May 2, 1967 O. G. HAYWOOD 3,316,657

AIR DEFLECTOR UTILIZING COANDA EFFECT

Filed Oct. 23, 1965

3 Sheets-Sheet 1

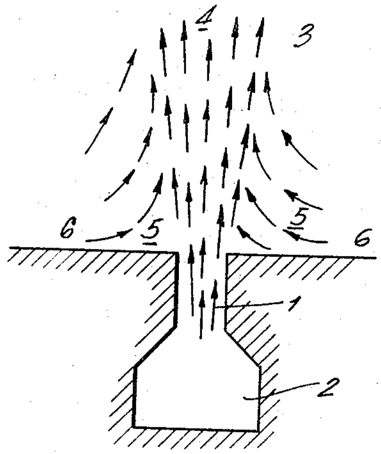

FIG. 1

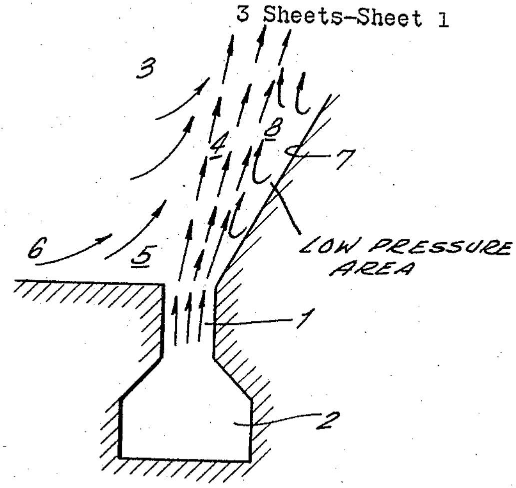

FIG. 2

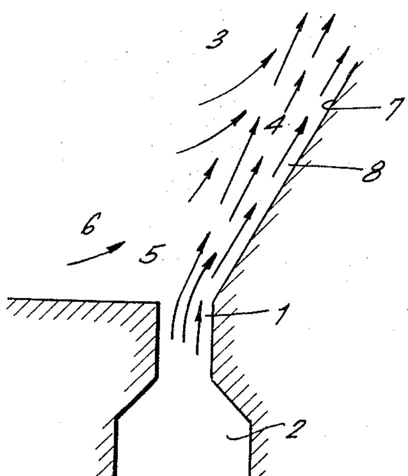

FIG. 3

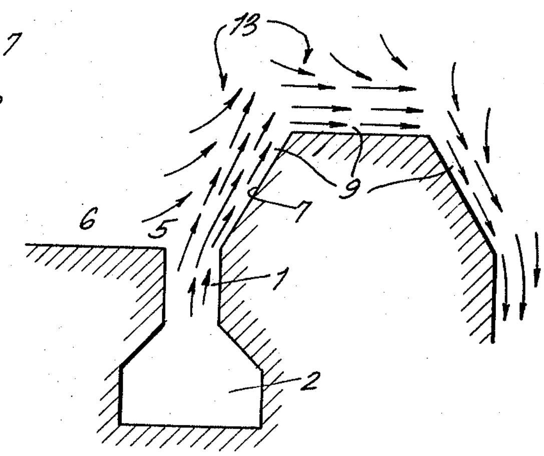

FIG. 4

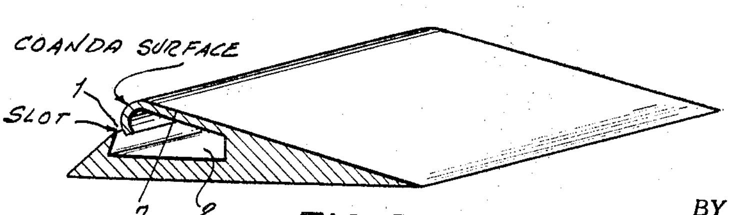

FIG. 8

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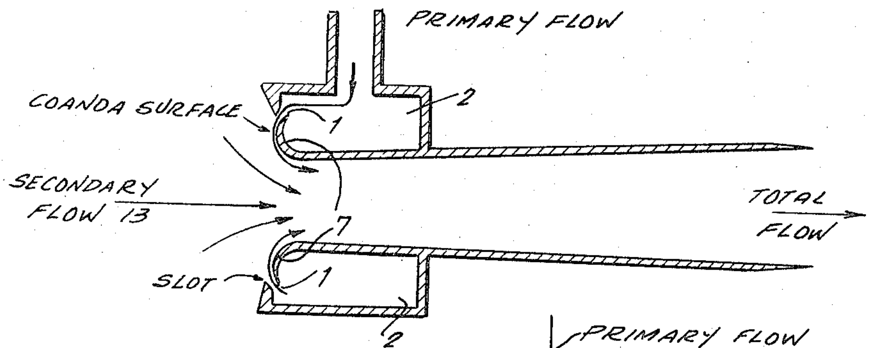
3 Sheets-Sheet 2

