ABSTRACT: Apparatus for use in floating sheet materials in the nature of continuous strips or webs. The improved flotation apparatus is particularly useful in the drying and/or curing of sheet materials such as printed or coated paper, fabrics or metal sheets or strips.
FLOATATION OF SHEET MATERIALS

BACKGROUND

In typical drying apparatus such as is presently in use in web offset printing, the sheet or web may be subjected to the direct impingement of flame so as to rapidly heat the web and the ink coating materials to the point of sustained evaporation, such heating being followed by an air impingement treatment which provides a means for the removal of the vaporizing ink solvents. In another typical example, the drying apparatus might consist of a device for impinging hot air on the web to provide the sole means for heating, vaporizing and ventilating the printed or coated surfaces.

In either case, it is necessary that all contact with the wetted surfaces be avoided until the ink or other coating has been dried, and in the past, this has been extremely difficult if not impossible to accomplish, particularly since it is customary to print the web material on both sides at the same time.

When it is desired to dry both sides of a web simultaneously utilizing air impingement for ventilation or heating, the air nozzles must be so designed as to prevent and/or avoid contact with the wetted surfaces. Also, every precaution must be taken to avoid or eliminate possible vibration or fluttering of the printed or coated web since such fluttering will frequently force the wetted material into contact with one or more of the air nozzles, and any such contact with the web, even though only momentary, can cause severe smearing and consequent need for rejection of the coated material due to the rapidity of advancement of the web through the drying zone. In addition, such nozzle contact with the printed or coated surface can and sometimes does cause nozzle plugging, thereby necessitating shutdown of equipment for cleaning purposes.

In prior efforts to overcome these objectionable occurrences, it has been the practice to either reduce the air outlet velocity at the nozzles or to increase the distance between the air nozzles and the web to minimize the possibility of web contact, or both. In either case, the air velocity is greatly reduced at the point of its impingement on the web surface, and this decreases the efficiency of the dryer very undesirably. In such cases, it becomes necessary to compensate for the loss of efficiency by increasing the length and, consequently, the cost of the dryer.

SUMMARY

It is therefore an important object of the present invention to provide an improved apparatus for web positioning and flotation, particularly for drying purposes, which obviates the aforesaid objections and disadvantages of prior devices of this general type.

Another object of this invention is to provide a novel and improved web positioning and flotation apparatus which is extremely flexible in its adaptations, highly efficient in operation, and which permits the use of optimum impingement velocities without need for utilizing auxiliary devices for aiding in the positioning of the web as it is being treated or worked upon.

A further object of the invention is to provide an improved web flotation device particularly adaptable for drying purposes which has a unique and improved air nozzle arrangement in which the nozzles are protected from plugging in the event of web-to-nozzle contact.

Still another object of this invention is to provide an improved web or sheet drying apparatus especially adapted for the effective handling of sheet materials having both sides wetted and wherein the air impingement nozzles are positioned with a greater than normal web-to-nozzle clearance without any appreciable loss in impingement velocity.

An additional object of the present invention is to provide an improved flotation and positioning apparatus which is devoid of critical clearance requirements, which will handle all types of sheet materials with a high degree of efficiency, which is extremely effective in the free suspension of the web without flutter or vibration, and which permits maximum air impingement velocity.

These and other objects and advantages of the invention will become apparent from the following detailed description.

THE DRAWINGS

A clear conception of the construction and mode of operation of a typical flotation apparatus for web drying purposes may be had by referring to the drawings accompanying and forming a part of this specification wherein like reference characters designate the same or similar parts in the several views.

