

May 22, 1956

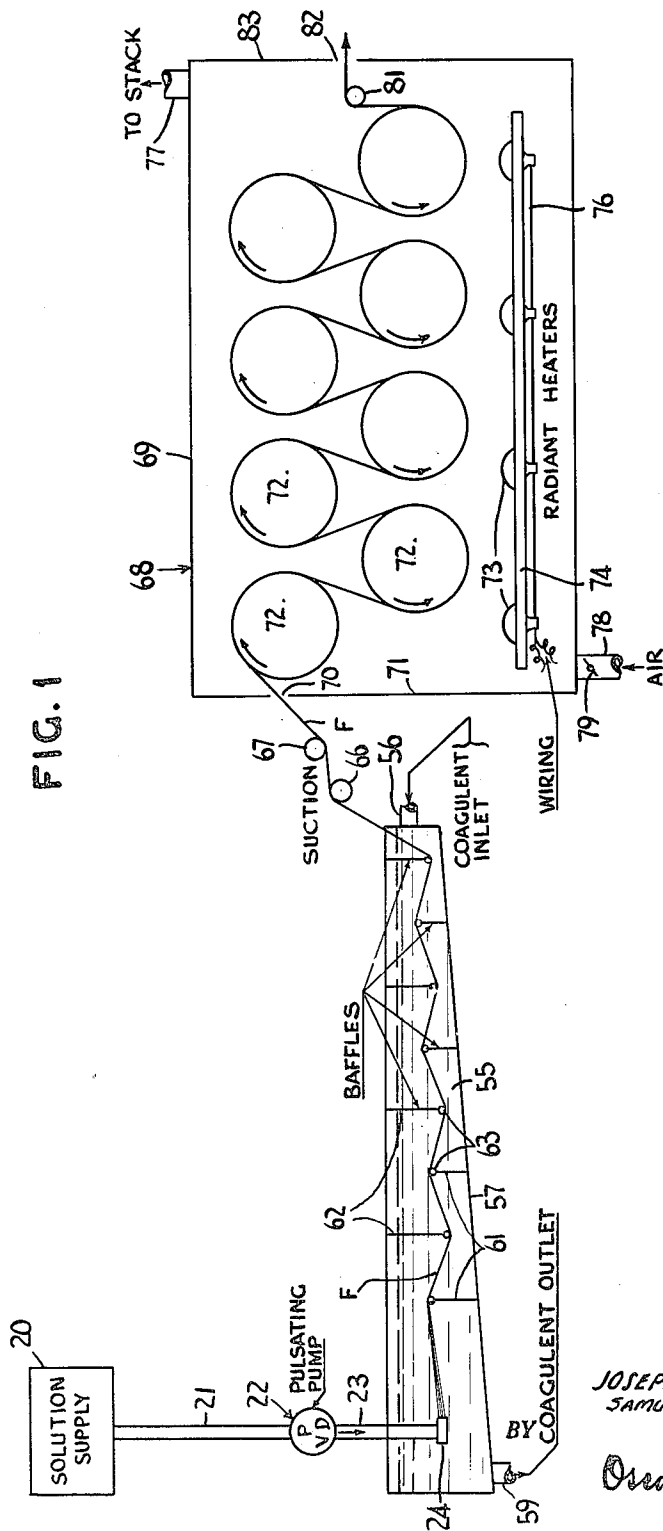
S. M. TERRY ET AL

2,746,839

METHOD OF SPINNING SHAPED FILAMENTS OF PLASTIC MATERIALS

Filed June 26, 1953

4 Sheets-Sheet 1



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May 22, 1956

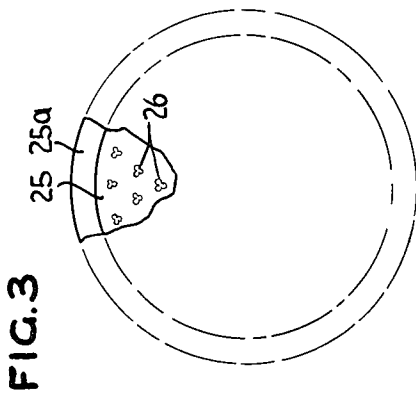
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METHOD OF SPINNING SHAPED FILAMENTS OF PLASTIC MATERIALS

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FILE 3

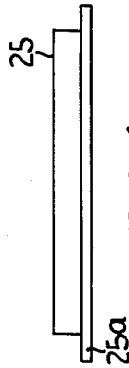


FIG. 4

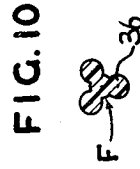
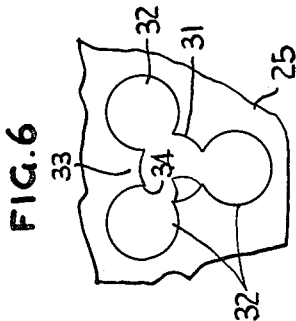


