July 4, 1961 L. B. GIBBINS ET AL 2,990,575

APPARATUS FOR PRODUCTION OF VARYING DENIER FILAMENTS

Filed Sept. 24, 1956

2 Sheets-Sheet 1

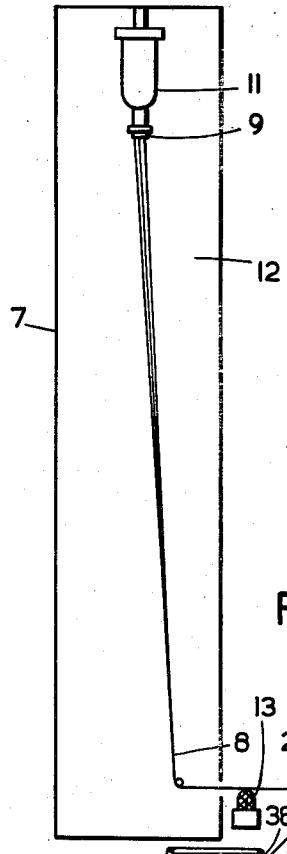


FIG. 1

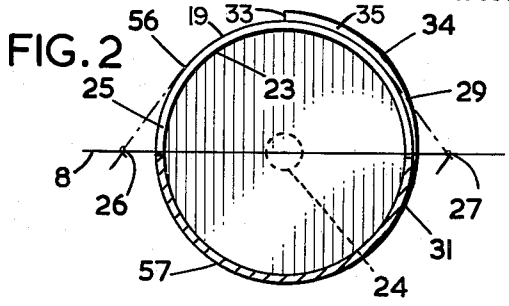


FIG. 2

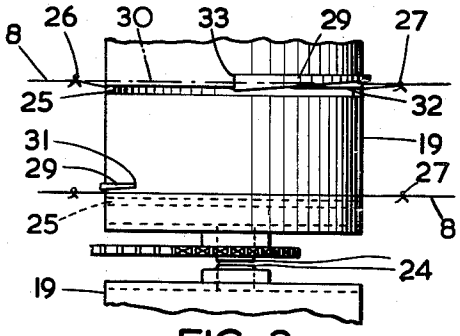
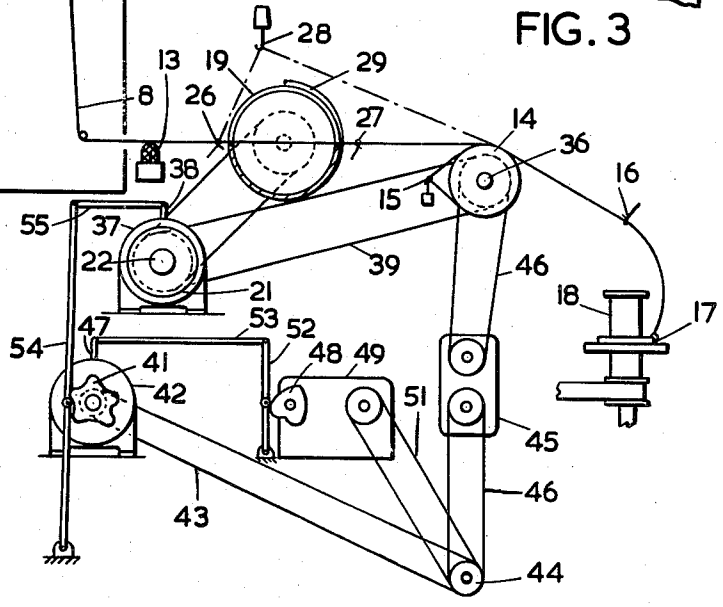


