Oct. 20, 1970 M. S. M. LEFEBVRE 3,534,453

PROCESS FOR CONVERTING TEXTILE THREADS

Filed Jan. 15, 1968 4 Sheets-Sheet 1

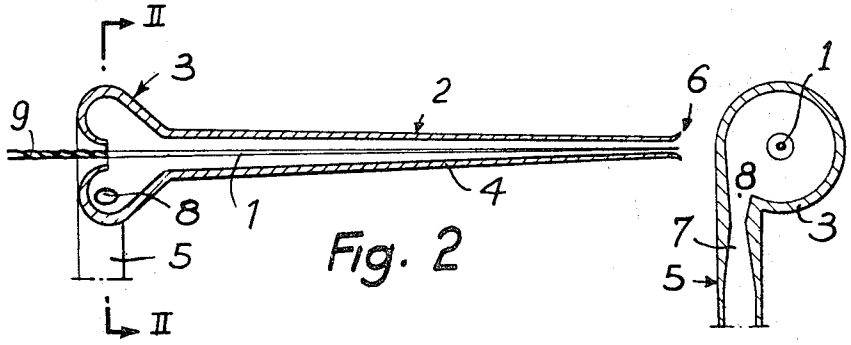


Fig. 2

Fig. 2a

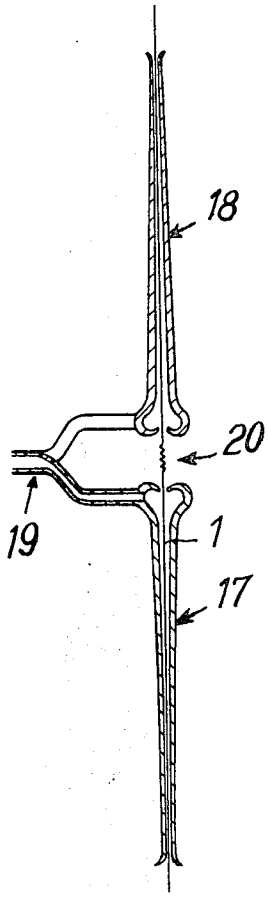


Fig. 3

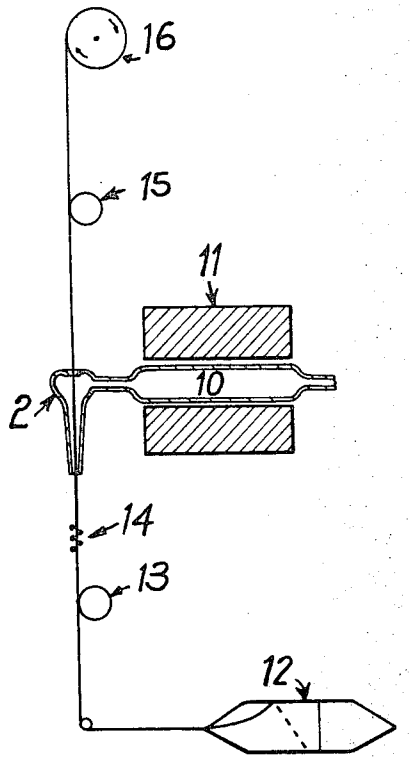


Fig. 1

PROCESS FOR CONVERTING TEXTILE THREADS

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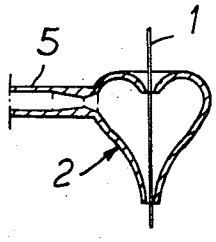


Fig. 4

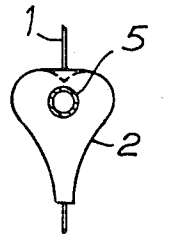


Fig. 4a

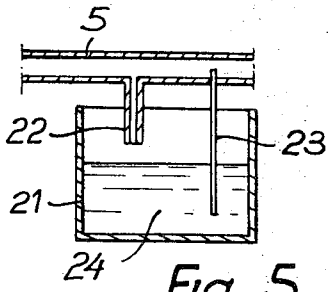


Fig. 5

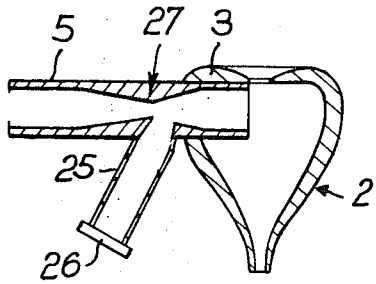


Fig. 6

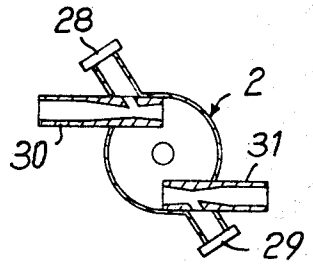


Fig. 7

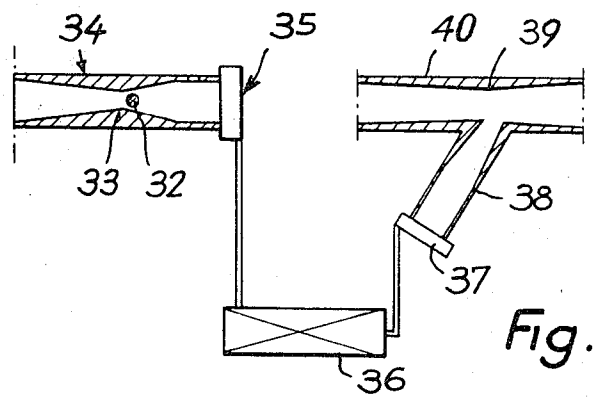


Fig. 8

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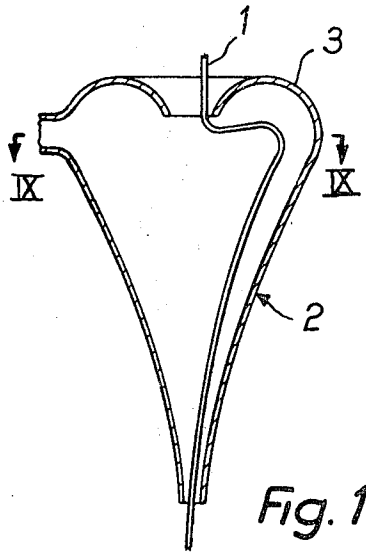


Fig. 10

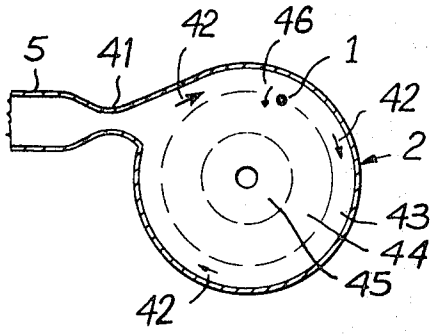


Fig. 9

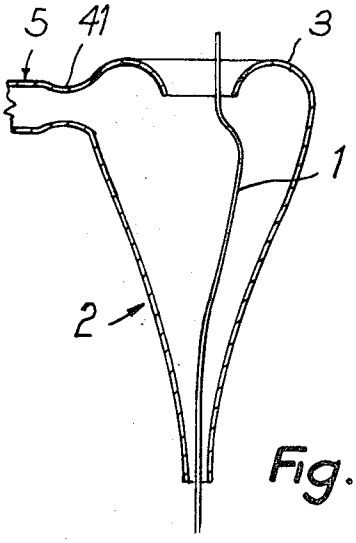


Fig. 12

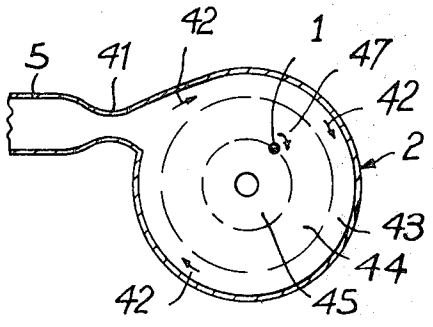


Fig. 11

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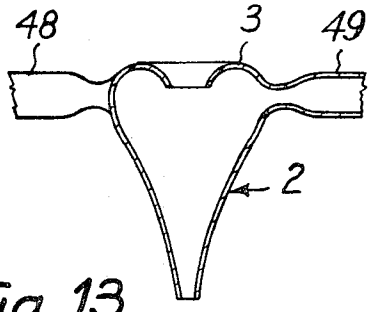
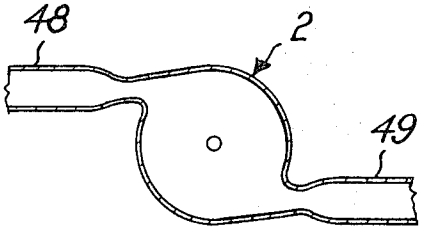


Fig. 13

Fig. 14



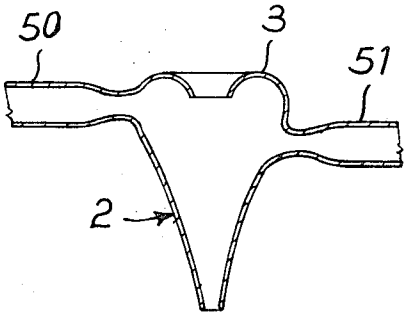
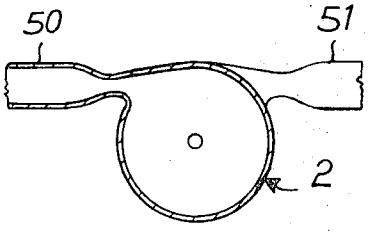


Fig. 15

Fig. 16



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3,534,453

PROCESS FOR CONVERTING TEXTILE THREADS

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Claims priority, application France, Mar. 23, 1967, 18,862
Int. Cl. D02g 1/16
U.S. Cl. 28—72.12 8 Claims

ABSTRACT OF THE DISCLOSURE

A conversion process for textile thread in which the thread moves in hot gas subject to the action of shock waves which deform and fix the thread.

In a known process for converting and more particularly texturising threads of textile materials, a hot gas stream, for example, air, and a thread are introduced into a nozzle. The air stream is rotated and therefore provides a simple, rapid and cheap way of twisting the threads, as well as fixing them in the twisted state. This process is relatively slow and cannot provide very fine texturing.

It is an object of the invention to enable a wide variety of textured yarns, which may or may not have twist, to be produced at speeds, e.g. of the order of 1500 metres/minutes, never previously approached.

The invention accordingly provides a process for converting textile filaments wherein a filament of fibres or of continuous textile material moves in a preferably hot gas flow; and shock waves are produced very near the filament and deform the same and by means of heat, fix the fibres in their deformed state.

The invention also relates to facilities for performing the process.

For a better understanding of the invention, a detailed description will now be given of variants of the process hereinbefore defined and of embodiments of the facilities for carrying such variants into effect, reference being made to the accompanying drawings wherein:

FIG. 1 is a diagrammatic view of an embodiment of a system using the process according to the invention;

FIG. 2 is a diagrammatic view in section of an embodiment of the nozzle of the system shown in FIG. 1;

FIG. 2*a* is a view in end elevation of an axial section on the line II—II of the nozzle shown in FIG. 2;

FIG. 3 is a diagrammatic sectioned view of another embodiment of the facility according to the invention;

FIG. 4 is a diagrammatic sectioned view of another embodiment of the nozzle;

FIG. 4*a* is an end view corresponding to FIG. 4;

FIG. 5 is a diagrammatic sectioned view of a dye evaporated associated with a nozzle;

FIG. 6 is a diagrammatic sectioned view of another embodiment;

FIG. 7 is a diagrammatic end view of a variant of the facility shown in FIG. 6;

FIG. 8 shows how the facility shown in FIG. 6 can be used to copy a yarn which has already been texturised;

FIG. 9 is a sectioned plan view of a nozzle operating in accordance with another variant of the process according to the invention;

FIG. 10 is a view in axial section of the nozzle shown in FIG. 9;

FIG. 11 shows a variant of the facility shown in FIG. 9;

FIG. 12 is a view in axial section of the facility shown in FIG. 11;

FIGS. 13 and 14 show another variant of the facilities shown in FIGS. 9 and 11, and

FIGS. 15 and 16 show another variant of the facilities shown in FIGS. 9 and 11.

In the process according to the invention, a thread 1 (FIGS. 1 and 2), is brought into a nozzle 2 comprising an inlet annulus 3, an elongated duct 4 and intake duct 5. The thread 1 enters the interior of the nozzle 2 through a central orifice 6, and a stream hot gas such as air at a pressure above the critical pressure enters the bulb or annulus 3 through the duct 5. The radial and axial inclination of the duct 5 relatively to the nozzle axis is such as to produce the familiar effect of the required amount of twisting, fixing and untwisting. The air then flows first through a convergent portion 7 and the through a divergent portion 8 and the flow becomes supersonic. Near the thread 1 the flow changes over abruptly from supersonic to subsonic, so that a shock wave is produced which deforms the thread at the height of the bulb 3. As the thread moves along inside the nozzle 2, the shock waves thus produced texturise, in accordance with the invention, the thread over its whole length so that a texturised roving or yarn 9 is obtained at the nozzle exit. Consequently, the thread 1 in the nozzle 2 is given texturising effects produced from the shock waves and twisting effects produced by the whirling flows.

The fibres at the level of the bulb 3 have a very high temperature. There is therefore heat fixing of the deformation by direct contact between the thread and the hot fluid, so that the heat is absorbed very rapidly.

FIG. 1 shows a complete installation in which the nozzle 2 is associated with a reactor 10 disposed inside an electric oven 11. The recator 10 takes the form of a large-diameter tube which heats the air and increases its kinetic energy. Thread 1 from a bobbin 12 is moved by doffing cylinder 13 which evens out uneven tension, whereafter the thread 1 goes through a grid or ring type tensioner 14 which determines the tension between the first doffer 13 and a second doffer 15, the textured yarn being taken up on a bobbin 16. One possibility with this system is that the tension of the yarn in the nozzle can be varied so that textured products of different qualities can be obtained.

In another variant, shown in FIG. 3, the process according to the invention provides for the association of two identical nozzles 17, 18 connected to a common hot-air supply duct 19. The path of the yarn or thread 1 is the common axis for the two nozzles. The yarn 1 is rotated to the right in one nozzle and then to the left in the other so that a local twist which the hot fluid fixes by heat is produced at a place 20.

In another variant of the process according to the invention and shown in FIGS. 4 and 4*a*, a separate hot-fluid supply duct 5 centred on the axis of the nozzle 2 can be used for each nozzle, in which event the associated twist feature disappears and the texturising effect is the result solely of the shock waves.

In another variant of the invention, shown in FIG. 5, each nozzle of the kind just described can be associated with a dye evaporator mainly comprising a tank 21 and two ducts 22, 23 connected to the hot air supply duct 5. Liquid 24 to be evaporated goes through the duct 23 into the duct 5 and is evaporated therein. One feature of this process is that, in cases in which the evaporator is associated with nozzles in which the fluid forms a whirling motion, dyed textured yarns can be produced which has a high dye concentration also, the dye can be injected while the fibre yarn is at its most spread-out, thus ensuring satisfactory dyeing throughout the body of the yarn. Also, two different dyes can be injected into the nozzle at two places corresponding to two states of the yarn, so that the yarn interior can be dyed in one way and the yarn exterior can be dyed in a different way; to this end, a single nozzle comprises a number of hot air supply ducts which are identical to the duct 5 and which are disposed at various places of the nozzle. Of course, the evaporation facility just described can be

adapted to any nozzle, whatever the direction and number of the hot air supply ducts may be.

In the variant shown in FIG. 6, the fluid supply duct 5 has associated with it a secondary duct 25 closed by an ultrasonic generator in the form of a loudspeaker 26 comprising a metal diaphragm or any other diaphragm or member adapted to produce "hyper-frequency" vibrations. On no-load operations, the pressure upstream of a venturi 27 is just below the critical pressure. In the bulb 3 the hot fluid changes over to subsonic flow. Corresponding to each vibration transmitted by the diaphragm 26 is a pressure wave which produces a local pressure increase in the venturi throat, the fluid changing over to supersonic flow in the nozzle. The changeover from one form of flow to another produces a shock wave which texturises the yarn.

Of course, the ultrasonic generator just described is of use with any of the nozzles hereinbefore described and can be used together with the evaporation facility shown in FIG. 5. A number of ultrasonic generators of the same frequency can be associated with the said number of hot air supply ducts distributed uniformly around the nozzle axis. Each generator produces a shock wave field which is staggered in time by an amount corresponding to the inverse of the number of generators. The generators can produce a rotating shock wave field whose frequency is the same as the frequency of the generators.

In the case shown in FIG. 7, two generators 28, 29 are associated with one another and are disposed in two hot air supply ducts 30, 31 disposed symmetrically of the axis of the nozzle 2. The resulting shock wave fields are therefore in phase opposition.

The use of ultrasonic generators enables the invention to be used to reproduce a standard yarn. To this end, and as shown in FIG. 8, a yarn 32 which it is required to copy is placed in the throat of a venturi 33 in a duct 34 through which air flows. A microphone 35 is placed at one end of the duct 34 and transmits the vibrations which it picks up to an amplifier 36 connected to an ultrasonic generator 37 disposed in a duct 38 which extends to a venturi 39 of a hot air supply duct 40 for a nozzle (not shown). A textured yarn can therefore be produced which accurately copies the features of the control or standard yarn 32 as "analysed" by the microphone 35.

The aim of other variants shown in FIGS. 9–16 is to speed up texturisation and the twisting-untwisting effects of the yarns.

In the embodiment shown in FIGS. 9–12, the apparatus comprised as previously a nozzle 2 whose bulb 3 receives hot air through a duct 5 comprising a venturi 41. The air in the duct 5 is at a pressure above the critical pressure. As the air goes through the venturi 41, the flow becomes supersonic and takes the form of a vortex whose axis is the axis of the nozzle 2 and which rotates in the direction indicated by arrows 42 and whose supersonic portion is bounded by the boundary layer in contact with the nozzle walls and by the leakage fluid flows at the nozzle entry and exit. The nozzle exit orifices are of large enough diameter not to disturb the annular flow.

In FIG. 9, which is a section along the line IX—IX of the device shown in FIG. 10, there are three concentric flow zones 43–45. The outer zone 43 is formed by the boundary layer and is the boundary near the nozzle walls for the supersonic flow. The central zone 44 is the supersonic flow zone, and the innermost zone 45 is the zone of return subsonic flow. The relative position of the boundary between the zones 43 and 44 depends upon the Reynolds number of the flow in contact with the nozzle walls. The relative position of the boundary between the zones 43 and 44 depends upon the air intake pressure at the nozzle entry and corresponds to the minimum radius of curvature at which the latter pressure balances centrifugal force.

Referring to FIG. 10, yarn 1 for treatment enters through the bottom orifice of the nozzle, goes therethrough and leaves the nozzle through its top orifice associated with the bulb 3.

In a first kind of operation, the yarn 1 is in the positions shown in FIGS. 9 and 10 and is disposed at the boundary between the flow zones 43 and 44. The yarn 1 experiences an overall rotation, in the direction of the flows, around the nozzle axis. The positioning of the yarn between the zones 43 and 44 is stable, for if the yarn enters the zone 43 its rotational speed around the nozzle axis decreases—since the linear flow speed is subsonic and decreases with distance away from the axis—the centrifugal force balanced by the yarn tension decreases, and the yarn tends to move back towards the nozzle axis. If the yarn enters the supersonic zone 44, it is surrounded by the pressure shock wave which forces it towards the boundary between the flows 43 and 44, in which zones there are shock waves limiting supersonic flow. Also, if the yarn enters the zone 44 its rotational speed around the nozzle axis increases, centrifugal force increases, and so the yarn tends to return to the boundary between the zones 43 and 44. The yarn is therefore stabilised. Also, the yarn has its outer surface near the subsonic flow of the zone 43 and its inner surface near the supersonic flow of the zone 44. A torque is therefore produced which tends to twist the yarn in the direction indicated by the arrow 46 and opposing the overall rotation of the yarn around the nozzle axis.

The speed of yarn rotation around the nozzle axis is of the order of 20,000 r.p.m. and the twist speed its higher than one million r.p.m. Because of its rotation around the nozzle axis, the initially twisted yarn untwists and spreads out, and so the rate of yarn twisting increases.

In a second kind of operation, the yarn is in the positions shown in FIGS. 11 and 12 and located on the boundary between the flow zones 44 and 45. The yarn is of an overall rotation around the axis in the directions of the flows. The position between the zones 44 and 45 is an unstable one, for if the yarn enters the zone 45 its rotational speed around the nozzle axis decreases, so that centrifugal force decreases and the yarn tends to enter the zone 45 even further. The overall rotational speed of the yarn increases and the same tends to enter the zone 44 further.

However, some stability can be obtained. The yarn enters the zone 44, it is surrounded by a pressure shock wave which tends to bring the yarn into contact with the shock waves bounding the supersonic flow zone 44, so that the yarn tends to take up a position at the boundary between the zones 45 and 44. Consequently, by adjustment of yarn intensioning, the yarn can be positioned as required either between the zones 43 and 44 or between the zones 44 and 45. Similarly and by analogy with what happens in the embodiment shown in FIG. 9, the yarn experiences a twisting torque which in this case twists the yarn in the same direction—indicated by the arrow 47—as the direction of overall yarn rotation around the nozzle axis. However, since the difference between the flow velocities on either side of the yarn is less than in the previous case, the twist speed is also less.

In a third kind of operation, the tension is adjusted permanently so that the yarn can go very rapidly from the position in FIG. 9 to the position in FIG. 11, then back to the position shown in FIG. 9, and so on, so that a single yarn having zones of opposite twist can be produced very rapidly.

FIGS. 13–16 show variants of the facilities shown in FIGS. 9–12.

Referring to FIGS. 13 and 14, the nozzle 2 comprises two identical hot air supply ducts 48, 49 disposed symmetrically of the nozzle axis 2 and at the level of the bulb 3. This feature helps to increase the fineness of texturing. In this case an increased number of hot air supply ducts can be provided.

Referring to FIGS. 15 and 16, the nozzle **2** comprises two identical hot air supply ducts **50**, **51** which are disposed at two different levels of the nozzle and which are adapted to produce flows in opposite directions. A friction zone is therefore produced between two supersonic flows, the friction zone having two shock wave zones in which the associated planetary twist and the texturing by shock waves proceed more rapidly.

Of course, a dye or blueing evaporator similar to the one shown in FIG. 5 can be associated with the facilities shown in FIGS. 9 and 10.

Also, in all the facilities hereinbefore described yarn deformation is fixed thermoplastically by the yarn being heated by the fluid flowing through the nozzle. Of course, the yarn can, if required, be heated prior to entering a nozzle supplied with cold air, or the wire can be preheated and the nozzle supplied with hot air.

The process according to the invention makes it possible to produce a wide variety of textured yarns, with or without twist, at speeds, e.g. of the order of 1500 metres/minute, never previously approached. The texturing is much more regular than conventional processes can provide, inter alia by a pneumatic and thermodynamic looping of the facilities. The yarns are textured without rough contact of moving mechanical parts, and so delicate materials can be textured.

Also, in the facilities shown in FIGS. 1–3 and 6–8, a yarn having a variable twist can be produced by modification of the angle which the yarn leaving the nozzle makes with the nozzle axis; the maximum angle at which the nozzle can be used corresponds to an untwisted textured product. In the special case in which a double nozzle is used, a yarn without twist is produced if the textured product goes through a double nozzle whose direction of rotation is the opposite of the first double nozzle supplied with cold air, during the cooling of the "textured" yarn.

In the facilities shown in FIGS. 9–16, on the other hand, two opposite twists can be fixed separately or alternatively on a single yarn.

The products provided by the process and the variants thereof hereinbefore described can be recognized in several ways. One such way is a reversal of the direction of twist over a reduced length of the processed yarn, due mainly to random contacts between the yarn and the nozzle wall. Another sign is the appearance of a falze Z- or S-twist on the discrete filaments, due to the filaments rubbing on a surface which is either real (e.g. the nozzle wall) or virtual (boundary layer between a supersonic flow and a subsonic flow).

I claim:

1. A process for converting textile threads, comprising moving a textile thread in a stream of gas, heating the thread so that it is hot as it moves in the stream of gas, generating shock waves in the stream of gas near the thread, subjecting the moving thread to said shock waves whereby to deform it, and fixing the thread in its deformed state.

2. A process as set forth in claim **1**, comprising subjecting the fiber to tension as it is subjected to shock waves in the gas stream.

3. A process as set forth in claim **1**, comprising heating the gas which flows in the stream, and heating the thread by contact with the heated gas stream.

4. A process as set forth in claim **1** wherein a plurality of fibers constituting a thread are similarly heated, moved in a gas stream, subjected to shock waves in the gas stream, and fixed in their deformed state.

5. A process as set forth in claim **1**, characterized in that the shock waves are produced near the thread by the change in flow of gas from the supersonic to the subsonic state.

6. A process as set forth in claim **3**, characterized in that the gas stream in the supersonic state is directed on to the thread to be treated.

7. A process as set forth in claim **3**, characterized in that the gas stream in the supersonic state is directed substantially perpendicularly to the thread axis so as to produce a whirling flow therearound.

8. A process as set forth in claim **1**, characterized in that the shock waves are modulated by microwave-frequency vibrations imparted to the gas flow when the same is initially in the supersonic state.

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JAMES KEE CHI, Primary Examiner

U.S. Cl. X.R.

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