June 11, 1968 J. G. SIMS 3,388,198

METHOD FOR PRODUCING IRIDESCENT FILAMENT

Filed Jan. 27, 1966

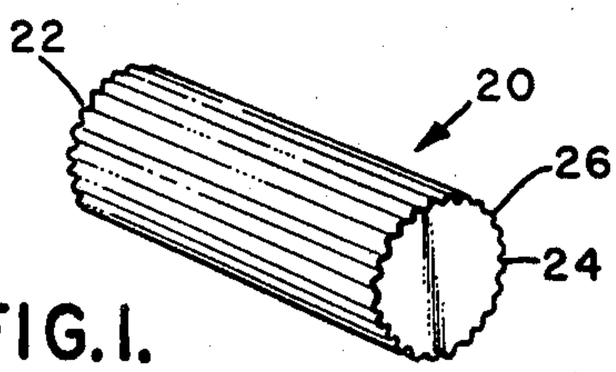


FIG. 1.

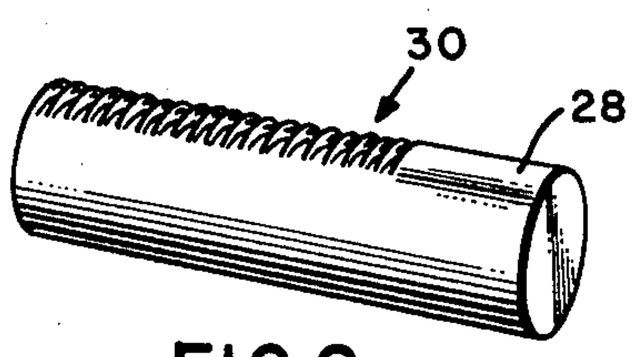


FIG. 2.

