

Feb. 16, 1960

R. F. DYER

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Filed Sept. 13, 1956

2 Sheets-Sheet 1

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Fig. 5

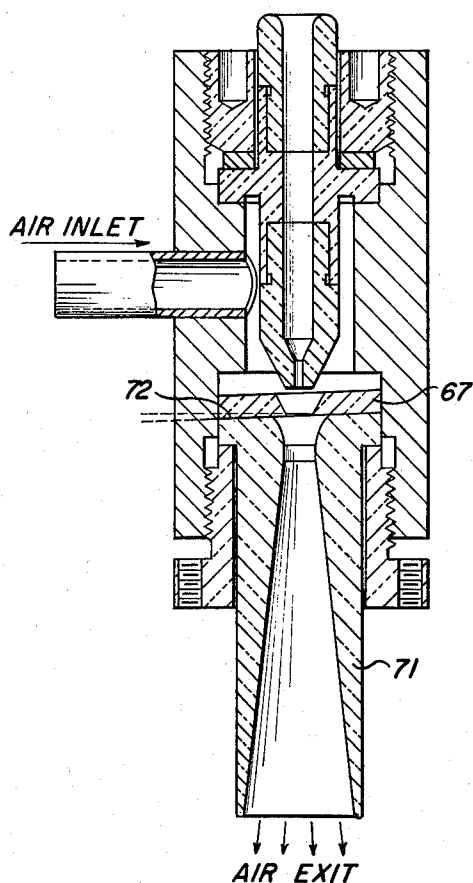
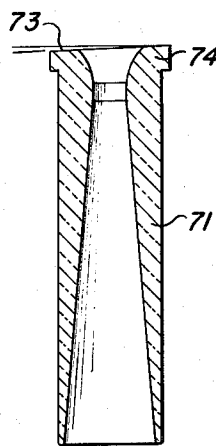


Fig. 6



RICHARD F. DYER
INVENTOR.

BY *Daniel J. Mayne*
Harold N. Powell

ATTORNEYS

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JET DEVICE FOR BLOWING YARN AND PROCESS

Richard F. Dyer, Kingsport, Tenn., assignor to Eastman Kodak Company, Rochester, N.Y., a corporation of New Jersey

Application September 13, 1956, Serial No. 609,642

16 Claims. (Cl. 28—1)

This invention relates to devices useful for treating filamentary materials. More particularly, this invention concerns jet devices adapted for use in blowing air onto yarn.

This application is a continuation-in-part of my application Serial No. 400,544, filed December 28, 1953.

In the textile industry there are many instances where devices of the class described are utilizable in the handling and the treating of filamentary material such as filaments, fibers, yarn, thread, tows and the like. For example, in some instances such devices are useful in motivating the material. In other instances the devices may be used to apply a certain type of treatment to the attenuated material. Or, in a number of situations, combination of motivation and treatment may be desired. The various purposes for which devices in accordance with the present invention may be utilized will be further apparent from the description which follows.

For example, in U.S. Patent 1,683,478 the general use of an air jet to motivate filamentary material is described. In U.S. Patent 2,100,588 the use of an air jet to impart a curl to yarn filaments is shown and in U.S. Patent 2,067,251 and air jet is provided to fluff up and loosen up a bundle of filaments by placing them in a state of substantial but incomplete parallelism. The latter patent actually fluffs up or bulks the yarn enough so as to require a yarn takeup speed after the jet which is less than the delivery speed to the jet, and the contraction in yarn length results in an increase in denier. This patent shows the use of the jet to motivate the yarn material.

One difficulty with these existing jet devices and other of the prior art, however, was their inefficiency particularly as regards the large volume of air at high pressures which was required to make such jets operative. In general, such jets were intended for processing heavy tows of yarn of say 20,000 denier with no particular attempt to use very high velocity air.

