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(54) Process for depositing microcapsules into multifilament yarn and the products produced

(57) The invention is directed to a process for depositing additives into a yarn having multi-filaments comprising steps of; separating the multi-filaments of the yarn into individual filaments while winding the yarn; injecting the additive onto the individual filaments; and promoting the individual filaments of the yarn to close up one against the other whereby the additive are entrapped within the multi-filaments. The invention also concerns an apparatus for depositing microcapsules into a multi-filaments of a yarn and the multifilament yarn produced.

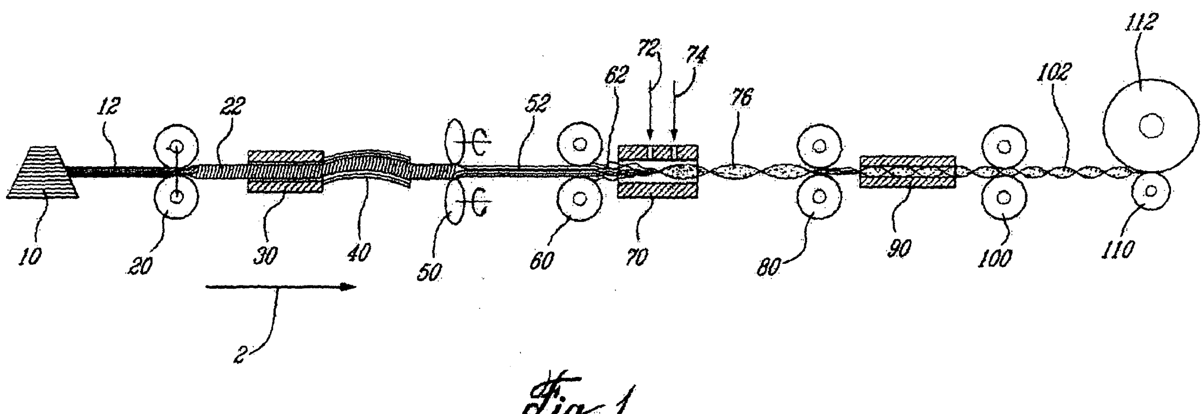

Fig. 1

EP 1 609 896 A2

Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to a process for providing additives to yarn made of multifilament textiles.

DESCRIPTION OF THE PRIOR ART

[0002] Micro-encapsulation has been used in the textile industry since the early 1990's. Many textile manufacturers are looking into the use of microcapsules to functionalize their products by giving textiles: a durable scent; a means for applying a cosmetic, such as a body lotion, or a pharmaceutical product.

[0003] Microcapsules applied to textile materials impart characteristics which depend on the nature of the active substances present inside the microcapsules. The large number and variety of active substance that can be used is further proof of the usefulness of the micro-encapsulation technique in the fabrication of different textiles which have many applications.

[0004] Microcapsules have been applied to the textile webs (woven, knitted and no woven fabrics), fibers, and monofilaments or multifilament yarns. The majority of described techniques for applying of microcapsules to the textiles is designated for the webs finishing.

[0005] Impregnation is one method of web/fabric finishing. The web is placed in a treatment bath, such as a "pad" machine, which contains both charged microcapsules and a binder. Optionally products include: dispersing agents; pressure absorbing agents; softening agents and surfactants alone or in combination may also be added. The treated fabric must be dried and/or cured (soaking process); or squeezed and dried and/or cured (padding process). The binders anchor the microcapsules to the fabric. Suitable binders for microcapsule finishing include: polymeric melamine compounds; polymeric glyoxal compounds; polymeric silicone compounds; polyalkylene glycols; poly(meth)acrylates; polymeric fluorocarbons and epichlorohydrin-crosslinked polyamidoamines. The surfactants present in the bath facilitate interactions between the components of the bath and the fabrics and improve the "fabric hand" after treatment. The drying/curing processes are necessary for water/solvent evaporation from the treated fabric and in some cases for activating some binders requiring higher temperature to bind the web/fabric.

[0006] The impregnation method (padding or soaking) is described in U.S. Patent 4,882,220 where microcapsules containing a fragrance are applied to a fabric by soaking, padding and printing processes. In U.S. Patent Application 2002/0166628, the soaking method is disclosed. Canadian Patent Application 2,483,279 describes applying microcapsules by soaking and padding. Finishing of fabrics with microcapsules containing skin-conditioning agents by soaking, padding, coating, spraying and printing method is described in U.S. Patent 5,232,769. Japan Patent document JP 11012953 describes the method for obtaining an antiinflammatory and/or analgesic textile material by textile finishing with microcapsules containing a biological active agent.

[0007] Microcapsules have also been applied to textile fabrics using a coating process. The fabric to be treated is exposed to microcapsules coated with the binder in a coating machine. Here any excess of coated microcapsules is eliminated from the fabric, for example, by a knife system. The coated fabric is then dried and/or cured. This method is described in U.S. Patent 3,479,811, where expandable micro-spheres are incorporated on the surface of the fabric by the coating process. Canadian Patent 1240883 describes a coating process for microcapsules containing thermo chromic pigments. The coating method to functionalize fabric by microcapsules is also described in Korean Patents KR 2002056779 and KR 2001069654. Electrically conductive and electromagnetic radiation absorptive fabric was obtained by microcapsules coating described in U.S. Patent Application 2004/0212.

[0008] Other methods of applying microcapsules to textile fabrics include: spraying described in International Patent WO 00/05446, in Korean Patent KR 2002082692 and in two Japan Patents JP2000178873 and JP02200602; printing described in European patent EP 1231319 printing allows only selected areas of textile fabric to be functionalized; and doping a spinning solution with the microcapsules and extruding the fibers already finished, as described in U.S. Patent 3,852,401.

[0009] All these methods for applying microcapsules on yarns require an additional treatment step which may be long and laborious. Thus, there is a need for a process for applying microcapsules to yarn "on-line" during a normal finishing process of yarns.

[0010] Furthermore with the yarn treatments discussed, only the yarn surface is coated by binder and microcapsules. This gives the fabric a "rough hand" which is not acceptable for many products like, especially products which will be in contact with the body. Thus, there is also a need for microcapsules finishing yarns which can be used which have a "fabric hand" which is soft final products.

SUMMARY OF THE INVENTION

[0011] In one aspect of the invention there is a process for depositing additives into a yarn having multi-filaments comprising steps of; separating the multi-filaments of the yarn into individual filaments while winding the yarn; injecting the additive onto the individual filaments; and promoting the individual filaments of the yarn to close up one against the other, whereby the additives are entrapped within the multi-filaments.

