

- [54] TOW DEWATERING JET DEVICE
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- [73] Assignee: Eastman Kodak Company, Rochester, N.Y.
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- [21] Appl. No.: 424,518

### Related U.S. Application Data

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- [51] Int. Cl.<sup>2</sup> .... F26B 5/14; B05B 1/04; B05B 1/20; B05B 13/00
- [58] Field of Search.... 239/289, 568, 589, 597-599, 239/601, 602; 15/306 A; 19/66 T; 28/71.3, 75 R; 34/12, 23, 34, 70, 115, 122, 130, 155, 160; 68/19.1, 20

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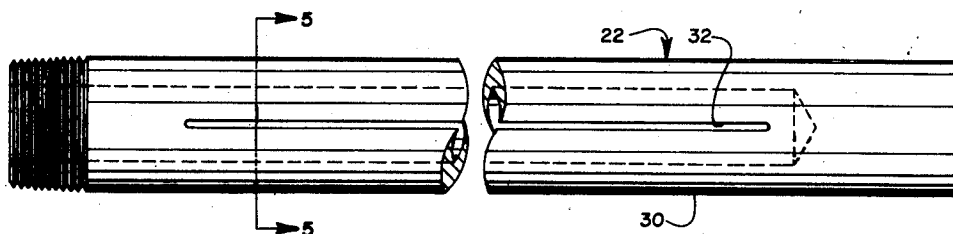
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Primary Examiner—Robert S. Ward, Jr.

### [57] ABSTRACT

In a process for treating continuous length filamentary tow of man-made fiber that is moved through a heated water bath, drafted and then in due course of processing is subsequently moved into a heatsetting chamber where it is heatset, the improved method of removing water from the tow by guiding the tow immediately from the heated water bath to and displacing it under and around the surface of an improved dewatering jet device and partly wrapping the tow around that portion of the dewatering jet device within which is the jet opening through which air is blown against the wrapped around portion toward the upstream portion of the tow and through the tow. The improved dewatering jet device is a cylindrical body member provided with an axially extending slot-like opening having substantially parallel walls and a depth to width ratio of about 5:1 and a radius on the outer lips of the opening of about 1/32 inch.

