

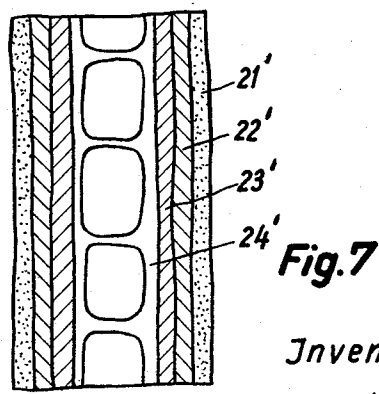
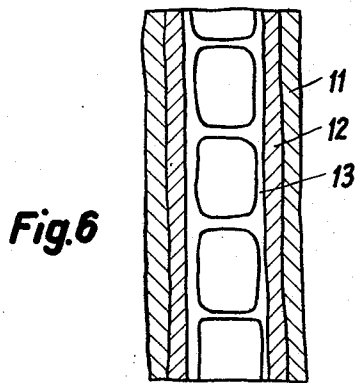
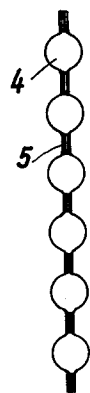
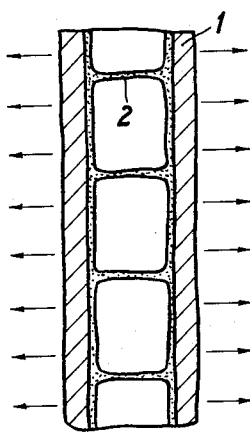
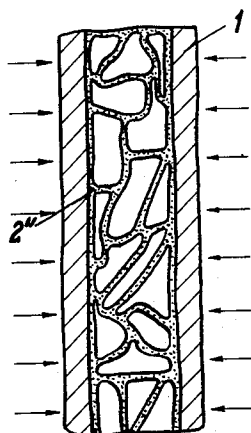
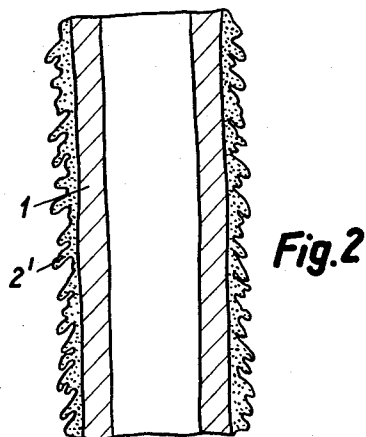
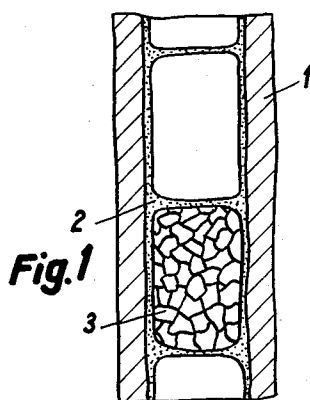
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3,015,873

COMPLEX ARTIFICIAL FILAMENTS

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COMPLEX ARTIFICIAL FILAMENTS

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This invention relates to complex artificial filaments comprising two or more longitudinal sections of different spinning materials. Such filaments may comprise a hollow gas-filled core or may consist of compound structures of two or more different spinnable materials joined in centrally symmetrical or non-symmetrical distribution.

An object of the invention resides in the fact that artificial filaments of monotonic cross-sectional composition have rather primitive qualities in use even if made of modern highly adaptable materials of polymeric molecular structure. Contrary thereto the highly adaptable natural filaments have a structural composition of a plurality of single layers which aid each other in an overall improvement of the finished filaments.

It is a primary object of this invention to provide artificial filaments of non-homogenous material as to cross-section of which the different materials also are heterogeneously distributed across the longitudinal section of the filament in substantially periodic repetition. These filaments differ from known so-called foam filaments by their regular structure both in cross and longitudinal sections and their imperforated sheath.

The production of these said artificial filaments is based on the use of multi-orifice spinnerets whereby the different materials of equal or different state of aggregations are joined in a geometrical configuration formed exactly during the spinning process. Such multi-orifice spinnerets are the subject matter of a co-pending application, Serial No. 570,401, filed March 8, 1956.