[0012] According to another aspect of the invention there is an apparatus for depositing microcapsules into a yarn having a plurality of filaments, the apparatus comprising; a supply spool, a take-up spool winding the yarn in a first direction between the supply spool and the take-up spool, a means for separating the yarn at, at least one separating point disposed between the supply spool and the take-up spool, the means for separating the yarn thereby exposing the filaments, and at least one nozzle proximate the separating point, the at least one nozzle injecting a liquid onto the filaments in a second direction transverse the first direction, the liquid having a the microcapsules suspended therein and thereby injecting the microcapsules.

[0013] According to yet another aspect of the invention there is a multifilament yarn having a cross sectional perimeter, the yarn comprising: individual filaments interconnected together to produce the yarn; and microcapsules having a range of diameter of 0.1 to 200 μm on the individual filaments within the perimeter of the yarn.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] Further features and advantages of the present invention will become apparent from the following detailed description, taken in combination with the appended drawings, in which:

Fig. 1. is a schematic representation of the process steps of an embodiment of the present invention where Partially Oriented Yarn (POY) is used as a starting material and the aspect of the filaments of the POY during processing is represented;

Fig. 2 is a schematic representation of the process of another embodiment of the present invention multiple Partially Oriented Yarns (POYs) are the starting material and produce a multifilament yarn which is textured by an air jet device and one POY being overfed onto the other;

Fig. 3 is a schematic representation of a system of injection of a dispersion of the microcapsule according to one embodiment of the present invention;

Fig. 4 is a cross section of a device for the deposition of the additives according to one embodiment of the present invention; and

Fig. 5 is a micrograph of microcapsules on the filaments within a Draw Textured Yarn of one embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0015] The invention is applicable to manmade textiles that include but are not limited to: polyesters, polyamides (nylons), aramids, polypropylene, and other synthetic and/or artificial multifilament yarns. Multifilament yarns are understood to be composed of a plurality of filaments.

[0016] The following terms are included to clarify the definition of the terms found in the application.

[0017] The term yarn is defined as a continuous bundle of textile fibers, filaments or materials in a form suitable for intertwining to produce a textile fabric. A multifilament yarn has two or more individual filaments intertwined. There are many forms of yarn such as; spun yarn where a number of fibers are twisted together; zero-twist yarn, where the filaments are laid together without any twist; twist yarn which includes a number of filaments with a twist.

[0018] Winding is understood to mean a process of transferring yarn or thread from one type of package to another to facilitate subsequent processing. The package or spool is understood as the forms for winding yarn, most of these packages are flangeless to allow high speed of unwinding.

[0019] There are two types of winders precision and drum winders. Precision winders are used for the most part with filament yarns, they include a cam driven traverse and an oscillating motor moving a traverse, that synchronize the spindle to produce packages with a wound diamond-pattern. Drum winders, including propeller type systems, are used principally for spun yarn, where a frictional contact drives the package.

[0020] The term texturing is understood as a process that produces random loops, crimping, or other operation which increases the texture of a yarn. These operations also increase insulation value, warmth and absorption of the yarn, and provides a different texture to the surface of a yarn. The present process of deposition of microcapsules requires the application of the microcapsules onto a textured yarn. Many types of textured yarns are known to the skilled practitioner they include: Draw Texture Yarn (DTY) and Air Textured Yarn (ATY). As will be described, non-textured or flat yarns may be used as a starting material.

[0021] Reference is made to a textile winding machine which is understood to include :a winder; a texturing machine, or a twister. A preferred embodiment of the texturing machine is a false twist texturing machine or an air texturing machine.

[0022] The textile handling machines listed above is not limitative and the skilled practitioner would understand that other textile winding machines may be used. Textile handling or processing includes: spinning; plying; twisting; texturing and coning. Textile processing includes many mechanical operations used to translate a textile fiber or yarn to a fabric or other textile material and would be understood by the skilled practitioner.

[0023] Micro-encapsulation is a technique of enclosing chemically, physico-chemically or biologically reactive material in tiny microcapsules from which the material can be released under particular conditions.

[0024] A microcapsule is composed of an outer wall or shell comprising a natural, semi-synthetic or synthetic, high molecular weight material such as gelatin; Arabic gum; agar agar; alginic acid and salts thereof; fatty acids; cetyl alcohol; collagen; chitosan; lecithins; albumin; starch; dextran; polypeptides; cellulose and chemically modified cellulose; polyacrylates; polyvinyl alcohol; polyvinyl pyrrolidone; polyurethane; polyolefin; polyamide; an aminoplast; polyester; polysaccharide; silicone resins; epoxy resins and formaldehyde resins. In a preferred embodiment the aminoplast is a melamine. Microcapsules have a particle diameter in the range from to 0.1 to 1000 μm, preferably between 0.1 to 200 μm, and most preferably 0.5 to 20 μm.

[0025] The process of the present invention is continuous, rapid, and substantially dry, it is executed over a short period of time, of as little as, 1/10 to 1 sec, while the classic soaking process may require from 2 to 3 hours, furthermore the dry conditions (dry yarn) provides good fixation of microcapsules. The process of the present invention is applicable to many kinds of yarn, allows for flexibility by allowing for the use of short runs of yarn, as well as, lower quantities of actively charged microcapsules to achieve the target activity of final product. Like all other yarns, the yarn of the present invention has a length and a perimeter. However, with the yarn produced by the process of the present invention, microcapsules are found within the perimeter of the yarn, not only on the perimeter, or outer surface, as with some processes. The present process is eco-friendly as active ingredients are recycled in the system and chemical losses are minimized, thus also improving cost effectiveness. The yarns finished by the process of present invention have a substantially uniform microcapsules distribution. The textiles webs fabricated from yarns of the present invention have a "soft hand" and are applicable to textile webs which gradually release encapsulated active substances and which may be in permanent contact with wearer's skin and body.

[0026] Figure 1 represents one embodiment of the process of the present invention for producing a multifilament Draw Textured Yarn (DTY) including deposited microcapsules according to the present invention in a textile winder. The process steps, as well as the schematic nature of the filaments of the yarn during the processing is represented in Figure 1. The direction of movement of the yarn during processing is indicated by the arrow 2. A supply spool 10 of a multi-filament partially oriented yarn (POY) 12 is fed from the spool 10 to a first shaft 20 also called an input feeding shaft or roll, rotating at a given speed. From this shaft 20 the yarn is fed to a second shaft or roll 60, which turns at a higher speed than the first shaft 20. Thus, the yarn 12 is simultaneously drawn, its length is increased and diameter diminished and twisted. The yarn 12 is twisted after the first shaft 20 by a friction device, such as a set of spindles or friction discs 50 which produce a twisted yarn 22. The yarn 22 enters a heater 30 where its temperature is increased so that the yarn 22 is thermo-fixed (130°C to 500°C). The heater 30 is followed immediately by a cooling zone 40 which may be at room temperature or may be cooled below room temperature. The cooler 40 has a smooth curved surface which facilitates the cooling and reduces the likelihood of breaking very fine filaments of yarn. The yarn 52 leaving the friction discs 50 may in some cases be straightened as represented in the Figure 1.