2 Claims, 10 Drawing Figures



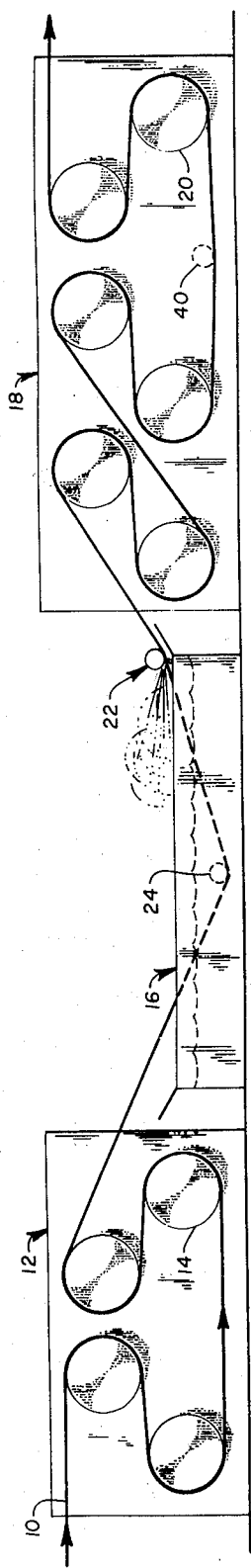


Fig. 1

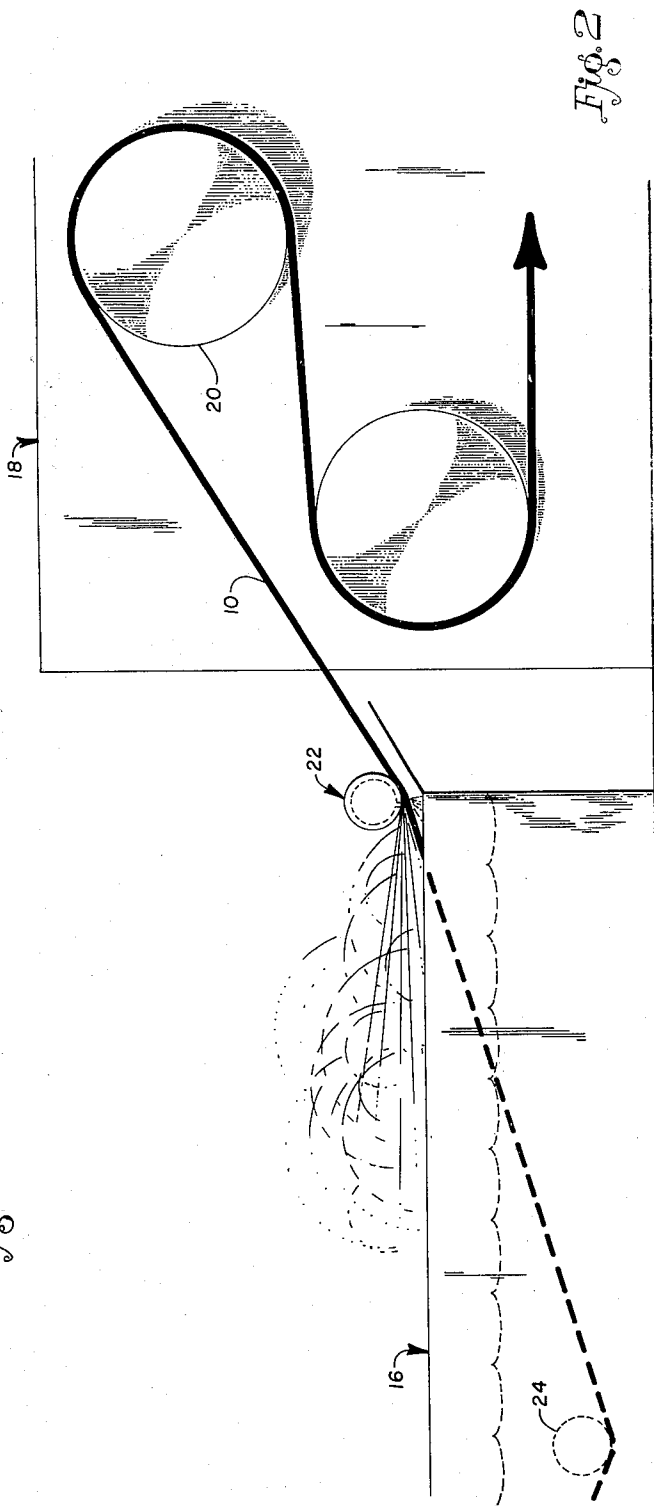
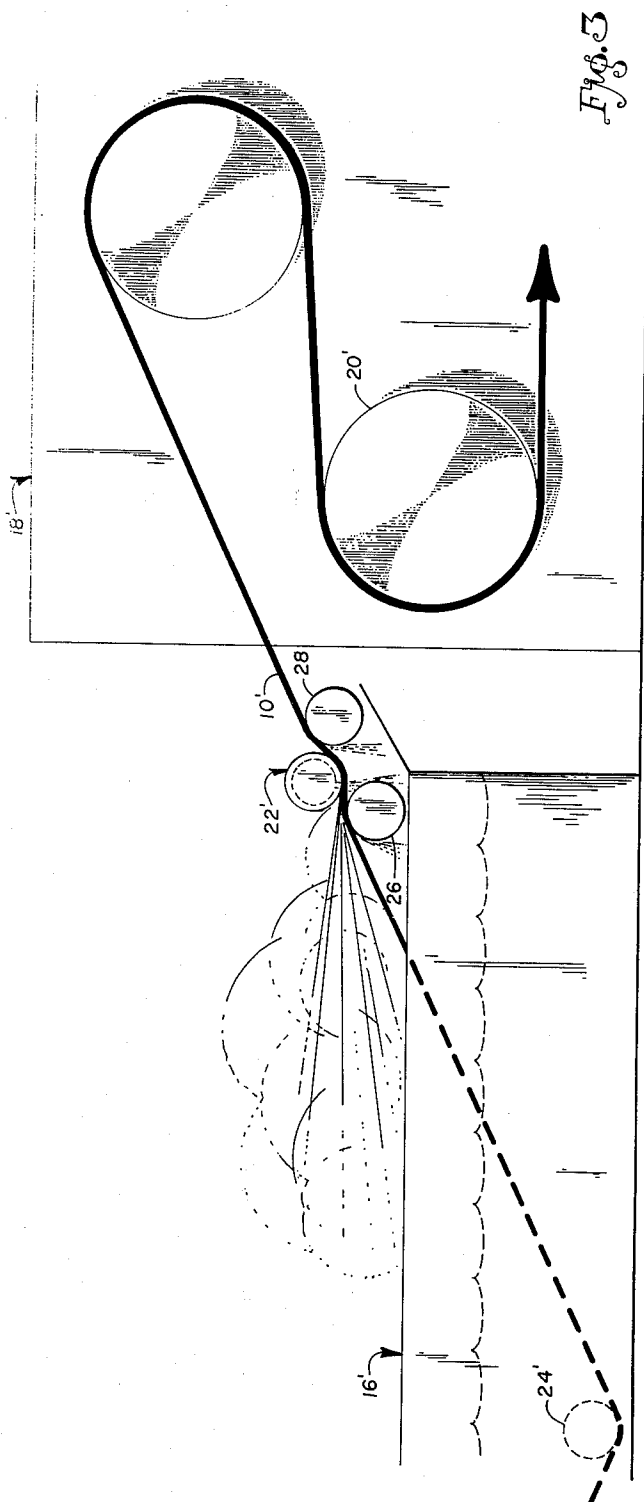