The heterogeneous distribution of the different filament materials in a longitudinal section may consist in a periodically repeating change of the ratio in the quantity of the different materials as to the cross-section of the compound filament.

The term "filament" denotes only a short term for filaments of all shapes and cross-sections, namely, round filaments as well as flat or ribbon-like structures. The spinning materials comprise all substances adapted to be shaped in solid, dissolved or molten state. The term "spinning" denotes only a short word for the all-embracing principle of the plastic working of materials under pressure or tension, in addition to "spinning" in the narrow technical sense, and it comprises also the extrusion pressing or drawing, of injection molding or pressure casting, etc.

This invention primarily has to do with materials of organic composition, as cellulose, cellulose compounds, aldehyde condensation products, albumin and other substances containing nitrogen-like casein, gelatine, and especially artificial resins comprising vinyl, acryl, styryl and other non-saturated groups, especially modern linear polymers. According to their natures, these spinning materials are shaped into various fibrous structures by loss of heat or drying out or by suitable solidifying agents as liquid precipitants, cooling gas, etc.

According to the demands on the mechanical and hygienic qualities of such filaments such as mechanical strength, heat insulating properties, humidity, or sweat storing properties, etc., the spinning materials are distributed among the inner or outer layers. In the following, some examples of artificial filaments made of two or more materials are listed:

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Filaments made of two materials

	(1) Sheath material	(2) Core material
5	Polyamide..... Do..... Viscose..... Do.....	Nitrogenous component. Foamy polyamide. Foamy viscose (by foam-generating components). Dull lustre viscose.

Filaments made of three materials

	(1) Sheath material	(2) Outer core material	(3) Inner core material
15	Polyamide..... Do..... Do..... Acetylcellulose.....	Formalized polyamide..... do..... Weakly acetylated cellulose and water-storing softener. do.....	Nitrogenous compound. Foamy polyamide. Do. Foamy acetyl-cellulose.

Filaments made of four materials

	(1) Sheath material	(2) Outer core material	(3) Intermediate core material	(4) Inner core material
25	Acetylcellulose covered with scales and softeners.	Polyamide.....	Formalized polyamide.	Foamy polyamide.

A preferred object of this invention consists of structures in the shape of so-called "cellular filaments" comprising a tube-like and imperforated sheath and partitions sub-dividing the hollow interior to form cells. As demonstrated by grasses, crop-grasses, etc., fibrous or rod-like structures of this type have an extremely high tensile strength and lateral stiffness and therefore are useful for many technical purposes. By microscopic examination it has been found that the cellular cavities filled with air or gas are able to take on external humidity by osmotic processes in the sheath. If the cavities are filled with a water-storing, e.g. swellable substance, rather considerable quantities of moisture can be absorbed by the filament. Thus, for the first time there is a possibility of producing textile filaments made of hydrophobic material like polyesters or polyamides comparable with cotton with regard to humidity and sweat adsorption. Furthermore, the gas content of the cells guarantees a very high heat insulating factor like that of natural filaments.

It is a further object of this invention to produce partitions of water-adsorbent material, e.g. formalized polyamide.

It is a further object of this invention to provide artificial filaments, the cavities of which are filled with pharmaceutical substances producing therapeutical or hygienic effects. Such impregnated filaments are useful for making clothing or for surgical treatment.

It is a further object of this invention to produce artificial filaments, the cavities of which are filled with a fatty substance which is unable to diffuse through the outer layer. Such filaments are effective against undesired absorption of moisture, bodily fat, etc.

It is a further object of this invention to produce artificial filaments, the cavities of which have been made incompressible by filling them with microporous solid substances, as aluminum hydroxide, silicagel, etc.

It is another object of this invention to produce cellular filaments provided with axially oblong partitions so that the cavities are separated from one another for a certain distance. Such filaments are shaped like a bubble chain and may be used instead of bedfeathers, as lining or upholstery material and generally everywhere where elastic and heat-insulating multi-layer fibrous structure is needed.