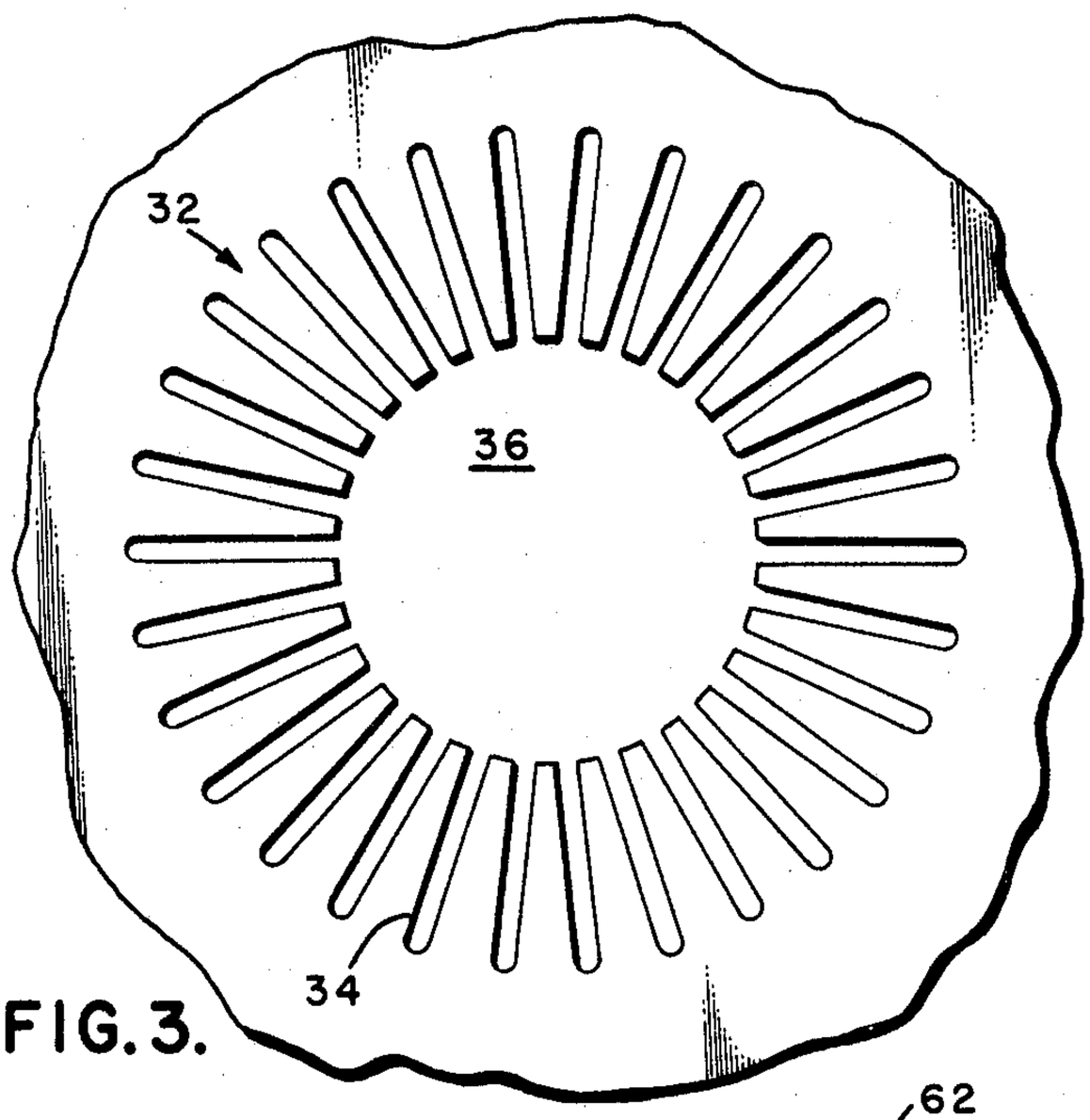


FIG. 3.

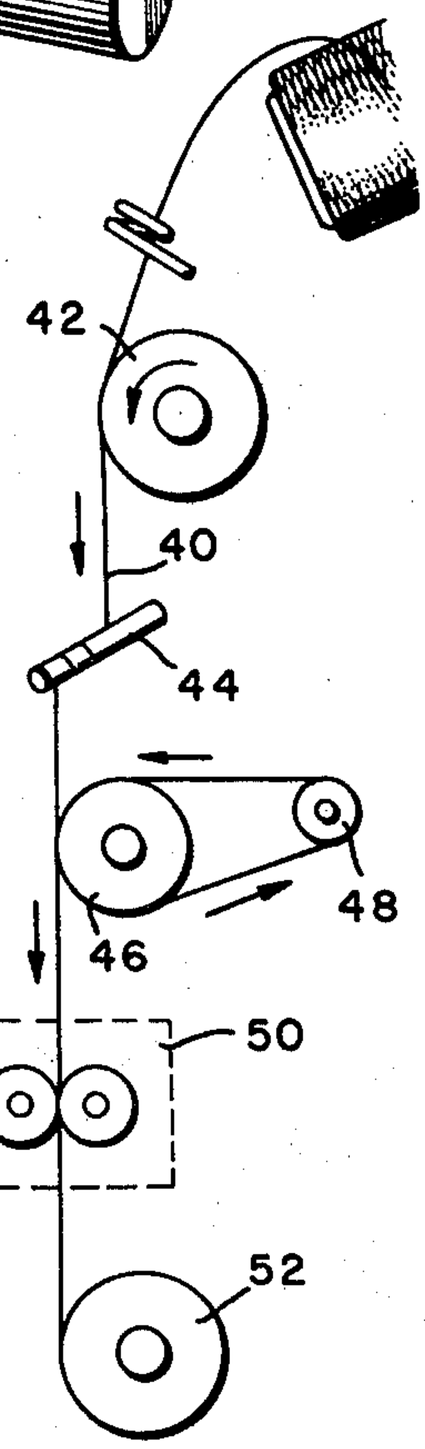


FIG. 4.

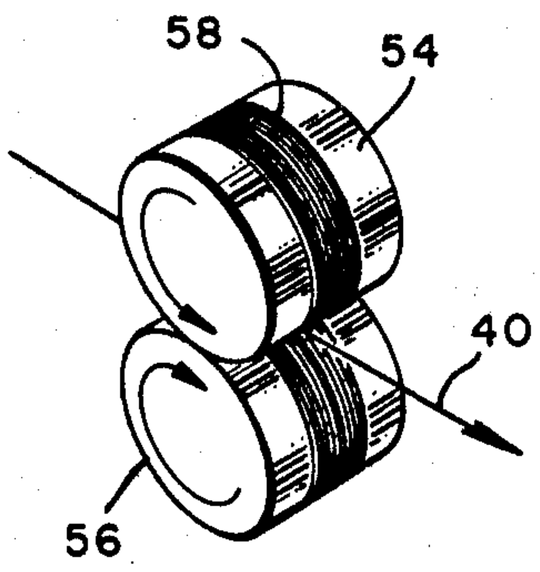


FIG. 5.

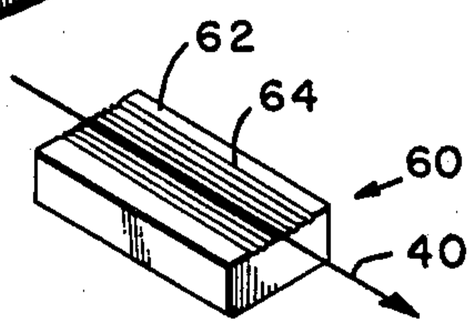


FIG. 6.