[0027] The tension between the second shaft 60 and the first shaft 20 caused by the greater speed of the second shaft 60 causes the filaments of the yarn 22 to be elongated while heated. The tension of the drawn yarn 62 leaving the second shaft 60 is lower due to the lower speed of shaft 80 (or the "2 bis" roll) in relation to shaft 60.

[0028] This reduction in speed is permissible because there is a reduction in the length of the yarn produced by the bulking of the yarn and its stretch behaviour. The yarn 62 has become somewhat crimped. Thus the operation of twisting and heating the yarn produces curling of the filaments lower than that of shaft 60, permitting retraction and bulking of the entire multifilament yarn. It should be noted that this reduction in tension or un-tensioning, causes the filaments in the yarn to separate to some degree. Therefore, the speed of a third shaft or "2-bis" roll, 80 which rotates at a marginally lower velocity than the second shaft 60, is related to the percentage of reduction of overall length of the yarn. Thus the shafts 60 and 80 serve as a means of separating the yarn into individual and exposed filaments.

[0029] The yarn travels or winds through an opening or passage extending through the body of device 70 in the direction indicated by the arrow 2. The filament in yarn 62 are separated as well as, possibly interlaced or intermingled in the device 70, where in a preferred embodiment there is an air jet 72. The yarn 62 enters the device 70 where the air jet 72 (at a pressure as much as 100 psi) is directed at the yarn 62 in a perpendicular or nearly perpendicular direction with respect to the of movement of the yarn 2. The yarn 62 comes into contact with air vortices produced by the air jet 72 which act as a means of separating of the filaments of the yarn 62 in a preferred embodiment. The air jet 72 enters the device 70, through an aperture transverse to the opening through the device 70. As the filaments move out of the jet 72 due to the movement of the yarn, they re-orient back onto each other, may produce braids or knots at regular intervals within the yarn 76. The skilled practitioner would understand that a gas jet, such as the air jet 72, are produced by a gas or fluid passing through an aperture, a hole, or a nozzle, and possibly via other devices such as a valve, which produces a very high velocity gas/fluid stream. The skilled practitioner would understand that the air in the air jet 72 may be replaced with another suitable gas or combination of gases such as an inert gas like nitrogen, helium, neon or argon if required. In a preferred embodiment the air/gas jet 72 may also be heated.

[0030] The device 70 includes a hole or nozzle for a stream 74 through which suspended microcapsules are injected into the device 70 at the point close to where the filaments have been separated from one another, into individual filaments, while winding through the device 70. This nozzle is located along the winding path of the yarn, and is located proximate to a point where the filaments have been separated. In a preferred embodiment the nozzle producing the liquid jet 74 is located downstream, with respect to the direction of travel of the yarn 2, of this yarn separating point. In a preferred embodiment, the microcapsules liquid jet 74 leaves a nozzle intersecting the yarn winding opening, the intersection of liquid nozzle and yarn winding opening is substantially opposite and/or slightly downstream of an aperture for an air jet 72. The liquid nozzle and the aperture may both be transverse to the yarn winding opening through the device 70. in a preferred embodiment the aperture for the jet 72 and the nozzle for the liquid stream 74 are perpendicular to the wall of the opening of the device. The stream or spray 74 of microcapsules will be injected into and adhere to the separated individual filaments and coat the filament surfaces. In another preferred embodiment, there are two air jets and two liquid jets and each air and liquid jet is in close proximity to one another and are situated along the wall of opening through the device 70. Furthermore, the orientation of the nozzles along the wall opening may be directed at the winding yarn so that the jet makes a perpendicular angle to the direction of travel of the yarn 2. The angle made between the direction of the liquid jet 74, the air jet 72 when either jet leaves the nozzle in a substantially straight line, and the direction of travel may vary by 30° from the perpendicular and as much as 45° from the perpendicular.

[0031] As the filament continues to wind through the jet device 70 it leaves the vortices produced by the air jet 72 and the filaments close up upon themselves thus sealing the microcapsules within the yarn. This braided, interlaced or intermingled and textured yarn 76 thus produced, includes microcapsules within the structure, as well as on the external surfaces of the yarn 76. The microcapsules are also found within the narrow hollows of the intermingled or entangled filaments. Because the microcapsules make it into these grooves or channels of the specific filaments of yarn, the yarn is expected to retain the microcapsules and therefore the properties of the materials within the microcapsules for a longer period of time, than in processes where the yarn is coated only on the surface. Figure 5 is a electro-micrograph of a yarn where the individual filaments include microcapsules.

[0032] The additives may be injected into the yarn directly after the shaft 60 without the aid of an air jet 72. But the use of an air jet improves the process by separating the individual filaments of 52 before inserting the microcapsules. The jet 72 separates the filaments to a greater extent than with only un-tensioning due to the effects of the operation of the shafts alone, and is thus a preferred mode of operation for this invention.

[0033] Throughout the disclosure the words; additive, microcapsule and nanocapsule are used interchangeably, each of which can have a single constituent or multiple components. The additives are preferably microcapsules in a range of diameter from 0.1 to 1000 μm, preferably between 0.1 to 200 μm, and most preferably 0.5 to 20 μm, where the microcapsules have an outer wall and a central core. The wall is adapted to bind to the filaments. In a preferred embodiment the outer wall of the microcapsule fuses with the individual filament by the action of heat and/or with the binder. The central core of the complete particle or microcapsule, may include a substance or material which is chemically, physico-chemically or biologically active or simply cosmetic. These materials may be topical skin lotions or medicines.

[0034] The chemically, physico-chemically or biologically active material enclosed inside of microcapsule may include the following types of substances: bioactive agents, drugs and pharmaceuticals; enzymes; dyes and pigments; fragrances; moisturizing agents; bleaching agents; depilatory agents; UV-block agents; softening agents; elasticity improving agents; flame-, moth-, crease- and soil-proofing agents; water repellent agents; anti-shrinking agents; cross-linking agents; magnetic particles; thermochromic, photochromic, electrochromic, piezorochromic, solvatechromic, carsolchromic materials; insects repellents; pesticides; static electricity-controlling or reducing agents; electrically conductive materials; radar-absorbing materials; reflecting particles; heat-absorbing and/or heat-releasing phase change agents; decontamination agents; zeolites; activated carbon; and combinations of these substances.

