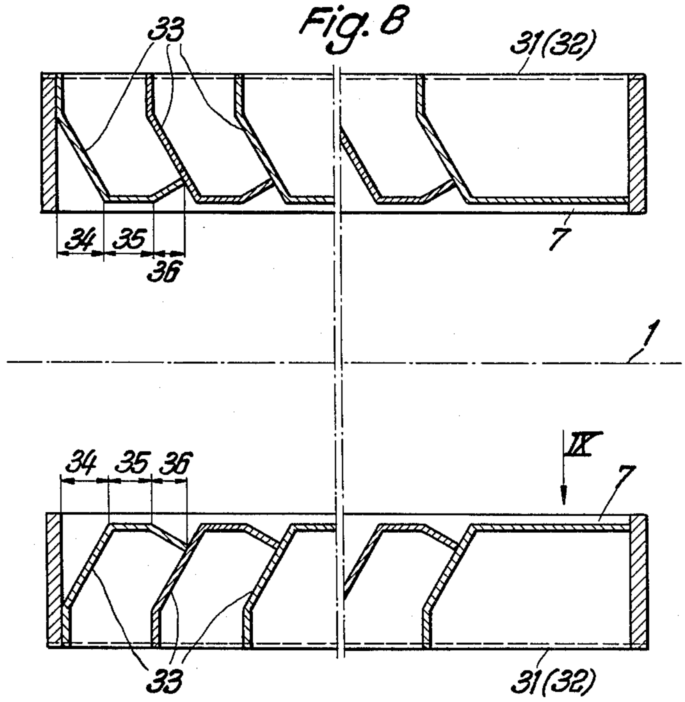
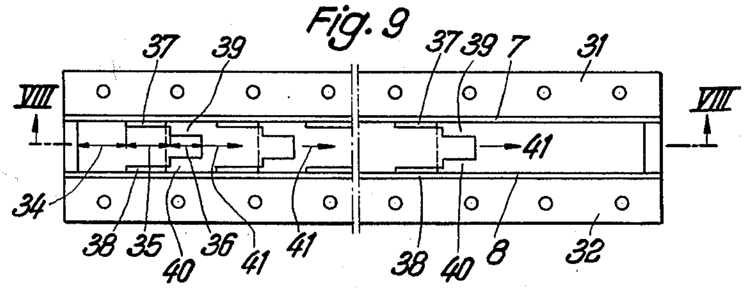


Fig. 9



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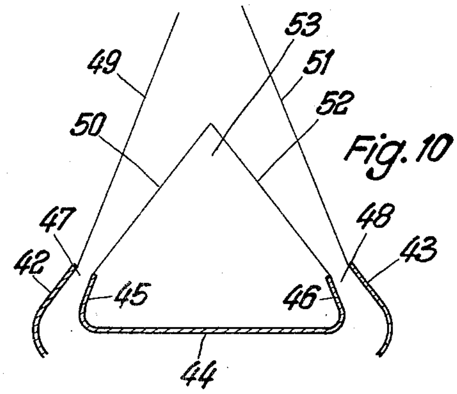
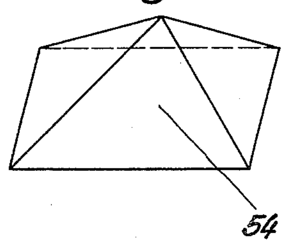


Fig. 10

Fig. 12



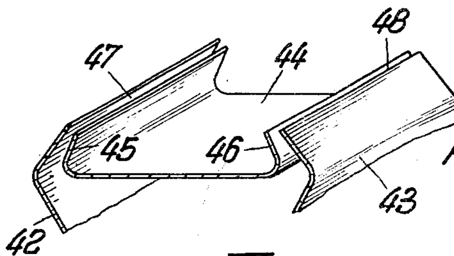


Fig. 11

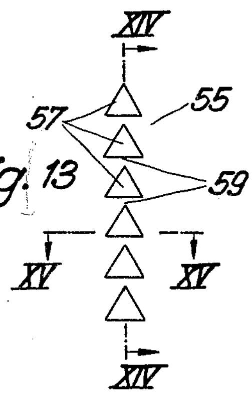


Fig. 13

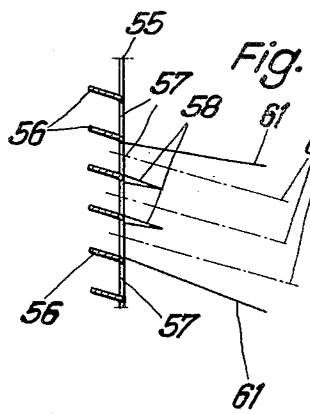


Fig. 14

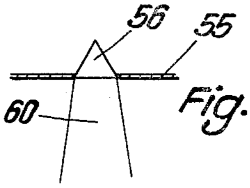


Fig. 15

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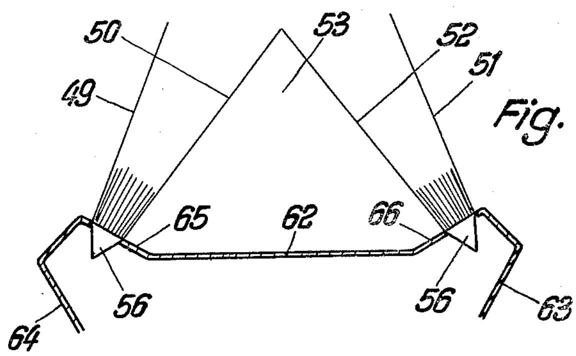


Fig. 16

Fig. 17

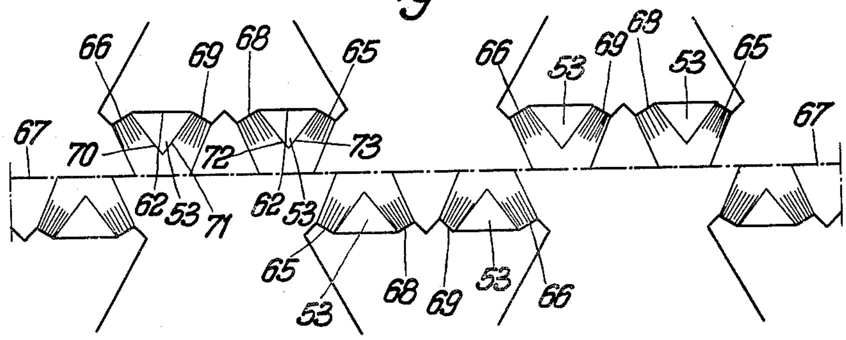
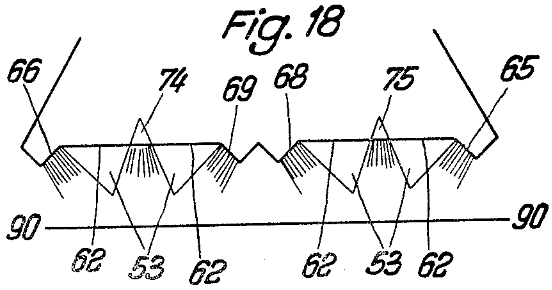


Fig. 18



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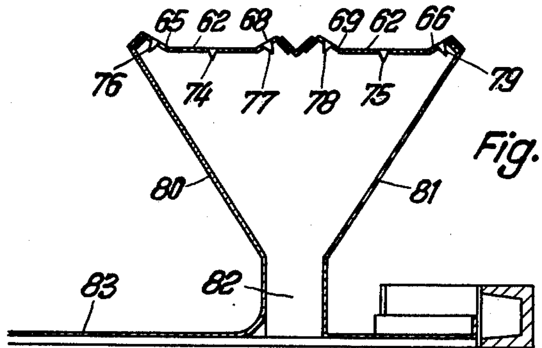