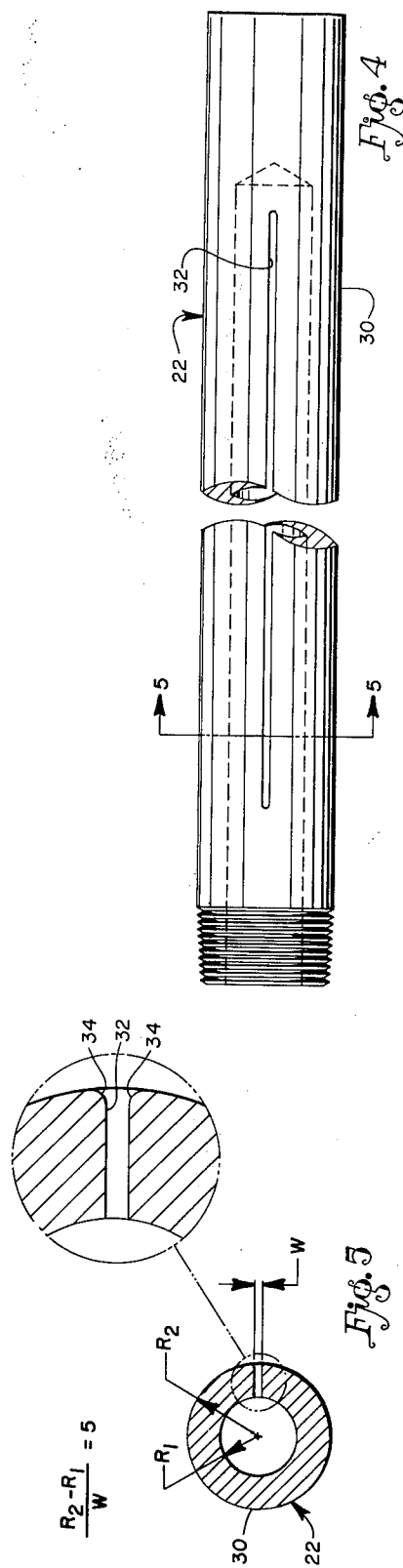
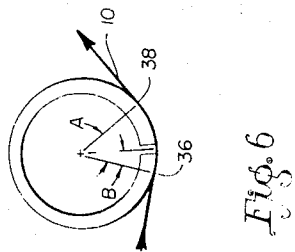
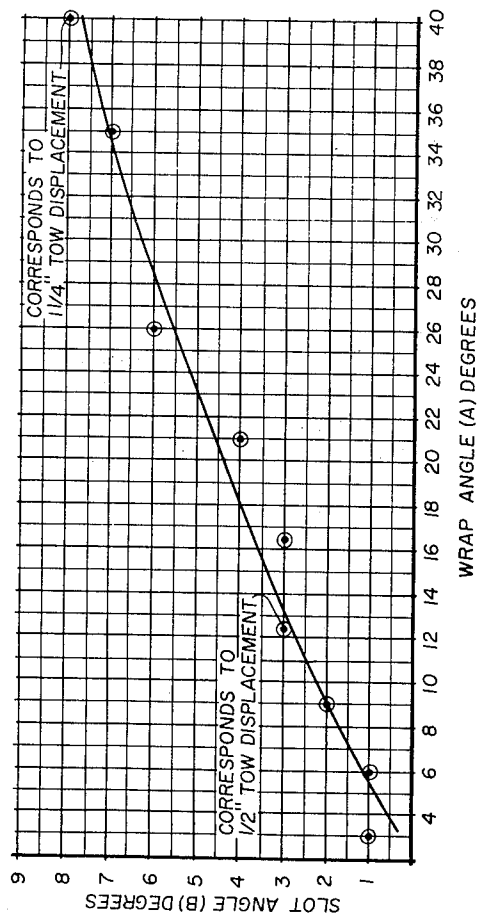


