METAL CORE COMPOSITE FILAMENTS

Filed March 25, 1957

Fig. 1

Fig. 1a

Fig. 2

Fig. 3

Fig. 4

Fig. 5

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This invention is concerned with filaments of synthetic polymers having a metal core.

The use of polymers as electrical insulators on wire is well known. Such polymers have been applied to preformed wires from a solution of the polymer, from a dispersion of the polymer followed by coalescence or fusion and forming a melt of the polymer.

The first procedure referred to above has the disadvantage that removal of the solvent is time-consuming and costly and it is also difficult to produce uniform costs of satisfactory thickness free from pin holes. Furthermore, such a process does not lend itself to the application of certain desirable insulating coatings such as polyamides and polyesters which are known for their toughness and good physical properties, because of the lack of volatile non-corrosive solvents which can be conveniently and safely used with such polymers.

The application of polymers to electrical conductors by means of their dispersion is also a difficult task, if the particles are to be coalesced by an organic liquid, the same difficulties are present as in the solution method of application. This method is usually limited to the application of very thin coatings unless the coating process is repeated many times, in which case the composite coating may not be sufficiently uniform.

The other method of coating which has been used in the past is the application of a melt of the polymer onto a preformed wire. In such processes, however, it is difficult to center the wire accurately enough to obtain uniform coatings.

With respect to those known coating processes which use heat, i.e., those involving fusion of polymer particles or the utilizing of coatings in the form of melts, such processes have been limited to products containing preformed wires having a melting point sufficiently above that of the polymer so that the wire would remain intact during the coating process.

Another serious limitation with the previous methods of coating electrical conductors is the fact in the case of very fine wires their handling during the coating operation as well as the proper application of the coating, are quite difficult. Many types of conductors that would be of great utility if coated, do not lend themselves to conventional coating processes because of their inherent weakness when in the form of very small diameter wires.

Furthermore, in order to obtain very fine wires, long and expensive wire drawing and annealing steps are required thereby adding considerably to the cost of the final insulated product.

It is known to eject a mixture of a molten metal and a fiber-forming polymer into an air jet to produce short, curiled filaments with irregular and nonuniform structure but such process does not relate to the making of filaments having a definite size and core component.

The most desirable physical properties of polymers such as polyamides and polyesters are obtained by orienting the polymers through a drawing operation. Known coating procedure produces little if any orientation. It has been proposed, for example, to partially orient the coating by drawing a metal core coated with the molten polymers through a die at a rate such that the core moves faster than the rate of feed of the coating to the wire. This method produces, however, only a small amount of orientation since the percent of draw possible is limited to the amount of draw given to the metal and is generally not in excess of 10% draw, the percent of draw being the percent of the original length that is permanently added (i.e., not regained on release of the drawing tension) during the drawing operation.

It has also been proposed to make decorative ribbon by laminating a thin metal film between two plastic films and then slitting to strips. By its very nature such a process is very time consuming and expensive, and is applicable only to relatively large denier ribbons.

It is an object of this invention to produce articles comprising a metal core surrounded by a synthetic polymer sheath. It is a further object of this invention to produce continuous fine filaments of a synthetic polymer having a metal core. A further object is concerned with the production of such filaments in the deniers used in the textile arts. Other objects will appear hereinafter.

The objects of this invention have been attained by simultaneously extruding a molten, synthetic, linear, fiber-forming, orientable polymer and a molten metal through a spinneret as a continuous sheath and core respectively of a composite filament and orienting the polymer sheath to the desired extent by a drawing operation. The metal core of the drawn filament is preferably less than 0.031 inch in its largest diameter perpendicular to its length with preferably a uniform cross-section along the length of the filament and comprises a metal that melts at or below the temperature at which the polymer or its solution is extruded.

