United States Patent [19]

Piper et al.

[11] **3,766,606**

[45] **Oct. 23, 1973**

[54] **APPARATUS FOR FORWARDING TOW**

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[73] Assignee: **E. I. du Pont de Nemours and Company**, Wilmington, Del.

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[21] Appl. No.: **245,350**

[52] **U.S. Cl.** ..... **19/65 T**, 226/97

[51] **Int. Cl.** **D01d 11/02**

[58] **Field of Search** ..... 19/65 T, 66 T; 34/10, 156; 226/7, 97; 425/464

[56] **References Cited**

UNITED STATES PATENTS

3,286,896	11/1966	Kinney	226/97
3,325,906	6/1967	Franke	34/10

Primary Examiner—Dorsey Newton

Attorney—Howard P. West, Jr.

[57] **ABSTRACT**

A fluid jet apparatus for receiving a ribbon of parallel continuous filaments, then heating and spreading the filaments for deposit on a moving surface as a nonwoven web includes an adjustable diffuser connected to the outlet end of the jet. The diffuser comprises a pair of spaced plates, adjustable with respect to each other, mounted to the outlet end of the jet. The plates are arranged to form aspiration slots at one end between the jet and the plates. The slots open into a central converging passage formed by the plates for confining and diverting gas out the open sides of the diffuser. The particular structural arrangement of the plates with respect to the jet permits development of static pressure in the diffuser which in turn causes a large percentage of jet fluid to exit from the open edges of the diffuser, generally parallel to the moving laydown surface, while less fluid accompanies the filaments to the laydown surface to reduce web disturbance.