FIG. 5



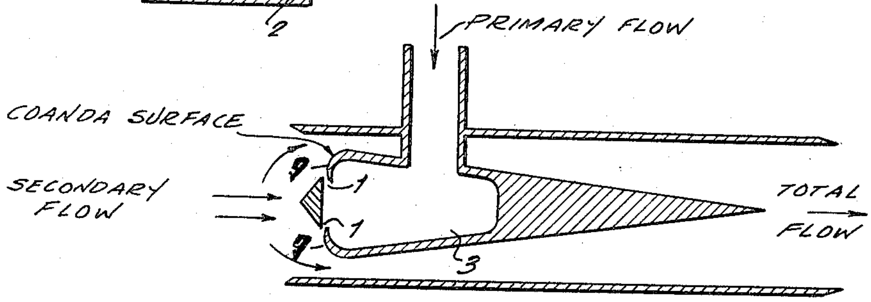


FIG. 6

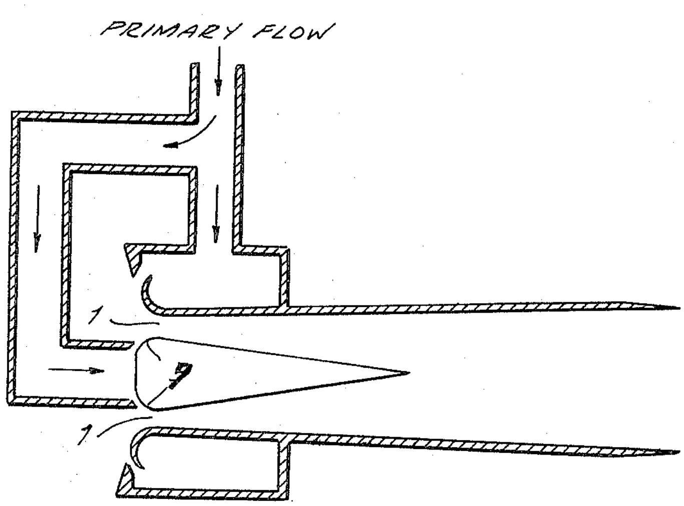


FIG. 7

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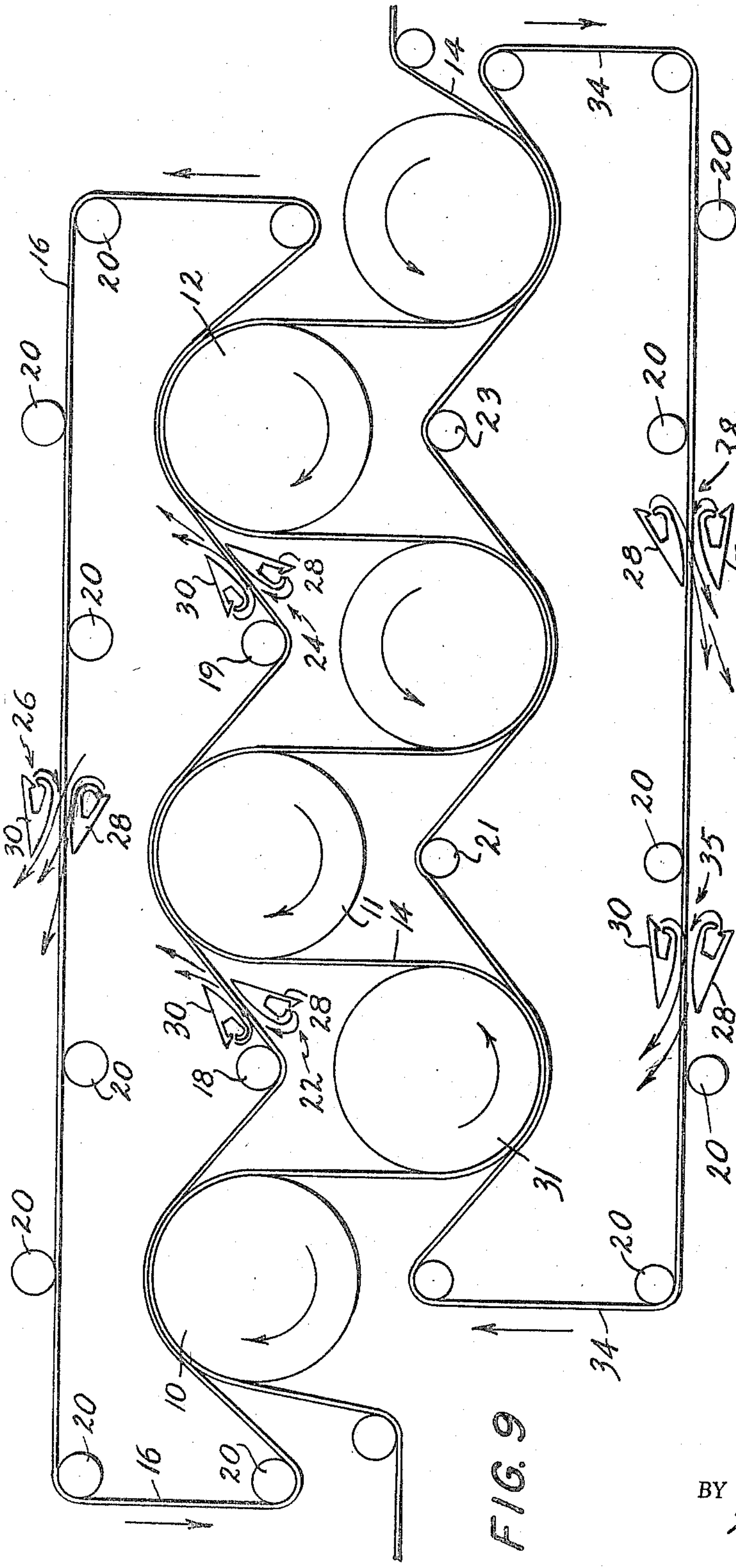

