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Marteny

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[54] **APPARATUS AND METHOD FOR APPLYING RADIO FREQUENCY ENERGY TO A MOVING WEB OF MATERIAL**

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[52] **U.S. Cl.** **34/1**, 34/49, 34/156

[51] **Int. Cl.** **B01k 5/00**

[58] **Field of Search**.....34/1, 49, 156

[56] **References Cited**

UNITED STATES PATENTS

3,629,948	12/1971	Hilton et al.	34/1
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FOREIGN PATENTS OR APPLICATIONS

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[57] **ABSTRACT**

A moving web of material, preferably of newly formed paper, is diverted from its normal path of travel and directed through a radio frequency drying area and returned to the normal path of progress. Radio frequency electrodes are arranged around an arcuate path which the web of material follows, thereby minimizing the space required to incorporate radio frequency drying into an existing process. The electrode holders have passages formed therein which are connected to a source of heated air. Air is emitted through the electrode holders and acts to form an air film which prevents the web from touching the electrodes or electrode holders. An enclosure around the electrode holder area has a plurality of nozzles attached to its interior portion. The nozzles are connected to a source of heated air, the air emitted from the nozzles acting as a position control device for the web. The air emitted from the nozzles and the air film act in balance to maintain the web at a specified elevation above the electrodes. If the web should break, a pressure-sensitive element within the electrode enclosure senses a decrease in pressure and turns off the radio frequency power to avoid any danger to operating personnel.