5 Claims, 5 Drawing Figures

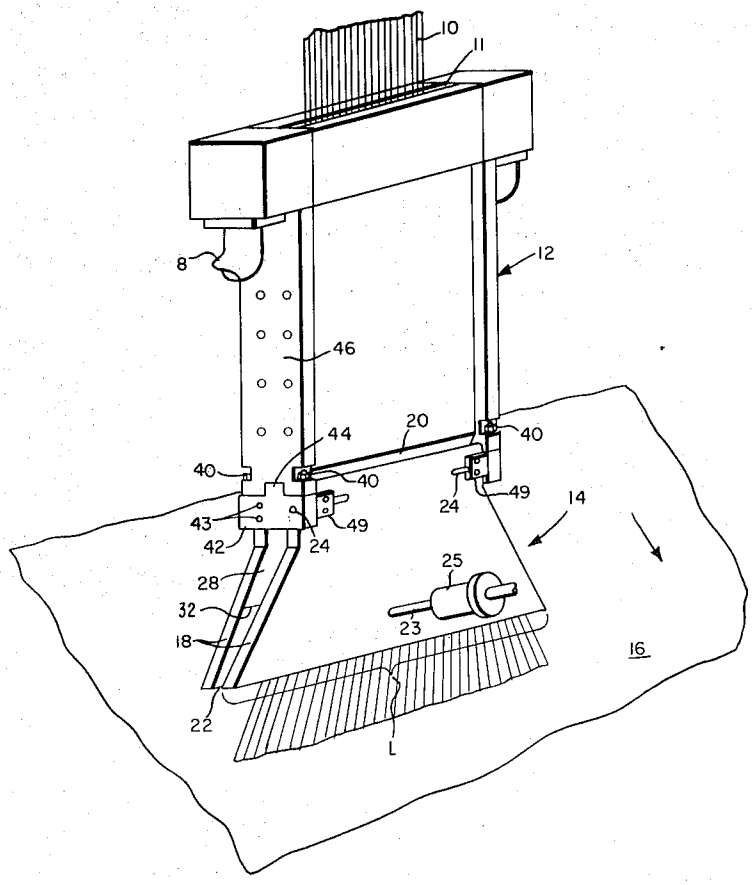


FIG. 1

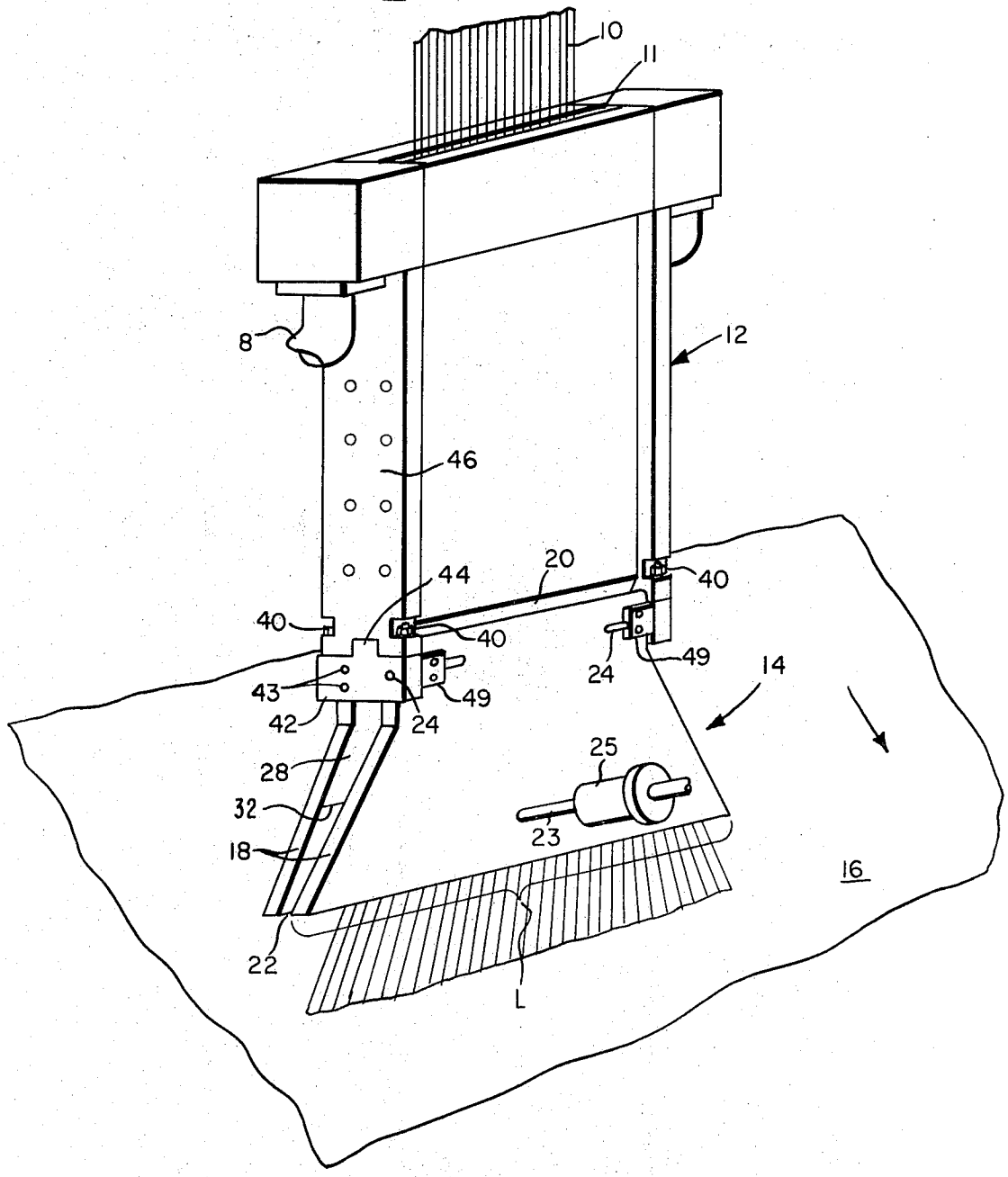

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FIG. 2.