FIG. 9

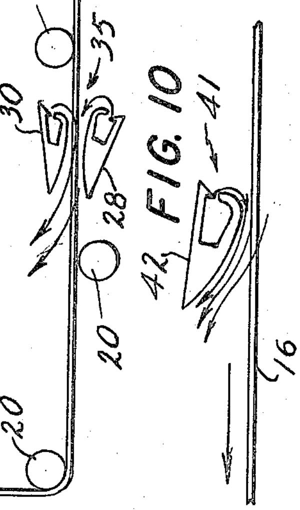

FIG. 10

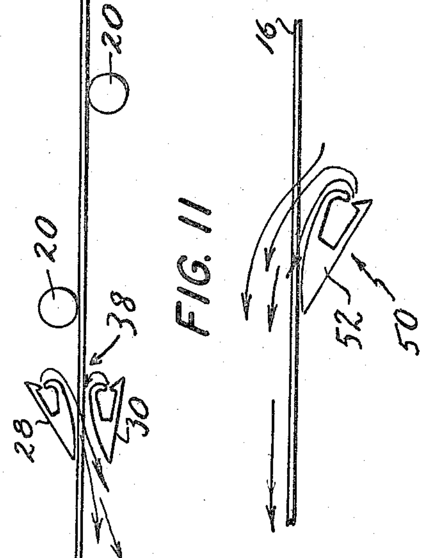

FIG. 11

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AIR DEFLECTOR UTILIZING COANDA EFFECT

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Filed Oct. 23, 1965, Ser. No. 503,255
18 Claims. (Cl. 34—111)

This invention relates to the manufacture and processing of paper and, more particularly, is concerned with improved apparatus which is useful in the dryer section of machinery on which continuous webs of "paper," meaning pulp, paper, paperboard, or other materials which are paperlike in form, may be made.

A typical continuous papermaking machine on which the invention taught herein may be practiced is the so-called Fourdrinier machine, which usually consists of three sections: the forming section, the press section, and the dryer section. In the forming section, an aqueous suspension of fibers is flowed onto an endless belt made from metal or synthetic filaments, and most of the water is removed therefrom by the use of well-known water extraction devices, such as fols, table rolls, and suction boxes. The continuous web formed thereby is then transferred to and passed through a series of nips formed by press rolls, which serves to remove additional water from the web and to compact it. Finally, the web is passed upward and downward over a series of heated dryer rolls or cylinders which are arranged parallel to each other in top and bottom arrays, for the purpose of further reducing its moisture content to the extent desired. In addition to effecting drying by the application of heat to the web, such dryer rolls may be made with a gas pervious roll surface through which air or other suitable drying media may be forced.

As the formed web of paper comes into sequential contact with the heated dryer rolls, it is pressed against each such dryer roll by means of one or more endless backing fabrics, which are usually referred to as "dryer fabrics" or "dryer felts," in order to increase the heat transfer from the rolls to the paper web, and to perfect the physical properties and characteristics of the finished sheet. Normally, separate dryer fabrics are used for the top and for the bottom dryer rolls. In the past, such dryer fabrics have ordinarily been heavy, relatively impervious, blanket-like structures called "dryer felts." More recently, dryer fabrics of a pervious or porous construction have been used whereby at least some of the moisture liberated from the paper sheet at it is pressed against each dryer roll can pass directly through such dryer fabric. Typically, such fabrics may be of woven construction, but may also be sheet-like belts which have been perforated, or other suitable structures. Preferably, such fabrics, belts, or structures are made from natural and/or synthetic materials, such as polymer resins, which are moisture resistant and substantially stable, physically and chemically, at the temperatures to which they are raised in the dryer section of the paper machine. Such temperatures usually are at least 50° F. less than the maximum temperature of the dryer rolls which, in current practice, rarely exceed 425° F. Such fabrics, belts, or structures are made "endless," which is to say, into the form of a closed loop, by being woven endless by the tubular weaving techniques which are well-known in the art of fabricating papermaker's fabrics, or by being woven flat and later having ends joined together by means of clipper hooks and pintle yarns, sewn seams, adhesives, ultrasonic sealing in the case of plastic sheet-like belts, or other well-known joining techniques.

Regardless of which type of dryer fabric is employed, however, there is a tendency for the steam and/or moisture-laden air which is generated as a result of the drying process to become entrapped on one or both sides of the dryer fabrics at various points along their paths of travel. This is especially so where tent-like "pockets" are formed by the various elements normally present in the dryer section of the papermaking machine. One such group of pockets is formed where a top dryer fabric is supported by rolls along its return run back toward the forward or web receiving end of the dryer section. Another group of such pockets is formed directly below each of the top dryer rolls, and directly above each of the bottom dryer rolls; each such pocket being an open-ended, substantially tubular enclosure extending in the cross-machine direction, directly below each such top roll or above each such bottom roll as the case may be, and being bounded by the roll itself, the web of paper on each side of the enclosure, and the dryer fabric opposite the roll in question. Still another such group of pockets is formed where a bottom dryer fabric is supported by fabric rolls (sometimes referred to as "pocket" rolls) positioned between the bottom dryer rolls.

