Nov. 22, 1966 G. A. KINNEY 3,286,896

METHOD AND APPARATUS FOR FORWARDING FILAMENTS BY JET MEANS

Filed July 14, 1964 2 Sheets-Sheet 1

FIG. 2

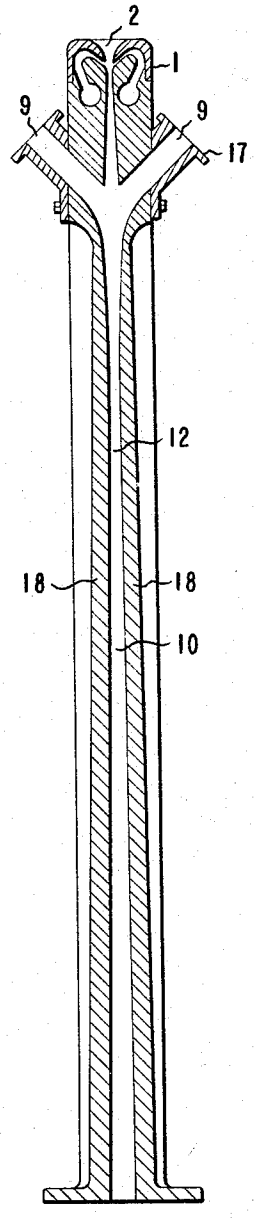


FIG. 3

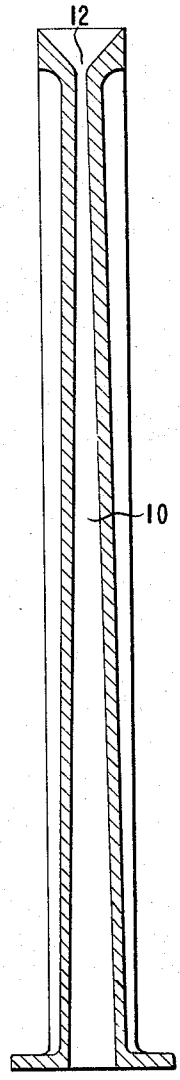
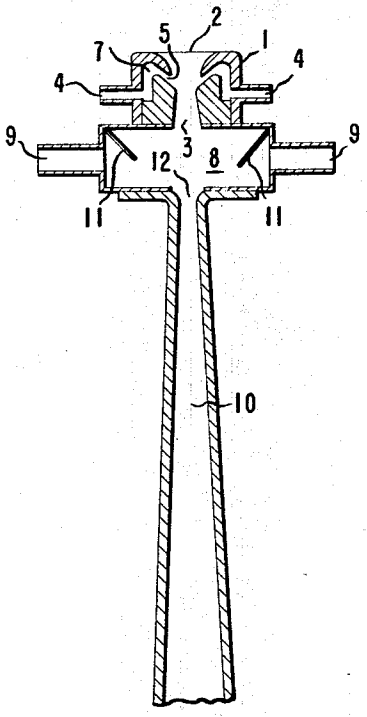


FIG. 1



INVENTOR
GEORGE ALLISON KINNEY

BY Sol Schwartz
ATTORNEY

Nov. 22, 1966 G. A. KINNEY 3,286,896
METHOD AND APPARATUS FOR FORWARDING FILAMENTS BY JET MEANS
Filed July 14, 1964 2 Sheets-Sheet 2