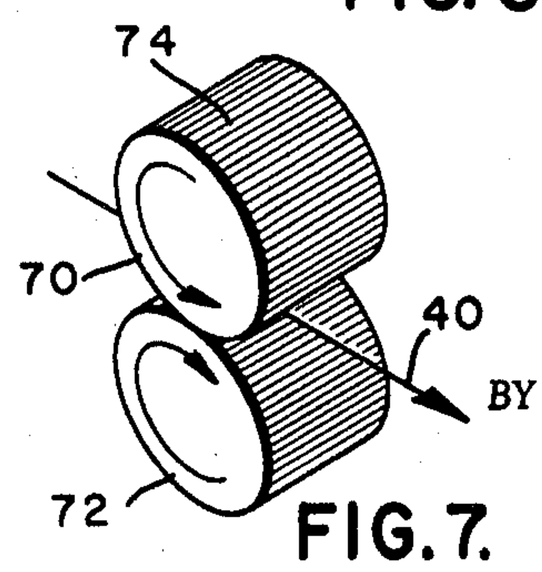


FIG. 7.

INVENTOR.
JAMES G. SIMS

BY Kelly O. Cooley

ATTORNEY

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METHOD FOR PRODUCING IRIDESCENT FILAMENT

James G. Sims, Pensacola, Fla., assignor to Monsanto Company, St. Louis, Mo., a corporation of Delaware

Continuation-in-part of abandoned application Ser. No. 249,846, Jan. 7, 1963. This application Jan. 27, 1966, Ser. No. 523,311

5 Claims. (Cl. 264—177)

This application is a continuation-in-part of my pending application Ser. No. 249,846 filed Jan. 7, 1963, and now abandoned.

The present invention relates to the provision of a yarn inherently displaying iridescence and, more particularly, to such a yarn in which the iridescence is produced by the configuration of the yarn surface.

The prior art iridescent yarns were usually produced by the incorporation inside the individual filaments of flakes or particles of iridescent materials such as pearl essence, mica dust, etc. Such teachings are embodied for example in U.S. Patent 2,712,190 to Sobel, entitled "Iridescent Material and Product."

A prior art iridescent effect in a sheet was produced by a process including elongation of a sheet to the point of plastic deformation, plating the sheet with a metal film, varnishing the plated surface, and annealing the resulting article. This produced an iridescent effect, presumably by the production of micro-unevenness (see U.S. Patent 2,992,125).

A principal object of the invention is to provide textile products displaying intrinsic iridescence.

A further object is to provide textile products of the above character wherein such iridescence is produced without requiring the addition of extraneous non-filamentary material.

A further object is to provide textile products of the above character in which the iridescence is not subject to fading upon dyeing, laundering, or moderate soiling.

A further object is to provide textile products of the above character which may be economically produced without requiring elaborate processing.

Other objects of the invention will in part be obvious and will in part appear hereinafter.

The invention accordingly comprises the several steps and the relation of one or more of such steps with respect to each of the others, and the article possessing the features, properties, and the relation of elements, which are exemplified in the following detailed disclosure, and the scope of the invention will be indicated in the claims.

For a more complete understanding of the nature and objects of the invention, reference should be had to the following detailed description taken in connection with the accompanying drawing, in which:

FIGURE 1 is a perspective view of a portion of an iridescent filament according to the present invention,

FIGURE 2 is a perspective view of a portion of a second embodiment of filaments according to the present invention,

FIGURE 3 is a plan view of a spinneret orifice which may be used to produce a filament such as that shown in FIGURE 1,

FIGURE 4 is a schematic view illustrating a conventional filament drawing apparatus incorporating an iridescence-producing step,

FIGURE 5 is a schematic perspective view illustrating an exemplary form of apparatus which may be used to produce iridescence in the FIGURE 4 system,

FIGURE 6 is a schematic perspective view of an alternative apparatus which may be used in the FIGURE 4 system, and

FIGURE 7 is a schematic perspective view of a further form of apparatus which may be used in the FIGURE 4 system.

Referring now to FIGURE 1, there is illustrated a filament 20 which inherently display iridescence due to the structure of its surface. As shown in FIGURE 1, filament 20 has an outer surface which is striated along its length in a series of striations 22. Striations 22 are composed of a series of evenly spaced parallel troughs 24 separated by crests 26. It has been discovered that if such striations are spaced in the range between 1 and 10 microns, and if the striations are spaced no more than 20° apart on the filament periphery, the filament exhibits iridescence intrinsically, without the necessity for incorporating material displaying iridescence in the filament. Preferably, the depth of the troughs is at least one-third of the lateral spacing between troughs, to give a more definite iridescence. Such a filament may be spun into yarn, woven into cloth, etc., and in general utilized for all the normal range of filament end uses.