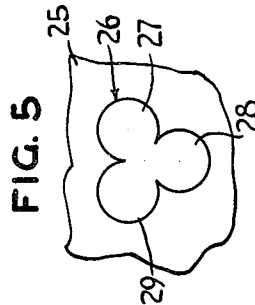
FIG. 10



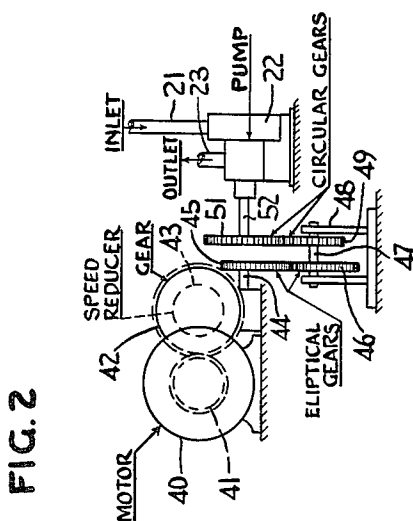
FIG. 11



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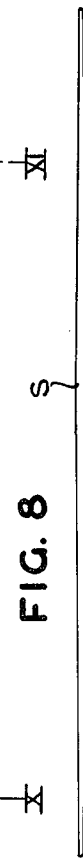
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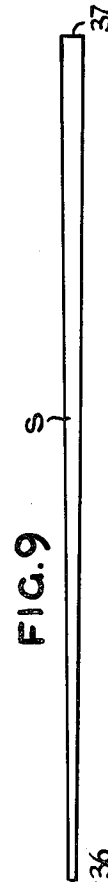
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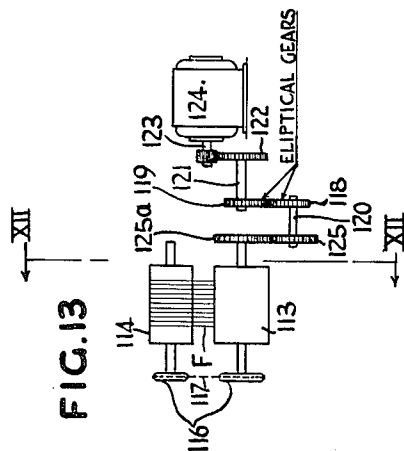
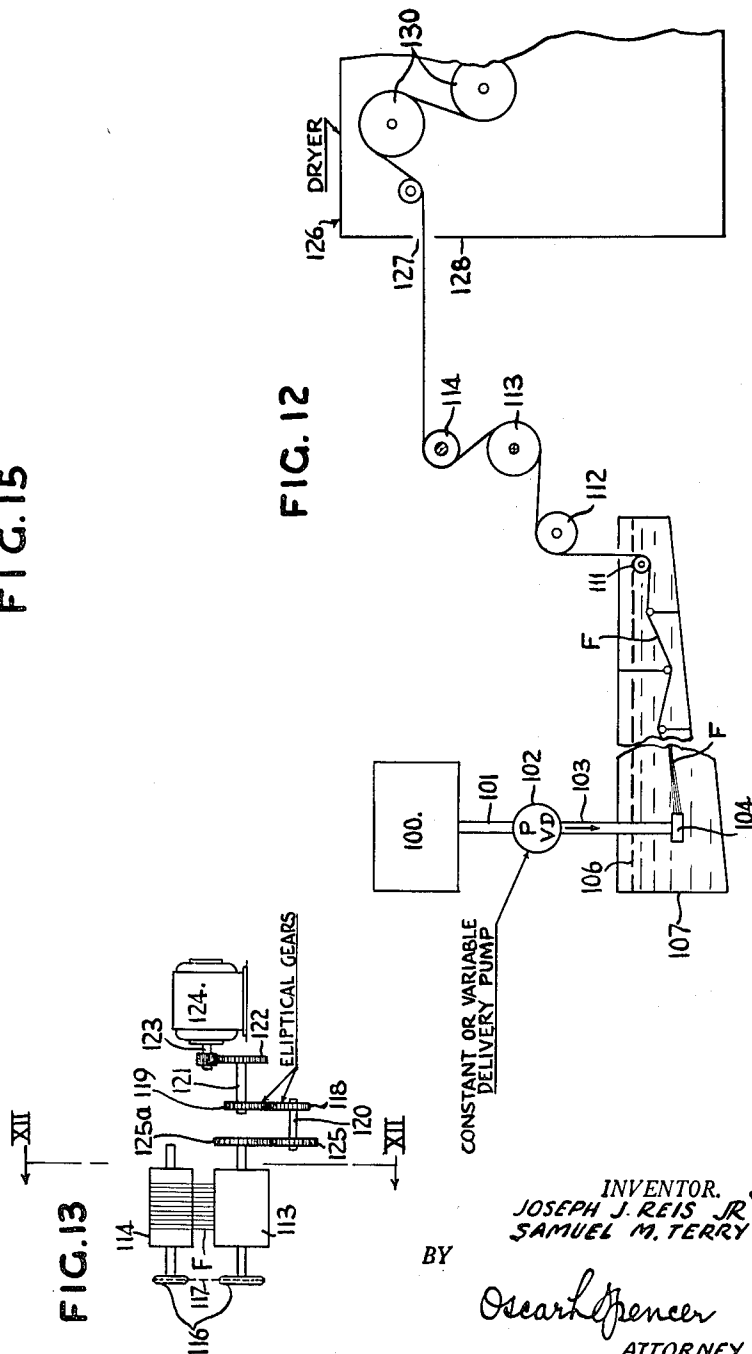
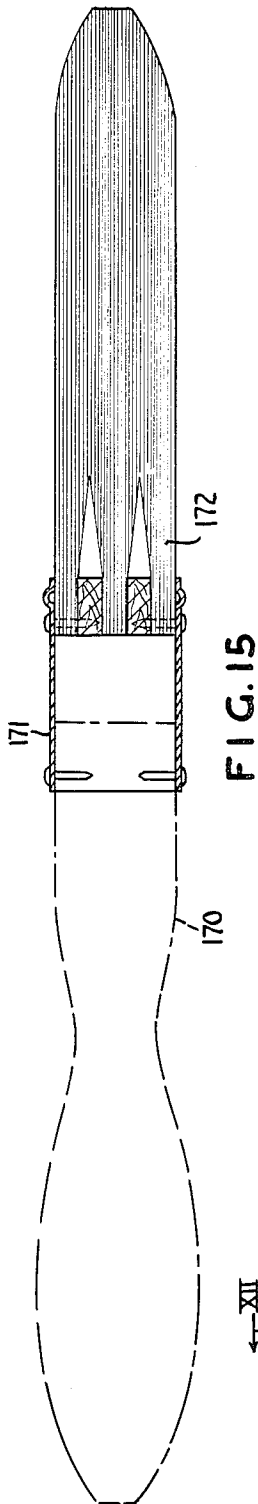
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METHOD OF SPINNING SHAPED FILAMENTS OF PLASTIC MATERIALS

