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[54] **PROCESS AND DEVICE FOR THE MANUFACTURE OF A STRING FOR STRINGING TENNIS RACKETS OR THE LIKE AND STRING RESULTING THEREFROM**

[75] Inventor: **Gerard Longeat**, Lyons, France

[73] Assignee: **Babolat VS**, Lyons, France

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[52] **U.S. Cl.** **57/7**

[58] **Field of Search** 57/296, 297, 233, 57/234, 250, 251; 428/357, 364, 373, 374; 156/244.12, 244.23, 166, 148; 264/136, 137

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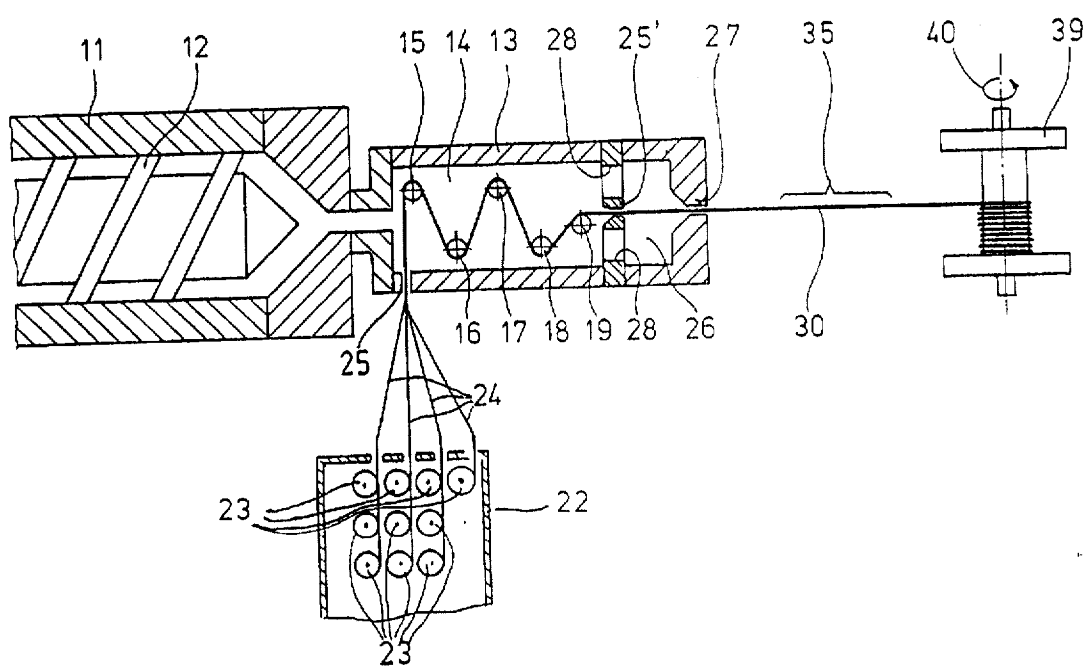
Primary Examiner—Charles T. Jordan
Assistant Examiner—Meena Chelliah
Attorney, Agent, or Firm—Oliff & Berridge, P.L.C.

[57] **ABSTRACT**

A process according to which filaments are embedded in a thermoplastic substance. The filaments pass through a chamber which is filled with a thermoplastic substance under pressure and made viscous by heating and the filaments run over a number of return members, thus having the effect of embedding the filaments in a matrix consisting of the thermoplastic. On leaving the chamber, the filaments pass through at least one die with the matrix in which they are embedded. The pseudo monofilament thus formed is subjected to a twist and is coated with a sheath of wear-resistant thermoplastic substance.