FIG. 1 is a removed sectional view of a typical flotation and positioning device showing the impingement zone of opposed jets;

FIG. 2 is a similar removed sectional view of a modification of the FIG. 1 device also showing the impingement zone of opposed jets;

FIG. 3 is a removed sectional view of a positioning device according to this invention and showing a balanced Coanda jet flowing into free space;

FIG. 4 is a removed sectional view of an identical positioning device embodying the invention but showing unbalanced Coanda jet flow into free space;

FIGS. 5, 5A, 5B, 5C and 5D are removed sectional views of the improved positioning device of FIG. 3 showing air flows when a Coanda jet is caused to impinge on an impervious material at various material-to-Coanda surface distances;

FIG. 6 is a sectional view of two identical positioning devices embodying the improvements and showing Coanda jet flow while positioning a web between nozzles;

FIG. 7 is a sectional view of two dissimilar positioning devices, both of which embody the invention, and showing the Coanda jet flow while positioning a web between the devices;

FIG. 8 is a sectional view of two dissimilar positioning devices both embodying the invention and each having a center zone air supply;

FIG. 9 is another removed sectional view of two dissimilar positioning devices as in FIG. 8 but each having an inadequate center zone air supply;

FIG. 10 is still another removed sectional view of two dissimilar positioning devices as in FIG. 8 but each having an excessive center zone air supply;

FIG. 11 is a cross section of a typical Coanda plate;

FIGS. 12, 13, 14, and 15 are plan views of Coanda plates showing a few of the possible orifice designs which may be used to create a center zone air supply;

FIG. 16 is a schematic cross section of a typical flotation dryer assembly embodying the present invention and using Coanda nozzles;

FIG. 17 is a removed section view of a suggested variation for the design of a Coanda positioning device; and

FIGS. 18, 19, 20, and 21 are removed section views of other suggested variations for the design of a Coanda positioning device.

DETAILED DESCRIPTION

In the description of this invention, an understanding of the Coanda effect and of the Coanda jet flows is assumed. However, the most important aspects of the Coanda effect are briefly described below.

First, when a gas or fluid flows along a solid surface, it tends to follow that surface contour within defined limits.

Second, Coanda nozzles have a great ability to efficiently entrain air from the surrounding atmosphere, and unlike a conventional nozzle discharging directly to atmosphere, a Coanda nozzle, with its protective surface on one side, is capable of being projected greater distances without appreciable loss in velocity and momentum.

The jet from a conventional nozzle discharging directly to atmosphere induces secondary flow partially due to the low pressure area near its vena contracta, but the greatest amount of secondary flow is brought about by the collision of the high-speed air molecules with the slower (or stationary) molecules of the surrounding atmosphere.
A conventional nozzle means can be defined by exacting boundaries as in FIGS. 1 and 2 wherein there is a definite and finite cutoff point; beyond which the air jet escaping to the surrounding atmosphere is no longer restrained and is not protected from exterior influences.

A Coanda nozzle means can be defined by exacting boundaries, even though it requires a surface on only one side of a moving air jet, as shown in FIGS. 3 and 4. If the orifices 3 and 4 are of such size and the energy within the plenum 1 is great enough, the distance that the Coanda jet stream 5 will travel along the Coanda surface 6 can be many feet in length. In the smaller dimensions of this invention, the air energy level within the plenum 1 will always be of adequate measure to sustain full Coanda jet flow across the maximum widths of apparatus, as shown in FIG. 4, whenever conditions so permit.

Referring to FIG. 3, an air jet discharging from a Coanda orifice 3 or 4, and following along a Coanda surface 6, creates a zone of substantially reduced pressure immediately adjacent to the Coanda surface 6. It is this reduced pressure which causes the jet to adhere to the Coanda surface 6.

In a conventional nozzle discharging to atmosphere as in FIGS. 1 and 2, the outlet velocity of the medium being moved is a direct function of the square root of the pressure difference ($\Delta P$) between the pressure inside the plenum walls 1 ($P_1$) and the atmospheric pressure ($P_a$). The maximum discharge velocity that can be obtained can be expressed by the equation:

$$\text{Velocity} = (P_1 - P_a)^{1/2}C$$

where $C$ is a constant of the particular medium and environment. Since in a Coanda nozzle there is a zone of substantially reduced pressure ($P_2$) immediately adjacent to the Coanda surface 6, where $P_2$ is less than $P_a$, the velocity of that portion of the Coanda nozzle nearest the Coanda surface 6 may be expressed by the equation:

$$\text{Velocity} = (P_2 - P_a)^{1/2}C$$

where $C$ is as above and the quantity ($P_2 - P_a$) is greater than ($P_1 - P_a$) because $P_2 < P_a$. Since the velocity part of a Coanda nozzle is higher than any velocity obtainable from a conventional nozzle, the average velocity of a Coanda nozzle is always higher at any given distance from an orifice, than the velocity of the jet stream escaping from a conventional nozzle at the same distance. In addition, the Coanda nozzle will create about itself, on its unbound side, an orderly and efficient air induction field 7 which will permit the nozzle stream to gather in surrounding air stream molecules with a minimum of collision and total energy loss, far superior to the observed energy losses of conventional nozzle air streams.