It is, therefore, apparent that the development of small, highly efficient jet devices particularly adapted for the motivating and treating of yarns in the range of 55 to 5000 denier represents a highly desirable contribution to this art. For example, it has been found that by applying high velocity air to yarn the cost of moving the yarn can be appreciably reduced, and also that under certain conditions novel and unusual yarn effects can be produced.

After extended investigation I have discovered certain novel jet devices which have utility for use in treating attenuated material, such as yarn, in various manners.

This invention has for one object to provide an improved device for use in motivating and/or treating filamentary material. Still another object is to provide a jet device as aforementioned which is particularly useful for applying a stream of air or similar fluid to yarn or the like material. Still another object is to provide a device which is of relatively simple construction and which is susceptible of use in various type of processes of treating filaments, fibers, yarn and the like material. A particular object is to provide a jet device that is especially adapted for use

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in producing bulked or lofted yarn. Other objects will appear hereinafter.

For an understanding of my invention, reference will be made to the attached drawings forming a part of the present application. In the attached drawings,

Fig. 1 is a sectional, side elevation view of one of the preferred jet devices in accordance with the present invention.

Figs. 2, 3 and 4 are likewise sectional, side elevation views of other species of jet devices.

Figs. 5 and 6 are sectional views of a jet generally corresponding to the jet of Fig. 1 or parts thereof for showing the tilting of the orifice plate as will be described hereinafter.

Referring to Fig. 1, there is shown in section the housing or outside shell 10 of a jet device in accordance with the present invention. This device is made up of the several inner members 7, 8, 11 and 12 which may be assembled together, for example by means of the threaded plugs 13 and 36. A passageway 14 extends through the jet device so that the filamentary material such as yarn may be passed from a position at 15 to exit at position 16.

This passageway or channel 14 in members 7, 8 and 12 is of substantially uniform diameter except that at the lower portion thereof at 18 provision is made for causing some constriction of the passageway to a conical shape.

Also, the outer surface of the lower portion of member 8 is suitably tapered as at 27, say to an angle between 50° to 90°, for providing in conjunction with the tapered surface 26 of orifice plate 37 an annular orifice or passageway for metering the air flow into the lower central passageway 21. This orifice plate construction 37 is an important feature of my device as will be explained in more detail hereinafter.

Referring further to lower member 11, there is provided at 21 a passageway of substantially uniform diameter, which passageway, however, flares outwardly a few degrees, as for example between 3° to 12° in the portion 22.

The exact construction of this portion of my jet is of some importance in order to assure a maximum velocity of air with a minimum air pressure in the passageway of uniform diameter and a smooth transition in the flared portion which exits to the atmosphere. For example, it has been found that highest efficiency results when the length of the uniform passage 21 is about 1/2 to 1 times its diameter and the diameter of the flared portion 22 at the exit 16 end is about 2 times the diameter of the uniform passageway 21, and the taper of the flare is between 6° and 10° included angle. In addition the inside diameter of the nozzle tip 30 should be about 75% of the diameter of the uniform passageway in member 11. These conditions result in a maximum intermingling of air and yarn in member 11 and also when the members 11 and 12 are properly positioned causes a suction in passageway 14 which makes the jet self-threading and particularly suitable for removing and conveying yarn away from a godet or feed roll where no subsequent wind-up operation is involved. It was also noted in using this jet design in the manner just described, i.e. to remove yarn from a roll, that the very high velocity of the air caused an appreciable separation and subsequent tangling or loopiness in the yarn when a large number of fibers made up the yarn strand. The increase in loopiness was much greater than had been obtained by previously known jet designs.

The upper portion of outside housing 10 is provided with a suitable inlet 23 such as a conduit, pipe, hose or the like for introducing the treating fluid such as air. This opening leads into the chamber 24 which chamber is of sufficient diameter to contain members 7 and 8 and to provide a relatively uniform space thereabout. The exact size of chamber 24 is not unduly critical. Preferably for the construction of this Fig. 1 being described, the open

diameter (before inserting parts 7 and 8) would be about a half inch. However, the diameter may be changed say to $\frac{3}{4}$ inch or 1 inch. With larger diameters deflectors could be inserted or a small amount of filling material such as compressed wire or screening could be inserted if desired. However, the construction shown gives good gas flow through the jet.