Referring now to FIGURE 2, an alternative filament 28 is illustrated having striations 30 which extend transverse to the axis of filament 28. Such transverse striations are equally effective in producing iridescence if they are similarly spaced within the range of 1 to 10 microns.

The longitudinally striated filament of FIGURE 1 may be produced either directly by spinning through a suitable orifice, as is presently preferred, or by embossing an ordinary filament after it has been spun. FIGURE 3 illustrates a suitable spinneret orifice which may be used to spin a filament such as is illustrated in FIGURE 1. As illustrated in FIGURE 3, the orifice 32 is provided with a large plurality of radial slots 34 extending outwardly from a central circular orifice 36. In actual practice, a partial plugging of the central orifice 36 is required in order to constrain the extruded polymer to flow properly through the narrow slots 34. This may be effectively done by placing a steel spherical insert, too large to pass through orifice 36, within the spinneret pack and centered atop orifice 36. Other means may be employed to partially obstruct polymer flow through central orifice 36.

As an example, the central orifice 36 may have a diameter of .050 inch, while the slots 34 may have a width of .0025 inch and a length of .025 inch. With central orifice 36 having the above diameter, a steel sphere having a diameter of 0.072 inch satisfactorily distributed the polymer. The axial length of the orifice may be 0.015 inch. The slots must have a length-to-width ratio of at least 5, and preferably 10 or more, if iridescence is to be achieved with practicable quenching rates. When thirty slots 34 having the above dimensions are equally spaced about central orifice 36, a filament may be extruded therefrom having thirty striations evenly spaced around its circumference. Such a filament may be suitably drawn to the desired size and used for the manufacture of intrinsically iridescent novel fabrics.

EXAMPLE I

A 6-hole spinneret as described above without the steel sphere was assembled in a spinneret pack for melt spinning nylon 66. The preheated pack was installed in a conventional spinning machine, and undelustered nylon 66 polymer at 293° C. was extruded through the spinneret. The extruding filament was cooled by a transverse current of air at 22° C. flowing at a lineal rate of 82 ft./min. The spun filaments were wound up conventionally on bobbins at the rate of 461 y.p.m. with the extrusion rate adjusted to yield a filament having a denier of 60.

It was observed that most of the polymer tended to channel through orifice 36 with only a small proportion of

polymer flowing through slots **34**. Cross sectioned filaments examined under a microscope revealed no perceptible lobes around the periphery of the section. The spinneret is removed, cleaned, and reassembled with the sphere, as described above, in each counterbore above orifice **36**; the pack is again installed in the spinning machine as before.

With the spheres in place, polymer extrudes quite uniformly across the entire capillary rather than channelling excessively at the center. The metering pump is varied over a range corresponding to spun filaments having final deniers ranging from 20 to 75. Polymer extrusion is uniform, but at the highest polymer flow rates, air bubbles tend to be trapped occasionally between two adjacent lobes of the filament, and filaments become difficult to quench in the standard air chimney. The pump is set to extrude 50 d.p.f. filaments at a speed of 46 y.p.m., and several bobbins of yarn are collected.

Examination of the filaments in strong light reveals a subtle display of spectral colors as the filament is rotated between the fingers and as the eyepoint is shifted relative to the light source. Hand-drawing the filament about 350% does not destroy the color effect but enhances it. Viewed directly against a bright light the filament is also seen to display soft bands or streaks of color, the streaks being predominately parallel to the axis of the filament. A microtoned cross section of the filament is examined at 860× with an optical microscope, and the periphery of the filament is seen to have a scalloped or lobed contour similar to that illustrated in FIGURE 1 although the lobes were not quite so distinct and uniform as there shown. The peripheral spacing of the lobes was estimated with a reticle to be approximately 9 microns, which corresponds to an average count of 2800 per lineal inch. Lateral views of the filament under the microscope indicates that the longitudinal ribs do exist as indicated in FIGURE 1 but refraction and diffraction of light, either from substage or overhead lighting, makes it difficult to obtain a well defined focus.

Five bobbins of the spun yarn are stocked on a conventional Whitin RG–4 drawtwister and yarn is drawn at a machine draw ratio of 4.05 to yield drawn 13 denier monofilaments. The peripheral spacing of the riblike striations is reduced in the drawing operation to about 4.4 microns, which corresponds to a count of 5700 striations per lineal inch.

Samples of the drawn monofilament are knitted into tubing on a circular knitter; two tubes are dyed black and medium blue, using the common dyestuffs Chromacyl Black and Anthraquinone Blue SWF, respectively. The subtle iridescent colors seen in the greiger fabric persists in the dyed tubes. The blue tube assumes localized predominantly reddish, green and purplish hues when viewed from various angles. The dyed black-grey tube displays virtually all colors of the spectrum, different colors appearing simultaneously at many different small areas of the fabric. It is to be remarked that the iridescence referred to throughout this specification is not a scintillating or gaudy display of color, but is a faint, soft coloration superimposed upon the stronger background color and provides a pleasing shifting luster effect that appears metallic under some viewing conditions.