Fig. 19

Fig. 20

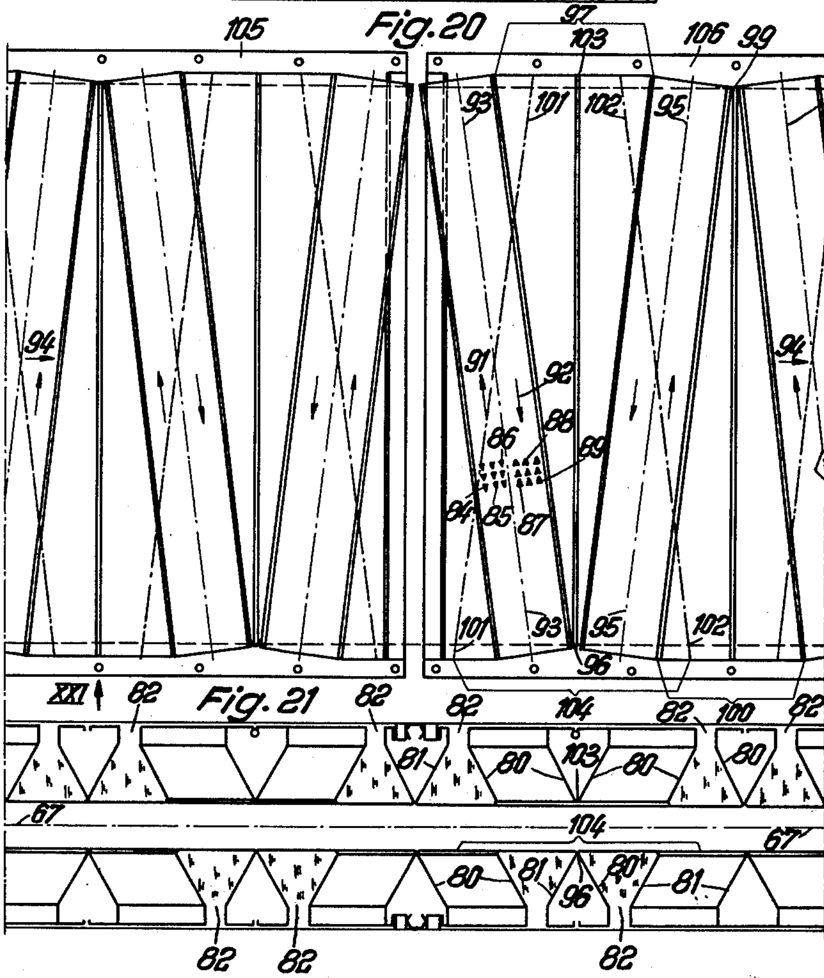

Fig. 21

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Fig. 22

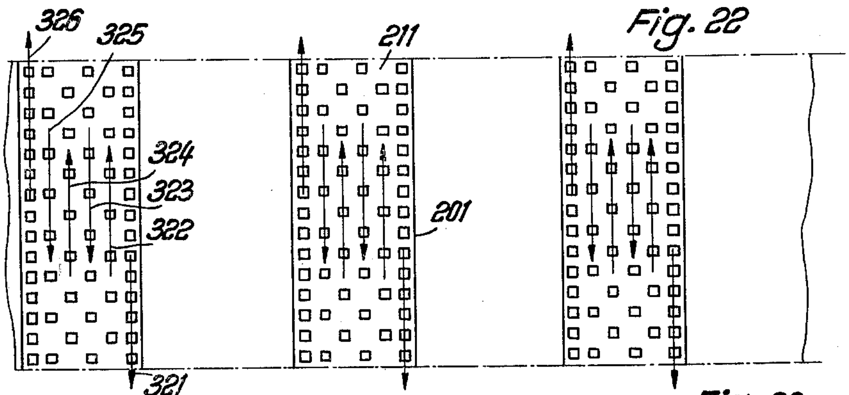


Fig. 23

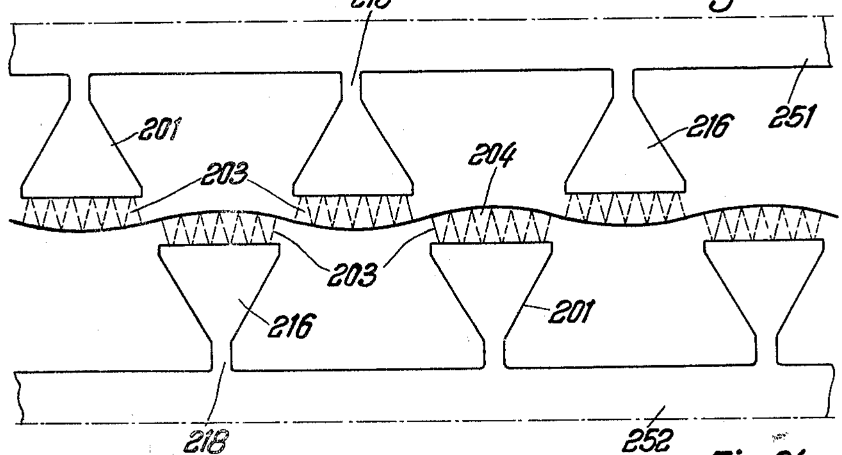
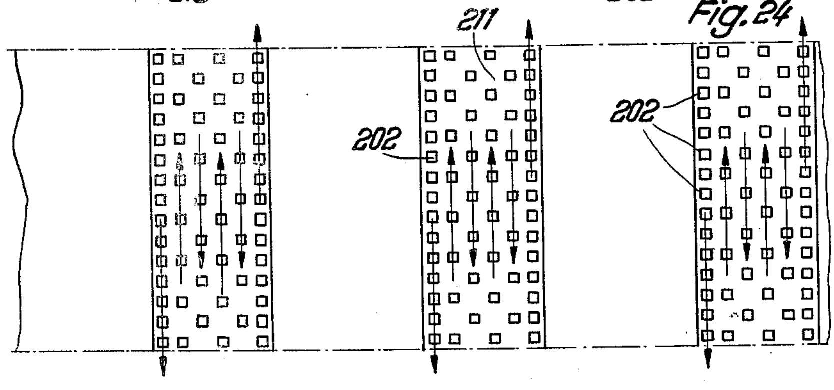


Fig. 24



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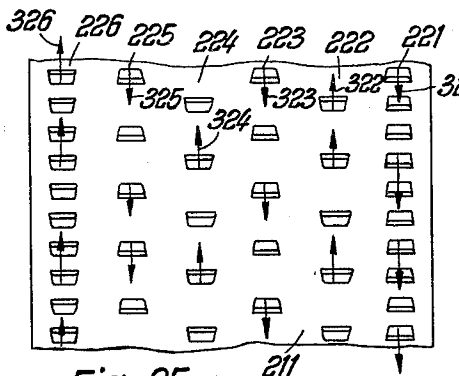

Fig. 25

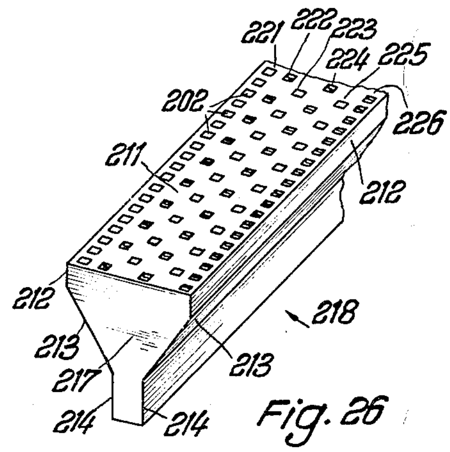

Fig. 26

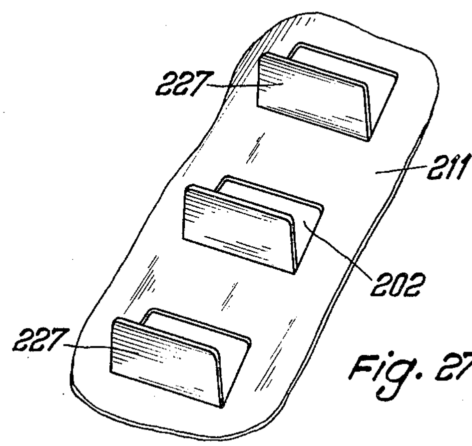

Fig. 27

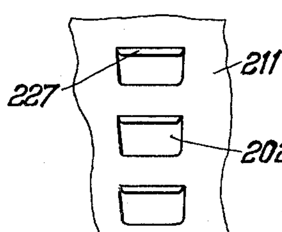

Fig. 28

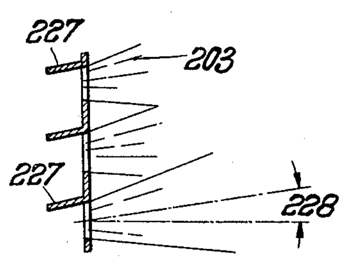

Fig. 29

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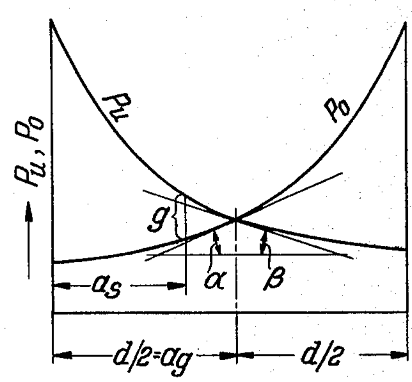

