

June 18, 1963

W. C. ASHBY ET AL

3,094,262

IMPROVED YARN HANDLING SUCKER GUN

Filed Nov. 25, 1960

2 Sheets-Sheet 1

FIG. 1a

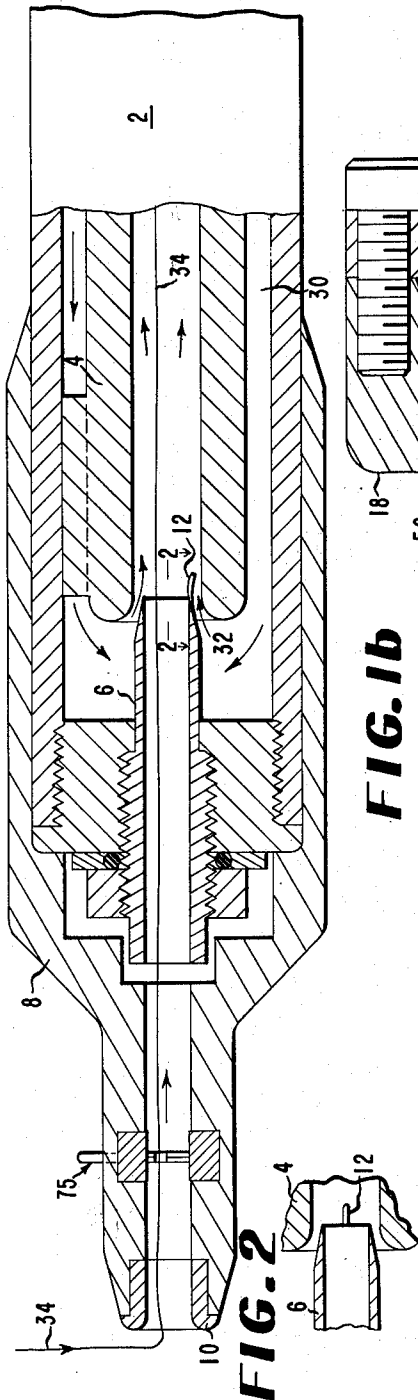
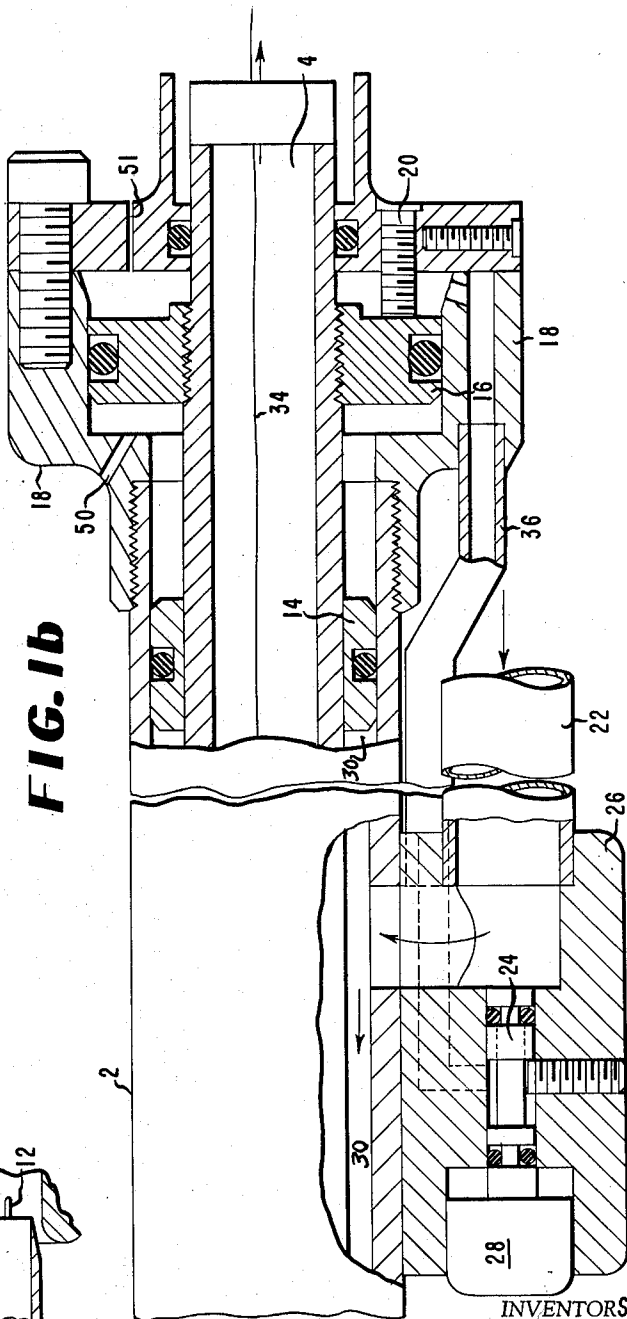