Such moist air and steam must, of course, be removed continually, in order to ensure that the moisture content of the web may be controlled and to promote the efficiency of the drying process. This is usually accomplished by forcing air transversely through the dryer section using suitably positioned blowers, and by drawing air from the general area of the dryer section with overhead exhaust fans. However, the effectiveness of these removal procedures is not entirely satisfactory for a number of reasons, among which are the resulting uneven temperature and moisture profiles across the web. It is readily apparent, therefore, that improvement in such removal procedures is desirable and presently needed.

It has now been found that the removal of such moist air and steam from the dryer section of a continuous paper-making machine utilizing one or more pervious dryer fabrics can be materially facilitated. This objective is achieved in accordance with this invention by providing one or more linear Coanda nozzles extending across the width of such dryer fabric at one or more desired locations adjacent to the broad surfaces of the fabric, and disposing such nozzles at an angle with respect to the dryer fabric such that a transfer of gas, including steam and/or moisture-laden air, from one side of the dryer fabric through the fabric to its other side will be effected.

The arrangement provided by the present invention may take any of several specific forms of embodiment. For example, a linear Coanda nozzle my be positioned closely adjacent to one side of the dryer fabric and disposed with respect thereto at an angle *diverging* from the direction of movement of the dryer fabric, so that the nozzle will cause gas to be sucked through the fabric from the opposite side of fabric to the nozzle side of the fabric. Alternatively, a linear Coanda nozzle may be positioned on one side of the fabric and disposed with respect thereto at an angle *converging* toward the direction of movement of the dryer fabric, so that the nozzle will cause gas located on its side of the fabric to be propelled there through to the other side. In either case, the resulting effect of the action of the nozzle is to cause at least a portion of the gas on one side of the dryer fabric to flow *through* the fabric to the other side.

Advantageously, a converging nozzle positioned on one side of the dryer fabric as indicated above is utilized in conjunction with a diverging nozzle positioned on the other side of the dryer fabric, also as indicated above. The two nozzles in such case may be so situated with respect to each other that the diverging nozzle acts in concert with the converging nozzle, which is positioned on the opposite side of the fabric and tends to push gas through the fabric at the same time the diverging nozzle is sucking it through. It has been found that one way to enhance such a concerted action of two nozzles is to position the diverging nozzle so that, using as a reference the direction of travel of the moving fabric, its point of divergence from the fabric is slightly ahead of the point of convergence of the other nozzle with the fabric, thereby causing gas pushed by the converging nozzle to flow through the fabric directly into the zone of suction created by the diverging nozzle on the opposite side of the fabric.

According to this invention, such a nozzle or set of nozzles, may be located at any point or points along the path traversed by a dryer fabric where it is desired to effect a flow of gas, such as moisture-laden air or steam, through the dryer fabric from one side to the other thereof. For example, such a nozzle or set of nozzles can be utilized in conjunction with a dryer fabric at any location along its return run back to the forward end of the dryer section, to move gas upward through a top fabric (which backs the web against the top periphery of each top dryer roll) or to move gas upward or downward through a bottom fabric (which backs the web against the bottom periphery of each bottom dryer roll). In addition, a plurality or series of two or more single nozzles or sets of nozzles may be used wherever appropriate.

Generally, nozzles may be formed from any suitable metal, although they may also be made from a wide variety of other materials, such as plastic, wood, or Fiberglas.

It also will be apparent to those skilled in the art that while the descriptions set forth herein are directed toward webs of paper, pulp, or paperboard, the principles of this invention may be practiced in a wide variety of applications where it is desired to transfer a gaseous medium from one side to the other of a moving pervious sheet, such as a fabric, used in processing materials as, for example, in paper-coating processes.

The invention will now be described in detail in connection with the accompanying drawings, in which:

FIG. 1 depicts a straight jet emerging into a symmetrical boundary;

FIG. 2 depicts a straight jet emerging into a non-symmetrical boundary;

FIG. 3 depicts a jet deflected by the presence of a non-symmetrical boundary, or so-called "Coanda" effect;

FIG. 4 depicts a jet turned through 180° using Coanda effect;

FIG. 5 is a cross-sectional representation of an "internal" Coanda nozzle;

FIG. 6 is a cross-sectional representation of an "external" Coanda nozzle;

FIG. 7 is a cross-sectional representation of a "composite" Coanda nozzle;

FIG. 8 is a perspective view of a "linear" Coanda nozzle;

FIG. 9 is a diagramatic view of a portion of the dryer section of a continuous papermaking machine provided with several installations of a preferred embodiment of this invention;

FIG. 10 is a diagramatic view of a portion of the return run of fabric in a dryer section of a papermaking machine which has been provided with an installation of another preferred embodiment of this invention; and

FIG. 11 is a diagramatic view of a portion of the return run of fabric in a dryer section of a papermaking machine which has been provided with an installation of still another preferred embodiment of this invention.

Before describing this invention, it will be necessary to explain the phenomenon known as "Coanda Effect," which is most frequently described as a tendency for a fluid to adhere to and be deflected by a boundary in its flow path. What is not so well-known is that the turning caused by the presence of the boundary leads to a surprising degree of momentum and flow augmentation under certain conditions. It is these latter aspects of Coanda Effect which

are particularly significant in the invention described herein.