FIG. 3



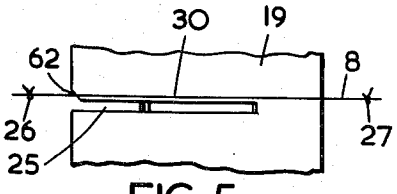


FIG. 5

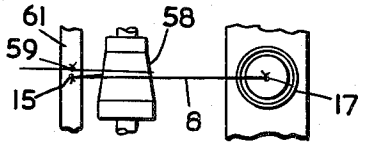


FIG. 4

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APPARATUS FOR PRODUCTION OF VARYING DENIER FILAMENTS

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FIG. 2a

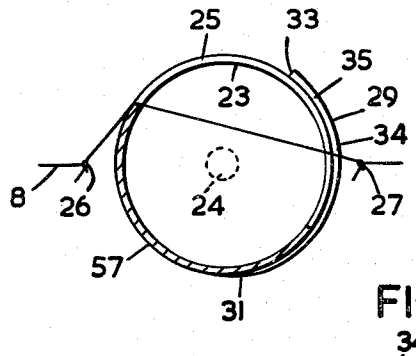


FIG. 2b

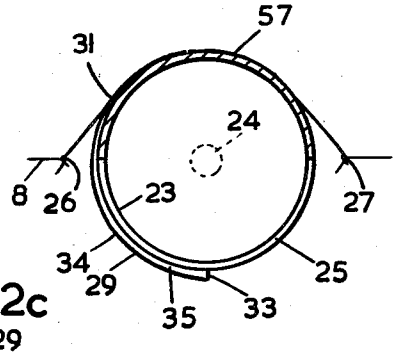


FIG. 2c

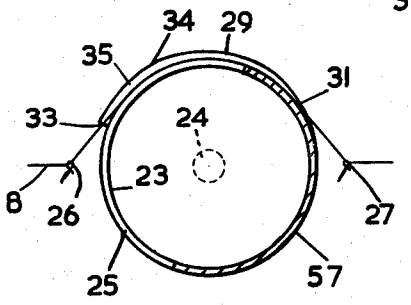


FIG. 3a

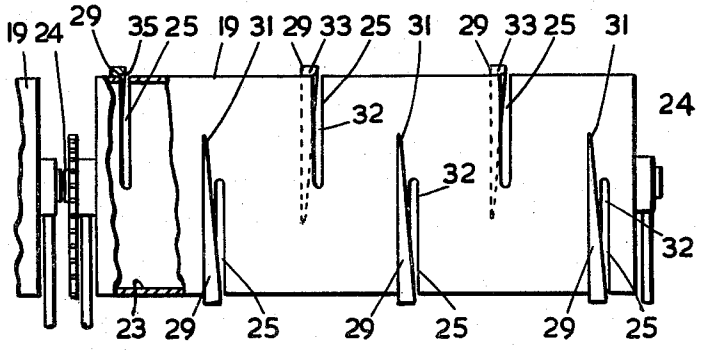
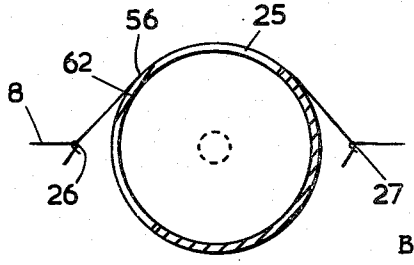


FIG. 5a



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APPARATUS FOR PRODUCTION OF VARYING DENIER FILAMENTS

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11 Claims. (Cl. 18—8)

This invention relates to the production and treatment of artificial filaments and particularly to the production of filaments whose denier varies along their length.

One way of making such filaments is by varying the rate of draw-down of the filaments, in the course of their production, from the spinning jet through which they are extruded. This can be done by drawing the filaments along a path whose length is caused to vary periodically, the filaments being passed over a deflecting surface, e.g. a cam, cam-operated guide or the like, which moves transversely to the path so as to deflect the filaments from their shortest path. The filaments are drawn away from the spinning jet at a higher linear rate while the path is lengthening, so producing thin places in the filaments, and at a lower rate while the path is shortening so as to produce thick places or slubs in the filaments. It has been found that in order to produce definite and pronounced slubs it is desirable that the movement of the deflecting surface to shorten the path of the filament should be as sudden and abrupt as possible. However, the speed with which the deflecting surface can be moved for this purpose is limited by considerations of inertia and other factors in the design of the apparatus used for the purpose. It has now been found that a rapid return of the filaments to their shortest path, resulting in the production of well-marked slubs in the filaments, can be effected by disengaging the filaments from their deflecting surface at or near the point of their maximum deflecttion so that their path can shorten without the necessity of rapidly moving the deflecting surface.