FIG. 1b



INVENTORS
WILLIAM CROPPER ASHBY
WILLIAM WALLAR BUNTING, JR.
ROBERT MEAGHER
THOMAS LARSON NELSON
KENNETH GILBERT SWAYNE
BY *Harry C. Braddock*
ATTORNEY

June 18, 1963

W. C. ASHBY ET AL

3,094,262

IMPROVED YARN HANDLING SUCKER GUN

Filed Nov. 25, 1960

2 Sheets-Sheet 2

FIG. 3

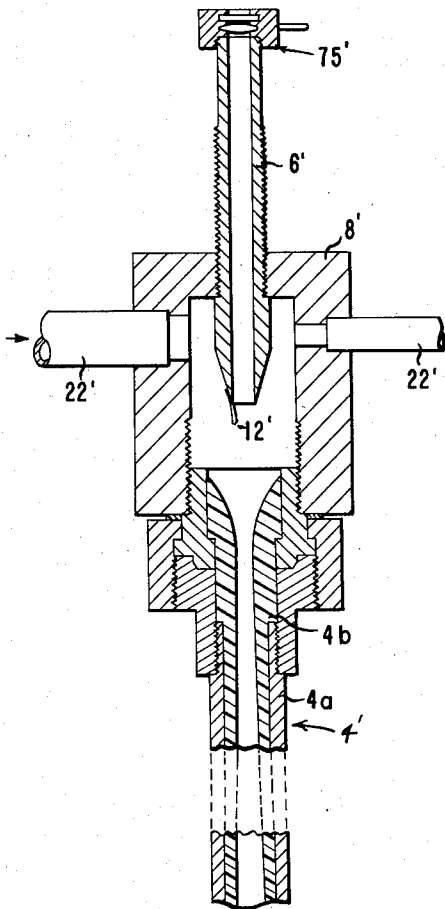


FIG. 4a

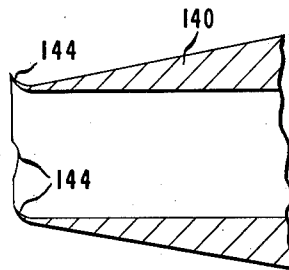


FIG. 4b

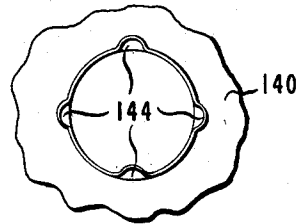


FIG. 5

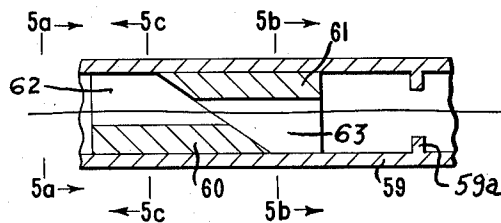


FIG. 5a FIG. 5b

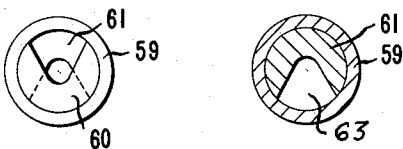


FIG. 5c

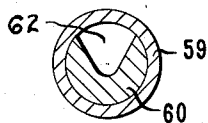
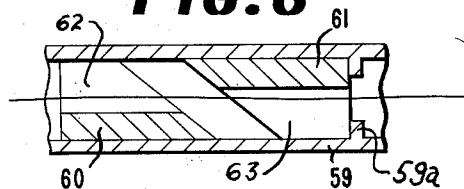


FIG. 6



INVENTORS
 WILLIAM CROPPER ASHBY
 WILLIAM WALLAR BUNTING, JR.
 ROBERT MEAGHER
 THOMAS LARSON NELSON
 KENNETH GILBERT SWAYNE
 BY *Harry E. Braddock*
 ATTORNEY