[0035] The yarn 76 continues to the third shaft 80 and the fourth shaft (also be called the delivery or nip roll), 100. In between the two rolls 80, 100 a heater 90 may be included. The optional heater 90, may evaporate any solvents or aqueous component injected with the microcapsules suspension and also helps to further bind the microcapsules to the filaments. The fourth set of shafts 100, serves to control overfeed in the temperature setting zone, before the yarn 102 is drawn or wound onto the take-up spool 112 with the aid of take-up shaft 110.

[0036] It is noted that many variations of location for the device 70 and the injection of microcapsules is possible. The device 70 has been located directly after the shaft 60 without the inclusion of an air jet, as well as, directly after the second heater 90 and before the nip roll 100. Microcapsules have successfully been applied and inserted into the multi-filaments of the yarn at various locations.

[0037] The deposition process of the present invention requires that the yarn be textured before the separation and deposition occurs. However, the starting yarns may be textured, immediately upstream of the process of the present invention, and this is described in Fig. 2. Thus Partially Oriented Yarn (POY), Fully Oriented Yarn (FOY). and Low Oriented Yarn (LOY) and combinations thereof, which are not textured yarns may serve as starting products but they must be textured before the microcapsules are deposited. In the mode proposed in Fig. 2, more than one spool of POY, FOY, LOY or combinations thereof is fed in a winding machine. Each POY or other yarn, passes over a heater into an air jet device. Figure 2 is an option of texturizing POY into a multi-filament yarn before the deposition of the additive/microcapsule. The direction of the movement of the yarn in Figure 2 is indicated by the arrow number 3. By the process of this invention spools (150, 160) feed POY onto feed shafts (170, 180) the filaments are drawn by a second set of shafts (220, 230) at a greater speed through a similar series of steps which include a heating step (190, 200) with the POY. These POY yarns can be further textured such that the feed rate of the yarns from the second shafts 220 and 230 are different in the order of -10% to +200% thus the yarn 231 leaving the shaft 230 may be fed at a speed as much as 200% greater than the yarn 221 leaving the shaft 220. The yarn 221 is called the core yarn while the yarn 231 is called the effect yarn in entering the air jet device 240 the air jet 242 has a tendency of enveloping the effect yarn 231 over the core yarn 221, to give a multiplicity of loops and thus the POY yarn which was only partially oriented is now a multi-filament yarn ready to have additives incorporated by the process of the present invention through the hole for jet 264.

[0038] Due to the high level of looping of the effect yarn 231 around the core yarn 221, the type of process arrangement often includes two stabilizing rollers 250 and 270, which reduce and stabilize the yarn produced to a more uniform thickness. In a preferred embodiment the microcapsule jet device 260, optionally including another air jet 262, is placed between the two sets of stabilizing rollers 250 and 270. As in previous examples the liquid jet 264 incorporates additives within the yarn, with individual filaments separated by un-tensioning of the yarn or by the action of an air jet.

[0039] The multi-filament yarn leaving the jet device 260 and roller 270, including microcapsules may once again be heated to evaporate the aqueous phase and so as to further adhere the microcapsules to the now multi-filament texturized yarn in heater 280. The heater 280 is between rolls 270 and 290. From the roll 290, the yarn is wound onto the take-up spool with the aid of take-up shaft. The take-up spool and shaft are not illustrated in Figure 2. Thus various methods of generating the textured micro-filament yarn required for the incorporation of microcapsules by the process of this invention are possible and would be clear to the skilled practitioner, and be used for the deposition of additives by the process of the present invention.

[0040] The skilled practitioner would also understand that other types of yarn using similar arrangements of textile handling equipment may generate multifilament textured yarn.

Preparation of the Suspension of Microcapsules

[0041] Figure 3 represents a tank 300 which includes a mechanically or magnetically driven agitator 310 where the suspension of microcapsules in aqueous phase is prepared. The tank 300 may include a means 320 which heat the suspension of particles in a controlled manner. The suspension is re-circulated from the tank 300 by means of a pump 330. The pump 330 is selected from the group of pumps which are designed to minimize the shear and thus the breakage of microcapsules in suspension. The types of pumps applicable are selected from the group consisting of peristaltic, diaphragm, progressing cavity, and centrifugal disc pumps. The skilled practitioner would understand that this group of pumps is not limitative and other pumps minimizing the shearing of microcapsules may be employed. The suspension is circulated in a piping or tubing system 332 to the typical jet device 370 where the multifilament yarn 360 will be intermingled by the action of the air jet 372 and coated by the action of the jet 374 of microcapsules. The suspension is not completely consumed by spraying onto the filaments and is collected in a vessel 380 for re-circulation by pump 339 back to the original reservoir 300.

[0042] The suspension of microcapsules may contain components that have a tendency to block jet 374 which requires periodic cleaning or de-blocking of the hole through which liquid jet passes during operation by periodic maintenance. This periodic cleaning may be performed by a mechanical device or through the selection of self-cleaning jets.

[0043] Fig. 4 illustrates a cross sectional view of a preferred embodiment of the present device 470 used to deposit additives such as microcapsules and nano-capsules into the filaments of a textured yarn. The device includes a body 400 defining a central opening or hole 405 which passes through the device 470, in a preferred embodiment the hole is cylindrical. The hole 405 is adapted to allow: the passage of textured yarn 62 at high speed into and through the opening 405, and the exit of the intermingled yarn 76 at the outlet end of the opening 405. The direction of the movement of the yarn 62 through the device 470 is indicated by the arrow 4.