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4 Sheets-Sheet 3



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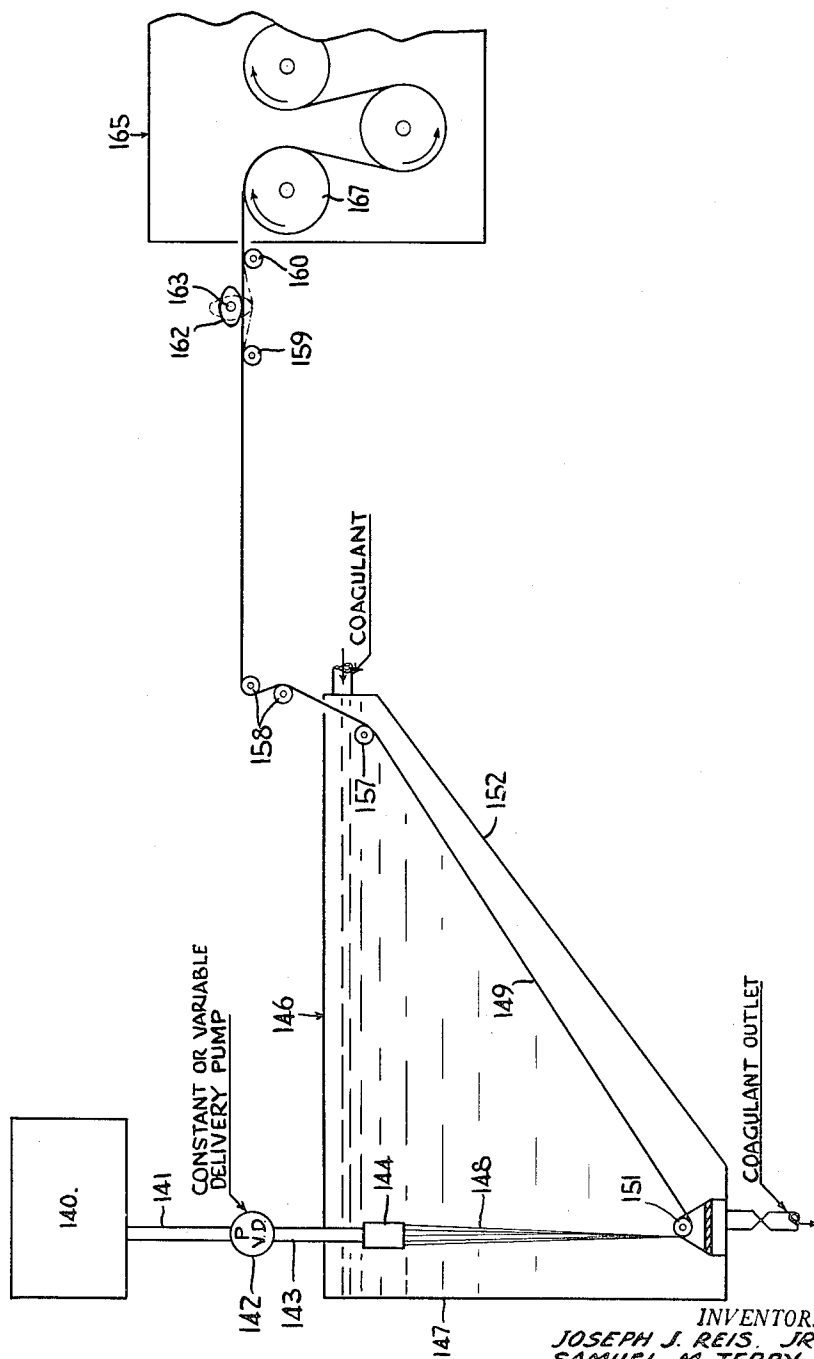
2,746,839

METHOD OF SPINNING SHAPED FILAMENTS OF PLASTIC MATERIALS

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FIG. 14



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2,746,839

METHOD OF SPINNING SHAPED FILAMENTS OF PLASTIC MATERIALS

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Application June 26, 1953, Serial No. 364,302

5 Claims. (Cl. 18—54)

This invention relates to a method of spinning through an orifice in a spinning head, threads of relatively uniform, predetermined cross sectional shape and periodically varying denier, and it has particular relation to a process of forming such threads by spinning a solution of a plastic material such as an ester of cellulose, vinyl resin or the like, into a coagulating bath designed to remove the solvent from the plastic and permanently to set the latter in thread form.

It has heretofore been proposed to form threads and filaments of fine denier from solutions of various plastic materials, such as cellulose esters and polymers of ethylenically unsaturated compounds, by dissolving them in an appropriate solvent and spinning them through orifices in a spinning head into a coagulating bath designed to take up the solvent and leave the plastic as filaments. In this manner, filaments of nearly uniform denier and being suitable for use as substitutes for silk and other natural fibers were formed.

It has also been suggested to impart to these filaments a fluctuating denier by variations of the pressure upon the solution during spinning operation or by varying the rate of take-up of the spun filaments or threads. Threads which when woven into fabric produce various pleasing effects were thus obtained. Likewise, coarser variable denier filaments which could be cut into sections and employed as tapered synthetic bristles in paint brushes, or similar brushes were obtained.

In one common system of spinning coarse variable denier threads, a cellulose ester such as cellulose acetate, or a mixed cellulose acetate-butyrate, was dissolved in methylene chloride and methyl alcohol and spun through a suitable orifice into a bath comprising a petroleum hydrocarbon, e. g., naphtha designed to extract out the solvent from the solution, thus causing the setting of the cellulose ester into a hardened state. In such operations, there was much shrinkage of the filaments as they emerged from the orifices in the spinning head or spinnerette, due to removal of solvent and this shrinkage was accompanied by flattening and distortions of the freshly formed filament into kidney, dumbbell, or "dog bone" sections and various other shapes having no relation to the shape (round) of the orifices.

In the use of synthetic bristles cut from such filaments, in the construction of brushes designed to carry a liquid material such as paint or the like, advantage was taken of these distortions in order to provide channels of high capillarity that would have a good capacity for holding the liquid material. However these filaments, because of the flatness, were characterized by a tendency to twist objectionably at the tips when they were employed in brushes.