It will be observed from the preceding description of my jet device that the internal construction thereof is such as to obtain a venturi effect on the air flow. I have found that it is particularly important in the jet construction to be used in processing yarn and the like, that there be reasonably exact concentricity. That is, there should be accurate concentricity of the tip of the nozzle as at 30 and the opening of the orifice plate 31 and venturi throat as at 21. In other words, considering the device of Fig. 1, passageway or channel 14 preferably is exactly aligned with the opening in the orifice plate and with passageway 21, which means that the spacing between surfaces 26 and 27 would be relatively uniform around the entire circumference thereof.

The importance of accurately aligning the parts has been demonstrated by test. Several jets were made up of substantially identical construction excepting that in a few of the jets the center line of certain of the parts, as parts 7 and 8, was off center a few hundredths of an inch. Such jets did not produce as good bulked yarn as those jets where the alignment was within one-hundredths of an inch. However, when the alignment of these jets was corrected, they produced good yarn.

The other parts in Fig. 1 are gasket 34, spring washer 25 and bottom plug 36. It is thought, as may be readily noted from the drawing, that it can be seen these parts assist in permitting the tight assembly of the jet, yet so that it can readily be disassembled for cleaning, replacement of parts or the like.

By the construction just described I have found that a stream of air may be effectively applied to filamentary material passing therethrough. The air may be applied in varying amounts and under various pressures.

Reference is now made to Figs. 2 to 4 inclusive, showing various other species of jet devices.

In these figures are shown jets in which the orifice plates 41, 42 and 43 are positioned somewhat differently. These jets, excepting that of Fig. 2, are generally somewhat less efficient in operation than the jets of Fig. 1 or 2. The amount of suction obtained is small and in some cases these two forms may not be self-threading. Insofar as imparting a loopy treatment to the yarn is concerned, they are about equal in performance to the jet of Fig. 1 but require somewhat more air pressure to achieve the same degree of loopiness. Their chief advantage is simplicity of manufacture.

However, in Fig. 2, as in Fig. 1, is shown a form of the jet which combines an orifice and a venturi which results in greatly increased efficiency and will impart improved loopiness to the yarn at lower air pressures than any of the other forms shown. The design proportions for this jet fall in the same range as those for the jet of Fig. 1. It is preferred to use wear resistant ceramic materials for the entrance tube and venturi so that excellent resistance to yarn abrasion can be obtained. That is, the parts 8, 11 and 12 may be made of a commercially obtainable material known as Alsimag. The various other parts such as 7, orifice plate 37, housing 10 and the like may be made from metal such as brass.

Fig. 4 is made up of the two parts, housing 51 and inlet tube 52 for the yarn, corresponding approximately to parts 10 and 7, 8 and 12 of Fig. 1. A suitable opening or other means is provided at 44 for attaching a conduit pipe or otherwise providing for the introduction of the air or like fluid. However, in this species of construction of Fig. 4 there is the difference that there are provided two orifice plate members 43 and 45. These plate members are provided with tapered orifices 46 and 47.

In these species of devices of Figs. 2 to 4, here again it will be observed that there is concentricity of the tip or end of the nozzle and the openings or opening of the orifice plates. As indicated above, it is desirable that various parts are aligned so that the yarn or the like material being treated may travel in a reasonably straight, unobstructed path through the jet.

The various species of jets shown in Figs. 2 to 4 may be used in some instances for imparting special treatment to filamentary material. Or, in some instances where material of a different size (denier) than normal or common filamentary material is being processed, these species of jets may be of value.

In all of my jet constructions when the jets are to be used for bulking yarn, it is important that the jet give air flow that is smooth and straight with little turbulence and no swirling of the air stream, in order that proper bulking may take place. My jet constructions with the various parts aligned as already discussed in detail, permit such uniform air flow to be accomplished. On the other hand, if a swirling or circular air flow does occur in the jet, the centrifugal force of this air flow may be such that it keeps the yarn pressed against the walls of the jet, thereby preventing the filaments from separating and forming loops. Consequently, improper jet construction and improper control of the air stream in the venturi of such jets may adversely effect the quality and production rates of bulked yarn.