25 Claims, 5 Drawing Sheets



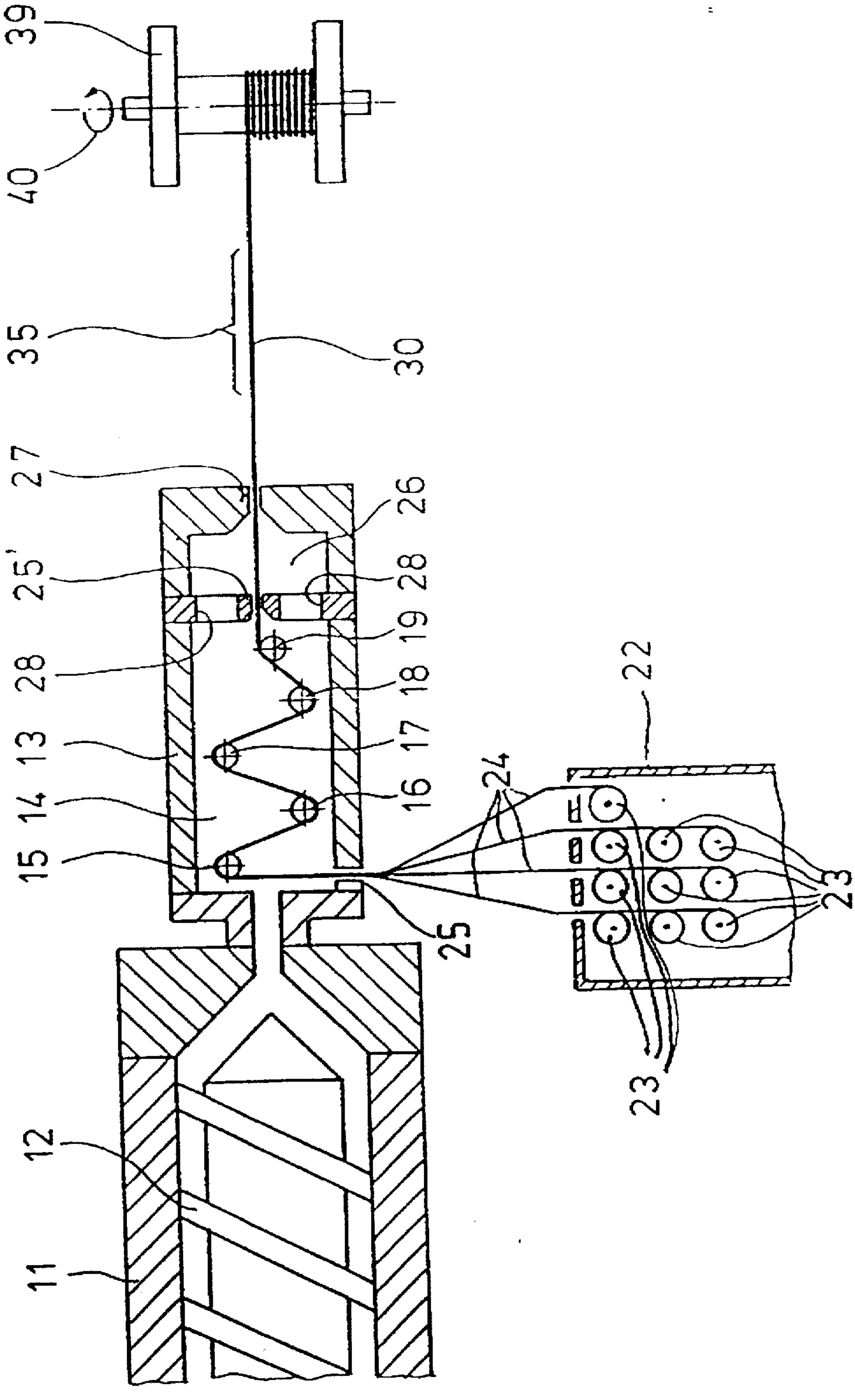


Fig.1

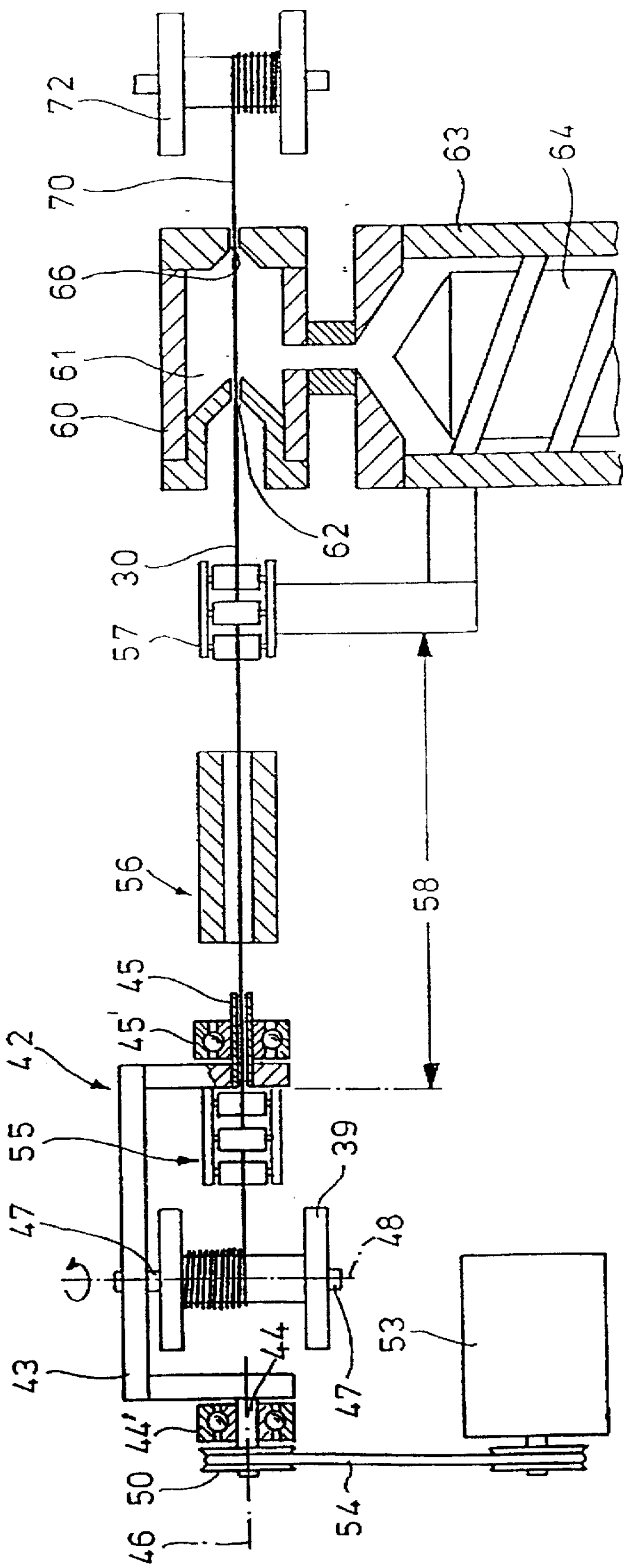

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Fig.2