In U. S. Patent 2,508,799 to J. J. Reis, is disclosed a process of preparing a filament having periodical variations of denier, the restricted portions being of a predetermined trefoil section, a section which is imparted thereto by an orifice of corresponding shape employed in the spinning operation. The thickened portions of the fila-

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ments on the other hand are of approximately dumbbell or kidney shape, not related to the shape of the orifice, which shape is attained by partial collapse of the section after it has been extruded into the coagulating bath. These filaments are also adapted for cutting into sections by shearing through the restricted trefoil portions to provide double bristles tapered in opposite directions and being adapted for locking in a channel to provide brush sections or to be further sheared through the thickened, collapsed portions into single length tapered synthetic brush bristles, which can be set in a socket of a brush in accordance with conventional practice. When bristles are so set, the flattened butt portions thereof tend to interleaf so that tube-like channels adapted to hold liquids such as paints or varnishes are provided between contiguous surfaces. These channels take up and hold the liquids such as paints quite well. During brushing operations the liquids are fed capillarily toward the trefoil tips, which are designed to give improved flexural characteristics to the tips of the brush bristles.

While the foregoing types of filaments were valuable for some purposes and have been used quite extensively, it has often been desirable to spin solutions of plastics into filaments of periodically variable denier and of a definite, but deeply striated cross-section corresponding from end to end to a similarly shaped orifice; however, it has not been practicable so to spin them. As above stated, it was feasible to form filaments of variable denier, the thin portions of which were of predetermined shape corresponding to an orifice; but the thickened portions lost the shape and usually flattened out to a kidney or dumbbell section in the spinning operation regardless of the shape of the orifice. It has heretofore been deemed that this collapsing or flattening action was due to the removal of solvents in the surface of freshly extruded filaments to form a shell which tended to collapse as further solvent was removed from the interiors. Coagulation was attended by a great reduction in volume, with resultant constriction of diameter. In the constricted portions, there was less solvent to be removed from the interiors and the shells, because of smaller diameter were stronger and less subject to collapse. Therefore, the restricted portions tended better to retain the shape of the die. This explanation was at least partially valid, though there would appear to be additional factors involved, which were a part of a chain of events which led to the loss of the trefoil section and ultimate flattening into a dumbbell section in the thicker portions of the filaments.

It has now been discovered that the tendency of the thickened portions of threads of periodically variable denier to distort from the original shape of the orifices begins at, or very close to the point of emergence in the coagulating bath. At this point, where the shells start to form, the liquid solution of plastic is being pushed out of the orifices into the shells and this action is especially pronounced during the period of increased rate of emission, which occurs when the threads are being spun under pulsating pressure, with alternate sagging and tautening of the filaments. The solution of plastic, being pushed out rapidly, tends to stuff the shell, stretching its circumference and causing it to approach a circular section. As the solvent is removed from the interior of the filaments, they shrink and flatten or assume other irregular sections. This distortion is promoted by the periodical sagging and tautening, with resultant bouncing of the filaments in the bath.

The alternate sagging and tautening is caused by discrepancies between speed of emission of the spinning solution and the take-up speed in the drawing operation. The take-up is adjusted to the average rate of emission of the filaments. During the interval when the jets are flowing rapidly, as when the thickened portions are being formed,

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the freshly formed filaments tend to sag into a more or less catenary curve. Similar periodic sagging effects may result if the filaments are spun at constant speed by continuous pressure from the spinning head, but the speed of take-up of the filaments is varied to produce variations of denier. As the take-up is periodically slowed down to provide for increased denier, the threads being spun at constant speed, may be emitted faster, during the slow phase of the take-up, than the take-up and there may be sagging effect. In either event, as the filaments alternately sag and tauten in the spinning operation, there is a substantial tendency to stuff the filaments and to slosh them transversely of their length up and down in the coagulating bath. Under the influence of the several factors, the thickened portions of the filaments start to distort very close to, or at the spinning orifice.

It has further been discovered that, with a properly spinnable solution of plastic and if care is taken to maintain the filaments, as they emerge from the spinning orifices, in substantially normal, or vertical position with respect to the plane of the spinnerette, and with little or no transverse movement, as can be done by maintaining the filaments continuously under slight tension, the tension tends to hold the filaments to predetermined shape. Doubtless the stretching of the shells provides space for the out-flowing plastic solution without inflation of the cross-section. The tension also helps to impart a rigidity to the shell which prevents its premature collapse to give an irregular section. It is thus possible continuously to spin filaments which are of variable denier and a cross-sectional shape corresponding to the shape of the spinnerette from which they are spun throughout their length, even when the filaments are of coarse size suitable for use as brush bristles and the like, and of complicated and deeply notched (trefoil) section. For purposes of the present invention, special emphasis is placed upon sections which are particularly hard to form, such as trefoil sections, or similar sections, in which there is deep striation of the filaments with the sides of the striations forming sharp, acute angles and even approaching parallelism, or tangency with respect to each other. This latter type of section is particularly desirable in the formation of synthetic brush bristles, such as are used in the manufacture of paint brushes because the deep striations are especially adapted capillaryly to hold substantial quantities of paint and to feed it longitudinally towards the tips, smoothly and without running, or spattering, as the supply is used up in normal painting operations.

In spinning filaments of periodically variable denier in accordance with the provisions of the present invention, various embodiments of apparatus designed to maintain the filaments continuously under slight tension at the points of emergence from the spinning orifices and in vertical plane with respect to the spinnerette or spinner head, may be employed.

One simple method of obtaining such results is to spin the solution horizontally under varying pressure to produce variations of denier while maintaining a rate of take up slightly in excess of the maximum rate of emission of the filaments. When the filaments are so spun under a pulsating pressure in the spinnerette or spinning head, it will be apparent that as the jets of liquid plastic from the orifice slow down to form the constrictions in the filaments, the rate of take-up of the filaments will be considerably faster than the rate of emergence of the spinning solution into the coagulating bath; therefore, the filaments or threads will be further substantially attenuated by a stretching action exerted by the take-up rollers. The continuous rate of take-up and the pulsating spinning pressure thus combine to produce a sufficient degree of variation of denier in the filaments.