In the field of high velocity air drying the advantages of a Coanda nozzle system of the present invention over that of a conventional nozzle system make it possible to design dryers with greater web to nozzle clearances without having to increase air quantities or velocities (both a measure of power input) to prevent a loss in impingement velocity. Also, the orderly method of outside air entrainment, as compared to the conventional method of molecular collision now makes it possible to have high impingement velocities without particular regard to web flutter or nozzle to web clearances.

All disclosures of this invention will assume the fluid to be air, and the web material to be paper or any related flexible material. However, the application of this invention to other fluids and materials will become obvious. An adequate method of furnishing an unlimited supply of air is also assumed. It is also assumed, for simplicity, that all devices shown are endless in length, thereby eliminating any consideration otherwise into the nozzle orifice openings 3 and 4 of the direction of web travel. In practice, transverse air can be eliminated by providing air tight end seals at the ends of each opposing pair of Coanda positioning devices. See FIG. 6. It is also assumed that the Coanda orifice openings are essentially continuous slots.

In FIGS. 3 and 4, a plenum housing 1, contains air at elevated pressure, forcing it out of the essentially endless and equal sized orifice openings 3 and 4 formed by the mechanical spacing of the Coanda plate 2 with the turned edges of housing 1. For each orifice size, there is a minimum radius R below which the air will not follow the Coanda plate 2, but will be projected in a straight path just as in a conventional nozzle. The air from orifice openings 3 and 4 follow the Coanda plate 2 around the radius R until they collide at the centerline forming a centerline main jet 8. The subatmospheric pressure formed on the exterior surface 6 of the Coanda plate 2 confines the air stream to the exterior surface 6, and, normal to the Coanda phenomenon, large quantities of surrounding air 7 are entrained into the Coanda air stream 5. The main jet 8 contains all of the orifice air, 3 and 4, plus all entrained air 7.

If during balanced Coanda flow, orifice 4 is momentarily blocked, the air flow pattern will change as shown in FIG. 4. With orifice opening 4 blocked, an imbalance occurs and the flow from orifice opening 3 remains on the Coanda surface 6 until it collides with the flow from orifice opening 4, forming a main jet 8 which will project upwards from the horizontal, at some angle dependent upon the length of path traveled by the air from opening 3, and the radius R. As in the case of FIG. 3, the main jet 8 contains all the air from orifices 3 and 4, plus all entrained air 7. It is significant to note that this new condition is stable and will remain so until orifice 3 is momentarily plugged. If orifice 3 is plugged, a new stable flow condition will exist with all flows reversed and opposite to that shown in FIG. 4.

Flow can be returned to the condition of FIG. 3 by momentarily blocking and opening both orifices 3 and 4 at the same time. Once a Coanda path has been established around the correct radius R it is a stable condition and requires considerable force to dislodge it. Orifice opening 3 can be somewhat different in size from orifice opening 4 and the conditions as described above will still essentially prevail. This phenomenon is of significant value in the practical application of this device in that it is not necessary to maintain closely held tolerances in the construction of orifice openings 3 and 4. When conventional nozzles are used to form zones of opposing force areas, as in FIGS. 1 and 2, the orifice openings must be carefully matched or a permanent and irreversible imbalance will exist.

FIGS. 5A, 5B, and 5C show a properly proportioned Coanda device essentially as described for FIG. 3, and the approximate air streams which exist when an impervious material 9 approaches the Coanda device of FIG. 3.