4 Claims, 3 Drawing Figures

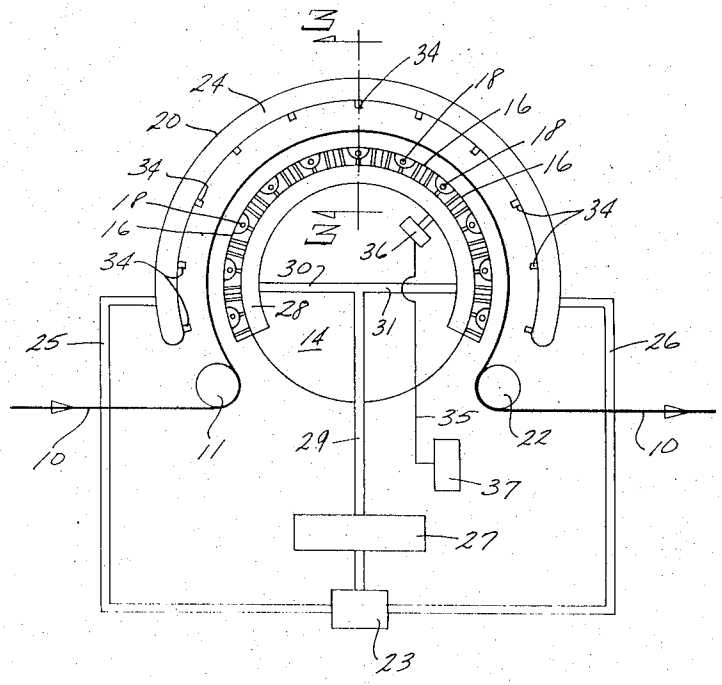

FIG. 1

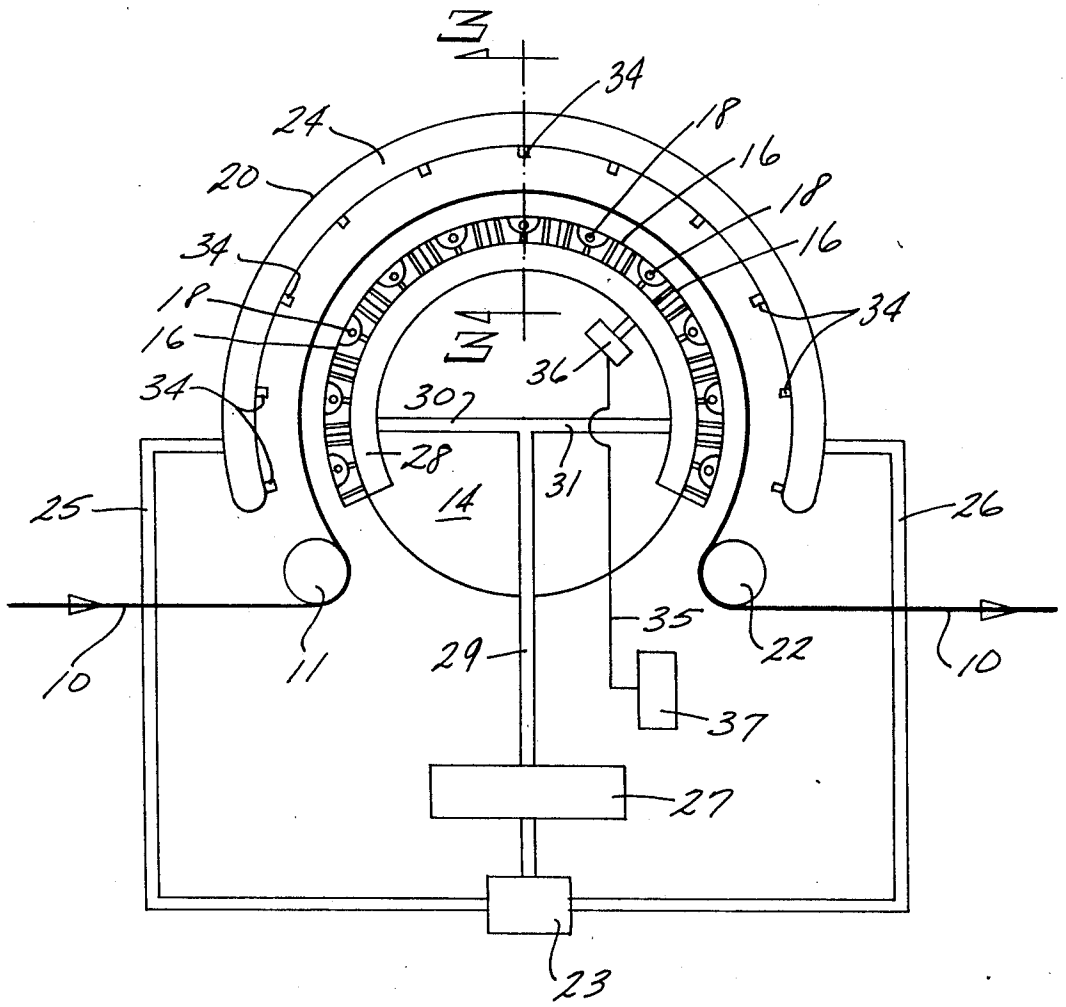

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