In the drawings:

FIGURE 1 is a top plan view of the upper plate or filter pack of a spinneret used in the practice of this invention;

FIGURE 1(a) is an elevation view in cross-section of the upper plate or filter pack taken along the lines 1a—1a of FIGURE 1. The right-hand half of FIGURE 1(a) is an elevation in cross-section along the plane of the right-hand half of line 1a—1a of FIGURE 1 and the left-hand half of FIGURE 1(a) is an elevation in cross-section along the plane of the left-hand half of line 1a—1a of FIGURE 1. It will be noted that the two portions of line 1a—1a of FIGURE 1 form an angle at the center of the figure. The two halves of FIGURE 1(a) have been assembled in this fashion in order to show the shape and direction of the filaments and cavities even though they may not fall along the central plane of the spinneret;

FIGURE 2 is a bottom plan view of the apparatus of FIGURE 1 taken at a somewhat different angle than FIGURE 1, line 1a—1a of FIGURE 2 likewise showing the dual plane cut of FIGURE 1(a);

FIGURE 3 is a top plan view of the bottom plate of a spinneret used in the practice of this invention;

FIGURE 4 is an elevation view in cross-section of the bottom spinneret plate shown in FIGURE 3 with the right-hand half shown in the plane of the right-hand half of line 4—4 of FIGURE 3 (drawn to the center) and with the left-hand half of FIGURE 4 being cut on the plane of the vertical portion (from the center downwardly) of line 4—4 of FIGURE 3. As in the case of FIGURE 2, FIGURE 4 is assembled in the manner indicated to show the shape and cavities of the bottom spinneret plate although, as is evident from FIGURE 3, these elements are not, in fact, aligned as shown in FIGURE 4;

FIGURE 5 is an elevation view, generally in cross-section, of the upper and lower plates of FIGURES 1, 1(a), 2, 3, and 4, in assembled positions utilizing the showing of FIGURE 4 for the lower plate and the showing of co-acting parts of FIGURES 1, 1(a) and 2 for the upper plate or filter pack. Here again, the drawing, with the center line indicated as in FIGURE 4, shows the
assembled spinneret with a full showing of the various elements, in the expedient manner of FIGURE 4 with the upper plate being shown, as assembled, in the position corresponding to that of the lower plate.

FIGURE 10 is an elevation partly in section of an extrusion pin shown in FIGURE 5.

FIGURE 7 is a cross-section taken on 7—7 of FIGURE 6;

FIGURE 8 is a cross-section taken on line 8—8 of FIGURE 6;

FIGURE 9 is a cross-section taken on 9—9 of FIGURE 6.

FIGURE 10 is a view in cross-section showing the details of the lower portion of the pin shown in FIGURE 6 while in operative position in the lower plate of FIGURES 3 and 4;

FIGURES 11—19 inclusive are schematic representations of filaments in lengthwise and cross-sectional view made in accordance with the invention. In all instances polymeric sheath 100 surrounds metal core material 101.

It can be seen from the drawings that top plate 1 of the spinneret adapted to receive the filter pack (not shown), has a central chamber 2 and an annular chamber 3 separated from each other by wall 4. In the bottom of chamber 2 are a plurality of holes 5 passing downwardly through plate 1 and diverging outwardly from each other. Holes 5 lead into shallow annular groove 6 formed in the top surface of lower plate 7 which, in assembling the spinneret, is fastened to plate 1 as described below. Holes 8 lead from the bottom of annular chamber 3 vertically downward through plate 1 and terminate at groove 6 of the lower plate 7. Pins 9, provided with longitudinal passages 10 therethrough are positioned in holes 8 with a press fit (and may be further fastened in place by a spline or other means for insuring a tight fit, if desired) with the upper ends of pins 9 extending above the bottom of annular chamber 3 as shown. The press fit of pins 9 may be supplemented by the action of circular serrations 11 provided at the top of the pins 9 to grip the inside of holes 8.

Pins 9 are circular in cross-section in the portion 12 in contact with holes 8, as shown in FIGURE 7, having a diameter sufficient to give a press fit in holes 8, pins 9 in the major portion 13 passing through plate 1, having a circular cross-section which is partly tapered at their lower ends, forming a circular cross-section throughout equal in diameter to the arcuate portions of sections 13 and 14 of pins 9 to insure a tight fit between the contacting surfaces.

It will be noted that annular orifice 19 is formed at the outer surface of plate 7 by the clearance between orifice 18 of the plate 7 and the outer and smaller cylindrical portion 16 of pin 9. The total area of the outer end of orifice 18 (inclusive of orifice 17 and the annular cylindrical portion 16 of pin 9) is collectively referred to as the extrusion orifice designated as 20 in the drawings.

Plates 1 and 7 are fastened with threaded bolts 21 passing through holes 22 in plate 7 with the bolt heads being received in counterbore 23 and abutting at their inner surface the shoulder of counterbore 23, bolts 21 being fastened into corresponding threaded holes 24 in plate 1. After the plates 1 and 7 are assembled and fastened in place by bolts 21, proper alignment is assured by insertion of tapered pins 25 of round cross-section having a drive-fit into tapered holes 26 of the plate 7 and registering tapered holes 27 of plate 1, the ends of pins 25 being drawn into position above and clear of the outer surface of plate 7.

