March 19, 1963 R. F. DYER ET AL 3,081,951

SLOT VENTURI FLUFFING JET

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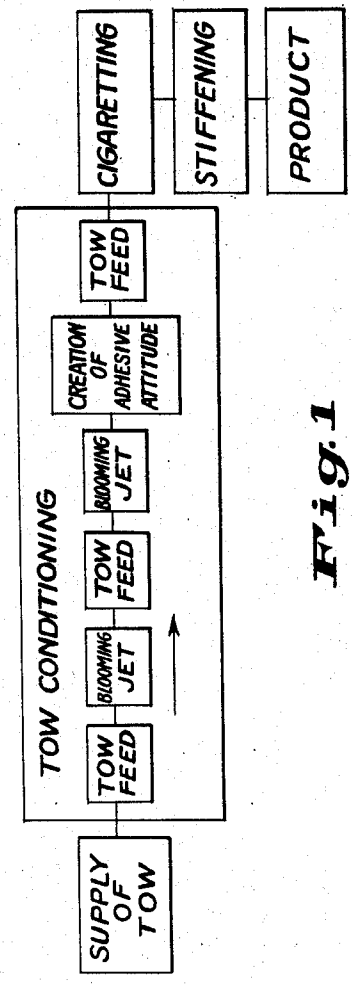


Fig. 1

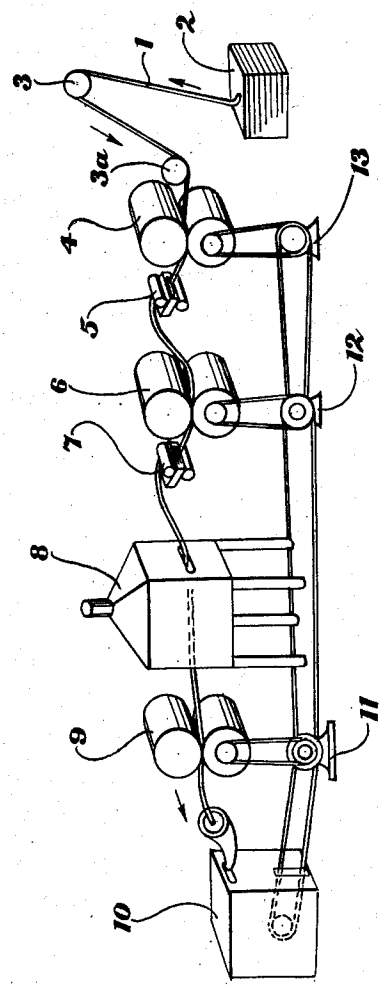


Fig. 2

Richard F. Dyer
Paul Gallagher
INVENTORS

BY R. Frank Smith
Harold N. Powell
ATTORNEYS

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Fig. 3

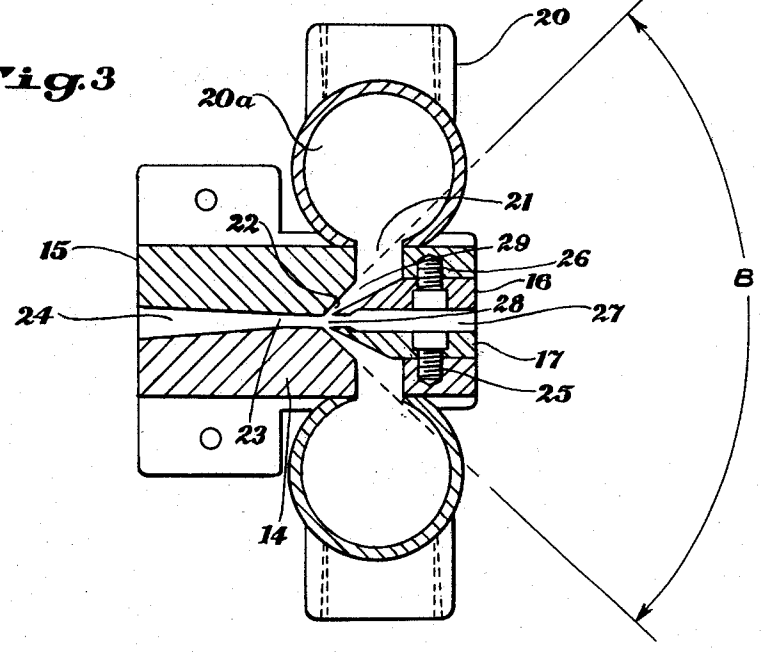
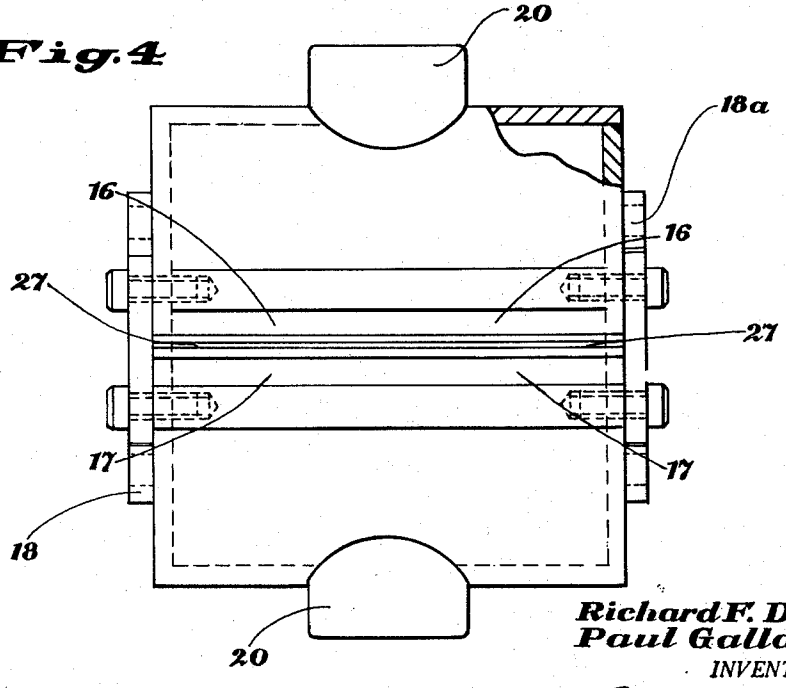


Fig. 4



Richard F. Dyer
Paul Gallagher
INVENTORS

BY R. Frank Smith
Harold N. Powell
ATTORNEYS

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Fig. 5

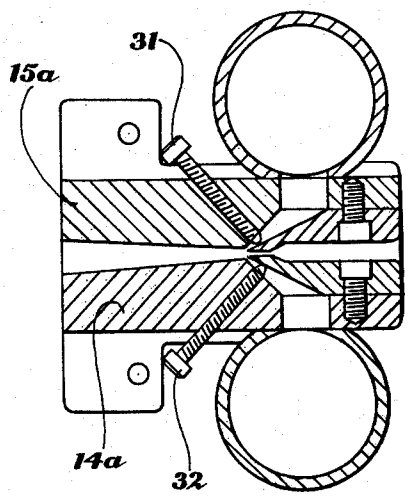


Fig. 6

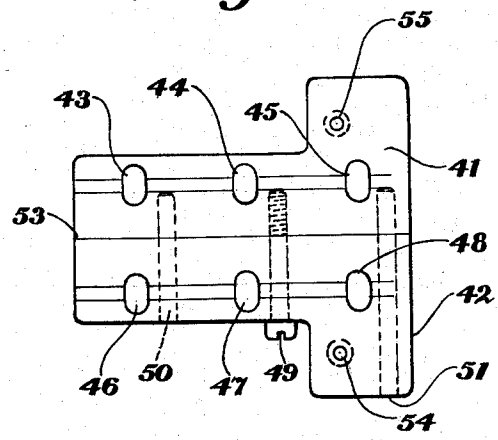
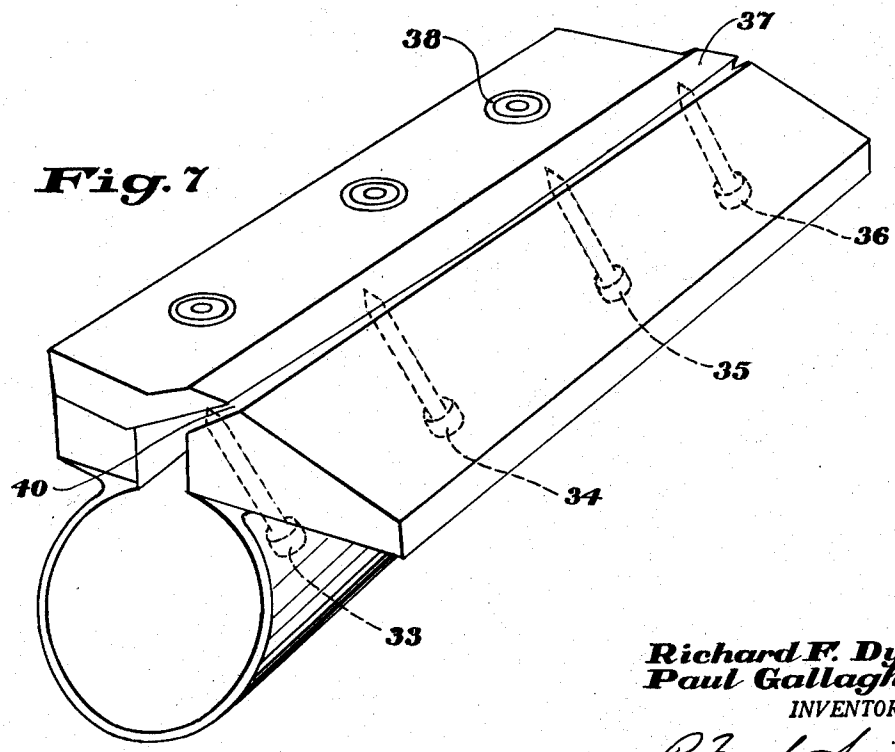


Fig. 7



Richard F. Dyer
Paul Gallagher
INVENTORS

BY R. Frank Smith
Harold N. Powell
ATTORNEYS

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3,081,951

SLOT VENTURI FLUFFING JET

Richard F. Dyer and Paul Gallagher, Kingsport, Tenn., assignors to Eastman Kodak Company, Rochester, N.Y., a corporation of New Jersey

Filed Dec. 2, 1959, Ser. No. 856,793
7 Claims. (Cl. 239—455)

This invention relates to a slot jet for use in the production of tobacco smoke filters suitable for cigarettes, pipes and cigarette and cigar holders. In particular this invention is concerned with a slot venturi jet for treating a continuous filament crimped tow to substantially increase the filtration efficiency thereof as will be apparent from the description which follows.

This application is a continuation-in-part of our application Serial No. 736,900, filed May 21, 1958.

In the industry at the present time a large number of tobacco smoke filters are made from crimped continuous filament tow. Such tow material is very useful for making such filter element constructions for a number of reasons. The continuous filament tow works well in automatic filter making machinery. The filaments due to their longitudinal arrangement contain elongated aligned parallel type passageways for the smoke. However, while in making filters from such tow, although it has been desired to preserve to some extent the longitudinal alignment, it has also been desired to alter the crimp arrangement in a manner that the crimps are out of registry, thereby producing shoulders in the filter upon which the smoke may impinge. Also the putting of the crimps out of registry enables the obtaining of a firmer filter with lower quantities of material.

In the art prior to the instant invention, various means have been used to alter the filament parallelism and to randomize the location of the knees of the crimp to some extent. Such means have included mechanical vibrators or strikers, pinch rolls and the like. However, such procedures as inducing a high static electrical charge on the tow by means of rubber rollers or the alternate application of high and then low tension by passing the tow from slow speed to high speed and then to low speed rolls or the beating of the tow by mechanical beaters have certain disadvantages. The generation of a high charge of static electricity on the tow may present a hazard if any volatile flammable matter is present or if at a later step in the process it is desired to treat the tow with certain liquids or powdered additives. The application of high tensions or the beating of the tow with vibrators may weaken the tow and may cause breaks therein and such prior art type of treatment may destroy to some extent the effectiveness of the crimp. In other words, in the prior art one must choose between a good crimp that remains in the treated tow or a deficiency of crimp that is randomized and, therefore, in each instance the most efficient and economical filter plug is not obtained.

Another and perhaps more serious problem encountered in the prior art type of operation is that it has not been possible to utilize tow having a particularly high degree of crimp. That is, highly crimped tow may have certain weak points at the point of crimp. Consequently, when it has been attempted to process highly crimped tow in accordance with prior art procedures with rolls or vibrators, such attempts have not been too satisfactory because of the breaking of the highly crimped tow. Furthermore, as already briefly mentioned, the prior art processes of beating and tensioning the tow in an effort to break up the registry of the knees of the crimp often causes the filaments to be strained beyond the yield point. Thus the sharp angular crimp originally in the filaments is often removed because the stresses of blooming the tow are great enough to permanently remove a substantial amount of the crimp.

It is, therefore, believed apparent that the development of a simpler more effective apparatus for treating continuous filament crimped tow for use in the manufacture of tobacco smoke filters whereby the tow may be opened up, the crimps placed out of registry and yet the crimp not removed from the tow as well as filament breakage avoided represents a highly desirable result. After extended investigation we have found an improved apparatus whereby prior art difficulties as above discussed may be eliminated or materially reduced.

One object of this invention is to provide an apparatus and means for processing a continuous filament crimped tow into a filter plug having a randomized filament arrangement, said filaments retaining a high degree of their original crimp so that a filter may be obtained which has an efficiency that is relatively high compared to the weight of the filter material. Another object is to provide a slot jet device which will give a well opened up tow suitable for filters without substantially impairing the strength or the degree of crimp in the individual filaments. A particular object is to provide a simple and effective apparatus arrangement for converting a dense continuous filament crimped tow into a well opened up filter tow readily susceptible to treatment with plasticizer and the like. A further object is to provide a slot venturi jet which contains relatively simple means for adjusting the critical dimensions of the gas slot. Still another object is to provide a jet of the class indicated which has improved means for inspection and cleaning of the jet.

For a more complete understanding of our invention reference will be made to the attached drawings forming a part of the present application. In these drawings FIG. 1 is a schematic flow diagram of the processing of the continuous filament tow into a filter plug for tobacco smoke filters.

FIG. 2 is a schematic diagram of an over-all apparatus arrangement of apparatus utilizing the venturi jet of the present invention which would be used in carrying out a process for making filters.

FIG. 3 is a detailed cross-sectional view of one embodiment of the fluffing jet of the present invention.

FIG. 4 is a part semi-diagrammatic front end view of the jet shown in FIG. 3.

FIG. 5 is a view similar to FIG. 3, but of a more complex and improved jet.

FIG. 6 is a side view of an improved end plate that may be used on the jets.

FIG. 7 is a perspective view of a part of the jet for better showing the feature of varying the width of the gas slot.

Referring now to FIG. 1, as indicated above the general over-all arrangement for making filters in accordance with the present invention is shown. As mentioned above, one object of the tow conditioning of filter tow is to convert the densely packed crimped tow from the supply package into a relatively fluffy resilient flat sheet of filaments which are in a randomized state, then to

establish an adhesive condition on the filaments by suitable procedure. In the present invention we prefer to apply a plasticizer to the filaments. The opened, banded flat sheet of adhesive filaments are then fed into the cigarette or plug making machine after which the plugs may be stiffened to form the final product. It is thought that the various legends on FIG. 1 render this figure understandable without further description herein.

Considering in more detail the tow conditioning means and apparatus in accordance with this invention, it will be seen that where opening and banding and fluffing were formerly separate steps, these steps are combined in our new process. The preferred system now involves feeding the tow at a constant rate to a blooming jet, taking up the bloomed tow at an equal or reduced speed relative to the feed rate and then subjecting it to the action of a second blooming jet, then to the bonding agent application, and finally removing it from the tow conditioning zone. During each blooming process the tow is under conditions which promote its relaxation.

In FIG. 2 the over-all apparatus arrangement is shown in more detail. Crimped and compacted tow 1 is withdrawn from bale **2** over guides 3 and 3*a* by the first pair of tow feed rolls **4**. The tow then passes through a jet **5** of the present invention which is supplied with gas at a pressure of 10 to 50 p.s.i. gauge. The design of the new jet of the present invention, as will be set forth in detail, is such that a high velocity gas flow is produced which is evenly distributed over the width of the rectangular-shaped jet. The action of this high velocity gas separates the individual filaments from each other and spreads the tow out into a band or sheet of filaments. At the same time the filaments are given a strong thrust by the air flow such that tension is generated in the tow between the rolls 4 and the jet 5. The tow then passes to roll pair **6** which is driven at such a speed relative to roll pair 4 as to allow the tow to be in a relaxed state between the jet **5** and the rolls **6**. In this area and particularly in the exit zone of the jet the filaments can thus be violently agitated and vibrated such that each filament is separated from the other and the crimp knees assume completely random position relative to each other.

This cycle of blooming or debundlizing is then repeated with roll pairs **6** and **9** and jet **7**. Here tension is again present between rolls **6** and jet **7** due to the influence of the high velocity jet air on the tow. Roll pair **9** however is driven at a speed relative to roll pair **6** so that between jet **7** and rolls **9** there is substantially no tension other than that required to prevent excessive sage in the tow. Also in the slack tension zone between jet **7** and rolls **9** there may be located spray booth **8** which applies plasticizer or other material to the tow. Since the tow is relaxed and the filaments well separated at this point excellent distribution and even application of the plasticizer or the like on each filament is possible.

The foregoing is thought sufficient to illustrate one use of the new jets of the present invention. Accordingly, the subsequent treatment of the tow after it leaves the jet is not a limitation on the present invention. However, subsequent treatments are illustrated below.

After leaving roll pair **9** the tow may be passed to the garniture of the cigarette making machine shown over-all at **10**. To insure good control over the process a common drive motor **11** drives all the individual rolls and the cigarette machine **10** by chain, cog belt or other positive drive means. Interposed between the motor **11** and roll pairs **4** and **6** there are variable speed transmissions **12** and **13** such that the relative speeds of roll pairs **4**, **6** and **9** can be adjusted to establish the desired degree of relaxation in each blooming stage.

In some cases it may be desired to eliminate one blooming stage and in this case, roll pair 4 and blooming jet **5** may be omitted with the tow passing directly from guide 3*a* to roll pair **6**. This arrangement may not bloom the tow as effectively as the two-jet assembly described above. However, the one-jet assembly of the present invention will process the tow better than prior art procedures. There are other alternatives. One is to retain maximum crimp in the bloomed tow which may leave a few groups of unopened filaments in the tow. The other is to use somewhat higher air pressure than is required with two jets. This will bloom the tow well but may remove some slight amount of crimp from the opened filaments.

Another alternative is to utilize one fluffing jet **7** and do some tension blooming between rolls **4** and **6** with or without the aid of a beater between the two sets of rolls. This method requires a larger tow to provide a specified filter efficiency and firmness. These several alternatives illustrate the flexibility of the use of the new jet of the present invention.

The design and construction of the new slot venturi jets **5** and **7** is of substantial importance and will now be considered in detail with relation to FIG. 3. The jet is composed of the parts as follows: venturi body plates **14** and **15**, nozzle plates **16** and **17** and end plates **18** and **18***a* (see FIG. 4). The venturi body plates have attached to one side a cylindrical air chamber **20***a* with air inlet nipple **20**. This chamber communicates through slot **21** with the interior of the jet to allow free passage of air or the like fluid. The venturi body parts when assembled to the end plates **18** and **18***a* coact to form a venturi throat **23** and a diverging venturi exit **24**. The two nozzle plates **16** and **17** are assembled to venturi body plates **15** and **14** respectively by cap screws as indicated at **25** and **26**. These nozzle plates coact with each other to form a slot-like yarn entrance passage **27** which converges at **28**. The nozzle plate **16** also coacts with venturi plate **15** to form a wedge-shaped chamber **29** terminating in a slotted orifice **22** which is in communication with the cylindrical air chamber **20***a* via slot passage **21**. At the down stream side of this chamber **29** it converges at an angle of 10–45 degrees, preferably 20 degrees so that air passing through is accelerated to a high velocity at the exit slot **22**. Nozzle plate **17** and venturi plate **14** coact in a similar manner. As apparent from FIG. 3 that although only slot **22**, air chamber **20***a*, etc. have been referred to specifically, that on the other part **14** there are comparable slots, chambers and the like. Hence, further description thereof appears to be unnecessary.

The tow enters the jet through passageway **27** and at the tip of the nozzle **28**, it is subjected to the impingement of the high velocity "sheets" of air emerging from the gas slots. In the throat **23** air and tow are intermixed and the velocity effect of the air generates a tension in the tow and a suction in the nozzle entrance **27**. This suction is strong enough to make the jet self-threading, i.e. it will suck the tow into the jet. As the high velocity gas and tow mixture leaves the venturi throat **23** and enters the diverging throat **24**, the air begins to lose velocity and expand. This action has the effect of "exploding" the tow and causing the filaments of the tow to diverge also, thus separating the filaments one from another. Also the filaments tend to vibrate much in the manner of ribbons attached to the front of an electric fan. This action further assists in separating the filaments. Recalling that between the jet and the downstream feed roll the tow is allowed to relax and contract, the filaments also move longitudinally realtive to each other so that knees of crimp in adjacent filaments are thrown out of phase in a completely random manner. Thus as the tow emerges from the jet the filaments are completely rearranged relative to each other as compared with their relative poistions on entering the area of high velocity gas flow.

So far we have considered only the cross section of the jet. We will now consider FIG. 4. The principal purpose of FIG. 4 is to illustrate that the jet shown in FIG. 3 is not the usual round or cylindrical type of jet

known in the prior art but is an elongated slot type of jet. In FIG. 4 the jet has been shown broken away on one corner to show the air chamber. The width of the jet may be, for example, 4–20 inches.

Referring in more detail to FIG. 4, it will be observed that the air inlet pipe is shown at **20** as are the nozzle plate parts **16** and **17**. The opening indicated at **27** is the entrance passageway for the tow being fed to the jet. FIG. 4 also shows parts **18** and **18***a* which are the end plates. An end plate may comprise merely a metal plate bolted onto the side of the parts discussed in the description of FIG. 3 to provide an end closure for the jet. Also, the construction of the end plate is such that the spacing of the two halves may be accomplished to the desired degree. However, as will be discussed in more detail with respect to FIG. 6, a special end plate construction may be provided for advantages of inspection and cleaning.

If we look in the transverse plane i.e., along the width of the jet, it will be seen that two even sheets of air are generated in the venturi throat from side to side of the jet. This is because air very quickly will equalize any variations in pressure or velocity in a given zone or enclosure. Thus if high pressure was present in the middle of the jet it would quickly level out by transfer of air from the high pressure spot to the adjacent low pressure spot. Furthermore, the cross sectional area of cylindrical chamber **20***a*, slot **21** and the entrance portion of wedge shaped slot **29** is large relative to the area of slotted orifice **22** so that a uniform pressure will be maintained at the orifice slot. The tow enters the jet with a width of from 2″ to 5″ compared to a jet width of 10″, for example. However, the continual leveling of air velocities and pressures tends to expand the tow width not only in the jet entrance but also in the venturi throat **23** and exit **24**.

To obtain the most efficient use of air compatible with the most effective blooming of the tow certain proportions have been found to be desirable. The angle of divergence of the venturi should be from 4 to 10 degrees with 8 degrees being preferred. The length of the diverging portion **24** should be about 4 to 10 times the length of the throat **23** and preferably about 7 times the length. The nozzle throat length **23** should be about 3 times its width. The total area of the air slots **22** should be about .10 times the area of the venturi throat. This latter ratio, however, is adjustable depending on the amount of suction or back pressure desired in the entrance nozzle **27**. A low ratio tends to increase the suction while too high a ratio causes back pressure or blow-back in the nozzle entrance **27**. The width of the jet is largely determined by the width to which it is desired to spread the tow. The proportion of the area of the venturi throat to the denier of the tow is not unduly critical but values in the order of one square inch per 50,000 denier are desirable. The included angle B (FIG. 3) is preferably 90° but may vary from 45 to 135°.

The manner in which the tow enters and leaves the jet can be arranged to improve the blooming. In general a straight line pass is less desirable. Bringing the tow in parallel to the jet axis and removing it at about a right angle produces improved results. Also about a right angle bend in the tow as it enters the jet and a second approximate right angle bend as it leaves with the tow either reversing its general direction of flow or ending up proceeding in the same direction are also beneficial in improving opening. This can be accomplished by positioning jets **5** and **7** somewhat above or below the bite plane of roll pairs **4** and **6** of FIG. 2. There should be no twist or false twist in the tow for best results. Judicious placement of the guide **3** will largely eliminate any false twist in the tow.

Referring to FIGS. 3 and 4 described above, it will be seen that air slot **22** as discussed is substantially uniform across the face of the jet. The correct setting of this slot is an important feature of the jet. The slot opening may be set by inserting a feeler gauge of the proper thickness at **22** and moving nozzle plate **16** on venturi plate **15** before screws **26** are tightened. The counterbored hole in nozzle plate **16** for screw **26** is large enough to provide this adjustment. For example, slot opening **22** may be about 0.004 in. It is usually not practical to machine the component parts to such close tolerances that slot **22** will be fixed at 0.004 in. Furthermore, it may be desirable to be able to adjust the slot from a minimum of about 0.002 in. to a maximum of about 0.008 in. Tows of different denier per filament and/or different total denier may require different air slot openings for the most efficient blooming action.

With a uniform tow, it is desirable to set the gas slots of FIGS. 3 and 4 reasonably uniform from end to end of the jet. If the slots are not uniform to the required extent, nonuniform blooming may occur. If a portion of the slot is wider than normal, more air is discharged at that portion. Since the filaments are under tension from the nip of the preceding rolls to the throat of the jet and also beyond the throat in the exit portion of the jet, somewhat more straightening of the filaments occurs at the crimp knees and that portion of the tow is excessively slack. If insufficient air is discharged from a portion of the jet less filament straightening results, and the tow will be tighter. Also it is obvious that the tow may not be bloomed sufficiently to get the crimps out of registry.

Referring now to FIGS. 5 and 7 where a further improved jet is shown, screws have been added to venturi plates **14***a* and **15***a* as shown at **31—36** of these figures. With these screws, as shown in FIGS. 5 and 7, it is possible to set nozzle plate **37** (FIG. 7) so that air slot **40** is about 0.001–0.002 inch and then by manipulation of the adjusting screws, the edge of nozzle plate **37** can be distorted enough to provide the desired slot opening. A different nominal slot opening can be obtained easily without loosening screws **38**. The distortion of the blade is an elastic deformation and the slot opening can be decreased (within limits) as well as increased. Slight inaccuracies in machining the blade or body piece can be compensated for by the use of the screws **31—36**.

In addition, it has been found that a certain controlled nonuniformity of the slot opening as just described may be a desirable feature of this design. Some of the crimped cellulose acetate tow produced for cigarette filters is crimped more tightly on the edges. These densely compacted groups of filaments are more difficult to open. By setting slot **40** at 0.005 inch at each end and 0.003 inch in the middle, more air acts on the edges of the tow and fluffing is uniform across the tow band. Certain other tows have a lower crimp on the edges than in the main portion of the band. With such tows it is possible to have the slot opening less at the ends than in the middle.

If desired, with the construction of FIGS. 5 and 7, the slot opening can be changed while the slot venturi jet is in use. With this mode of operation, the slot is opened or closed at various points as needed to provide uniform blooming of the tow.

While FIG. 7 shows four control screws **33—36** in each half of an 8-inch jet, more or fewer screws may be used. A spacing of 1.5 inches to 2 inches between control screws is preferred. While the screws partially block the tapered passage which culminates in slot **40**, this does not result in blank spots in the sheet of air emerging from the slot.

Referring now to FIG. 6, another refinement of this invention concerns split or separable end plates as shown. Since it is difficult to remove all water, oil, pipeline scale and other foreign matter from compressed air, cleaning of slot **22** or **40** may be required. The individual filaments in a filter tow may range in size from 10 to 40 microns, average diameter. The tow touches the end plates at the throat and in the diverging exit portion. For these reasons the end plates preferably are smooth and the air slots extend right to the end plates. Consequently, no

gasket is usually used between the end plate and the nozzle plate-venturi plate assembly.

Although a quick method of separating the two halves of the jet is desirable to facilitate inspection and cleaning of the air slots, the usual methods of accomplishing this are unsatisfactory as they entail either the use of a gasket to seal the ends of the air slots or they permit cracks in which filaments could be trapped. The construction of FIG. 6 overcomes these difficulties and is as follows:

Referring to FIG. 6 there is shown the two L-shaped members **41** and **42** which are adapted to be bolted to the sides of the venturi plates. This may be observed by noting parts **18** and **18***a* of FIG. 4. The two parts of the end plate of FIG. 6 are held together by a bolt at **49** in conjunction with dowels at **50** and **51**. The joint **53** of the two parts is accurately machined so that gas will not pass through it and filaments cannot be caught therein. The portions of the inner face of the two plates (which are in contact with the filaments) are machined smooth after assembly with the bolt **49** and the dowels **50** and **51**.

Elongated holes **43**—**48** are used to bolt the two halves of the jet together with provision for varying the width of tow slot **28** and venturi throat **23** (see FIG. 3). Thus gas slot **40** (FIG. 7) may readily be cleaned with a feeler gauge by removing bolt **49** at each end of the jet. Upon re-assembly, tow slot **28** is automatically maintained at its initial dimension.

Tapped holes **54**, **55** are used to mount the jet on the tow processing unit.

The apparatus of the present invention produces filters which have several advantages over those produced by prior art arrangements as is set forth in detail in our parent application Serial No. 736,900 referred to above.

The following example will serve to illustrate the use of the slot venturi jet of the present invention in opening tow. In this example the following pressures, speeds and like conditions were used.

Tow denier	57,000.
Denier/filament	3.
Crimps/inch	18.
Speed of roll set **4**	54.4 y.p.m.
Air pressure to jet **5**	25 p.s.i. gauge.
Speed of roll set **6**	54.5 y.p.m.
Air pressure to jet **7**	25 p.s.i. gauge.
Speed of roll set **9**	53.4 y.p.m.

The tow was under no tension between jet **5** and roll set **6** and between jet **7** and roll set **9** The speed of the roll sets **4** and **6** in this case were equal with the jet **5** being used to flex the tow much in the manner of a spring, but this flexing opened up the tow, randomized the filament arrangement and the locations of the crimp knees. Between roll sets **6** and **9**, an actual slight contraction of the tow was allowed to take place. Since crimped tow is highly elastic, it is possible to have two pairs of rolls at equal speeds but still have the tow relaxed slightly between the jet and the output rolls since this slack or relaxed condition represents recovery of the stretching done between the input rolls and the jet input due to tension generated by the jet air flow.

While the exact mechanism by which the air jets of the present invention bloom the tow is not fully known, it appears some of the following factors may be involved. It may be that the aspirating action of the jet applies tension without, however, applying excessive tension to many of the filaments as results from mechanical tensioning. Probably the air flow in the exit funnel of the jet is largely responsible for the debundlizing and filament separation.

Various gas pressures and the like may be used with our jets. For example, air pressures within the range of 5 to 100 p.s.i.g. may be used. The roll speeds of the variout rolls may be as follows: Input feed roll set 4, 30–200 y.p.m.; rolls **4** to **6** speed ratio, 1.20/1 to .7/1; rolls **6** to **9** speed ratio, 1.20/1 to .8/1.0. The total denier (T/D) of the tow may vary between 15,000 to 100,000 and the denier per filament (D/F) may be .1 to 8. As pointed out above, this invention works well on highly crimped filaments. Hence, the crimp in the tow would generally not be less than 7 crimps per inch and may be 17 or 18 per inch. In certain filaments the crimp may be higher, say up to 35 crimps per inch. Whereas, in spray booth **8** for cellulose ester filaments we used the plasticizer glycerol triacetate to the extent of 8–12% on the filaments, other plasticizers as dimethoxyethyl phthalate or triethyl citrate may be used. Or other materials such as dextrin or gum arabic in aqueous solution may be applied.

In the above description y.p.m. means yards per minute and is the measured roll surface speed. The term p.s.i. gauge means pounds per square inch above atmospheric pressure as measured by any standard pressure recording instrument.

Our jet may be used to process not only cellulose acetate filaments, but other textile filament tows may also be successfully bloomed by the apparatus of this invention. Such materials as cellulose acetate butyrate, cellulose acetate propionate, cellulose triacetate, acrylamide polymers and copolymers, polyolefins and polyester fibers may also be treated.

The invention has been described in detail with particular reference to preferred embodiments thereof, but 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. A slot venturi jet construction capable of use in the processing in both thickness and width of a multifilament crimped textile material, comprising the combination of two heavy, rigid body section plates placed adjacent to one another so as to form a venturi exit slot, the surfaces of which are plane, two rigid nozzle section plates with flexible lips placed adjacent to each other so as to form an entrance passageway within said body sections whereby two gas streams of high velocity may be provided and also to provide one passageway for a mixture of gas and the aforesaid textile material, end plates for positioning and holding the aforesaid parts in the desired relationship, including means for varying both the vertical and angular positions of said body and nozzle section plates, and further means associated with said nozzle section plates for warping the downstream lips of the nozzle section plates so as to vary the sizes of the gas entrance passageway without substantially changing the exit slot, said means extending through the body section plates and contacting the aforesaid flexible lips and adapted to uniformly adjust the width of said gas entrance passageway, and conduit means associated with the body section and adapted to supply gas through the slot venturi jet resulting from the aforesaid arrangement of parts.

2. A jet in accordance wtih claim 1 wherein the angle of divergence of the venturi portion is from 4–10 degrees.

3. A jet in accordance with claim 1 wherein the diverging portion of the venturi is 4–10 times the length of the throat section of the venturi.

4. A jet in accordance with claim 1 wherein the included angle formed between the body section and the nozzle section is from 10–45 degrees.

5. A jet in accordance with claim 1 wherein the total area of the gas slots is of the order of one tenth the area of the venturi throat.

6. A jet in accordance with claim 1 wherein the section plates are contacted with a plurality of control screws whereby the width of each gas slot opening may be controlled to between 0.002 to 0.008 inch.

7. In a venturi type slot jet in accordance with claim 1, end plates made up of two adjacently positioned members, said members being provided with elongated bolt holes whereby the width of the slot and the venturi throat may be varied.

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