Fig. 3 A

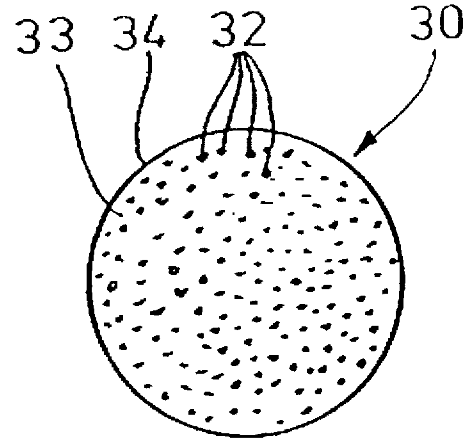


Fig. 3B

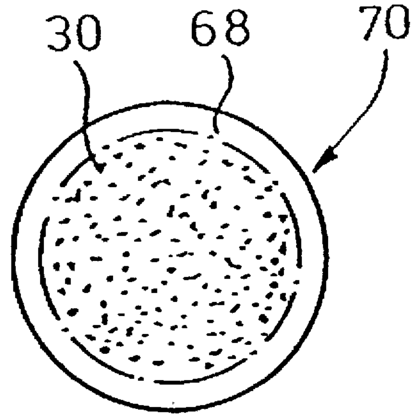
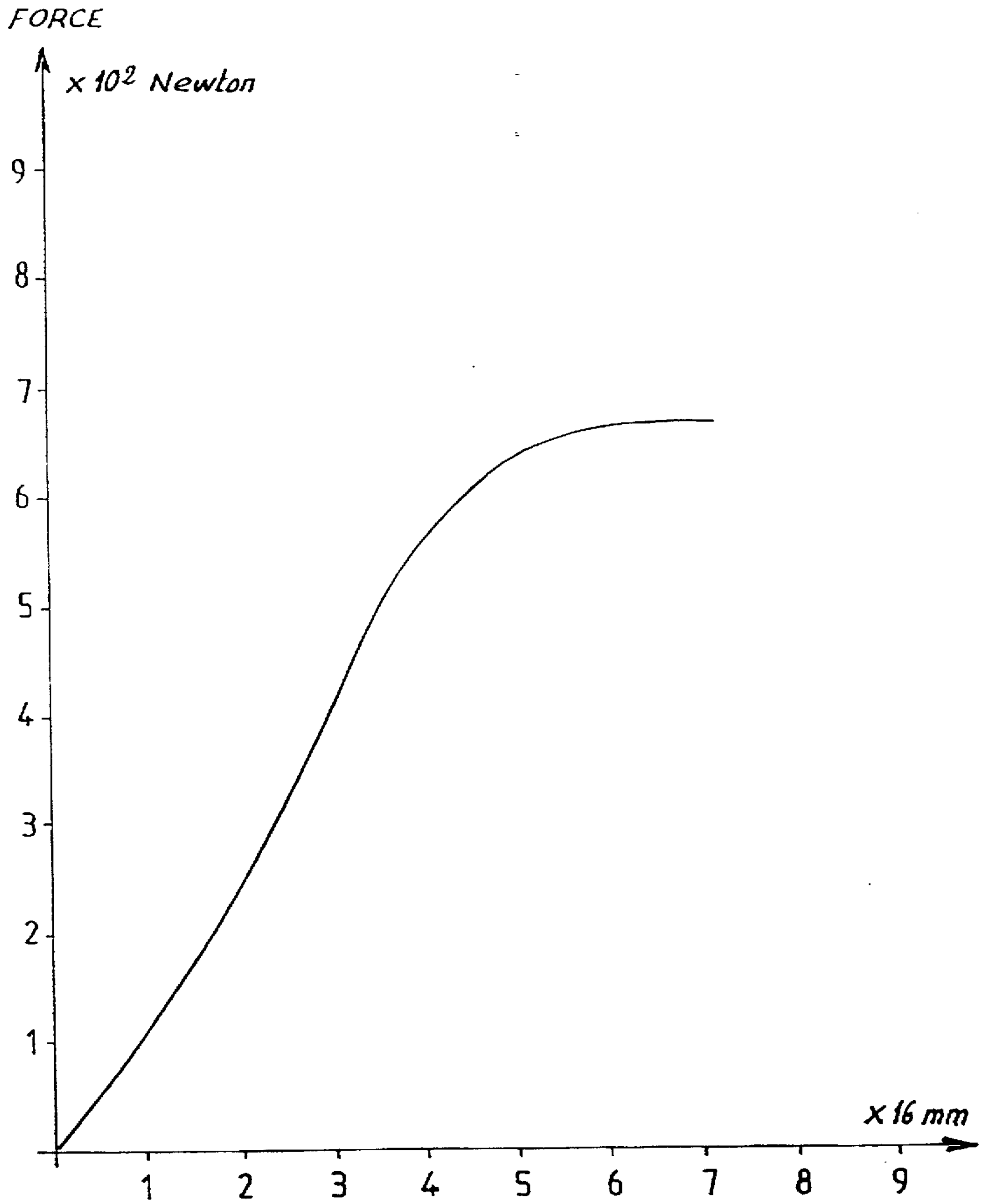