[0044] The wall of opening 405 is intersected by at least one hole for a liquid jet 474, which due to an un-tensioning caused either by the slight reduction of speed through the device, or by the inclusion in a preferred embodiment of an aperture for an gas or air jet 472 which will open the multifilament and allow the deposition of additives within the individual filaments of the yarn 62. Upon leaving the vortices of the air jet 472 the individual filaments of the yarn will have a tendency to close up one against the other, but the winding of the yarn through the rolls will further promote this closing of the individual filaments of the yarn. Fig. 4 represents a preferred embodiment which includes two liquid holes or nozzles 473, 475, which produce two liquid sprays (or jets) 474, 476. The number and placement of liquid holes can be increased or decreased depending on the speed of the yarn through the device 470, and would be understood by a skilled practitioner. In a preferred embodiment the hole(s) 473, (475), are liquid nozzle(s) and are located opposite an aperture 471 for the air jet 472 along the wall of the opening. The air jet hole 471 and the air jet 472 are once again used to separate the filaments of the yarn. This embodiment of the device has mechanical means for cleaning the liquid nozzles by a system of plungers 491 and 493 which scrap any build-up from the top of the liquid holes 473, 475. Arrow 495 represents the direction of the movement of the plungers 491, 493. In Fig. 4, one of the plungers 491 is in a retracted position, while plunger 493 is in an extended position removing any deposits of additives which may have built up in the hole 475. Other means for the cleaning of the nozzles 473, 475 can be envisaged and include the redirection or the addition of a the high pressure air jet towards the top of the liquid jets 473, 475. Many such alternatives are available and known to the skilled practitioner. In Fig. 4 the deposited microcapsules have been represented by varying sized triangles, indicating the incorporation of microcapsules on the surface and within the yarn 76.

[0045] The excess liquid from the jets 474, 476 passes out the end of the device at the outlet end of the device 470. This excess is collected in a tank or container 480 and re-circulated back to the liquid nozzles 473, 475 in a manner as represented in Figure 3. In a preferred embodiment, of the device 470 is enclosed in a casing, which is designed to collect the excess liquid from the jet 474, 476 and may be under a slight negative pressure so that any vapors can be evacuated from the surroundings and treated.

Preparation of the Aqueous Suspension of Microcapsules

[0046] Before being deposited an aqueous suspension of the microcapsules is required. The microcapsules are mixed with various ingredients to produce an aqueous suspension.

[0047] The microcapsules containing a wide variety of products encapsulated within an outer shell typically polymeric in nature, in one embodiment the encapsulated product is a scent of lavender which contains linolyl acetate. Commonly the outer shell is a type of polyurethane or similar compound previously described. The suspension in includes; the microcapsules in aqueous suspension; a binder; and a softener typically a silicon micro-emulsion.

[0048] The microcapsules, the binder and the softener are added in a ratio that varies from 35:35:30 to 48:48:4 with a preferred embodiment being 45:45:10. These mixtures are then dispersed in aqueous phase in a ratio up to 25 to 30% with a preferred embodiment being between 15 and 20%.

EXAMPLES

[0049] **Example 1)** Multifilament (pes) polyester yarn with lavender perfume microcapsules. Example 1 describes the production of a yarn that can be used to produce a fabric with a lavender aroma, mainly for underwear and hosiery.

[0050] The multi-filament polyester yarn with a final decitex of 78 and 72 filaments, is sprayed with a suspension composed of 85% water, 6.75% of polyurethane binder, 6.75% of concentrated microcapsule solution and 1.5% of a silicone softener. The microcapsules used has a mean diameter of 2 microns (μm). The deposition / application process was conducted on the false twist texturing machine.

[0051] The speed and other adjustments are standard for a DTY process with the following exceptions: the speed differential between the roll 60, and the rolls 80 of the spraying jet 70. These speeds were adjusted in order to have minimal tension on the yarn 62 and to facilitate the opening of the multifilament. This opening of the multifilament produces a yarn which has the microcapsules within the yarn. The speed of the nip rolls 100 is increased to provide more tension on the yarn in order to prevent yarn sticking on the "2 bis" roll, 80. The stickiness of the yarns derives from the fresh solution being sprayed thereon. The delivery rate of the liquid to the jet 70 is 0.139 ml/min and the air pressure is 20 psi.

[0052] The yarn produced in Example 1 was knitted on a "FAK" (Fiber analysis knitter) one feed laboratory knitting machine (Lawson Hemphill Inc.) with a E22 gauge.

Example 2) Multifilament polyamide (nylon) yarn with citronella (lemon grass) perfume microcapsules.

[0053] The multi-filament nylon yarn with a final decitex of 78 and 68 filaments was sprayed with a suspension composed of 85% water, 4.5% of polyurethane binder, 9% of concentrated microcapsule solution and 1.5% of a silicone softener. The microcapsules once again had a mean diameter of 2 microns (μm). The deposition process was conducted in the same manner, at the same speed and settings as described in Example 1. The delivery rate of the liquid to the jet 70 is 0.439 ml/min and the air pressure is 30 psi. The deposition of the microcapsules was conducted on a textile winding machine.

[0054] The yarn produced was knitted and compared statistically as in Example 1.

[0055] **Example 3)** Multifilament yarn polypropylene (pp) with lavender perfume microcapsules.

[0056] The multi-filament- pp (polypropylene) yarn with a final decitex of 78 and 68 filaments was sprayed with the solution composed of 80% water, 9% of polyurethane binder, 9% of concentrated microcapsule solution and 2% of a silicone softener. All components and conditions were maintained as in Examples 1 and 2. The delivery rate of the liquid to the jet 70 is 0.781 ml/min and the air pressure is 30 psi.

[0057] The yarns produced in Example 3 were knitted in the same manner as in Examples 1 and 2.

[0058] **Examples 4) and 5)** Multifilament Polyamide (nylon) yarn with lavender perfume microcapsules.

[0059] These Examples were prepared with multi-filament polyamide (nylon) yarn with a final decitex of 78 and 68 filaments and knit, as in the preceding Examples.

[0060] Example 4) used a solution composed of 85% water, 4.5% of acrylic copolymer binder, 9% of concentrated microcapsule solution and 1.5% of a silicone softener and delivery rate of the liquid to the jet 70 was 0.439 ml/min and the air pressure is 30 psi.

[0061] In Example 5) a solution composed of 80% water, 9% of polyurethane binder, 9% of concentrated microcapsule solution and 2% of a silicone softener was used, at feed rate of the liquid to the jet 70 of 0.781 ml/min and at an air pressure of 30 psi.

[0062] **Example 6)** A multifilament polyester (pes) yarn with a final decitex of 156 and 200 filaments was used, and sprayed with the solution composed of 60% water, 18% of polyurethane binder, 18% of concentrated microcapsule solution and 4% of a silicone softener. All the process conditions were maintained as in the preceding Examples. The delivery rate of the liquid to the jet 70 is 2.49 ml/min and the air pressure is 30 psi. The produced yarn was knit as in the previous Examples.

[0063] The Examples indicate that the method of deposition is effective on a variety of filaments of different materials and decitex (fineness of the yarn), through a range of deposition parameters. All five examples showed good deposition of microcapsules.

[0064] The embodiments of the invention described above are intended to be exemplary only. The scope of the invention is therefore intended to be limited solely by the scope of the appended claims.