In FIG. 5, the impervious material 9, hereafter called the web, is at a distance X from the Coanda nozzle surface 6. The air from orifices openings 3 and 4 plus the entrained air 7 combine to form a main jet 8. At a distance X the solid jet stream 8 impinges on the web 9 to form a pressure or force zone approximately Y' in width. Since the distance X is large, adequate space is available to provide for escape of the spent main jet 8 after it impinges on the web 9. Also because of the great distance X the main jet 8 will have had time to form into a jet stream not unlike that of a conventional nozzle and will have slowed down considerably but because of the large quantities of entrained air 7, the total momentum of the main jet 8 will be great.

In FIG. 5A the web at a distance Y will cause the solid jet stream 8 to create a force zone approximately Y' in width, Y' being larger in width than X'. Since the web 9 is now closer to the Coanda surface 6, the velocity of impingement on the web 9 is greater. The total force on the web 9 has increased as a function of the width Y' (or area) times the velocity impingement pressure.

In FIG. 5B the web at a distance Z will cause the solid jet stream 8 to create a force zone approximately Z' in width, Z' being larger in width than Y'. Typical dimensions for this device could, for example, be in the range of: overall width of plenum 1, 4 inches; overall width of Coanda nozzle plate 2, 5 1/2 inches; radius R, 1/4 inch; dimension Z, 1 inch; width of orifice openings 3 and 4, 0.05 inch, and width of force zone Z', 3
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It is of significance to note here that as the clearance between the web 9 and the Coanda surface 6 decreases from Y to Z that all of the air stream from the web 9 and Coanda jet stream 5 is forced to reverse its direction in a short arc because of the small clearance dimension Z. Some of the energy of the Coanda jet stream is spent compressing the air within the force zone, the air thus compressed is less elastic or resilient, and therefore now able to repel the thrust of the major portion of the Coanda jet stream. An extremely small, but significant part of the Coanda jet stream 5 remains adhered to the Coanda surface 6 and penetrates the force zone, thus providing a small but constant movement of air into the force zone.

In FIG. 5C the web 9 of FIG. 5B has been inclined at some angle α relative to the horizontal portion of the Coanda surface 6. Previous explanations have assumed the web 9 to be parallel to the horizontal portion of the Coanda surface 6. To accomplish this in practical applications, the web 9 would have to be absolutely rigid. In practical applications where the web material is of a flexible nature such as paper, plastic film, cloth, or lightgage metals, any ripple, vibration, flutter, or even minor stress variations could create a momentary set of conditions similar to those shown in FIG. 5C. With the web at position 9', rotated through some angle α, about a point on the centerline a distance Z from the horizontal portion of the Coanda surface 6, the flow of air to the left side is more restricted as in FIG. 5B, and the flow of air to the right side is less restricted than in FIG. 5B. Since the air on the left side of the force zone is being compressed more than the air on the right side of the force zone due to the higher impingement velocity on the left, more air will escape from the right side of the Coanda surface than from the left side. At this instant in time, Coanda surface flow from orifice opening 3 increases immediately, combines with the Coanda surface flow from orifice opening 4 and escapes to the right as shown by the jet stream arrows of FIG. 5C.

In general, flow conditions are similar to those described for the Coanda nozzle of FIG. 4, with the main jet stream 8 discharging to the right. The force zone will be of width Z', now off-center and to the left as shown. At all times, the reactions of a Coanda nozzle means involve or result in a dynamic cushion of air being formed between the web 9 and the Coanda surface 6. If the web 9 of FIG. 5C is inclined through an angle α downward to the right, all conditions will be as described above, but to the opposite sides. The direction of flow would be changed instantly with every movement of web 9. Laboratory tests have proven that an angle α of 2° or less will cause instant mass flow changes as described above.

In recalling the described events of FIGS. 5 through 5C, it is noted that as the Coanda device is placed closer to a web 9, the higher the compression of the air in the width of the force zone, and the greater will be impingement velocity on the web 9. It is significant to note that with the web 9 positioned as in FIG. 5B, that a large portion of the Coanda air stream 5 remains on the Coanda surface 6 until slightly past the point of tangency between the radius R and the horizontal plane of the Coanda surface 6, then makes a full 180° reversal in direction, without a definite or sharply defined zone of high velocity air impingement directly on the web 9.