Fig. 4



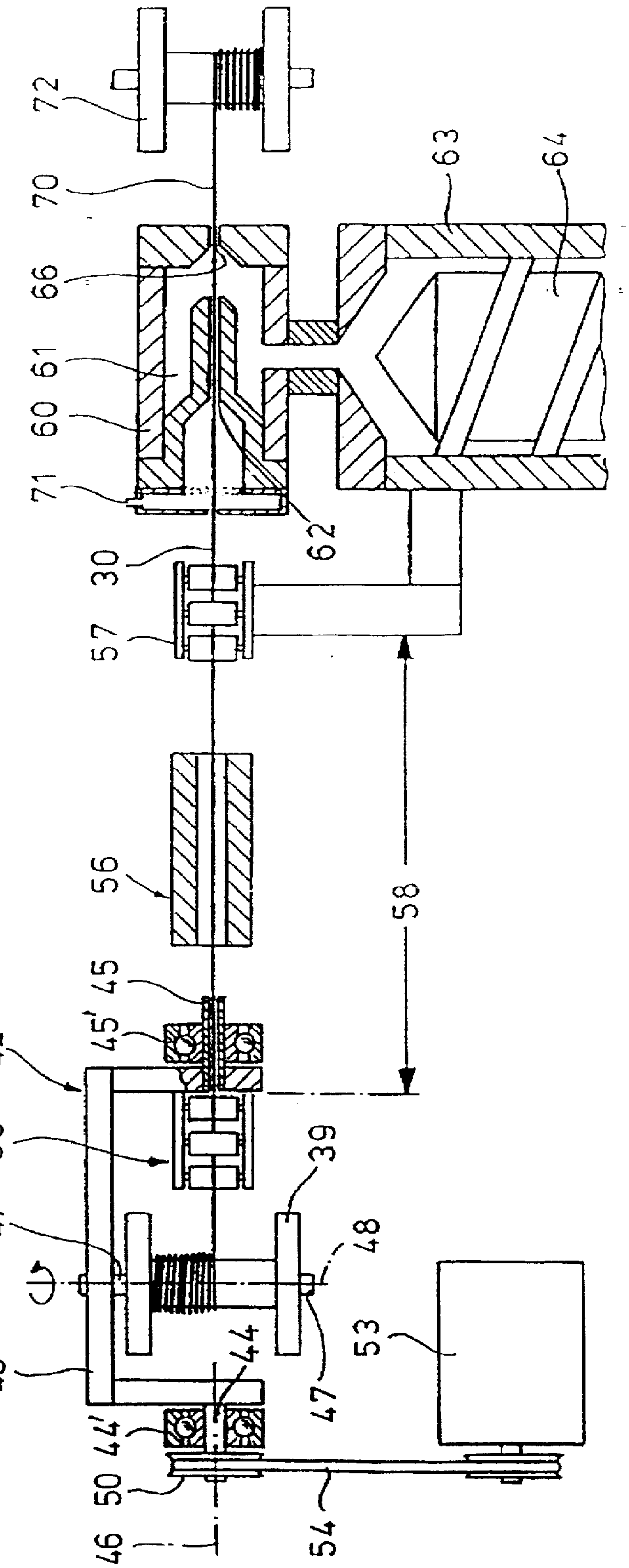

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Fig.5

PROCESS AND DEVICE FOR THE MANUFACTURE OF A STRING FOR STRINGING TENNIS RACKETS OR THE LIKE AND STRING RESULTING THEREFROM

BACKGROUND OF THE INVENTION

The present invention relates to a process for the manufacture of a string intended for stringing tennis rackets or the like, in which filaments are embedded in a thermoplastic substance. It also relates to a tennis string obtained by following this process and a device for implementing the process. A tennis string means a string intended for stringing tennis rackets or the like. A different use of this string is obviously not excluded.

A process of the abovementioned type is known from the document U.S. Pat. No. 4,707,977. A number of multiple strands consisting of monofilaments are combined in a die and a thermoplastic substance injected under pressure is injected onto and into this bundle of filaments so as to embed it in plastic. On leaving the die a twist is given to the bundle of filaments, it being possible for the string thus formed to pass again through a forming die before being cooled. It has been found, however, that the string thus formed does not yet satisfy all the requirements which are sought after, for example, in the case of a string intended for stringing a tennis racket, especially because of an insufficient bonding between the filaments and the plastic injected to embed them.