Fig. 30

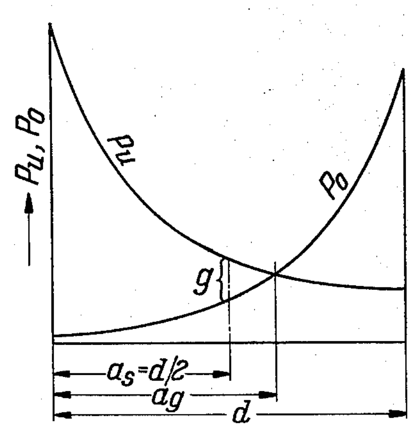

Fig. 31

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3,181,250
APPARATUS AND METHOD OF DRYING WEB MATERIAL BY DIRECTING HOLLOW GAS JET STREAMS AGAINST OPPOSITE FACES OF THE WEB

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13 Claims. (Cl. 34—23)

The present invention relates to methods of and apparatus for the drying, surface refinement, or similar treatment of materials moved preferably in longitudinal direction, in particular webs of paper, fabrics, plastics or similar.

Today it is ever widening common practice to provide such webs with a special surface layer, to impregnate or improve them in other ways. By treatments of this kind, the webs are generally given a moist, wet or sticky state that greatly hampers their immediate further processing because the moist side of these webs cannot be guided by means of the familiar supporting systems in which the web is supported by a plurality of rollers, stationary or rotating rods, or a belt and moved through a jet drier in a straight or curved path, as this would result in inadmissible damage to the surface. If only one side of the web is to be treated, such supporting systems may be used to carry the goods on the dry side. If both surfaces are to be treated, the second side can undergo treatment after drying the first having the first side serving as a bearing surface. In practice, however, such a method has proved to be too cumbersome and tedious, for the simultaneous drying of the top and bottom sides of the web, required for economical operation, is impossible with such a supporting system. Therefore, circulation air jet driers have already been developed blowing air vertically or obliquely upon the web through a plurality of slot or single nozzles arranged across the direction of feed of the web to be dried, whereby the moist material is both dried by the blower air and simultaneously supported by an air cushion formed by the blower jets without damage to the surfaces of the web. The blower jets applied to both sides of the web, however, exert widely varying impact forces, especially on thin materials, so that attempts were to date unsuccessful to move e.g. thin paper webs tension-free and supported only by an air cushion through such a jet drier utilizing economical blowing speeds.

In another tensioning system used, the tension of the paper web is stepped up and the jet speed reduced to such an extent that the web can withstand the varying forces of the blower jets without tearing or touching the nozzles. But this tensioning system does not make it possible to utilize economical blowing speeds in the order of more than 100 km./hr. so that the specific evaporation capacity of such driers is narrowly limited. A certain improvement can be achieved by the use of infra-red radiators, but these are uneconomical. As the tension of the paper web rapidly increases with the length of the drier, the use of this system is limited to short lengths. Webs to be refined on both sides are only pre-dried in such devices and finished in driers of the supporting system so that the fundamental limitation in capacity is thus not eliminated but merely lessened.

The drying devices known in the prior art have another disadvantage in that the material is steeply curved under the blower jet pressure both in the longitudinal and transverse directions. In order to prevent the web from touching the nozzles and/or muzzle surfaces, the latter must be arranged at a comparatively long distance

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from the center plane of the web, and this naturally results in poor drying efficiency. The blowing speed in the nozzles underneath the horizontally moving web is considerably higher than in the nozzles above the web. The air builds up pressure under the concave bottom side, thus balancing both the weight of the web and the impact of the upper jets. Stable equilibrium, however, is established only if the weight of the web, the web tension, and the upper and lower blowing speeds are carefully synchronized and kept constant. The specific evaporation capacity is lower than in the supporting system because the speed of the lower jets is greatly reduced on their relatively long path to the opposite web confining surface, while the speed of the upper jets is low anyway. The longitudinal and transverse curvature of the web leads to differences in tension causing the web to shrink irregularly during drying. The drying speed of the web transverse to the direction of feed is also irregular due to variations in the distance between the nozzles and web surfaces. A rise of the specific evaporation capacity can thus no longer be achieved by aerodynamic but only by thermodynamic measures which in turn involve the risk of undesirable secondary effects, such as the formation of skins, colour changes, or crystallization of the refining substances due to the sensitivity of the refining agents (plastics dispersions). If, therefore, any marked improvement is to be attained, the blowing speeds and sectional areas of the nozzles with reference to the web surface must be considerably increased. But the forces acting upon the web grow at a rate equal to the square of the blowing speed and linearly with the cross-section of the nozzles, whereas the rise in evaporation capacity even stays behind the increase in blowing speed. This relationship indicates that the forces caused by the drying medium and acting upon the web will necessarily be extremely, i.e. inadmissibly high if the capacity is to be markedly improved.

The problem is thus encountered to have the drying medium generate impact forces of such a magnitude that a tension-free web is automatically maintained in an imaginary ideal position between the nozzles without touching them. In this case the blowing speeds can be stepped up to an upper limit depending upon the tear strength of the web. The thermodynamic measures must only be used in such a way as to prevent damage to the refined surface. Despite this, the specific evaporation capacity reaches the degree necessary for economy in drying.

The method suggested for the solution of this problem and serving to dry, surface-refine, or otherwise treat material moved preferably in its longitudinal direction, in particular webs of paper, textiles, plastics foil or similar, both sides of which a drying medium is blown upon, is, according to the present invention, characterised in that the material is exposed to the influence of blower jets arranged at least in rows transverse to the direction of feed and having edge flows directed towards each other, said edge flows confining spaces tapered in the direction towards the web, in which a static excess pressure is generated and web-carrying air cushions are formed.

This method, arrived at after numerous experiments and tests, solves the problem on hand because the space confined by the blower jets in such a way as to form hollow jets is primarily filled with treating medium entirely at rest. It is thus capable of taking up the edge flow deflected at the web whereby a static excess pressure relative to the adjacent flows is formed. Media such as air being under static excess pressure within a confined space will cause the formation of some sort of cushion. By arranging several hollow jets in rows in a direction transverse to the direction of web feed, an equal number of air cushions is formed so that it merely requires a suitable distribution of the cushions relative to the length of the web to achieve an absolutely stable support of the web. If occurring on one side of the web only, this excess pressure would, naturally, cause the web to give way in the opposite direction. But since hollow jets are active on this side, too, the web will hit these counter-cushions when trying to yield under the pressure on the opposite side. The treating medium would be further compressed here if forces were encountered which could enforce such a condition. But except occasional disturbances, such forces are missing so that the web jumps elastically back. A surprisingly stable equilibrium is thus generated causing the web to be held in mid-air between the blowing nozzles as if suspended by invisible hands. This state of equilibrium is bound to be brought about because the web enters a sphere of heavier edge flow when approaching the nozzles due to the fact that the distance between the web and the jet-producing devices is reduced, and the deflection of the more powerful edge flow at the web is all the stronger and the static excess pressure in the space confined by the marginal jets becomes all the higher. This excess pressure immediately results in a widening of the distance between the web and the nozzle so that the stable support of the web in a center position between the hollow jets is a necessary consequence of the measures described.

In realizing the method, the hollow jets may initially be arranged in a lattice pattern at those spots where they are produced, thus not excluding the possibility of their reuniting in the course of their flow and forming jet walls with the build-up spaces mentioned in between, in which the supporting cushions are formed by the medium under excess pressure. However, the arrangement in a lattice pattern at the roots of the hollow jets is no indispensable requirement. The medium may also be arranged in screens forming prismatically extended build-up spaces of basically triangular or pentagonal cross section, the pentagon being preferably composed of a triangle and a parallel trapezium the smaller parallel side of which coincides with the base of the triangle, while the tip of the triangle belongs to the crest edge of the prism. The cushions thus have a beam-like configuration. The build-up spaces proper need not be closed off at the faces by additional jets, as the reactions of the solid walls of the drier, confining the treatment space along the edges of the web on the course of the flow of the medium are already felt here. Moreover, the face area of the build-up spaces is small in relation to the large build-up areas extending over the entire width of the web, especially when arranged diagonally relative to its direction of feed.