A second method of spinning with but little or no sag and bounce in the freshly formed filaments, involves spinning the plastic materials through the orifices under a constant pressure so that substantially continuous rate

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of extrusion is attained, periodic variation of the denier of the filaments being attained through increase or decrease in the rate of take-up of the filaments. The minimum rate of take-up should be at least slightly in excess of the continuous rate of spinning or emission of the filaments or threads from the orifices. Doubtless the variation in the rate of take-up of the filaments assists in producing a periodical variation of the differential between the pressures in the solution at points of entrance to and emergence from the orifices in the spinnerette or spinning head.

A third method of obtaining substantial normalcy between the filaments as they are spun from the orifices in the spinning plate with little or no transverse movement or bounce is to place the spinnerette with its face horizontal, in the bath, the latter being deep enough to allow the filaments to set or coagulate while in vertically suspended position.

Several different embodiments of apparatus designed to spin the filaments of periodically variable denier from solutions of plastics into a coagulating bath under such conditions that the filaments are maintained under tension and essentially normal with respect to the spinning plate and there is very little transverse vibration or bounce of the freshly formed filament contiguous to the spinning head, are diagrammatically illustrated in the appended drawings in which:

Figure 1 illustrates an apparatus of simple construction in which the filaments are spun under variable pressure into an essentially horizontal coagulating bath and are continuously taken up at such speed that there is slight tension in the filaments at all times.

Figure 2 is a side elevational view of a variable delivery pumping mechanism designed to force the solution of plastic through the spinning orifices under periodically variable pressure in order to produce the desired variations of denier in the filaments.

Figure 3 is a fragmentary view of a portion of a spinning plate having shaped orifices formed therein.

Figure 4 is a side elevation view of the spinning plate.

Figure 5 is a fragmentary view showing on an enlarged scale one of the spinning orifices in the plate illustrated in Figure 3.

Figure 6 is a fragmentary view showing on an enlarged scale a modified form of spinnerette opening.

Figure 7 is a view illustrating a portion of a filament spun in accordance with the provisions of the present invention.

Figure 8 illustrates a portion of the filament cut at two contiguous constrictions to provide double ended bristles suitable for use in certain types of brushes.

Figure 9 illustrates a tapered bristle formed by cutting the bristle of Figure 8 in its mid-portion.

Figure 10 is a sectional view on the line X—X of Figure 7 illustrating on an enlarged scale a tip portion of a bristle spun in accordance with the provisions of this invention.

Figure 11 is a view similar to Figure 10 but illustrating a section at XI—XI of Figure 7 through a bristle near the butt portion thereof.

It is to be understood that in the several Figures 3, and 5 through 11, sectional proportions are greatly exaggerated because of impracticability of illustrating them in true scale.

Figure 12 is a diagrammatic view on line XII—XII of a second embodiment of the apparatus in which periodically variable take-up is employed.

Figure 13 is a detail of variable take-up means.

Figure 14 is a diagrammatical view of apparatus for spinning solutions of plastic vertically in order to reduce, or eliminate any tendency of the filaments to sag transversely after they leave the spinning head.

Figure 15 is a simplified sectional view through a brush embodying bristles manufactured in accordance with the provisions of the present invention.

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In the embodiment of apparatus as illustrated diagrammatically in Figure 1 of the drawings, a solution of a plastic material suitable for forming bristles, is spun horizontally as filaments, into an elongated coagulating bath under a pulsating pressure designed to impart periodic variations of denier in the threads and the filaments are taken up continuously at a speed slightly in excess of the maximum rate of emission of the threads into the coagulating bath.

In the apparatus shown, plastic material in solution-form, of proper viscosity and solids content is contained in a reservoir 20, which preferably, is disposed in somewhat elevated position so that the solution will flow therefrom under gravity. The solution is conducted from the reservoir by downwardly directed conduit 21 which supplies it to an appropriate variable delivery pumping mechanism and which is indicated at 22 in Figure 1 by convention and in greater detail in Figure 2. The solution of plastic is discharged from the pump under pulsating pressure through a conduit 23 which is illustrated as a single line, but in actual practice, may involve any desired number of branches in order to accommodate a plurality of spinning heads 24. The details of this spinning head are conventional and no attempt has been made to illustrate any of them except the plate.

A cupped spinning plate 25 with attaching rim 25a for head 24 is provided with suitable spinning orifices 26, as illustrated in Figure 3. A preferred form of orifice especially for use in the spinning of synthetic bristles in accordance with the provisions of the present invention involves a trefoil section such as is illustrated on an enlarged scale in Figure 5, or a modification thereof as illustrated in Figure 6. In the trefoil, the lobes 27, 28 and 29 approach tangency with respect to each other so that the longitudinal grooves are formed in the filaments, and in which sides are disposed sufficiently close together to exert a strong capillarity, so that when sections of the filaments are employed as bristles in brushes, liquids such as paints, or varnishes are more readily retained than they would be by bristles of round section. The orifices may be formed by drilling openings of circular section so that their circumferences intersect about a common axis. Preferably the openings are spaced approximately 120° about said axis and the axes of the lobes are equal distance from the central axis.

In the modification of the spinnerette opening illustrated in Figure 6, a central opening 31 is drilled in the plate and a plurality of equally spaced openings 32, are drilled, and at uniform distances from the central opening, in such manner that the circumferences of the side openings intersect the circumference of the central opening. Substantial grooves 33 of considerable depth and width are provided between the contiguous lobes of the modified trefoil. The grooves become V-like, as indicated at 34 at the intersections between the central opening and the lobes, at their point of intersection. This construction is especially desirable inasmuch as a maximum amount of liquid will be retained in the capillary channel 33 of the brush bristles. Also the shape facilitates the drawing or spinning operation in forming the filaments inasmuch as any tendency of the lobes to merge or run together as the liquid is drawn out of the orifices is reduced to the minimum. In both forms of orifices, the centers of the lobes form an equilateral triangle and likewise the lobes are circumscribable by an equilateral triangle. Added lobes to provide other regular figures could be formed; but they would increase costs and would not appreciably improve the product.

A filament, F, spun from an orifice has alternating constrictions and expansions as shown at 34a and 34b.

Filaments spun from the orifices illustrated in Figure 5 are of trefoil section throughout their length. A section, such as section S, has the same shape at tip 36 and butt 37 though on different scale. The same is true of

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filaments spun through the modified orifice of Figure 6, or through an orifice of any other probable shape.