Fig. 2





RELATIONSHIP BETWEEN TOW WRAP ANGLE  
AND JET SLOT ANGLE

Fig. 7

Fig. 8

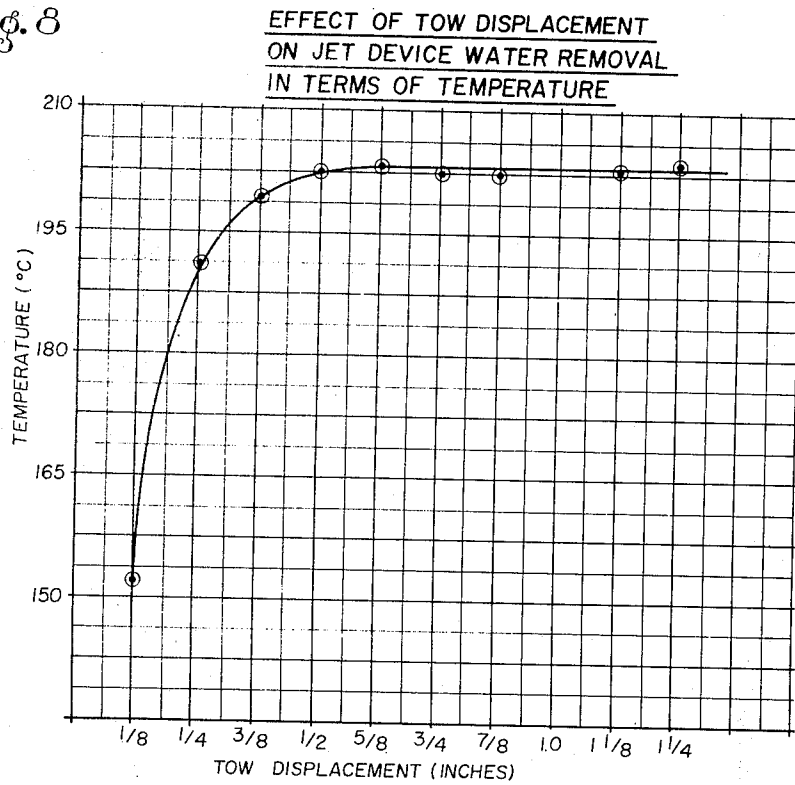
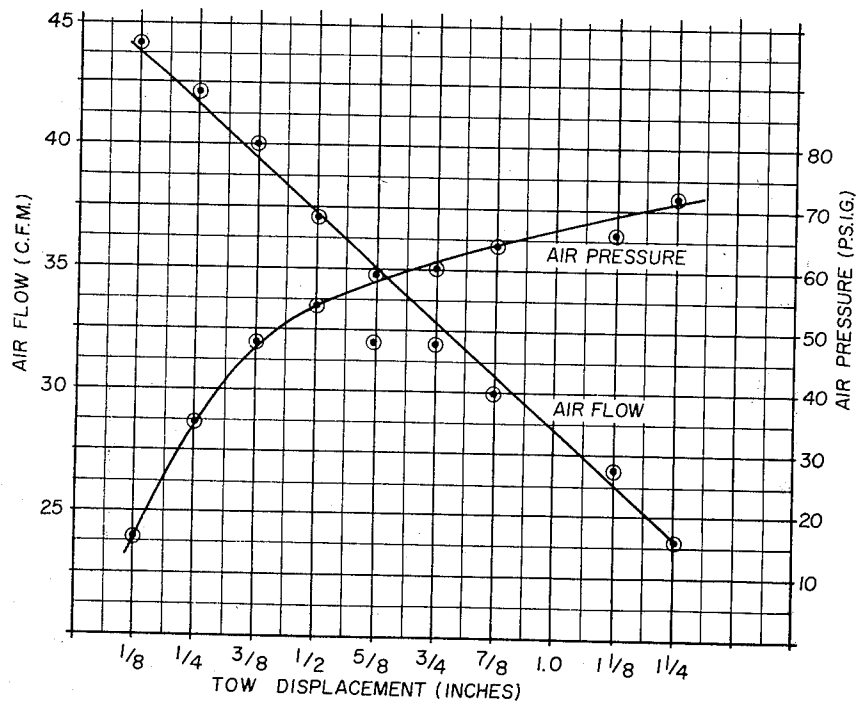
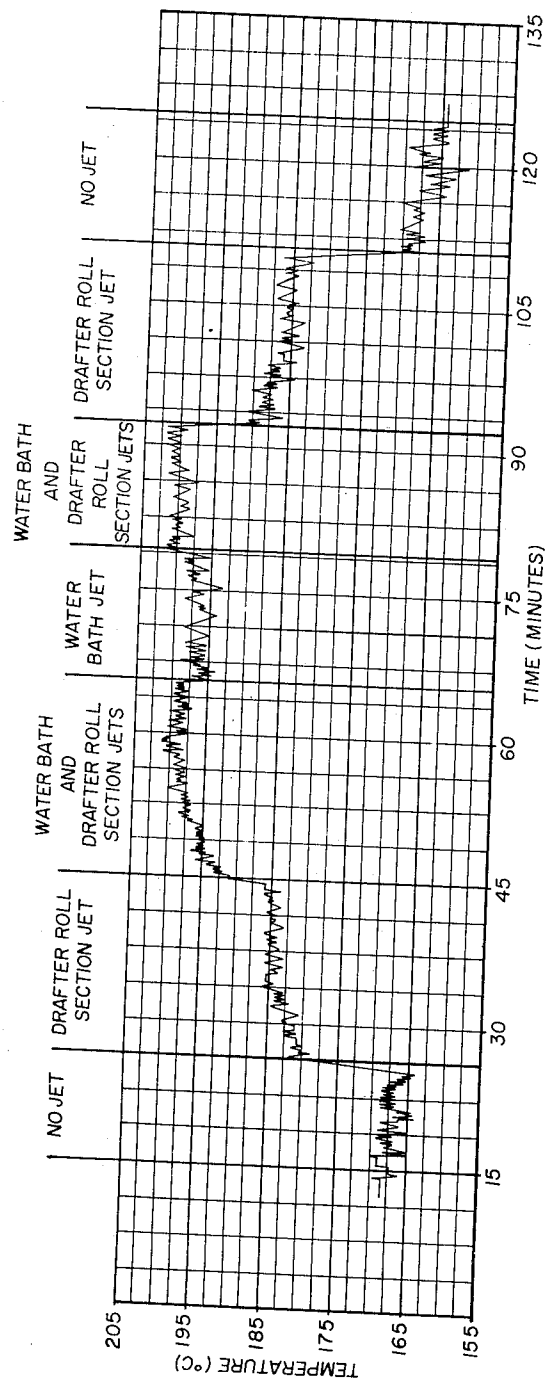