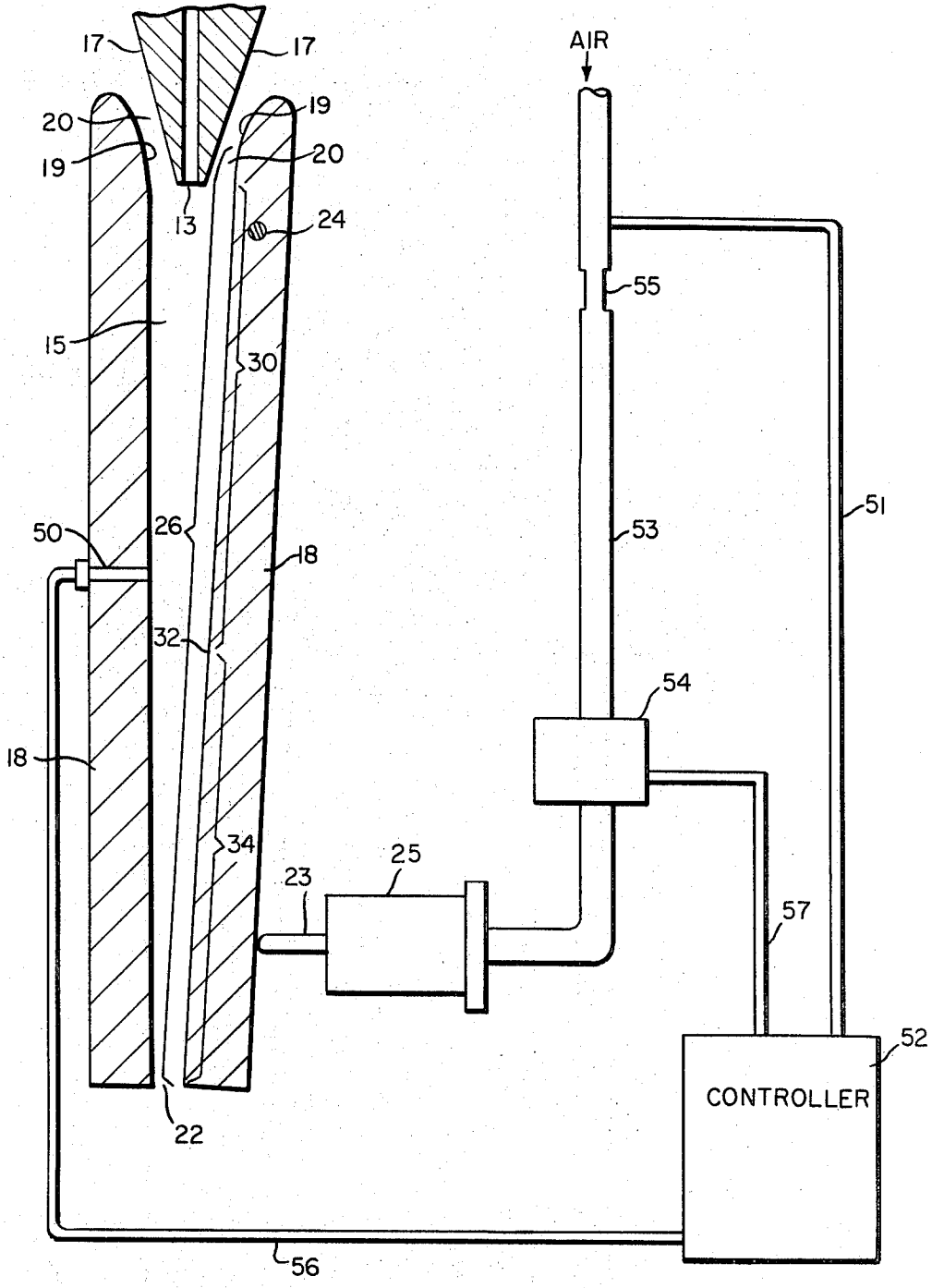

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FIG. 3

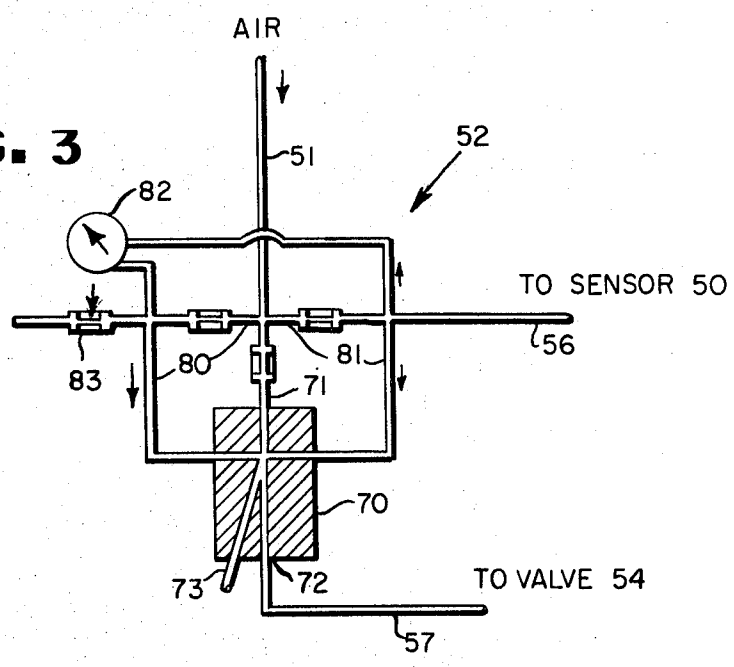


FIG. 4

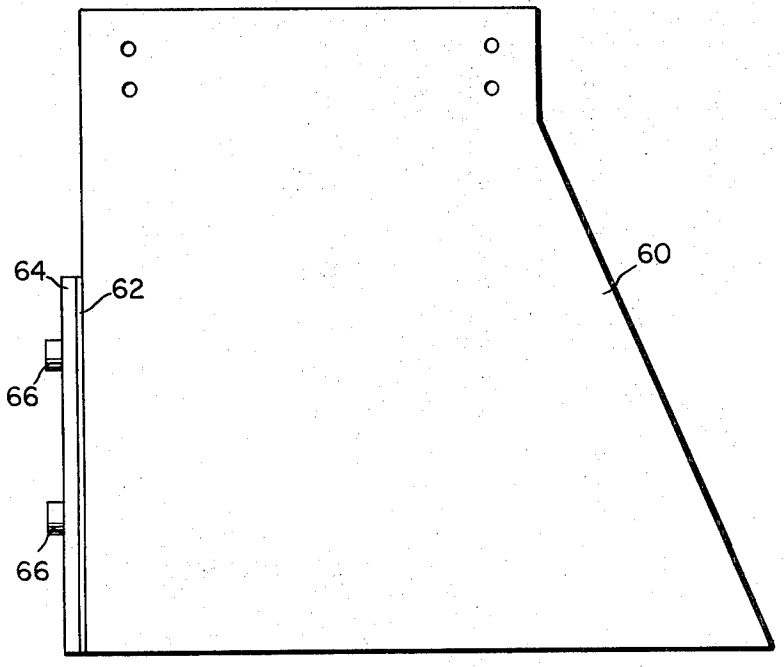
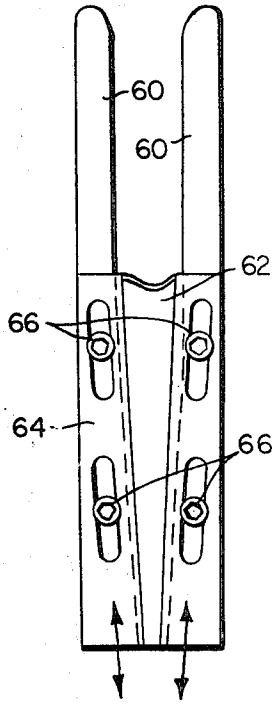


FIG. 5



APPARATUS FOR FORWARDING TOW

BACKGROUND OF THE INVENTION

This invention concerns an apparatus for receiving a ribbon of parallel continuous filaments, heating to promote shrinkage and spreading for deposit on a moving surface as a nonwoven web.

Kinney, U.S. Pat. No. 3,338,992, describes a process for preparing a uniform nonwoven web by forwarding a multifilament strand and applying an electrostatic charge to the filaments while under tension supplied by a fluid jet to promote separation of the filaments when tension is released. The separated filaments are deposited as a nonwoven web on a moving collecting surface and may later be subjected to a heating operation to promote bonding. A particularly useful nonwoven web may be prepared in this way using filaments which develop spontaneous elongation in the heating operation. Kitson and Reese in U.S. Pat. No. 2,952,879, describe a method for preparing such filaments, which comprises passing polyethylene terephthalate filaments having a crystallinity of less than about 35 percent through a zone at a temperature of at least 90° C. for a time sufficient to shrink the filaments between 20 percent and 70 percent and thereafter cooling before the crystallinity reaches the maximum level achievable in the zone. In the preparation of nonwoven webs, the heating zone may consist of a fluid jet device where the filaments are subjected to rapid heating by a hot gas usch as air or steam where the filaments undergo the required 20 to 70 percent shrinkage. The jet device is preferably the slot type, i.e., a device wherein the filament passage is rectangular in cross section. The flow of gas through the jet provides a sufficient tension on the filaments to forward them but insufficient to prevent shrinkage. This tension is at least partially released as the filaments pass out of the jet and the filaments then become more susceptible to handling in a diffuser.