SUMMARY OF THE INVENTION

The invention is therefore intended to obtain an intimate bonding between the filaments and the plastic which embeds them, by a manufacturing process of the abovementioned type and at a low prime cost.

According to the process of the invention, the filaments pass through a chamber in which they run over a number of return bodies and which is filled with a thermoplastic substance under pressure and made viscous by heating, thus having the effect of embedding the filaments in a matrix consisting of this thermoplastic substance, on leaving the chamber the filaments pass through at least one die with the matrix in which they are embedded, the pseudo monofilament thus formed is subjected to a twist and is then coated with a sheath of wear-resistant thermoplastic substance. A tennis string is thus obtained, containing a high proportion of filaments and exhibiting an elongation/tension characteristic which is particularly favourable for the stringing of a tennis racket and resembling a gut string. Given that a die, at least can be precisely adapted to the number of monofilaments employed and that the latter are practically parallel to each other, a high proportion of filaments can be obtained in the pseudo monofilament obtained, by virtue of this process, the various filaments being very well embedded in the thermoplastic substance as a result of the multiple changes of direction to which they are subjected. Because of the twist and of the subsequent sheathing with a resistant plastic a tough final product is obtained which retains its form during the game of tennis or the like.

According to a preferred method of implementing this process, on leaving the first chamber the filaments in their matrix of thermoplastic substance pass successively through an intermediate die, a second chamber filled with heated thermoplastic substance and then an exit die. In this way it is possible to obtain, at the exit of the intermediate die, a pseudo monofilament which has a high proportion of filaments and then, by passing through the second chamber and the exit die, to deposit onto this pseudo monofilament a thin film of thermoplastic substance adhering perfectly to this pseudo monofilament. For this purpose, the last die is a few per cent larger in diameter than the intermediate die.

According to an advantageous embodiment of this process the pseudo monofilaments are wound onto a reel on leaving the die, this reel is placed on a rotating unwinder and the pseudo monofilament situated on it is unwound from the reel while applying thereto a rotation on two orthogonal axes, imparting the desired twist to the pseudo monofilament. This twist is advantageously from approximately 30 to 150 turns/m and preferably between 60 and 100 turns/m. During the twisting the pseudo monofilament advantageously passes through a heating tube where its matrix of thermoplastic substance and its outermost layer are heated and softened. This heating will be advantageously exploited to ensure an intimate bonding between the matrix and the subsequently extruded sheath. After the sheath extrusion, cooling and solidification of the matrix set the twist.

The length of pseudo monofilament to which the twist is applied is preferably limited by a combined system of a rotating roller brake and a stationary roller brake. The rotating roller brake is preferably situated upstream of the heating tube, while the stationary roller brake is preferably situated downstream of the heating tube.

The sheath can be produced with the same thermoplastic substance as the matrix in which the filaments are embedded, but it is preferably made of a substance which, depending on the use requirements of the string, is particularly tough, resistant to impacts, stable to light and insensitive to moisture, so as to make the string particularly resistant to stresses to which it is subjected, especially during the stringing of the racket or, subsequently during the game of tennis. The outer sheath preferably has a thickness of 0.05 to 0.1 mm so as to protect the filaments over the whole outer face of the pseudo monofilament, in order that the string shall retain its full strength, even under the effect of mechanical stresses.

BRIEF DESCRIPTION OF THE DRAWINGS

Other characteristics and advantages of the invention emerge from the detailed description which follows of an embodiment shown, by way of example without any limitation being implied, in the attached drawing, in which:

FIG. 1 is a view of the device for implementing the first stage of the process according to the invention,

FIG. 2 is a view of a first embodiment of the device for implementing the second stage of the process according to the invention,

FIGS. 3A and 3B are, respectively, a sectional view of the pseudo monofilament such as can be manufactured during the first stage of the process according to the invention (FIG. 3A) and of the pseudo monofilament surrounded by an outer sheath (FIG. 3B), that is to say the finished tennis string as resulting from the second stage of the process according to the invention,

FIG. 4 is a diagram which shows the elongation/tension characteristic of a tennis string obtained by implementing the process according to the invention, and

FIG. 5 is a view of a second embodiment of the device for implementing the second stage of the process according to the invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

FIG. 1 shows, on the left, an extruder 11 with an extruder screw 12 by means of which a thermoplastic substance originating from a hopper (not shown) can be injected into a tool **13** which has a closed chamber **14**. The tool **13** is kept at a constant temperature of, for example, 150° C. by a thermostatic heating device (not shown). The extruder screw **12** maintains a pressure of, for example, 3 bar in the cavity **14**. The thermoplastic substance employed may be, for example, a polyamide which has a low or intermediate viscosity at the controlled temperature.

In the chamber **14** there are, from the left towards the right in FIG. 1, for example, five return members **15** to **19**. In this example, ten reels **23** of multiple strands **24** consisting of uncoated monofilaments are placed in a rack **22**. The multiple strands **24** originating from the rack **22** enter, via a side opening **25**, the chamber **14** of the tool **13**. From the opening **25** these multiple strands **24** run, for example, successively towards the return member **15** by which they are diverted by approximately 160° towards the return member **16** by which they are diverted by approximately 140° towards the return member **17** by which they are diverted by 140° towards the return member **18** by which they are finally diverted by 140° towards the return member **19**. These multiple changes in direction result in a fanning out of the multiple strands so that each constituent monofilament can be sheathed in an optimum manner by the mass of plastic in the chamber **14**.

On leaving the last return member the multiple strands are directed towards a first die **25'** which can also be referred to as the intermediate die and the purpose of which is to form a pseudo monofilament which contains a high proportion of filaments and a low proportion of the matrix in which these filaments are embedded. From the first die **25'** the filaments pass through an outer chamber **26** in the direction of a second die **27** which may also be referred to as the last die and the purpose of which is also to form a pseudo monofilament **30** which contains a high proportion of filaments and a low proportion of the plastic matrix in which these filaments are embedded. In addition, the second die is intended to give the strand **30** a smooth surface. The chambers **14** and **26** are joined together by openings **28** and therefore contain the same molten plastic of low to intermediate viscosity. The temperature of this molten plastic is generally lower than the melting temperature of the monofilaments of the multiple strands **24**. The temperature of the molten mass is chosen so as to ensure an intimate bonding between the matrix and the surface of the constituent monofilaments of the multiple strand.

It should be noted that, owing the diversion on the return members **15** to **19**, the multiple strands **24** are flattened and fanned out, with the result that the monofilaments are in close contact with the molten plastic in the tool **13**. The strands could also be diverted in a direction perpendicular to the plane of the drawing in FIG. **1** in order to further improve the contact with the molten mass, but it has been found that with the type of return shown an excellent contact has already been obtained between the various monofilaments and the molten plastic. At the exit of the last die **27** a strand **30** is obtained which although consisting of many separate monofilaments—has the appearance of a monofilament and this is why it referred to here as a pseudo monofilament.

The last die **27** has, conveniently, a diameter which is a few hundredths of a millimeter, for example from 2 to 4%, greater than the intermediate die **25'**; for example in one embodiment, the intermediate die **25'** had a diameter of 1.2 mm and the last die **27** a diameter of 1.25 mm. It should be pointed that these dies are designed so as to leave only a thin layer of thermoplastic substance on the strand, outside, that is to say that, in a first stage of the process, the device of FIG. **1** makes if possible to produce a pseudo monofilament **30** such as is shown on a larger scale and very diagrammatically in FIG. 3A. It is essential that the individual monofilaments should be placed very close to the outer surface of the strand. The latter contains, for example, approximately 1,000 individual filaments **32** which have been embedded, in chambers **14** and **26**, in a matrix of thermoplastic substance **33**. The number of individual monofilaments is a function of the strength required in the tennis string and is generally between 700 and 2,800.

The filaments **32** may be made of polyethylene or polyamide, preferably polyamide **4-6**, and their embedding or sheathing substance may be polyethylene, polypropylene, or polyamide, and preferably polyamide **4-6**. The melting point of the plastic embedding matrix **33** is preferably less than that of the filaments **32**. Finally, the proportion of filaments **32** which this string contains is advantageously approximately between 55 and 90% by weight.

If it is assumed, for example, that each of the ten multiple strands **24** contains approximately 140 monofilaments, the pseudo monofilament **30** contains approximately 1,400 monofilaments in all. On its outer face, the strand **30** (FIG. 3A) preferably has only a thin layer of plastic **34** which would be hardly sufficient to protect the outer monofilaments.

On leaving the last die **27** the pseudo monofilament **30** is cooled in the region **35**, for example by a fan—not shown—and then wound onto a reel **39**, as shown by the arrow **40**. The reel **39** therefore contains the pseudo monofilament **30** with a thin outer layer **34** of thermoplastic substance.

The reel **39** with the pseudo monofilament **30** is placed, as shown in FIG. **2**, in rotating unwinder **42**. In this embodiment which is shown here by way of example, this unwinder comprises a C-shaped stirrup provided with two rotary shafts **44**, **45** and mounted in two ball bearings **44'**, **45'**, and which can therefore rotate about a lengthwise axis **46**. Perpendicularly to this lengthwise axis **46**, a spindle **47**, which defines a transverse axis **48**, is fastened to the stirrup **43**. The reel **39** is mounted so that it rotates on this spindle **47**, with the result that it can rotate about the lengthwise axis **46** and the transverse axis **48**.

A pulley **50** mounted on the end of the shaft **44** can be driven in rotation by a motor **53** by means of a trapezoidal belt **54**.

The shaft **45** is hollow, as shown, with the result that the pseudo monofilament **30** can pass through it. A roller brake **55** is mounted on the stirrup **43** so that it can rotate with it on the shaft **45**. It prevents the twist of the strand **30** from being propagated to the reel **39**.

As it leaves the hollow shaft **45**, the pseudo monofilament **30** is guided through a heating tube **56** the purpose of which is to heat the plastic matrix **33** and the outer plastic layer **34** (FIG. 3A) so as to soften them. The heating tube **56** is followed, as shown, by a stationary roller brake **57** which is intended to limit to the region **58**, situated between the two roller brakes **55** and **57**, the twist which is imparted to the pseudo monofilament **30** by preventing it from being propagated towards the right in FIG. **2**.

On leaving the stationary roller brake **57** the pseudo monofilament **30** which has received a twist of, for example, 70 turns/min and which has been heated through the heating tube **56** passes, through an entry opening **62**, into a sheathing tool **60** whose chamber **61** is filled with a molten mass of polymer. The polymer is injected, by an extruder **63** provided with a screw **64**, into the chamber **61**, which is maintained at a temperature of, for example, 200° C. by a thermostatically controlled heating device—not shown. In this tool an intimate bonding is obtained between the plastic matrix **33**—heated by the heating tube **56**—and the molten polymer mass held in the sheathing tool **60**. The temperature of the molten mass may be higher than the melting temperature of the multiple strands **24**, one of the reasons being the relatively high speed of the strand **30** in this molten mass, which may be of the order of 100 m/min.

The sheathing tool **60** has an exit die **66** whose diameter is slightly greater than that of the pseudo-monofilament **30** which passes through it; for example this diameter may be 0.1 mm greater than the diameter of the strand **30**, that is to say that when the latter has, for example, a diameter of between 1.2 and 1.25 mm; the diameter of the exit die **66** is, for example, 1.35 mm.

The molten polymer held in the chamber **61** is at a relatively high pressure which, depending on the polymer employed, is of the order of 2 to 100 bar and is typically approximately 60 bar. This is necessary because the sheathing employs a plastic of high viscosity which endows the sheath with the mechanical characteristics which it requires, that is to say better wear resistance and impact strength, and greater rigidity than the matrix of thermoplastic substance **33** in which the filaments **32** are embedded and which, in addition, is stable to light and insensitive to moisture. As shown in FIG. 3B, the pseudo monofilament **30** is therefore coated, in the chamber **61**, with a sheath **68** made of this polymer and whose thickness is of the order of 0.05 to 0.1 mm. Its shape and its thickness are determined by the exit die **66**, from which the finished tennis string **70** therefore comes out and—after suitable cooling—is wound onto a reel **72**.

It is generally found that the filaments of the finished string which are embedded in a plastic matrix, prestressed, exhibit a very small loss in tension, because the prestressing is in practice set irreversibly by the mass of plastic.

Only a single plastic string which has a single pseudo monofilament used as its core has been considered in the above description. It is also possible, however, to twist together a number of pseudo monofilaments and to provide them with a common sheath. It is also possible in this case to plait strands of different colours.

Examples of tennis strings according to the invention are shown below:

EXAMPLE 1

Ten multiple strands **24** are employed, all of which contain 144 filaments each at 940 dTex of polyamide **4.6** (melting point temperature approximately 290° C.). A suitable polyamide **4.6** which can be used is sold under the name "Stanyl" by the company DSM, and has a glass transition temperature of 82° C., a Young modulus of 34 g/d. In the chamber **14** these filaments are diverted five times and pass, at a speed of 1 m/min, through a melt of polyamide EMS D 590 G in which they are embedded. This melt is maintained at a temperature of 180° C. and a pressure of 2 bar. On leaving the last die, the pseudo monofilament **30** has an external diameter of 1.25 mm and a proportion of filaments of approximately 70% by weight.

In the device of FIG. **2** the pseudo monofilament **30** is subjected to a twist of 80 turns/min and, in the sheathing tool **60**, it passes at a speed of 2 m/min through a polymer melt of polyamide B35 BASF, maintained at 300° C. at a pressure of 10 bar. On leaving the exit die **66** the final product **70** has an outer diameter of approximately 1.35 mm. It has a tensile strength of about 66 daN. Its characteristic elongation/tension curve **80** is shown in FIG. **4**.

EXAMPLE 2

A core is employed which has been manufactured according to the same process as in Example 1.

The device described with reference to FIG. **2** is modified in the case of this process, in so far as the tool **60** is used in combination with a vacuum chamber **71** through which the strand **30** passes before entering the chamber **61** filled with the molten polymer.

The pseudo monofilament **30** is subjected to a twist of approximately 70 turns/m and passes through the sheathing tool **60** at a speed of approximately 40 m/min. A sheath is then deposited onto the pseudo monofilament, which is applied firmly to the core, owing to the reduced pressure prevailing in the vacuum chamber, and which bonds to it. In this exemplary of embodiment and in contrast to the exemplary embodiments described above, the core and the sheath are therefore no assembled by cohesion or adhesiveness. The polymer melt, Ultramide B35, is maintained at a temperature of approximately 245° C. The finished product has a final diameter of 1.35 to 1.4 mm.

Within the scope of the invention the filaments may be, for example, made of polyester, polyamide, particularly polyamide **4.6**, aramid, polyimide and polyetherketone.

The plastic for embedding the filaments (in the chamber **14**, **26**) may be, for example, made of polyamide, particularly polyamide **4.6**, copolyamide, polyester, polyurethane, hot melt adhesive and elastomer.

The plastic for manufacturing the sheath **68** may be, for example, made of polyamide, particularly polyamide **4.6**, copolyamide, polyester, polyurethane, elastomer and polyacetal.

It should be pointed out very particularly that a tennis string according to the invention retains its shape; for example when it is slightly flattened under the effect of a stress, it regains its initial shape, circular in cross-section, after the stress is released.

Since the thermoplastic substance employed for the sheath **68** is other than that for the matrix **33**, it is possible, in each case, to use plastics which are the best for the purpose in question. In particular, a substance of high melting point, which has the necessary strength, may be employed for the sheathing plastic.

Various alternative forms and modifications are obviously possible within the scope of the invention.

I claim:

1. A process for the manufacture of a tennis string intended for stringing rackets in which filaments are embedded in a thermoplastic substance, wherein the filaments pass through a chamber filled with the thermoplastic substance under pressure and made viscous by heating in which the filaments run over a number of return members, thus having the effect of embedding the filaments in a matrix consisting of the thermoplastic substance, on leaving the chamber the filaments pass through at least one die with the matrix in which they are embedded, thus forming a pseudo monofilament that is subjected to a twist and is coated with a sheath of wear-resistant thermoplastic substance.

2. The process according to claim **1**, wherein on leaving the chamber the filaments embedded in the matrix pass successively through a first die, a second chamber filled with the heated thermoplastic substance and finally a second die prior to twisting.

3. The process of claim **1**, wherein the pseudo monofilament is wound onto a reel on leaving the at least one die said reel is placed in a rotating unwinder which is used to rotate said reel about its lengthwise axis and about a transverse axis perpendicular to the lengthwise axis, the pseudo monofilament situated thereon is unwound from the reel while applying thereto a rotation about the two above-mentioned orthogonal axes of rotation, which imparts the desired twist to the pseudo monofilament.

4. The process according to claim **3**, wherein the pseudo monofilament is subjected to a twist of 30 to 150 turns/m.

5. The process of claim **3**, wherein a twist of 60 to 100 turns/m is applied.

6. The process according to claim **4**, wherein during the twist the pseudo monofilament passes through a heating tube.

7. The process according to claim **3**, wherein the action of twisting the pseudo monofilament occurs over a length of the pseudo monofilament between a roller brake rotating with the unwinder and a stationary roller brake.

8. The process according to claim **1**, wherein filaments (**32**) are employed made of plastic of one of the group consisting of polyester, polyamide, polyamide **4.6**, aramid, polyimide, polyester ketone and polyethylene.

9. The process according to claim **1**, wherein a plastic of one of the group consisting of polyamide, polyamide **4.6**, copolyamide, polyester, polyurethane, polyethylene, polypropylene, hot melt adhesives and elastomers is employed for at least one of embedding the filaments (**32**) and sheathing the pseudo monofilament (**30**).

10. The process according to claim **1**, wherein a melting point of the embedding matrix is lower than that of the filaments.

11. The process of claim **1**, wherein a melting point of the embedding matrix is approximately equal to that of the filaments.

12. The process according to claim **1**, wherein a melting point of the thermoplastic substance forming the sheath is lower than that of the filaments.

13. A tennis string obtained by the process according to claim **1**.

14. The tennis string according to claim **13**, wherein the proportion of filament is approximately between 55 and 90% by weight.

15. The tennis string according to claim **13**, wherein the number of pseudo monofilaments is approximately between 700 and 2,800.

16. A device for manufacturing a tennis string, comprising: a chamber intended to receive a thermoplastic substance made viscous by heating and containing return members to divert filaments a number of times within the viscous plastic and embedding the filaments in a matrix consisting of the thermoplastic material; and at least one die downstream from said chamber for forming a pseudo monofilament.

17. The device according to claim **16**, wherein at an exit of the chamber is arranged for the filaments embedded in the plastic to pass therethrough.

18. The device according to claim **17**, wherein a first die and a second die are arranged at the exit of the chamber.

19. The device according to claim **18**, wherein the diameter of the second die is slightly greater than that of the first die.

20. The device according to claim **16**, further comprising a rotating unwinder which allows a reel containing the pseudo monofilament to be rotated about its lengthwise axis and about a transverse axis perpendicular to the lengthwise axis and in that this rotating unwinder is also provided with a roller brake rotating therewith, in order to limit a twisting action on said pseudo monofilaments to a length situated downstream of the roller brake.

21. The device according to claim **20**, wherein a stationary roller brake is provided, arranged at a certain distance from the rotating roller brake.

22. The device according to claim **20**, wherein downstream of the rotating unwinder, a sheathing tool is provided for sheathing the pseudo monofilament with an outer sheath of good mechanical strength.

23. The device according to claim **22**, wherein the sheathing tool has a chamber for receiving a molten polymer, an entry opening and an exit die.

24. The device according to claim **23**, wherein a vacuum chamber is used in combination with the sheathing tool.

25. The device according to claim **18**, wherein a diameter of the second die is greater than that of the first die by 2%–6%.

* * * * *