FIG. 4

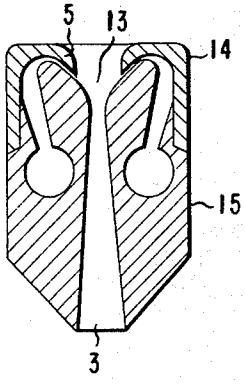


FIG. 7

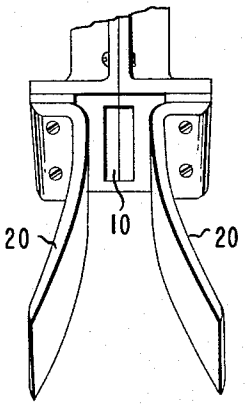


FIG. 8

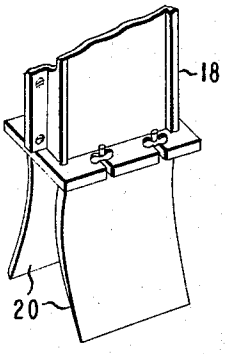


FIG. 5

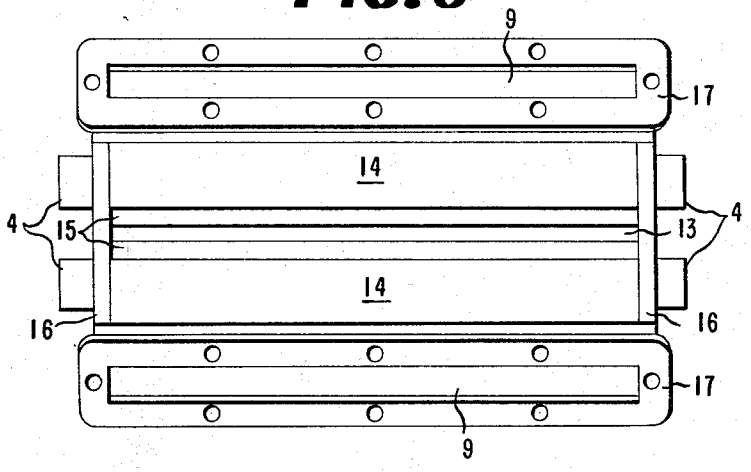
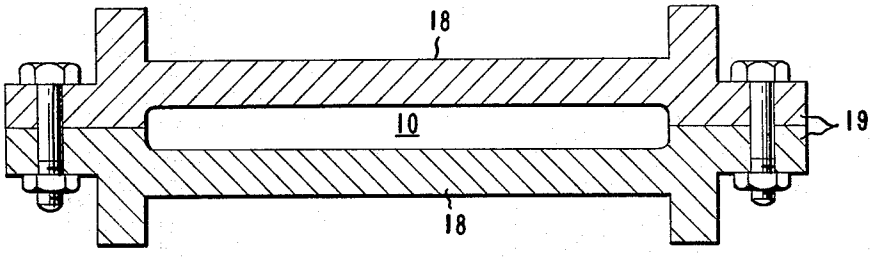


FIG. 6



INVENTOR
GEORGE ALLISON KINNEY

BY Sol Schwartz
ATTORNEY

United States Patent Office 3,286,896
Patented Nov. 22, 1966

3,286,896

METHOD AND APPARATUS FOR FORWARDING FILAMENTS BY JET MEANS

George Allison Kinney, West Chester, Pa., assignor to E. I. du Pont de Nemours and Company, Wilmington, Del., a corporation of Delaware

Filed July 14, 1964, Ser. No. 382,578
4 Claims. (Cl. 226—97)

This invention relates to filament-forwarding devices, in particular to filament-forwarding jet devices which utilize the tension exerted by a gas stream to effect forwarding of the filaments.

Jet devices have been utilized in the textile industry for many years to effect drawing, texturing, stripping, annealing, etc., of synthetic yarns. In most cases these jets have evolved into sophisticated precision devices using high pressure air. In addition to the cost involved in generating this high pressure air, other disadvantages of such jets are (1) their tendency to plugging by yarn or foreign matter, (2) the cost of manufacturing to the close tolerances required and (3) the need for frequent and delicate adjustments.

Jet devices have been found to be of special value in a recently developed process for the production of nonwoven fabrics from continuous synthetic organic filaments. In this process, described in British Patent 932,482, a multifilament strand of continuous filaments is electrostatically charged and forwarded towards the receiver, the filaments are allowed to separate due to the repelling effects of the applied electrostatic charge, and are then collected on the receiver as a random nonwoven sheet which is essentially free from filament aggregates. Jets are ideally adapted for use as filament-forwarding devices in this process since, upon exit from the jet, the forwarding tension applied to the filaments is rapidly released, thus permitting the filaments to separate from each other due to the electrostatic charge.