The phenomenon called "Coanda Effect" is easier to understand by considering first the two-dimensional case. Referring to FIG. 1, if a slot **1** exists between a chamber **2** of fluid at elevated pressure and a region **3** of lower pressure, fluid will flow through the slot and emerge in the form of a jet **4** into the region of lower pressure. This jet will have a certain momentum, or product of mass-flow and velocity, which will be determined uniquely by the area of the slot and the pressure drop across it. The flow of the jet will tend to produce a low-pressure region **5** in the vicinity of the slot so that surrounding fluid is induced to flow toward the jet and becomes entrapped by it. As mixing takes place, the average velocity of the flow decreases and the mass increases until, at some distance away from the slot, the jet dissipates in random motion of fluid particles. If one were to measure the total momentum of the flow at any point after emergence from the slot **1** it would not exceed, at least in principle, the momentum at the slot **1**, and as mixing increased, the random motion of particles would be expected to decrease with distance from the slot **1**. All momentum changes would take place by collision of particles.

If the geometry in the vicinity of the slot opening is changed by the introduction of a boundary **7** as in FIGURE 2, it can be seen at once that the induced flow of fluid toward the jet **4** will be hampered on the side where the new boundary has been introduced. This will lead to a region **8** of reduced pressure between the jet **4** and the boundary **7**. The existence of the region of reduced pressure causes a deflection of the jet **4** which further reduces the pressure in the region **8** and leads to further deflection until, as shown in FIGURE 3, the jet lies on the boundary itself with a region **8** of greatly reduced pressure right at the boundary. By means of the same principle, the flow can be further turned by successive changes in direction of the boundary as illustrated in FIGURE 4, which may be made continuous so as to produce a smooth curve.

The deflected jet now has three characteristics which are of considerable interest. First, the velocity on the unbounded side of the jet will be equal to the velocity in the jet of FIGURE 1, while the velocity everywhere else in the jet will be higher, due to the greater pressure drop induced by the boundary **7**. Hence, the average velocity of the *deflected* jet will be higher than the average velocity of a straight jet created by the same supply pressure chamber **2**.

Second, since the pressure in the deflected jet is everywhere equal to or less than the pressure in the straight jet and the slot size remains the same, the average *momentum* of the deflected jet will be higher than that of a straight jet created by the same supply pressure.

Third, there will exist a pressure gradient across the jet which, under steady-state conditions, creates a static pressure field similar to that created by flow past an airfoil. This field induces a secondary flow **13** of considerable magnitude, and, depending on the geometry used, may be converted into either high static lift or high mass-flow rates. Because of the momentum augmentation in the primary and because the secondary flow **13** is induced by a pressure field rather than by less efficient collision processes, the total flow produced by the deflected jet is characterized by substantial momentum augmentation and a high degree of energy transfer efficiency.

The discussion so far applies generally to all fluids, whether compressible or incompressible. If the fluid involved is compressible, there is an additional characteristic of interest. With Coanda effect, the existence of an average pressure in the jet lower than ambient leads to greater expansion of the fluid than would be the case with a straight jet, as evidenced by the momentum augmentation produced, so that less random motion is evident in the combined exit flow from a Coanda nozzle than would be expected from a conventional ejector. Since a greater portion of the original potential energy in the primary emerges as *ordered* kinetic energy, the exit temperature of the flow is substantially lower than would be obtainable with a conventional ejector. This effect may prove to be of value in certain applications, such as the one herein described, where temperature rise must be minimized.

The foregoing discussion has considered Coanda Effect in only two dimensions. There are several ways in which the basic principle may be extended to three dimensions. First, we may create a figure of revolution about an axis internal and external nozzles to produce composite nozzles Coanda Nozzle, shown in FIGURE 5. Also, rotation about an axis external to the flow produces an external Coanda Nozzle, as in FIGURE 6. Or we may combine internal and external nozzles to produce composite nozzles of various types; for example, the type shown in FIGURE 7. Still another configuration, and the one which will be particularly useful in the application herein described, is to use the two-dimensional configuration heretofor described in FIGURES 2 through 4 and merely extend it flat through the third dimension, with the deflecting boundary in the shape of a wing or a foil, as illustrated in FIGURE 8, thereby producing a linear Coanda nozzle. It will be noted that this structure is, in effect, the internal Coanda nozzle illustrated in FIGURE 5 except in flat rather than circular configuration. The choice of embodiment depends upon the application and the boundary conditions of the flow.

The dryer section partially shown in FIG. 9 includes a plurality of horizontally disposed top dryer rolls **10, 11, 12,** and bottom dryer rolls **31, 32, 33**; all of which are rotatable and, usually, heated. The continuously formed web **14** is successively passed between the top and bottom dryer rolls for the purpose of driving off residual moisture from the web to a predetermined extent. Means (not shown) are provided for rotating such dryer rolls in unison so that the continuous web **14** can be moved through the dryer section without breaking. In addition, other means (not shown) are provided for controllably admitting steam or some other suitable heating medium into the dryer rolls in order to furnish the heat utilized to effect the desired drying of the web. The surfaces of such rolls which come in contact with the web may optionally be solid or made from porous material such as sintered metal fibers, or sintered powder metal, or fused glass, or thermoplastic or thermosetting material, through which gas may be blown or sucked.