According to the present invention, therefore, a method of imparting variations in denier to artificial filaments by drawing them from a point where they are in a stretchable condition through a path in which they are deflected at intervals by a moving deflecting surface so as to vary the length of said path, comprises periodically disengaging said filaments from said surface during their deflection by a movement transverse to said path and to said deflection so that said filaments are free to return abruptly to a shorter path. Thus filaments can be drawn, in the course of their production by extrusion from a spinning jet, away from the neighborhood of the spinning jet where they are in a soft and stretchable condition, by means of a roller rotating at uniform speed. On their way to the roller, the filaments may be passed over a deflecting member moving periodically across the path of the filaments so as to lengthen or shorten their path from the jet to the roller, the member having a deflecting surface terminating at an edge, and the filaments are pushed laterally, while deflected by said surface, over said edge and so off the deflecting surface. The filaments are then free to return of themselves to their shortest path, to be picked up again in due course by the deflecting surface and deflected again, and so on.

A convenient form of deflecting surface is that of a roller rotating about an axis at right-angles to the path of the filaments and cut away round part of its periphery to form an edge, preferably extending half-way round the roller or more, close to the direct path of the filaments, means being provided to move the filaments transversely over the edge to drop into the cut-away portion.

The cut-away portion may thus be in the form of a deep slot capable of receiving the filaments when they are moved transversely over the edge of the slot. The unslotted portion of the roller circumference picks up the filaments at each revolution of the roller and, as the roller rotates, the filaments continue to be retained on the roller surface alongside the slot until they are shifted laterally across the surface and drop into the slot again. In this way their path is alternately lengthened and rapidly shortened. The transverse movement of the filaments is preferably effected, at a suitable moment during the rotation of the roller, by the conformation of the roller itself rather than by separate shifting means acting in timed relationship with the rotation of the roller. Thus, there may be provided an upstanding fin on the roller surface, lying nearly parallel to the slot and spaced therefrom where the fin first comes abreast of the filaments, but crossing the edge of the slot at a small angle so as to force the filaments laterally into the slot. Alternatively, the edge of the slot may be bevelled at a suitable point on the circumference of the roller so that when the filaments reach the bevel they slip over the edge and into the slot when the slot is in the position to offer the shortest path to the filaments.

Insead of being slotted, the roller may be cut away at its end to form a step, one-half or less of its periphery being of greater axial length than the remainder of its periphery. Indeed, a composite slotted roller designed to deal with a plurality of multi-filament threads or ends can be built up by assembling a number of short stepped rollers end-to-end. The method of the invention is preferably carried out not on a single end consisting of a number of filaments drawn from a single jet, but on a series of multi-filament ends drawn from a series of spinning jets as normally provided in spinning metiers for the production of artificial filaments. A number of such ends can be dealt with by a single deflecting roller, the roller being furnished with a series of slots disposed along its length at intervals corresponding to the spacing of the jets. Such slots should preferably be formed at different angular positions round the roller in order to balance the roller. A convenient arrangement is one in which the slots are alternately on opposite sides of the roller. It is preferred to use a hollow roller supported at its ends on stub shafts which do not extend along the length of the roller. In this way the slots can effectively extend round a full half or even more of the periphery of the roller so that the filaments can drop a distance equal to the radius of the roller or even more when disengaged from the surface thereof. It is desirable that the deflecting roller should be driven with a mean peripheral speed of the same order as that of the draw-roller and at a speed which is caused to fluctuate irregularly above and below the mean (though preferably not more than 10% above the draw-roller speed) so as to introduce an irregularity in the spacing of the slubs in the filaments. Such irregularity of spacing is desirable as avoiding unwanted patterning effects in fabrics woven or otherwise produced from yarns consisting of the filaments made in accordance with the invention. Alternatively or in addition, instead of drawing the filaments away at a uniform speed the drawing speed may be caused to fluctuate, e.g. by using a tapered drawing roller and traversing the filaments to-and-fro along the taper.