Fig. 9

EFFECT OF TOW DISPLACEMENT  
BY JET DEVICE ON AIR FLOW RATES  
AND AIR PRESSURE



EFFECT ON HEATSET TOW TEMPERATURE  
OF VARIOUS JET DEVICES

*Fig. 10*

## TOW DEWATERING JET DEVICE

This is a division of application Ser. No. 257,406 filed May 26, 1972 now U.S. Pat. No. 3,786,574.

## BACKGROUND OF THE INVENTION

This invention is directed to a method and to apparatus for practicing the method by which liquids are removed from a continuous length tow of filamentary material such as a tow of synthetic or manmade polymeric material while the material is undergoing various processing operations in the production of textile fibers.

In the production of textile fibers from continuous length synthetic fiber tow, the tow is transported through various treating stations, such as heating, drafting, heatsetting, cooling, crimping, or crimping and then heatsetting followed by cooling, and other operations, depending upon the desired physical and chemical properties to be imparted to the fibers in the tow. One well-known practice is that of heatsetting synthetic or man-made materials, such as materials including polyester fibers of polyethylene terephthalate, at a constant length in order to produce a high tenacity fiber. The Hebelier patent, U.S. Pat. No. 3,044,250 granted July 17, 1962, and the Patton et al. patent, U.S. Pat. No. 3,500,553 granted March 17, 1970, discuss holding continuous length filaments of tow at constant length while the tow is being heatset. Regular tenacity fibers of polyester, for instance, as distinguished from high tenacity polyester fibers, are usually heatset under free shrink conditions. In either instance, however, the fibers have usually undergone treatment in a liquid bath at some stage prior to heatsetting and cannot be brought up to heatsetting temperatures until the liquid has been substantially removed or evaporated in some manner. In reference again to synthetic fiber such as polyethylene terephthalate, the desired temperature for heatsetting is usually such that cannot be readily obtained unless the moisture or liquid from the water bath has been removed and the fiber becomes bone-dry so that the fiber can be brought up to temperature of about 200°C. and held at that temperature for a predetermined length of time.

It is critical that the fiber tow be heated uniformly; if moisture or liquid remains on part of the fibers making up the tow while the dry fibers in the tow are brought up to the desired heatsetting temperature, the later processed staple fibers will not be a desirable quality product that has useful sale value. The difficulty in removing such liquid stems from the fact that the liquid, such as water, is trapped between the filaments of the tow, and there may be hundreds of thousands of filaments in a tow. For instance, a tow band having a width of about 8 inches and a thickness of about 3/32 inch may have in excess of 600,000 continuous length filaments. The size of the tow band and the number of filaments will differ, of course, depending upon a number of factors. Water will not only be trapped between the filaments but also the filaments on the outer surfaces of the tow or tow band tend to serve as insulation for the filaments inwardly of the surface filaments, thereby making it difficult to evaporate the trapped liquid and raise the temperature of the filaments that are encased with liquid.

The Saxon patent, U.S. Pat. No. 3,481,012 granted Dec. 2, 1969, discloses a roll that may be heated by use of a circulating fluid medium in the interior of the roll,

the roll being used singly or in series to heat tow passing partly therearound to reduce the moisture content in the tow to a predetermined extent prior to the operation of heatsetting. Although this approach is effective in applying heat uniformly to the tow, the fabrication of the rolls is complex and expensive.