While any convenient embodiment of pump adapted to produce a regularly pulsating or variable pressure in the spinnerette may be employed, a convenient but simplified form is illustrated in Figure 2 of the drawing. This apparatus involves a source of power such as a conventional electrical motor indicated diagrammatically at 40 having a pinion gear 41 engaging and driving a gear 42 of a speed reducing mechanism of conventional design indicated at 43. This mechanism is provided with an output shaft 44 having an elliptical gear 45 engaging a second elliptical gear 46 upon a shaft 47 which is journaled in bearings 48 upon any convenient support.

The elliptical gears 45 and 46 provide for a continuously varying rate of speed of rotation in the shaft 47, in a cycle corresponding to the variations of denier in the filaments. The shaft is provided with conventional circular gear 49, meshing with gear 51 on a shaft 52 of the rotary pump 22, whereby the pressure exerted by the latter is caused to fluctuate in accordance with the variations of speed produced by the operation of the elliptical gears.

It will be understood that in order to vary the average output of the pump 22, the relative size of the gears 49 and 51 may be changed in order to speed up or slow down the rate of rotation of the pump. It is thus possible to vary the distance between the constrictions and enlargements of the filaments as spun and also to some extent, to control the average denier of the threads or filaments without changing the elliptical gears.

The ratio of the major and minor axis of the elliptical gears control the degree of variation of denier in the filaments and are selected to obtain the desired fiber taper ratio (usually between 1.4 to 1 and 2 to 1).

The apparatus, as illustrated in Figure 1, comprises an elongated trough 55, designed to hold a coagulating liquid which will dissolve out the solvents from the plastic material being spun. Of course the nature of the coagulant will depend upon the solvent employed in preparing the spinning solution. In case cellulose acetate is the plastic, methylene chloride admix with methyl alcohol is usually employed as a solvent; the petroleum hydrocarbons are then very satisfactory coagulating media. Coagulant is admitted to the trough 55, through conduit 56, continuously or intermittently as may be desired, in order to maintain a reasonably low concentration of dissolved solvent in the coagulating bath.

As shown in the drawing, the trough is formed with a sloping bottom 57 designed to permit spent coagulating medium which has increased in density by taking up heavy solvent from the plastic, to settle toward the spinning head 24. Spent coagulant is drawn off through conduit 59 and may be subjected to distillation in order to separate coagulant and solvent so that they may be reused, if so desired.

Trough 55, may be provided with a series of upwardly projecting baffles 61 and downwardly projecting baffles 62 designed to produce a degree of transverse flow in the coagulating medium as it progresses along the trough. This transverse flow applies particularly to those portions where the plastic has already set. The edges of the several baffles are provided with rounded beads 63 constituting smooth surfaces over which the filaments or threads in their progress through the bath may be drawn. It will be observed that the threads indicated at F are constrained to a zig-zag path by the baffles which assist in exposing the filaments to the washing action of the coagulating bath.

It will be appreciated that in order to prevent distortion of the filaments, it is usually desirable to provide a substantial free stretch or reach between the spinnerette and the first of the baffles, in order to permit adequate extraction of solvent to obtain a reasonable degree of firmness of the plastic material before actual contact is made with

a solid surface. A reach of about 2 to 4 feet is suggested as being satisfactory for the purpose. In this zone there is but little transverse movement between the coagulant and the threads. It will be observed that the first of the baffles is disposed in upwardly projecting position in order to provide a slight degree of support to the filaments in the zone near to the spinning head, thus reducing the degree of tension required to prevent sag and bounce. The last of the baffles is indicated as being downwardly projecting, so that it provides a shoe over which the filaments can be bent upwardly for withdrawal from the bath. Means to suck free liquids from the filaments, as they emerge from the coagulating bath may be provided and in the drawings, are illustrated as comprising a pair of conduits 66 and 67, which may have slotted faces contacting the filaments. They may be connected to a source of vacuum (not shown) whereby suction can be applied to the filaments in order to remove free liquid.

Apparatus to dry the filaments is illustrated diagrammatically at 68 and includes a chamber 69 having a slot 70 in one end wall 71 thereof, through which the filaments F may be passed to and about a system of drying rollers 72. These drying rollers are, preferably, driven at constant speed by any appropriate means (not shown). The rollers may be heated to expedite drying of the filaments by means, such as hot water or steam, introduced into cavities in the rollers by conventional conduit means (not shown). If preferred the rollers may be heated electrically by induction, or by current introduced through appropriate slip ring and brush contacts. For purpose of illustration radiant heaters such as infra-red lamps 73 are indicated as being carried upon a supporting bar 74 in a position whereby heat will be directed upon the rollers and the filaments thereupon. The radiant heaters may be supplied with current in any convenient manner, for example, by means of conductors 76.

It is usually desirable to provide some means for exhausting fumes from the chamber 69 and to this end, the latter may be provided with a stack 77. The stack, if desired, may be provided with means for recovering solvents entrained in the exhaust gases, or, if preferred, the gases may be discharged directly to the atmosphere. In event that the natural openings in the drying chamber are insufficient for adequate admission of air for the removal of the vapors from the filaments, the drying chamber may also be provided with suitable inlet means such as conduit 78 having a damper 79 for the regulation of the rate of admission of air.

Filaments from the drying rollers 72 may be deflected over a small idler roller 81 and passed out of the drying chamber through an appropriate slot 82 in the end wall 83 thereof. The dried filaments may be passed to an appropriate reeling mechanism for winding them up into hanks or spools as may be desired, or they may be passed to any convenient cutting mechanism whereby they may be severed into sections of suitable lengths such as the bristle sections illustrated in Figures 8 or 9. They could also be cut up into lengths by manual means, if desired.