Gaskets 28 and 29 are inserted in plate 7 prior to assembling the spinneret and are pressed in place as shown respectively into circular grooves 30 and 31 (gasket 28 being additionally pressed into a corresponding circular groove 32 in plate 1) when plates 1 and 7 are fastened together, so as to prevent leakage of the polymer fluid, metal or gas between the plates.

The apparatus is connected with suitable piping and filter packs (not shown) as required to supply a molten polymer and a molten metal to the spinneret.

In the melt-spinning processes preferred in the practice of this invention, molten metal flows from annular chamber 3 through longitudinal passages 10 of pins 9 and out of the spinneret as the core of the composite filament. Molten polymer flows from central chamber 2 through holes 5 into annular groove 6 (through which pins 9 pass) downwardly through the passages in plate 7 formed by the annular pin (at its non-annular periphery) and hole 18 of plate 7 (shown clearly in FIGURE 10 which represents pin 9 in plate 7 turned from its position in FIGURE 6 in order to show the clearance between pin 9 and plate 7), then along the groove formed at neck 15 and outwardly as a sheath through annulus 19.

It is, of course, understood that the design of apparatus is capable of considerable variation. Thus pins 9, instead of being non-circular in cross-section within plate 7, may be circular in cross-section with sufficient clearance being provided between the pins 9 and holes 18 to permit passage of the polymer around the pins 9 as a sheath.

In the examples, the relative viscosity (ηr) i.e., the viscosity of a solution of polymer relative to that of the solvent is used as the measure of the molecular weight. The polyamide solutions contained 5.5 grams of polymer in 30 ml. of 90% formic acid and the viscosity was measured at 25° C. The polyester solutions contained 2.15 g of the polymer in 20 ml. of a 7/10 mixture by weight of trichlorophenol/pheno1 and the viscosity was measured at 25° C.

The following examples in which parts, proportions and percentages are by weight unless otherwise indicated, are intended to illustrate this invention and in no manner to limit it.

**Example 1**

A spinneret similar to that shown in FIGURES 1 to 10 of the drawings was constructed with only one hole in which the outside diameter of the extrusion orifice 20 was 0.030 inch, the outside diameter of the end 16 of tube 9 near the orifice was 0.022 inch in diameter and the inside diameter of the tube 9, i.e., the diameter of orifice 17, was 0.011 inch. Using this spinneret, poly(ethylene terephthalate) of relative viscosity 30 and the binary eutectic mixture of tin and lead having a melting point of 181° C. were simultaneously spun at 270–275° C. into a stream of air at 30° C. moving in a direction concurrently with the path of travel of the formed filament. Straight filaments having a continuous uniform core of metal completely and uniformly surrounded by a covering of the polyester were produced.

**Example 2**

A six-hole spinneret similar to that shown in FIGURES 1 to 10 of the drawings having extrusion orifices 20 with an outside diameter of 0.035 inch and end 16 of center tubes 9 having an outside diameter of 0.029 inch and an inside diameter for orifice 17 of 0.004 inch was made.
Poly(ethylene terephthalate) of relative viscosity 32 was melt-spun as a sheath around a molten core of an alloy comprising 40% bismuth, and 60% tin having a melting range of 138°-170°C. The composite sheath was maintained at 288°C and the composite filaments were spun into air at room temperature (75°F) at 500 yards per minute. The as-spun filaments had an outside diameter of approximately 0.006 inch with a uniform metal core of about 0.0043 inch in diameter. The core occupied about 50% of the filamentary volume. Longitudinal and cross-sectional views of the filaments are shown in FIGURE 11 (one filament) and FIGURE 12 (several filaments) respectively. The ends of the metal core of a two foot length of the as-spun yarn were silvered to facilitate making connections and electrical measurements made. The yarn had a resistance of 100 ohms per foot and carried a current of 0.10 ampere for an indefinite period of time without causing any change in appearance of the polymeric sheath or making the composite filament hot. Under a current of 0.125 ampere the metallic core fused apart. This yarn, as spun, was drawn 100% in a 125°C oil bath by hand to give a strong filament with a continuous metal core. The composite filament was of about 0.003 inch completely surrounded by a uniform polyester sheath. The as-spun filaments could not be drawn at room temperature since the core broke at a low elongation and the sheath soon after. However, a filament prepared in a similar manner but with about 28°C at room temperature 50% of the core fractured into segments. A filament with an oriented sheath and a similarly segmented core was also made by cold drawing a similar filament with a 33% core.