My novel jet constructions which contain an orifice plate therein, also possess further advantages. For example, it is possible in my jets to slightly tilt the orifice plate. This may be accomplished by placing a shim under one side of the orifice plate or grinding a small section away from the shoulder of part 11, Fig. 1. The amount of tilting of the orifice plate would be only a few hundredths of an inch. Such tilting permits the production of bulk yarn with smaller loops than when the orifice plate is not tilted. Also, a slight tilting may assist in increasing the production rate of bulk yarn from a particular jet.

That is, referring to Fig. 5, the orifice plate 67 (which substantially corresponds to orifice plate 37 of Fig. 1) may be tilted for example one-half to five degrees as shown at 72. Since the jet shown in Fig. 5 otherwise is substantially similar to the jet of Fig. 1, further description of the other parts does not appear to be required.

The accomplishment of the tilting of the orifice plate as discussed above, may be further understood by referring to Fig. 6. In this Fig. 6 there is shown a part 71 substantially corresponding to part 11 of Fig. 1. As indicated at 73, the shoulder 74 may be ground off a slight amount, for example .0022-.028 inch in order that the orifice plate aforementioned will be tilted slightly when the jet is assembled.

The jets of the present invention possess a number of other advantages as compared with prior art jets. The jets of the present invention generally permit the use of lower air pressure than jets heretofore used for the same purpose. The action of the jets of the present invention is much gentler on the yarn than prior art jets. The small jets of the present invention will accommodate most any size yarn from 75 denier to 900 denier without having to make changes in the jet parts. The large jets will handle from 900-7000 denier without changing parts.

The jet devices described above may be used to process yarn, particularly to convert multi-filament continuous yarn into bulked yarn. In order to operate the jet of Fig. 1, the air supply to opening 23 could be of the order of 5-50 lbs. p.s.i. Under such conditions the yarn coming off a Godet roll would be motivated through the jet device at a tension of about .05 gram/denier for the purpose of keeping waste yarn from accumulating on the rolls during a doffing of bobbins or a yarn break at the windup means.

The yarn emerging from the jet positioned adjacent the

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Godet roll, as just described, I observed to have substantial number of whorls and loops on its surface.

It is believed apparent from the foregoing that it can be observed that the tension and motivation accomplishable by the jet is dependent to a certain extent on the pressure of the air or other fluid supplied to the jet, the quantity thereof and the like factors. This is illustrated in further detail by reference to the following table:

Jet Air, p.s.i. gage	Exhaust Air, c.f.m.	Jet Air, c.f.m.	Intake Air, c.f.m.	Cu. Ft. Jet Air Per Hr.	Tension, Gram/Denier
10	3.9	2.5	1.4	150	.02
20	5.8	3.8	2.0	228	.05
30	6.8	5.0	1.8	300	.07
40	8.8	6.3	2.2	378	.07
50	9.8	7.3	2.5	438	.10
60	10.9	8.1	2.8	486	.10
70	12.0	9.25	2.75	555	.10

In considering the above table, it will be kept in mind that lower or higher pressures than those illustrated in the table may be used, and the particular pressure used is controlled, to some extent, by the type jet being employed. For example, referring to the jet construction of Fig. 2, pressures between 3 and 15 lbs. p.s.i. are utilizable with good results.

Referring to the jet of Fig. 3, for example, the use of air pressure of the order of 7 to 9 lbs. produced good uniform loopiness in yarn passing therethrough.

In all of the jets described, it is possible to equip the orifices (or make the entire part) where the filamentary material may come in contact with the parts with suitable wear resistant surfaces. Ceramic materials containing titanium oxides, aluminum oxides and silica have been found to be quite satisfactory.