EXAMPLE II

Another 6-hole spinneret with overall dimensions as indicated in Example I was prepared. The counterbore of all holes was 0.118 inch in diameter and the flat bottom was milled to within 0.020 inch of the spinneret face. In five counterbores a single circular capillary was formed 0.020 inch long by 0.011 inch diameter. The sixth capillary was composed of 18 radial slots 0.030 inch long by 0.0025 inch wide, the ends nearest the common center of the capillary being arranged on a circle 0.040 inch in diameter so that the slots did not intersect; this arrangement eliminates the open central area.

This 6-hole spinner was installed in a conventional melt spinning machine as previously indicated in Example I. Underlustered nylon 66 having a standard formic acid relative viscosity of 53 (as determined by the method described in U.S. Patent 2,385,890) was extruded through the spinneret with the spinning unit maintained at 290° C. Again extrustion at various rates indicated that the test capillary provided stable flow except at very high flow rates or at extremely low flow rates in which air bubbles were trapped irregularly along the filament. With pumps set to provide a 60 denier filament at 461 y.p.m. spinning speed, several small bobbins of test monofilament were collected.

Examination of the test filament in strong light reveals that the diffracted color patterns are visible from a somewhat limited range of eyepoints, principally at those positions providing a "glancing" incidence of the light. Microscopic examination of cross section revealed 18 crenulations or lobes around the periphery as indicated in FIGURE 1 but not so prefectly regular. The peripheral spacing of the lobes was estimated as 16 microns or about 1600 striations per lineal inch. Samples of the filament are hand-drawn approximately 400% and the color effect is enhanced, bands now being visible over a wider range of eyepoints; in the hand-drawn filament the striations are spaced peripherally at a rate of about 3000 per lineal inch.

EXAMPLE III

The 6-hole spinneret with 30-slot orifices and spherical inserts is assembled in a standard spinneret pack used in a conventional monofilament extrusion system supplied by a one inch screw extruder. Filaments pass directly into a water tank where they are quenched and are brought out over pin guides to a continuous stretching unit having conventional feedrolls and drawrolls with a heated plate between them. Filaments are wound up singly or combined together on a spool.

The preheated spinneret pack is installed in the extruder and nylon 66 polymer containing 0.3% TiO_2 delusterant and having a formic acid relative viscosity of 55 is extruded through the spinneret at a controlled temperature of 294° C. The extrusion rate is varied widely and the jets of polymer are seen to be stable over a wide range.

The extrusion rate is set to yield filaments having a spun denier of 68 at a spinning speed of 128 y.p.m. The water in the quench bath is adjusted to a level 1¾ inch below the spinneret face, and water temperature is controlled at 45° C. with heaters. From the feedrolls, running at peripheral speed of 128 y.p.m., the filaments pass lightly over a chrome-plated shoe, 4 inches wide and 18 inches long, controlled at a temperature of 185° C.; the filaments pass on to drawrolls operating at 592 y.p.m. peripheral speed and thence to a spool windup operating effectively at 550 y.p.m. but whose exact speed is controlled to maintain a tension of approximately 4 gms. in each filament as it is wound up. The drawn filaments have a denier of 16; this sample is designated A.

Microscopic examination of cross sections of the spun filaments indicate that the crenulated or scalloped periphery is very distinctly defined as indicated in FIGURE 1. Peripheral spacing of the ribs is seen to be about 10 microns or 2500 striations per inch. The cross section of drawn filaments is also seen to preserve very distinctly formed lobes as indicated in FIGURE 1 and the spacing is estimated to be about 5 microns or 5000 striations per inch. Again it is found that the lateral ribs cannot be brought into sharp focus when viewed under the microscope. Even on the spool, the filaments reveal a subtle interplay of pale spectral color against the white background of scattered light.

Spools of sample A filaments are stocked on the creel of a plytwister, and 13 filaments are brought together and twisted to 2 t.p.i. to provide a yarn with total denier of about 215. A small warp spool of the resultant yarn is

prepared and is used to weave a sample tape 1½ inch wide for judging suitability of the yarn for upholstery fabrics. Several pieces of tape are dyed light pastel colors and deeper shades. In the lighter colors the interplay of the diffraction bands of color produces an attractive, subtle opalescent appearance in combination with the background color. In the darker shades of green, brown, and navy blue the superimposed shifting spectral colors provide an attractive subtle metallic luster effect. The yarn is judged to be suitable for upholstery fabric, particularly in automobiles and patio chairs.

EXAMPLE IV

Operating conditions of the extrusion apparatus referred to in Example III are changed to produce nominal 5 denier filaments. The feedroll speed is 245 y.p.m. and polymer extrusion rate is reduced to yield spun filaments having 14 d.p.f. Other conditions are unchanged.

The extruding filaments are observed to "wander" about on the surface of the water in the quench tank. Examination of spun filaments reveal diffraction colors are almost completely absent except for occasional segments of the filament; apparently the lobs of the filament degenerate and round out prior to quenching. A small quantity of Tamol-N wetting agent is added to the water and the reduced surface tension appears to reduce the "wandering" of the filaments with a small improvement in the diffraction performance of the resultant filaments. The water in the bath is replaced, and a layer of light paraffin oil about 1½ inch deep is poured on top of the water. This oil has a gravity of 44° API, and at the operating temperature of the bath has a specific gravity of about 0.78 compared with about 0.95 for the extruding nylon 66. The filaments now enter the quench oil layer directly with negligible "wandering." At the spinning speed involved, no emulsification of the oil and water occurs, the oil separating readily from the water as the filament enters and leaves the water phase of the quench bath. The resultant drawn filaments are designated sample B, and are of 4.8 d.p.f.

Both the drawn and the spun filaments of sample B display perceptible diffraction colors when viewed from practically any angle. Cross sections of the spun filament indicate that 30 lobes are well defined around the periphery although not quite so distinctly as in sample A, this observation being difficult to make with certainty because of the small scale of the crenulation and the smearing action of the microtone. A segment of drawn filament is prepared for observation by the shadowing technique, and an electron micrograph at 4000× is made of a lateral view. The micrograph clearly reveals the presence of the parallel ribs or ridges along the filament surface. Measurement by scaling between the ribs lying near the filament axis, where parallax error is least, indicates that the rib spacing is about 2.8 microns, or a peripheral rib density of 9,000 per lineal inch.

Twenty sample B filaments are plied together and given one t.p.i. of twist to form a 95 denier yarn. The yarn is spooled and is used to knit a strip of tricot fabric on a sample tricot machine. After standard scouring, pieces of fabric are dyed various pastel and medium shades. The spectral colors are quite prominent particularly at discrete points where loops occur in the courses of yarn. At normal observing distance the diffraction colors blend together to provide a subtle but live luster effect. In bleached white fabric the opalescent luster is again readily perceptible. Such fabric is judged to be particularly suited to shirting and lingerie, having an exotic silklike sheen and iridescence without objectionable gaudiness frequently seen in iridescents.

As the preceding examples illustrate, striated filaments of the invention may be melt spun directly from multi-slotted spinneret capillaries if proper precautions are taken. All of the well-known expedients in spinning non-circular filaments generally are applicable. Viscosity of the polymer should be as high as is practicable, filaments are to be quenched rapidly by using special baffles if necessary to direct cooling air on the filament immediately as it extrudes from the spinneret, etc. As the number of slots are increased, the re-entrant angle between slots decreases, and preserving the lobes in the resultant filament is more difficult. Slots may be tapered or otherwise shaped to aid in resolution of the lobes in the filament although spinneret manufacturing methods set some limitations practically.

The most generally satisfactory method of quenching is to use a liquid bath of other body of fluid having a high heat capacity and which can be applied effectively to the filaments immediately as they extrude. Because of its availability, high specific heat, and low cost, water is preferred for cooling baths; however, as illustrated in Example III, the high surface tension and buoyancy of water toward most melt spun polymers creates a problem when filaments are spun having a spun denier less than about 25. For these filaments a liquid having a specific gravity about 0.05 less than that of the extruding polymer is preferred. Many of the common paraffin hydrocarbon oils are well adapted for this use, and since they are essentially immiscible, these oils may overlay a body of water. In selecting a quenching liquid, materials that adversely react with the polymer are to be avoided and safety hazards due to toxicity and flammability under the given operating conditions must be considered. Dense polymers such as polyethylene terephthalate may be spun directly into water to which a small quantity surface active agent has been added to reduce surface tension.

Theoretically, the greater the lineal density of striations around the filament, the more effective it should be as a generator of diffraction colors. Practically, however, it is found that little is to be gained beyond 25,000 striations per inch; to exceed this density of striations for most textile denier filaments would require capillaries with more than 50 slots or legs, and quenching becomes a severe problem for commercial operation. An almost unavoidable microroughness exists on the surface of most melt-spun filaments and the scale of this roughness usually interferes with the generation of regular striation much beyond 25,000 per inch by direct spinning methods. Although interference colors may be produced by larger filaments having fewer than about 2000 striations per lineal inch, it is generally better to have a striation density of at least 2500 and preferably 5,000 per inch to insure strong coloration to any commercial size filament when viewed from all angles with respect to the incident light.

In general, the smaller the denier of the filament, the larger the striation density should be, but it is primarily important to exceed the lower limit of about 2500 striations per lineal inch. Spinneret capillaries with at least 20 radial legs and preferably more than 25 are suitable for producing filaments according to the invention, and 50-slot capillaries are useful and can be made to operate satisfactorily for moderate sized and larger filaments.

The minimum number of slots for a capillary can be calculated quite simply from the known density of the solid filaments and the chosen denier. The circumference of the equivalent circular filament is calculated and this circumference divided by the desired spacing of the striations; this quotient is the number of lobes, or slots, minus one. For example, 12,000 striations per inch is equivalent to a spacing of 2.1 microns; a circular filament of a certain polymer and denier is calculated to have a circumference of 71.3 microns. 71.3 divided by 2.1 is 34; therefore, a capillary having 35 slots or legs would be required. This calculation is not exact but the error in any practical case is less than 2% and, since only integral numbers of slots can be used anyway, more elaborate calculation is not justifiable or necessary.

The direct spinning of the iridescent filaments of the invention is applicable to all of the commonly melt-spun fibers. It is especially useful and practical with the polyamides, nylon 66, nylon 610, and nylon 6; with polyesters

such as polyethylene terephthalate and copolyesters commonly melt spun; and with polyolefins such as isotactic polypropylene and high density polyethylene. The presence of delusterant or colored pigment in the polymer is immaterial since the diffraction color arises from the ordered surface structure of the filament; however, translucent or undelustered polymer does not yield slightly more intense color since some transmitted as well as reflected light is diffracted.

It should be understood that a filament will display iridescence if only a portion of its periphery has crenulations as above described, although best results are obtained when crenulations are provided around substantially the entire periphery. In cases where the filament is not symmetrical about an axis, the crenulations or striations should be uniformly spaced at 20° or less about the centroidal axis or center of mass of the filament.

The cross sectional area of orifice **32** should be at least 10, and preferably 25 or more, times the cross sectional area of filament **20** when filament **20** is first solidified.

Instead of directly spinning the filament into the striated form, as by using a spinneret as illustrated in FIGURE 3, an ordinary filament or a strand or threadline composed of a bundle of individual filaments may be striated after spinning. Such a process is illustrated in FIGURES 4 through 7. Referring to FIGURE 4, there is shown a conventional drawing operation incorporating the novel striating step. As shown therein, a threadline **40** is fed from a suitable supply roll **42** to a snubbing pin **44**. After leaving the snubbing pin **44**, several turns of threadline **40** are passed about a conventional draw roll **46** and a separator roll **48**. Threadline **40** then passes through the striating mechanism **50** after which it is wound on a suitable take-up device **52**. Suitable exemplary striating mechanisms for use in the FIGURE 4 system are shown in FIGURES 5 through 7.

Referring now to FIGURE 5, the striating mechanism may be provided by a pair of suitable rolls **54** and **56** between which threadline **40** is clamped as it passes. As illustrated, roll **54** has its cylindrical surface ruled in a series of circumferential grooves **58**. It has been found that grooves **58** should be spaced in the range of 1 to 10 microns, i.e., there should be between 2500 and 25,000 grooves per axial inch of roll **54**. Threadline **40** is pressed against roll **54** and roll **56**, and presumably at least one of rolls **54** and **56** is driven at a peripheral speed approximately equal to the speed of threadline **40**. In order to protect the extremely fine grooves **58** on roll **54** from damage, it is generally preferable to make at least the outer surface of roll **56** of some resilient material which will not mar roll **54** in case of contact between the rolls.

A suitable heating mechanism is preferably provided to assist in impressing the striations upon threadline **40**. This may be accomplished by heating roll **54** by conventional heating means to a degree sufficient to slightly soften the outer surface of the individual filaments contacting roll **54**. As an example, roll **54** may be maintained at approximately 175–210° C.; or the threadline may be preheated to this temperature by an auxiliary heater just prior to the threadlines' contacting roll **54**.

If only roll **54** is ruled, passing threadline **40** between rolls **54** and **56** a single time produces filaments having one surface intrinsically iridescent due to the impression thereon of striations from contact with roll **54**. Optionally, both rolls may be ruled to produce filaments having striations on opposite sides.

As an alternative to the pair of opposed rolls **54** and **56**, longitudinal striations may be impressed on the surface of an ordinary filament by passing it under moderate tension over a suitable heated grooved surface, such as the ruled block **60** illustrated in FIGURE 6. Block **60** has its preferably slightly convex upper surface **62** ruled in a series of grooves **64**, approximately 2500 to 25,000 grooves per inch. Block **60** is preferably heated to a suitable degree by conventional heating means in order to assist the striating process as threadline **40** is drawn along the upper surface **62**. A pair of blocks **60** may be provided, either opposed to each other on opposite sides of the threadline, or longitudinally spaced along the threadline axis, in order to provide striations on opposite sides of the threadline.

Referirng now to FIGURE 7, there is shown a striating mechanism which produces lateral striations on the filaments of a threadline, instead of the longitudinal striations produced by the FIGURES 5 and 6 devices. The FIGURE 7 mechanism comprises a pair of clamping rolls **70** and **72** between which threadline **40** is passed. Roll **70** has a plurality of grooves **74** provided on its outer cylindrical surface parallel to its axis, grooves **74** being spaced apart approximately 1 to 10 microns. As threadline **40** is passed between rolls **70** and **72**, its surfaces which contact roll **70** are embossed to provide transverse striations, similar to those illustrated in FIGURE 2. Similar to the apparatus shown in FIGURE 5, preferably only one roll is provided with grooves, and the grooved roll is preferably heated to assist in the striation process. Although the other roll **72** is preferably provided with a soft surface to prevent damage to ruled roll **70**, optionally roll **72** may be similarly provided with grooves either parallel to its axis or circumferential. Although roll **70** is illustrated as grooved around its entire perimeter, if desired, grooves **74** may be provided in regularly or irregularly spaced groups about roll **70**, to provide spaced striated sections on the filaments such as illustrated in FIGURE 2.

It will be understood that, while the above disclosure with respect to FIGURES 5 through 7 relates to producing striations on filaments or threadlines, a completed textile article such as a fabric may have such striations impressed thereon by passing the fabric between heated rolls such as **56** and **54** in FIGURE 5, or between rolls such as **70** and **72** in FIGURE 7. This will produce striated areas on the surface of the article.

Accordingly, the above disclosed invention efficiently provides for textile products displaying intrinsic iridescence, wherein the iridescence is produced by the surface configuration of the article independent of incorporation of extraneous non-filament forming material within the filament. The iridescence produced in the textile products according to the present invention is not subject to fading upon dyeing, laundering or moderate soiling. The present invention is generally applicable to thermoplastic filaments, and may be economically applied to existing textile processes without extensive modifications.

It will thus be seen that the objects set forth above, among those made apparent from the preceding description, are efficiently attained and, since certain changes may be made in carrying out the above process, and in the articles set forth without departing from the scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawing shall be interpreted as illustrative and not in a limiting sense.

It is also to be understood that the following claims are intended to cover all of the generic and specific features of the invention herein described, and all statements of the scope of the invention which, as a matter of language, might be said to fall therebetween.

Having described my invention, what I claim as new and desire to secure by Letters Patent is:

1. A method for producing an iridescent filament, comprising in combination:

(a) extruding a crenulated filament formed of a molten fiber-forming polymer through a spinneret orifice, said spinneret orifice having a cross section including a plurality of substantially radial slots peripherally spaced about the centroid of said orifice, said slots being peripherally spaced no greater than 20° from one another with respect to said centroid,

(b) solidifying said filament,

(c) and taking up said filament at a rate such as to reduce the cross-sectional area of said filament while molten to less than 10% of the cross-sectional area of said orifice.

2. The method defined in claim 1, wherein said spinneret orifice comprises at least twenty said slots.

3. The method defined in claim 2, wherein said slots are at least five times as long as said slots are wide.

4. The method defined in claim 1, further comprising the step of drawing said filament after said filament is solidified.

5. The method defined in claim 1 wherein said slots are so peripherally spaced that there are between 2500 and 25,000 crenulations per inch along at least a portion of the periphery of said filament.

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JAMES A. SEIDLECK, *Primary Examiner.*

J. WOO, *Examiner.*

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,388,198 June 11, 1968

James G. Sims

It is certified that error appears in the above identified patent and that said Letters Patent are hereby corrected as shown below:

Column 2, line 5, "display" should read -- displays --. Column 3, line 17, "46" should read -- 461 --; line 51, "greiger" should read -- greige --. Column 4, line 1, "spinner" should read -- spinneret --; line 20, "prefectly" should read -- perfectly --. Column 5, line 22, "lobs" should read -- lobes --. Column 6, line 11, " of", first occurrence should read -- or --; line 38, "operation should read -- operation --; line 70, "calculation" should read -- calculations --. Column 8, line 7, "Referirng" should read -- Referring --. Column 9, line 7, claim reference numeral "2" should read -- 1 --; line 12, claim reference numeral "1" should read -- 4 --.

Signed and sealed this 24th day of February 1970.

(SEAL)

Attest:

Edward M. Fletcher, Jr.

Attesting Officer

WILLIAM E. SCHUYLER, JR.

Commissioner of Patents