1

3,094,262

IMPROVED YARN HANDLING SUCKER GUN

William Cropper Ashby and William Wallar Bunting, Jr.,
Wilmington, Del., Robert Meagher, Wallingford, Pa.,
and Thomas Larson Nelson, Newark, and Kenneth Gil-
bert Swayne, Hockessin, Del., assignors to E. I. du Pont
de Nemours and Company, Wilmington, Del., a corpo-
ration of Delaware

Filed Nov. 25, 1960, Ser. No. 71,662

8 Claims. (Cl. 226-97)

This invention relates to the field of textile yarn-handling or manipulating devices and, in particular, to a portable device capable of picking up a running length of yarn and maintaining the yarn under tension until it can be transferred to a yarn take-up or other winding device.

In handling threads of either natural or synthetic origin, it is frequently desirable that the thread be collected temporarily by an auxiliary device rather than by the regular collecting or windup apparatus. For example, U.S. Patent No. 2,667,964, to Miller describes such a conventional yarn-handling device. This invention is considered to be an improvement over the Miller device.

It is an object of this invention to provide an improved efficient yarn-handling device capable of quickly picking up a running length of yarn and maintaining the yarn under high tension until it has been transferred to a yarn take-up or winding device.

It is a further object of this invention to supply an improved yarn-handling device capable of providing a high inlet air velocity for very rapid picking up of a running length of yarn and thereafter producing and maintaining a desired high level tension on the yarn until the yarn line has been transferred to a suitable take-up device.

A still further object is to provide such an improved portable yarn-handling device incorporating these features capable of expeditiously transferring a running length of yarn under suitable tension between points separated by considerable distances.

Another object is the provision of an improved yarn-handling device which can apply sufficient tension to handle yarns moving at extremely high-speeds, e.g., 2,000 to 3,000 yards per minute without forming any appreciable slack or allowing tension in the yarn to drop a significant amount.

Yet another object is the provision of such a yarn-handling device which can handle effectively multi-filament yarns to which a finish has been applied and which are wet and tend to stick together and act like a monofilament.

Yet another object is the provision of an improved handling device which is simple in construction yet efficient and reliable in operation. Other objects will become apparent from the description hereinafter.

The aforementioned objects are accomplished by apparatus embodying features of this invention, which apparatus provides basically a portable yarn-handling device comprising a primary-air inlet tube; a secondary-air inlet tube; an air outlet tube; the outlet slideably mounted to form with the secondary-air inlet tube a variable annulus; the secondary-air inlet tube and the outlet tube forming a passageway for the yarn through the device the improvement comprising the combination of an annulus or orifice configuration with an improved outlet tube configuration and also a turbulence generating means mounted on the end of the secondary-air inlet tube and extending into the outlet tube.

In the drawings, FIGURES 1a and 1b are longitudinal cross-sectional partial views of inlet and outlet

2

portions respectively of a yarn handling device embodying features of the present invention.

FIGURE 2 is a partial longitudinal cross-sectional view of the preferred turbulence generating element taken along the line 2-2 of FIGURE 1.

FIGURE 3 is a longitudinal cross-sectional view of a modified yarn-handling device of this invention illustrating the composite outlet tube construction.

FIGURE 4A and B are respectively a partial longitudinal cross-sectional view and an end view of the inner end of the auxiliary air and yarn inlet tube showing a modified form of the turbulence generating means.

FIGURES 5, 5a, 5b and 5c illustrate in longitudinal cross-section a particular auxiliary air inlet restriction device for use with yarn-handling devices of this invention in the closed position and transverse cross sections taken through the device, along the lines 5a-5a, 5b-5b and 5c-5c respectively.

FIGURE 6 is a longitudinal cross-sectional view of the device of FIGURE 5 showing it in the open position.