Another method disclosed for removing liquid that appears to be less complex and less expensive in fabrication is shown in the Osban et al. patent, U.S. Pat. No. 3,199,214 granted Aug. 10, 1965. The patent discloses passing under tension a wet synthetic fiber tow band under one hollow conduit and over a following hollow conduit, with each hollow conduit being provided with orifices through which gas moving at a high velocity is directed against the tow band as it passes across and is deflected by each of the hollow conduits. According to the patent, the high velocity gas removes excess liquid from the tow band and slightly opens up the tow to provide passageways communicating between each filament of the tow and the surrounding environment in preparation for subsequent treatment. It is necessary to open up the tow somewhat in preparation for a subsequent treatment because the squeeze rolls prior to the two hollow conduits served to compress the tow and compact the filaments of the tow into "a relatively dense impermeable mass". The subsequent treatment illustrated is a "conditioner" wherein the tow may be treated by surrounding it with heated unsaturated humid air for conditioning the filaments by evaporation of moisture therefrom.

## SUMMARY OF THE INVENTION

In a process for treating continuous length filamentary tow of man-made fiber that is moved through a heated water bath, drafted and then in due course of processing is subsequently moved into a heatsetting chamber where it is heatset, the invention, therefore, provides an improved apparatus for practicing the improved method by which the tow is displaced or deflected from its path and is guided under a dewatering jet device that is positioned at the downstream exit from and above the heated water bath. The tow is deflected around that portion of the surface of the dewatering jet device within which is the opening through which air is blown, the deflection being predominantly on the downstream side of the dewatering jet device with respect to the movement of the tow, and water is removed by blowing air from the opening of the dewatering jet device against the surface of and through the tow so that most of the water is primarily blown upstream of the tow while other water is blown through the tow in return to the water bath. The improved dewatering jet device is a cylindrical hollow body member of predetermined length and is provided with a slot-like opening extending over a portion of the length of the body member and having substantially parallel walls and a depth to width ratio of about 5:1 and a radius on the outer lips of the opening of about 1/32 inch.

For reasons unknown to the inventors, it has been found that by positioning a dewatering jet device, which has a slot-like opening or slot having the depth to width ratio of 5:1, at the exit of the heated water bath where the tow has just emerged from the water, not only is a greater amount of water removed subsequently enabling the tow to be more effectively and uniformly heatset but also the jet device is not noisy and deafening to operating personnel and it is more ec-

onomical to use because it requires less air consumption. It was found that the results were significantly different over those resulting from positioning the dewatering jet device farther downstream of the processing line where there was less water remaining on the tow. In the latter instance the dewatering jet device used more air, removed proportionately less water from the tow and was deafening to operating personnel with a decibel rating of about 103 dBA, as measured on the A scale of a standard sound level meter. On the other hand, the dewatering jet device at the exit of the heated water bath could not be detected against a background noise of about 90 to 92 dBA. Under the Occupational Noise Exposure section, U.S. Department of Labor Safety and Health Standards, Table I, (Federal Register, Volume 34, No. 96, May 20, 1969, including corrections issued in July, 1969, Walsh-Healey Regulation) the permissible noise exposure duration at 103 dBA for operating personnel is slightly over 1 hour but less than 1½ hours per day. The permissible noise exposure for 90 to 92 dBA is from 8 to 6 hours per day, respectively.

The inventors have also found that a correlation can be established between temperature readings, taken for instance at the exit end of the heatsetting oven (not shown) and effective location, adjustment and angular orientation of the dewatering jet device. This assumes, of course, that other conditions on the tow processing line remain the same.

In using such temperatures correlation inventors have discovered that for removing water and most effective position for the dewatering jet device is at the exit of the heated water bath; with the slot through which air is emitted being angularly oriented so that its axis or jet slot angle B, as measured from the upstream tangent point at the beginning of the wrapping engagement made by the tow with the jet device toward the downstream tangent point where the tow terminates contact with the jet device, extends from about 3° to about 8°; with the wrap angle A extending correspondingly in the range of about 12° to about 40°. It has also been discovered that when the dewatering jet device is pressed against the tow to deflect or displace the tow about one-half inch from its straight line path as its emerges from the heated water bath toward the first roll in a drafter roll section the most amount of water is removed. It has further been discovered, however, that by pressing the dewatering jet device still further against the tow until the extent of deflection or displacement of the tow is about 1¼ inches, the least amount of air flow is used to achieve about the same amount of water removal as occurred at one-half inch displacement.

### BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

FIG. 1 is an elevational view of a portion of a tow processing line showing a first drafter roll section, a heated water bath, the dewatering jet device at the exit of the tow from the heated water bath, followed by a second drafter roll section;

FIG. 2 is an enlarged elevational view of a portion of FIG. 1 in which may be seen water being removed in a fog or spray by the dewatering jet device;

FIG. 3 is an enlarged elevational view of a portion of FIG. 1 but illustrating an alternate arrangement wherein snubber bars are employed before and after the dewatering jet device;

FIG. 4 is a view of the dewatering jet device;

FIG. 5 is a cross-sectional view of the dewatering jet device taken along line 5—5 of FIG. 4;

FIGS. 6 and 7 show, respectively, a graphic illustration of the jet slot angle relative to the tow wrap angle, and a graph illustrating the relationship of the two angles as to water removal efficiency;

FIG. 8 is a graph illustrating effect of tow displacement or deflection by dewatering jet device on water removal efficiency;

FIG. 9 is a graph illustrating effect of tow displacement or deflection by dewatering jet device on air flow rates and air pressure; and

FIG. 10 is a graph illustrating effect on tow temperature without a dewatering jet device, by a dewatering jet device located at the water bath, by a jet device located at the second drafter roll section, and by jet devices in tandem operation at both the water bath and the second drafter roll section.