The filamentary material resulting from the treatment of continuous multi-filament yarn in the several jets which have been described above, gives a product which may be used for substantially all the purposes for which comparable untreated continuous yarn has heretofore been used. That is, the treatment of the yarn in the jets of the present invention renders the yarn more bulky and softer but there are still obtained continuous filaments which may be woven into fabrics or otherwise used the same as yarn that has not been processed in the jet of the present invention. For example, a 300 denier cellulose acetate yarn having 75 filaments, when processed in the jet in accordance with Fig. 1, was converted into a product of the following characteristics:

Example 1

Input Yarn	Output Yarn
300 Denier. 75 Filaments. 32 Cu.Ins./Lb. Specific Volume. Smooth Lustrous Appearance.	360 Denier. 75 Filaments. 80 Cu.Ins./Lb. S.V. Loopy, Worsted-like Appearance.

After twisting the foregoing yarns they were woven into a crowfoot satin as filling yarn. The warp was composed of 108 ends of 150 denier 38 filament .9 t.p.i. twist yarn. The fabric had the following characteristics:

Input Yarn Fabric	Output Yarn Fabric
300/75/22 Bright Luster. 40 Picks/Inch. 3.70 ozs./sq. yard fabric weight. .010" Fabric Thickness. 39.7° F. Temperature Rise. (High temperature rise indicates poor insulation properties.) Fabric had smooth silky hand.	360/75/5Z Bright Luster. 36 Picks/Inch. 3.94 ozs./Sq. Yd. .014" Fabric Thickness. 30.7° F. Temperature Rise. (High temperature rise indicates poor insulation properties.) Fabric had lofty, light, and worsted-like hand.

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The jet used for processing this yarn had the following dimensions:

Diameter of inlet to nozzle 12	.125"
Diameter of outlet of nozzle 8	.047"
Diameter of orifice hole 31	.094"
Included angle of nozzle 8	60°
Included angle of orifice 37	90°
Entrance angle of venturi 11	35°
Venturi throat diameter	.106"
Venturi throat length	.062"
Venturi exit angle	10°
Air pressure used	8 p.s.i. gage.
Air usage	2.5 to 3.0 cfm. standard air.

Example 2 illustrates the processing of a heavy denier cellulose acetate yarn in a jet as shown in Fig. 1, but modified to handle large yarns.

Input Yarn	Output Yarn
1800 Denier. 110 Filaments. .75 Twist t.p.i. Z. Smooth lustrous yarn.	2200 Denier. 110 Filaments. .75 Twist t.p.i. Z. Loopy wool-like yarn.

The foregoing output or treated yarn was 3 plied with 1½ turns/inch S twist and tufted into a loop pile rug to which the yarn imparted a high degree of cover, resilience and good wool-like appearance which could not be obtained with the untreated input yarn.

The jet used for processing this yarn had the following dimensions:

Diameter of inlet to nozzle 12	.156"
Diameter of nozzle outlet 8	.145"
Included angle of nozzle 8	60°
Diameter of orifice hole 31	.177"
Entrance angle of venturi 11	60°
Included angle of orifice 37	90°
Venturi throat diameter 11	.189"
Venturi throat length 11	.150"
Venturi exit angle 11	10°
Air pressure used	20 p.s.i. gage.
Air usage	10 cfm. standard air.

However, the jet devices of the present invention may also be used in the removal of waste yarn from Godet to feed rolls. The yarn removed by means of the jets herein described is by reason of its bulky separated filament state more readily redissolved and thus improves the recovery of waste yarn and its processing for re-spinning. Therefore, the exact manner of utilizing the jets herein described is not a limitation on the present invention.

While in the above description, reference has been made to treating of cellulose acetate yarn, in a similar manner other yarns such as cellulose acetate butyrate, cellulose acetate propionate, polyester, acrylic and the like yarns may be processed in a comparable manner. The denier of the yarn is usually between 150-450. However, heavy denier, say 3000 to 8000 may also be processed. The number of filaments are preferably above 30.