As shown in FIGURE 1, the main body of the device is formed by primary air inlet tube 2. Outlet tube 4 is slideably mounted inside tube 2. The secondary-air inlet tube 6 is mounted at one end in the primary-air inlet tube 2 in such a manner that its longitudinal or axial position with relation to the outlet tube 4 can be adjusted to restrict or open the orifice 32 formed between the inner ends of tubes 4 and 6. Housing unit 8 is mounted at the yarn inlet end of the primary-air inlet tube 2 and functions as the tip of the device. A bore in the housing unit 8 is located on the same axis as the bore of the secondary-air inlet tube 6 and functions as an extension of the inlet tube. Mounted in the end of the housing 8 is a wear-resistant bushing 10 which can be easily replaced when worn. Mounted on the end of the secondary-air inlet tube 6 is a projecting element 12, which extends into the bore of the outlet tube 4 and into the flow of main inlet air moving through the orifice 32. On the yarn outlet end of the outlet tube 4 there is mounted a fixed piston 14 and a fixed piston 16, with piston 16 having a larger transverse cross-sectional area than piston 14. A housing 18 is attached to the downstream or end of the primary-air inlet tube 2 and contains piston 16 and a mount for an adjusting screw 20. In the space between the pistons 14 and 16, the housing 18 is vented to the atmosphere by a large passage 50. The cover on the housing 18 is provided with a small vent passage 51 communicating with the side of the piston opposite from that of vent passage 50. Tube 22 supplies the primary air (80 to over 150 p.s.i.g.) to the device at housing unit 26. Valve 24, mounted in housing 26 and operated by push button 28, or other suitable device, controls the air supply to piston 16 via an auxiliary tube 36. In operation primary air under pressure is supplied to tube 22 and passes through passageway 30, formed by the interior surface of primary-air inlet tube 2 and the exterior surface of outlet tube 4, into the annular orifice 32 formed between the inner ends of outlet tube 4 and the secondary-air inlet tube 6 and thence down the bore of the outlet tube 4 to the yarn and air discharge end of the device which may be connected to any suitable yarn collection apparatus (not shown). The high pressure air in passage 30 also exerts a pressure on piston 14 urging it toward the yarn discharge end of the device and thus urging the yarn tube 4 and the piston 16 in the same direction until the latter abuts adjusting screw 20; when the yarn tube 4 is thus pulled away from the yarn inlet tube 6, the annular orifice 32 is said to be in the "open" position (shown) as hereinafter discussed. When push button 28 is depressed, valve 24 admits air under pressure to the right side of piston 16 (the area of which is appreciably larger than that of piston 14) thus causing pistons 14 and 16 as well as the yarn tube to move to the

left, in effect making the cross-sectional area of the annular orifice 32 smaller (not shown); in this situation the annular orifice 32 is said to be in the "restricted" condition. When valve 24 admits high pressure air to the space to the right of piston 16, a minute amount of air will escape to the atmosphere through hole 51; however, the pressure on piston 16 remains ample to overcome the pressure on piston 14. The function of hole 51 is to permit the high pressure air to "bleed" down, after valve 24 is closed, thus permitting piston 14 to move yarn tube 4 to the right.

In the restricted condition of the annular orifice 32, the pressure in the zone adjacent the orifice will be reduced by virtue of Bernoulli's principle which, in brief, states that minimum pressure occurs when kinetic energy is maximum. Thus the high velocity air through the orifice 32 creates a low pressure at the inner end of the secondary-air inlet tube 6 and causes secondary air to flow into the bore of housing 8 and the bore of secondary air inlet tube 6 from the surrounding atmosphere. In the open condition of orifice 32 the configuration of the orifice is in effect a converging-diverging nozzle capable of producing supersonic flow conditions at the supply pressures used. The bore of the outlet tube 4 is substantially constant, but diverging slightly to maintain nearly constant air velocity in the tube and accommodate growth of the boundary layer along the wall surface. The characteristics of this tube constitute an important aspect of the invention. This tube serves to prevent a substantial decrease in the kinetic energy of the moving air, a continuing pressure drop is maintained along its length. In order to function properly, it has been found that at the high pressures of 90# p.s.i.g. and above required for the desired high yarn of velocities and tensions, the total included angle of this bore must be between about 10 minutes and about 1° with the preferred angle of from 15' to 45'. For supply pressures higher than about 90# p.s.i.g., the optimum angle of divergence is somewhat larger.

In operation, with the orifice 32 in its restricted condition, the secondary-air which is caused to flow from the atmosphere into and through housing 8 and secondary-air inlet tube 6 causes a yarn line 34, when placed close to bushing 10, to be drawn into the inlet tube and down the outlet tube. The combined action of the flow of the secondary-air and the flow of the primary air through the outlet tube 4 maintains the yarn moving although under a low tension.