When the filaments used in this process come directly from a spinneret, jets may be used to effect either the desired drawing of the filaments or to strip the filaments for mechanical drawing means, for example, draw rolls. In an alternative method of operating the process, jets may be used to provide the forwarding tension needed to remove already formed and oriented filaments from packages and to direct them toward the web-laydown zone. In either case, the performance requisites of the laydown jets are different from the requirements of jets used to impart bulk, crimp or entanglement between filaments. Thus, the jets used in the web-laydown process of the aforementioned patent must develop sufficient forwarding tension on the yarn to meet the requirements of the particular process modification being used. For example, if draw rolls are used, the jet must apply sufficient tension to prevent draw-roll slippage and to pull the yarn strands from the last draw roll. The jets must be designed to minimize air turbulence so that bunched or ropey filaments, that is filament aggregates, are not evident in the web. In addition the jets must discharge the filaments in a well-dispersed orderly manner to permit uniform nondirectional web formation. These requirements are to a certain extent incompatible, since high tension is obtained by high air velocity, yet high velocity creates excessive turbulence which leads to filament entanglement. Previous attempts in the art to reconcile the above requirements have gone in the direction of smaller air and yarn passages with correspondingly small dimensional tolerances.

For convenience in the ensuing discussion reference will be made to air as the gas to be used in the filament-forwarding jet devices. Although air is the most convenient and least expensive gas to use, it will be recognized that other gases may be used if desired.

An object of the present invention is to provide a filament-forwarding jet device which operates on low-cost, low-pressure air.

A further object is to provide a jet device with large dimensional clearances thereby minimizing the tendency to plug.

A still further object is a jet device with broad dimensional tolerances.

Another object is a jet device which provides filament-forwarding tension with a minimum of turbulence thus maintaining the filaments substantially free from entanglement.

Still another object is a jet device which will discharge filaments in a well-dispersed orderly manner to permit uniform nondirectional web construction.

These and other objects are obtained according to this invention by a filament-forwarding jet device comprising a combination of an aspirator portion and a jet portion. The aspirator portion has means defining a main passageway having an entrance and exit for substantially straight line filament travel, and means defining an additional passageway intersecting said main passageway for supplying gas under pressure to said main passageway and arranged at an angle so that the introduction of such gas will provide a suction at the entrance to said main passageway. The jet portion comprises means defining a channel having a constriction downstream of its inlet. The inlet of the channel is operatively connected with the exit of the main passageway of the aspirator portion. The main passageway of the aspirator portion and the channel of the jet portion are axially aligned. Means are provided for introducing low pressure gas into said channel at a point of the constriction in the channel but below the exit of the main passageway of the aspirator portion. This inlet for low-pressure gas provides a supply of such gas that supplements the gas introduced to the aspirator portion by the high-pressure supply and through suction so that the total amount of gas presented to the channel upstream of the constriction is sufficient to maintain a pressure differential between the inlet and exit of the channel of the jet portion. Due to this pressure differential, air flows through the channel and as it passes through the constricted region, its velocity increases and it thereby exerts a forwarding tension on the filaments introduced at the entrance of the aspirator portion as more particularly described below.

The aspirator portion of this improved forwarding device provides yarn access to the device and because of the suction at the opening or entrance of the filament conduit constituting the main passageway of the aspirator portion, the jet device of the invention is self-threading. The aspirator portion also acts as a check valve to permit the maintenance of a differential pressure across the elongated filament conduit constituting the channel of the jet portion. The aspirator portion must have a design which will permit it to operate against a back pressure equal to or greater than the pressure differential which must be maintained across the said channel.