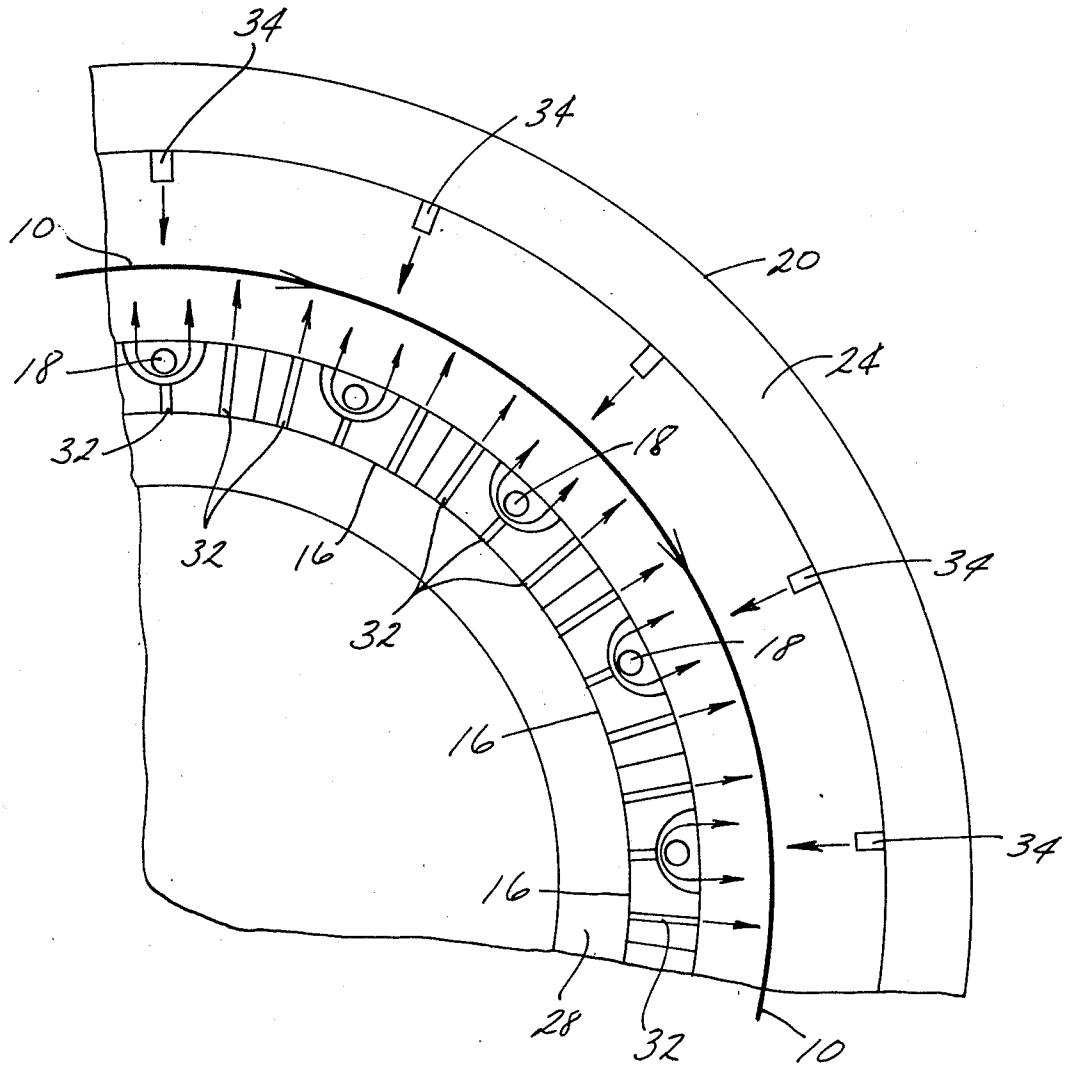
FIG. 2



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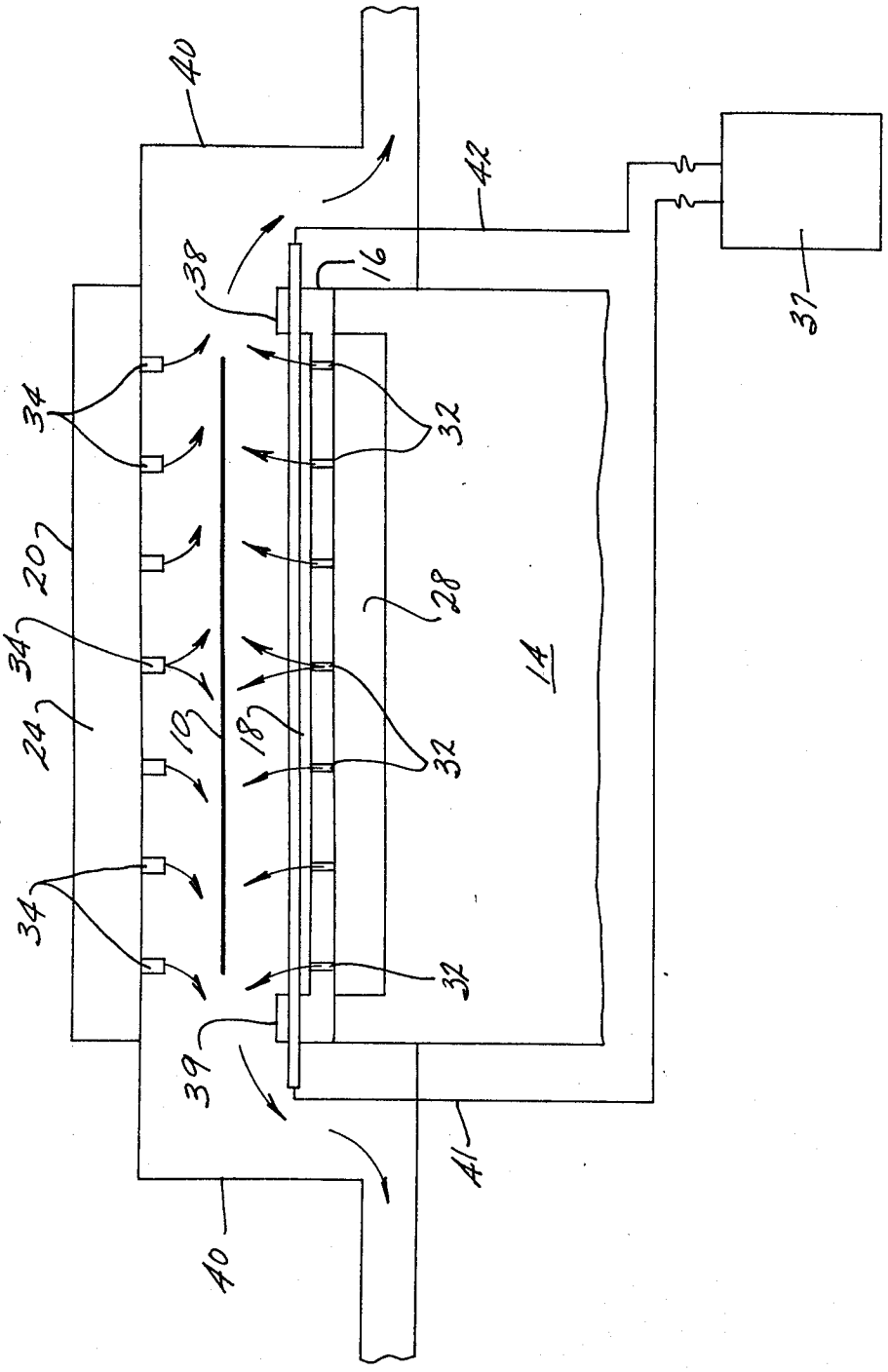