It is a further object of this invention to produce artificial filaments provided with cellular cavities loosely filled by a solid substance. Such filaments are useful for technical as well as aesthetic purposes.

It is a further object of this invention to produce artificial filaments having a rough or bristly outer surface. Filaments of this type have no lustre and therefore appear like natural filaments. If the appendages are long enough, the heat insulating property, the felt-ability and other textile qualities are improved.

It is another object of this invention to produce artificial filaments comprising dyes or pigment embedded in the cellular cavities. Such filaments will produce special optical effects. These dyes or pigments may be fluorescent or phosphorescent.

It is a further object of this invention to produce artificial filaments provided with reflecting inner surfaces by applying a reflecting silver layer by methods known in the mirror art.

It is another object of this invention to produce artificial filaments provided with light-sensitive inner surfaces. The light sensitive substance may consist of a diazo compound sensitive to the short wave part of the spectrum. Light sensitive filaments of this type need not be stored in a dark room like those made of light sensitive silver salts. Fabrics or webs made of such filaments may be ornamented by mere photographic processes. Furthermore, these diazo compounds may be used as dyestuff coupling components for producing colored patterns without printing screens, etc.

This invention is not restricted to simple cellular filaments but may also be used for improving artificial filaments comprising a plurality of axially extending chains of cells distributed in cross-section.

This invention also deals with filament bundles comprising a plurality of single filaments shaped according to this invention. Therefore, it is a further object of this invention to produce a filament structure comprising at least two substantially parallel filaments interconnected by material bridges in regular intervals and not by textile ligatures as is normally the case.

These filament structures may have predetermined cavity volumes and bristly surfaces or both and can be produced in large sizes by appropriate spinning apparatus.

Furthermore, this invention deals with the methods of producing filaments and filament structures of the before-mentioned kinds. Therefore, another main object of this invention relates to a method of producing complex artificial filaments comprising the steps of feeding the spinning material forming the filament sheath, to the ring nozzle of a spinneret comprising at least two nozzle stages and the spinning material forming the filament core to the nozzle inside the ring nozzle of said spinneret and acting on said core material when still in plastic condition to periodically change its cross-sectional content along the longitudinal axis of the forming complex filament and to set said complex filament. If the core material has a foamy structure it is preferred to cause the fine foam bubbles to unite in a minority of larger bubbles filling the hollow cross-section of the filament.

The foamy material can be produced in different ways. The dispersion may be performed by mechanical means, especially by ultra-sound and in the storage vessel or during the passage of the material up to the spinneret nozzle. It is also possible to generate the foamy core material by a pulsating mixing of the core material and gas at the nozzle outlet serving to transfer the vibrations.

The foamy material also can be produced by chemical reactions decomposing the primary core material. This material may produce gaseous reaction products. The internal decomposition may be due to unstable chemical structure or possibly may be caused by thermal influence.

The foamy structure also can be produced by saturating the core material with compressed gas and releasing the pressure at the nozzle outlet to liberate the excess of gas

as a form of fine bubbles as in the case of opening a bottle of champagne.

There are also several methods of changing the original fine foam into coarser bubbles. A preferred principle of operation consists in temporarily reducing the viscosity of the material and using the surface tension forces activated thereby to reduce the free surface of the bubbles as in the case of a soap bubble. Actually the low-viscous material separates from the gas and contracts to form surfaces of minimum surface energy. In the present case there are built up partitions of hyperbolic shape bridging the core space of the tubular filament at intervals. In an embodiment of this method a solvent is introduced into the foamy core of the filament of which the sheath has become solidified, for reducing the viscosity of the core material and again removed by thermal influence when the bubbles have become coarse. The dried out core material will thus form the partitions. In many cases the surface tension forces will become efficient by mere heating of the foamy core material inside the tubular filament. The heating may be done inductively by adding substances of high electric A.C. resistance or low specific heat.

Experiments have shown that during production of the filaments according to the invention the surface tension forces of the sheath material may constrict the hollow tubular filament and keep off the core material. For avoiding this inconvenience the surface tension of the sheath material has to be kept low. This may be done by an appropriate gaseous phase surrounding the filament structure leaving the nozzle orifice, or by reducing the viscosity of the sheath material by cooling. It is also useful to avoid or at least to reduce the so-called stretch spinning effect. For this reason, the sheath material may be fed through a narrow nozzle in quantities corresponding with the desired width of the final sheath. Another principle of operation consists in leaving unchanged the surface tension forces of the sheath material and reduce the formation of the foamy core material by enlarging the resistance of passage along the inner nozzle by reducing the cross-section of the nozzle and/or by raising the viscosity of the foamy core material.

Artificial filaments provided with a rough and especially bristly outer surface may be produced in several ways.

According to one embodiment of this part of the invention a three stage spinneret is used and the outer ring nozzle is fed with a foamy material generating an additional layer of rather coarse bubbles on the sheath of the tubular filament produced by the two inner nozzle orifices in the previously described manner. These outer foam bubbles are then caused to burst open into splinters forming the desired appendages of the sheath of the tubular filament. It will be noted that these superficial foam bubbles are not connected to the core by passages across the sheath as in the case of the known filaments of foamy consistency throughout the whole material.

According to another embodiment of this part of the invention, an additional layer of non-stretchable material is generated on the sheath of the tubular filament and subdivided by adhering warty splinters by stretching the solidified tubular filament this stretching is not followed by the non-stretchable material and is thereby torn into small pieces.

A third possibility of producing cellular filaments provided with rather long and bristly appendages consists in connecting a plurality of filaments simultaneously spun in clusters by local material bridges formed mechanically, that is, by vibrating nozzles or by ultrasonic vibrations generated in the viscous material and thereafter tearing off these bridges by an additional procedure. Spinning under the influence of ultrasonic vibrations will also cause an uneven surface of the filament.

Furthermore, according to still another embodiment

of the invention, an irregular end and especially bristly outer surface of the tubular filament may be produced by making the sheath out of a material filled with magnetic particles and subjecting it, when still viscous, to the influence of an annular magnetic field, pulling out of the outer surface of the filament the magnetic particles and parts of the sheath material adhering to each particle. The magnetic particles later may be removed by shearing or by chemical solvents. By proper adjustment of the viscosity of the sheath material rather long fibers can be pulled out to produce filaments of wool-like appearance and qualities.

The magnetic particles may also be left in the bristly filaments to be used as electroinductive heat generators. Filaments of this kind are useful for medical purposes.

By the just-described method of connecting filaments by local material bridges filament structures of cushion or mat-like appearance may be produced.

Structures in the form of bladder chains may be produced by using the surface tension forces previously mentioned. Accordingly, the sheath material may be spun in a state of low viscosity eventually caused by periodic elevations of the temperature in or outside the nozzle orifice.

It is also possible to pulsatingly feed the eventually gaseous core material which periodically will expand the low viscous sheath material into a bubble chain. The feed of the core material may be controlled by membrane controlled valves.

This invention also deals with the production of small dimensioned filament structures in bubble form. An embodiment of this invention consists in producing a bubble chain in the previously described manner, subdividing it into separate bubbles by interrupting the connecting sections, causing the bubble sections to freely pass a gaseous or fluid medium, reducing the viscosity of the filament material to form bubbles of equal wall thickness due to the surface tension forces set free and finally solidifying these bubbles before being collected. This method imitates the production of soap bubbles on a manufacturing scale. The volume of the bubbles may be increased by introducing gas generating substances into the cavity of the bubble. The specific weight of such artificial bubbles depends on the bubble size and is always very low. The bubbles are also compressible and are therefore very useful for life jackets and sound and/or heat insulating structures. For improving the capacity of resistance against mechanical and/or thermal stresses the bubbles may be left incompletely filled. Such untight bubbles may be produced by enlarging the bubble volume when its sheath is in the plastic state, solidifying the sheath material in its expanded state and to again normalize the conditions which caused the volume enlargement.