The filaments emerging from the jet require particular treatment to avoid sticking in the diffuser and must be spread out into wider ribbons to promote uniformity in the webs which are collected. Franke, U.S. Pat. No. 3,325,906 and De Gusman, U.S. Pat. No. 3,334,161, describe diffusers of the prior art. Both of these disclosures relate to use of a diffuser attached to a jet of rectangular cross section. The diffusers operate by providing four diverging walls which allow the gas to expand and slow down as it travels through the diffuser. Filaments may also be spread in a gas stream by use of converging diffuser plates. Apparatus for such purpose has been described in Isakoff, U.S. Pat. No. 3,593,074.

SUMMARY OF THE INVENTION

The present invention provides a jet and diffuser combination with adjustable diffuser plates, the jet having inlet and outlet ends connected by a filament passage of generally rectangular cross section. The diffuser comprises a pair of spaced plates mounted to the outlet end of the jet, one end of the plates extends above the outlet end of the jet and is spaced therefrom to form two generally rectangular slots. The other ends of the plates extend below the outlet end of the jet to form a converging diffuser passage in axial alignment with the jet filament passage. The slots are in communication with the diffuser passage and the outside of the jet for introducing air by aspiration into the primary fluid stream, and the diffuser passage terminates in an exit slot. In the preferred embodiment, the diffuser passage has open sides and from the jet outlet to th diffuser exit, the passage is formed of successive curved, straight and converging lengths.

One of said plates is pivotally mounted to the outlet end of the jet for swinging movement toward and away from the other plate to change the size of the exit slot. Means are also provided for moving the pivotally mounted plate according to the forwarding conditions or static pressure existing in the diffuser passage. Preferably, the exit slot has a width less than the combined widths of the two rectangular slots formed near the outlet of the jet. The particular structural arrangement of the plates with respect to the jet permits development of static pressure in the diffuser which in turn causes a large percentage of jet air to exit from the open edges of the diffuser, parallel to the moving laydown surface, while less air accompanies the filaments to the laydown surface to disturb web formation.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of the fluid jet and diffuser combination of thei invention.

FIG. 2 is a schematic diagram showing relative placement of the diffuser plates with respect to the jet walls and the pressure control system for adjusting the diffuser exit slot.

FIG. 3 is a schematic of the controller of FIG. 2.

FIGS. 4 and 5 are elevation and end views of diffuser plates with an edge control seal.

DETAILED DESCRIPTION OF THE ILLUSTRATED EMBODIMENTS

Referring to FIGS. 1 and 2, a ribbon of continuous filament fibers 10 is forwarded by means of a fluid slot jet 12 through a diffuser 14 toward an impervious flexible belt 16 moving in the direction of the arrow and covering a suction means (not shown) for collection as a nonwoven web. The fluid jet 12 has a filament inlet 11 and a filament outlet 13 both of rectangular cross section and the diffuser 14 has a rectangular filament entrance 15 for receiving a ribbon of filaments from the jet. Although only one jet apparatus position has been illustrated, multiple positions may be provided wth the jet diffuser combination of the invention, these being diagonally placed across a collecting belt as described by Knee in U.S. Pat. No. 3,402,227 (FIG. 9).

The diffuser is characterized by two diffuser plates 18 which at their upper ends are located in close proximity to the lower outside surfaces 17 of each of the two wide walls of the jet at the outlet 13, sufficient space being provided for aspiration of air through rectangular aspiration slots 20 between upper inside surface 19 of the diffuser plates and the outside surface 17 of the jet and the plates form a diffuser exit slot 22 which is rectangular in cross section. the inside surfaces of the diffuser plates converge from the aspiration slots 20 to the diffuser exit 22. At least one of the diffuser plates 18 is adjustable, pivoting on pins 24 to provide an exit slot 22 which at its narrowest setting has a width less than the combined widths of the two aspiration slots 20. The two diffuser plates 18 form passage 26 to confine the escaping gas from the jet and spread the gas stream, thereby promoting spreading of the filaments into a wider ribbon. Excess gas is discharged through escape opening 28 on one or both sides of the diffuser 14. The upper inside surfaces 19 of the diffuser plates in the as-

piration gaps **20** are inwardly curved to form with the lower outside surface **17** of the wide jet walls a generally converging-diverging channel.