The supply of air required to maintain a pressure differential across the channel of the jet portion is greater than the output from the aspirator portion, including both the feed and aspirated air, i.e., that introduced by suction in the entrance of the main passageway, and therefore, it is necessary to have an auxiliary gas supply to the channel of the jet portion. This gas is supplied directly or through a gas chamber connecting the inlet of the channel and the exit of the main aspirator passageway, at a pressure corresponding to the pressure differential which is maintained across the channel. It will

be at a lower pressure than the air which is fed to the aspirator portion.

In order for the jet device of this invention to provide the desired filament-forwarding tension, it is necessary that there is a constriction in the channel of the jet portion. The constriction normally has a cross-sectional area of less than one-half the total cross-sectional area of the supply lines leading to the jet portion channel. These supply lines include the exit of the aspirator portion and the one or more auxiliary gas inlets to the channel. This constriction may be close to the inlet of the channel or it may be located downstream therefrom. The former position may be used when the channel has the form of a nozzle, that is, with straight sides downstream from its constriction. The filament conduit constituting the channel in the preferred embodiment has the curved sides of a true venturi. The constricted area, that is, the venturi throat in this modification, is preferably at a distance from the entrance of about one-fifth to one-third the total length of the channel.

In order to provide the required pressure differential across the channel and filament-forwarding tension while preventing turbulence and filament entanglement, large volumes of low-pressure gas are supplied to the channel entrance. Provision of this entire supply of gas solely through the aspirator portion would require either (1) that high pressure gas be supplied, which would result in excessive air turbulence and filament entanglement, or (2) that the openings of the feed gas inlets to be aspirator portion be enlarged. Both of these alternatives result in less efficient use of the fluid energy put into the system than is obtained with the instant filament-forwarding device.

One important function of the aspirator portion of the filament-forwarding jet device of the invention is that it makes the device self-threading. It also provides a means of introducing the filaments into the device for without it, the low-pressure gas stream supplied at the entrance to the channel would exhaust at the inlet of the main passageway of the aspirator portion.

The cross section of the filament entrance to the main passageway of the aspirator portion can be a circle or rectangle, or some other configuration. The preferred design will depend on the configuration of the filament bundle to be forwarded by means of the jet device. Thus for a round tow, a round opening or entrance may be most appropriate; while with a flat ribbon of filaments, a slot entrance will be preferred. With either type, the entrance and exit of the main aspirating passageway and the inlet and exit of the channel of the jet portion will be aligned in order that the filaments can best pass through the device without becoming tangled. For convenience, axial alignment as used herein is intended to signify the required arrangement of the main passageway and the channel with respect to their longitudinal axes.

The invention will be further understood by reference to the drawings in which:

FIGURE 1 is a diagrammatic cross-sectional sketch of filament-forwarding jet devices of this invention;

FIGURE 2 is a cross-sectional view of a preferred embodiment of the filament-forwarding jet device of this invention;

FIGURE 3 is a cross-sectional view of an alternative embodiment of the channel in the jet portion;

FIGURE 4 is an enlarged cross-sectional view of the aspirator portion of the device of FIGURE 2;

FIGURE 5 is an enlarged end view of the aspirator portion of the jet of FIGURE 2;

FIGURE 6 is an enlarged, cross-sectional view about one-fourth the way down along the length of the jet portion of FIGURE 2; and

FIGURES 7 and 8 are perspective views of the exit of the jet portion of FIGURE 2 showing the optional use of diffuser plates.

Referring to FIGURE 1, aspirator portion **1** is shown with filament passageway entrance **2** and exit **3**. Feed air under pressure is supplied to the aspirator portion through inlets **4** and is distributed across feed air gap **5** via plenum chamber **7**. The aspirated air which enters entrance **2** through suction and the feed air pass through exit **3** into gas chamber **8**. Gas chamber **8** has air supply inlets **9** through which the auxiliary air required to maintain a pressure differential across channel **10** is supplied. The air chamber is shown with air distributors **11** to indicate that turbulent flow is to be avoided in the air chamber. Perforated plates or screens may be positioned as indicated at **11** to provide this function, but a preferred method is to angle the auxiliary air inlets as shown in FIGURE 2 so that the secondary air is moving toward the inlet to the channel in essentially straight line flow and at a velocity and flow rate as close as practical to that of the aspirator portion discharge air. The channel **10** as shown in FIGURE 1 has the form of a nozzle and the constriction **12** is located near the inlet to the channel from the air chamber.