### DESCRIPTION OF THE PREFERRED EMBODIMENT

In reference to the drawings, and initially to FIG. 1, the tow 10, a continuous length filamentary tow of man-made fiber, such as polyester tow, enters a first drafter roll section 12 with the rolls 14 being driven at a predetermined rate of speed. The tow then enters a heated water bath indicated at 16 where the tow is heated to a predetermined temperature preparatory to being drafted by the second drafter roll section 18. The rolls 20 of the second drafter roll section are driven at a predetermined rate of speed greater than the rate of speed of the rolls of the first drafter roll section in order to draft the tow to a predetermined extent. The tow emerges from the heated water bath and passes under and into engagement with dewatering jet device 22 that is positioned at the exit of and above the heated water bath. The tow is displaced or deflected partly around and by the jet device from the path the tow would otherwise follow between the heated water bath and the first roll engaged by the tow on the second drafter roll section 18. Water is removed from the tow by the dewatering jet device to a predetermined extent preparatory to subsequent processing of the tow following the second drafter roll section. Such subsequent processing includes heat treating of the tow (not shown) in a manner well known in the art, such as illustrated in the aforementioned patents to Hebel and Patton et al.

The extent to which the dewatering jet device may be depressed against the tow may be dependent upon the spacing between the tow and the structure supporting the bath, and the location of the tow guide member 24 in the heated water bath relative to the location of the first roll in the second drafter roll section to be contacted by the tow. It may be desirable, especially if the tow is spaced relatively close to the heated water bath with insufficient space to obtain desired wrap angle, to aid the displacement of the tow by means of snubber bars 26 and 28 shown in an alternate arrangement (FIG. 3) in which the wrap angle A may be increased by depressing against the tow the dewatering jet device 22' between the snubber bars to a predetermined distance. An additional advantage derived from use of snubber bars to either side of the dewatering jet device is that some squeegee action occurs with water being removed from the underside surface of the tow. In the alternate arrangement of Fig. 3 components that are

the same as that disclosed in FIGS. 1 and 2 have been identified by the same reference numbers which have prime marks beside them to distinguish the alternate arrangement from the arrangement disclosed in FIGS. 1 and 2.

FIGS. 4 and 5 disclose in more detail the construction of the dewatering jet device 22 (FIGS. 1 and 2) or 22' (FIG. 3) which comprises a cylindrical body member 30 of a predetermined length and defining along its length an axially extending slot 32 of a length dependent upon the width of the tow to be treated. For reasons not entirely clear to inventors it has been found that effective water removal occurs when the depth of the slot in the cylindrical body member is about five times the width of the slot and with substantially parallel walls. This can readily be achieved by selecting cylindrical hollow bar stock meeting the following conditions:

$$\frac{R_2 - R_1}{W} = 5$$

wherein  $R_1$  = the inner radius of the body member;  $R_2$  = the outer radius of the body member; and  $W$  = the width of the slot, as may be observed from FIG. 5. Another factor that appears to have some significance is the formation of a small radius 34 at each of the outer lips of the slot 32. If the radius is too small the lips will be too sharp and the tow will be damaged. In the instance of the particular body member 30 illustrated, with the outside diameter of the body member being about 1.312 inches, the small lip radius of the slot lips is about 1/32 inch or 0.031 inch, the slot width is about 1/16 inch or 0.062 inch and the depth of the slot is about 5/16 inch or 0.312 inch. It is thought that the air flow is straightened out more with this deep parallel wall slot construction and that the particularly small lip radius decreases Coanda effect around the lips for better air penetration of the tow and thus removes more water. In the operation of the dewatering jet device, the device may be suitably adjusted both in an angular orientation of the slot relative to the tow and depression against the tow by mechanical structure (not shown) that will support the device for such adjustments. The material from which the body member 30 is made is preferably a non-plucking, wear resistant material. For instance, the device illustrated is made of stainless steel and detonation coated such as by Union Carbide with their UCAR LA-2 (pure aluminum oxide) and lapped to a 20 rms (root means square) microinch finish.