Once the yarn is moving through the device it is highly desirable to apply forces such that the yarn will be brought to a high tension level in as short a period of time as possible; to this end, the annular orifice 32 is brought to its open condition, by releasing push button 28, whereupon high velocity air in the tube 4 will exert tension on the yarn 34. Under this condition the pressure in the region of the annular orifice 32 is higher; i.e., suction is at a minimum. When the yarn 34 has been brought to an appreciable tension level, the device may be manually transported to bring the yarn into proximity with other apparatus for the purpose of transferring the yarn to that apparatus.

When the annular orifice 32 is in its open condition the pressure in the region of the orifice is super-atmospheric; therefore, a flow of air exists through tube 6 countercurrent to the direction of yarn movement. If an adequate supply of high pressure primary air is available in the region of the annular orifice 32, the rate of air flow and hence the air velocity in the outlet tube 4 will be unaffected by the existence of any countercurrent flow in tube 6 hence such flow is not deleterious to the operation of the device. However, in terms of air consumption, more economical operation may be achieved if such flow is minimized; this may be accomplished by the use of an adjustable restriction in the tube 6 or, preferably, in the bore of the housing 8 by means of the apparatus such as

that shown in FIGURES 5, 5A, 5B, 5C and 6. FIGURES 5A, 5B, 5C and 6 show a tube 59, intended for use on the free end of the housing unit 8, which tube 59 contains two generally cylindrical members 60 and 61. The members 60 and 61 are cut on a matching bias or miter and are provided, respectively, with longitudinal V shaped slots 62 and 63 such that when the mitered ends of the members 60 and 61 are in abutment the V slots are 180° apart. The member 60 is firmly secured to the inside of the tube 59 while the member 61 is free to slide axially inside the tube being backstopped, however, by the internal flange 59a as shown in FIGURE 6. When the annular orifice of the device is in the restricted position, atmospheric pressure or suction caused by flow of air through the device will push the member 61 against the flange 59a thus opening a comparatively large flow passage through the V's 62, 63 (FIGURE 6); when the annular orifice of the device of this invention is in the open position, super-atmospheric pressure inside the device will cause air flow to be reversed in the air and yarn inlet tube to push member 61 into abutment with member 60 (FIGURE 5A) thus effectively reducing the flow area to the adjoining roots of the V's 62, 63 as shown in FIGURE 5A and reducing leakage back through the air and yarn inlet tube. The device of FIGURES 5 and 6 is thus "automatic."

Adjustments for obtaining optimum performance of the device are made sequentially. The annular orifice 32 is first placed in the restricted, or yarn string-up, condition whereupon the inlet tube 6 is axially adjusted, by means of the screw threads provided, until the velocity of the secondary inlet air reaches a maximum. In this condition, of course, the pressure at the inner end of the inlet tube 6 is sub-atmospheric. When the best setting has been achieved, the inlet tube 6 is locked in position by means of the jam nut that is provided. Next, the device is shifted to the open condition (by release of push button 28) whereupon the yarn tube 4 is adjusted axially, by means of the screw 20, until a maximum yarn tension condition is reached with a moving threadline. Thereafter, it is only necessary to manipulate the push button 28 to cause the yarn tube to shift to either of the desired positions.

The tension that can be applied to the yarn can be expressed by the Newton equation

$$F = \frac{CDV^2A}{2}$$

where C is a characteristic drag coefficient, D is the mass density, V is the relative velocity, and A is the area of contact. It will be seen from this equation that in handling a specific multi-filament yarn, four factors affect the tension applied to a yarn; length of the yarn exposed to the high velocity air, velocity of the air stream, effective surface area of contact of air stream and yarn, and the mass density of the fluid.

In the improved yarn-handling device embodying the principles of the present invention, during the maximum tension condition the air flow is believed to reach supersonic conditions and is maintained in the very high velocity condition substantially throughout the length of the outlet tube to give a maximum average air stream velocity and maintain it in contact with the yarn for a maximum distance. Also, it has been found, and an example will be given below, that the insertion of a small tab element 12 or some other device to create an extremely turbulent condition or a very high degree of agitation in the fluid stream just beyond the annulus 32 greatly increases the tension on the yarn 34 when all other conditions are kept the same. The greatly agitated fluid stream is characterized by the existence of a high degree of turbulence, severe velocity gradients, eddies, vortices, and the like and may be characterized further by rotation of the fluid stream in whole or in part. The operation and function of this tab element is not fully understood. However, it is believed that the turbulence generator or tab element may cause

5

the multi-filament yarn to oscillate or vibrate laterally and thus to open up and somewhat entangle and thus present a substantially larger effective area for the air to operate upon. This is quite important with wet yarns moving at a high velocity and which have usually a tendency to adhere together and act like a monofilament yarn. It is important that the yarn guiding surfaces within the bushing and the auxiliary air and yarn inlet tube be arranged to direct the yarn into the vicinity of the tab in the orifice.