A slot jet device of the type shown schematically in FIGURE 1 with the long dimension of the slot being 6 in. (15 cm.) is fabricated with the following dimensions:

Aspirator portion:
- Length ---------- About 6 in. (15 cm.).
- Filament opening **2** (at minimum width) ----- 0.75 in. (1.91 cm.).
- Feed air gap **5**---------- 0.030 in. (0.076 cm.).
- Width of aspirator throat-- 0.190 in. (0.482 cm.).

Air chamber (low-pressure gas supply means):
- Length ---------- About 7 in. (18 cm.).
- Width between air inlets-- About 6 in. (15 cm.).

Jet portion channel:
- Length of channel------- 48 in. (122 cm.).
- Width at constriction **12**-- 0.50 in. (1.27 cm.).
- Width at exit---------- 2.25 in. (5.7 cm.).

Feed air supplied at the aspirator portion at 120 s.c.f.m. (3400 liters/min.) and 5 p.s.i.g. (0.35 kg./cm.^{2}) aspirates about 80 s.c.f.m. (2300 liters/min.) air against a back pressure of 1.25 p.s.i.g. (0.088 kg./cm.^{2}) maintained in the air chamber. The flow of auxiliary air into the air chamber amounts to about 400 s.c.f.m. (11,300 liters/min.) and the total air exiting from the jet portion channel is about 600 s.c.f.m. (17,000 liters/min.). When a filament ribbon comprising 725 polypropylene filaments, 8 d.p.f. (0.9 tex.) is led from a pair of draw rolls into the opening of the filament-forwarding jet device, the aspirating action makes the device self-threading. The tension on the filament ribbon is adequate to prevent draw-roll slippage and to strip the filaments from the last draw roll. When an electrostatic charge is applied to the filaments by passing them through a corona discharge device prior to their entry into the jet device, the filaments coming out of the jet device exhibit good filament separation and can be collected as a uniform nonwoven web with essentially no filament aggregates. Customary jet problems associated with stripping back of broken filaments and plugged yarn passages are not encountered.

A preferred embodiment of the jet devices of this invention is shown in FIGURE 2 and further details of this embodiment are indicated in FIGURES 4, 5, and 6. As before, the jet device comprises an aspirator portion **1**, low-pressure air supply inlet **9** and jet portion channel **10**. The aspirator portion as shown in FIGURES 4 and 5 may consist of nozzle plates **14** and throat plates **15** which are machined and equipped with fastening means (not shown) to coact with each other to form feed air gap **5**. These plates when combined and attached to end plates **16** with fastening bolts (not shown) form aspirator throat **13** which diverges to exit **3**. End plates **16** carry inlets **4** for supplying feed air to the aspirator portion.

The aspirator portion shown in FIGURES 4 and 5 has a wide opening between nozzle plates **14** relative to the

width of the aspirator throat **13**. This provides a large shear area leading into the throat and thereby a high level of aspirated air is obtained.

As indicated in FIGURES 2 and 5, auxiliary air under low pressure (but above atmospheric) is provided to channel **10** of the jet portion through air inlets **9** which are equipped with flanges **17** to provide for convenient attachment to a high-volume source of low-pressure air. As shown, the inlets extend across the entire width of the channel and are directed downwardly to minimize air turbulence in the channel.

Channel **10** in the jet portion of this preferred embodiment has the curved sides of a true venturi with the construction (venturi throat) located about one-fourth of the way down the channel from its entrance. A cross section of the channel approximately at this point is shown in FIGURE 6. The filament conduit or channel in the jet portion is formed by plates **18** having flanges **19** by which they are locked together. Plates **18** may be cast from aluminum by sand-casting or shell-molding processes. By the latter method close tolerances (less than 10 mils) (less than 0.25 mm.) and good surface finishes (125 microinch) (0.0032 mm.) can be obtained without the need for subsequent machining. Machining may be used at the flanges to eliminate air leakage. It will be recognized that other metals or plastics can also be used for the construction of the jets of this invention.