The purpose of the jet device is to remove the water that is held between the filaments in the tow band, and when this is done, and if done effectively, the tow will then present a smaller heat load to the heatset oven. The air emitted from the slot against the displaced tow is in effect compressed and in passing through the tow strips off the water held between the filaments. Some of the air will blow along the top of the tow stripping the water from the surface of the tow, while some air will pass entirely through the tow, but most of the air seems to penetrate into the tow and travel for a short distance between the filaments before emerging in the form of a spray or fog directed back to the heated water bath, depending upon adjustment, the spray or fog being illustrated in the drawings. It is also thought that there may be some sealing effect of the slot dependent

upon the extent of wrap angle and jet slot angle that the tow makes with respect to the dewatering jet device so that the air is compressed as it is emitted from the slot and thus is forced into and between the filaments making up the tow band or tow. It has been observed that the slot is substantially sealed off when the slot is about the center of the wrap angle so that little air is emitted.

As stated previously, with the discovery of being able to rely upon tow temperatures, such as might be taken at the exit of the heatset oven (not shown), it is possible to determine an effective location for the dewatering jet device, effective slot angular orientation, and effective tow displacement by depression of the dewatering jet device into the tow.

FIGS. 6 and 7 illustrate the relationship between tow wrap angle and jet slot angle with wrap angle being measured from the upstream tangent point 36, which is at the beginning of tow contact with the dewatering jet device, toward the downstream tangent point 38, which is where the tow moves out of contact with the jet device on its way to the second drafter roll section 18. The wrap angle is designated A; and the jet slot angle is designated B, which is measured from the upstream tangent point 36 toward the downstream tangent point 38 to the center or axis of the slot. In order to understand the significance of the graph shown in FIG. 7 it is necessary to correlate this with the other illustrated graphs that will be described herein.

The graph in FIG. 8 illustrates the effect of tow displacement on water removal in terms of temperature, and it may be observed that when the tow is displaced by the jet device about one-half inch, the maximum temperature results, with further tow displacements up to and including (1 1/4) inches resulting in approximately the same temperature as that with one-half inch displacement.

The graph in FIG. 9, however, illustrates the effect of tow displacement by the jet device on air flow rates and air pressure and shows that by increasing the displacement of the tow from 1/2 inch up to about (1 1/4) inches a more economical air flow in cubic feet per minute is achieved. It will thus be seen that increasing the tow displacement results in increased air pressure and decreased air flow.

In reference again to FIG. 7 when the tow is displaced one-half inch the wrap angle A is about 12.5° and the slot angle B is about 3°; and when the tow displacement is about 1 1/4 inches the wrap angle A is about 40° and the slot angle B is about 8°.

FIG. 10 shows the effect on heatset tow temperature by comparing a dewatering jet device located at the heated water bath with a dewatering jet device located at the second drafter roll section, and in tandem operation with jet devices being located at the water bath and at 40 in the second drafter roll section, as shown in phantom lines in FIG. 1. It will readily be observed that when jet devices are operated in tandem, i.e., at two locations at the same time, the water removal as shown by temperature increase is only slightly improved over the use of a dewatering jet device located at only the heated water bath; and that the use of the dewatering jet device at the heated water bath shows a significant improvement in terms of temperature over a situation where there is no dewatering jet device in operation. The graph further shows that when the measurements were repeated successively, as viewed from left to right, the two sets of results were fairly repeatable.

It has been found, therefore, that the particular location, adjustment and angular orientation, and the jet slot depth to width ratio of the dewatering jet device have produced unexpected results in terms of water removal efficiency, relative quiet operation and lower air consumption. The hollow conduit devices shown in the aforementioned Osban et al U.S. Pat. No. 3,199,214, for instance, do not appear to recognize the criticalness of jet orifice size, angular orientation, and spacing of the hollow conduit devices from the water bath. Inventors cannot explain why the above described factors are proving to be effective; but can only offer some theories as speculated upon above. Dewatering jet devices placed at other locations along the tow processing line have not been found to be as significantly effective as the location described herein at the heated water bath. Similarly, the mere punching of holes or slots in hollow rods or conduits without giving any regard to size, shape and the like of such holes or slots has not appeared to be as significant as that described herein. The nature of this operation is such that can only be evaluated on an actual production line. It is for this reason that the actual noise made by the dewatering jet device at the water bath could not be detected over that of the operating tow lines. It is only known that by placing the

dewatering jet device downstream at the second drafter roll section or at other locations resulted in a noise factor that could not be tolerated for any length of time by operating personnel, the noise was significantly noticeable; but at the water bath location whatever noise was made could not be picked up by the sound meter against the ambient background noise.

While the invention has been described in detail with particular reference to preferred embodiments thereof, it will be understood that variations and modifications can be effected within the spirit and scope of the invention as described hereinabove and as defined in the appended claims.

We claim:

1. An improved dewatering jet comprising a cylindrical hollow member of predetermined length and defining through the wall of the member a slot-like opening extending over a portion of the length of the member and having substantially parallel walls and a depth to width ratio of about 5:1 and a radius on the outer lips of the opening of about 1/32 inch.

2. An improved dewatering jet as defined in claim 1, and wherein the width of the slot-like opening is about 1/16 inch and the depth thereof is about 5/16 inch.

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