Claims

1. A process for depositing additives into a yarn having multi-filaments comprising steps of;

- separating the multi-filaments of the yarn into individual filaments while winding the yarn;
- injecting the additive onto the individual filaments; and
- promoting the individual filaments of the yarn to close up one against the other, whereby the additives are entrapped within the multi-filaments.

2. The process of claim 1, wherein the additives are microcapsules in a range of diameter from 0.1 to 200 µm, wherein the microcapsules comprise an outer wall and a central core.

3. The process of claim 1, wherein the steps are performed on the yarn during operation of a textile winding machine.

4. The process of claim 3, wherein the textile winding machine is selected from the group consisting of a winder, a texturing machine and a twister.

5. The process of claim 4, wherein the texturing machine is a false twist texturing machine.

6. The process of claim 4, wherein the texturing machine is an air texturing machine.

7. The process of claim 1, wherein separating multifilaments of the yarn is produced by an un-tensioning of the yarn between two shafts of a textile winding machine.

8. The process of claim 1, wherein separating of multifilaments of the yarn is produced by a gas jet directed at the yarn.

9. The process according of claim 1, wherein injecting the additive onto the individual filaments is via a liquid jet.

10. The process according to claim 1, wherein the yarn is selected from the group consisting polyesters, polyamides, polypropylene, polyethylene, aramids, synthetic multifilament yarns and artificial multifilament yarns.

11. The process according to claim 1, wherein the yarn having multi-filaments is produced by texturing a Partially Oriented Yarn (POY) or Fully Oriented Yarn (FOY).

12. The process of claim 2, wherein the central core comprises a material that is chemically, physicochemically or biologically active, and the material is selected from the group consisting of bioactive agents; drugs and pharmaceuticals; enzymes; dyes and pigments; fragrances; moisturizing agents; bleaching agents; depilatory agents; UV-block agents; softening agents; elasticity improving agents; flame-, moth-, crease- and soil-proofing agents; water repellent agents; anti-shrinking agents; cross-linking agents; magnetic particles; thermochromic, photochromic, electrochromic, piezorochromic, solvatechromic, carsolchromic materials; insects repellents; pesticides; static electricity-controlling or reducing agents; electrically conductive materials; radar-absorbing materials; reflecting particles; heat-absorbing and/or heat-releasing phase change agents; decontamination agents; zeolites; and activated carbon; and combinations thereof.

13. The process of claim 2, wherein the outer wall is a natural, semi-synthetic or synthetic, high molecular weight material such as gelatin; Arabic gum; agar agar; alginic acid and salts thereof; fatty acids; cetyl alcohol; collagen; chitosan; lecithins; albumin; starch; dextran; polypeptides; cellulose and chemically modified cellulose; polyacrylates; polyvinyl alcohol; polyvinyl pyrrolidone; polyurethane; polyolefin; polyamide; an aminoplast; polyester; polysaccharide; silicone resins; epoxy resins and formaldehyde resins.

14. An apparatus for depositing microcapsules into a yarn having a plurality of filaments, the apparatus comprising;

- a supply spool,
- a take-up spool winding the yarn in a first direction between the supply spool and the take-up spool,
- a means for separating the yarn at, at least one separating point disposed between the supply spool and the take-up spool, the means for separating the yarn thereby exposing the filaments, and
- at least one nozzle proximate the separating point, the at least one nozzle injecting a liquid onto the filaments in a second direction transverse the first direction, the liquid having the microcapsules suspended therein and thereby injecting the microcapsules.

15. The apparatus of claim 14, wherein the at least one nozzle is located downstream of the separating point.

16. The apparatus of claim 14, comprising;

- a body disposed between the two spools, the body defining an opening through which the yarn winds in the first direction and
- the at least one nozzle oriented to intersect the opening, and thereby directing the liquid having the microcapsules towards the yarn.

17. The apparatus of claim 14, wherein the means of separating the yarn comprising

- a first and a second shaft, the shafts disposed between the supply and the take-up spool,
- the first shaft winding the yarn at a first speed and
- the second shaft winding the yarn from the first shaft rotating at a second speed lower than the first speed, thereby producing an un-tensioning of the yarn.

18. The apparatus of claim 16, wherein the means of separating the yarn comprises at least one aperture defined in the body, the aperture connected to a supply of pressurized gas, passage of the gas through the aperture producing a gas jet directed at the yarn transverse the first direction.

19. The apparatus of claim 18, wherein the aperture directs the gas jet to produce an angle when intersecting the first direction, the angle varying from perpendicular to the first direction, to 30° from the perpendicular to the first direction.

20. The apparatus of claim 18, wherein the at least one nozzle, is two nozzles.

21. A multifilament yarn having a cross sectional perimeter, the yarn comprising:

- individual filaments interconnected together to produce the yarn; and
- microcapsules having a range of diameter of 0.1 to 200 μm on the individual filaments within the perimeter of the yarn.

22. The yarn of claim 22, wherein the microcapsules comprise an outer wall and a central core.

23. The yarn of claim 23, wherein central core comprises a material that is chemically, physico-chemically or biologically active and the material is selected from the group consisting of bioactive agents; drugs and pharmaceuticals; enzymes; dyes and pigments; fragrances; moisturizing agents; bleaching agents; depilatory agents; UV-block agents; softening agents; elasticity improving agents; flame-, moth-, crease- and soil-proofing agents; water repellent agents; anti-shrinking agents; cross-linking agents; magnetic particles; thermochromic, photochromic, electrochromic, piezorochromic, solvatechromic, carsolchromic materials; insects repellents; pesticides; static electricity-controlling or reducing agents; electrically conductive materials; radar-absorbing materials; reflecting particles; heat-absorbing and/or heat-releasing phase change agents; decontamination agents; zeolites; and activated carbon; and combinations thereof.

24. The yarn of claim 23, wherein the yarn is selected from the group consisting polyesters, polyamides, polypropylene, polyethylene, aramids, synthetic multifilament yarns and artificial multifilament yarns.