Movable in conjunction with the web and arranged to press such web against at least the top portion of each of the top dryer rolls **10, 11, 12** is an endless, porous, top dryer fabric **16**. As indicated in FIG. 9, such dryer fabric passes under rotatable fabric rolls **18, 19** positioned between each pair of dryer rolls somewhat below the center of rotation of each such dryer roll, so that good contact between the continuous web **14** and the successive top dryer rolls is assured. On the return run (shown in the upper portion of FIG. 1), the dryer fabric **16** passes over (or under as required) a plurality of rotatable return rolls **20**. Means (not shown) may be provided for rotating one or more of the fabric rolls and/or one or more of the return rolls as may be necessary to insure proper movement of the endless dryer fabric. Similarly, the bottom dryer rolls **31, 32, 33** are operated in conjunction with a bottom backing fabric **34**, positioned below the bottom dryer rolls, which also is supported by fabric rolls **21, 23** positioned between the bottom dryer rolls, and by return rolls **20**.

The result of the successive passage of the continuous web **14** around and in contact with the dryer rolls is the generation of steam through liberation of moisture from the web. A portion of such generated steam escapes through the porous dryer fabric while the web **14** is held in contact with each dryer roll by the dryer fabric. The remainder of such generated steam escapes as the con-

tinuous web is removed from intimate contact with the surface portion of each dryer roll. In the former case, such steam tends to accumulate, for example, in the area under the return run portion of the endless dryer fabric **16**, and in the pockets formed by the bottom fabric **34** and the fabric rolls **21, 23**; and in the latter case pockets of steam tend to form, for example, in the pockets formed above and below the dryer rolls by the dryer fabric, the web of paper, and the several dryer rolls. Of course, a certain amount of migration of such steam as well as heated, moisture-laden air upward through the various layers of dryer fabric takes place by natural convection. However, in order to accelerate expulsion of such steam as it accumulates, means (not shown), such as fans, may be provided for causing air to move transversely through the dryer section, and other means (not shown) may be provided for exhausting steam and/or moisture-laden air from the general region of the dryer section.

In accordance with the invention, such steam removal is aided by the provision of one or more arrangements to facilitate the passage of moist air through a porous dryer fabric at points along its path of travel where it is not pressing the web into intimate contact with a dryer roll. Any number of such arrangements may be installed in a given dryer section as its layout permits, and such arrangements may take any of several forms of embodiment, as previously indicated.

The five arrangements, **22, 24, 26, 35,** and **38** shown in FIG. 9 are similar and comprise some of the preferred embodiments of the invention. As will be apparent, arrangement **22** is associated with the top dryer fabric **16** about midway between fabric roll **18** and dryer roll **11**; arrangement **24** is similarly associated with the top dryer fabric **16** about midway between fabric roll **19** and dryer roll **12**; arrangement **26** is associated with the top dryer fabric **16** along its return run portion; and arrangements **35** and **38** are associated with the bottom dryer fabric **34** along its return run portion. Each such arrangement comprises a linear Coanda nozzle **28** positioned adjacent to one side of one of the dryer fabrics and extending in the cross-machine direction thereof, and a linear Coanda nozzle **30** located near the nozzle **28** and positioned closely adjacent to the opposite side of the same dryer fabric therefrom, and also extending in the cross-machine direction. The primary or inducing air flow in each such nozzle may be supplied by pneumatic feedlines (not shown), such as are commonly used around such machinery in connection with auxiliary mechanisms which, in turn, may be supplied by a compressor (not shown), or other air pressure source.

Each nozzle **28** is disposed with respect to the backing fabric at an angle *converging* in the direction of movement of such dryer fabric. In other words, each nozzle **28** is so oriented in relation to the surface of the fabric that the flow of gas which it induces has its origin in the region adjacent to the same surface of the fabric to which the nozzle **28** is adjacent, and extends through the fabric into the region adjacent to the opposite surface of the fabric.

Each nozzle **30** is disposed with respect to the backing fabric at an angle *diverging* in the direction of movement of such dryer fabric. That is to say, each nozzle **30** is so positioned and oriented with respect to the surface of the dryer fabric that the flow of gas which it induces has its origin substantially in the region adjacent to the surface of the fabric *opposite* the surface to which the nozzle **30** is adjacent, and extends through the fabric into the region adjacent to that surface of the fabric to which the nozzle **30** also is adjacent. Generally, such a nozzle should be positioned so that it nearly touches the surface of the fabric in order to ensure that the preponderance or at least a substantial portion of the induced air flow comes from the opposite side of the fabric, but still far enough from the fabric to ensure that the primary air flow from the Coanda nozzle is not interfered with.

The net effect of both the diverging nozzle **30** and the converging nozzle **28** is to set up a pressure gradient from one side of the dryer fabric to the other side thereof. As a consequence, gas, such as moist air and/or steam, on one side of the dryer fabric is caused to flow therethrough. It should be noted that in each of the embodiments illustrated in FIG. 9, the converging nozzle **28** was positioned substantially opposite its associated diverging nozzle **30** but on the other side of the fabric therefrom. By this means, gas may be moved from the zone of increased pressure created by each converging nozzle **28** through the fabric and directly into the corresponding zone of decreased pressure created behind its associated diverging nozzle **30**. In the case of arrangements **22** and **24**, moist air is moved from the steam pockets formed by the top dryer fabric **16** and the paper web with dryer rolls **31** and **32** respectively into the region immediately above such top dryer fabric **16** and the dryer rolls **11**, **12**, from whence it can more readily be blown transversely out of the dryer section by fans or other means or transferred upward through the fabric **16** on its return run. Similarly, in the case of arrangement **26**, the moist air is moved from the area of accumulation below the return run of the top dryer fabric **16** into the region above such return run, from whence it can much more readily be exhausted.