FIGURE 3 shows an alternative embodiment of the channel **10** having the straight sides of a nozzle downstream from the constriction **12** which is located close to the inlet to the channel.

FIGURES 7 and 8 show the optional use of curved diffuser plates **20** parallel to and equidistant from the center line of the slot-shaped exit. These diffuser plates influence the size, shape and velocity of the air stream after it leaves the exit. For a 6-inch (15-cm.) slot having an exit of about 1.2 inches (3 cm.) wide the diffuser plates may be placed 1.2 to 1.75 inches (3.0 to 4.5 cm.) apart. The open ends between the plates allow room air to be entrained which causes the air stream and the bundle of airborne filaments to flatten out 90° out of phase with the direction of the slot.

The filament forwarding method of the present invention may be described as follows: A bundle of filaments is drawn by suction into the entrance of a filament passageway in a first zone corresponding to the aspirator portion described above. A gas stream under pressure, is directed into said filament passageway at such an angle of incidence with respect thereto as to provide suction at the entrance of said first zone. The filaments traverse the length of the filament passageway, leave the aspirator portion and are then directed to a second zone corresponding to the jet portion described above. The exit of the first zone is operatively connected with the inlet of the second zone and the filaments exiting from the first zone are directed to the inlet of the second zone. A gas stream is now introduced in the vicinity of the inlet of the second zone, at a pressure lower than that of the feed gas to the aspirator portion, in such a way that gas turbulence is minimized. The bundle of filaments and the combined gas streams namely, that issuing from the exit of the aspirator portion, and that introduced in the vicinity of the inlet to the jet portion, proceed downstream in the second zone. A constriction downstream in the jet portion reduces the cross section of the gas stream thereby increasing its velocity and imparting a tension to the filament bundle. As the constriction is passed, the gas stream decelerates and the tension on the filaments is released as they leave the second zone or jet portion.

Slot devices of the types shown in FIGURES 2 and 3 with the long dimension of the slot being 6 in. (15 cm.) are fabricated with the dimensions indicated below and are operated with air feed pressures as shown.

	Venturi type (Figure 2)	Nozzle type (Figure 3)
Aspirator portion:		
Feed air gap 5	0.030 in. (0.076 cm.)	0.030 in. (0.076 cm.).
Filament entrance 2 between plates 14 (at minimum width).	0.75 in. (1.91 cm.)	0.75 in (1.91 cm.).
Width of throat 13	0.109 in. (0.482 cm.)	0.190 in. (0.482 cm.).
Length, top of plate 14 to exit 3	5.75 in. (14.6 cm.)	5.75 in. (14.6 cm.).
Divergence angle, throat 13 to exit 3	7°	7°.
Feed air pressure	1.25 p.s.i.g. (0.088 kg./cm.²)	1.25 p.s.i.g. (0.088 kg./cm.²).
Low-pressure gas supply:		
Air inlet 9	1.0 in. (2.5 cm.)	1.0 in. (2.5 cm.).
Auxiliary air pressure	0.3 p.s.i.g. (0.021 kg./cm.²)	0.3 p.s.i.g. (0.021 kg./cm.²).
Jet portion channel:		
Length	42 in. (107 cm.)	42 in. (107 cm.).
Length, aspirator portion exit 3 to constriction 12.	About 10 in. (25 cm.)	About 1 in. (2.5 cm.).
Width at constriction	0.50 in. (1.27 cm.)	0.50 in. (1.27 cm.).
Width at exit	1.17 in. (2.97 cm.)	2.00 in. (5.08 cm.).
Exit air flow	308 s.c.f.m. (8,700 liters/min.)	485 s.c.f.m. (13,700 liters/min.).
Exit air velocity	2,110 y.p.m. (1,930 meters/min.)	2,500 y.p.m. (2,290 meters/min.).
Yarn tension [1]	About 0.15 g./denier	About 0.15 g./denier.