Example III

A spinneret similar to that used in Example II was used to spin a sheath of the polyester previously used around the core of an alloy comprising 48% bismuth, 28.5% lead, 14.5% tin and 9.0% antimony melting over the range 103-227°C and having an ultimate elongation of less than 1% at room temperature. The molten polymer and molten metal were simultaneously spun as sheath and core respectively at 288°C into air at room temperature and the yarn wound up at 500 yards per minute. The continuous filaments produced had a continuous core completely and uniformly surrounded by a sheath of poly(ethylene terephthalate) similar to the filament of FIGURE 11 but with the core comprising approximately 25% by volume of the cross-section of each filament. A sample of the yarn was drawn 160% (the as-drawn yarn was 260% of original undrawn length) in a 135°C oil bath to yield filaments with continuous and uniform metal cores having a tensile strength of 18,000 pounds per square inch, an ultimate elongation (permanent potential further elongation at break under standard elongation testing conditions) of 287% and a denier per filament of 85.

A 370% draw in a 125°C oil bath gave a yarn in which the core was just broken into tiny segments completely enclosed by the sheath. A 220% draw at 90°C gave the core in conjunction with hollow spaces in the yarn, a longitudinal view of the yarn section being shown in FIGURE 13. A 220% draw at 75°C gave a yarn in which the metallic core had been broken into tiny segments and the surrounding polymer sheath had necked down at the points where the core had broken, so that each filament had alternate thick and thin portions.

Example IV

Using a one-hole spinneret similar to that used in Example II poly(ethylene terephthalate) of relative viscosity 37 was melt-spun as a sheath around the molten core of the alloy which comprises 40% bismuth and 60% tin melting over the range 139-170°C. The composite filaments were spun at 290°C and at 130 yards per minute into a 1-foot tube of water at 33°C which was pumped concurrently with the direction of the thread line motion. Spinning was good and continuous filaments were obtained, a typical filament cross-section having a diameter of 0.009 inch and a core 0.006 inch in diameter which is equivalent to 45% core by volume, being otherwise similar to FIGURES 11 and 12. A portion of the as-spun yarn was hand-rolled along the length of the filament with a metal roller at room temperature to yield ribbon-shaped filaments approximately 0.050 inch wide similar in appearance to the flattened filaments shown in FIGURE 14. As shown in FIGURE 14, certain of the filaments were not flattened since the pressure of the hand-roller was not, in this case, effectively applied to all filaments. The rolling did not break the sheath or separate the two components and the resulting ribbon had a much higher degree of reflectivity than the dull appearing as-spun yarn, so that it presented a glittering shiny surface. The rolling produced an increase in length equivalent to a 30% elongation of the as-spun fiber. The product had a tensile strength of 10,400 pounds per square inch.

Taking a filament of the composite yarn elongated a maximum of 3.7% without breaking the core by drawing at room temperature alone but a combination of rolling and drawing permitted an overall elongation of 35% without breaking the core.

Example V

Poly(ethylene terephthalate) of relative viscosity 37 and tin maintained at 285 and 280°C respectively were melt-spun as the sheath 84% and core 16% by volume respectively of a composite filament with a sheath similar to that shown in FIGURES 1-10, but with only one spinning orifice. The monofilament was extruded down from the spinneret through a two inch air space at ambient temperature into a 1 foot long tube of water at constant head of pressure at 30°C that flowed concurrently with the filament. Good spinning was enjoyed and the filament was continuously wound up at 121 yards per minute. The as-spun filament (0.0085 inch in diameter) of 800 denier per filament had a tensile strength of 8,300 pounds per square inch (0.32 g.p.d.) and an ultimate elongation of 648%. The filaments had a shiny, continuous, tin core completely surrounded by polymer. A sample of the filament was elongated 400% by drawing over a pin at room temperature. This treatment fractured the core into small longitudinal segments so that the filament resembled that shown in FIGURE 13 with a diameter of about 0.0045 inch. Hand-rolling of the drawn yarn with a metal roller flattened the filament and afforded a decorative ribbon 0.017 inch wide and 0.002 inch thick with shiny glittering sequin-like segments of tin (0.012 inch wide, 0.0015 inch thick and 0.10 inch apart) in the core completely surrounded by a polyester sheath with an appearance similar to that of FIGURE 19. Physical properties of these products are given below:

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Tenacity, g.p.d</th>
<th>Tensile Strength, p.s.i.</th>
<th>Ultimate Elongation, %</th>
<th>Mn Denier/Filament</th>
</tr>
</thead>
<tbody>
<tr>
<td>As-spun</td>
<td>0.80</td>
<td>8,300</td>
<td>648</td>
<td>0.8</td>
</tr>
<tr>
<td>Drawing</td>
<td>2.1</td>
<td>54,500</td>
<td>18</td>
<td>29</td>
</tr>
<tr>
<td>Drawing plus</td>
<td>1.6</td>
<td>41,500</td>
<td>14</td>
<td>27</td>
</tr>
</tbody>
</table>

Mn as used herein signifies initial modulus in grams per denier.

Another sample of the same as-spun yarn as above was rolled with a metal roller to give an increase in length equivalent to a 70% elongation of the original length. The flattened filament with a continuous metal core had a cross-section similar to those shown in FIGURE 15. The rolled filament was then drawn over a pin at room temperature to give a total elongation of 250% of the filament's as-spun length. The drawn fila-
ment had a continuous metal core and its cross-section resembled that of FIGURE 16 where it can be noted that the filament apparently drew up in cross-section away from a ribbon shape. Rolling of the drawn filament flattened the filament once more and gave a ribbon 0.010 inch wide and 0.0007 inch thick. A continuous metal core and its cross-section resembled that of FIGURE 17 where it can be noted that all these filaments displayed a bright shiny core but the reflectivity was much greater with the rolled filaments. Physical properties of these products are given below:

<table>
<thead>
<tr>
<th>Filament Treatment</th>
<th>Tenacity, g.p.d.</th>
<th>Tensile Strength, p.s.i.</th>
<th>Ultimate Elongation, Per cent</th>
<th>MI</th>
<th>Denier per Filament</th>
</tr>
</thead>
<tbody>
<tr>
<td>As-spun</td>
<td>22</td>
<td>8,500</td>
<td>66</td>
<td>6.2</td>
<td>26</td>
</tr>
<tr>
<td>Rolling</td>
<td>0.20</td>
<td>13,000</td>
<td>56</td>
<td>13</td>
<td>35</td>
</tr>
<tr>
<td>Rolling plus</td>
<td>1.00</td>
<td>21,000</td>
<td>72</td>
<td>21</td>
<td>450</td>
</tr>
<tr>
<td>drawing plus</td>
<td>1.1</td>
<td>28,000</td>
<td>79</td>
<td>21</td>
<td>50</td>
</tr>
<tr>
<td>Rolling plus</td>
<td>1.1</td>
<td>28,000</td>
<td>79</td>
<td>21</td>
<td>50</td>
</tr>
</tbody>
</table>

It was quite surprising that the above sequence of rolling and drawing allowed the tin core to be elongated to a total of 250% since the core of the as-spun yarn fractured when elongated 25% by drawing without prior rolling. When it was attempted to roll and draw a length of cast tin similar to the core of the above filament, the tin drew about 30% before breaking after being increased in length 10% by rolling.

Example VI

The polymer of Example V was replaced with poly(hexamethylene adipamide) of relative viscosity 41, and sheath-core filaments spun as before. The as-spun filaments (which were 0.0076 inch in diameter) containing 70% core by volume were elongated 20% by rolling and then drawn over a pin at room temperature to an overall elongation of 190% of the as-spun length without fracturing the core. The rolled and drawn filaments had a flattened cross-section similar to FIGURE 18, being about 0.008 inch by 0.0017 inch in cross-section, and displayed a reflective, continuous metal core completely surrounded by the polyamide sheath. The rolled and drawn filaments had a tenacity of 0.76 g.p.d. (tensile strength of 42,800 p.s.i.), an ultimate elongation of 31%, a MI (initial modulus) of 12 g.p.d. and a denier per filament of 391.