An embodiment of this part of the invention consists in subjecting the bubble to a subnormal outer pressure, temporarily reducing the viscosity of the sheath material e.g. by heat to permit the bubble to expand and become solidified in this expanded state and finally restoring the normal outer pressure.

Another embodiment of this invention consists in introducing a fluid of comparably low vapour pressure into the cavity of the bubble e.g. by osmotic diffusion across the sheath, elevating the inner pressure of the bubble by temporarily vaporizing said fluid, permitting the bubble to expand and solidify in the previously described manner, reducing the inner pressure by cooling and finally removing the expansion fluid.

The before described bubble chains may be formed into fleece or matlike structures by arranging a plurality of such bubble chains in side-by-side and superposed positions and materially uniting them at the points of contacts, e.g. by temporary infrared heating. Such structures are highly elastic and heat insulating. Instead of

bubble chains a plurality of single bubbles may be united in the same way.

A further principal subject matter of this invention consists in a method of producing complex artificial filaments of the described types comprising the steps of primarily combining the different materials to form an elongated structure in the shape of a rod or wire having the final complex sectional structure and to change this raw stock into complex filaments of the desired number by known methods of the wire drawing technics. The advantage of this method consists in the possibility of using larger installations and especially nozzles of larger diameter for the production of the complex raw stock and normal and simple dies for drawing the raw stock into filaments of the desired final number.

The annexed drawing illustrates various embodiments of the invention in which,

FIGURE 1 is a longitudinal section of a form of filament with filled core,

FIGURE 2 is a longitudinal section of a modified filament showing appendices thereon,

FIGURE 3 is a longitudinal section showing a cellular thread in a state of production,

FIGURE 4 is a longitudinal section showing the cellular thread of FIGURE 3 in another stage of production,

FIGURE 5 is a diagrammatic side view of another embodiment of the invention.

FIGURE 6 is a longitudinal section of a further modified filament, and

FIGURE 7 is a longitudinal section of another modified filament.

In FIGURES 1 to 4, reference numeral 1 designates the material forming the tube sheath of constant size. In the embodiments according to FIGURES 1, 3 and 4 the foamy material 2 is positioned inside the sheath 1, and in the embodiment according to FIGURE 2, the foamy material 2' is positioned outside said sheath 1.

FIGURE 1 diagrammatically shows the special embodiment of the invention whereby the cells formed by the core material 2 are filled with a loose filler 3 made of different material.

In the embodiment shown in FIGURE 2 the thread component 2' forms bristly appendices on the outer surface of the tube sheath 1.

FIGURES 3 and 4 diagrammatically show two stages of a cellular thread. FIGURE 3 shows the thread in an intermediate state of production, the interior of the tube sheath 1 still being filled with irregularly shaped bubbles made of the primarily foamy core material 2'. This foam is again liquified by a solvent diffusing through the tube sheath 1 in the direction of the arrows of FIGURE 3 thereby changing into a much smaller number of much larger cells separated by walls perpendicular to the thread axis due to surface tension effect taking place in the liquified mass 2, when finally the solvent is again removed from the inner space of the hollow thread in the direction of the arrows of FIGURE 4.

FIGURE 5 shows a so-called bubble chain consisting of thin-walled gas-filled, and substantially spheroid hollow chambers 4 and short, thread-like bridges 5 having a full or hollow cross-section and uniting the hollow chambers 4.

FIGURE 6 shows a filament having three layers of which 11 is the outer sheath as polyamide, 12 is the inner sheath as formalized polyamide and 13 is the core as a series of cells of polyamide.

FIGURE 7 shows a filament of which 21' is the outer sheath and is composed of acetylcellulose. The intermediate sheath 22' is a polyamide and the inner sheath 23' is a formalized polyamide. The core 24' is composed of a series of cells consisting and made of a polyamide.

We claim as our invention:

An extruded filament consisting of a sheath and a core composed of different materials and united with

one another by intermixture at the contact area of the different materials, the core consisting of a sequence of cells each shaped against the inner surface of the sheath and separated from each other by partitions extending in spaced relation each with its central cross sectional plane at right angles to the longitudinal axis of the filament and each partition being shaped by surface tension.

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