FIG. 3

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APPARATUS AND METHOD FOR APPLYING RADIO FREQUENCY ENERGY TO A MOVING WEB OF MATERIAL

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates generally to the drying of newly manufactured paper. More particularly, the invention relates to the drying of such paper by the use of radio frequency energy. Most specifically, the invention relates to an apparatus and method for efficiently incorporating radio frequency drying into an existing paper manufacturing line.

2. Description of the Prior Art

The use of radio frequency energy for the drying of newly formed paper is well known in the art, for example, such drying is taught in U.S. Pat. No. 3,399,460. However, the use of electrical energy to dry paper is relatively expensive compared to the conventional steam-heated drum-type drying used in most paper mills. In a co-pending application, U.S. Ser. No. 128,959, filed Mar. 29, 1971 and assigned to the same assignee as the subject invention, the use of radio frequency drying in a particular critical moisture range of paper to obtain maximum efficiency and economy is taught. However, the electrode systems of the prior art for use in such a scheme, have conventionally been of an elongated configuration. This has limited the applicability of radio frequency drying to existing paper-making lines because of the difficulties in integrating a relatively long drying section in the existing floor plan. In addition, there has always been the danger of the wet paper web touching the electrodes and possibly causing a short circuit in the system. The present invention overcomes these difficulties by diverting the paper web from its normal path of travel through an external arcuate electrode configuration and floating the web of paper on an air film over the electrodes.

SUMMARY OF THE INVENTION

This invention discloses an apparatus for applying radio frequency energy to a moving web of material, preferably newly formed paper, having a plurality of electrode holders arranged about the periphery of an arcuate path followed by the moving web. The electrode holders carry a plurality of individual electrodes and are connected to a source of radio frequency energy. The entire electrode holder and electrode array is enclosed by an arcuate cover, which thereby forms an enclosed volume. Streams of heated air are directed through passages in the electrode holders to float the web of material above the electrodes and electrode holders, while a counterstream of heated air is directed from nozzles in the interior of the enclosure to balance the air film and thereby hold the web at a fixed position above the electrodes and electrode holders. A pressure-sensitive switch controls the radio frequency generator and will disable the system in the event of a break in the web of material. Also disclosed is a method of efficiently utilizing radio frequency energy in the selective drying of a paper web by diverting the web from its normal path of travel into an arcuate path of travel and floating the paper web over the electrodes which apply the radio frequency energy.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic cross sectional elevation view of the apparatus of the present invention.