In arrangement **35**, relatively cool and/or dry air is moved from below the return run of the bottom dryer fabric **34** through the fabric into the zone enveloped by the fabric **34**. The effect of this is to replace the steam and moisture-laden air entrapped in that zone after liberation from the web **14** through the fabric **34** as they pass together over the surfaces of the bottom dryer rolls **31**, **32**, **33**. Such replaced steam and moisture-laden air will be forced outward from the zone of entrapment both ways in the cross-machine direction, and also will be forced upward through the fabric **34** from the pockets formed by the fabric **34** as it passes over the fabric rolls **21**, **23** into the pockets formed by the top dryer rolls **11**, **12** with the paper web and the bottom fabric **34**, from whence it may be moved outward both ways from such pockets in the cross-machine direction by fans or other propelling means.

It will be noted that in all of the heretofore discussed arrangements **22**, **24**, **26**, **35**, the natural tendency of the steam and/or moisture-laden warmed air to move upward through the layers of fabric has supplemented the dynamic effect of each such arrangement. Arrangement **38** demonstrates how the principles of this invention may be used advantageously to counteract such a natural tendency of relatively warm or hot gas to rise through convection, in order to deal more effectively with the problems heretofore discussed. In arrangement **38**, in contrast to arrangements **22**, **24**, **26**, **35**, the converging nozzle **28** is positioned adjacent to the *upper* surface of the fabric **34**; that is, the surface toward which air would naturally tend to move by convection. Diverging nozzle **30** is positioned adjacent to the lower surface of the fabric **34**, substantially opposite the converging nozzle **28**. The effect of this arrangement is to overcome the natural tendency of hot air to move upward through the fabric **34** by convection, to a point where steam or hot moisture-laden air, for example, in the enclosure formed by its backing fabric **34** actually will be moved downward through the fabric to its underside, from whence it may be exhausted away from the dryer area by fans or other means.

It will be apparent that a similar arrangement might be used to advantage at other points. Thus, by utilizing such an arrangement of nozzles, for example, between bottom fabric roll **21** and the point of contact of the backing fabric **34** with bottom dryer roll **32**, steam and/or moisture-laden air may readily be removed downward from the pocket formed by the bottom dryer fabric **34**, the web **14**, and the top dryer roll **11**. Conversely, the nozzles could be arranged at this point to transfer steam and/or moisture-laden air upward from the pocket below the roll **21** to the pocket above the roll **21**. As will be clear, then, each of the arrangements heretofore described exerts a positive acceleration on the steam or moisture-laden air being removed from the continuous web as it passes through the dryer section, and facilitates removal of such air from the dryer section region.

The individual effect of such diverging and converging nozzles is illustrated respectively in FIGS. 10 and 11; each of which in itself constitutes another useful embodiment of this invention. Arrangement **41** is shown in FIG. 10 as being associated with a top dryer fabric **16** along its return run portion, although it could obviously be associated with a bottom dryer fabric too. Arrangement **41** is comprised of the nozzle **42** positioned on the top side of the dryer fabric and extending in the cross-machine direction thereof. Like nozzle **30** of arrangement **26** shown in FIG. 9, nozzle **42** is so disposed with respect to the dryer fabric that an angle *diverging* therefrom in the direction of movement of such dryer fabric. The effect is also similar in that gas, such as moist air or steam, on the under side of the backing fabric is induced to flow therethrough to the side of the fabric adjacent to which the nozzle **42** is positioned. Obviously such a diverging nozzle might be positioned on the *underside* of a top or a bottom dryer fabric to cause gas to be moved through the fabric from the upper to the underside thereof in the fashion of nozzle **30** in arrangement **38** in FIG. 9.

Arrangement **50** is shown in FIG. 11 as being associated with a top dryer fabric **16** along its return run portion, although it too could be associated with a bottom dryer fabric, as will be apparent from the discussion which follows. Arrangement **50** comprises a nozzle **52** positioned on the underside of the dryer fabric and extending in the cross-machine direction thereof. Like nozzle **28** of arrangement **26** shown in FIG. 9, nozzle **52** is also disposed with respect to the dryer fabric at an angle converging in the direction of movement of such dryer fabric. Again, a similar effect is obtained in that gas, such as moist air or steam, on the underside of the dryer fabric is also induced to flow therethrough to the side of the fabric opposite to that to which the nozzle **52** is adjacent. It will also be obvious that such a converging nozzle might be positioned on the top side of a bottom or top dryer fabric to cause gas to be moved through the fabric from the upper to the underside thereof in the fashion of nozzle **28** of arrangement **38** in FIG. 9.