To get direct nozzle jet impingement it is necessary to position the Coanda surface 6 close enough to the web 9 so that the resultant increase in air compression and size of the force zone 10 will be great enough to prevent the Coanda jet stream from traveling to the point of tangency between the radius R and the horizontal plane of the Coanda surface 6, as shown in FIG. 5D. The largest portion of the Coanda air stream 5 will then be stripped from the Coanda surface 6 and caused to impinge directly on the web 9 with substantial force, such force being a direct function of the air static pressure contained within the plenum walls 1. Typically, good impingement can be obtained using the general dimensions as described above in combination with a web to Coanda surface clearance of 1/8 inch or less. In some industrial applications, however, a clearance dimension of 3/8 inch is impractical.

With two opposing Coanda devices positioned as shown in FIG. 6, at some clearance dimension from the web 9 and direct impingement from the Coanda air streams 5, the web 9 will be automatically and rapidly positioned at the point of force balance between the two devices. If the web 9 moves away from the upper Coanda device, the area and total force of the high pressure force zone 10 will decrease. As the web 9 moves towards the upper Coanda device, the high pressure zone 10 and consequently the total force beneath the web 9 increases. The total force differential existing on each side of the web 9 forces the web toward the weaker force field thereby increasing its value until perfect balance is obtained.

In a machine employing the Coanda devices, if web flutter, or high amplitude angular movements are caused by an outside force, conditions as described for FIG. 5C can and will exist. However, with opposed Coanda devices, the explanation of FIG. 5C still holds true, since as described above for FIG. 6, countering and opposite force fields will be set up to retrieve and maintain the web in a plane parallel to the horizontal portion of the Coanda surface 6. Whenever web-to-Coanda plate separations occur that are too great to maintain the Coanda air stream 5 separation, the main jet 5A is reformed instantly as in FIGS. 5 and 5A and this single but solid air jet drives the web 9 toward its centered, balanced-force position. At all times, whenever the web 9 is a distance of 1/8 inch or more away from the Coanda surface 6, there is a solid, dynamic cushion of air preventing the web 9 from making contact with the Coanda surface 6.

FIGS. 1 and 2 show typical positioning devices in use today wherein conventional nozzles are used in an attempt to form static air cushions by angling two opposing air jets towards each other. In this design there are always maximum clearance limitations. If the web 9 is permitted to float or drift to a position where the web to nozzle clearance D is great enough to permit nozzle convergence, a zone of extremely high turbulence is created which can cause severe web flutter. Obviously in practical drying applications such an effect would be detrimental to the end product if such flutter were to cause smearing or nozzle plugging. In the design of high velocity dryers using conventional nozzles, it is necessary to operate positioning devices in close proximity to the web in order to avoid convergence and also to maintain a static pressure pocket with enough strength to position the web when it is being acted upon by outside forces tending to cause sheet flutters and vibrations.

Most conventional positioning devices now in use in high velocity drying are generally limited to a maximum web-to-device clearance in the range of 3/8 to 1/8 inches. The Coanda device described herein will position webs without web turbulence, at web-to-Coanda plate clearances in excess of one inch, using the same air power input as required by conventional devices.

Because the Coanda air stream 5 is essentially a nozzle means, and the Coanda surface 6 is the most distant part of the nozzle means from the web 9, it can be said that the Coanda surface provides the nozzle means for instant and accurate automated positioning of a nozzle jet such that the discharge of the jet will always provide either a moving air film 5, or a dynamic pressure zone 10 between the surface being positioned and the Coanda plate, and always one or the other, dependent upon whether or not the web 9 to Coanda surface 6 clearance is maximal or minimal.

The apparatus of FIG. 6 discloses an improved positioning device, of particular value in positioning heavy somewhat rigid materials such as paper board, sheet steel or heavy films. Lighter weight material such as magazine paper stock is extremely flexible and rapidly responsive to variations in tension control while being processed, that is, printed, coated, etc. If, during processing, tension is momentarily minimized and some web stack is permitted, the flexible material may be drawn into the return air passages 20 as shown in FIG. 16. Such movement would generally cause smearing of the coat-
ing or ink, and very possibly cause the material to fracture or tear necessitating loss of production time to retread the material through the coating or printing machine and if conventional nozzles were used, additional time loss would be required to clear the nozzle openings in the event they were smeared shut with coating or ink.