FIG. 2 is a schematic cross sectional elevation view of a portion of the apparatus of FIG. 1 at a greater scale than that used in FIG. 1.

FIG. 3 is a sectional schematic view of the apparatus of the present invention taken along the line 3—3 in FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENT

It will be apparent to those skilled in the paper-making art that the drawings show only a very small portion of a total paper-making process. The section shown is one in the conventional steam drum drying sections of a paper-making line. The particular point in the line is in the critical moisture range of the paper web which is disclosed in the previously mentioned co-pending application. As may be seen in FIG. 1, the moving web of paper **10** is diverted over a roller **11** in an arcuate path. The advantage of this invention over the prior art may be readily seen at this point. The web of paper **10** is exposed to radio frequency energy as it passes along the arcuate path of approximately 6 feet in diameter as opposed to the necessity of having a 12 to 15 foot long linear length of the electrodes of the prior art. The web **10** is thus allowed to bypass the main stream of operating equipment making possible the introduction of selective radio frequency energy drying of the web **10** without major modifications of the existing operating equipment. In this preferred embodiment, a cylindrical supporting member **14** serves to define the arcuate path followed by the paper web **10**. However, the actual path followed could be that of an inverted U or of a U if a greater length of exposure to radio frequency energy was desired. The support member **14** serves to carry a plurality of electrode holders **16** arrayed about the periphery of the support member **14**. The electrode holders **16** are preferably of a smooth, hard inorganic material that will not be carburized by the electric field. Furthermore, the electrical properties of the electrode holders **16** should be similar to those of air. A material that has been found suitable for this purpose is Corning 1991 glass manufactured by the Corning Glass Works of Corning, N. Y. Each electrode holder **16** serves to support an individual electrode **18**. It will be noted that the electrode holders **16** all have a depressed U-shaped channel section near their center in which the electrodes **18** rest. Thus, the electrodes **18** are depressed below the surface of the electrode holders **16**. The array of electrode holders **16** and electrodes **18** are surrounded by an enclosing structure **20** to provide a sealed volume within which the web **10** passes.

The web **10** is directed in an arcuate path by the roller **11** around the periphery of the support member **14** and exits from the enclosure around a re-entry roller **22** which places the web **10** back into the mainstream of the paper-drying process. The enclosure **20** is of a double-walled construction to provide a plenum chamber **24** into which heated air under pressure is introduced through inlets **25** and **26** from a heated air source **27** through a pressure regulator **23**. The electrode holders **16** are similarly mounted over a second

plenum chamber 28, which is a part of the support member 14, the plenum chamber 28 being fed hot air under pressure from the heated air source 27, through an outlet line 29 connected to inlet members 30 and 31.

Turning now to FIGS. 2 and 3, it will be seen that a series of passages 32 are drilled through the electrode holders 16 and communicate with the second plenum chamber 28. As air is introduced into the second plenum chamber 28 through the inlets 30 and 31, this air exits through the passages 32 through the electrode holders 16. The result of this air flow is to provide an air film over the electrode holders 16 upon which the paper web 10 floats. That is, as the paper web 10 passes through its arcuate path from the diverting roller 11 to the re-entry roller 22, it is never allowed to touch the surface of the electrode holder 16, but rather floats a short distance away from the upper surface of the electrode holders 16. Communicating with the plenum chamber 24 are a plurality of nozzles 34 which allow the air from the plenum chamber 24 to be directed against the upper surface of the paper web 10. Thus, as clearly seen in FIG. 2, there is a balancing effect between the air emitted from the nozzles 34 and the air emitted from the passages 32 which holds the paper web 10 at a particular elevation above the electrode holders 16. By varying the pressure differential between the two air flows, the elevation of the paper web 10 above the electrode holders 16 may be adjusted for varying conditions. The air pressure of the air emitted by the nozzles 34 is controlled by adjustment of the pressure regulator 23 which feeds the two inlet lines 25 and 26. As previously noted, the air introduced into the plenum chambers 24 and 28 is preferably air heated to a temperature above that of the ambient air. The heated air helps remove any moisture which is driven from the paper web 10 during the application of radio frequency energy and helps prevent any condensation on the electrodes 18 or the electrode holders 16 which might lead to electrical short circuits in the radio frequency energy circuit.