In one application of the principles of this invention to a yarn-handling device a yarn string-up device with the following dimensions was run with and without a metal tab. Outlet tube 4: length 18", divergent angle 0°30 minutes, I.D. of bore .250", radius of curvature forming the O.D. of annulus 32, .03" to .09"; secondary-air inlet tube: bore .140", total included angle on tip forming the I.D. of annulus 32, 40°; metal tab: length .25", width .093", thickness .032".

Table 1

Primary Air Flow in s.c.f.m. (Supply pressure at 90 p. s. i.)	Tension, grams	
	Without Tab	With Tab
30.....	5	16.5
40.....	20	27
45.....	27.5	32.5

This test was run with 70-34 polyester fiber yarn with a finish running at 3,000 yards per minute.

The following demonstrates the critical aspects of the diverging angle of the bore of the outlet tube 4. A device, with a metal tab 12, as described above, was used, all conditions except this angle being held constant.

Total included angle—minutes:	Yarn tension, grams
5.....	20
10.....	23
20.....	26
30.....	25.5
40.....	24.5
50.....	23.5
60.....	22.5
1°30.....	20

A modified form of turbulence generating means is shown in FIGURES 4A and 4B. Suitable turbulence levels can be created by the use of an auxiliary air and yarn inlet tube 140 having its inner end provided with scalloped portions 144 circumferentially spaced around the edge. As shown, all but one of the scalloped portions are turned outwardly, the remaining one is turned inwardly to obtain the desired results.

It will be seen that a novel improved arrangement for a yarn-handling device has been provided. The preferred yarn-handling device of this invention utilizes in the maximum tension condition a supersonic air flow and also includes a small turbulence generating structure which contributes to the greatly improved tension levels which are needed in the yarn at high yarn speeds. In addition, a convenient and rapid means has been provided to shift the gun between the maximum auxiliary air inlet velocity and the maximum tension conditions of operation.

A modified yarn-handling device is illustrated in FIGURE 3 which shows a desirable composite outlet tube construction. The composite outlet tube 4' comprises an outer sleeve or casing 4a formed of metal, and an inner liner member 4b formed of suitable moldable or castable plastic material such as, for example, an epoxy resin. If desired the plastic material may be suitably reinforced, e.g., with glass fibers, and the outer casing eliminated. The construction of the inner member of such cast or molded plastic material provides a simple, economical way to form the desired nozzle con-

6

figuration and tapered outlet tube contour without expensive machining operations. In addition, such a liner provides optimum wear and frictional characteristics for the yarn and air passing therethrough.

In compliance with the patent statutes a preferred embodiment of this invention has been described but it is to be understood that various modifications could be made without departing from the spirit of the invention or the scope of the appended claims:

We claim:

1. A yarn-handling device comprising an air inlet tube, an air outlet tube having an outer exit end and an inner end, a passageway between said inlet and said outlet tubes, the outer exit end of said outlet tube provided with an elongated section of substantially constant cross-sectional area, an auxiliary air and yarn inlet tube having an outer end and an inner end, one of said air outlet and auxiliary air and yarn inlet tubes mounted for movement relative to the other, said inner end of said air and yarn inlet tube mounted to form in cooperation with the inner end of said outlet tube, a variable annular orifice, said orifice forming, in one condition of its variation and in cooperation with said elongated section, a converging-diverging nozzle, said device further comprising a conduit connecting said air inlet tube to a source of high pressure air, the pressure of the air in the inlet tube during operation of the device, the contour of said nozzle, and the elongated section each cooperating to produce supersonic air flow in said nozzle and maintain extremely high air flow velocities substantially throughout the elongated section of said outlet tube, and manually actuatable pneumatic means to rapidly and selectively vary the longitudinal relative positions of said outlet tube and said auxiliary inlet tube in order to vary the annular orifice, the improved device further comprising a baffle means cooperating with said orifice for creating a zone of great agitation in the air flowing through said nozzle and said outlet tube.