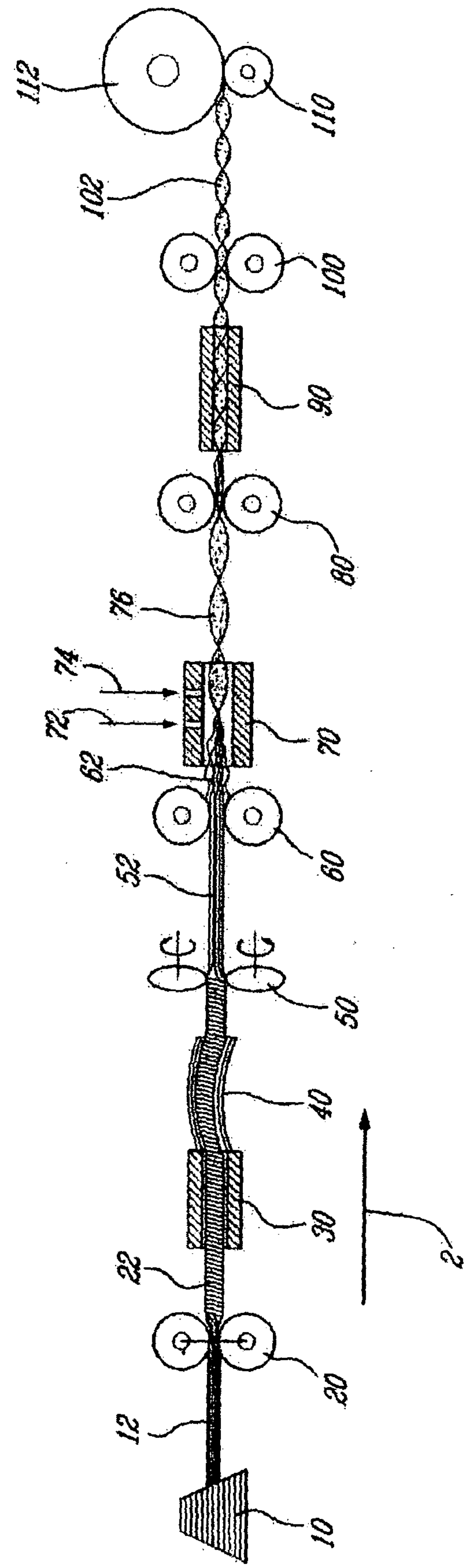

Fig. 1

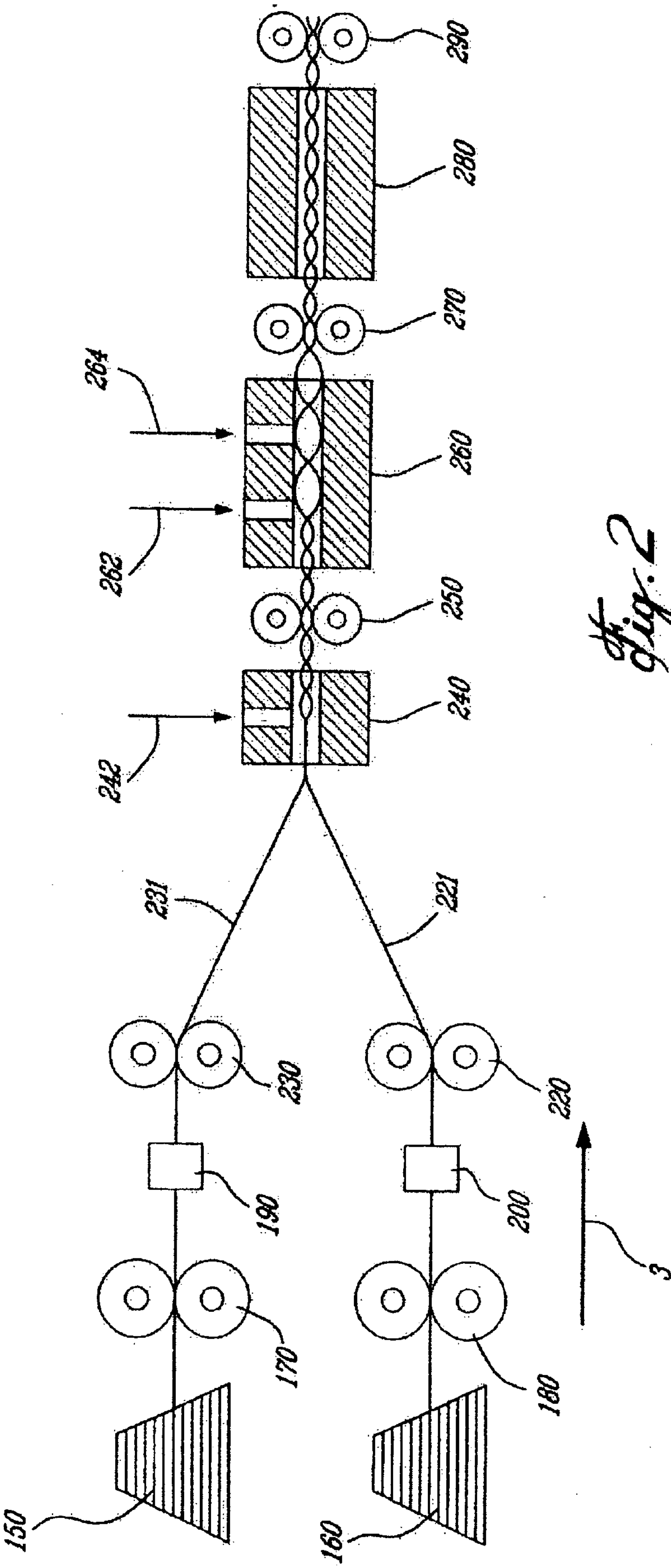
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Fig. 2