As a safety measure, a pressure-sensitive switch 36, shown in FIG. 1, is used to sense the pressure in the plenum chamber 28. So long as the paper web 10 is continuously passing over the plurality of electrode holders 16, a particular back pressure will be generated in the plenum chamber 28 due to the interference of the paper web 10 with the free exit of air from the passages 32 in the electrode holders 16. Should the paper web 10 break while traversing the arcuate path about the electrode holders 16, the pressure within the plenum chamber 28 would experience an immediate drop, due to the lack of back pressure caused by the presence of the paper web 10. The pressure sensitive switch 36 is connected to a radio frequency energy generator 37 by suitable wiring 35 and will turn off the radio frequency energy in the event a break occurs to prevent any possible exposure of operating personnel to the dangerous radio frequency energy. As shown best in FIG. 3, the nozzles 34 connected to the plenum chamber 24 are not only arrayed about the periphery of the enclosure 20 but also extend across the width of the enclosure 20. Similarly, the passages 32 through the electrode holders 16 also extend across the entire width of the electrode holder 16. This, of course, is necessary because of the substantial width of the paper web 10 which passes through this apparatus. Also seen most clearly in FIG. 3 are two extending vertical bosses 38 and 39 on the ends of the electrode holders 16. These bosses are drilled through so that the electrode 18 may be inserted through the bosses 38 and 39 and held in position in this manner in the channel formed in the electrode holder 16. It will be noted that the electrodes 18 extend beyond the ends of the electrode holders 16 to allow connection to the source of radio frequency energy 37 in a conventional and well known manner by suitable wiring means 41 and 42. Also, it may be seen that the air which comes from the plenum chamber 28 through the passages 32 in the electrode holder 16 and the air which comes from the plenum chamber 24 through the nozzles 34 is exhausted from the enclosure 20 through exhaust manifolds 40 which close the ends of the enclosure 20 and complete the enclosed volume of the radio frequency energy applying area. Thus, the moisture laden air from the enclosed volume is removed to insure that there will be no condensation on the electrodes 18.

What I claim is:

1. The method of applying radio frequency energy to a moving web of material comprising the steps of diverting said web from its normal path of travel into an arcuate path, floating said web on an air film over a plurality of electrodes located about the periphery of said path, applying radio frequency energy to said web from said electrodes as said film floats over said electrodes, sensing the pressure of said air film, signaling a decrease in the pressure of said air film, discontinuing application of said radio frequency energy in response to said decreased pressure signal, and returning said web to its normal path of travel.

2. The method of claim 1, further including the steps of directing air at said web on the side of said web opposite said air film through a plurality of air emitting nozzles, and positioning said web above said electrodes in response to the pressure differential between said air film and the air directed by said plurality of nozzles.

3. The method of Claim 2 wherein said air in said air film and said air directed through said air emitting nozzles is heated to a temperature greater than ambient air temperature.

4. Apparatus for applying radio frequency energy to a moving web of material directed in an arcuate path comprising, in combination: an arcuate supporting member defining the arcuate path for said web; a plurality of electrode holders arranged about the periphery of said arcuate supporting member, each of said electrode holders having a plurality of passages formed therethrough, one end of each of said passages opening adjacent said web; a source of air connected to the opposite end of said passages to thereby form an air film between said electrode holders and said web; a plurality of electrodes individually carried by said plurality of electrode holders; a source of radio-frequency energy connected to said electrodes; an arcuate enclosure radially spaced from said arcuate supporting member to define a closed volume therebetween through which said web is directed; a plurality of air emitting nozzles located on the interior of said arcuate enclosure and directed toward said web; a controllable source of heated air connected to said plurality of air

emitting nozzles to balance the force on said web of the air film generated by said air emitting passages formed through said electrode holders, thereby controlling the elevation of said web above said electrode holders; means for exhausting the air from said arcuate enclosure; and an air pressure sensitive switch having a sensing element located intermediate said air emitting passages in said electrode holders and said source of air, said switch being connected to said source of radio frequency energy to deactivate said source of radio frequency energy when said sensing element indicates a decrease in air pressure.

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