In order to increase the effect produced by the invention it is desirable that the part of the path over which variation in length takes place should be limited in extent, e.g. by the provision of stationary guides shortly before and shortly after the deflecting member. In this way, the amount by which the length of the path is changed for a given distance of deflection is increased.

Thus, with a roller as described above, stationary guides may be disposed just before and just after the roller, the former being of greater importance than the latter since, shortly after passing the deflecting roller the filaments proceed to the constantly rotating roller by which the drawing away of the filaments is effected. The drawing roller serves as a feed roller supplying the filaments to a suitable collecting device, preferably a twisting and winding device such as a ring-spindle. The filaments as forwarded by the feed roller are associated together for collection as a multi-filament yarn or thread, in which the variations in denier of the different filaments coincide and reinforce one another because the filaments have all been treated in the same way. If desired, however, e.g. for the purpose of multiplying the frequency of the variations in the resulting yarn or thread, groups of filaments having a different pattern of denier variations, or groups having the same pattern of denier variations but not in coincidence with one another, may be associated to form a single yarn or thread. Thus, filaments from different jets, or even two or more groups of filaments from the same jet, may be subjected together to the action of the same deflecting member but may reach it by paths of different constant lengths, so that the denier variations generated at the jet, being at different distances along the different filaments from the point where the filament paths meet, do not coincide in the resulting thread. While this procedure reduces the ratio between the thickest and the thinnest portions of the threads, the effectiveness of the present invention in giving sharp and well defined variations to the individual filaments makes it possible to afford such a diminution in some cases. A relatively slight, but sharp and frequent variation is likely to find a more lasting popular demand than a more markedly exaggerated effect.

The filaments of varying denier produced by the invention may be formed into yarns, either alone or twisted and doubled with threads of other natural or artificial filaments or fibres. Or they may be cut or reduced to staple lengths, either continuously with their production or subsequently thereto, and spun into yarns, either alone or mixed or blended with other natural or artificial filaments or fibres and such spun yarns may, if desired, be twisted or doubled with the same or other yarns to form any desired type of thread. The yarns or threads of varying denier may be applied to the production of fabrics or articles either alone or in association with yarns or threads of regular artificial filaments or of other natural or artificial filaments or fibres. They may be used, for example, in the warp and/or weft in weaving operations; in knitting operations, for example in the production of warp knitted fabrics; in circular hosiery or other knitting machines; in braiding or cording operations; in net or lace making operations; or in any other fabric-forming textile operation.

The invention is particularly applicable to the imparting of varying denier to artificial filaments in the course of their production by spinning or extrusion, and particularly to filaments of cellulose acetate or other organic derivative of cellulose produced by the dry-spinning or evaporative method. It may also be employed, however, in other methods of spinning, e.g. wet-spinning or melt-spinning, and in the production of filaments of other materials, e.g. regenerated cellulose filaments, nylon or polyamide filaments, e.g. of polyhexamethylene adipamide and polyester filaments e.g. of polyethylene terephthalate. Moreover, the invention may also be employed for imparting a varying denier during the stretching of previously spun filaments. In such a case, instead of a spinning metier for the production of artificial filaments, there is employed a source of supply of previously spun filaments and means for bringing the filaments to a plastic and stretchable condition, e.g., a zone for heating said filaments or for applying to them a suitable softening agent, for example solvents, solvent vapours, hot water or moist steam. Or again, the invention may be used for the cold-drawing of filamentary material, e.g. nylon, to produce a cold-drawn material of varying denier.

By way of example, one form of apparatus in accordance with the present invention for the production, by the evaporative method of cellulose acetate filaments of varying denier and the method of using it to carry out the method of the present invention, will now be described in greater detail with reference to the accompanying drawings, in which

FIGURE 1 is a diagrammatic side elevation of the apparatus,

FIGURES 2, 2*a*, 2*b* and 2*c* are side elevations in different positions and FIGURES 3 and 3*a* plan views on a larger scale of the deflecting roller shown in FIGURE 1,

FIGURE 4 shows a modification of the drawing roller shown in FIGURE 1, and

FIGURES 5 and 5*a* show modifications of the deflecting roller shown in FIGURE 1.

The apparatus comprises a dry-spinning metier **7** for the production of a series of threads **8**, each consisting of a plurality of filaments, each thread being extruded from a multi-hole spinning jet **9** supplied at constant volumetric rate with spinning solution through a suitable filter element **11**. The jet **9** and filter element **11** are disposed at the top of a cell or cabinet **12** down which the filaments proceed, being hardened by evaporation of volatile solvent therefrom on their way, and from the bottom of which they are led out. The thread of filaments **8** leaving the spinning cabinet **12** is passed over a lubricating device **13** adapted to apply a finish to the filaments and proceeds in a generally horizontal direction to a feed roller **14** rotating at uniform angular speed and provided with a back guide **15**. The roller **14** is adapted to forward the thread **8** to the balloon guide **16** of a ring-spinning device **17** by means of which the filaments of the thread **8** are twisted together and wound on a bobbin **18** as a twisted yarn.

On their way from the lubricating device **13** to the feed roller **14** the filaments pass over a deflecting roller **19** about 9" in diameter. A series of such rollers **19** is provided along the length of the metier **7**, one for each six spinning jets **9**. Each roller **19** is driven individually through a clutch **21** from a common countershaft **22** extending along the metier **7**. Each roller **19** is in the form of a hollow shell **23** supported at each end on short axles **24** which do not extend internally along the axis of the roller. At intervals along the length of the roller **19** corresponding to the spacing of the spinning jets **9** along the length of the metier **7** the roller is formed with six slots **25** each extending at right-angles to its axis round half of the periphery of the roller. Nearly opposite each slot **25**, a pair of stationary thread guides **26**, **27** are situated. The guide **26** is situated just before and the guide **27** just after the roller **19**, at the level of the axis thereof and both are offset a short distance to one side of the slot **25**. A hook guide **28**, for temporary use during starting operations, is disposed above the roller **19**. Alongside each slot **25** and secured to the roller surface is a radially extending fin **29** reaching circumferentially of the roller from a point at about the middle of the length of the slot **25**, to a point a little beyond the end of the slot. The leading end **31** of the fin is spaced further from the edge **32** of the slot than the transverse plane (as described in FIGURE 3 at **30**) containing the two guides **26**, **27**. In extending backwards round the roller **19**, however, the base of the fin **29** gradually approaches the edge **32** of the slot **25** at an angle of about 5°, and reaches it at the trailing end **33** of the fin. The trailing part of the fin from **33** to **34** is of a uniform height of about ½" but the leading part from **34** to **31** where the fin is well clear of the plane **30** diminishes in height and merges into the roller surface. The face **35** of the fin adjoining the slot **25** is not quite vertical but leans

over slightly towards the slot **25** so that, while the base of the fin at its trailing end **33** coincides with the edge **32** of the slot the crest of the fin at this point overhangs the slot.

The countershaft **22** is driven at a variable speed from the shaft **36** which carries the feed rollers **14**. The drive is effected by way of a variable speed gear **37** of known type in which two plates or discs are arranged face-to-face and carried respectively by collinear input and output shafts, and are coned or bevelled at their edges on the sides facing one another; the coned portions are engaged by spherical members rotatable about integral spindle axes which, while coplanar with the input and output shafts, are arranged at a variable angle thereto. Thus, while one disc engages with a larger portion of each of the spherical members the other engages with a smaller portion so that their relative speeds can be varied according to the variable angle of the spindles of the spherical members. The angle of the spindles is varied by means of a diaphragm or iris plate coaxial with the input and output shafts and rotatable through a moderate angle (about 40° each way) by means of a control lever **38**. The countershaft **22** constitutes the output shaft of the device **37** while its input shaft (not shown) is driven from the shaft **36** by means of a chain **39**. The speed of the shaft **22** is varied, through the control lever **38**, by means of a multi-node cam **41** which in turn is driven from a second variable speed gear **42** similar to the gear **37** and driven through a chain **43** from the main shaft **44** of the metier, from which the shaft **36** is itself driven through a change-speed gear box **45** and chains **46**. The nodes of the cam **41** are irregular as to both height and angular extent. The control lever **47** of the gear **42** is in turn actuated by a heart cam **48** driven from the main shaft **44** through a reduction gear **49**, giving a speed reduction of the order of 1,000:1, and a chain **51**. The control lever **38** is connected to the cam **41** through a lever **54** and link **55** while the control lever **47** is connected to the cam **48** through a similar lever **52** and link **53**. By these means the countershaft **22**, and thereby the slotted rollers **19**, are driven at a speed which varies according to a pattern which is repeated only after a very long period.

In the operation of the apparatus described above, the filaments **8** are first threaded over the lubricating device **13** through the guide **26** and over the hook guide **28**, and are thrown-on to the feed roller **14** on which they are temporarily collected. When spinning is established in this way, the filaments **8** are disengaged from the guide **28** and engaged with the slotted roller **19** and guide **27**. They are then engaged with the back guide **15** and thrown-on to the balloon guide **16** and bobbin **18**, for the operation to proceed. In the course of the subsequent operation, the filaments **8** passing through the two stationary guides **26**, **27** extend, at one stage, in a straight line through the slot **25** and along a diameter of the roller **19** as in FIGURES 1 and 2; at this stage the roller **19** is positioned so that the slot **25** extends round its upper half and the ends of the slot lie in a horizontal line as in FIGURE 1. As the roller **19** rotates, the unslotted portion **57** of its periphery picks up and deflects the filaments from their straight path as shown in FIGURE 2*a* so that they are caused to pass over the unbroken roller surface as in FIGURE 2*b*. As the leading end of the slot **25** comes round, the filaments continue to be carried by the roller surface alongside the slot **25** as in FIGURE 2*c*, on account of the disposition of the two stationary guides **26**, **27** slightly offset from the slot. In due course the leading end **31** of the raised fin **29** on the roller surface comes abreast of the filaments and at first does not disturb their passage over the roller. On continued motion of the roller, however, the fin urges the filaments axially along the roller until they are disengaged from the roller surface and caused to drop into the slot. This takes place at the moment when the trailing end **33** of the fin **29** reaches the point, indicated at **56** in FIGURE 2, where the tangent from the first guide **26** (i.e. the line of the thread **8** in passing from the first guide **26** over the roller **19**) meets the roller. This is shortly before the ends of the slot **25** are again in a horizontal line. When the tread **8** drops into the slot **25** it becomes slack. In a very short time, this slack is taken up by the rotation of the feed roller **14** and the timing should be such that, just as the slack is taken up, the ends of the slot **25** come into a horizontal line so that the filaments on tightening assume a direct path along the diamter of the roller **19**, whereupon the cycle is repeated. The position of the trailing end **33** of the fin **29** at about the mid-point of the slot **25** is approximate. It may need to be a little behind or a little in front of this point for the timing as indicated above to be at its optimum.

While the filaments **8** are being deflected from the straight path from one stationary guide **26** to the other **27**, their path is lengthening, and the filaments are drawn down from the jet **9** at a rate greater than the peripheral speed of the feed roller **14**. As the filaments drop into the slot **25**, however, they cease to be drawn down from the jet **9** and emerge therefrom at a rate determined by the volumetric rate of extrusion of the spinning solution. This causes a thick place in the filaments which passes down the spinning cabinet **12** and is hardened by evaporation. When the roller **19** again deflects the thread, the hardening of the thick places prevents it from being drawn out, the drawing taking place at the freshly forming parts of the filaments **8** in the immediate neighbourhood of the jet **9** where the filaments are in a more soft and extensible condition. In consequence, the resulting filaments have variations in denier along their length in which the thick or slub portions are well marked in comparison with the thin portions. The countershaft **22** from which the deflecting rollers are driven is rotated with a mean speed such that the mean peripheral speed of the deflecting rollers is about equal to that of the feed roller. However, the speed of the countershaft **22** is caused to fluctuate by driving it through the speed-varying or "scrambler" gear **37—55**, so as to break up the regularity of the variation in denier along the length of the yarn. A range of speed variation of plus or minus 10% is suitable for the purpose. It is preferable, however, that the maximum peripheral speed of the roller **19** should not at any time much exceed the peripheral speed of the roller **14**, to avoid the production of excessive slack between the two rollers. For this reason it is desirable that, during its variation, the speed of the roller **19** should for the most part be below that of the rollers **14**, the filaments **8** being thus caused to slip forward over the surface of the roller **19** when necessary.

In FIGURE 4 is shown a modification of the arrangement shown in FIGURE 1 in which, instead of the cylindrical drawing roller **14**, a tapered roller **58** is employed. In addition to the back guide **15**, there is provided a further guide **59** at the horizontal level of the top of the roller **58**, both guides **15** and **59** being mounted on a horizontal traverse bar **61** extending the length of the metier. The bar **61** is traversed to-and-fro so that the guides **15**, **59** supply the thread **8** to different portions along the length of the tapered roller **58**, thus varying the speed of drawing of the filaments. The traverse bar **61** may be operated at a variable speed by means of gear similar to the gears **37**, **42** described above. The arrangement shown in FIGURE 4 may be used in place of the variable speed drive for the roller **19** described with reference to FIGURE 1, or in addition thereto.

FIGURES 5 and 5*a* show a modification of the slotted roller **19** wherein instead of providing a fin **29** as described with reference to FIGURE 1, the edge of the slot **25** is bevelled as indicated at **62**, the bevel being wide enough to reach the transverse plane **30** containing the guides **26**, **27** and containing the direct path of the thread

8 over the roller. When the bevelled portion 62 reaches the tangent point 56 (shortly after the position indicated in FIGURE 5*a*) the thread 8 slips over the bevel and drops into the slot 25.

Having described our invention, what we desire to secure by Letters Patent is:

1. Apparatus for imparting variations in denier to artificial filaments, said apparatus comprising a pair of guides, a first roller for drawing filaments along a path defined by said guides, a second roller rotatable about an axis substantially at right angles to said path and disposed in said path, the periphery of said second roller being cut away round part only of a transverse section of the roller close to but out of the direct path between the guides, thereby providing an edge displaced, axially of the roller, from a plane which is at right angles to the roller and includes the path between the guides and means for pushing said filaments laterally over said edge while deflected by the roller surface.

2. Apparatus according to claim 1 wherein the cutaway portion of the second roller constitutes a deep slot.

3. Apparatus according to claim 1 wherein the means for pushing the filaments over the edge as the second roller rotates are carried by said roller surface.

4. Apparatus according to claim 3 wherein the means for pushing the filaments over the edge comprise an upstanding fin extending round the surface of the second roller close to the edge, said fin approaching and reaching said edge as it extends backwards round said roller.

5. Apparatus according to claim 2 wherein the edge is bevelled over part of its peripheral length, the bevel reaching substantially to the direct path of the filaments over the second roller.

6. Apparatus according to claim 2 wherein the second roller has a plurality of cut-away portions for dealing with a plurality of bundles of filaments, said cut away portions being displaced from one another round the periphery of the roller.

7. Apparatus according to claim 1 comprising means for periodically varying the rate of drawing of the filaments by the first roller.

8. Apparatus according to claim 7 wherein the means for effecting the periodically varying rate of drawing comprises a tapered drawing roller, guide means for directing the filaments to said roller, and means for traversing said guide means to-and-fro along said roller.

9. Apparatus according to claim 1 comprising means for varying the frequency of deflection of the filaments by the second roller.

10. Apparatus according to claim 1 comprising a spinning metier for the production of artificial filaments serving as a first supply from which the filaments are drawn away by the roller.

11. Apparatus for imparting variations in denier to artificial filaments, said apparatus comprising a filament guide, a roller for drawing filaments along a path from said guide to said roller, a deflecting surface carried by a member continuously rotatable about an axis transverse to said path and situated generally between said guide and said roller whereby at one part of the rotation of the member the deflecting surface is out of said path and at another part of the rotation of the member the deflecting surface moves towards the roller and simultaneously across said path, and a projection carried by and extending outwardly from said surface and the axis of rotation of the latter, the said projection being adapted to lead filaments being drawn by the roller from said guide, and while said filaments are deflected by said surface, to and over an edge of the surface.

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