FIG. 7 shows an apparatus design with the ability to cope with great variations in tension. The upper and lower devices are essentially as previously described except that the lower device is of smaller width. A satisfactory variation would be on overall Coanda plate width of 2.5 inches in the upper and 2.5 inches on the lower, using orifice openings in the range of 0.50 to 0.70 inches. The positioning reactions and pressure force buildups will occur as described above, but now the total force exerted by the top Coanda device will be greater than the total force exerted by the bottom Coanda device. However, with all orifices 3 and 4 of about the same size, in keeping with practical commercial tolerances and practices, the unit pressure of orifice openings on each side of the web 9 will be the same. The unit pressure on the top of the web 9 acts over a larger area, and where this unit pressure is not opposed by a like unit pressure, the web 9 will be caused to deflect downward, away from the motivating force as shown by dotted line 11. The appropriate axis of bending will be at the intersection of the web 9 with a centerline drawn from the midpoint of each opposing pair of offset nozzles 3 and 4.

By mounting the Coanda nozzles of FIG. 7 side by side, in alternate order as shown in FIG. 16, where 17 is a Coanda positioner with a narrow Coanda plate, and 18 is a Coanda positioner with a wide Coanda plate, it is possible to neutralize the composite resultant of all upper and lower force fields 10.

The use of this mounting method provides the Coanda system with the tendency to position the web with a sine wave pattern as shown in FIG. 16. Because these tendency forces exist, any slack which may appear in the web being processed will immediately be absorbed into the sine wave pattern, thereby preventing any slack or loose portions of the web from making contact with any parts of the Coanda positioning devices.

In all positioning devices disclosed thus far it is apparent that high velocity jet impingement does not take place under a Coanda positioner unless web to Coanda surface clearances are fairly small, approximately 0.01 inch or less.

FIG. 8 is essentially the same device as shown in FIG. 7 except that additional nozzle openings 12 have been added along the centerline of the Coanda plate 2. Typical hole patterns suitable for this purpose are shown in FIGS. 11, 12, 13, 14, and 15. Orifice openings 12 serve a twofold purpose: firstly, they provide an additional and effective source of high velocity air impingement which essentially reduces the center to center distance between impinging jets and increases the heat and mass transfer coefficients of the apparatus close to optimum. Secondly, the nozzles 12 provide an air supply to the pressure zone 10 thereby making it possible to maintain the high pressure required to peel the Coanda air stream from the Coanda surface 6 to obtain direct jet impingement on the web 9 at greater web-to-Coanda surface distances. Sizing of the center holes 12 is critical in relation to the size of the nozzle openings 3 and 4, and to the design of the Coanda surface-to-web clearances desired.

If the centerline air supply 12 is insufficient, no appreciable change in performance over the device of FIG. 7 is noted. FIG. 9 shows typical air stream patterns for such a device.

FIG. 10 shows typical air stream patterns if the centerline air supply 12 is too great. A great excess of air essentially duplicates conditions as though the web 9 to Coanda surface 6 distance were very small. Air must escape from the escape zone 10 at such a rapid rate that in doing so, the largest portion of the Coanda nozzle air stream 5 is deflected outward at such an angle as to prevent direct impingement on the web 9.

It is obvious, therefore, that for each design of web to Coanda surface distance desired, that it is possible to select various combinations of orifice openings 3 and 4, and centerline supply air openings 12, such that it is possible to obtain any desired angle of impingement between the Coanda nozzle air stream 5 and the web 9.

FIG. 8 shows the air streams of a balanced flow Coanda positioning and drying device. The centerline supply orifices 12 provide the correct amount of air to provide adequate dynamic pressurization of the force zone 10 such that portions of the Coanda air streams 5 are peeled from the Coanda surface 6 and caused to impinge directly on the surface of web 9. With the device of FIG. 8 it is possible to duplicate all of the conditions of the device of FIG. 8, but at much greater clearance distances between the web 9 and the Coanda surface 5.