The polyamide was replaced with linear polyethylene of 4.7 melt index (ASTM Std. D1238-52T) density of 0.96 and melting point of 150°C, and a filament spun by extruding the polyethylene at 250°C simultaneously with the molten tin at 60 yards per minute into a water quench as in Example V. Lengths of the filaments containing a continuous tin core completely surrounded by a sheath of polyethylene could be elongated 60% by drawing after first elongating the filaments 30% by rolling. In the drawings, it is desired to point out that the small black specks occurring in the various views of filament cross-sections, e.g., FIGURES 14-17 and 19, represent the media used in mounting the filaments in the preparation of filament specimens to be photographed.

The metal core of the filaments of this invention can be made of any metal that is molten at a temperature at which the polymer for the sheath is stable. Such metals include tin, lead, bismuth, lithium, selenium and their alloys with each other and such metals as an antimony and zinc as for example, bismuth solder, battery plate, white metal, aluminum solder, and eutectic alloy to name a few.

For the sheath of the filaments of this invention any fiber-forming polymer that can be spun into filaments at a temperature at which the metal core is molten can be used such as polyesters, polyamides, polyethers, polyacetals, polyurethanes, polyureas, polyetherethers as polyethylene and polytetrafluoroethylene and polyvinyl polymers as polyacrylonitrile, polyvinyl chloride, polyvinilidene chloride and their copolymers to name a few. Because of their commercial availability, ease of processing and excellent properties, polyesters, polyamides, or polyurethanes are preferred. United States patents 2,071,250; 2,071,253; 2,130,523; 2,130,948; 2,190,770; 2,465,319 and in other places are preferred.

Although the process of this invention has been illustrated with melt-spinning, the desired two-component filaments can be plasticized-melt-spun as described, for example in U.S. Patent 2,706,574 issued to Rothrock on April 19, 1955, or spun by wet-spinning or dry-spinning methods, from a solution of a polymer component and the molten metal. Also, dispersion spinning methods (as in the case of polytetrafluoroethylene) can be used where desired.

Although the composite filaments of this invention having continuous metal cores can be used in an as-spun condition made without any intentional drawing during the spinning, it is generally preferable to increase their strength by orientation of the sheath. The temperature of drawing can be modified up to the melting point of the polymer so as to attain the maximum elongation of the metal. A part or all of the elongation obtained by such temperature drawing, of course, can be replaced by drawing during the spinning in which case the filaments are wound up at a rate much greater than that at which they are extruded from the spinneret. Filaments with cores of some metals having a high extensibility can be drawn at room temperatures, while with others a temperature near or above the melting point of the metal needs to be used.

It has been found that greater extensibility of the metal core without fracturing can be obtained in some cases if a combination of rolling and drawing is used in sequence. These steps can be combined as, for example, by drawing a filament through a slit afforded by the smooth edges of two rods that squeeze the filament at a constant pressure.

In spinning the filaments of this invention, a relatively rapid rate of quenching is preferred in order to solidify the polymer and so prevent possible formation of globules of metal in the core due to the surface tension of the molten metal. Such quenching can be accomplished by a flow of gas or by spinning into a liquid, preferably at a temperature of 0°C-80°C.

The filaments of this invention having intermittent segments of metal in the core can be made by drawing a composite filament under such conditions that the metal core fractures. In general, this can be done at temperatures below the melting point or minimum value of the melting temperature range of a metal. The total elongation of the filament in the draw must exceed the ultimate elongation of the metal. This will vary from metal to metal, but in general, the elongation necessary, which may range from 50 to 1500%, to produce the desired strength in the polymeric sheath will be sufficient to fracture the metal in the as-spun filaments. In order to provide enough strength for the polymer to hold its form during the drawing step, the sheath of the as-spun filament should comprise about 5 to 95% of the fiber volume, with the range of 25%–95% sheath being preferred. The total force to break the core must be less than the force required to break the sheath. Knowing the tensile strengths of the two polymers after the drawing temperature, the core to sheath ratio can be adjusted to afford a segmented core by drawing. A given ratio of filament components is obtained with a given spinneret by adjusting the flow rates of the two liquids that are spun, as for example, by changing the polymer feed pump rate or by altering the air pressure that might be used, for example, to extrude the molten metal.

With some metals having a sufficiently high surface tension, it is possible to obtain an intermittent core by drawing the filaments at temperatures above the melting
point of the metal so that the metal contracts into segments in the core. In other cases, this same result is attained in spinning when the quenching is slow.

While the invention may be applied over a wide range of denier, it is preferred that the filaments as spun have a denier of 20 to 4,000 and that the drawn filaments have a denier of 2 to 2,000.