It is not absolutely necessary to have the hollow jets blow upon a confining surface or plane formed by the material in a substantially vertical direction. As will be demonstrated with reference to the accompanying drawings, it is always possible to give the jets a deviating direction or deflect them from a direction once determined in order to perform additional duties.

Such additional problems are brought about by the fact that webs of certain fabrics have a tendency to flutter at the edges in spite of the floating condition in general. This may be entirely negligible in one case while in another it may interfere with the treatment or spoil the material by contact with solid parts. To remedy fluttering, it proved to be particularly advantageous in these cases to give the blowing jets directional components deviating from the main direction towards the web. There are webs of material for which even this is not sufficient so that the additional means of alternating the direction of the lateral components according to a certain schedule must be resorted to, particularly in those cases where the web has the tendency to move edge-wise in its own plane. This is realized in the simplest manner by arranging nozzles consecutively in the direction of web feed, having the jet rows or screens blow across the direction of web feed, and giving them main flow components inversely directed towards each other. Due to the formation of distances between hollow jets consecutively arranged in the direction of web feed and contributing to the formation of buildup spaces also successively located in the direction of web feed, this results in a wedge-shaped cross section of the intermediate spaces, this wedge-shaped configuration being directly aimed at because it greatly helps to eliminate fluttering even if the web has an acute tendency to this phenomenon. Another procedure has proved to be satisfactory to greatly suppress the tendency to flutter even in the most severe cases, namely to arrange the jet rows or screens cross-wise above and below the web, preferably in such a way that mirror symmetry is established by the uniform angular position of their center lines relative to the shortest line extending through the point of intersection of the center line and connecting opposite points at the web edges. Staggered arrangement in the direction of web feed is also an advantage.

Beyond this, the following points must be mentioned:

Thus it is necessary to provide for a progressive formation of cushions between the hollow jets and the web of material so that the approaching web is elastically pushed back into its center or nominal position. The resilient buffer must not only be a little progressive but must be extremely progressive, and it is formed in build-up spaces confined by the web, by blowing jet screens, and by the base in which the jet orifices are located. To enable the build-up pressure to form there, it is necessary that the base surface between the outlet rows have as little connection to escape channels as possible. It is further desirable that the jet screens be directed towards each other to maintain their effort to fill the build-up spaces during undisturbed flow. Thus the jet screens should be as self-contained as possible to prevent the escape of treating medium build up within the build-up spaces. However, it is not necessary that the screen be completely closed. It may also consist of a jet grid or lattice because a tight jet lattice will automatically form a screen due to the spreading of the jets. The arrangement of individual jets may be advantageous in exceptional cases because with a given quantity of air for a jet screen, the width of the individual jet can be made greater than the width of an open gap or slot. For this reason, a jet screen formed of individual jets is more rigid over a wider range. Furthermore, the arrangement of narrowly spaced jets makes it possible to realize the lateral component desired.

In order to avoid the lateral escape from a build-up space, two build-up spaces may be formed by three jet screens, all having the same lateral component. If immediately beside such a triple-row jet arrangement an equal one with an opposed lateral component is now located, two opposed transverse flows are established over the web, which rub each other and build up air pressure which in turn promotes the effectiveness of the air cushion.

On account of the easy formability of thin webs, the slightest disturbance or the practically natural position results in the web being corrugated. On a powerful flow, these corrugations have an effect similar to that of the wings of an aircraft so that the convex side could be attracted despite the presence of a progressive cushion. This, however, is prevented by the lateral components described above.

The description indicates that each build-up space is confined by the web proper, which means that the pressure in the build-up space is the higher the closer the web approaches the nozzles. Since not only the excess pressure in the build-up space but also the effective width of the build-up space across the web becomes greater during the approach of the web towards the nozzles, the progressive effect is attained. The build-up space terminates at the edges of the web and is open at the side so that the excess pressure escapes within the area of the web edges in a direction transverse to the direction of web feed, producing a cross flow away from the web edge that might give rise to fluttering movements of the web edges. This fluttering would normally be promoted by the flow-off between rows of nozzles extending in parallel. For keeping the edge at rest, it is suitable to minimize the cross flow in the area of the edge as far as possible or to baffle it. This is achieved by giving the nozzles a staggered or zigzag arrangement whereby wedge-shaped intermediate spaces for flow-off are formed. If the lateral component of the blowing jets bordering on this intermediate space is selected in opposition to the possible flow-off direction, the cross flow at the tip of the wedge will be deflected to a large extent and adequately relieved of the lateral components so that the edges do not tend to flutter.

By adopting the above procedures, it is possible to treat even the most sensitive webs with maximum blowing speeds, it hereby not being necessary always to realize all of these procedures. In a drier for extremely heavy material, for instance, it is the bearing or supporting capacity, i.e. the effectiveness of the air cushion, which is the decisive factor. Lateral components can be dispensed with in this case, as a heavy material is not so elastic and formable that the progressive buffer would not make it resume its nominal position.

By materials comparatively low in weight and not easily formable, e.g. thin cardboard, even less stringent requirements have to be met. This explains why the principal method stated already is successful in many cases. But since the consumer is more and more exacting in his demands, requiring, for example, the prevention of web edge oscillations for papers with a weight far less than 100 g./m.^{2} and with the possibility of tearing even on light contact with a solid object, it was necessary to state further procedures covering also those exacting specifications.

A method according to the present invention may also be modified in such a way as to subject the material to the effect of blower jets participating in the formation of cushions and arranged in rows across the direction of web feed, giving the transverse flow of these jets lateral components with directions alternating from one row to the next. The air will then not emerge from the nozzles in the form of hollow jets but as jets which confine spaces tapered toward the web only in combination with jets from adjacent nozzles, a static excess pressure and a supporting cushion being engendered within these spaces. It has been found that the constant directional change of the lateral components from one row to the other makes for a particularly well-guided movement of the web and that the tendency to flutter in the critical edge areas is hereby greatly reduced. The achieved effect can then be further increased by exposing the material to the influence of jets emerging from nozzles arranged with a variation in their spacing or pitch from one transverse row to the next. A further improvement in drying is reached if the material is exposed to jets produced in the transverse rows at the edge of each cushion where they are spaced closer than the jets in the other transverse rows contributing to the formation of cushions.

The equipment for realizing the former method is principally characterised by the provision of nozzle heads charged with the working medium and having outlet sections transversely arranged relative to the direction of web movement, said outlet sections having openings with baffles so that the working medium emerges between the baffles and confining nozzle walls on the one hand and between the baffles themselves on the other hand in the form of hollow jets the edge flows of which are directed towards each other and confine a space located on the side of the baffle facing the web and tapered or constricted in the direction towards the web. Complete confinement

can be achieved if the baffles are retained by stem-like supports which in turn are held by the nozzle walls located opposite the walls forming the cross section. But such a structural arrangement is very expensive. The full effect of the invention is brought about also by fixing the baffles to the nozzle head walls forming the cross section. Although this fixation interrupts the complete confinement of the spaces surrounded by the hollow jets, such interruption is negligible and does not adversely affect the ultimate purpose of the invention, namely the stable and freely floating position of the web. Moreover, the divergency of the flows causes the flow threads to reunite down stream of the baffle supports.

In practice, the baffles will be arranged like scales and shaped as reeds with a configuration ensuring the shape of the hollow jets desired.

An apparatus for realizing the latter method of providing lateral components with alternating directions from one transverse row to the next for the blowing jets produced in the consecutive transverse rows is different from the devices already mentioned in that it is not equipped with such baffles, but has plain recesses with deflectors arranged transversely relative to the direction of web feed in the surfaces of the nozzle banks from which the jets emerge, said deflectors alternating in their inclination towards the related recesses from one row to the other. These recesses preferably have a rectangular or slightly trapezium-like shape. The confinements of the recesses belonging to the same transverse row may be connected with the deflectors, the shape of which can be just congruent with the recesses, along suitable edges parallel with the longitudinal direction of the web, while the deflectors at the recesses in subsequent transverse rows are then attached to opposite edges of the recess confinements, all deflectors being located on the side away from the material treating space.

According to the feature of subjecting the material to blowing jets variably spaced from one transverse row to the next, the recesses in the rows of nozzles may be arranged with different density, said density being greater in the rows along the edges of the nozzle bank than in the other rows of the same nozzle bank. In order to fully utilize the advantages offered by such an arrangement of the nozzles in the air jet outlet surface, the nozzle banks can be arranged parallel relative to each other and perpendicular relative to the longitudinal direction of the web, and may also be staggered for half a pitch on opposite sides of the web.