FIGS. 17, 18, 19, 20, 21, and 22 show a few of the alternate methods possible to design a Coanda positioning device using the information of this disclosure. Materials of construction can obviously be of any substance suitable to the atmosphere, that is, temperature, humidity, corrosion, etc. that the device must operate in. Other modifications will become apparent to those skilled in the art.

Various modes of carrying out the invention are contemplated as being within the scope of the following claims particularly pointing out and distinctly claiming the subject matter which is regarded as the invention.

1. Apparatus for floating sheet material in the nature of a continuous web, comprising, means forming a linear Coanda nozzle extending in a direction transversely of web travel adjacent a surface of the web, said nozzle being oriented with respect to the web so that the flow of gas induced by said nozzle originates adjacent the surface of the web facing said nozzle and is directed over the Coanda surface longitudinally of the direction of travel of the web.

2. Apparatus according to claim 1, wherein a pair of linear Coanda nozzles are provided, said nozzles being parallel to one another and being spaced longitudinally of the direction of web travel.

3. Apparatus according to claim 2, wherein the nozzles are so oriented with respect to the web that the flow of gas induced by each nozzle originates adjacent the surface of the web facing the respective nozzle and is directed over the Coanda surface longitudinally of the direction of travel of the web and toward the other nozzle.

4. Apparatus according to claim 2, wherein a Coanda plate spans the space between the Coanda nozzles, and additional nozzle means are formed in said plate intermediate said spaced Coanda nozzles.

5. Apparatus according to claim 4, wherein the additional nozzle means comprises a series of spaced orifices in the plate and extending in a path transversely of web travel.

6. Apparatus according to claim 3, wherein a plurality of pairs of longitudinally spaced Coanda nozzles are provided.

7. Apparatus according to claim 3, wherein means forming a linear Coanda nozzle are provided both above and below the web.

8. Apparatus according to claim 1, wherein a pair of Coanda nozzles are provided above the web and a pair of Coanda nozzles are provided below the web, all of said nozzles being parallel to one another, and the nozzles of each pair are spaced longitudinally in the direction of web travel.

9. Apparatus according to claim 8, wherein a plurality of pairs of longitudinally spaced Coanda nozzles are provided both above and below the web.

10. Apparatus according to claim 8, wherein the nozzles are so oriented with respect to the web that the flow of gas induced by each nozzle originates adjacent the surface of the web facing the respective nozzle and is directed over the Coanda surface longitudinally of the direction of travel of the web and toward the adjacent nozzle.

11. Apparatus according to claim 8, wherein a Coanda plate spans the space between each pair of Coanda nozzles, and additional nozzle means are formed in each plate intermediate the respective pairs of Coanda nozzles.
12. Apparatus according to claim 11, wherein each of the additional nozzle means comprises a series of spaced orifices in the respective plate, each series of orifices extending in a path transversely of web travel.

13. Apparatus according to claim 8, wherein the Coanda nozzles of the upper pair are spaced apart a distance different than the nozzles of the lower pair.

14. An apparatus set forth in claim 1 further characterized in that said apparatus includes a plenum Coanda supporting air pressure, and said linear Coanda nozzle is located adjacent one side of said plenum. Coanda

15. The apparatus as set forth in claim 14 further characterized in that said plenum includes a coanda plate extending along the direction of web travel, and the air from said nozzle travels along said coanda plate.
UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,549,070  December 22, 1970
John W. Frost et al.

It is certified that error appears in the above identified patent and that said Letters Patent are hereby corrected as shown below:

Column 10, line 1, "Coanda" should read -- for --; line 3, cancel "Coanda".

Signed and sealed this 6th day of April 1971.

(SEAL)
Attest:

DWARD M. FLETCHER, JR.  WILLIAM E. SCHUYLER, JR.
Attesting Officer  Commissioner of Patents
Disclaimer


Hereby enters this disclaimer to claims 1, 2, 7, 8, 9, 10, 13, 14 and 15 of said patent.

[Official Gazette January 13, 1976.]