In the embodiment of apparatus illustrated in Figure 12 of the drawings, take-up mechanism designed to produce variations in the denier of the spun filaments as they emerge from the spinning orifices by change of speed of the take-up is shown. The apparatus includes a supply reservoir 100 substantially corresponding to the reservoir 20 in Figure 1 of the drawings. Plastic dissolved in a suitable medium to provide a liquid, spinnable mixture is discharged from the reservoir through conduit 101 and is fed under pressure developed by a pump indicated by convention at 102, through conduit 103 to spinnerette 104 in coagulating bath 106 in trough 107. The pump 102 may be a constant delivery pump designed to extrude the spinnable solution under substantially constant pressure in the spinning head. The trough 107 may be identical, or substantially identical with that illustrated in Figure 1 of the drawings, though for purposes of conservation of

space, it is illustrated in Figure 12 as having portions broken away. The filaments indicated at F are passed under a guide roller 111 and are drawn upwardly and bent over suction tubes 112 for the removal of the free liquids.

Any conventional, or other suitable take-up device capable of periodic variations of speed may be employed to produce periodical variations of denier in the filaments through variations in the speed of take-up in the zone contiguous to the spinner head 104 in the coagulating bath. For purposes of illustration, there is shown a take-up roller 113, which may be contiguous to, or have contact with a second take-up roller 114 if so desired. These rollers may be provided with sprockets 116 about which is trained a sprocket chain 117 designed to maintain equality of speed between the two rollers. Rollers 113 and 114 are driven at periodically varying speeds by means of elliptical gears 118 and 119, the former of which is keyed on the shaft 120 and the latter of which is keyed on shaft 121 having gear 122, driven by suitable means such as a pinion upon the shaft 123 of a motor 124. A gear 125 on shaft 120 transmits motion to gear 125a on the shaft of roller 113. By changing gears 125 and 125a, the length of the sections in the filaments can be varied.

It will be apparent that as the elliptical gears 118 and 119 are revolved, they produce periodic fluctuations in the speed of rotation of the rollers 113 and 114 which are translated into a change of speed of withdrawal of the filaments from the spinner head 104, producing variations of denier of the threads. It is desirable that the minimum speed of withdrawal be at least equal to and preferably slightly in excess of the rate of emission of the spinning solution from the spinnerette 104. This can easily be attained by adjustment of the pump 102 and/or the rate of rotation of the shaft 121.

The pump 102 is diagrammatically indicated as being constant delivery, variations of denier being produced by varying the rate of take-up. Take-up speed should always be sufficient to maintain the filaments taut and level in the bath.

Means to dry the freshly formed filaments includes a chamber 126 having a slot 127 in an end wall 128 thereof. The filaments are trained about appropriate heated rollers 130 which preferably are driven at substantially constant speed so adjusted as to equal the average speed of the intermittently variable rollers 113 and 114.

Figure 14 is a diagrammatical view of an embodiment of apparatus whereby filaments of periodically variable denier may be extruded from a spinnerette having a plate horizontally disposed in order that the filaments will emerge from the spinning orifices in a vertically pendant position, without sag or bounce. In the specific embodiment of apparatus, the threads are emitted vertically or substantially vertically downwardly. However it is obvious that the direction of spinning could be reversed so that the jets would be emitted upwardly. It is considered, however, that downward spinning has advantages inasmuch as the gravity of the threads or filaments tends to maintain them under tension in a vertical position at all times. Periodical variation of denier in this embodiment of apparatus may be effected by pulsating the spinning pressure in the spinnerette, or by variations in the rate of draw introduced by appropriate devices.

In the apparatus shown in Figure 14 a supply tank 140 for a solution of spinnable plastic may be provided with a downwardly directed discharge conduit 141 having a pump 142. The pump may be variable delivery for production of variations of denier through variations of pressure exerted by the pump; or may be constant delivery, with variations of denier being effected by varying take-up. Pump 142 discharges through conduit 143 to a spinner head 144 which is submerged in a bath of coagulant for the plastic solution disposed in container 146. One side 147 of the container constitutes a vertical spinning leg and should be of sufficient height to permit

a sufficient degree of setting of the solution of plastic being spun to admit of its subsequent deflection as hereinafter described, without appreciable distortion. Plastic threads 148 from spinnerette 144 are deflected into an upwardly inclined run or reach 149 of the receptacle by shoe 151 having a smooth guide surface over which the threads will slide without appreciable friction. Shoe 151 rests on the bottom of the receptacle under its own weight and may be raised to a position just below the spinning head to admit of starting the threads through the bath. Subsequently it can be lowered to the bottom.

Filaments, after they have passed under shoe, pass obliquely upwardly along inclined section 152 of the bottom of the receptacle and under shoe bar 157 about which the threads or filaments are bent to direct them upwardly. Suction tubes 158 are disposed near the exit end of the coagulating bath in position to suck away free liquids carried by the threads.

If it is desired to vary the speed of take-up of the threads in order to impart periodic variations of denier to threads spun by constant pressure, or to provide uniform tension of take-up on threads spun under varying pressure, appropriate apparatus may be provided contiguous to the suction tubes 158. Any suitable instrumentality for the purpose may be employed. For purposes of illustration, there are shown a pair of guide bars 159 and 160, suitably spaced and having a device designed rapidly to speed up and then to slow down the rate of draw of threads passing between them. The device for producing such action, as shown in the drawing, includes a rotary member 162 of ovate section secured on a shaft 163 and being designed to be rotated by motor means (not shown). It will be evident that the member 162 can be of such shape as to impart to the filaments the desired degree of variation of tension as the member is rotated. It will be apparent that the degree of enlargement of constriction of the filaments, as they are spun, can be regulated by appropriately proportioning the major and minor axes of the member 162 to obtain a desired degree of change in the speed of drawing of the filaments as the member 162 is rotated. By increasing or decreasing the rate of rotation of the member 162 the spacing of the alternate constrictions and expansions in denier of the filaments being spun can be regulated.

Means to dry the filaments includes a chamber 165 having drying rolls 167 driven, preferably, at constant speed of approximately the average rate of draw of the filaments from the coagulating bath and being faster than the rate of emission from the spinnerette, whereby to maintain some degree of tension on the filaments at all times. Mechanism to drive the rolls 167 is not disclosed since such means is conventional.

It is possible to spin filaments of predetermined sectional shape in a wide range of denier by varying the cross-sectional area of the spinning orifices. Sizes of orifice up to or above 0.00125 inch square can be used with good retention of sectional shape. Naturally, the average sectional area of the filaments is much less, owing to the withdrawal of solvents in coagulation.