Some embodiments of the invention will now be exemplified with reference to the accompanying drawings.

FIG. 1 shows the basic design of the lower blower box in an apparatus serving to realize the method suggested; it is supplemented by a similar or identical upper blower box (not shown). FIG. 2 is a sectional view of the blower box and the adjacent parts along the line II—II in FIG. 1. FIG. 3 is an elevation of the lower blower box in the direction of the arrow II in FIG. 1. FIG. 4 shows the general arrangement of a jet drier designed according to FIGS. 1–3 in a longitudinal section, FIG. 5 being an elevation of the lower blower box in the direction of the arrow V in FIG. 4. FIG. 6 is a sectional view of a variety of the jet drier shown in FIG. 4, while FIG. 7 represents a sectional view of another variety of the jet drier. FIG. 8 is a sectional view of opposite blower boxes of a jet drier in which the baffles are formed by reeds arranged like scales, the section following the line VIII—VIII in FIG. 9 which shows an elevation of the lower blower box in the direction of the arrow IX in FIG. 8. FIG. 10 shows a different design of the blower box where tthe formation of individual hollow jets was dispensed with and beam-like build-up spaces are formed extending transversely relative to the direction of web movement and over the entire width of the web so that the web is supported by the beam-shaped cushions formed under excess pressure within the build-up spaces. FIG.

11 is a perspective view of the arrangement shown in FIG. 10. FIG. 12 shows the shallow pyramidal shape of a build-up space to be achieved when individual hollow jets are used to form a build-up space so shaped. FIG. 13 is an elevation of the nozzle cross sections used in such a case, FIG. 14 being a sectional view along the line XIV—XIV of the nozzle-forming blower box wall and FIG. 15 a sectional view of the same wall along the line XV—XV. FIG. 16 is a sectional view of a blower box designed according to the features shown in FIGS. 10 and 13. FIG. 17 demonstrates how the blower boxes are in this case arranged relative to the web. FIG. 18 is a diagrammatic view of another variation of a blower box, while FIG. 19 is a sectional view of the practical configuration of such a blower box. FIG. 20 is an elevation of a blower box arrangement according to FIG. 19 and FIG. 21 shows a side elevation of this blower box arrangement viewed in the direction of the arrow XXI in FIG. 20. FIG. 22 is an elevation of the nozzle banks located above the web, from which the jets emerge in consecutive transverse rows with counter-directed lateral components. FIG. 23 is a side elevation of the nozzle banks arranged above and below the web and connected to the common blower boxes. FIG. 24 is an elevation of the nozzle banks located underneath the web. FIG. 25 shows the partial view of a jet outlet surface in a larger scale. FIG. 26 is the partial perspective view of a nozzle bank. FIG. 27 is a perspective view of the nozzle arrangement with deflectors generating the lateral components. FIG. 28 is an elevation of the outside of the jet outlet surface in a scale enlarged relative to FIG. 25. FIG. 29 is a sectional view of FIG. 28. FIGS. 30 and 31 are diagrams showing the distribution of pressure in the area between two jet outlet surfaces and in the drying area under somewhat modified conditions of pressure respectively.

In FIGS. 1–3 representing an apparatus for the drying treatment of webs of material, **1** is the web of material moved in the direction of the arrow **2**, e.g. a web of paper to be passed through the drying space **3** between the blower boxes **4** and **5** (see FIG. 4) in a stable floating position. For this purpose, nozzle boxes **6** with a rectangular cross section are mounted on the blower box **5** so that the side walls **7** and **8** of each nozzle box **6** shown in FIG. 3 are forming a slot **9** through which the drying medium **10** in the dotted area can escape. It emerges from the slots in the form of a hollow jets **11** and **12** because baffles **13** are located in the free nozzle slots **9**, said baffles being supported by plates **14**. A primary flow **11** between the wider spaced consecutive baffles **13** and a secondary flow **12** between the narrower spaced baffles **13** and the nozzle box walls **7** and **8** are clearly distinguishable. Between the hollow jets, both flows together confine a space **15** tapered in the direction towards the web **1**. If the indicated position of the web **1** now corresponds to the center plane between the blower boxes **4** and **5** (see FIG. 4), the web **1** will deflect the marginal jets confining the spaces **15** in the direction of the arrows **16** and **17**. In the spaces **15** originally filled with stationary drying medium, a static excess pressure is built up so that the drying medium within the spaces **15** behaves like cushions supporting the web **1**. Since there is a number of spaces **15** that corresponds to the quantity of nozzle slots **9** and baffles **13**, cushions are formed over an equal area so that the web **1** is practically supported at a major portion of its lower surface and carried by cushions, preferably air cushions, of this kind. Due to the fact that cushions are formed also on the upper side of the blower box **4** as shown in FIG. 4, a stable center position of the web **1** is established between the blower boxes and the purpose of the invention is thus served.

FIG. 4 also shows that it is advisable to give the opposed hollow jets a staggered arrangement, either singly

or in groups, in the direction **2** of the movement of the web **1**. Such a staggered arrangement of groups is shown in FIG. 4 where the group forming the nozzle slots **18** and **19** with the primary and secondary flows being produced by drying medium from the blower box **5** is followed by a group forming the nozzle slots **20** and **21** drawing the drying medium from blower box **4** so that the directions of flow of the hollow jets produced by the baffles **13** in both groups are directed towards each other.

When the hollow jets are produced and/or the jet-producing devices arranged in this way, the web substantially assumes the configuration shown in FIG. 4. This slightly undulating movement of the web in direction **2** is negligible in many cases. In others, however, the problem arises of moving the web in mid-air through the drying space **3** in a fully stretched and straight condition. This can be achieved by means of the procedure shown in FIG. 6. Here, too, the nozzle boxes **6** are attached to the blower boxes **4** and **5** in such a way as to make their center planes extend perpendicular to the plane of the web **1**, but the side walls **22** and **23** forming the nozzle slots **9** (also walls **24** and **25**) are bent away from the center planes of the nozzles boxes **6** in such a way that the hollow jets **26** produced at **24**, **25** and **13** would pass the hollow jets **27** produced at **24**, **25** and **13** if the web **1** were removed. In other words, the hollow jets **26** and **27** are produced and/or the drying medium used for their production is deflected in such a way that flow threads of the hollow jets consecutively arranged in a direction transverse relative to the direction **2** of the web **1** are located in a common plane which in turn intersects the center plane of the moving web at an acute angle, meaning, of course, certain threads of the primary flow **11** or secondary flow **12** whereas there can be no question of a middle flow thread since there are no such threads in the spaces **15**.

Furthermore, FIG. 7 offers the possibility to stretch the web **1** also in the direction extending perpendicular relative to the direction of stretch indicated in FIG. 4. Without the arrangement shown in FIG. 7 the web would have the shape shown in that figure because hollow jets produced in the direction indicated in FIG. 1 do not exert forces that might cause the web to stretch. If, however, the hollow jets are directed as shown by the arrows **28** and **29** in FIG. 7, the components causing the web to stretch in a direction perpendicular relative to the direction **2** are produced. There is a resultant force in the direction of the arrow **30** in FIG. 7, but the web is fully capable of withstanding this resultant up to a limit determined by the tearing strength of the web. The web tension prevents the web from moving away in the direction of the arrow **30**, especially since the web is guided at its edges in the usual manner outside the drying space **3**. According to the example shown in FIG. 7, the hollow jets are produced and/or the drying medium is deflected in such a way that flow threads located in one plane and contained in the hollow jets consecutively arranged in a direction transverse relative to the direction **2**, all said jets having the same blowing direction, hit the center plane of the moving web at an acute angle, it being possible, of course, to provide the arrangement shown on both sides in FIG. 7 on one side only. Nor is it necessary to have the jets always blow in the direction of the arrow **28** or **29** and make them hit the web at a constant acute angle relative to the web plane. This angle may also be variable if required by the nature of the web material, e.g. if the surface refinement is applied in strips or bands so that special conditions have to be considered. The same applies to the arrangement and configuration of the baffles which may be smaller at those portions of the web where it is heavier due to an extra thick layer on the surface, and which may be larger in those places where lighter portions of the web are to be carried by hollow jets, so that a heavier edge flow is produced making for a higher static pressure in the spaces **15**.