I claim:

1. A jet device adapted for use in the textile industry, comprising an elongated outer member which includes a head portion and a tail portion, said member being provided with an air chamber in the member, said air chamber communicating with a relatively thin ceramic orifice plate positioned between the head and tail portions, said plate merging into a flared venturi-type passageway, a tube member having a substantially uniform passageway therethrough positioned in the air chamber so that said passageway discharges into said orifice plate, the apparatus assembly being characterized in that the

passageway and the orifice member are in relatively accurate concentricity.

2. A jet device adapted for use in the textile industry, comprising an outer member which has head and tail sections, said member being provided with an air chamber in the head section, said air chamber communicating with an orifice plate positioned about mid-way of the member, said orifice plate connecting with a venturi member, an elongated tube member provided with a substantially uniform passageway therethrough positioned in the air chamber, which passageway is positioned to discharge into the center of said orifice plate, the apparatus assembly being characterized in that all of the passageways through the jet are in accurate concentricity.

3. A jet device particularly adapted for treating continuous multi-filament yarn to convert the yarn to bulked yarn, which comprises a jet housing which housing is provided with an inlet adapted for the introduction of air into an air chamber within the interior of said housing, a tube member provided with a passageway of substantially uniform diameter positioned in one end of said housing and leading through said air chamber, a wider passageway on the other end of said housing and a relatively thin slightly tilted orifice plate within the housing positioned so that the first-mentioned passageway and the air chamber discharge through said orifice plate into the last-mentioned passageway.

4. A jet device particularly useful for treating continuous multi-filament yarn, comprising an elongated jet housing having an inlet on the side thereof adapted for the introduction of air into an air chamber within the interior of said housing, a tube member positioned in one end of said housing, said tube member being provided with a substantially uniform passageway therethrough, which passageway and tube member terminate in a conical tip, said tube member being comprised of a plurality of parts removably positioned in the end of said housing, a venturi-type tube member having a flared exit portion removably positioned by means of a threaded plug in the other end of said housing, and an orifice plate having a tapered orifice therein positioned between the two tube members, said tube members and orifice plate being aligned so that yarn entering one end of the device may pass in a substantially straight line through the device and out of the other end thereof.

5. A jet device as in claim 4 but in which the orifice plate is tilted not more than a few hundredths of an inch.

6. A jet device particularly adapted for treating continuous multi-filament yarn for converting the yarn into bulk yarn comprising a jet housing provided with an inlet means on the side of the housing for introducing air into an air chamber of about $\frac{1}{2}$ " diameter within the interior of the housing, an externally relatively smooth tube member provided with a substantially uniform passageway of less than $\frac{1}{2}$ " diameter extending through said air chamber, said tube closing up one end of said air chamber, an orifice plate positioned on the other end of said air chamber and aligned with said tube so that said tube can discharge substantially concentrically through the opening in said orifice plate and the other end of said housing being provided with a removably positioned venturi-type of tube.

7. A jet device adapted for use in the textile industry, comprising an elongated outer housing, including a head portion and a tail portion, said housing being provided with an air chamber in the head thereof, said air chamber communicating with a relatively thin orifice plate positioned about mid-way of the housing, said orifice plate being at least approximately centered in the housing, another member provided with a substantially uniform passageway therethrough positioned in the air chamber, said other member being positioned to discharge at least approximately into the center of said orifice plate, a venturi member composed of a converging portion of less than 135° included angle, a short cylindrical throat por-

tion and a diverging exit portion of less than 30° included angle located below said orifice plate, the apparatus assembly being characterized in that the passageway, orifice plate, and venturi member are in relatively accurate axial alignment.

8. A jet device adapted for use in the textile industry comprising an elongated outer housing, which housing includes a head member and a venturi tail member, the housing being provided with an air chamber in the head thereof, the air chamber communicating with a relatively thin orifice plate positioned generally adjacent the exit end of the air chamber, the aforementioned tail member being positioned generally adjacent the orifice plate on the opposite side thereof from the air chamber, this venturi tail member being characterized in that it is composed of a converging section, a short parallel tube-like section and a diverging section.