The use of various soluble plastics adapted to form threads by spinning from solution into a coagulating bath are contemplated as being within the scope of the present invention. Cellulose acetate is one of the more common and less expensive materials of this class and accordingly its use will be more fully illustrated by specific examples. Other soluble resins such as the vinyl resins which can be precipitated or coagulated from solution, are also included as being adapted for spinning in accordance with the provisions of the present invention. Other spinnable cellulose esters than cellulose acetate contemplated by the present invention, include the cellulose butyrates and mixed esters of cellulose and acetic acid and butyric acid. The invention also includes cellulose acetate sorbate and similar esters. The spinnable vinyl resins include vinyl chloride. Still another vinyl resin which may be spun

from solution, in accordance with this invention, is acrylonitrile and copolymers of acrylonitriles such as are disclosed in U. S. Patent 2,538,730.

The solvents and the coagulants for the various plastics are well known and are not a feature of this invention. Naturally some degree of adjustment, of concentrations of plastics, rate of spinning and the like, must be made for each spinnable solution and for different deniers of filaments.

For cellulose acetate, a system having good spinning characteristics, may have the following characteristics:

Cellulose acetate of a grade of a relatively high degree of substitution is to be preferred. For example, the degree may be within the range of about 2.3 to 2.9 where the maximum degree is represented as 3.

Various solvents of cellulose acetate may be employed in making up the spinning solution, however, methylene chloride mixed with methyl alcohol to form a solution in which 92 to 97 per cent by weight of the methylene chloride, the rest of the solution (solvent) being methyl alcohol is satisfactory. The spinning solution may comprise about 20 to 22 or 23 per cent of cellulose acetate with the preferred range being 21 to 22 per cent. With cellulose acetate of a high degree of acetyl substitution this concentration tends to be quite sharp. If other cellulose esters, or other plastics are employed the concentrations should be adjusted to attain optimum spinning properties. The spinning solution has a viscosity of 60,000 to 300,000 centipoises and preferably about 90,000 to 100,000 centipoises. These higher viscosities are found materially to assist in the spinning of filaments which retain their shape regardless of variations in denier. The viscosity is sufficient to impart a substantial resistance to stretching of the filaments even at the points of emergence from the orifices. It also increases the resistance to transverse distortion near the orifice. They apply quite generally to the various solutions of plastics.

In some instances, it is found that the spinning characteristics of the solution of plastic are improved by inclusion of a small amount of a coagulant such as mineral spirits in the solvent system. This latter system is particularly useful in the spinning of the mixed cellulose acetate-butyrate ester. These mixed esters are often relatively difficult to spin. However an ester of a total acyl content of 47 per cent in which the ratio of acetyl to butyryl is approximately 2 to 1, can be extruded from a solution of methylene chloride containing a small concentration of the coagulating liquid. The latter materially assists in the retention of the shape of the spinnerette in the filament. Also the small amount of coagulating liquid assists in reducing the tackiness or stickiness of the filaments and thus reduces a tendency thereof to stick to the face of the spinnerette plate.

The solutions in the apparatus of Figure 1 spins satisfactorily into a bath of petroleum naphtha at a rate of about 10 feet per minute. To provide filaments which carry the shape of the spinning orifice throughout their length.

Still another spinnable plastic is sold commercially as Vinylite VAGH, which is partially hydrolyzed vinyl chloride-vinyl acetate copolymer. Tetrahydrofuran is a good solvent for this plastic and mineral spirits is a good coagulant. A suggested mixture comprises:

	Percent by weight
Vinylite VAGH	38
Tetrahydrofuran	45½
Mineral spirits	11½
2,4 tolylenediisocyanate	5

In Figures 15 of the drawing is shown an illustrative brush such as is used in painting, which comprises bristles formed in accordance with the provisions of the invention. The brush comprises handle 170 of wood, plastic, or the like having a conventional ferrule 171 of sheet metal and constituting a socket; bristle tuft 172 formed of synthetic

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bristles spun in accordance with the provisions of this invention to have shaped striations from butt to tip is disposed in the socket. The tuft 172 may be formed by setting and curing the butt portions of the bristles in a cement of rubber or plastic in well known manner.

We claim:

1. In a method of spinning a thread of periodically variable denier and uniform predetermined lobate section throughout the length of the filament, the steps which comprise spinning into a coagulating bath a spinnable solution of a plastic material in a liquid solvent therefor, the spinning being effected through an orifice formed in a plate, of a shape corresponding to the shape of the section desired in the thread, spinning further being effected by a differential of pressure upon the solution of plastic materials between opposed faces of the plate and being variable with the variation desired in the denier of the thread and withdrawing the freshly formed thread while maintaining the angle thereof with respect to the plate substantially constant during variations of pressure whereby to obviate bounce and intermittent sagging of the filament in the bath as it is spun.

2. A method as defined in claim 1 in which the plastic material being spun is cellulose acetate.

3. In a method of spinning a thread of periodically variable denier in a predetermined non-circular section of substantially uniform shape throughout the length of the filament, the steps which comprise spinning into a coagulating bath a spinnable solution of cellulose acetate in a liquid solvent thereof, the cellulose acetate in the

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solvent being of a concentration between 22 and 23 per cent by weight and the solution being of a viscosity of approximately 60,000 to 300,000 centipoises, spinning being effected through an orifice in a plate, the orifice being of a shape corresponding to the section desired in the thread, spinning further being effected by a differential of pressure upon the solution of plastic material between opposite faces of the plate and being variable with variation desired in the denier of the thread, and withdrawing the freshly formed thread while maintaining the angle thereof with respect to the plate substantially constant during variations of pressure whereby to eliminate bounce of the thread in the bath until after it has become sufficiently set to prevent loss of sectional shape by such bounce.

4. The method of claim 3 in which the orifice in the plate is substantially of trefoil cross-section.

5. The method of claim 3 in which the orifice is of trefoil cross-section, the solvent of the cellulose acetate is methylene chloride and methyl alcohol and the bath is of a petroleum hydrocarbon which is a solvent for the methylene chloride and methyl alcohol.

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