FIGS. 8 and 9 show an embodiment of the invention suitable for practical application. Again the nozzle slot 9 is formed by the side walls 7 and 8, and flanges 31 and 32 are provided to connect the blower box heads 7, 8, 31, 32 with the supporting nozzle box walls 6. Between the walls 7 and 8, reeds or tongue shaped deflectors 33 are inserted which have the shape shown in FIGS. 8 and 9. As shown, the reeds 33 have a section 34 of maximum width, an adjacent section 35 of smaller width, and a section 36 of minimum width. Since the reeds 33 are arranged in a scale-like pattern as shown in FIG. 8, screen-shaped secondary flows are produced in the free sections 37 and 38, additional secondary flows in the sections 39 and 40, and a primary flow of the drying medium in the direction of the arrow 41. This primary flow 41 immediately rejoins the secondary flows from the sections 37–40 produced by the adjacent reed, the portions of the reeds extending over the sections 35 and 36 then again operating as baffles. Counter to the direction of the arrows 28 and 29 in FIG. 7, parallel hollow jets are produced again forming spaces 15 confined by the primary and secondary flows and, contrary to the presentation in FIG. 1, inclined towards the web plane counter to the direction of the arrows 28 and 29 in FIG. 7. As the staggered arrangement shown in FIGS. 4 and 5 is also used at the same time, the stabilization of the web 1 in FIG. 8 combined with the stretching of the web in a plane shown in FIG. 7 is again brought about.

It has been mentioned already that it is not necessary to produce the hollow jets individually. FIGS. 10 and 11 show an arrangement having the hollow jets confining the build-up spaces in the form of screens. A deflector 44 extending over the width of the web is located in the outlet section of the nozzle head side walls 42 and 43. It is not necessary to arrange the nozzle head 42–44 perpendicular relative to the direction of web movement. The center line of the nozzle head may also intersect the direction of web feed at an angle smaller than 90 degrees. The edges 45 and 46 of the deflector 44 are bent up so that slot nozzles 47 and 48 are formed in conjunction with the nozzle head side walls 42 and 43 with screens of drying medium emerging from said nozzles. The screens are confined by the marginal flows 49, 50 and 51, 52, thus forming a flow-free prismatic space 53 in which a static excess pressure is built up according to the description relating to FIG. 1. In this manner, a beam-shaped cushion is formed having a triangular cross section in its upper and a trapezium-like cross section in its lower portion with the base of the triangle coinciding with the smaller one of the parallel sides of the trapezium. Naturally, the crest edge of the cushion formed by the top of the triangle is hypothetical only, but the cushions of drying medium, e.g. air cushions, flatten at their upper portions so that the web is supported over a relatively wide area.

In some cases the embodiment shown in FIGS. 10 and 11 is inadequate to cope with the circumstances encountered. It has then proved to be suitable to subdivide the build-up spaces across the web and attempt to realize the build-up spaces 54 shown in FIG. 12 and characterized in that they have a substantially pyramidal configuration with a relatively small height so that the desirable flattening occurs at the upper portion of the cushion filling out the build-up space.

In order to achieve such a formation of the build-up spaces, the procedure exemplified in FIGS. 13–15 is followed, where triangular reeds 56 are bent out of the confining wall 55 of the nozzle head positioned towards the web, and at least two rows of reeds are provided side by side. The portions of the nozzle head wall 55, situated between the outlet openings 57 and formed by punching and bending the reeds 56, are acting as baffles. Since the jets emerging from the openings 57 are divergent, the emerging jets 60 unite to form a hollow screen 61 outside the gusset spaces 58 caused by lee phenomena of the flow at the places 59, the center lines of the individual jets being identified by 62.

FIG. 16 shows the actual design of such a nozzle head where two edge portions 63 and 64 with a cap-shaped cross section are attached to a central straight nozzle head surface 62 facing the web, so that edge surfaces 65 inclined at an obtuse angle towards the surface 62 are formed, from which the reeds 56 are bent outward. Here again, a build-up space 53 according to FIG. 10 is formed and confined by the hollow jet screens 50 and 52. It is not necessary that the reeds 56 at the nozzle head walls 65 and 66 are arranged in parallel. In certain cases it is desirable to give the reeds 56 bent outward from the nozzle head wall 66 an inclination opposite to that of the reeds 56 bent out of the nozzle head wall 65 in FIG. 14. The hollow jet screens confined by the marginal flows 49, 50 and 51, 52 thus have an opposite directional component in addition to the primary flow directed towards the web.

FIG. 17 shows another variation of the nozzle head under substantially the same conditions as those shown in FIGS. 10–16, also showing the general arrangement relative to the web with a center line indicated by the dashed and double-dotted line 67—67. Contrary to FIG. 16, additional surfaces 68 and 69 of the same configuration are provided besides the surfaces 65 and 66 inclined towards the nozzle head wall 62, so that two build-up spaces 53 per nozzle head are formed. The reeds bent out of the surfaces 66 and 69 have the same inclination while others (not shown, but compare 56 in FIG. 14) bent out of the surfaces 65 and 68 are again directed in parallel, whereas they are inversely directed relative to the position of the reeds bent out of the surfaces 66 and 69. This means, therefore, that the hollow jet screens 70 and 71 confining the first build-up space 53 have, in addition to the primary flow, another flow component in a direction opposite to the flow component of the hollow jet screens 72 and 73 forming the second build-up space.

Another variety is shown in FIG. 18 where the nozzle head has reeds 74 and 75 bent from the middle of the flat nozzle head walls 62 so that a total of four build-up spaces 53 is now formed per nozzle head. Here again, it is possible either to give the reeds bent out of the inclined surfaces 65, 66, 68, 69 an equal inclination or alternate the inclination singly or in groups. However, particularly good conditions were attained when the reeds 74 were given a position parallel with the reeds bent out of the surfaces 66 and 69 while giving the reeds 75 an inclination opposite to that of the reeds 74, the reeds 75 thus again having a position parallel with the reeds bent out of the surfaces 65 and 68.

FIG. 19 shows the structural configuration of a nozzle head diagrammatically shown in FIG. 18. There are reeds 74 and 75 arranged in rows according to the presentation in FIGS. 13–15. There are other rows of reeds 76, 77, 78 and 79 bent out from the surfaces 62 and/or 65, 68, 69 and 66. The reeds 74, 76 and 77 are parallel relative to each other, and so are the reeds 75, 78 and 79 but these have an inclination opposite to that of the reeds 74, 76 and 77. The nozzle head side walls 80 and 81 graduate into a rectangular neck 82 attached to the blower box 83.

FIG. 20 shows an elevation of the outlet openings relating to the rows of reeds 76, 74, 77 and/or 78, 75, 79. The row of reeds 76 is related to the row 84 of triangular openings, reeds 74 to openings 85, 77 to 86, 78 to 87, 75 to 88 and, finally, row 79 to row 89. This means that the hollow jets emerging from the openings 84–86 have a flow component in the direction of the arrow 91 in addition to the primary flow directed towards the web (90—90 in FIG. 18). The hollow jets emerging from the rows of openings 87–89 therefore have the inversely directed flow component indicated by the arrow 92. This makes for the formation of the four build-up spaces 53 shown in FIG. 18, which have a steep slope towards the direction 94—94 according to the center line 93—93 of the nozzle head viewed. The position and distance of the center line of the next nozzle head 95—95 is so selected that the nozzle heads almost touch each other at 96 while having a greater distance at 97. Relative to the next nozzle head with the center line 98—98, the nozzle head with the center line 95—95 is arranged so that there is another contact point 99 and a wider gap at 100. Since the web (90 in FIG. 18) is not shown in FIG. 20, the nozzle heads underneath the web are viewed in elevation. The nozzle heads above the web (not shown but indicated by their center lines) are mirror symmetrical but staggered relative to the lower nozzle heads in such a way that the center lines 101—101 and 102—102, for instance, have their least distance at that spot where the lower nozzle heads have their widest gap 97. This means, therefore, that the upper nozzle heads (not shown) touch at point 103 while having their widess gap at point 104. Thus a mirror image staggered arrangement is created of the upper and lower nozzle heads relative to one another, whereby the build-up spaces 53 are formed. The general arrangement is shown in FIG. 21. Viewed in the direction of the arrow XXI in FIG. 20, the greatest distance 104 between the upper nozzle heads is seen at that spot where the lower nozzle heads make contact at point 96. It is further shown in FIG. 20 that the blower boxes are not completely continuous but assembled in sections as shown by 105 and 106 which can be conveniently installed and dismantled.

FIG. 23 shows the arrangement of nozzle banks 201 with a somewhat modified structure. As shown in detail in FIG. 26, such a nozzle bank 201 is confined by a jet outlet surface 211 in which recesses 202 are provided in rows 221–226. To the surface 211, the side parts 212 are attached at right angles, followed by the converging slope walls 213 which in turn graduate into the parallel extensions 214. At the faces the nozzle banks are closed by plates 217 outlined according to the configuration of the walls 212–214. On the side directed away from the surface 211, an opening is formed through which the hollow spaces 216 of the nozzle banks 201 are connected with the blower boxes 251 and 252 shown in FIG. 23.

As is further shown in FIG. 23, the nozzle banks 201 above the web 204 are staggered for half a pitch relative to the nozzle banks 201 underneath the web 204. The blower jets 203 supporting and simultaneously drying the web emerge from the recesses 202. FIG. 27 shows the location of the deflectors 227 on edges of the recesses 202, it being shown in particular in FIGS. 28 and 29 that the deflectors 227 are inclined towards the recesses 202 in such a way that the center lines of the jets 203 emerging from the recesses 202 form an angle 228 together with a plane perpendicular to the jet outlet surface 211. The deflectors proper may be formed by simply bending them outward from the surface 211, at the same time producing the recesses 202.

FIG. 25 shows clearly that the baffles or deflectors 227 serving to generate the lateral components are attached to opposite edges of the recesses 202 belonging to consecutive rows so that the lateral components of the jets in consecutive rows are inversely directed as shown by the arrows 321–326.

The jet outlet surface 211 can be a continuous metal plate with the recesses or openings 202 so arranged that there is uniform pitch in the rows 222–225 and a narrower pitch in the rows 221–226, bringing the number of recesses 202 per unit of length up over that in rows 222–225. The jet outlet surface 211 may also be assembled of strips in a number corresponding to the number of transverse rows 221–226, said strips each being provided with a suitable number of recesses 202.

It has already been mentioned that the pressure must be extremely progressive to push the web, when running astray, back into its center position as quickly as possible and insure adequate stability in web guidance. FIG. 30 is a diagram of the required distribution of pressure over the drying area. The various values of pressure are plotted over the distance

$$\frac{d}{2}+\frac{d}{2}$$

from a jet outlet surface above the web to another jet outlet sunrface underneath the web. The pressure supplied by the lower nozzle bank has its highest value in close proximity of the jet outlet surface and decreases towards the opposite jet outlet surface according to the curve Pu in FIG. 30. The same applies to the value Po. Both curves intersect at the distance

$$\frac{d}{2}$$

the pressure curves Po and Pu having a gradient corresponding to the tangents of the angles α and β respectively. This rising value must constantly increase towards the jet outlet surfaces in order to satisfy the demand for progressivity.

As soon as a web with the unit weight g is introduced into the drying area with the pressure distributed according to FIG. 30, it will assume a position corresponding to the distance a_s so that it is not exactly in the middle between the two confining surfaces of the drying area. This eccentric position naturally being detrimental, the air jets emerging from opposite outlet surfaces are adjusted in such a way as to make the pressure of the lower and upper jets follow curves Pu and Po respectively (FIG. 31). The point of intersection of the two curves Po and Pu, i.e. the point of equal pressure in the upper and lower jets, takes a position corresponding to the distance a_g from the lower confining surface of the nozzle bank. A web with the unit weight g introduced into such a pressure field will, as shown in FIG. 31, then float in the center position between the upper and lower confining surfaces, that is, at a distance a_s being equal to half the distance d.

In the claims:

1. A method of contactless guiding an elongated web of flexible material during its movement in longitudinal direction substantially in one plane, comprising the steps of directing streams of compressed gaseous material onto opposite faces of said web as the same is moving in longitudinal direction in a plane; and arranging adjacent gas streams on each side of said web in such a manner that adjacent gas streams form together substantially tubular gas jets which respectively enclose non-fluid flowing spaces tapering toward the respective face of said web, so that portions of said gas streams impinging on the respective faces of said web will be deflected into said non-fluid flowing spaces to create therein respectively gas cushions with a static pressure in excess of atmospheric pressure, whereby, during deviation of said web to one side of said plane, the gas cushions on said one side will be compressed while the gas cushions on the other side will be expanded to create thereby an equalizing force tending to maintain said web substantially in said plane during its movement.

2. A method of contactless guiding an elongated web of flexible material during its movement in longitudinal direction substantially in one plane, comprising the steps of directing streams of compressed gaseous material onto opposite faces of said web as the same is moving in longitudinal direction in a plane; arranging said gas streams on each side of said web in adjacent rows of streams extending respectively transverse to said longitudinal direction; arranging adjacent streams in each row in such a manner that said adjacent gas streams form together substantially tubular gas jets which respectively enclose non-fluid flowing spaces tapering toward the respective face of said web, so that portions of said gas streams impinging on the respective faces of said web will be deflected into said non-fluid flowing spaces to create therein respectively gas cushions with a static pressure in excess of atmospheric pressure, whereby, during deviation of said web to one side of said plane, the gas cushions on said one side will be compressed while the gas cushions on the other side will be expanded to create thereby an equalizing force tending to maintain said web substantially in said plane during its movement; and arranging the streams of gas in adjacent rows of streams in such a manner that

planes of symmetry of said gas jets extending in direction of said rows are in successive rows alternatively inclined in opposite directions and at acute angles to the plane of said web.

3. A method of contactless guiding an elongated web of flexible material during its movement in longitudinal direction substantially in one plane, comprising the steps of directing streams of compressed gaseous material onto opposite faces of said web as the same is moving in longitudinal direction in a plane; arranging said gas streams on each side of said web in adjacent rows of streams extending respectively transverse to said longitudinal direction; arranging adjacent streams in each row in such a manner that said adjacent gas streams form together substantially tubular gas jets which respectively enclose non-fluid flowing spaces tapering toward the respective face of said web, so that portions of said gas streams impinging on the respective faces of said web will be deflected into said non-fluid flowing spaces to create therein respectively gas cushions with a static pressure in excess of atmospheric pressure, whereby, during deviation of said web to one side of said plane, the gas cushions on said one side will be compressed while the gas cushions on the other side will be expanded to create thereby an equalizing force tending to maintain said web substantially in said plane during its movement, and inclining said gas streams in successive rows alternatively in opposite directions and transverse to the direction of movement of said web.

4. Apparatus for contactless guiding of an elongated web of flexible material during its movement in longitudinal direction substantially in a plane comprising, in combination, a plurality of gas ejecting means respectively arranged on opposite sides of said plane for ejecting streams of compressed gas onto opposite faces of said web, said gas ejecting means on each side of said plane being arranged in such a manner that the streams of gas emanating from adjacent gas ejecting means form moving substantially tubular gas curtains respectively enclosing spaces tapering from the respective gas ejecting means toward the respective face of said web, so that portions of the gas streams respectively producing said gas curtains and impinging on the respective face of said web will be deflected by the latter into said enclosed spaces to create therein gas cushions with a static pressure in excess to atmospheric pressure, whereby during deviation of said web to one side of said plane, the gas cushions on said one side will be compressed while the gas cushions on the other side will be expanded to create thereby an equalizing force tending to maintain said web during its movement substantially in said plane.

5. Apparatus for contactless guiding of an elongated web of flexible material during its movement in longitudinal direction substantially in a plane comprising, in combination, a plurality of gas ejecting means respectively arranged on opposite sides of said plane for ejecting streams of compressed gas onto opposite faces of said web, said gas ejecting means on each side of said plane being arranged in a plurality of rows extending transverse to said direction of movement and in such a manner that the streams of gas emanating from adjacent gas ejecting means form moving substantially tubular gas curtains respectively enclosing spaces tapering from the respective gas ejecting means toward the respective face of said web, so that portions of the gas streams respectively producing said gas curtains and impinging on the respective face of said web will be deflected by the latter into said enclosed spaces to create therein gas cushions with a static pressure in excess to atmospheric pressure, whereby during deviation of said web to one side of said plane, the gas cushions on said one side will be compressed while the gas cushions on the other side will be expanded to create thereby an equalizing force tending to maintain said web during its movement substantially in said plane.

6. Apparatus for contactless guiding of an elongated web of flexible material during its movement in longitudinal direction substantially in a plane comprising, in combination, a plurality of gas ejecting means respectively arranged on opposite sides of said plane for ejecting streams of compressed gas onto opposite faces of said web, said gas ejecting means on each side of said plane being arranged in a plurality of groups of rows extending substantially parallel to each other and transverse to said direction of movement of said web with the gas ejecting means in each individual row spaced equal distances from each other and with said distances in the outer rows of each group smaller than that in the rows between said outer rows, said gas ejecting means being further arranged in such a manner that the streams of gas emanating from adjacent gas ejecting means form moving substantially tubular gas curtains respectively enclosing spaces tapering from the respective gas ejecting means toward the respective face of said web, so that portions of the gas streams respectively producing said gas curtains and impinging on the respective face of said web will be deflected by the latter into said enclosed spaces to create therein gas cushions with a static pressure in excess to atmospheric pressure, whereby during deviation of said web to one side channels directed toward one face of said web and the of said gas outlet channels, the deflector means in each channel being spaced from each other and from said side of said plane, the gas cushions on said one side will be compressed while the gas cushions on the other side will be expanded to create thereby an equalizing force tending to maintain said web during its movement substantially in said plane.

7. Apparatus for contactless guiding of an elongated web of flexible material during its movement in longitudinal direction substantially in a plane comprising, in combination, a plurality of elongated channel means adapted to be connected to a source of compressed gas and arranged on opposite sides of said plane and on each side of said plane in a plurality of rows extending transverse to said direction of movement, the channel means on one side of said plane being formed with gas outlet channels directed toward one face of said web and the channel means on the other side of said plane being formed with gas outlet channels directed toward the other face of said web; and plate shaped deflector means in said gas outlet channels and defining in the latter gas outlet openings having annular gas outlet portions respectively surrounding said plate shaped deflector means and through which compressed gas in said channels may escape in form of gas jets onto the respective face of said web in such a manner that jets escaping through said annular gas outlet portions form moving gas curtains enclosing between themselves spaces tapering from said gas outlet openings toward the respective face of said web and so that portions of said gas jets respectively producing said gas curtains and impinging on the respective face of said web will be deflected by the latter into said enclosed spaces to create therein gas cushions with a static pressure in excess to atmospheric pressure, whereby during deviation of said web to one side of said plane, the gas cushions on said one side will be compressed while the gas cushions on the other side will be expanded to create thereby an equalizing force tending to maintain said web during its movement substantially in said plane.

8. Apparatus for contactless guiding of an elongated web of flexible material during its movement in longitudinal direction substantially in a plane comprising, in combination, a plurality of elongated channel means adapted to be connected to a source of compressed gas and arranged on opposite sides of said plane and on each side of said plane in a plurality of rows extending transverse to said direction of movement, each of the channel means having a pair of spaced side walls extending substantially parallel to each other in said transverse direction and defining between themselves gas out-

let channels and the gas outlet channels of the channel means one side of the plane being directed toward one face of said web while the gas outlet channels of the channel means on the other side of said plane being directed toward the other face of said web; and a plurality of substantially plate shaped deflector means located in each of said gas outlet channels, the deflector means in each channel being spaced from each other and from said side walls to form annular gas outlet openings about each deflector means through which compressed gas in said channel means may escape in the form of gas curtains increasing in thickness toward said web so as to define in the area between each deflector means and the web an enclosed space tapering toward said web and so that part of the gas impinging on the respective face of said web will be deflected by the latter into said enclosed spaces to create therein gas cushions with a static pressure in excess to atmospheric pressure, whereby during deviation of said web to one side of said plane, the gas cushions on said one side will be compressed while the gas cushions on the other side will be expanded to create thereby an equalizing force tending to maintain said web during its movement substantially in said plane.

9. Apparatus for contactless guiding of an elongated web of flexible material during its movement in longitudinal direction substantially in a plane comprising, in combination, a plurality of elongated channel means adapted to be connected to a source of compressed gas and arranged on opposite sides of said plane and on each side of said plane in a plurality of rows extending transverse to said direction of movement, the channel means on one side of said plane being formed with gas outlet channels directed toward one face of said web and the channel means on the other side of said plane being formed with gas outlet channels directed toward the other face of said web; and a plurality of tongue shaped deflector means located in said gas outlet channels partly overlapping each other in longitudinal direction of the latter, each of said tongue shaped deflector means having opposite side edges spaced at least in part from corresponding side edges of said gas outlet channels so as to define with the latter gas outlet openings having annular gas outlet portions respectively surrounding said plate shaped deflector means and through which compressed gas in said channels may escape in form of gas jets onto the respective face of said web in such a manner that jets escaping through said annular gas oulet portions form moving gas curtains enclosing between themselves spaces tapering from said gas outlet openings toward the respective face of said web, so that portions of said gas jets respectively producing said gas curtains and impinging on the respective face of said web will be deflected by the latter into said enclosed spaces to create therein gas cushions with a static pressure in excess to atmospheric pressure, whereby during deviation of said web to one side of said plane, the gas cushions on said one side will be compressed while the gas cushions on the other side will be expanded to create thereby an equalizing force tending to maintain said web during its movement substantially in said plane.

10. Apparatus for contactless guiding of an elongated web of flexible material during its movement in longitudinal direction substantially in a plane comprising, in combination, a plurality of elongated channel means adapted to be connected to a source of compressed gas and arranged on opposite sides of said plane and on each side of said plane in a plurality of rows extending transverse to said direction of movement, the channel means on one side of said plane being formed with gas outlet channels directed toward one face of said web and the channel means on the other side of said plane being formed with gas outlet channels directed toward the other face of said web; and a plurality of tongue shaped deflector means arranged in a row partly overlapping each other between said side walls of each channel and each

connected at one end thereof to said side walls, said tongue shaped deflector means having at said connected end a width equal to the spacing between said side walls and the width of each of said tongue shaped deflector means being stepwise reduced toward the free end thereof so as to define between the reduced portions of said tongue shaped deflector means and said side walls gas outlet openings having annular gas outlet portions respectively surrounding said plate shaped deflector means and through which compressed gas in said channels may escape in form of gas jets onto the respective face of said web in such a manner that jets escaping through said annular gas outlet portions form moving gas curtains enclosing between themselves spaces tapering from said gas outlet openings toward the respective face of said web, so that portions of said gas jet respectively producing said gas curtains and impinging on the respective face of said web will be deflected by the latter into said enclosed spaces to create therein gas cushions with a static pressure in excess to atmospheric pressure, whereby during deviation of said web to one side of said plane, the gas cushions on said one side will be compressed while the gas cushions on the other side will be expanded to create thereby an equalizing force tending to maintain said web during its movement substantially in said plane.

11. Apparatus for contactless guiding of an elongated web of flexible material during its movement in longitudinal direction substantially in a plane comprising, in combination, a plurality of elongated channel means adapted to be connected to a source of compressed gas and arranged on opposite sides of said plane and on each side of said plane in a plurality of rows extending transverse to said direction of movement, each of the channel means having a pair of spaced side walls extending substantially parallel to each other in said transverse direction and defining between themselves gas outlet channels and the gas outlet channels of the channel means one side of the plane being directed toward one face of said web while the gas outlet channels of the channel means on the other side of said plane being directed toward the other face of said web, said side walls having elongated edge portions directed toward said web and being inclined toward each other; an elongated deflector means located in each of said outlet channels between said inclined edge portions of said side walls, each of said elongated deflector means having a U-shaped cross section open toward said web and having opposite leg portions extending along said elongated edge portions of said side walls spaced therefrom to form therewith annular gas outlet passages converging toward said web through which compressed gas in said channel means may escape in the form of gas curtains increasing in thickness toward said web so as to define in the area between each deflector means and the web an enclosed space tapering toward said web, so that part of the gas impinging on the respective face of said web will be deflected by the latter into said enclosed spaces to create therein gas cushions with a static pressure in excess to atmospheric pressure, whereby during deviation of said web to one side of said plane, the gas cushions on said one side will be compressed while the gas cushions on the other side will be expanded to create thereby an equalizing force tending to maintain said web during its movement substantially in said plane.

12. Apparatus as defined in claim 7 and including a guide surface at each of said gas outlet openings and extending substantially in direction of movement of said web and including an acute angle with the plane of said web.

13. An apparatus as defined in claim 12 in which said gas outlet openings in each of said channel means are arranged in a plurality of substantially parallel rows and in which said guide surfaces at the outlet openings of adjacent rows are oppositely inclined at acute angles to the plane of said web.

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