[1] Exerted on ribbon of 725 polypropylene filaments, 8 d.p.f. (0.9 tex.) moving at 800 6.p.m. (730 meters/min.).

As indicated above, the aspirator portion and the low-pressure gas supply means of the two jet devices are identical. The same feed air and auxiliary air pressures are also used. The jet portions of both devices develop adequate yarn tension to insure no slippage on the draw rolls and to strip the filaments from the last draw roll. Although both embodiments can be used, the venturi design gives better filament uniformity and a lower degree of turbulence. These improved results may be due to the lower exit air flow and velocity in the venturi design. The venturi also exhibits smoother acceleration and deceleration curves than the nozzle type when evaluated at a pressure differential of 0.3 p.s.i.g. (0.021 kg./cm.²).

The air pressure requirements of the jet devices of this invention are easily met with air pressures of 10 p.s.i.g. (0.7 kg./cm.²) and lower. Air pressures of this magnitude are readily obtained with low-cost, high-capacity blower systems. The jet devices have wide yarn passages and are free from critical precise mechanical requirements. They thus are well suited for application as filament-forwarding devices and are especially well adapted to use in the aforementioned process for production of continuous-filament, nonwoven fabrics.

What is claimed is:

1. A jet device for forwarding filaments while maintaining said filaments substantially free from entanglement comprising an aspirator portion and a jet portion, said aspirator portion comprising means defining a main passageway having an entrance and exit for substantially straight-like filament travel, means defining an additional passageway intersecting said main passageway for supplying gas under pressure to said main passageway and arranged at an angle so that the introduction of such gas will provide a suction at the entrance to said main passageway, and said jet portion comprising means defining a channel having a constriction downstream of its inlet and said inlet being operatively connected with the exit of the

main passageway of the aspirator portion, the main passageway of the aspirator portion and the channel of the jet portion being axially aligned, and means for introducing low-pressure gas into said channel at a point upstream of the said constriction but below the exit of the main passageway of the aspirator portion.

2. The jet device of claim **1** wherein the means for introducing low-pressure gas into the channel is constituted by a gas chamber connecting the exit of the main passageway and the inlet of the channel, which chamber is provided with the auxiliary gas supply means.

3. The jet device of claim **1** wherein the channel of the jet portion has the curved sides of the true venturi.

4. A method for forwarding a bundle of filaments while maintaining said filaments substantially free from entanglement comprising drawing said bundle of filaments into the entrance of a filament passageway in a first zone by suction, directing a first gas stream under pressure into said filament passageway and at an angle of incidence thereto creating the aforementioned suction, directing the

filaments existing from said first zone into a second zone operatively connected with the first zone, introducing a second gas stream into said second zone in contact with the filaments, and in the vicinity and general direction of the filaments entering the second zone and at a pressure lower than that of the first gas stream, in such a manner that gas turbulence is minimized, accelerating the flow of gas downstream in said second zone by constricting the cross section of the gas stream whereby tension is applied to the bundle of filaments, and then decelerating the gas stream by enlarging its cross section thereby releasing the tension applied to the filaments as they leave the second zone.

References Cited by the Examiner

UNITED STATES PATENTS

2,121,802	6/1938	Kleist	226—97
3,185,400	5/1965	Maxey	226—95

ANDRES H. NIELSEN, *Primary Examiner.*

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,286,896 November 22, 1966

George Allison Kinney

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 3, line 29, for "be" read -- the --; columns 5 and 6, in the table, second column, line 3 thereof, for "0.109" read -- 0.190 --; same table, in the footnote, for "800 6.p.m." read -- 800 y.p.m. --; column 6, line 68, for "straight-like" read -- straight-line --.

Signed and sealed this 12th day of September 1967.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents