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PROCESS AND APPARATUS FOR TEXTURING FILAMENTS

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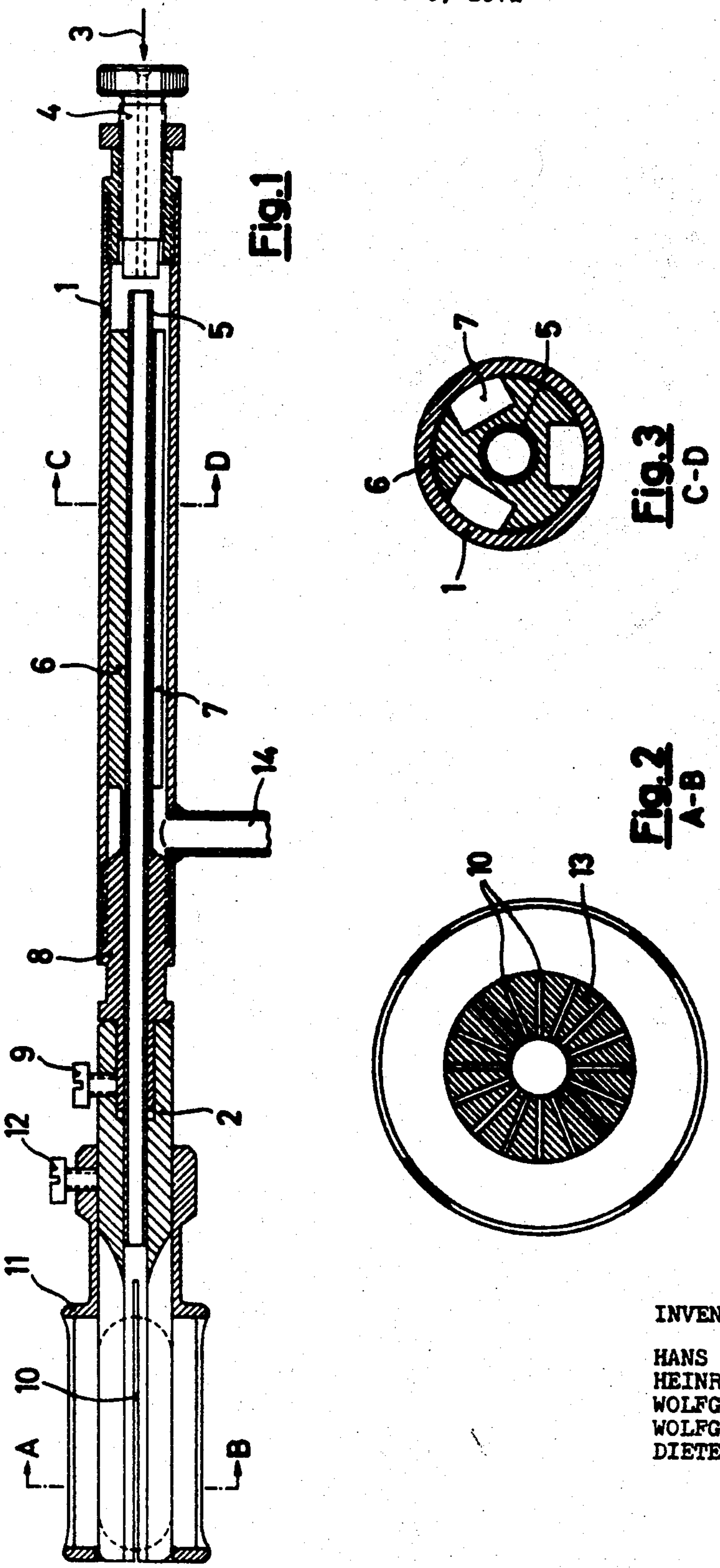

Fig.1

Fig.2 A-B

Fig.3 C-D

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PROCESS AND APPARATUS FOR TEXTURING FILAMENTS

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ABSTRACT OF THE DISCLOSURE

Process and apparatus for texturing filaments by subjecting the filaments to a flowing heated gaseous medium. The filaments are exposed to a turbulently flowing medium in two zones, an exchange between the medium and the ambient air taking place in the second zone. By means of this process and apparatus filaments made of synthetic linear materials of high molecular weight may be textured at high filament speeds.

This invention relates to a process and apparatus for texturing filaments by the action of a heated medium, the filaments being passed through tubular processing zones where they are exposed to the action of a turbulently flowing heated, preferably gaseous, medium.

A large number of processes for modifying the structure of normally smooth filaments composed of organic synthetic materials of high molecular weight is known, for example the use of stuffer boxes, false twisting, heated gears or knife edges. Other processes known for crimping filaments use streams of air.

According to one known process (Swiss Pat. 378,459) the filament to be textured is supplied by a heated medium to a chamber at a temperature ensuring fixing of the filament, crimping being effected by the action of the medium. Crimping of the filament is modified by causing some of the medium to leave the said chamber through lateral outlets, whilst the remaining part of the medium compresses the filament and ejects it from the chamber.

In another known process (Swiss Pat. 433,580) freshly spun polyamide-containing fibers are subjected, whilst still in a virtually amorphous, plastic state, to the quenching effect of a compressible medium at high speed, by which means the fibers are drawn and oriented between the spinneret and the point of application of the medium, which is applied to the fibers at an angle such that the resulting turbulent flow causes irregular crimping and tangling of the fibers.

However, these processes are not satisfactory in all respects. For example, the rate at which the filaments are textured in these processes may be inadequate or the action of the air inside the air nozzle may cause irregular drawing of the filaments, in which case the latter will show varying degrees of dyeability.

It is an object of the invention to provide a process and apparatus for the manufacture of evenly textured filaments, the said process and apparatus being simple, trouble-free and capable of high rates of production.

In accordance with the invention, the process com-

prises the manufacture of textured filaments composed of synthetic linear materials of high molecular weight by passing the filaments through tubular zones which the filaments are subjected to the action of a flowing heated medium, preferably a gas, wherein the filaments are subjected to a turbulently flowing medium in a location between a filament inlet channel and a filament guide channel in which the filaments are heated to a temperature at which re-orientation occurs in the filaments, the flow of medium being such that it guides the filaments through the filament guide channel and past a point where there is a sudden increase in cross-section causing a suction effect, and into and through a slightly tapered processing zone having radical orifices extending in the longitudinal direction and through which a turbulent partial exchange takes place between the flowing medium and the ambient air so as to cause a sudden temperature drop, the length of said orifices and the distance between the filament guide channel and the said orifices being adjusted so as to promote resonance and cause a continuously moving stellate baffling effect to be automatically exerted on the filaments in the reduced temperature zone where the filaments are stabilized without adhering to each other.

The invention also comprises an apparatus for the manufacture of textured filaments of synthetic linear materials of high molecular weight using flowing heated medium, preferably a gas, in tubular processing chambers, which apparatus comprises a closed first processing chamber having an inlet tube for the supply of medium, a filament inlet channel at one end of the processing chamber, a filament guide channel which projects into the said processing chamber from its other end, said filament guide channel being rigidly attached to the said first processing chamber and the ratio of the internal diameter of the filament guide channel to that of the filament inlet channel being from 1.1 to 4:1 and the distance between the filament guide channel and the filament inlet channel being from 0.1 to 3 mm., and a second, slightly tapered processing chamber located at the free end of the filament guide channel and provided with slots, the length of which may be adjusted by means of a displaceable metal member.

According to an advantageous embodiment of the apparatus of the invention, the displaceable metal member is in the form of a muzzle cover.

According to a further feature of the invention, the filament guide channel is connected to the first processing chamber by means of a centering element which is advantageously in the form of a flow guide.

By filaments we mean continuous structures such as yarns, bundles of filaments, individual filaments or tapes, flat filaments and split fibers obtained from sheeting, and strips of sheeting. The filaments denier may be for example from 1 to 30 and preferably from 10 to 30. The number of individual filaments in the bundles or yarns may be from 2 to several thousand. The filaments in the filament bundles or yarns may be stretched or partially stretched before being subjected to crimping. It is also possible to use filaments having a round cross-section or a profiled, for example trilobate, cross-section. It may be convenient for the bundles of filaments or yarns to exhibit a certain amount of twist, for example a twist of up to 30 turns per meter and in particular of up to 25 turns per meter. Such a twist serves to hold the bundles of filaments or yarns together to a certain extent such that the structure is easier to manipulate.

Suitable synthetic linear or substantial linear fiber-forming organic high polymers for the production of the filaments are, in particular, conventional linear synthetic high molecular weight polyamides having recurring carbamoyl groups in the backbone, linear synthetic high molecular weight polyesters having recurring ester groups in the backbone, filament-forming olefin polymers, filament-forming polyacrylonitrile or filament-forming acrylonitrile copolymers containing a major proportion of acrylonitrile units, and cellulose derivatives such as cellulose esters. Suitable high molecular weight compounds are, for example, nylon 6, nylon 6,6, polyethylene terephthalate, linear polyethylene and isotactic polypropylene.

A preferred way of carrying out the process of the invention is described below:

The filaments to be crimped are drawn from a supply package and fed by means of a conventional conveying device at a constant, adjustable speed through a filament inlet channel to the filament guide channel. At the same time, a heated gaseous medium is passed under pressure through a centering element in a direction opposite the direction of movement of the filaments, to the inlet of the filament guide channel, where the stream of medium impinges on the filaments approximately perpendicularly thereto. The stream of heated gaseous medium is diverted through 180°, during which process flow losses occur to an extent depending on the dimensions of the filament guide channel and the filament inlet channel. Another factor influencing the flow losses is the distance between the two guide channels. This distance is also a factor controlling the amount of turbulence caused by the diversion of the gas stream. Under the action of the turbulent flow of heated gaseous medium, the filaments are heated to a temperature at which re-orientation and recrystallization processes take place, and the filaments are loosened, that is, the individual filaments are separated from each other, and the filaments are conveyed by friction forces through the filament guide channel into and through a processing zone. This processing zone, which is in the form of a slotted nozzle, is the zone where the actual texturing of the filaments takes place due to an exchange occuring between the flowing medium and the ambient air and the turbulence thus caused. The conditions of flow, that is, the degree of turbulence, are determined by the length of the slots, which may be adjusted by a displaceable metal member, and also by the distance between the end of the filament guide channel and the point of commencement of the longitudinal slots, and may be set at an optimum level such that the flowing medium is subjected to a resonance amplifying effect. The resonance peak may be ascertained from the noise produced and is readily determined by simple experiment. At the point of commencement of the slots, as considered in the direction of flow, subatmospheric pressure occurs due to the speed of the flowing medium and the sudden increase in cross-section of the filament guide channel. The resulting sucking effect and consequent suck-in of the ambient air lead to a sudden temperature drop in the flowing medium, which results in fixing of the crimped filaments decelerated by friction.

The slots serve not only to allow ambient air to flow into the processing zone but also to cause the crimping action on the filaments to be such that a stellate roving is formed. Such so-called stellate crimping represents an improvement in filament crimping as regards the three-dimensional properties (specific volume, bulk).

It may be advantageous to arrange for the filaments or filament bundles coming from a stretching apparatus to be passed directly to the apparatus of the invention by conveying means. However, it may be desirable to clean the filaments or filament bundles before texturing, for example by passing them through a cleaning device.

The filaments, after being threaded through the apparatus, are conveyed through the filament guide channel and slotted nozzle by means of the stream of gaseous medium. No special equipment is required to withdraw the treated filaments from the apparatus. However, as the filaments leaving the slotted nozzle have relatively high temperatures, it is advantageous to cool them either hanging freely or under slight tension, before they are wound up. If they are left to cool on the package, excessive stresses occur in the filaments. A suitable cooling device, for example, is one in which the filaments are cooled between a delivery roll and a coolent-cooled cooling sleeve. To ensure that the filaments are entrained by the rotating delivery roll, the latter is provided with a special surface, for example a covering of velvet. The surface of the cooling sleeve is of polished metal. The filaments may then be fed to a take-up package.

Suitable gaseous media for use in the present invention are those normally used in the treatment of filaments, for example nitrogen, carbon dioxide, steam and air, the latter being particularly preferred for economical reasons. It may be desirable to filter the gaseous media to remove solid particles. Surprisingly, the air causes no discoloration (yellowing) of the filaments at the temperatures used, which are usually very high.

In order to insert a permanent crimp, the filaments must be softened by the gaseous medium without adhering to each other. The necessary temperature of the gaseous medium may vary within wide limits. In general, a temperature of from 80° to 550° C. has been found useful in the process of the invention. The actual temperature required depends on the melting or softening range of the fiber-forming materials, on the period of action of the gaseous media on the filaments, on any preheating which may have taken place and on the thickness of the filaments. The gaseous medium may be at a temperature well above the melting or decomposition point of the filament-forming materials used, particularly when the filaments are passed through the processing zones at a high speed, that is, at short residence times.

If the bundle of filaments is fed through the crimping apparatus at a relatively low speed, for example at from 50 to 150 m./min., it is advantageous to use the gaseous medium at a temperature which is only slightly above the softening range of the high molecular weight material used, for example from 10 to 30° C. above the said softening range. Examples of softening ranges are: linear polyethylene from 80° to 90° C.; polypropylene from 80° to 120° C.; nylon 6,6 from 210° to 240° C.; nylon 6 from 165° to 190° C.; polyacrylonitrile from 215° to 255° C. and polyethylene terephthalate from 190° to 230° C. If the bundle of filaments is fed to the first processing zone at higher speeds, the resulting shorter residence times of the filaments in the zones call for higher temperatures of the gaseous medium. For example, where a bundle consisting of 268 filaments of nylon 6 and having a total denier of 4400 is fed to the apparatus at a speed of about 800 m./min., the gaseous medium must be at a temperature of from 350° to 430° C., and at a speed of introduction of the filaments of 1200 m./min., the temperature of the gaseous medium should be from 470° to 520° C., the bundle of filaments not being preheated in either case. The upper limit of the temperature of the gaseous media used is at about 550° C. and is set by the thermal resistance of the materials of which the crimping apparatus is made. The optimum temperatures for each type of filament may be readily determined by simple experiment.

It will be appreciated that the temperature of the gaseous medium required to impart a permanent crimp to the filaments may advantageously be reduced by preheating the bundle of filaments. It is often convenient to feed filaments or filament bundles, which have just been drawn at from 120° to 160° C., to the processing zones of the invention while still hot.

Alternatively, the filaments may, of course, be passed over conventional heating means, such as heated godets or plates, before being fed to the apparatus of the invention.

The rate of flow of the gaseous medium is substantially determined by the pressure at which it is passed into the apparatus used and by the size of the apparatus. We have found initial gas pressures of from 3 to 7 atmospheres gage and particularly from 4 to 6 atmospheres gage to be convenient.

Gas throughputs of from 3 to 7 $m.^3$/hr. and particularly from 3.8 to 5.8 $m.^3$/hr. (S.T.P.) have been used in the apparatus of the invention.

The invention is described below with reference to one embodiment of the apparatus of the invention illustrated diagrammatically in the accompanying drawings, in which:

FIG. 1 is a longitudinal section through the two processing zones located in line with each other;

FIG. 2 is a cross-section of the apparatus shown in FIG. 1 taken along the line A–B of FIG. 1; and

FIG. 3 is a cross-section of the apparatus shown in FIG. 1 taken along the line C–D of FIG. 1.

Referring to FIG. 1, an advantageous embodiment of the apparatus of the invention essentially comprises two inter-connected processing chambers **1** and **2** arranged in line with each other. The first processing chamber **1** consists of a cylindrical tube having female screw-threads at each end. To one end of this tube there is screwed a filament inlet channel **4** serving to feed the filaments **3** to the processing chamber **1**, to the other end of which a filament guide channel **5** is screw-connected. That portion of the filament guide channel **5** which is near its end next to the filament inlet channel is surrounded by a centering element **6** provided with longitudinal air grooves **7**. A portion of the filament guide channel **5** remote from the filament inlet chamber is surrounded by a bush provided with a male screw-thread. A second processing chamber **2** is disposed on the free end of the filament guide channel **5** projecting from the processing chamber **1**. The second porcessing chamber **2** tapers very slightly in the direction of travel of the filaments and consists, as shown in FIG. 1, of a cylindrical slotted nozzle which fits coaxially over the filament guide channel **5** and is fixed in position thereon by means of a set-screw **9**. That portion of the nozzle which projects beyond the end of the filament guide channel **5** is provided with slots **10**. The distance between the end of the filament guide channel **5** and the point of commencement of the slots **10** is from 0.1 to 3 times and preferably from 0.8 to 1.4 times the external diameter of the filament guide channel **5**. The texturing effect increases with the number of slots, from 4 to 18 slots having been found to give favorable results. The width of the slots is conveniently from 0.3 to 1 mm. and preferably from 0.4 to 0.6 mm. The length of the slots **10** may be varied by moving a cylindrical metal element **11** which surrounds the nozzle coaxially and may be fixed in position thereon by means of a set-screw **12**. In a particularly advantageous embodiment, this displaceable metal element **11** is in the form of a muzzle cover.

The muzzle cover protects the sensitive lamellae **13** of the nozzle from mechanical damage and keeps the cross-section of the muzzle of the slotted nozzle constant irrespective of thermal and other stresses.

The gaseous medium required for the treatment of the filaments **3** passed through the chambers **1** and **2** is fed through the inlet **14** in a direction substantially perpendicular to the direction of travel of the filaments. The internal diameters of the filament inlet channel **4** and the filament guide channel **5** bear a relation to each other such that the major portion of the gaseous medium passes into the filament guide channel **5** to drive the filaments **3** (fed in through the filament inlet channel **4**) through the filament guide channel **5** into and through the processing chamber **2**.

The ratio of the internal diameter of the filament guide channel **5** to that of the filament inlet channel **4** is conveniently from 1.1 to 4:1, preferably from 1.8 to 2.2:1. The actual dimensions depend on the thickness of the filament or bundle of filaments to be crimped. It is generally convenient to use internal diameters which are not greater than necessary for filament transport, in order to minimize the consumption of gaseous medium. The distance between the filament guide channel **5** and the filament inlet channel **4** is from 0.1 to 3 mm. and preferably from 0.15 to 0.3 mm.

The overall dimensions of the apparatus of the invention as shown in FIG. 1 are relatively small; they are generally in the decimeter range and are advantageously between 10 and 30 cm.

The filaments treated according to the invention are elastic and very bulky and voluminous. It is not necessary to employ special means for separating the individual filaments in the crimped yarns or filament bundles. The individual filaments in the yarn or filament bundle show a serrated structure having serrations pointing in various directions. The filaments may be referred to as three-dimensionally crimped filaments. Due to their serrated structure, the textured filaments of the invention are elastic when subjected to tensile stresses. The great bulk and fullness of the filaments imparts particularly high covering power and a warm and pleasant handle to, say, woven fabrics produced from such filaments, if, for example, the filaments treated according to the invention are made into carpets, the pile of the carpets shows excellent resilience and covering power. The crimped filaments have a significantly greater affinity for dyes than untreated filaments.

The crimped filaments also show a good blooming effect, that is, they may be almost completely straightened by treatment by heat under tension to render them highly suitable for fabrication, e.g. for tufting, whilst they will regain their crimped structure almost completely when treated with hot water, as in dyeing operations for example.

The new process and apparatus are very simple and thus exceptionally trouble-free. The small size of the apparatus is worthy of particular note. Since the process and apparatus involve no complicated moving parts, none of the drawbacks associated with mechanically moved parts in other texturing devices, particularly at high rates of production, is evident in the present apparatus.

An outstanding advantage is the speed at which the filament may be crimped. Good texturing results are obtained when the filaments leave the second processing zone at speeds as great as 1200 m./min. or higher. We have found that such speeds are still feasible when texturing relatively high-denier filaments, such as filaments of up to 30 denier, in particular filaments of from 10 to 30 denier.

EXAMPLE 1

A 3900 den yarn made up of 67 individual filaments of nylon 6 is withdrawn from a package and passed through a stretching apparatus. The temperature of the initial stretching godet is 75° C. and that of the final godet is 110° C. The preheated, stretched filaments are then passed to the crimping apparatus shown in FIG. 1 at a speed of 800 m./min. Air is passed through the inlet **14** at a temperature of 300° C. and a pressure of 5.8 atmospheres. The internal diameter of the filament inlet channel **4** is 1.2 mm. The distance between the filament inlet channel **4** and the filament guide channel **5** is 0.3 mm. The filament guide channel **5** has an internal diameter of 2.4 mm. and an external diameter of 3.0 mm. and a total length of 127 mm. The cylindrical slotted nozzle located on the end of the filament guide channel **5** has an external diameter of 10 mm. and a length of 71 mm. The slotted nozzle has 16 slots extending over the full thickness of the nozzle wall and having a width of 0.5 mm. and a length of

39 mm. The muzzle cover **11** surrounding the slotted nozzle is positioned such that the exposed length of the slots is 28 mm. The muzzle cover stabilizes the muzzle of the slotted nozzle irrespective of thermal and other stresses. Resonance adjustments may be readily carried out by altering the position of the slotted nozzle on the filament guide channel. The filament passed through the apparatus shown in FIG. 1 shows particularly good crimp characteristics, because the turbulent movements imposed on the filaments in the processing zone **1** and the interior of the slotted nozzle **2** causes a continuous baffling effect.

The crimped yarn has the following properties: one measure of the texturizing effect is the so-called crimp rigidity by which is meant the following value. When a crimped filament is loaded with a weight of 0.002 g./denier, it experiences a length increase of "1" units. When it is loaded with a weight of 0.2 g./denier it experiences a length increase of "L" units. The "crimp rigidity" is given by the following expression:

$$\frac{L-1}{L}\times 100=\%$$

After storing in water at 60° C., the yarns crimped by the process of the invention have a crimp rigidity of 18.3%. The individual filaments in the yarn have an average of 100 serrations per 100 mm. The tensile strength is 2.93 g./denier, the breaking extension is 50% and the residual shrinkage after boiling is 2.5%.

The blooming effect is determined by carrying out three measurements of the crimp rigidity as follows:

(a) directly on removal from the package,
(b) after relaxation of a sample for 24 hours under normal conditions, and
(c) after boiling a sample for 5 minutes in water.

The values obtained under (a), (b) and (c) are 5.7%, 8.2% and 22.5% respectively. Relatively low, comparable values under (a) and (b) and a relatively high value under (c) are typical of a good blooming effect.

EXAMPLE 2

A prestretched yarn of nylon 6 is fed to a crimping apparatus as shown in FIG. 1 at a speed of 1250 m./min. The temperature of the air blown through the inlet **14** at a rate of 5 m.³/hr. is 540° C. The dimensions of the crimping apparatus are the same as those given in Example 1. The total weight of the yarn is 1150 denier and its breaking load is 4.02 kg. The yarn is boiled for 5 minutes and then has a crimp rigidity of 17.8%.

EXAMPLE 3

An 1180 den prestretched yarn of nylon 6 is preheated on passing through a roller drive and fed to an apparatus as shown in FIG. 1 and having the dimensions given in Example 1 at a speed of 1400 m./min. The temperature of the air blown in through the inlet **14** is 570° C. The crimped yarn has a breaking load of 3.4 kg. and a crimp rigidity of 16.7% following a boiling treatment lasting 5 minutes.

EXAMPLE 4

A 1200-den prestretched yarn of polyethylene terephthalate comprising 72 filaments is conveyed to an apparatus of the kind described in the previous examples by a feed mechanism such that the yarn travels at a speed of 850 m./min. The temperature of the blown air was

325° C. The textured yarn has a breaking load of approximately 3.8 kg. and a crimp rigidity of 31% following a boiling treatment lasting 5 minutes.

EXAMPLE 5

A 1000-den prestretched yarn of nylon 6,6 comprising 68 filaments is fed to the same apparatus as that described in the previous examples at a speed of 900 m./min. under a tensile stress of 50 g., where it is heated and textured by air blown in at a temperature of 390° C. and at a rate of 5.4 m.³/hr. The textured yarn has a breaking load of 4.3 kg. and a crimp rigidity of 17.2% following a boiling treatment lasting 5 minutes.

EXAMPLE 6

A 3000-den yarn of polyacrylonitrile comprising 200 filaments is fed to the same apparatus by a feed mechanism at a speed of 150 m./min. Air is blown into the apparatus at a rate of 5.6 m.³/hr. and a temperature of 510° C. The textured yarn has a breaking load of about 5.2 kg. and a crimp rigidity of 17.5% following a 5-minute boiling treatment.

We claim:

1. A process for the manufacture of textured filaments composed of synthetic linear materials of high molecular weight by passing the filaments through tubular zones in which the filaments are subjected to the action of a stream of a heated medium, preferably a gas, wherein the filaments are subjected to a turbulently flowing medium in a location between a filament inlet channel and a filament guide channel, in which the filaments are heated to a temperature at which re-orientation processes occur in the filaments, the flow of medium being such that it guides the filaments through the filament guide channel and and into and through a slightly tapered processing zone where there is a sudden increase in cross-section causing a suction effect, said zone having radial orifices extending in the longitudinal direction and through which a turbulent partial exchange takes place between the flowing medium and the ambient air so as to cause a sudden temperature drop, the length of said orifices and the distance between the filament guide channel and said orifices being adjusted so as to promote resonance and cause a continuously moving stellate baffling effect to be automatically exerted on the filaments in the reduced temperature zone, where the filaments are stabilized without adhering to each other.

2. A process for the manufacture of textured filaments as claimed in claim **1**, wherein the filaments treated are filaments of linear synthetic polyamides of high molecular weight and containing recurring carbamoyl groups in the backbone, filaments of linear synthetic polyesters of high molecular weight and containing recurring ester groups in the backbone or filaments of linear isotactic polypropylene.

3. A process for the manufacture of textured filaments as claimed in claim **1**, wherein the filaments treated are filaments of nylon 6 or nylon 6,6.

4. A process for the manufacture of textured filaments as claimed in claim **1**, wherein the filaments treated are filaments of polyethylene terephthalate.

5. An apparatus for the manufacture of textured filaments of synthetic linear materials of high molecular weight by means of a flow of a heated medium, preferably a gas, in tubular processing chambers, comprising a closed first processing chamber **1** having an inlet tube **14** for the stream of medium, a filament inlet channel **4** at one end of the said processing chamber **1**, a filament guide channel **5** which projects into the said processing chamber **1** from its other end, said filament guide channel **5** being rigidly attached to the said first processing chamber **1** and the ratio of the internal diameter of the filament guide channel **5** to that of the filament inlet channel **4** being from 1.1 to 4:1 and the distance between the filament guide channel **5** and the filament inlet channel **4** being from 0.1 to 3 mm., and a second, slightly tapered processing chamber **2** located at the free end of the filament guide channel **5** and provided with slots **10**, the length of which may be adjusted by means of a displaceable metal member **11**.

6. An apparatus as claimed in claim **5**, wherein the displaceable metal member **11** is in the form of a muzzle cover.

7. An apparatus as claimed in claim **5**, wherein the filament guide channel **5** is connected to the first processing chamber **1** by a centering element **6**.

8. An apparatus as claimed in claim **7**, wherein the said centering element **6** serves as flow guide.

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