In the preferred apparatus, the diffuser passage **26** is characterized by a smooth curve starting at the upper inside surfaces **19** of the diffuser plates. Downstream, the surfaces become straight, as designated by length **30,** and continue to inflection point **32.** The lower surfaces of the two diffuser plates converge in a length **34** and terminate in exit slot **22.** Because of the reduced area at the exit slot, air flow is reduced and a considerable portion of the air is diverted out the gas escape openings **28** between the two plates (FIG. **1**).

Several variations of the diffuser contour are possible. One important point, however, is that the contours of the two plates should converge. The two plates **18** preferably have areas of parallelism (defined by lengths **30** in FIG. **2**). There must be no areas of divergence from jet outlet slot **13** to diffuser exit slot **22.**

The diffuser is fastened to the jet device by means of a bracket **42** which is mounted to jet end plate by means of bolts **40.** The mountinj bracket **42** is keyed for accurate placement underneath the jet by tab **44** which assists in providing accurate placement with jet end plate **46.** One diffuser plate **18** is rigidly attached to mounting bracket **42** by means of bolts **43.** The other diffuser plate is mounted for swinging movement around pivot **24.** The width of diffuser exit slot **22** is adjusted by means of air cylinder **25** and piston **23.** An air supply provides pressure against piston **23** which in turn pushes against the pivotally mounted diffuser plate **18** which it engages. An opposing pressure is exerted by air coming through the jet **12.** The width of diffuser exit slot **22** is widened by reducing pressure in the air supply and narrowed by increasing pressure in th air supply.

When the diffuser plates are quite thin, pivot pins **24** may pass through a bracket **49** attached to the outside of the plate.

FIGS. **2** and **3** illustrate a combination swath width control system which is adapted for release of fiber plugs which may develop in the exit of the diffuser. In this system, a sensor **50** is placed in the fixed diffuser plate **18.** This sensor is connected by tubing **56** to a pressure control device **52** such as the Corning Schmitt trigger Model 191456. The Schmitt trigger is a fluidic control element which is very sensitive to pressure differential and has a low switching hysteresis. It may be biased to operate at a prescribed pressure level and will switch when the control is slightly higher or lower than this prescribed level. Air from a regulated supply flows to the pressure control device **52** and valve **54** such a a Corning Fluid Amp Interface Valve Model 192621-LP (5–40 psig) through pipes **51** and **53.** Air for the three-way valve **54** passes first through valve air restrictor **55.**

The controller **52** includes Schmitt trigger **70,** connected between air supply line **51** and valve **54** and a pressure biasing system connected to the trigger **70,** line **51** and the sensor **50.** The pressure biasing system includes pipe loops **80** and **81** between line **51** and trigger **70** with loop **80** connected to a variable restrictor **83** and loop **81** connected to tubing **56** leading to sensor **50.** Guage **82** is connected parallel to loops **80** and **81.** In operation, the trigger **70** is biased by balancing loops **80, 81** so that air flows straight through trigger **70** from inlet **71** to outlet **72** and on through pipe **57** to valve **54.** This pressure applied to valve **54** holds the valve open admitting air to cylinder **25.** Pressure in loops **80** and **81** is adjusted via restrictor **83** to maintain a higher pressure in loop **80** than in loop **81** to keep the main air stream flowing through the trigger **70** as described. In addition, the pressure in loop **80** is somewhat higher than the pressure in the diffuser passage so that there is a flow of air through sensor **50** into the diffuser. In the event a plug develops in the exit **22** of the diffuser, pressure will build up in the diffuser to an extent to cause pressure to build in loop **81** and switch the air stream flowing through the trigger **70** from the outlet **72** to outlet **73.** This in turn diverts the air from valve **54** which closes cutting off air to cylinder **25.** With air pressure cut off from the cylinder, the pressure build up in the diffuser **14** causes pivotally mounted plate **18** to swing outwardly releasing the plug. Once the plug is released, the pressure drops to normal allowing the trigger **70** to reset.