9. A jet device for bulking yarn comprising a housing separated into an upper and lower section by a gas inlet pipe leading to the side of the housing, a gas chamber within said housing, a tube which terminates in a conical tip leading through said gas chamber, and at least one thin plate orifice positioned below said tip and a venturi nozzle positioned below said thin plate orifice, the apparatus being characterized in that said tip and said orifice are positioned in relatively accurate concentricity.

10. A jet device adapted for use in the textile industry, comprising an outer member which has head and tail sections, said member being provided with an air chamber in the head section provided with an inlet for the introduction of a gaseous media into said chamber within the head section, said air chamber communicating with an orifice plate positioned about mid-way of the member, said orifice plate connecting with a venturi member, an elongated tube member provided with a substantially uniform passageway therethrough positioned in the air chamber, which passageway is positioned to discharge into the center of said orifice plate, the apparatus assembly being characterized in that all of the passageways through the jet are in accurate concentricity.

11. An apparatus for treating a plurality of strands of continuous multi-filament yarn which apparatus is adapted to convert static air pressure into velocity pressure with a minimum of air turbulence and a maximum of streamlined flow, said apparatus comprising a body member having upper and lower portions, a tube terminating in a nozzle threaded into the upper portion of said body member and extending into the body member, an orifice plate having a centrally positioned orifice located within said body member so that said orifice is aligned with said nozzle, a venturi tube abutting said orifice and threaded into the lower portion of said body member, said venturi tube having an entrance throat and a straight portion approximately equal to the diameter of said orifice, an exit throat in the lower portion of said venturi, said exit throat having an exit taper of about 10° whereby air flow is at very high velocity through the orifice, loses velocity in the entrance throat but regains velocity in the straight portion and thereafter expands evenly and loses velocity in the exit taper.

12. An apparatus for treating a plurality of strands of continuous multi-filament yarn which apparatus is adapted to convert static air pressure into velocity pressure with a minimum of air turbulence and a maximum of streamlined flow, said apparatus comprising a hollow body member having upper and lower portions, a tube terminating in a nozzle securely affixed to the upper portion of said body member and extending into the body member, an orifice plate having a centrally positioned orifice located within said body member so that said orifice is aligned with and is closely associated with said nozzle, a venturi tube abutting said orifice and securely fastened to the lower portion of said body member, said venturi tube having an entrance throat slightly larger than said orifice,

and a straight portion approximately equal to the diameter of said orifice, an exit throat in the lower portion of said venturi, said exit throat having a taper whereby air flow is at very high velocity through the orifice, loses velocity in the entrance throat but regains velocity in the straight portion and thereafter expands evenly and loses velocity in the exit taper.

13. A process for treating continuous multi-filament yarn, which comprises introducing said yarn into a jet containing a nozzle, plate orifice and venturi and into the center of a column of high velocity streamline air flow in association therewith, impinging said air flow at a low angle of incidence onto said yarn in such a manner that the yarn is maintained substantially in the center of said streamline air flow, while at the same time being thoroughly admixed with the air, in sequence decelerating and then accelerating said streamline air flow to a high velocity and then evenly decelerating said streamline air flow such that the yarn is caused to expand radially, then contract and reform into yarn while being maintained in the central portion of the air stream and abruptly removing said treated yarn from the streamline air flow in a radial direction.

14. A process in accordance with claim 13 wherein the streamline flow which while exerting forces in axial and radial directions on the yarn does not exert any torque forces which would cause the yarn to twist or turn to any substantial extent.

15. The process in accordance with claim 13 wherein the streamline flow is free of any centrifugal motions of the air flow which might tend to push the yarn filaments against the walls of the venturi.

16. A process in accordance with claim 13 wherein the orifice plate is aligned with and is closely associated with said nozzle so that the rate of air flow is substantially equal at each point around the annular opening formed by the nozzle and the plate orifice.

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