2. The improved device of claim 1 which further comprises a variable means cooperating with said auxiliary air and yarn inlet tube for restricting the flow of air through said auxiliary air and yarn inlet tube.

3. The improved device of claim 1 in which said means for creating a zone of agitation in the flowing air comprises a plurality of scallops formed in the inner end of said auxiliary air and yarn inlet tube.

4. The improved device of claim 2 in which said variable means comprises first and second transversely positioned abutment elements positioned in said auxiliary air and yarn inlet tube, each abutment element provided with an axially extending yarn guiding groove diametrically opposed to the groove of said other element, said elements mounted in said tube for relative movement with respect to each other in an axial direction between a first arrangement in which said elements are spaced a given distance apart and a second arrangement in which said elements are substantially in abutting relationship such that the diametrically opposed grooves form a restricted orifice permitting passage of the yarn along the length of both elements.

5. An improved yarn-handling device comprising in combination an air inlet tube, an air and yarn outlet tube having an inlet end and an outlet end, a passageway connecting said inlet and outlet tubes, the outlet tube provided between its ends with an elongated section of substantially constant cross-sectional area, an auxiliary air and yarn inlet tube mounted in alignment with said outlet tube, and in cooperative association with, and for relative motion with respect to the inlet end of said outlet tube to form a variable annular orifice, the outlet end of said auxiliary inlet tube and the inlet end of said outlet tube cooperating to form in one given condition of its variation a converging-diverging nozzle arrangement, a conduit member connecting said air inlet tube to a source of high pressure air, the pressure of the air in the

7

inlet tube during operation of the device, the configuration of the converging-diverging nozzle arrangement, and the elongated section of the outlet tube each cooperating to produce supersonic air flow at the nozzle arrangement and maintain extremely high air flow velocities substantially throughout the elongated section of the outlet tube to exert a high tension on a yarn line entering the auxiliary inlet tube and passing through the device to the exit end of the outlet tube, the improved device further comprising a turbulence generating element projecting into the variable orifice, said element having an effective cross-sectional area of very small magnitude with respect to the cross-sectional area of the orifice.

6. The improved device of claim 5 which further comprises a manually actuatable pneumatic means for rapidly and selectively varying the relative longitudinal positions of the inlet end of the outlet tube and the outlet end of the auxiliary inlet tube to vary the annular orifice opening between a maximum opening maximum yarn tension position and a minimum opening maximum auxiliary air velocity position.

7. The improved device of claim 6 in which said elongated portion of said outlet tube is provided with a very gradually increasing inner diameter defined by side walls which represent slightly diverging conical surface along the direction of air flow having an included angle of from about fifteen to forty-five minutes in order to substantially maintain the extremely high air flow velocity undiminished and a very gradual pressure drop along its length.

8. A yarn-handling device comprising an air inlet tube, an air outlet tube having an outer exit end and an inner end, a passageway between said inlet and said outlet

8

tubes, the outer exit end of said outlet tube provided with an elongated section of substantially constant cross-sectional area, an auxiliary air and yarn inlet tube having an outer end and an inner end, one of said air outlet and auxiliary air and yarn inlet tubes movable relative to the other, the inner end of said inlet tube mounted to form in cooperation with the inner end of said outlet tube, and in further cooperation with said elongated section, a variable annular orifice, said orifice forming in one condition of its variation a converging-diverging nozzle, said device further comprising a conduit connecting said air inlet tube to a source of high pressure air, the pressure of the air in the inlet tube during operation of the device, the contour of said nozzle, and the elongated section each cooperating to produce supersonic air flow in said nozzle and maintain extremely high air flow velocities substantially throughout the elongated section of said outlet tube, and reciprocating means operatively connected to said outlet tube to rapidly and selectively vary the longitudinal relative positions of said outlet tube and said auxiliary inlet tube in two directions in order to rapidly vary the annular orifice.

References Cited in the file of this patent

UNITED STATES PATENTS

1,118,552	Honiss	Nov. 24, 1914
2,667,964	Miller	Feb. 2, 1954
2,731,262	Morrow	Jan. 17, 1956
2,971,683	Paulsen	Feb. 14, 1961

FOREIGN PATENTS

842,762	Great Britain	July 27, 1960
---------	---------------	---------------