The sensor **50,** which is 3/32 inch diameter hole in the upper section of the fixed diffuser plate, is supplied, by the feedback circuit, with 0.5 psig air so that bleed occurs into the diffuser. When a plug forms a change of internal pressure equivalent to as little as 1 inch of water is enough to trigger release. An over-pressure of 3 inches of water is a reasonable working level so as to allow for string up and swath adjustment by an operator without accidentally causing release.

Additional features are needed for diffusers which are located at either edge of the collecting belt **16.** FIGS. **4** and **5** show a suitable design for these edge diffusers. Essentially, one edge of the diffuser plate **60** is cut at 90° to the top edge and a flexible edge control seal is added to prevent air from carrying filaments off the edge of the belt. This is seen in detail in FIG. **5** where the edge is partially closed by a flexible sheet **62** held by clamps **64.** The flexible material and the clamps are fastened to the two diffuser plates **60** by bolts **66.**

In operation of the invention, a ribbon **10** of electrostatically charged filaments of polyethylene terephthalate and polyethylene terephthalate copolymers is drawn into the jet **12** by aspiration and is carried through the jet by means of hot air introduced through air duct **8** of FIG. **1.** The construction of the jet is similar to that of Cope, U.S. Pat. No. 3,302,237. Under the influence of the hot air stream, th filaments shrink while passing through jet apparatus. The temperature of the air in the jet is between 225° and 235° C. Upon issuing from the jet, the filaments pass from filament outlet **13** of the jet into the filament entrance **15** of the diffuser. Air is aspirated through aspiration slots **20.**

Typically, a ribbon **10** is about **6** inches wide. The exit of the diffuser **4** is about **19** inches above belt **16** and is about 12½ to 13 inches in length (L, FIG. **1**). The degree of spreading at the diffuser exit depends partially upon the charge level. With a charge of about 2 microcoulombs/gram the swath width may be varied for example from about 23 inches to about 32 inches by changing the diffuser exit gap from 0.280 inch to 0.150 inch. With a charge of about 4 microcoulombs/-gram the swath width may be varied from about 31 to about 50 inches using the same exit gap range. Each aspiration gap **20** is typically set with an 0.250 inch width at the narrowest point.

What is claimed is:

1. In a filament forwarding apparatus including a jet having inlet and outlet ends connected by a filament passage of generally rectangular cross section, a dif-

fuser comprising: a pair of spaced plates mounted to the outlet end of the jet, one end of the plates extending above said outlet end and being spaced therefrom to form two generally rectangular slots, the other end extended below said outlet said plates forming an open sided diffuser passage in axial alignment with said jet filament passage, said slots being in communication ith said diffuser passage and the outside of the jet, said diffuser passage having successive curved, straight and converging lengths, said curved length being adjacent the outlet endof the jet, said converging length terminating at said exit slot, the filaments being forwarded through the jet and diffuser passages by a gas, said gas developing static pressure in the diffuser; and means for pivotally mounting one of said plates to the outlet end of the jet for swinging movement toward and away from the other plate to change the size of the said exit slot.

2. The apparatus as defined in claim **1,** said exit slot having a width less than the combined widths of said two rectangular slots.

3. The apparatus as defined in claim **1,** including means for moving said pivotally mounted plate according to the static pressure in the diffuser passage.

4. The apparatus as defined in claim **3,** said means for moving according to the forwarding conditions in the diffuser passage comprising: a pressure sensor in communication with said passage; an air cylinder engaging said one plate adjacent said exit slot; a source of pressurized air connected to said cylinder; and means for cutting air off from said cylinder, said means being actuated by said sensor.

5. In a filament forwarding apparatus including a jet having inlet and outlet ends connected by a filament passage of generally rectangular cross section, a diffuser comprising: a pair of spaced plates mounted to the outlet end of the jet, said plates forming an open sided diffuser passage in axial alignment with said jet filament passage, said diffuser passage terminating in an exit slot; means for pivotally mounting one of said plates to the outlet end of the jet for swinging movement toward and away from the other plate to change the size of the exit slot; a pressure sensor in communication with said diffuser passage; an air cylinder connected to said one plate adjacent said exit slot; and a control means connected to said cylinder for admitting and releasing air to said cylinder for operating said cylinder to move said one plate, said control means being actuated by said sensor.

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