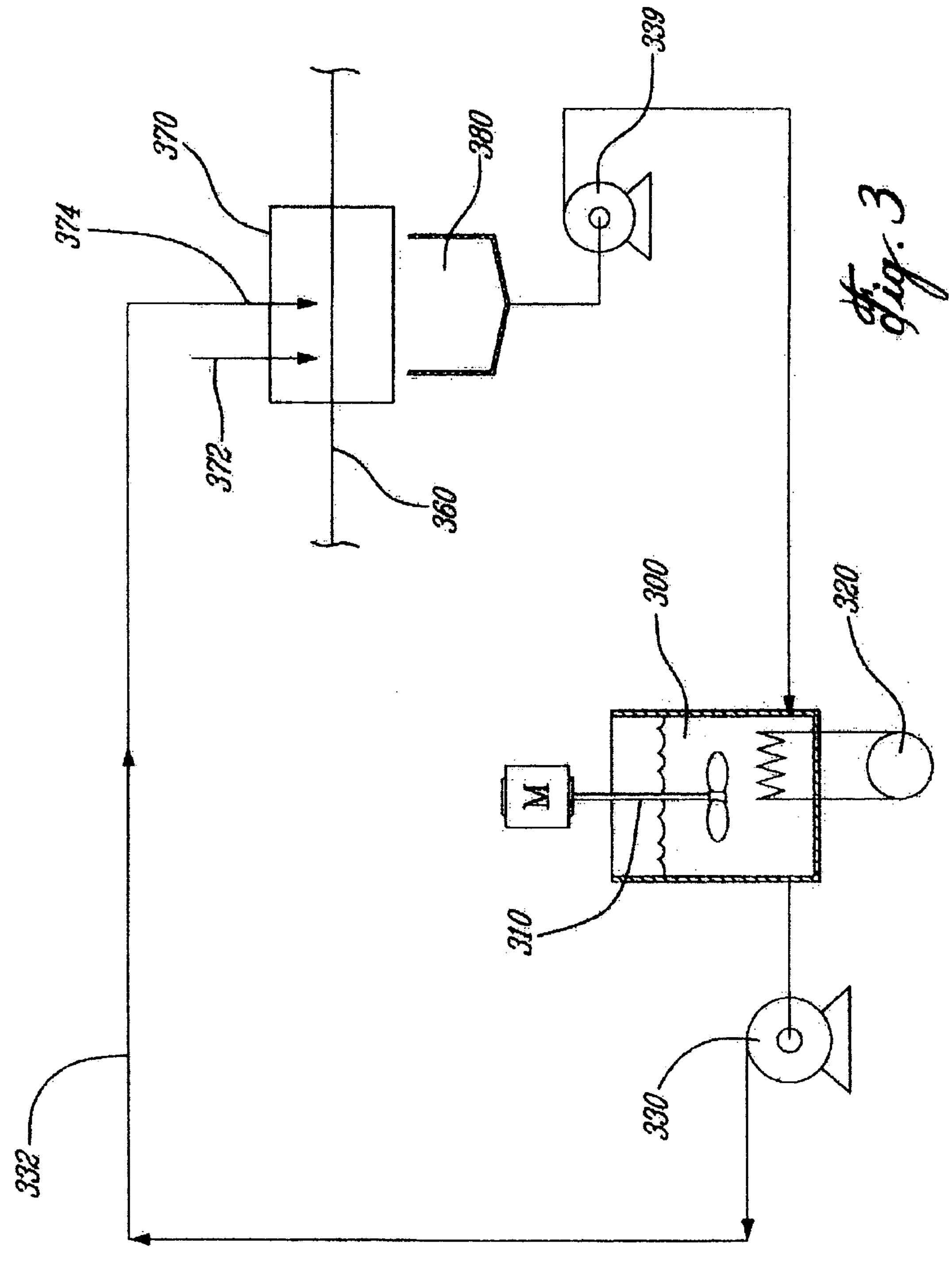

Fig. 3

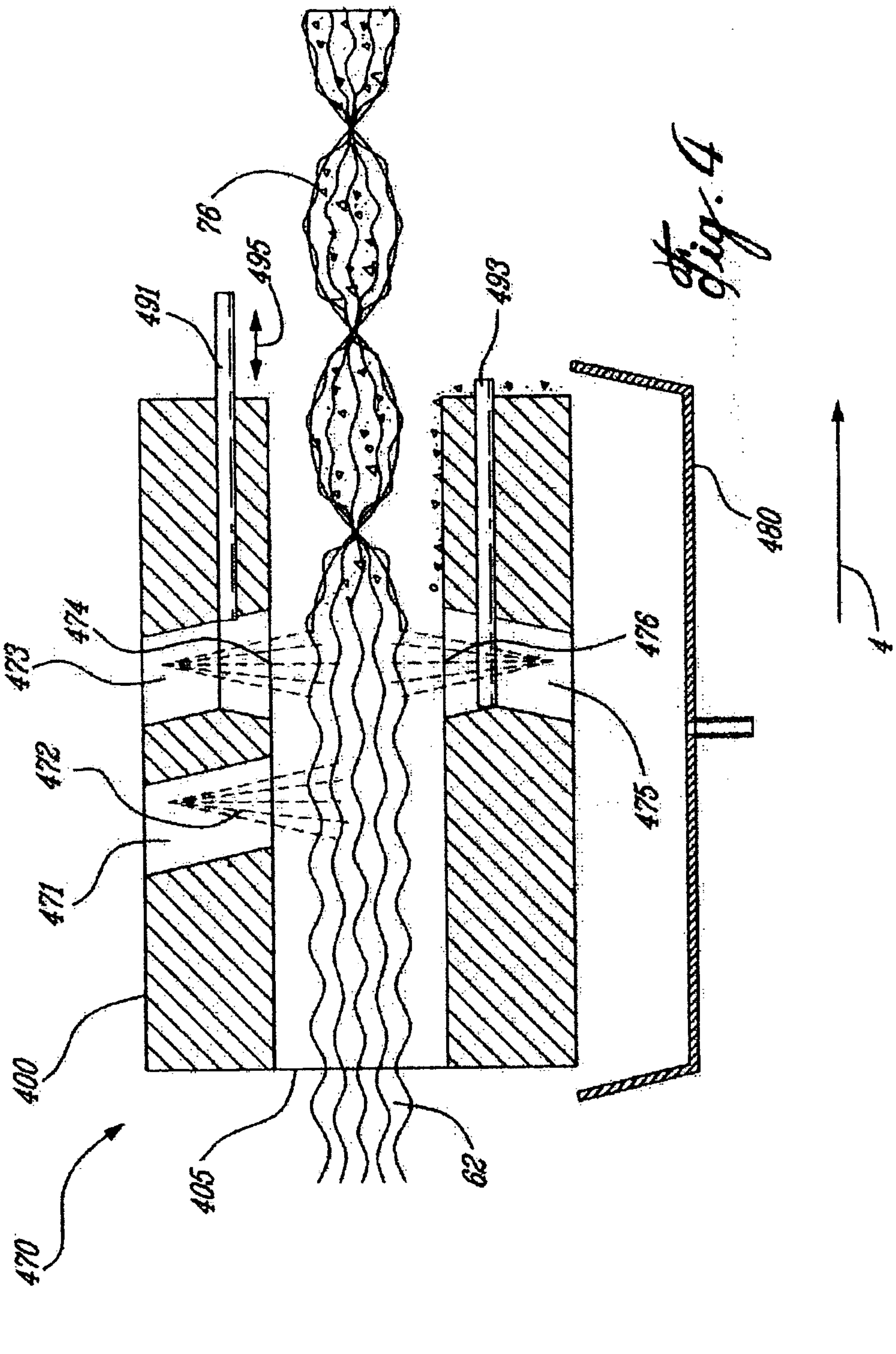

Fig. 4

Fig. 5