The filaments of this invention are of advantage in textile applications due to their strength and appearance. Those filaments with continuous or intermittent reflective cores can be used to make all manner of novel fabrics. The appearance of the filaments can be altered by co-spinning dyes or pigments in the polymer sheath or by dyeing the filaments or fabrics. In this way, filaments resembling gold lame can be formed at a fraction of the cost of the conventional gold-wound or gold-coated filaments. The opaqueness of the metal core to beta and gamma radiation can be utilized in the fabrication of clothing to provide protection against atom bomb debris, for example.

Those filaments with continuous metal cores can be used as insulated conductors and those having small diameter cores of low melting metals are useful as microammeters. Fabrics made of the filaments of this invention can be used to provide shielding around electronic equipment. The solubilities and thermoplasticities of the polymeric sheaths can be used to coalesce the contacting edges of the filaments in a fabric, for example, into a form-stable covering that will not be displaced by vibration of the equipment and yet reduce the usual electronic noise.

Although reference has been made herein to the making of flat, ribbon-like filaments by rolling metal core filaments of this invention, no claim is made in this application to such flattened filaments or their production (although they are embraced within the broad scope of the present invention) since they form the subject matter of the patent application of Robert W. Bundy Serial No. 648,374 entitled "Composite Filaments and Their Manufacture" filed on even date herewith. Also, the species represented by a flattened fractured core and its preparation form the subject matter of the said patent application of Robert W. Bundy.

Since the invention is capable of considerable variation beyond as well as inclusive of the illustrations given herein, it will be understood that any modification which conforms to the spirit of the invention, is also intended to be included within the claims.

I claim as my invention:

1. A shaped article comprising a metal core and an adherent oriented polymer sheath disposed about said core, said metal core having a melting point below the temperature at which the polymer for the sheath becomes unstable.

2. A shaped article comprising a metal core and an adherent oriented sheath of synthetic linear polymer of uniform diameter disposed about said core, said metal core having a melting point below the temperature at which the polymer for the sheath becomes unstable.

3. A shaped article comprising a metal continuous core and an adherent oriented sheath of synthetic linear polymer of uniform diameter disposed about said core, said metal core having a melting point below the temperature at which the polymer for the sheath becomes unstable.

4. A shaped article comprising a metal discontinuous core and an adherent oriented sheath of synthetic linear polymer of uniform diameter disposed about said core, said metal core having a melting point below the temperature at which the polymer for the sheath becomes unstable.

5. A textile filament comprising a shaped article comprising a metal core and an adherent oriented sheath of synthetic linear polymer disposed about said core, said metal core having a melting point below the temperature at which the polymer for the sheath becomes unstable.

6. The article of claim 5 characterized in that the composite filament has a denier between 2 and 2,000.

7. The article of claim 5 in which the sheath comprises 5%–95% of the filament.

8. The article of claim 5 in which the sheath comprises 25%–95% of the filament.

9. A shaped article comprising a metal core and an adherent oriented sheath of synthetic linear polymer of uniform diameter disposed about said core, said metal core having a melting point below the melting point of the polymer for the sheath.

10. A textile filament comprising a shaped article comprising a metal core and an adherent oriented sheath of synthetic linear polymer disposed about said core, said metal core having a melting point below the melting point of the polymer for the sheath.

11. A textile filament comprising a metal core and an adherent oriented polyester sheath disposed about said core, said metal core having a melting point below the temperature at which the polymer for the sheath becomes unstable.

12. The filament of claim 11 wherein the polyester sheath is poly(ethylene terephthalate).

13. A textile filament comprising a metal core and an adherent oriented polyamide sheath disposed about said core, said metal core having a melting point below the temperature at which the polymer for the sheath becomes unstable.

14. The filament of claim 13 wherein the polyamide sheath is poly(hexamethylene adipamide).

15. A textile filament comprising a metal core and an adherent oriented addition polymer sheath disposed about said core, said metal core having a melting point below the temperature at which the polymer for the sheath becomes unstable.

16. The filament of claim 15 wherein the addition polymer sheath is polyethylene.

References Cited in the file of this patent

UNITED STATES PATENTS

<table>
<thead>
<tr>
<th>Patent Number</th>
<th>Date</th>
<th>Invention</th>
</tr>
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<tbody>
<tr>
<td>1,370,800</td>
<td>Mar. 8, 1921</td>
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