It will be readily apparent that single vane embodiments, such as those discussed heretofore in connection with arrangements **41** and **50**, are by no means confined, in their utilization, to any particular location along the path of travel of the dryer fabric with which they are associated, but may be used to advantage at many different points along such paths of travel, including locations between the dryer and fabric rolls. It will also be apparent that single vane embodiments may be advantageously used in groups of several such single vanes each, with the vanes in each group arrayed in proximity and sometimes even in parallel to each other along one surface of a given fabric.

It should be understood that the terms, and expressions used herein and the embodiments which have been illustrated and discussed are by way of illustration, but not of limitation, of the principles of this invention, and that this invention may be practiced in a wide variety of paper-making and processing apparatus, as well as other machinery by persons skilled in the art.

I claim:

1. In an apparatus for drying a continuous sheet of paper,

an endless pervious belt movable in conjunction with said sheet and arranged to press said sheet against the drying means in said apparatus,

and a linear Coanda nozzle extending substantially in the direction of the width of said belt adjacent to one surface thereof at a desired location along the path of travel of said belt where it is not in contact with said sheet,

said nozzle being so oriented with respect to said belt that the flow of gas induced by said nozzle will originate in the mass of gas adjacent to the same surface of said belt as is said nozzle, will converge with said belt at an acute angle to the direction of travel of said belt, and will pass substantially totally through said belt to the side of said belt opposite that to which said nozzle is adjacent.

2. The device described in claim **1** wherein said belt is made from material which is characterized by resistance to moisture and by being substantially physically and chemically stable at temperatures in the range to which said belt is exposed along its path of travel through said apparatus.

3. The device described in claim **2** wherein said belt is made from a synthetic polymeric material.

4. The device described in claim **3** wherein said belt is a woven fabric.

5. The device described in claim **2** wherein said nozzle extends across the full width of said belt.

6. In an apparatus for drying a continuous sheet of material,

an endless pervious belt movable in conjunction with said sheet and arranged to press said sheet against the drying means in said apparatus,

and a linear Coanda nozzle extending substantially in the direction of the width of said belt adjacent to one surface thereof at a desired location along the path of travel of said belt where it is not in contact with said sheet,

said nozzle being so oriented with respect to said belt and so positioned with respect to said surface of said belt that at least a substantial portion of the flow of gas which is induced by said nozzle will originate in the mass of gas adjacent to the surface of the belt opposite that to which said nozzle is adjacent, will pass through said belt, and will diverge from the surface of said belt at an acute angle to the direction of travel of said belt into the mass of gas adjacent to the same surface of said belt as said nozzle.

7. The device described in claim **6** wherein said belt is made from material which is characterized by resistance to moisture and by being substantially physically and chemically stable at temperatures in the range to which said belt is exposed along its path of travel through said apparatus.

8. The device described in claim **7** wherein said belt is made from a synthetic polymeric material.

9. The device described in claim **8** wherein said belt is a woven fabric.

10. The device described in claim **7** wherein said nozzle extends across the full width of said belt.

11. In an apparatus for drying a continuous sheet of material,

an endless pervious belt movable in conjunction with said sheet and arranged to press said sheet against the drying means in said apparatus,

and a first linear Coanda nozzle and a second linear Coanda nozzle, both of which extend substantially in the width direction of said belt on opposite sides thereof from each other at desired locations along the path of travel of said belt where it is not in contact with said sheet,

said first nozzle being so oriented with respect to said belt that the flow of gas induced by said first nozzle will originate in the mass of gas adjacent to the same surface of said belt as is said first nozzle, will converge with said belt at an acute angle to the direction of travel of said belt, and will pass substantially totally through said belt into the mass of gas adjacent to the side of said belt, opposite that to which said first nozzle is adjacent,

said second nozzle being so oriented with respect to said belt and so positioned with respect to the surface of said belt that at least a substantial portion of the flow of gas induced by said second nozzle will originate in the mass of gas adjacent to the surface of the belt opposite that to which said nozzle is adjacent, will pass through said belt, and will diverge from the surface of said belt at an acute angle to the direction of travel of said belt into the mass of gas adjacent to the same surface of said belt as is said second nozzle.

12. The device described in claim **11** wherein said belt is made from material which is characterized by resistance to moisture and by being substantially physically and chemically stable at temperatures in the range to which said belt is exposed along its path of travel through said apparatus.

13. The device described in claim **12** wherein said belt is made from synthetic polymeric material.

14. The device described in claim **12** wherein substantially all of the flow of gas induced by said first nozzle will flow directly into the flow of gas induced by said second nozzle.

15. The device described in claim **13** wherein said belt is a woven fabric.

16. The device described in claim **14** wherein said belt is a woven fabric.

17. The device described in claim **15** wherein said nozzle extends across the full width of said belt.

18. The device described in claim **16** wherein said nozzle extends across the full width of said belt.

References Cited by the Examiner

UNITED STATES PATENTS

2,052,869	4/1936	Coanda	239—2
2,082,411	6/1937	Merrill	34—160 X
2,574,844	11/1951	Roden	34—160 X

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,316,657 May 2, 1967

Oliver G. Haywood

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 1, line 23, for "fols" read -- foils --; line 49, for "at" read -- as --; column 5, line 4, for "obtainable" read -- obtained --; line 12, for "and external nozzles to produce composite nozzles" read -- to the flow and produce a so-called "internal" --.

Signed and sealed this 28th day of November 1967.

(SEAL)
Attest:

Edward M. Fletcher, Jr.
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents