April 16, 1968 MAKOTO YAMAMOTO 3,377,671

APPARATUS AND PROCESS FOR YARN TREATMENT

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Fig. 1A.

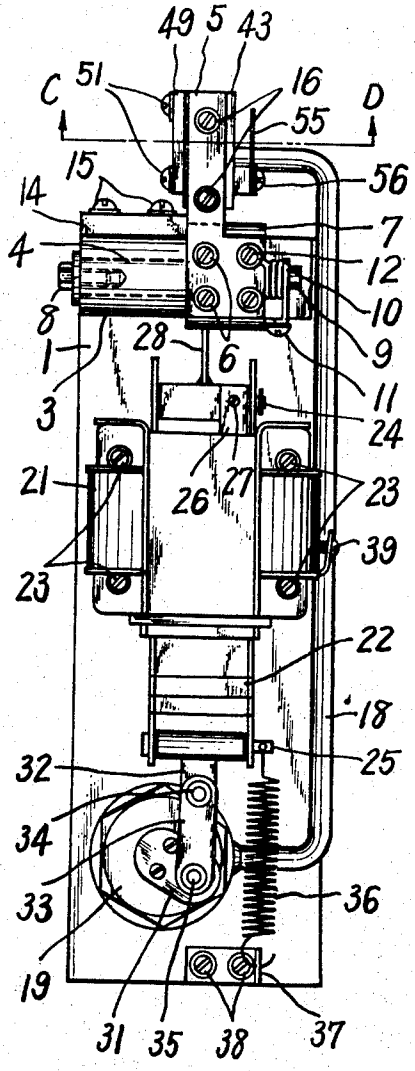
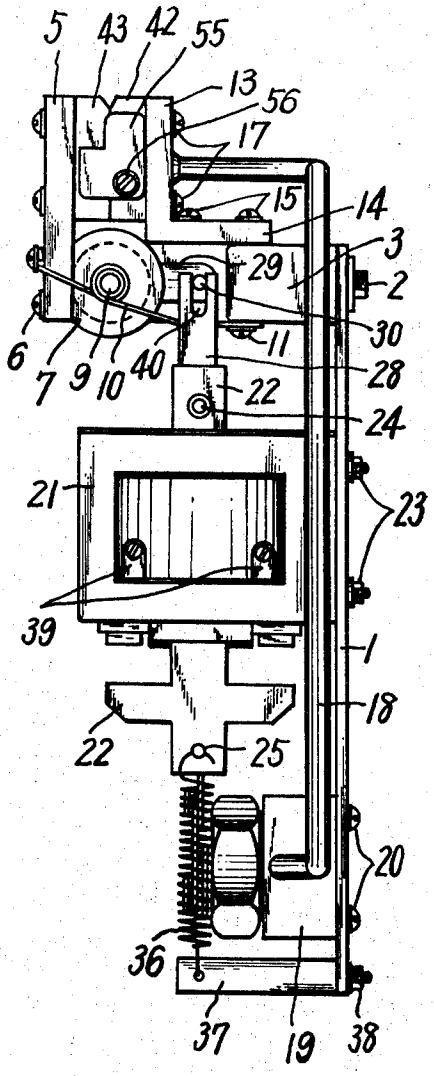



Fig. 1B.




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Fig. 2.

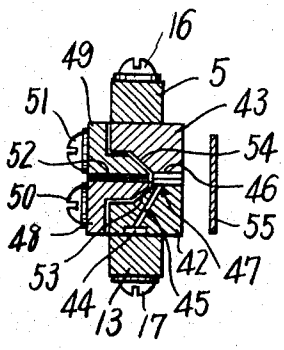



Fig. 3.

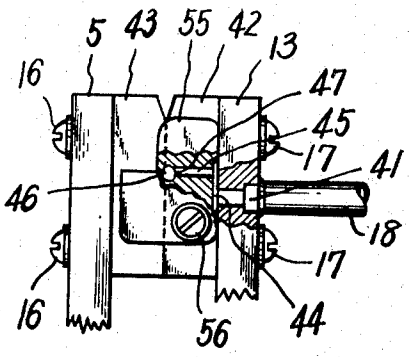



Fig. 4.

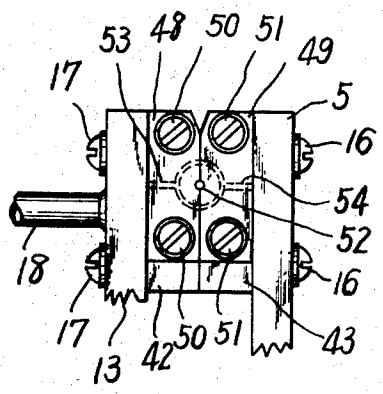
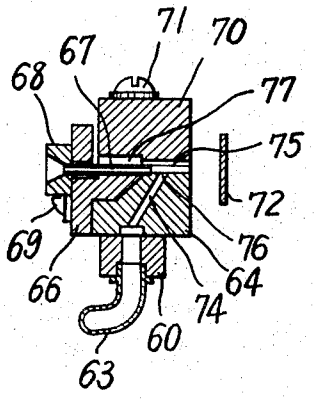



Fig. 5.




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Fig. 6.

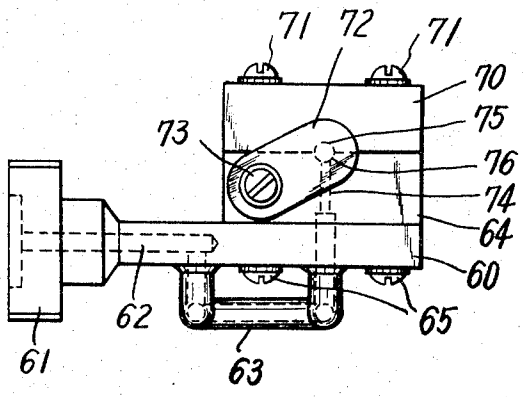
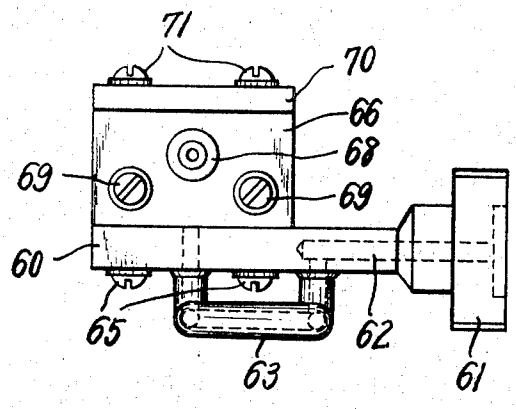



Fig. 7.




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3,377,671

# APPARATUS AND PROCESS FOR YARN TREATMENT

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Filed Aug. 23, 1965, Ser. No. 481,627
3 Claims. (Cl. 28—1)

## ABSTRACT OF THE DISCLOSURE

A process in which a yarn consisting of a number of fibers is placed under turbulence to form a number of loops, curls and entanglements, and a nozzle with various openings therein providing the necessary turbulence to carry out said process.

This invention relates to a process for the manufacture of textured yarn wherein a yarn consisting of a number of fibers is placed under the turbulence of fluid to form a number of loops, curls and entanglements in the fibers and also relates to a nozzle in the apparatus for manufacturing said textured yarn.

In the manufacture of textured yarn, it is very important for the improvement of processing performance to suitably establish the twisting of the jet stream ejected from the nozzle, that is to say, the rotation of fluid, corresponding to the twist number, yarn denier and physical properties of the starting feed yarn. If the amount of jet fluid is sufficient and the take-off of yarn from the fluid is good under the establishment of the conditions described above, the fiber may be taken off as textured yarn. In such a case, however, the processing performance is not considered an important problem. In manufacturing a textured yarn industrially, it is necessary to employ a process wherein the turbulence of the fluid is formed more strongly and efficiently, the starting feed yarn is fed into the area of turbulence so as to be subjected to the disturbance more readily, and the textured yarn is more easily taken from the area of turbulence. Moreover, for producing a textured yarn stably and uniformly, a nozzle for manufacturing the textured yarn should be so strong and durable that it is not easily disordered by the operation, and when the nozzle includes an adjusting system the adjustment of each nozzle should be carried out smoothly and easily.

As a result of studying a process for the manufacture of textured yarn and a nozzle of an apparatus for manufacturing said textured yarn, the inventor has found that the turbulence of fluid is formed more strongly and efficiently and the loops, curls and entanglements of yarn are formed more strongly improving the efficiency of the manufactured textured yarn, if the stream of fluid has been disturbed before the area of turbulence processing which forms loops, curls and entanglements, and that it is very important that a starting feed yarn is fed to the stream before the area of turbulence in order that the yarn may be more easily subjected to the turbulence.

The turbulence of the stream before the area of turbulence processing can be effected relatively easily by the establishment of one or more fluid inlets which introduce the fluid transversely to the direction of jet passage. However, it has been found that in order to provide a very desirable processing performance to yarn by means of such a nozzle, it is important that the sectional area of the jet passage and the section of the fluid inlet are selected in a specified relation. The stream from the inlet to the jet passage is partially discharged so that the relation between the flow rate projecting with a yarn from the passage and the flow rate from the outlet and



yarn guide opening may be set in a specified range, and further, in this case, it is an important factor to guide the yarn into the nozzle in such manner that the yarn may be subjected to the turbulence without importing a large influence to the turbulence.

The first object of the invention is to provide a nozzle for manufacturing a textured yarn characterized by providing one or more fluid inlets which introduce the fluid transversely to the direction of jet passage, providing a fluid outlet discharging the fluid, and a yarn guide opening introducing a yarn of many fibers in the vicinity of the fluid inlet of the jet passage, whereby the yarn introduced from the guide opening enters into the jet passage and combines with the fluid from the fluid inlet, a portion of the fluid entering from the fluid inlet to the jet passage being discharged from the outlet, and the yarn and the fluid being ejected from the jet passage to form the area of turbulence processing producing a textured yarn.

The second object of the invention is to provide a nozzle for manufacturing the textured yarn according to the invention.

The invention relates particularly to a process for the manufacture of textured yarn by introducing a fluid transversely into the jet passage, passing a yarn of many fibers through the jet passage and ejecting the fluid, and also to the improvement of the nozzle in the apparatus for manufacturing said textured yarn.

When a fluid inlet which introduces the fluid transversely is established at the jet passage, for guiding the fluid into the jet passage, the turbulence occurs strongly and as a result loops, curls and entanglements are formed strongly. However, for providing more strongly and more equally the processing performance in the invention, an outlet discharging the fluid and a yarn guide opening introducing the yarn are established in the vicinity of the fluid inlet of the jet passage.

Thus, since a portion of the fluid from the fluid inlet is discharged from the outlet, the turbulence becomes stronger, the yarn is guided accurately to the position of said turbulence and processed more uniformly to efficiently obtain a very excellent textured yarn.

The invention will be explained more fully with respect to a nozzle for manufacturing the textured yarn.

FIG. 1–A is a front view of an apparatus for carrying out the method of the invention;

FIG. 1–B is a right side view of FIG. 1–A;

FIG. 2 is a sectional view taken along the line C–D of FIG. 1–*a*;

FIG. 3 is a side view partly in section of principal portion of the nozzle as shown in FIG. 1–B in an enlarged scale;

FIG. 4 is a back side view of FIG. 3 in an enlarged scale;

FIG. 5 is a sectional view of the modified nozzle for carrying out the method of the invention;

FIG. 6 shows the right side view of FIG. 5;

FIG. 7 shows the left side view of FIG. 5.

Referring to FIGS. 1–A and 1–B, the nozzle is so developed that the yarn guiding operation to a nozzle occupying the substantial part of manual handling in the manufacture of textured yarn can be made as easy as possible and it may be used for an automatic or semi-automatic textured yarn manufacturing machine, and as an improvement in the nozzle of the inventor's previous invention. The nozzle consists of an assembly composed of members secured to a base 1, and its main part is mounted to the nozzle body 3 secured to the base 1 by a screw 2. The nozzle body forms a bearing or hinge and a hinge shaft 4 is fitted tightly to the nozzle body. In FIG. 1–A, a head 7 which is integral with the shaft

4 is provided on the right of the shaft and a movable arm 5 is mounted to the head by screws 6. The left end of shaft 4 is tightly clamped by a lock nut 8 to remove the side clearance of shaft 4. A projection 9 is extended to the right of the shaft 4, head 7 and a torsion spring 10 are inserted to the projection 9 and each end of the spring is secured by screws 11 and 12 respectively. Thus, the movable arm 5 is subjected to a clockwise force in FIG. 1–B. On the other hand, a fixed arm 13 is made integral with a fitting plate 14 which is secured to the nozzle body 3 by screws 15. The main part of the nozzle for manufacturing a textured yarn is divided into two parts between the fixed arm 13 and movable arm 5 and these parts are secured to each arm by screws 16 and 17. Both parts of the nozzle are closed together by the force of torsion spring 10 during the manufacturing of textured yarn, one end of pipe 18 is connected to the fixed arm 13 and the other end of pipe 18 is connected to a cock 19 and a fluid is fed through the pipe 18 to the fixed arm. The fluid (not shown) is fed from the left of cock 19 in FIG. 1–A. The cock 19 is secured to the base 1 by screws 20. 21 is an electromagnet and the cock and nozzle (which means a portion for manufacturing a textured yarn mounted to the nozzle body 3) are operated by a connecting rod equipped to a movable piece 22. The electromagnet is fixed to the base 1 by screws 23, pins 24 and 25 are equipped to the moving piece, and an adjusting piece 26 which limits the displacement of moving piece is engaged to the pin 24 and clamped by a lock nut 27. The lower end of connecting rod 28 is engaged to the pin 24 and the top is connected to a lever 29 associated to the head 7 of shaft 4 by a pin 30. An arm 31 is provided to the cock 19 and connected to a connecting rod 32 of which one end engages the pin 25 of the movable piece of the electromagnet through a link 33 and pins 34 and 35. The movable piece 22 is so stretched by a spring 36 of which one end is engaged to the pin 25 that the electromagnet may be opened. The other end of the spring engages a fixing member 37 secured to the base by screws 38.

FIGS. 1–A and 1–B show the condition in manufacturing a textured yarn, wherein the cock 19 is open and a fluid is being fed to the nozzle. When the manufacturing of textured yarn is stopped, the electric-current is passed to a coil of the electromagnet through the terminal 39, whereupon the movable piece 22 of the electromagnet is moved upwardly in the figure and shuts the cock 19 at the initial part of its movement. The fixing position of cock 19 may be settled by the screw 20 to adjust the movement of movable piece 22. A slit 40 (FIG. 1–B) is provided at the upper end of the connecting rod 28 so as not to transmit the movement of the connecting rod 28 to the lever 29 until the cock is closed. Thus, the lever 29 is acted upon by a force during the latter half part of the movement of the movable piece 22 to move the movable arm 5 around the shaft 4 counterclockwise to open the nozzle. The movement of movable arm 5 can be adjusted by the position of nozzle 3 to the base 1 and the position may be fixed by means of screw 2. The nozzle is used in such a way that a yarn may be simply inserted therein. When the processing is started, the current supply to the electromagnet 21 is interrupted. Thus, the attractive force of the electromagnet is cut off, the movable piece 22 moves downwardly due to the action of the spring 36, the nozzle is shut at first by the force of spring 10, the movable piece is then further moved by the force of spring 36 to open the cock 19 and fluid is delivered to the nozzle to begin the processing.

The nozzle will now be described in detail. The fixed arm 13 is provided with a fluid feed inlet 41 connected to a pipe 18 (refer to FIG. 3). A jet passage piece 42 is secured to the fixed arm 13 by screws 17 and a jet passage piece 43 to the movable arm 5 by screws 16 (refer to FIGS. 2 to 4). In these figures, the nozzle is under the condition of manufacturing a processed yarn and the fluid introduced from the fluid feed inlet 41 is introduced through a fluid inlet 47 into a jet passage 46 which is constructed to extend over jet passage pieces 42 and 43 through a slit 44 and a fluid introducing hole 45 (refer to FIG. 2). The yarn guide pieces 48 and 49 are secured to the jet passage pieces 42 and 43 by the screws 50 and 51 respectively, a yarn guide opening 52 is provided between the yarn guide pieces 48 and 49, thereby a yarn is guided to the jet passage 46. The fluid outlets 53 and 54 are provided between the yarn guide pieces 48 and 49 and the jet passage pieces 42 and 43 respectively, a portion of fluid coming from the fluid inlet 41 is discharged from the outlets 53 and 54, and the starting feed yarn fed from the yarn guide opening 52 is combined with the major portion of fluid coming from the fluid inlet 41 and ejected through the jet passage to the outside of nozzle. In front of the nozzle, an obstacle 55 (FIGS. 2 and 3) for the fluid is secured to the jet passage piece 42 by a screw 56. It is important to join each of the pieces 5, 43, 42, 13, 48 and 49 with each other as tightly as possible, preventing the leakage of fluid and, a yarn or fibre from being caught between the pieces 42 and 43 as well as the pieces 48 and 49 so that the proper adjustment may be made to manufacture a textured yarn in good condition. For this purpose, the jet passage pieces 42 and 43 are secured to the yarn guide pieces 48 and 49 by the screws 50 and 51 respectively and the two assemblies composed of said each pair of pieces are joined together. They are secured to the fixed arm 13 by the screw 17 and to the movable arm 5 by the screw 16. Thus, a complete assembly is formed and secured to the nozzle 3 proper, and the head 7 of shaft 4 by the screws 15 and 6 respectively. In this case, however, it is fundamentally important to finish each piece extremely accurately and this assembly process is applied on the basis of such accuracy in processing.

The operation of nozzle will be explained further in detail with reference to FIGS. 1 to 4. Since the nozzle guides a yarn to the nozzle by opening the jet passage, the top of jet passage pieces 42 and 43 in FIG. 1–B are cut off so as to facilitate the guiding of yarn more readily. When the condition of manufacturing a textured yarn becomes worse temporarily by a very short unevenness of fed starting yarn, the shrinkage ability in manufacturing a textured yarn is reduced to blow off the yarn and the fluid forward and the yarn is ejected past the area of turbulence processing without changing its direction of progress after it is ejected, since it is subjected to less turbulence, while the yarn ejected from the jet passage is taken off at the left directly after ejection in the normal manufacture of textured yarn as shown in FIG. 1–B. For getting off such condition as quickly as possible and giving a force to come back to the original state, the obstacle 55 is arranged in front of the nozzle. When a yarn is blown, the yarn and the fluid are ejected against the obstacle 55 to increase the turbulence, and the advancing direction of yarn is bent by the obstacle so that the yarn is subjected to the turbulence increasing the formation of loops, curls and entanglements back to the original normal condition. In this case also, however, somewhat unevenness in processing is formed. It is natural that a textured yarn should be manufactured with a sufficient allowance for conditions of shrinkage to avoid such unevenness. The obstacle is not necessarily so great that the progress of fluid ejecting from the jet passage may be interrupted sufficiently and the fluid blocked. Accordingly, it covers scarcely the jet passage as seen directly from the top in FIG. 1–B. Since the obstacle serves also as a guide in introducing yarn, it is constructed as an L so as to contain at least a portion of locus of the center of the jet passage of jet passage piece 43 transversely to the passage piece in such manner that a yarn is received first in the jet passage of the jet passage piece 43 and then it is closed when the yarn is introduced and the jet passage is closed. The obstacle

may be placed generally in front of the jet passage and apart 1.5 to 6 times the diameter of jet passage. A member such as guide plate may be likewise provided to the yarn guide piece (not shown). Since the jet passage is opened by passing electric current to the solenoid coil in this nozzle, a yarn may be guided by inserting the yarn solely. For adjusting the nozzle, the screw **16** is slightly loosened and the electric current is interrupted, then, the jet passage is closed and the fluid is ejected. Then, the end of the jet passage piece is parted slightly to observe the condition of yarn in such manner that the jet passage piece **43** is moved transversely to the axis of jet passage. It is very easy to obtain a satisfactory condition within 2 to 5 minutes by this operation. For making the adjustment easier, the obstacle is removed and the yarn and fluid are ejected freely in front of the nozzle, whereupon a flame-like substance is formed during the manufacturing of a textured yarn when the condition is seen by naked eyes. The most desirable condition occurs when the flame is minimal. On taking off to the left of FIG. 1–B at this time, a very preferred processing condition may be observed. The screw **16** is then tightened and the obstacle is mounted.

In the embodiment of nozzle shown in FIGS. 1 to 4, a similar effect can be attained in a very simple nozzle structure by modifying the shape of the yarn guiding piece and using a pipe in place of the piece. Such embodiments are shown in FIGS. 5 to 7.

The nozzle base **60** is constructed as shown in FIG. 6, wherein the left end of the nozzle forms a male **61** for a fluid union to connect the nozzle, a base is provided at the right thereof to assemble the whole nozzle and the fluid received from the union is fed to the main part of the nozzle by means of a fluid feed opening **62** and a pipe **63** in the nozzle. A jet passage piece **64** is air-tightly secured to the nozzle by screws **65**. On the other hand, a yarn guide pipe **67** is secured to a fitting tool **66** for said pipe by means of adhesive or solder as shown in the figure and a yarn inlet piece **68** is secured to the left end of said pipe by calking with adhesive or solder. A yarn guiding metal tool consisting of **66**, **67** and **68** is secured to the jet passage piece **64** by a screw **69**. Another jet passage piece **70** is secured to the jet passage piece **64** by a screw **71**. An obstacle **72** for the fluid is secured in front of the nozzle by a screw **73** and the assembly of nozzle is completed.

Illustrating the nozzle further, since the jet passage piece **64** and the nozzle **60** are made perfectly air-tight, the fluid from the fluid feed opening **62** of the nozzle is fed to a fluid inlet opening **74** of jet passage piece and fed to the jet passage through a fluid inlet **76** at the center of a jet passage **75** formed across the jet passage pieces **64** and **70**. The major part of fluid introduced into the jet passage from the fluid inlet is ejected through the jet passage together with the starting yarn fed to the nozzle through the yarn guide pipe at the right of FIG. 5 and the starting yarn is processed. While the major portion of fluid is ejected from the jet passage to the area of turbulent processing, it is ejected from the yarn guide pipe and positively from the outlet opening **77**.

It is necessary to adjust the nozzle prior to starting the manufacture of processed yarn in this nozzle. For this adjustment, the rotation of fluid may be principally adjusted as in the nozzle shown in FIGS. 1 to 4, by which very satisfactory processing performance may be attained. The adjustment may be performed in the same manner as described previously. While the screw **71** is loosened slightly, a starting feed yarn is introduced into the yarn guide pipe and guided and the fluid is ejected from the nozzle. By this procedure, a skilled person can make the proper adjustments within about 2 minutes and a person not skilled within about 5 minutes. When the yarn is taken out of the nozzle upwardly in FIG. 5, a very satisfactory textured yarn is manufactured.

Additional explanation regarding the nozzles shown in FIGS. 5 to 7 will be made. The processing performance in the case in which the yarn guide pipes are located close to the lower wall of the jet passage as shown in FIG. 5 is more or less different from that in the case when they are located close to the upper wall, and when the fluid introducing hole is inclined as shown in FIG. 5 the performance is different than when the hole is perpendicular to the jet passage. Positioning the yarn guide pipe nearer the fluid inlet provides better results as long as there is no influence on the fluid from the fluid inlet. Positioning it a distance of about ⅕ to 5 times, more particularly ⅔ to 1.5 times, of the diameter of jet passage from the center of the fluid inlet gives good results. In the case in which the fluid inlet is inclined to the jet passage as shown in FIGS. 1 to 7, with the yarn guide pipe located close to the upper wall of jet passage, the yarn guide pipe may be located more to the right in FIG. 5 so that the yarn is subjected to the turbulence more positively and more preferable processing performance may be attained. Then, the diameter of the yarn guide pipe should be considered in guiding a yarn to the nozzle. Since it is proper to consider that a knot is contained in the yarn, a diameter within the range of 500 to 1,000 deniers allows the knot to pass relatively easily. The yarn guide pipe is under the negative pressure condition in passing a yarn and the operation is performed easily. However, when the diameter of the yarn guide pipe is increased to some extent and the distance from the entrance of the yarn to the outlet is shortened as in the nozzle according to the invention, the yarn can be passed relatively easily by bending the end of the yarn, and twisting it to insert it into the yarn guide pipe even though no fluid is passed through the nozzle at all. When the negative pressure, i.e. suction is desired to be applied in guiding the yarn, a fluid may be injected from the middle part of the yarn guide pipe to cause suction in the yarn guide pipe only when guiding the yarn. However, the suction can be attained by placing the yarn guide pipe on the lower wall of jet passage as shown in FIG. 5, at a distance of ⅔ to 1.5 times the diameter of the jet passage from the center of the fluid inlet to reduce the amount of fluid introduced into the nozzle. Under such conditions, the yarn is guided and then the cock is opened full to begin the processing of the yarn. Since in such nozzles it is rather convenient to take up the yarn coming to the jet passage by hand and put it on the machine, when the yarn is guided to the nozzle and the operation is started, the obstacle may possibly be in the way of passing the yarn. The obstacle may be therefore, so constructed as to rotate around the screw **73** and to stop at the position when the hand is let free. Thus, the obstacle is turned transversely in such manner that the yarn coming to the jet passage may be caught by hand and the obstacle returned to the normal position after charging the yarn to the machine. It is important to secure the yarn guide pipe to the free end as short as possible. Since to render the distance from the mounted position of the yarn guide pipe to the free end as short as possible. Since it is preferable to heap solder on the yarn guide pipe, it is preferable to cut the corresponding portion of the jet passage piece as shown in FIG. 5 to form a gap.

In order to attain the objects of the invention, it is necessary to determine in general the fundamental diameter of the fluid inlet opening and the fluid introducing hole. Since the flow rate and the energy necessary and sufficient for forming loops, curls and entanglements is determined in accordance with the properties of the yarn, yarn denier and size of monofilaments, when a compressed air of about 2–25 kg./cm.$^2$ is employed as in the usual manufacture of textured yarn, the diameter of the fluid introducing hole may be determined very easily. In this procedure, a diameter of about 1.0 to 1.4 mm. is given to a yarn denier below 150 deniers, 1.2 to 2.0 mm. to 150 to 400 deniers and 1.5 to 2.5 mm. to 400 to 5,000 deniers. A larger diameter of the jet passage than that of the fluid introducing hole gives better results and a sec-

tional area of the jet passage within 1 to 5 times more especially about 1.5 times of available sectional area of fluid inlet or fluid introducing hole (the sum of sectional areas for two or more than two fluid inlets), gives the most preferable processing performance. The length of the jet passage at the side where the fluid lower than the center of the fluid inlet is ejected is generally 1 to 3 times the diameter of the jet passage, 5 to 8 times also gives good results. For the length of the jet passage on the upper stream side of the center of the fluid inlet, the preferred length differs depending upon the type and structure of the nozzle. For the structure of nozzle as shown FIGS. 1 to 4, it is generally preferable to have the length of the jet passage ⅓ to 5 times the diameter of the jet passage. A length ⅔ to 1.5 times the diameter achieves the most preferable processing performance. For the nozzle as shown in FIGS. 5 to 7, however, since the jet passage is jointed to the outlet of fluid, it may be of a larger length. Here, the object of the invention is to introduce a fluid from the fluid inlet into the jet passage where the direction of the flow of the fluid is changed, enforcing further the diffusion and disturbing the stream of the fluid. For this purpose, the outlet is provided so that it performs this function. Since the discharge of the fluid is also carried out from the yarn guide pipe or yarn guide opening, the sum of the sectional areas of the outlet and the yarn guide pipe or yarn guide opening comes into question. It may be most desirable to employ an outlet having a sectional area of 0.2 to 5 times that of the fluid introducing hole. The approach of the yarn guide pipe or yarn guide opening provides a better result so long as there is no adverse effects on the fluid, and a textured yarn can be manufactured with efficiency. A considerably good result may be obtained even when it is positioned a distance of 3 to 5 times the diameter of the jet passage from the center of fluid inlet.

While, there is only one fluid inlet shown in the drawing but more inlets may be employed. Although, the fluid introducing hole is inclined with respect to the jet passage in the drawing, for promoting the progress of yarn it may be perpendicular or inversely inclined. From the result of experiments however, it is found preferable to arrange it at an angle of about 30° to the vertical direction, and at the side where the progress of the yarn is promoted. When one fluid is employed, arranging the fluid introducing the opening eccentrically to the jet passage should be absolutely avoided, and the opening should be formed as close to the center of the jet passage as possible. The deviation of the jet passage is not visible and in general is at most about ⅕ mm. within the range of the twine capable of manufacturing a textured yarn. Thus, the fluid introducing opening may be adjusted quite satisfactorily to the rotation of fluid without arranging said opening eccentrically to the jet passage at all. When a very slight eccentricity is recognizable by the eyes, the rotation increase is too great in general to provide good processing. For two, or more than two fluid inlets, when one inlet is arranged eccentrically to the jet passage and is kept within such a range that the rotation of the fluid is not large in relation to the other fluid inlet, a processed yarn may be manufactured satisfactorily by subsequent adjustment, so that, in this case, it is not necessary to arrange the fluid inlets non-eccentrically. However, it can be understood from the above description that it is sufficient to have no eccentricity.

While the obstacle is provided in front of the jet passage in the drawing illustrating the invention, for the reason described above, this is not always necessary. In general, with the nozzle having the obstacle as such, when the yarn forced out of the jet passage is taken off transversely, the curvature of the yarn changes its direction of progress and is bent suddenly which the jet fluid runs against and concentrates in a small area causing the strong disturbance. The formation of loops, curls and entanglements is apt to occur by the bending by yarn more easily and a processed yarn may be manufactured very efficiently and strongly. In this case, the yarn does not generally run against the obstacle. In particular, in strong processing, the textured yarn is taken off transversely approximately at the jet passage piece. As described previously, the obstacle is not necessary under normal conditions, but is used in abnormal conditions; however, when a textured yarn is manufactured, sufficient shrinkage force is provided, without using the obstacle at all. Instead of the obstacle, as seen from many literatures and patents, a jet aperture having a larger sectional area than the jet passage, known in general as a "venturi," may be provided. In this case, the jet passage of the venturi piece is equal or greater in its sectional area than the preceeding jet passage and the length of the jet passage can be as short as 1 to 0.5 mm. or 0 with good result. It is no need of course here to arrange an obstacle. When the jet outlet is arranged in such manner, the curvature of the textured yarn is reduced by the jet outlet, and the processing performance is probably apt to be inferior to the use of obstacle alone. The difference is in general not so great for a yarn of good processing performance such as a starting yarn of twisted yarn.

The effect obtainable by the invention is not recognized to a great extent for a yarn in which K is from 40 to 300 in the equation

$$T=K\sqrt{\frac{9000}{D}}$$

wherein $T$=twist number per 1 m.; $D$=denier of starting yarn. An improvement in processing performance of about 10 to 40% can be observed over the previous method. For the difference between the use of an obstacle and that of a jet outlet, the processing performance in the former case is generally about 10 to 40% better. For a yarn of $K$=0 to 40, more especially, $K$=0 to 10, the producer's twist of filament yarn, manufacturing efficiency by the process of the present invention, is increased 2 to 5 times. In this case also, of course, a preferable processing performance may be attained by the use of an obstacle. The difference between the obstacle and the jet outlet has been described above. For the obstacle (same as the case without using the obstacle), since the bending of yarn is great, at which the turbulence occurs to perform the processing and loops and curls are formed, a nep is formed naturally by a slight change in processing. Accordingly, in this case, the condition should be established to manufacture a textured yarn with allowance in processing force and avoiding more than necessary the variation. On the contrary, by applying the characteristics, a new decorative yarn forming a number of neps can be manufactured.

For actually 0 or about zero twist as in producer's twists, it is important in particular to provide sufficient twists between fibres to prevent the slipping out of the loops and the curls during weaving, knitting and use. For this purpose, it is important to provide an outlet to diffuse violently the fluid from the fluid inlet in the jet passage and then to bring to the area turbulence processing. It is important to provide a yarn guide opening to disperse the yarn violently, then deliver it to the turbulent processing area.

In the area of a small number of twists, wherein K is 0 to 40, such as in producer's twist, it is found that the rigidity of the fiber composing a yarn is a factor which dominates the processing performance of the yarn. From a study of this phenomenon, it is found that the processing performance is in general not good for a soft fiber, that is to say when the size of the monofilament is small, the Young's Modulus is small, or both are small. In particular for nylon, polypropylene, polyoxymethylene fiber and a kind of water soluble fiber of polyvinyl alcohol series, of which Young's Modulus is small and monofilament denier is below 3 and especially from 25 to below 2. For the representative commercial nylon yarn of 70 deniers and 34 filaments, a satisfactory textured yarn can not be obtained at a twist number of about 18 per

meter by a conventional process. However, in such nylon yarns, if the shrinkage is increased, a textured yarn can be manufactured easily and efficiently and the lower limit of shrinkage is about 25%. For an approximately equal size of filament, the lower limit of shrinkage falls as the Young's Modulus becomes greater; i.e. about 14 to 16% for a commercial viscose rayon of 75 deniers and 30 filaments, and about 12 to 15% for a commercial Tetron of 75 deniers and 36 filaments. It is believed that this phenomenon has relation to the separation of the fiber in the nozzle, which is based on the fact that such a limit of shrinkage is removed at all from a twisted yarn such as $K=40$ in processing such twisted yarn. Further, the limit can be totally removed by performing previously the twisting-fixing-releasing or opening to such extent as $K=20$ to 100. To solve the phenomenon further, viscose rayon, cellulose acetate and hydrophilic fibers of polyvinyl alcohol series may be treated with borax or boric acid to improve Young's Modulus and the processing performance. Further, a polymer having a high Young's Modulus such as styrene may be mixed-spun with a polymer having a low Young's Modulus such as nylon, polyvinyl chloride, polypropylene and polyoxymethylene etc. to manufacture a hard fiber and to improve the ability for manufacturing a textured yarn.

By practicing the present invention a very strong textured yarn can be obtained very efficiently. The invention displays in particular a great effect in manufacturing a textured yarn of large shrinkage at very high speed.

The dimension of one nozzle according to the invention which is thought as the most preferable nozzle for 20 to 150 deniers is as follows: the diameter of jet passage is 1.6 mm., the diameter of fluid introducing opening is 1.3 mm., the number of fluid inlet is one, the angle of the fluid introducing opening to the vertical line of jet passage is 30°, the length of jet passage in front of the center of fluid inlet is 3 mm., the diameter of yarn guide opening is 0.65 mm., the distance from the center of fluid inlet to the yarn guide opening is 1.5 mm., the position of yarn guide opening is at the side of fluid inlet in the jet passage, and the sectional area of outlet is 1.7 mm.$^2$. For yarn deniers outside of this range, a suitable nozzle may be easily considered and designed from the above values and the description of the specification.

For the nozzle according to the invention, any liquid and gas may be used as fluid. Compressed air is preferably used economically and the use of compressed air is most preferable from the point of processing performance.

The invention will be explained further in detail by the following examples.

*Example 1*

Using polyethylene terephthalate (trademark: Tetron) yarn of 75 deniers, 36 filaments and 600 t./ms. and the nozzle as shown in FIGS. 1 to 4, a good processed yarn was manufactured at a feed speed of 150 m./min., a winding-up speed of 130 m./min. and using a compressed air of 3 kg./cm.$^2$.

*Example 2*

Using polyethylene terephthalate (trademark: Tetron) yarn of 75 deniers, 36 filaments and 12 t./ms. and the nozzle as shown in FIGS. 5 to 7, a good processed yarn was obtained of which loop and relax did not slip off by applying a tension, at a feed speed of 100 m./min., a winding-up speed of 84.5 m./min. and using a compressed air of 4 kg./cm.$^2$. The nozzle, in which the diameter of jet passage was 1.6 mm., the diameter of fluid introducing hole 1.3 mm., the inner and outer diameter of yarn guide pipe were 0.75 mm. and 1.0 mm. respectively, was equipped upward from the jet passage and apart 0.5 mm. from the center of fluid inlet.

*Example 3*

Using a viscose rayon of 75 deniers, 30 filaments and 107 t./ms., a good processed yarn without fluffy was manufactured under the same condition as in Example 2, of which loop and relax did not slip off under tension.

*Example 4*

Using a viscose rayon of 120 deniers, 30 filaments and 86 t./ms. and the nozzle as shown in FIGS. 5 to 7, a good processed yarn without fluffy was obtained at a feed speed of 80 m./min., a winding-up speed of 68 m./min. and using a compressed air of 4 kg./cm.$^2$, and of which loop and relax did not slip off under tension. The nozzle, in which the diameter of jet passage was 1.6 mm., the diameter of fluid inlet 1.3 mm., the inner and outer diameter of yarn guide pipe 0.8 mm. and 1.05 mm. respectively, was equipped downward from the jet passage and apart 1.5 mm. from the center of fluid inlet.

What I claim is:

1. A process for manufacturing textured yarn by ejecting a yarn having a large number of fibers together with a compressed fluid through a jet passage of a nozzle into a turbulent processing area thereby forming a large number of loops, curls and entanglements in the yarn, comprising, introducing said fluid into the jet passage through a fluid inlet passage substantially transversely against the jet passage, introducing said yarn into the jet passage from an opening in a yarn guide passage positioned in the vicinity of the opening of the fluid inlet passage to the jet passage, discharging a portion of the fluid introduced into said jet passage from a fluid outlet passage other than the jet opening of the jet passage positioned in the vicinity of the opening of the fluid inlet passage, thereby disturbing the flow of the fluid and the yarn, and subsequently ejecting a major portion of the fluid and the yarn from the jet opening of the jet passage to the turbulent processing area causing disturbances and forming loops, curls and entanglements in the yarn.

2. A nozzle for manufacturing textured yarn comprising, a yarn guide passage, a fluid inlet passage, a fluid outlet passage, and a jet passage, said jet passage having a jet opening, said yarn guide passage opening into the jet passage and toward the jet opening of the jet passage, said fluid inlet opening into the jet passage so as to introduce fluid substantially transversely against said jet passage, each opening of said yarn guide passage and said fluid inlet passage being positioned adjacent to each other, said fluid outlet passage opening into the jet passage in the vicinity of the openings of the yarn guide passage and the fluid inlet passage, whereby a portion of the fluid introduced into the jet passage through the fluid inlet passage is discharged from the fluid outlet passage disturbing the flow of the fluid and the yarn in the jet passage, a major part of the fluid being ejected together with the yarn from the jet opening of the jet passage to the outside of the nozzle forming a processing turbulent area.

3. A nozzle according to claim 2, wherein said jet passage has a sectional area of 1 to 5 times of available total sectional area of fluid inlet opening, and an outlet having a sectional area of 0.2 to 5 times the effective total sectional area of fluid inlet and is arranged within the range of 5 times the diameter of jet passage from the center of fluid inlet.

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